Lyman alpha imaging of Green Pea galaxies –
connecting the escape of ionizing photons to the spatial distribution of Lyman alpha

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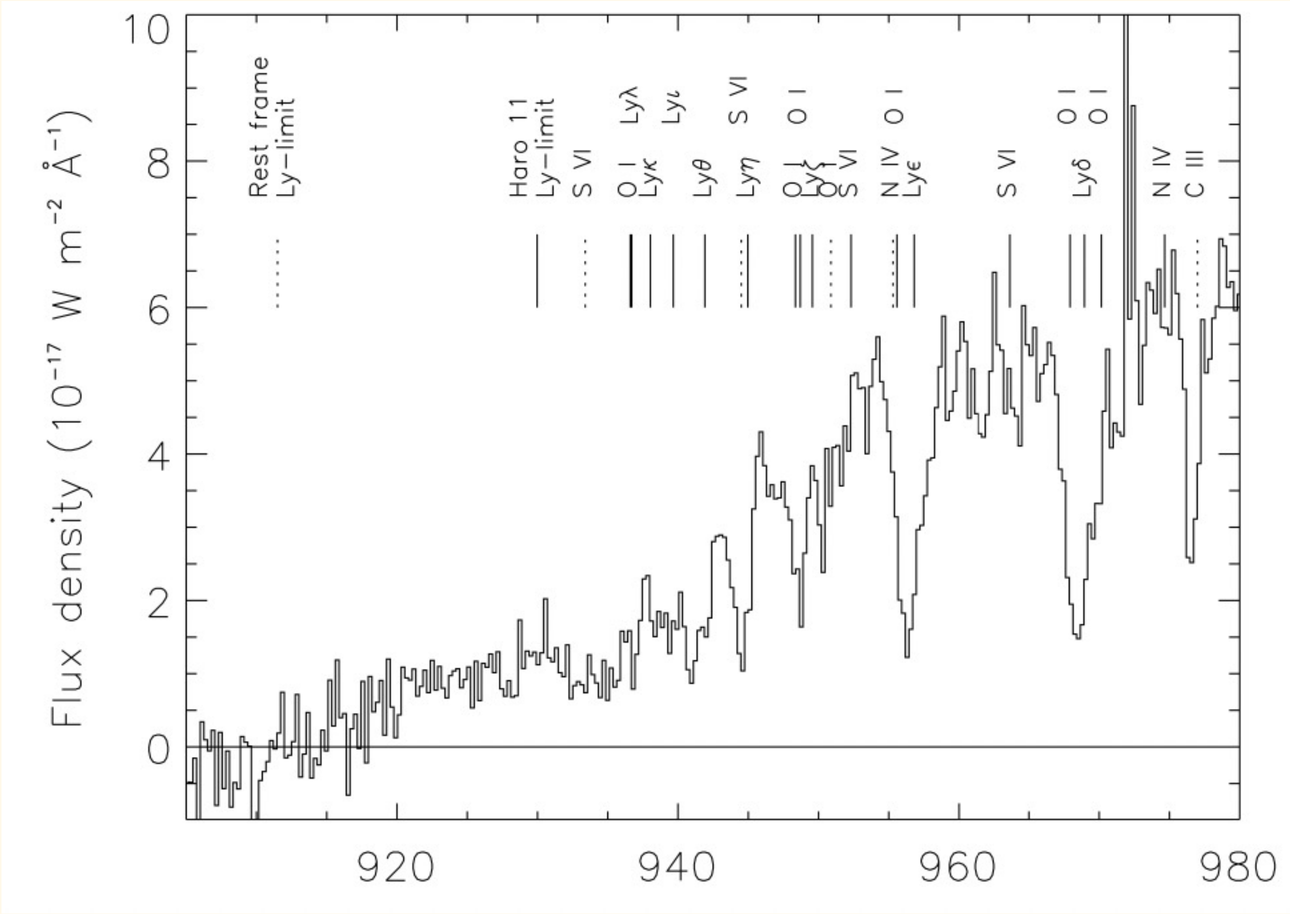
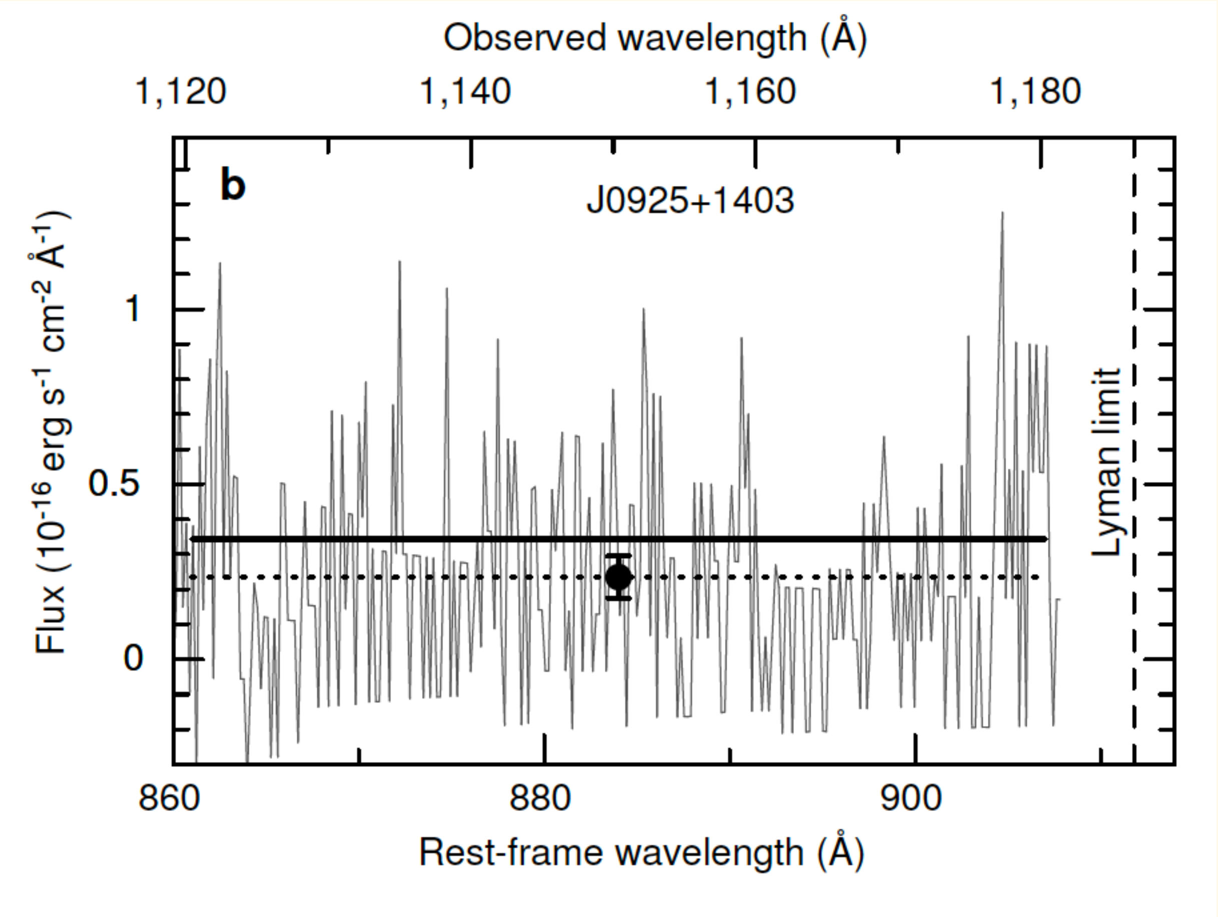
The first direct detections of LyC radiation from nearby starforming galaxies are less than twenty years old.

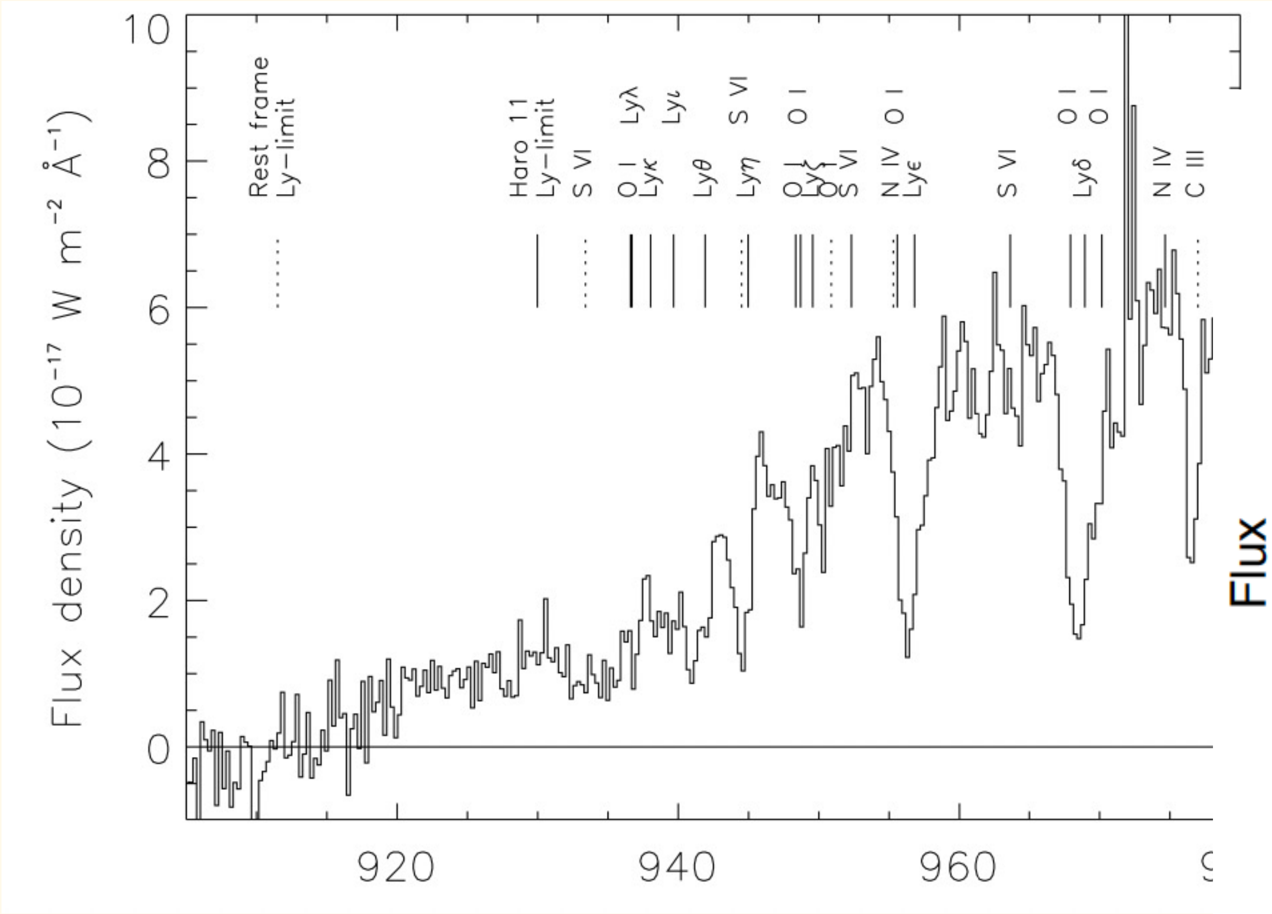


Haro 11, Bergvall et al. 2006

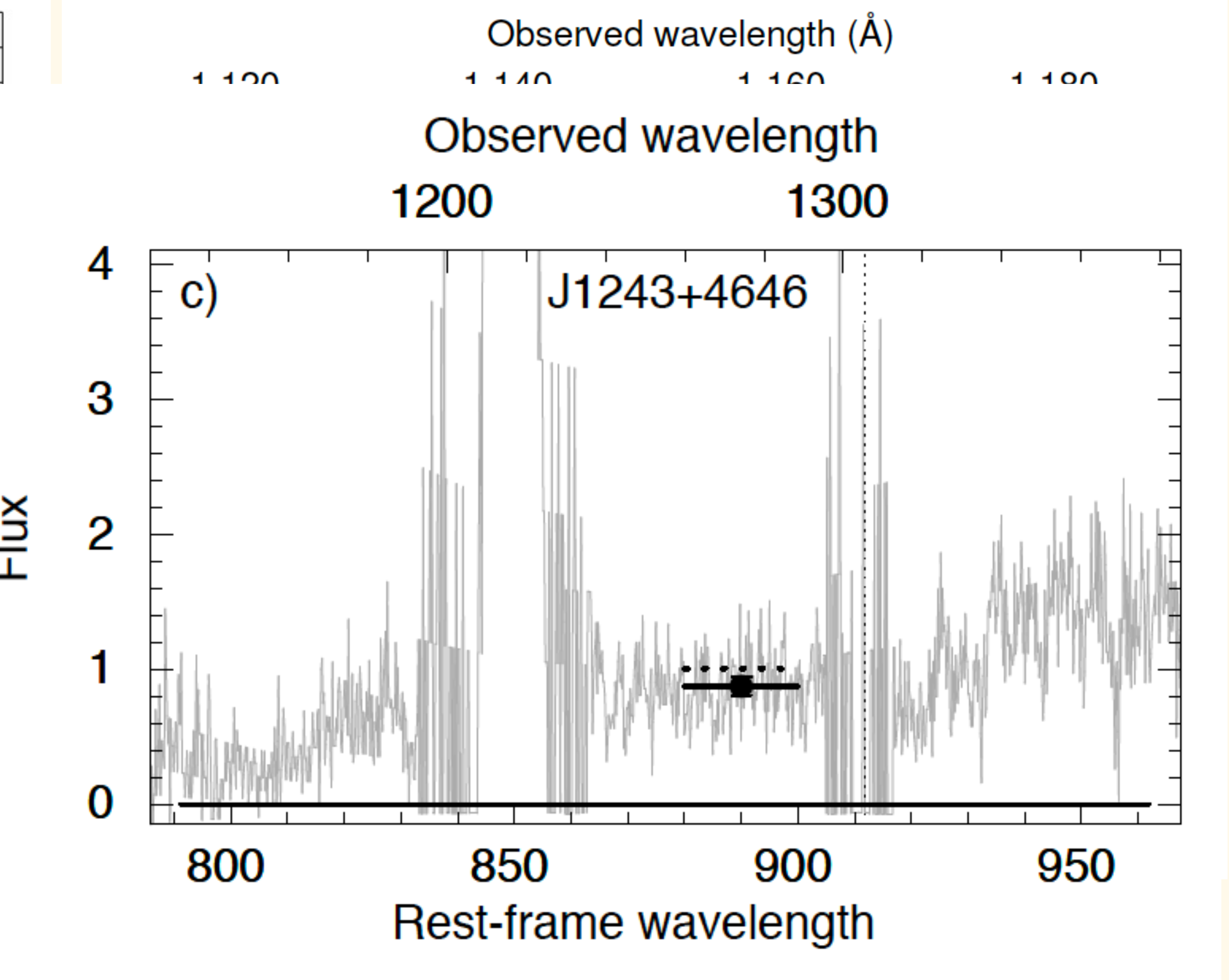


Izotov et al. 2016b

The sample grew fast, due to focused efforts by the community, and possibly that we know what to look for…

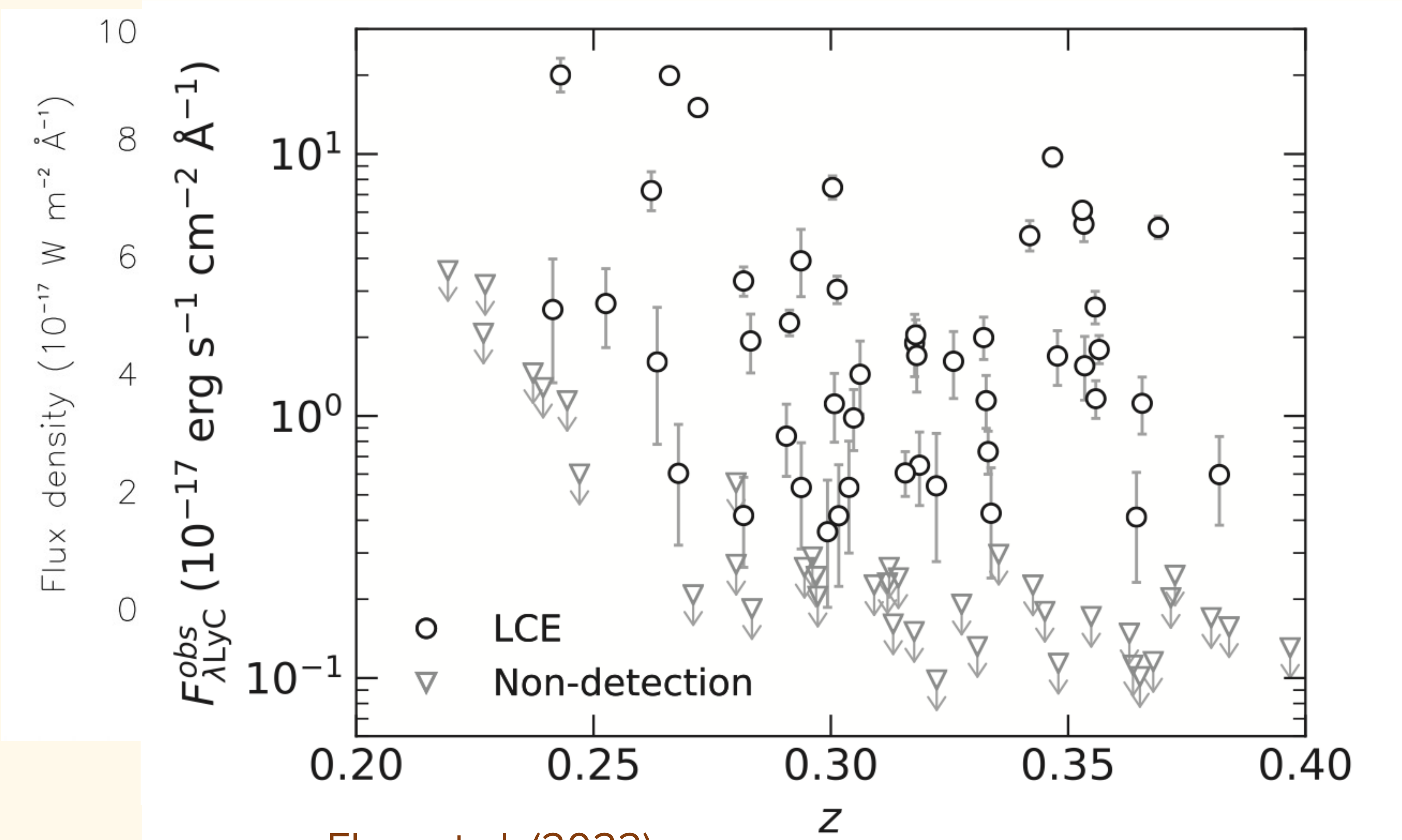


Haro 11, Bergvall et al. 2006

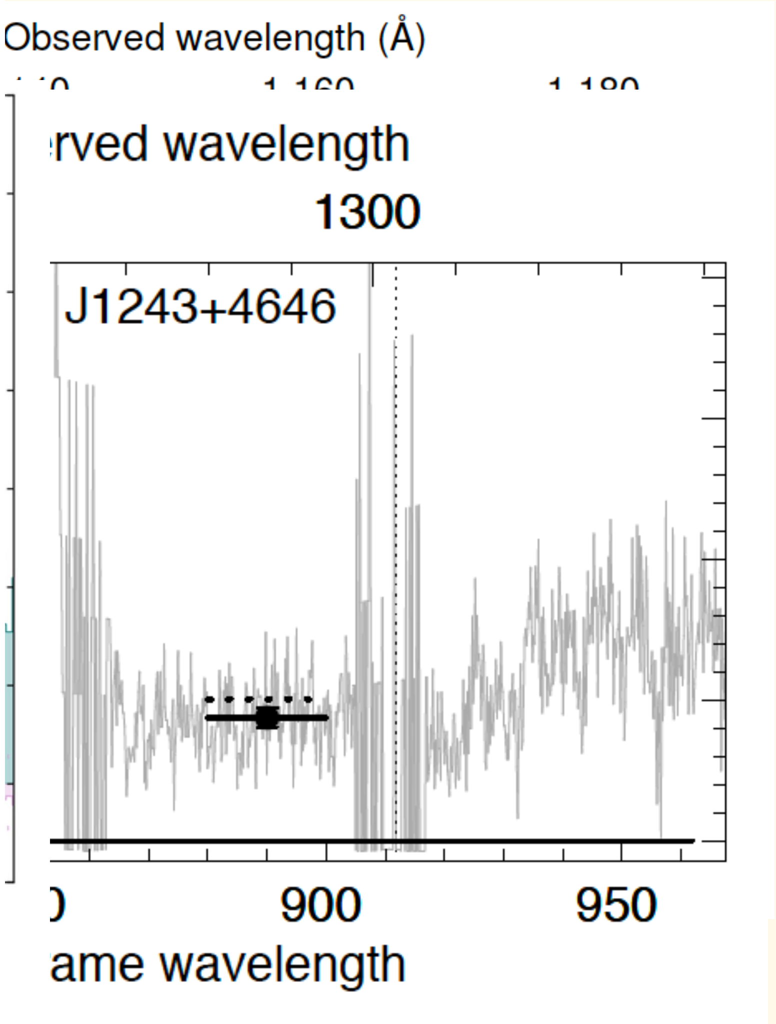


Izotov et al. 2018

The LzLCS observations provided a broader sample of galaxies to look for LyC escape.

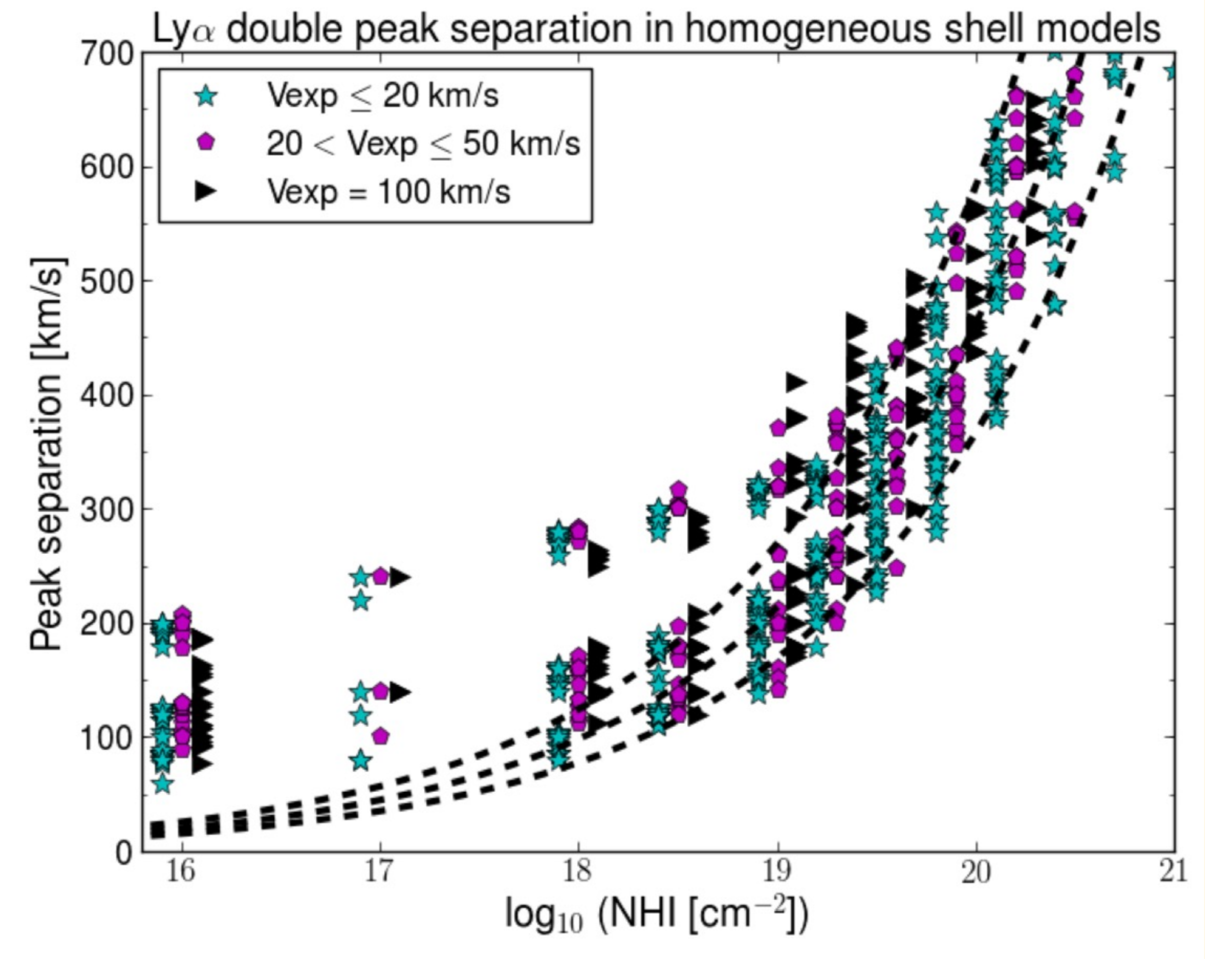


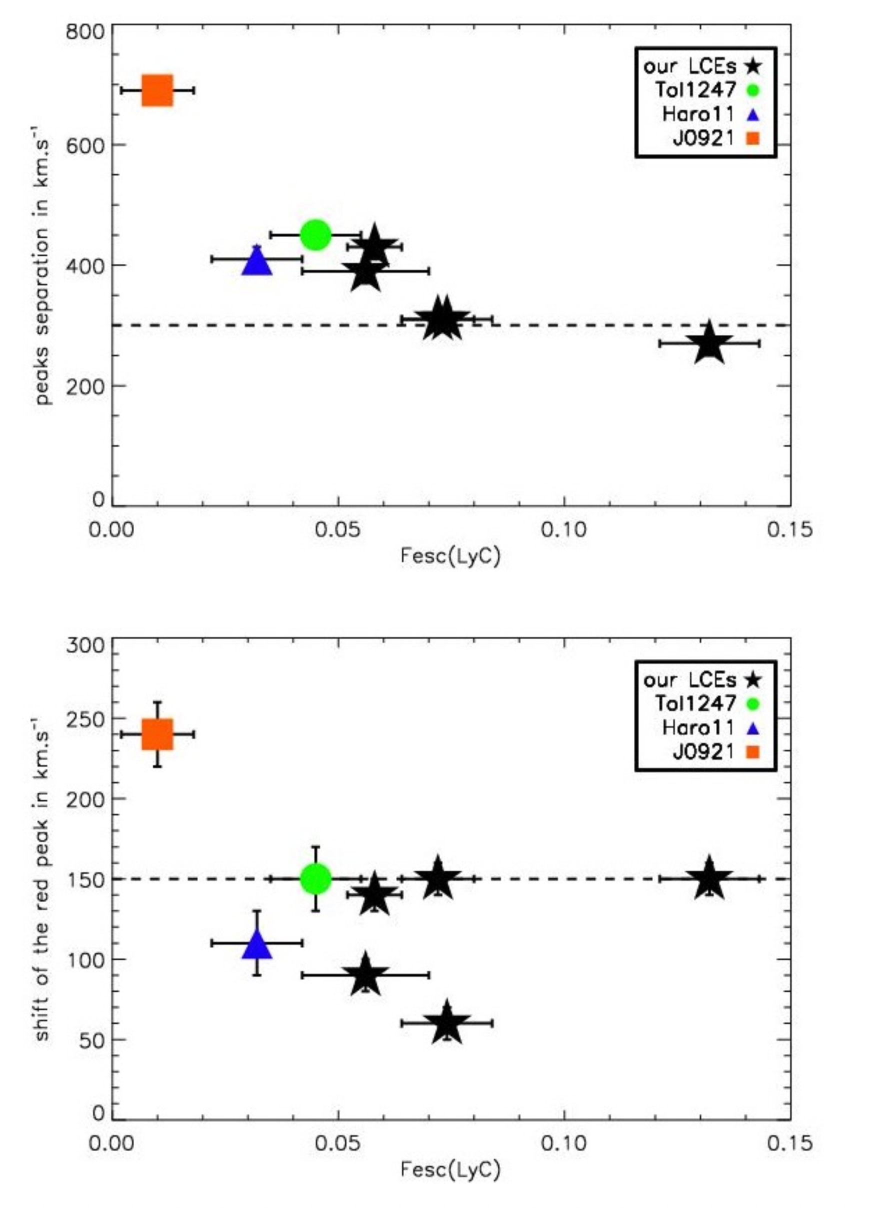
Flury et al. (2022)



Izotov et al. 2018

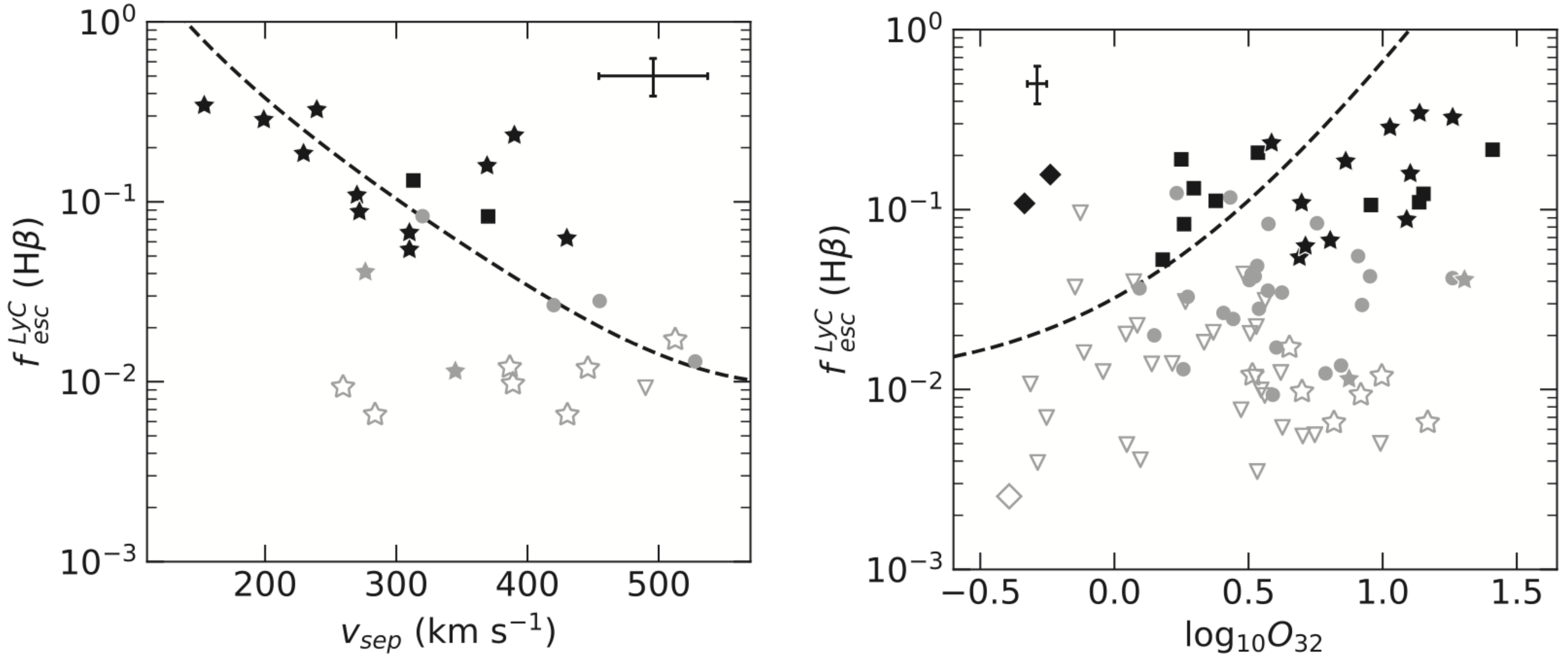
Lyα escape and radiative transfer are connected to LyC escape.





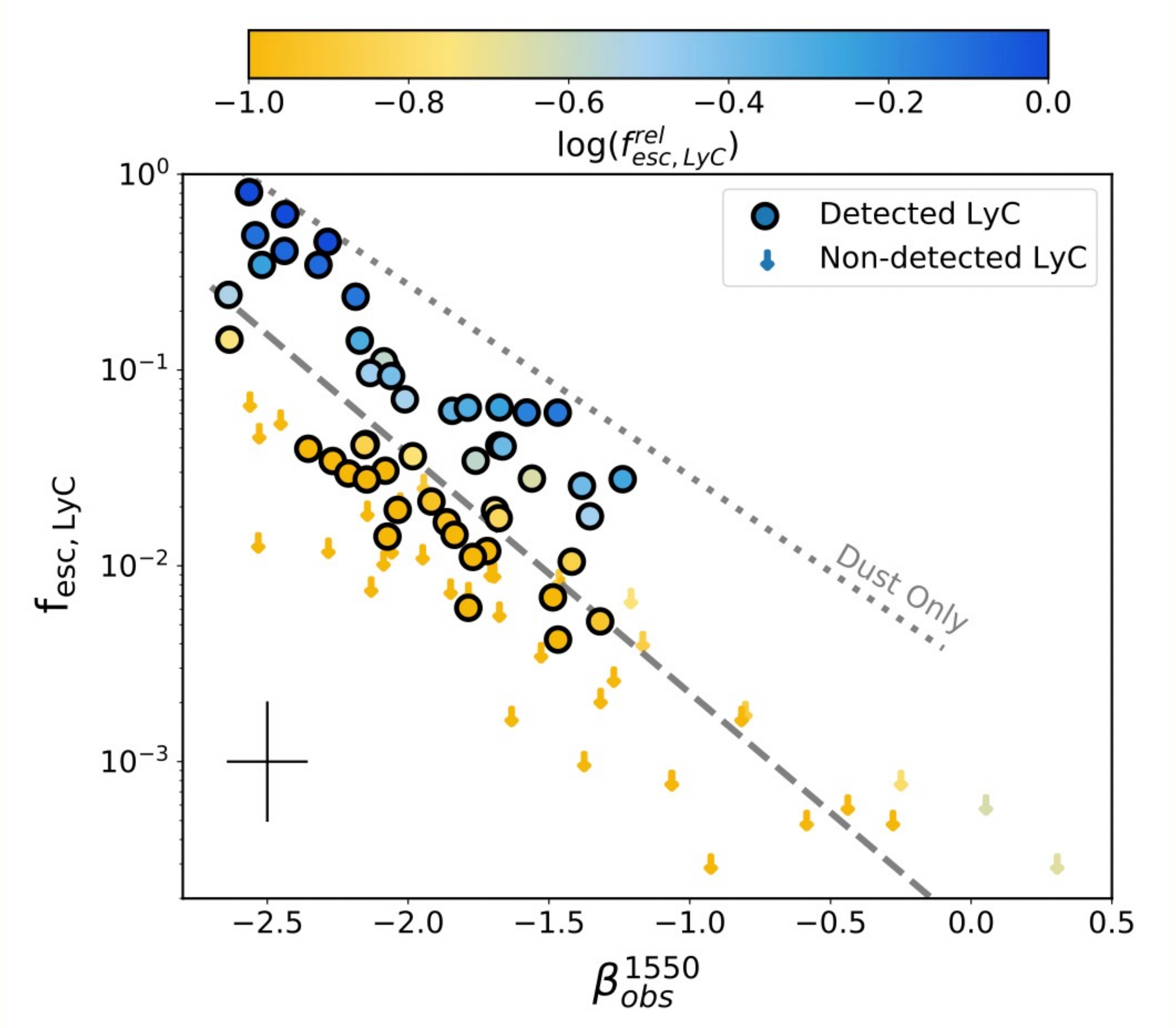
Verhamme et al. 2015, 2018

Lyα escape and radiative transfer are connected to LyC



Flury et al. (2022)

LyC escape and extinction



Dust also has a big effect on the escape.

LyC photons can be absorbed by neutral hydrogen or dust.

→ need diagnostics that relate to both of these

Chisholm et al. (2020)

Q: Do Lyman continuum leaking galaxies have more spatially compact Lyα emission?

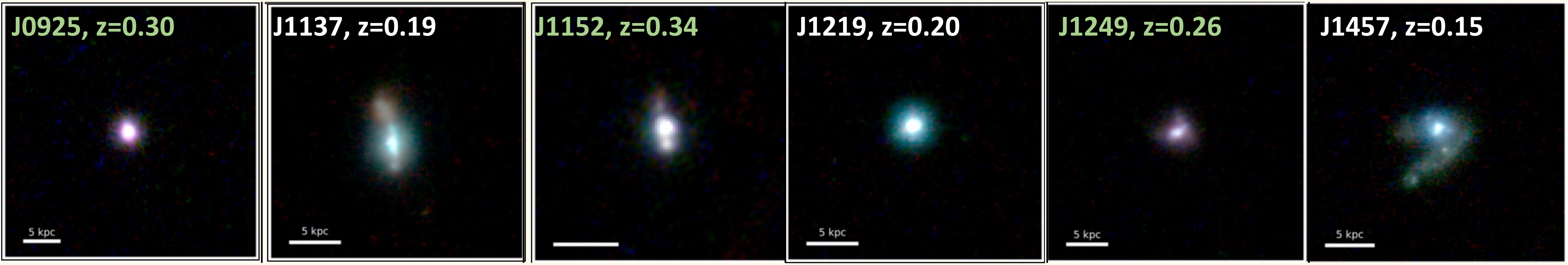
- LyC leaking galaxies have lower HI column density along the line-of sight -> double peak with low peak separation. The Lyα photons should then scatter less before escaping.

  ➡ Low halo fractions

- Could provide a measure of effective neutral gas column density, rather than a line-of-sight measurement. Indication of LyC escape even in galaxies with unfavorable sightlines?

Observations:

- 6 Green Pea galaxies, 3 continuum leakers (LCEs) from Izotov et al. (2016a,b) and LzLCS, 3 GPs at somewhat lower redshift (Orlitova et al. 2018).

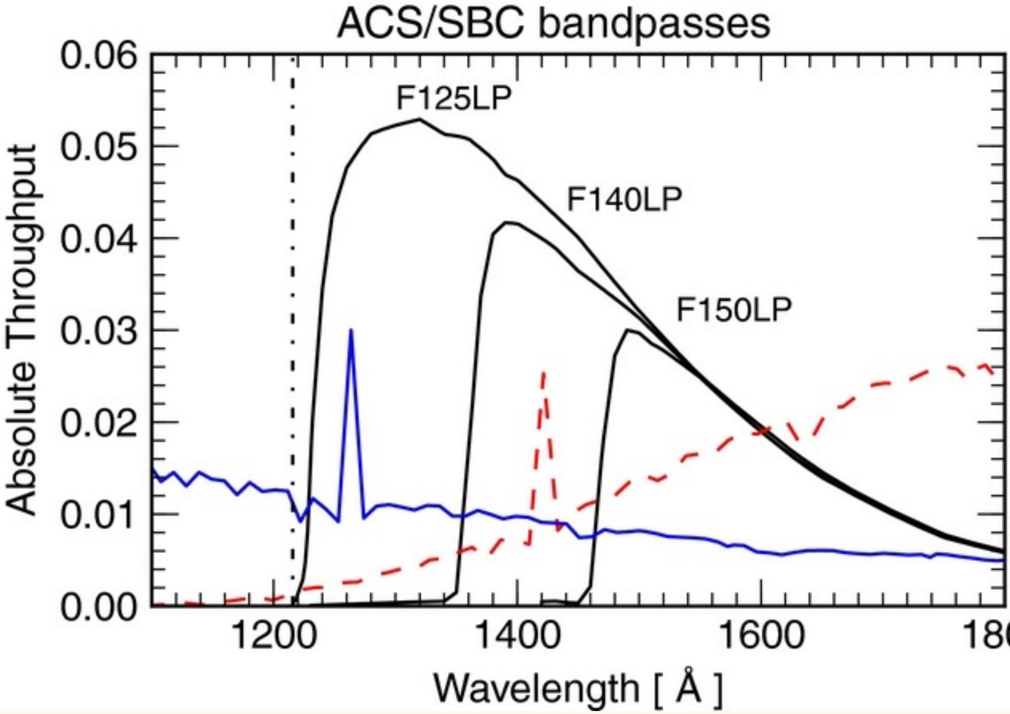


- Also includes galaxies from LARS (Rasekh et al. 2022, Melinder et al. 2023). The full data set of HST imaging for LARS will be available as a MAST HLSP very soon.

Observations

HST Imaging

- 3 FUV broadband filters (ACS/SBC)
- 3 optical broadband filters (ACS/WFC3)
- 2 NB filters for Hβ, Hα (ACS/WFC3)



Pixel SED fitting using 2 FUV filters and 3 optical broadband filters. Standard X^2 fitting on each pixel (LaXs, Melinder et al. 2023).

- Starburst99 template spectra, fitting with 3-4 free parameters, age, $E(B-V)_{s,}$ and mass. Two populations + nebular cont.
- Assumptions: Attenuation law, Z and NII from SDSS, SSP SF history.

Observations

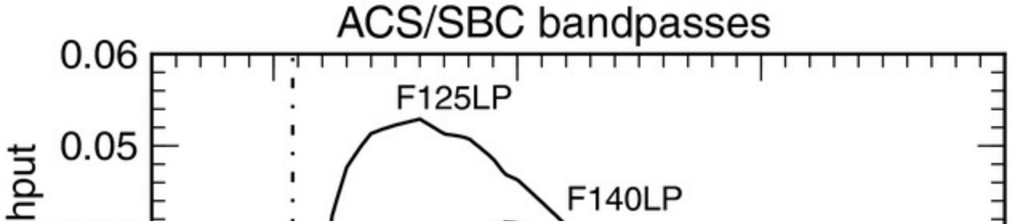
HST Imaging

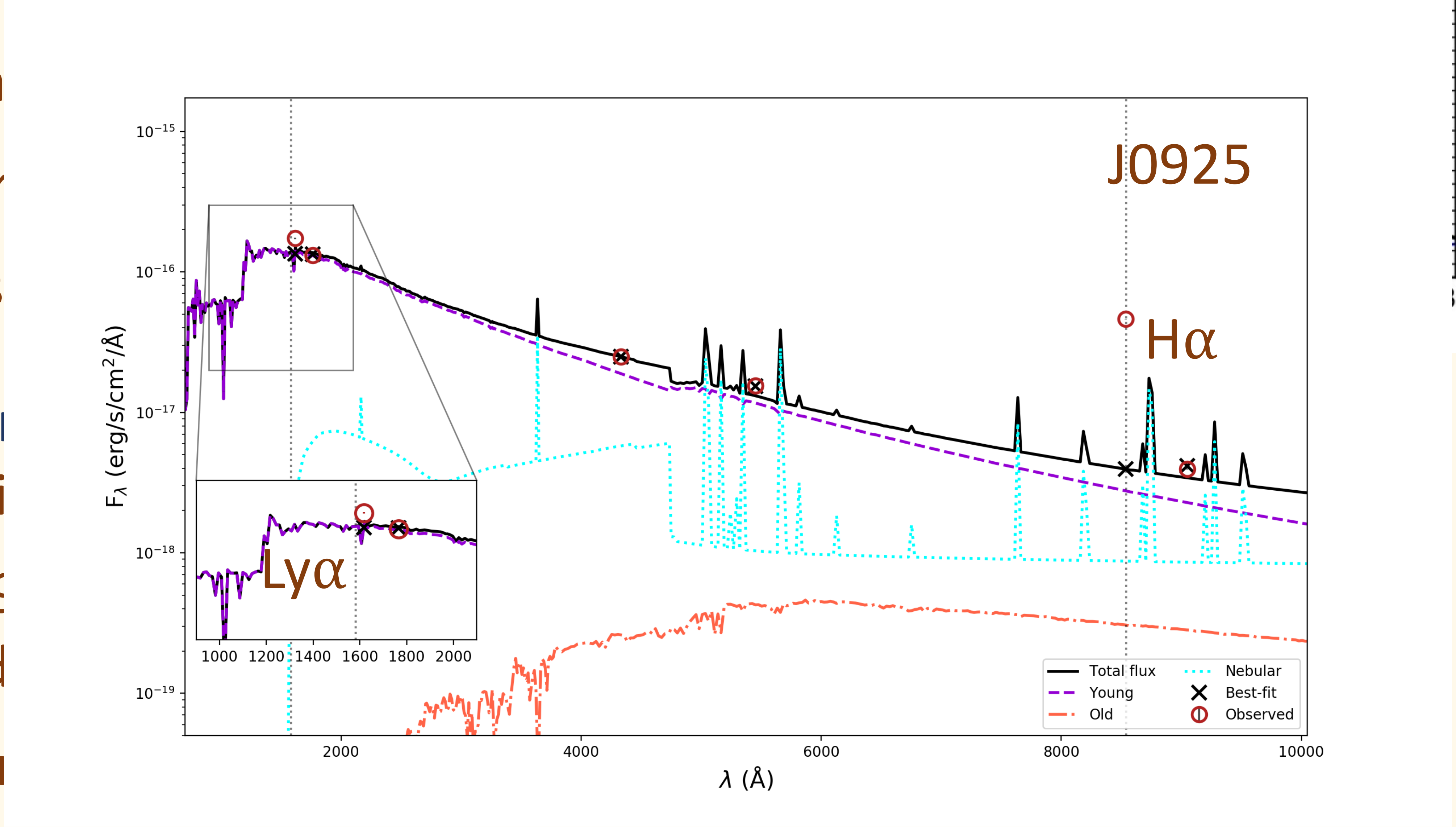
- ◆3 FUV broa
- ◆3 optical br
- ◆2 NB filters

Pixel SED fitti

Standard X^2 fi

- ◆Starburst9
  E(B-V)$_s$, and
- ◆Assumptio





Lyα compactness

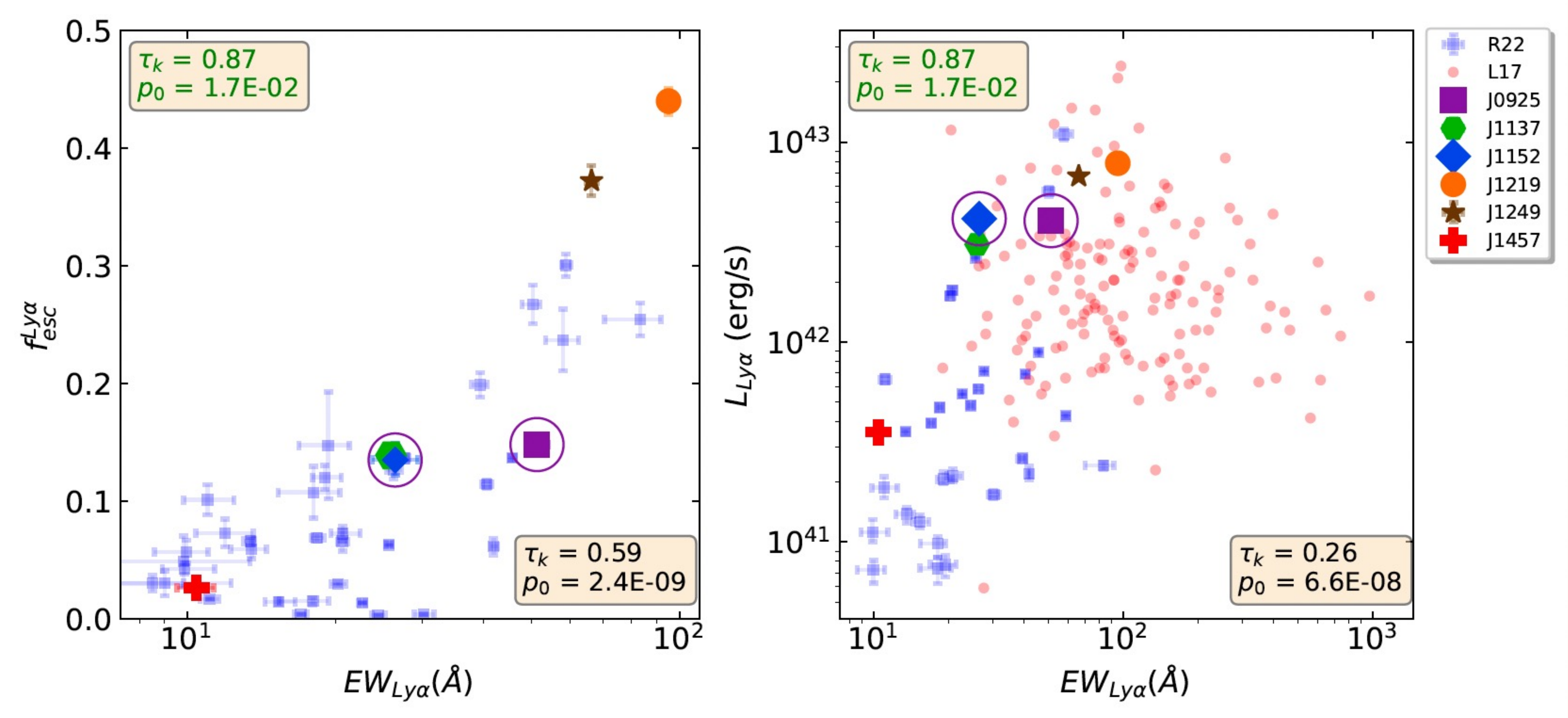
We estimate the compactness by deriving halo fractions (HF) of Lyα (Rasekh et al. 2022). We define

$$HF = \frac{L_{halo}}{L_{core} + L_{halo}}$$

The core and halo regions are defined by using a star formation rate density map (from dust corrected FUV stellar continuum). Fluxes/σ_{SFR} measured in circular annuli/apertures.

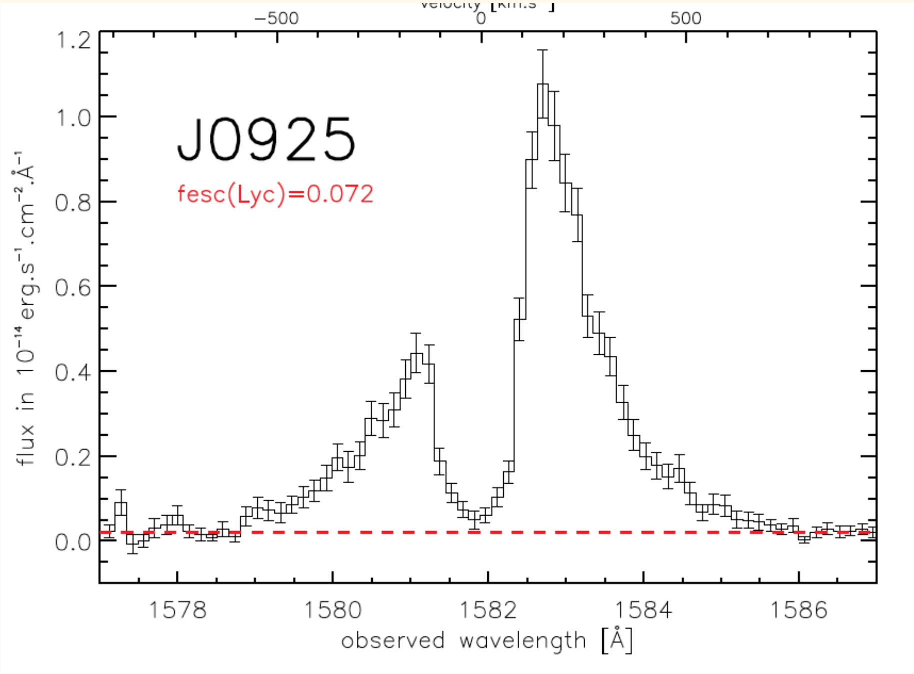
Core: $0 < r < r_{core}$ (r_{core} is the radius where $\sigma_{SFR} > 0.01\ M_{\odot}/yr/kpc^2$)
Halo: $r > r_{core}$ (exponential fit integration used).

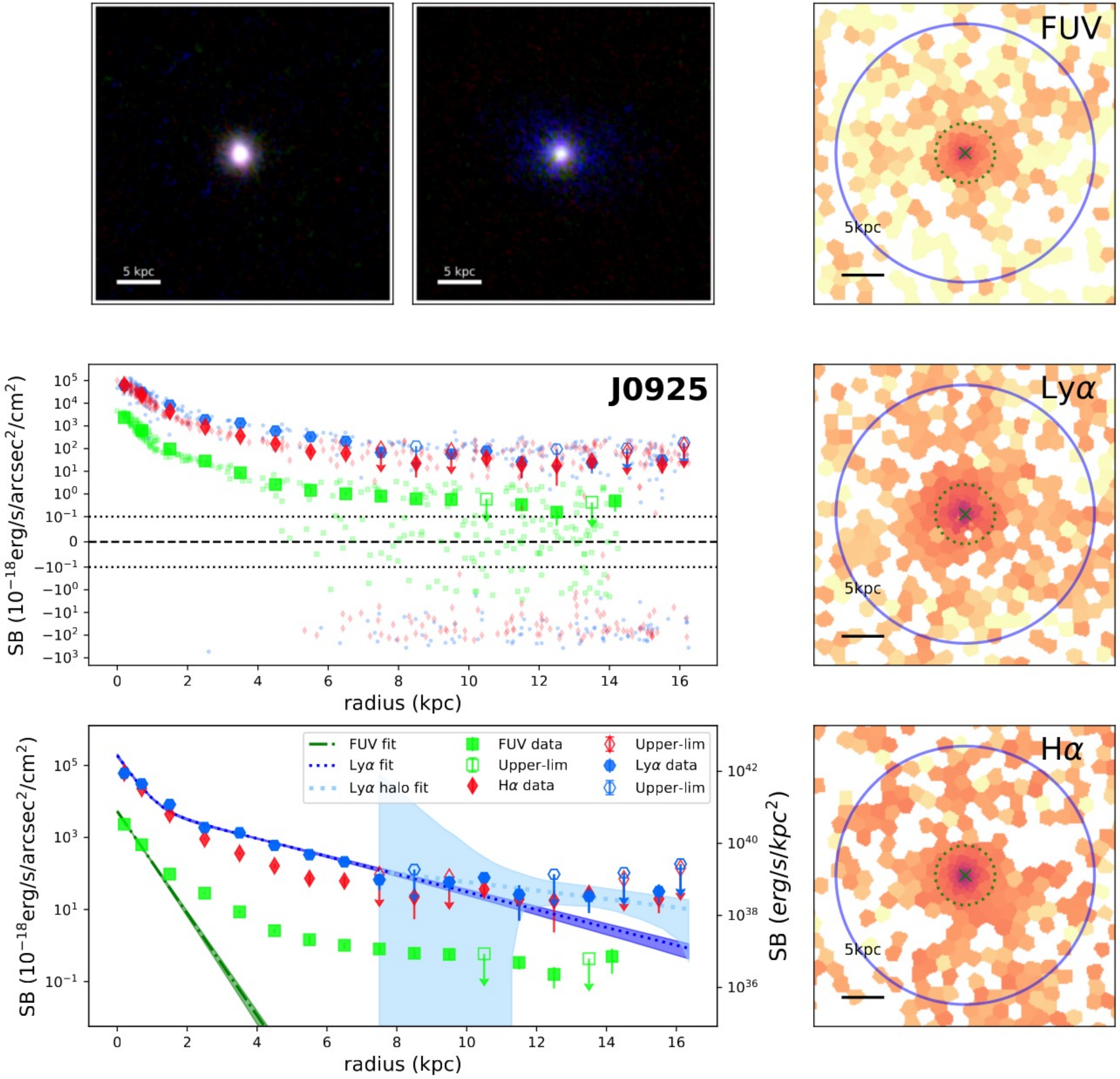
Ly**α** global measurements compared to LARS (Melinder et al. 2023), and MUSE (Leclercq, 2017)



J0925, f_{esc}(LyC)=7%

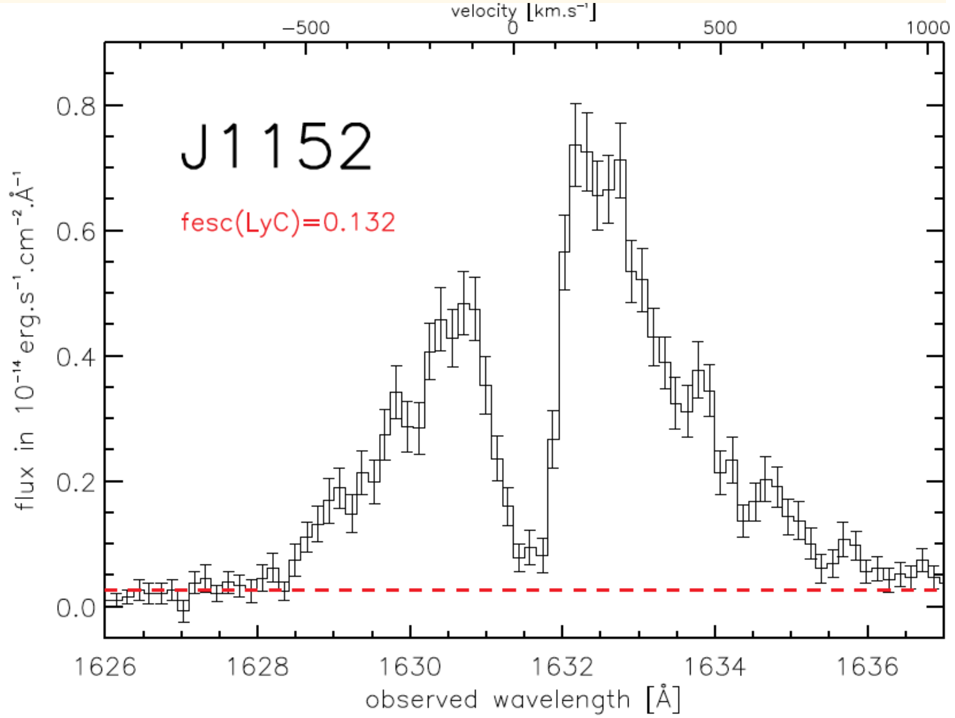
Verhamme et al. (2018)

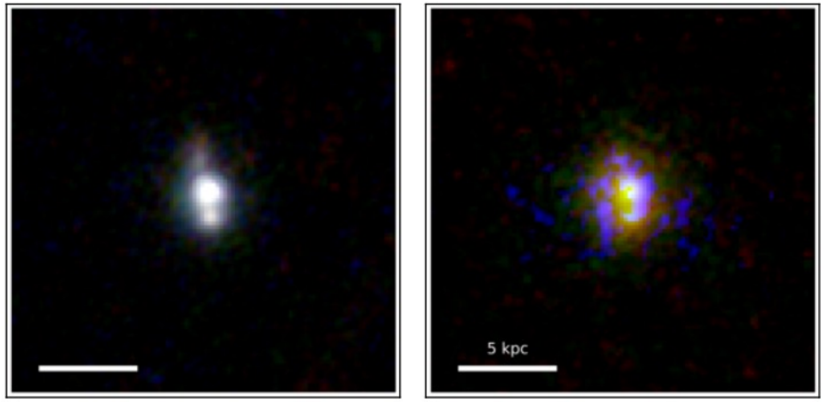


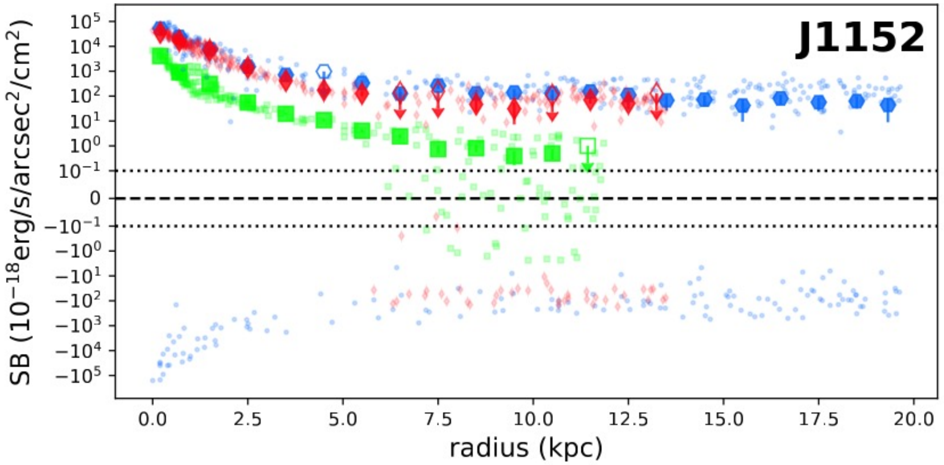


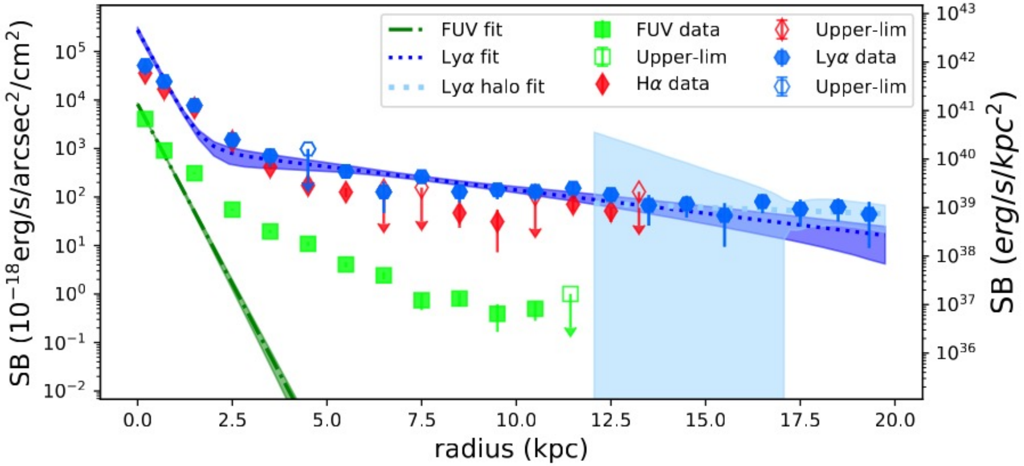
J1152, f_{esc}(LyC) =13%

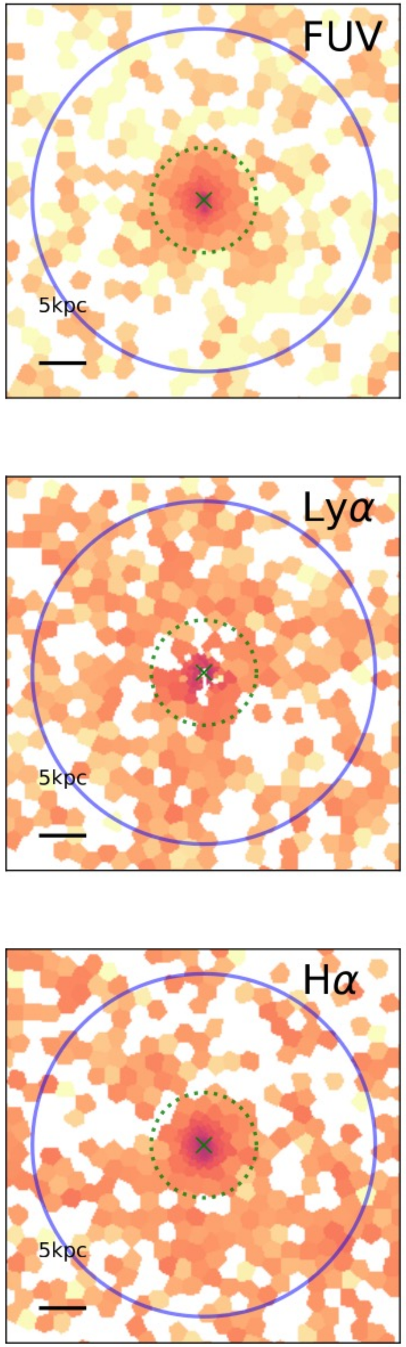
Verhamme et al. (2018)





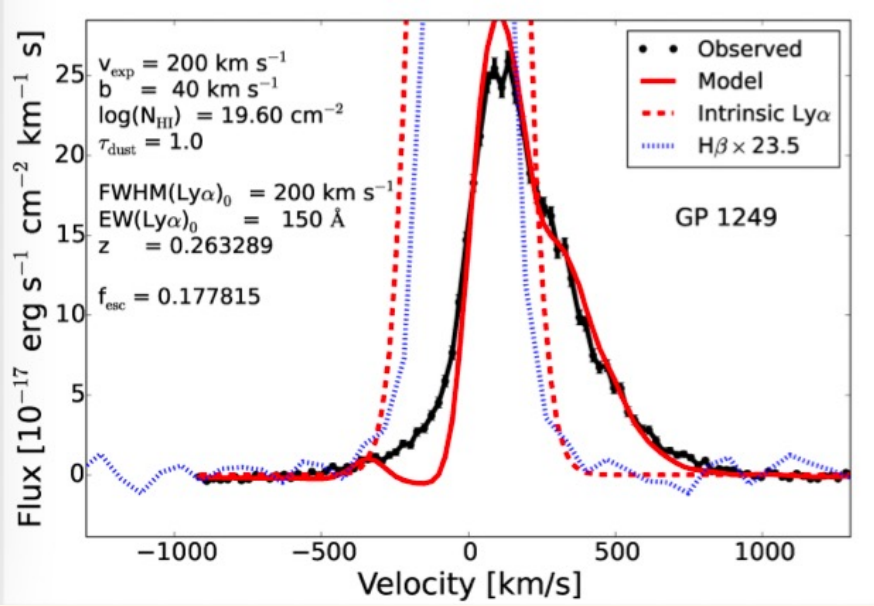


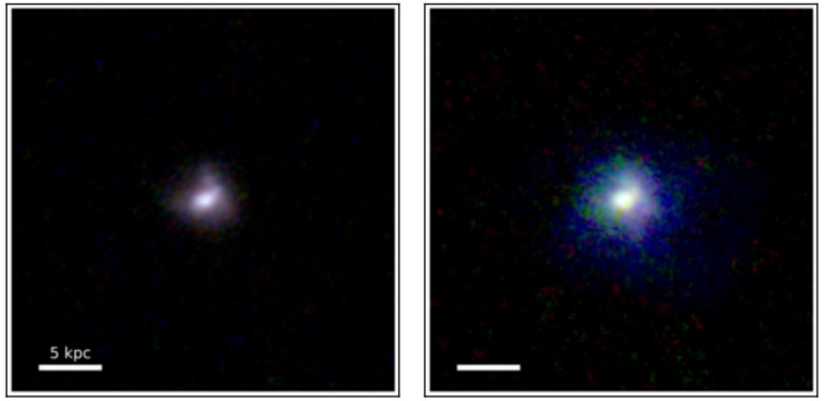


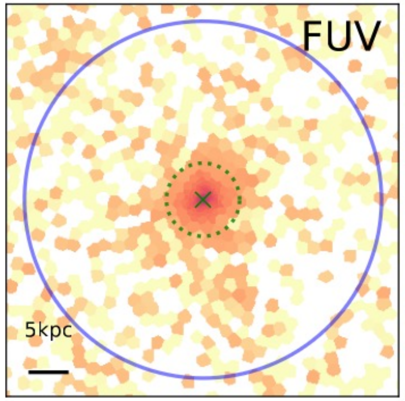


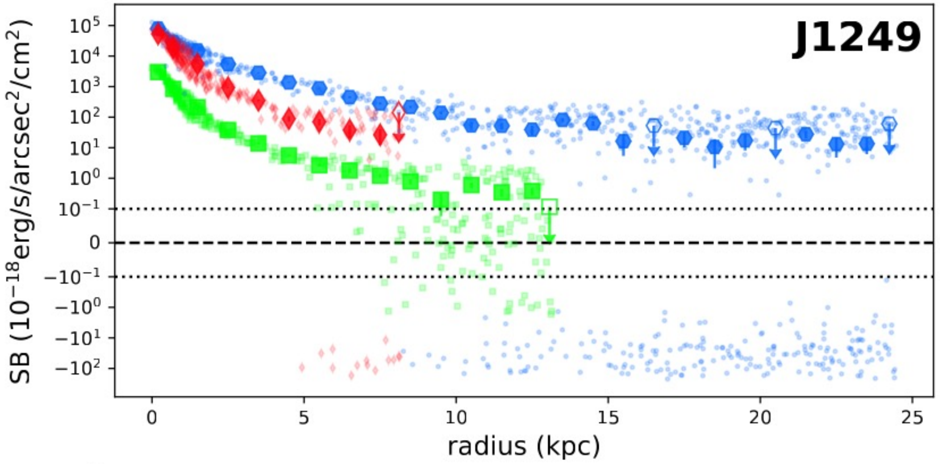
J1249, f_{esc}(LyC) = 3%

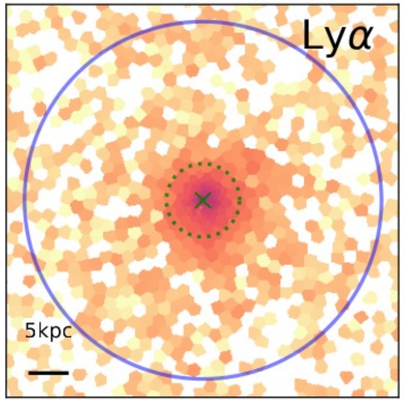
Orlitova et al. (2017), no blue peak?

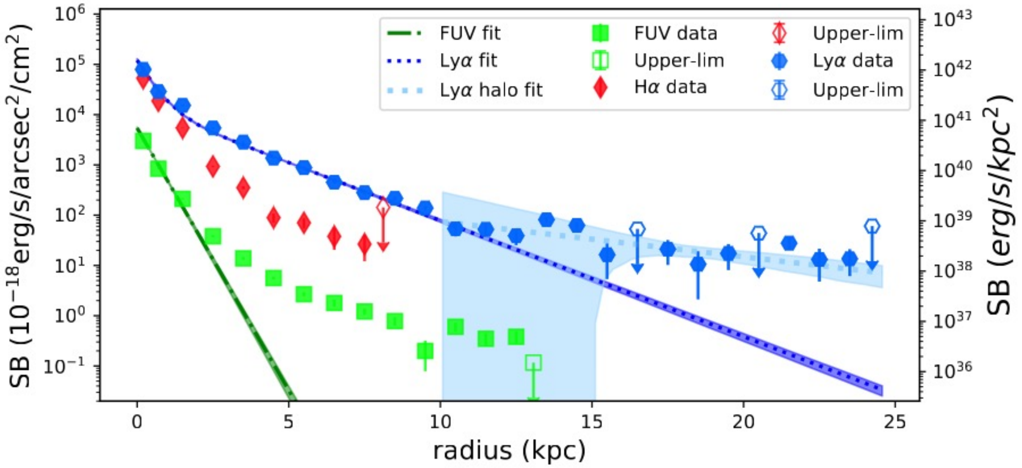


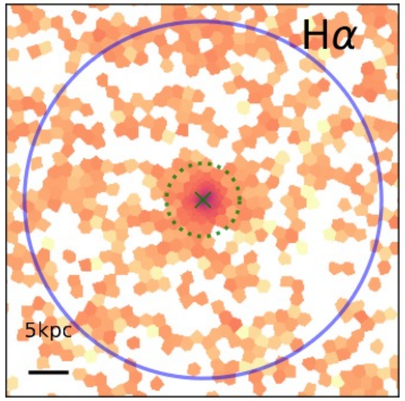








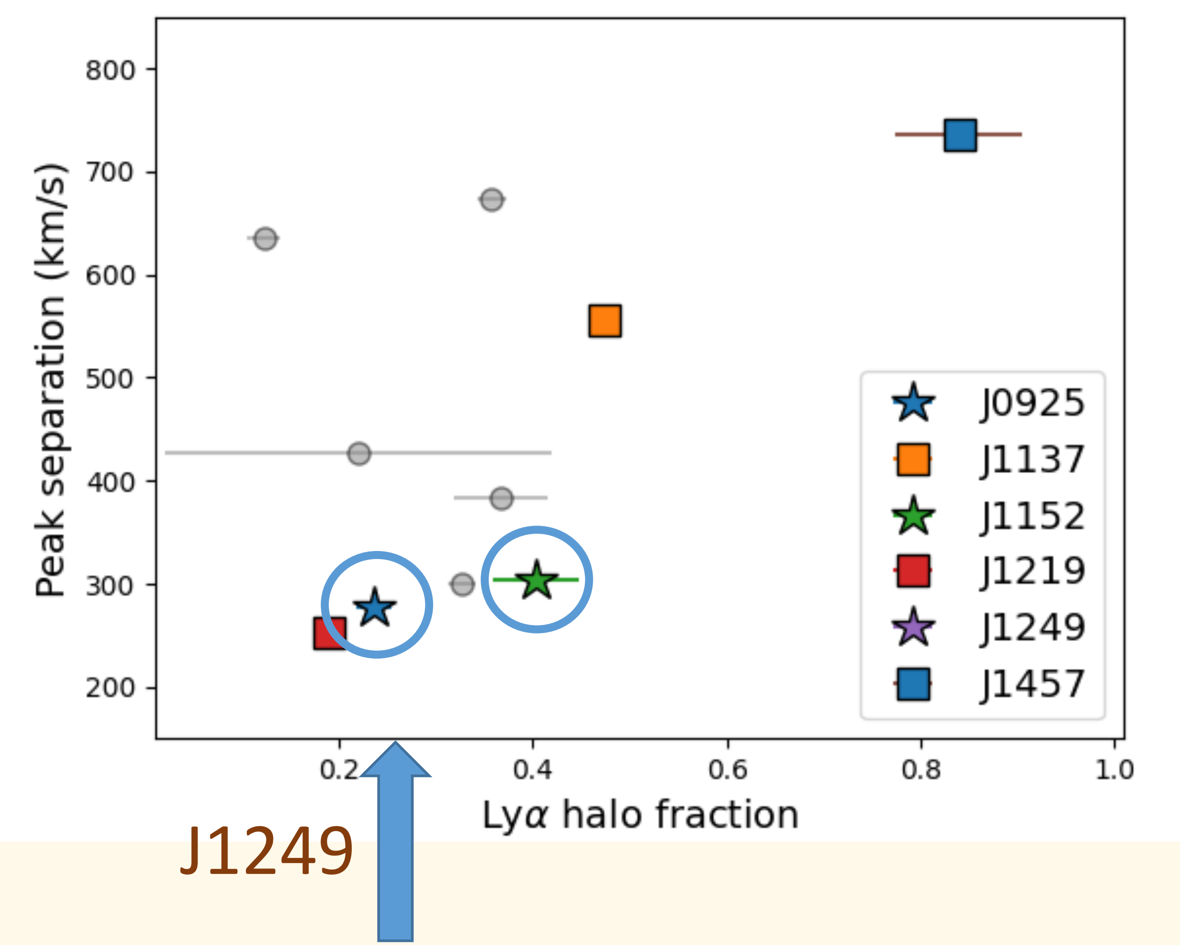




Lyα halo fraction as a probe of LyC escape

We only have direct LyC observations of 3 galaxies in the GP sample (and none in LARS+).

We instead use peak separation as a proxy for escape. This results in a total of 5 GPs (excluding J1249), and 5 galaxies from Rasekh et al. (2022)

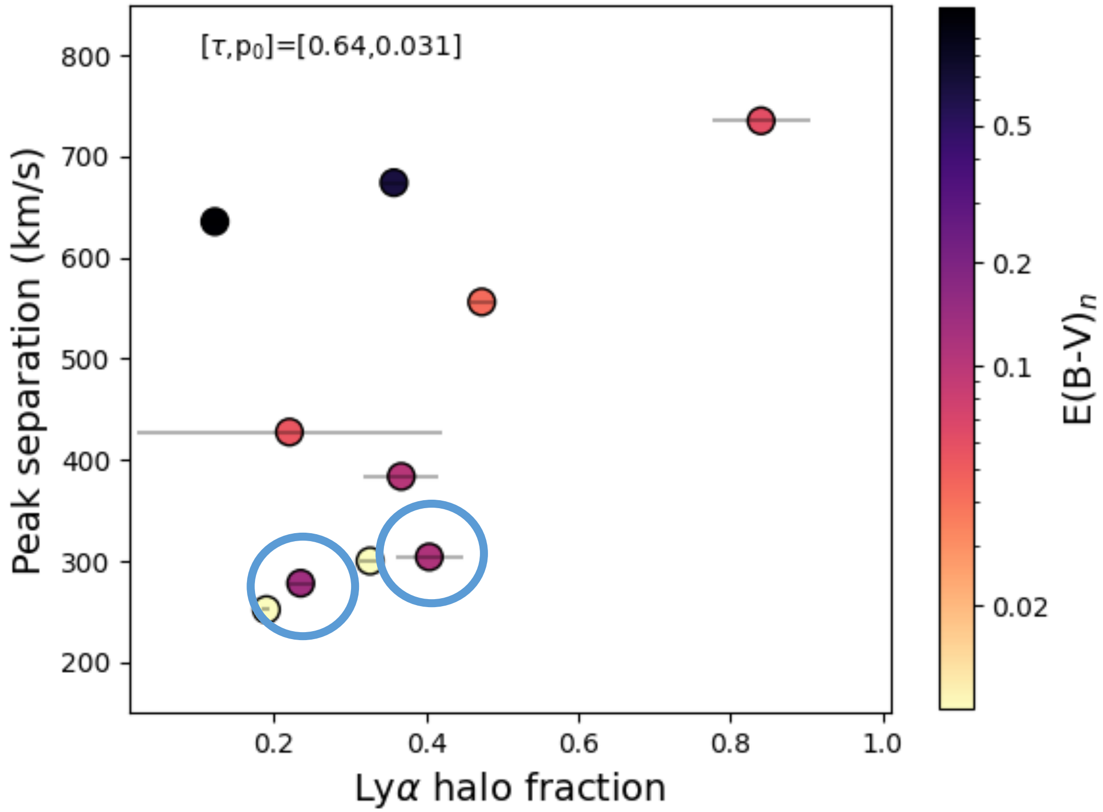


Lyα halo fraction as a probe of LyC escape

What's going on with the outliers?

-> The answer seems to be dust. Applying a cut of $E(B\text{-}V)_n<0.5$ gives a quite strong, but uncertain, correlation (tau=0.64, p0=0.031).

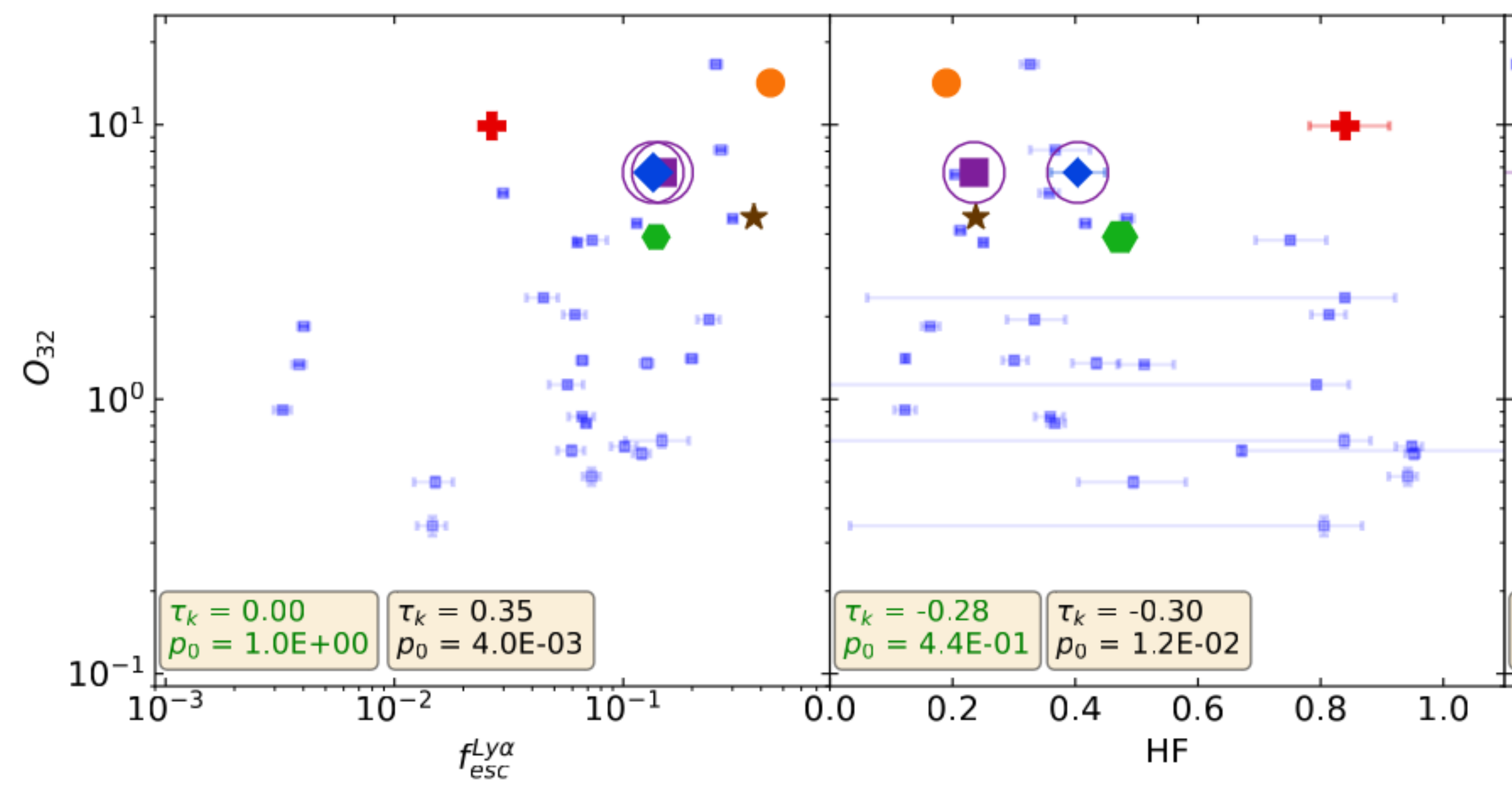
Caveats: the number of data-points is low and the redshift range quite large (0.03-0.35).



Lyα halo fraction as a probe of LyC escape

Looking at O32, we can compare to more of the LARS galaxies.

Weak anti-correlation:
tau= -0.3, p_0= 0.012



Summary and open questions

- Peak separation and halo fraction are correlated (when applying a cut on extinction).

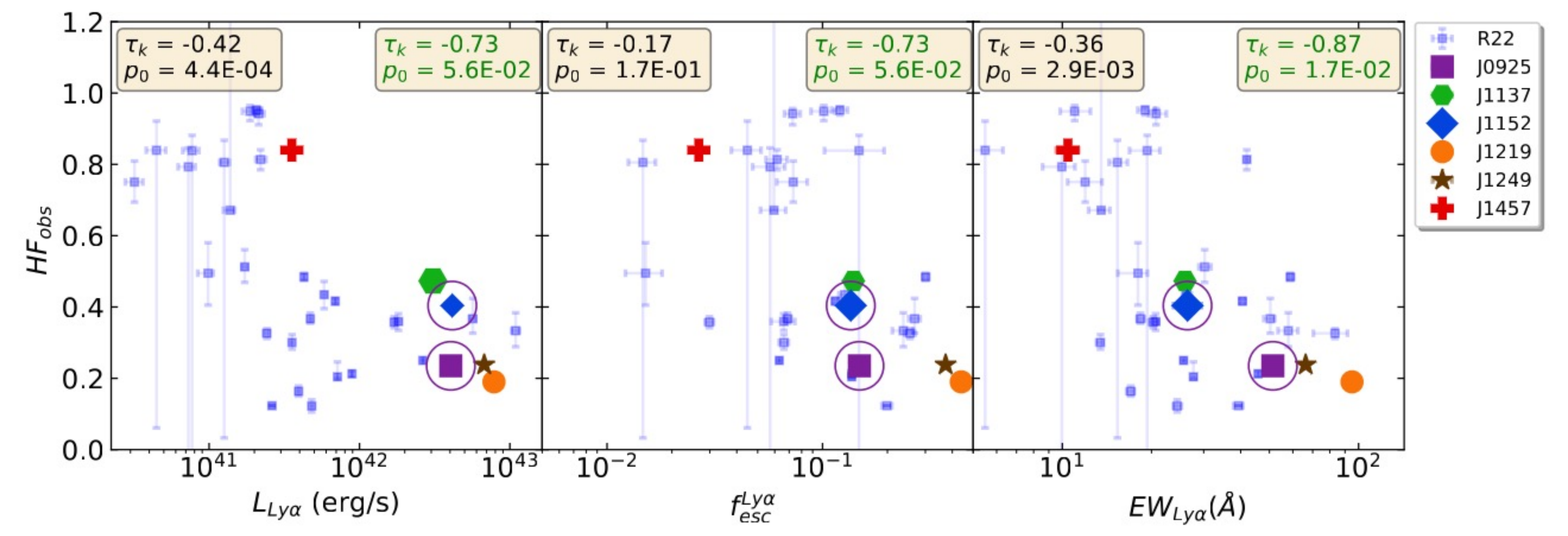
  → Anti-correlation of LyC escape and halo fraction? (BUT few sources)

- Galaxies can show compact Lyα for different reasons. Low optical depths lead to less photons ending up in the halo, but dust absorption has the same effect.

  → Need multiple diagnostics to get LyC escape

- More data on Lyα spatial distribution in the nearby samples are being obtained (Izotov galaxies and LzLCS).

Comparion of Lyα halo fraction and other LyC diagnostics.



At higher redshift (~4) Marchi et al. (2017) found larger LyC escape in a stack of compact Ly**α** emitters.