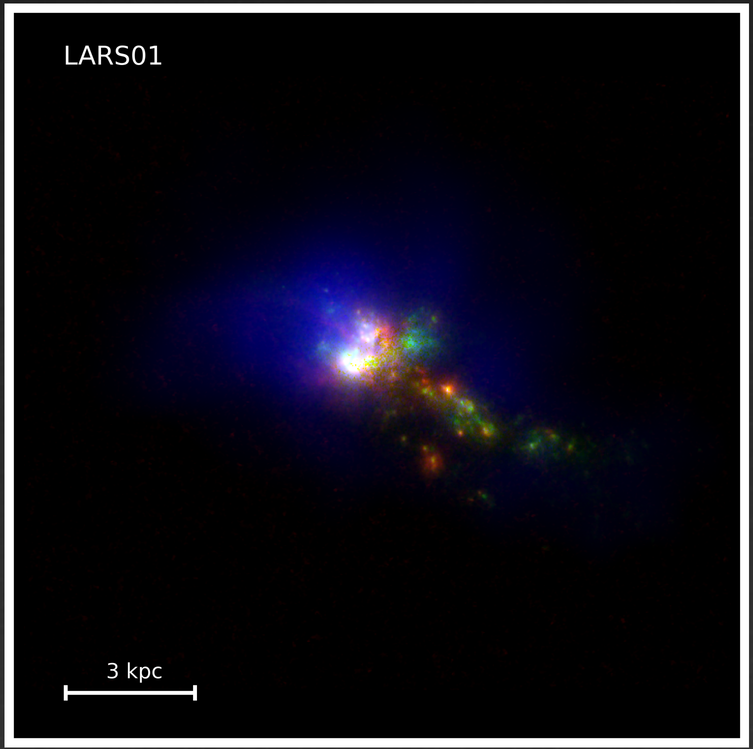
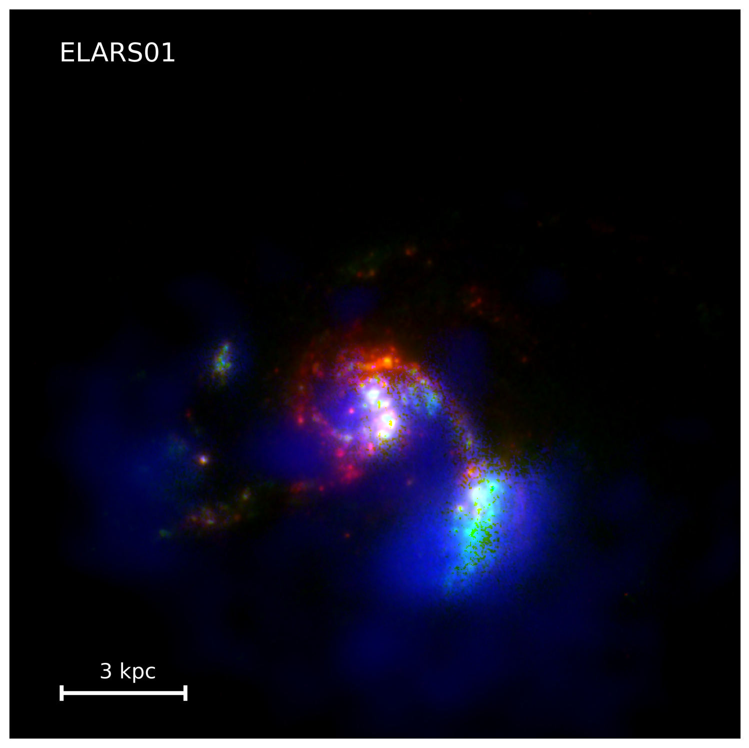
# Lyman α imaging of 45 star-forming galaxies - The Lyman alpha Reference Sample


**Jens Melinder**



Stockholm University


LARS
LYMAN ALPHA REFERENCE SAMPLE

RYMDSTYRELSEN
Swedish National Space Board

# The LARS team

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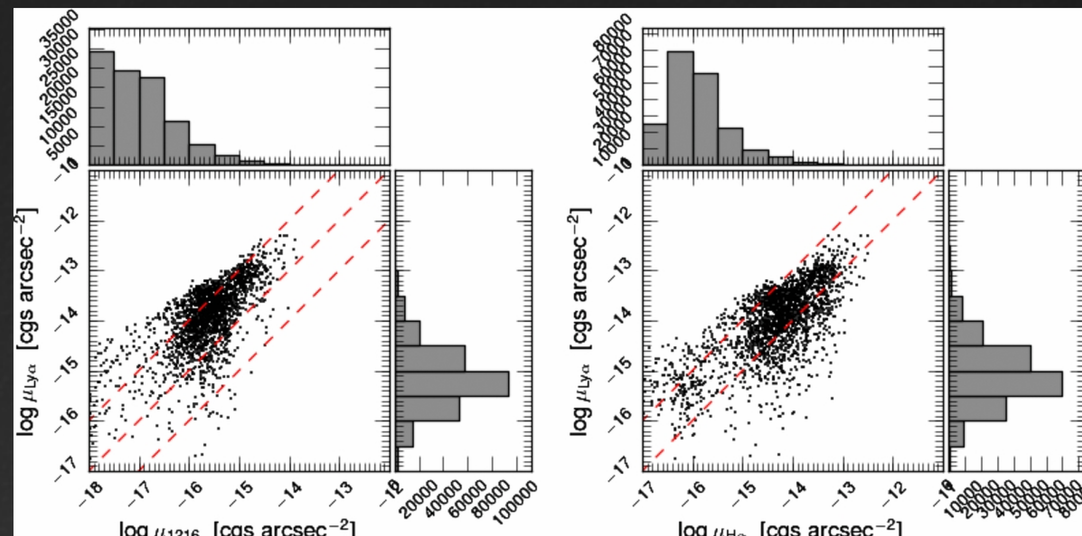
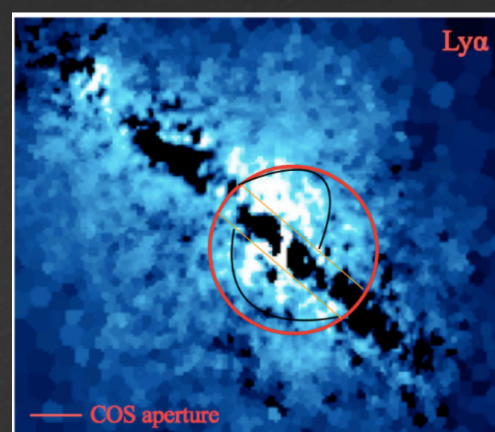
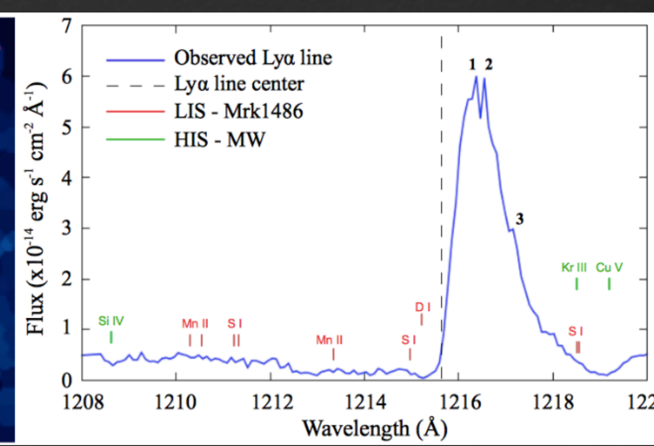
# The original LARS

The first 14 galaxies observed within the project showed that Lyα was found in emission in almost all cases (12/14) for a high SFR sample. The imaging showed that Lyα scattered far out from where the photons were produced.

- Imaging presented in Hayes et al. (2013, 2014), Östlin et al. (2014), Guaita et al. 2015, Micheva et al. 2018
- COS spectroscopy: Duval et al. (2016), Rivera Thorsen et al. (2015). IFU spectroscopy: Herenz et al. (2016)
- VLA HI observations, Pardy et al. (2015)
- Dust studies, Bridge et al. (2018)

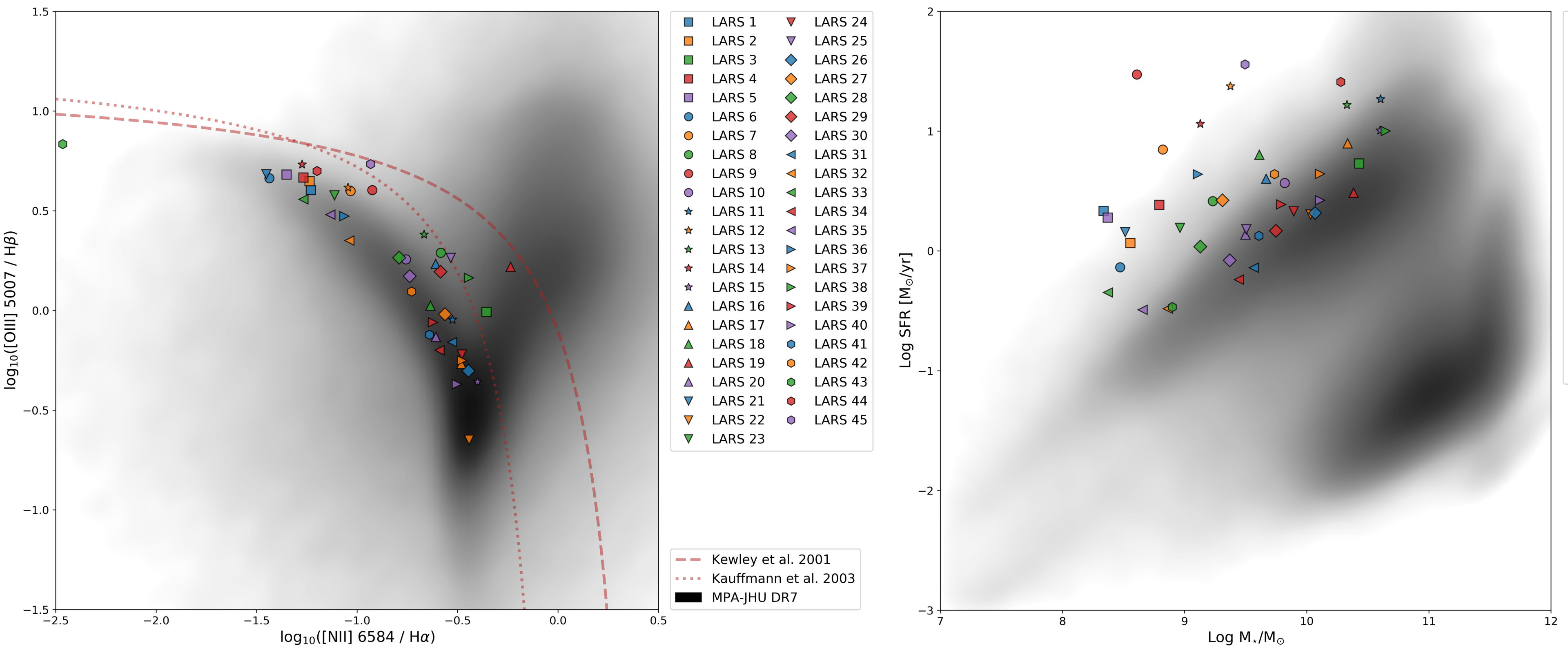


# LARS goals and sample

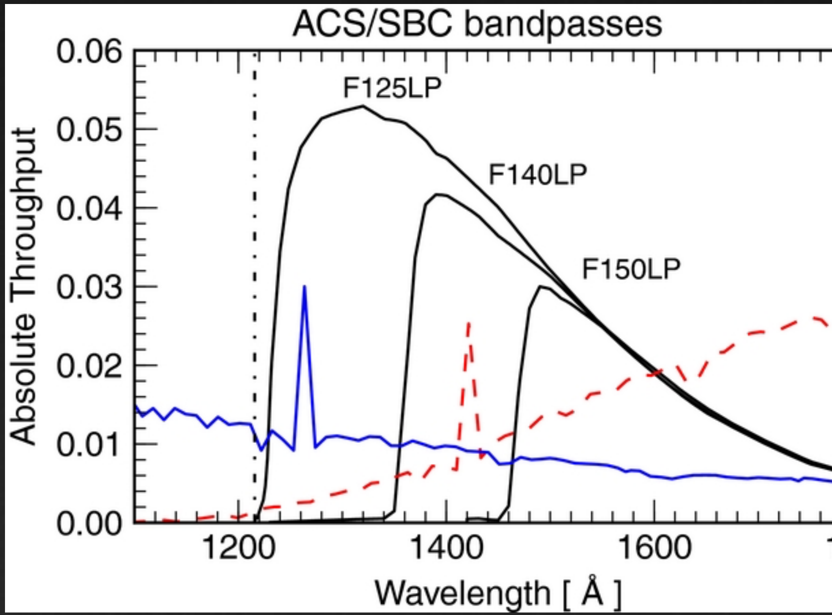
”The primary goals are to return detailed observations of the H I Lyα emission line, and to do so in a sample that is simultaneously as free from bias as possible, statistically meaningful enough to observe trends within the sample, and comparable in selection to galaxies observed in the high-z universe.” – Hayes et al. (2013).



# Observations

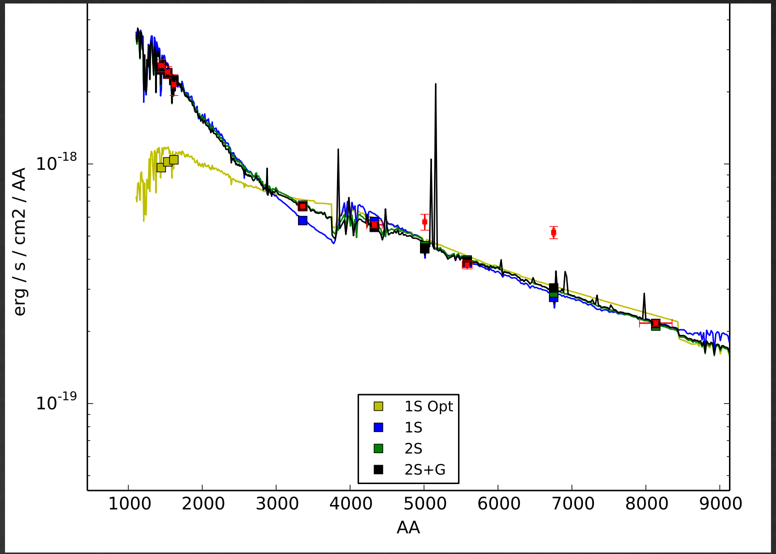
## HST Imaging

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




Pixel SED fitting using 2 FUV filters and 3 optical broadband filters. Standard $X^2$ fitting on each pixel.

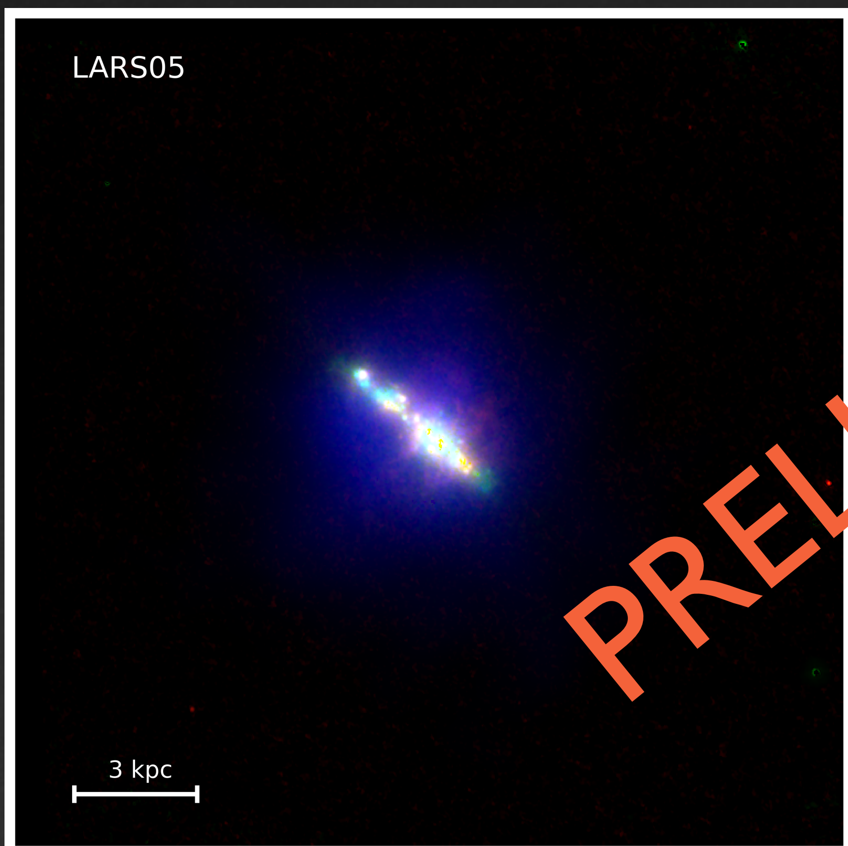
- Starburst99 template spectra, fitting with 3-4 free parameters, age, $E(B-V)_s$, and mass.
- Two stellar populations and nebular continuum.
- Assumptions: Attenuation law, Z and NII from SDSS, SSP SF history.

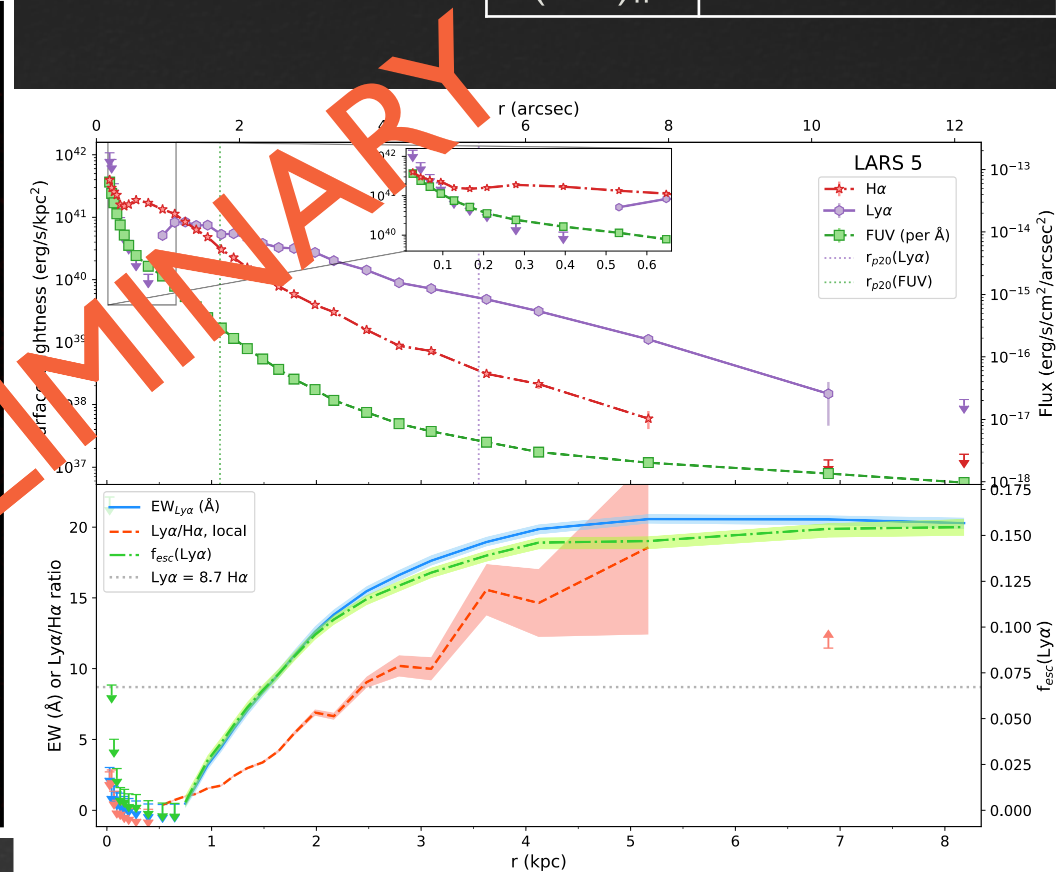


# LARS05

Typical Lyman α emitting galaxy in the original LARS. Quite compact dwarf irregular galaxy with some dust. Lyα seems to escape transverse to the major axis.

| | |
|---|---|
| EW(Hα) | 314 Å |
| EW(Lα) | 20 Å |
| $f_{esc}$(Lα) | 0.16 |
| $M_\star$ | 8e9 $M_\odot$ |
| L(FUV) | 3.6e40 erg/s/Å |
| $E(B-V)_n$ | 0.11 |

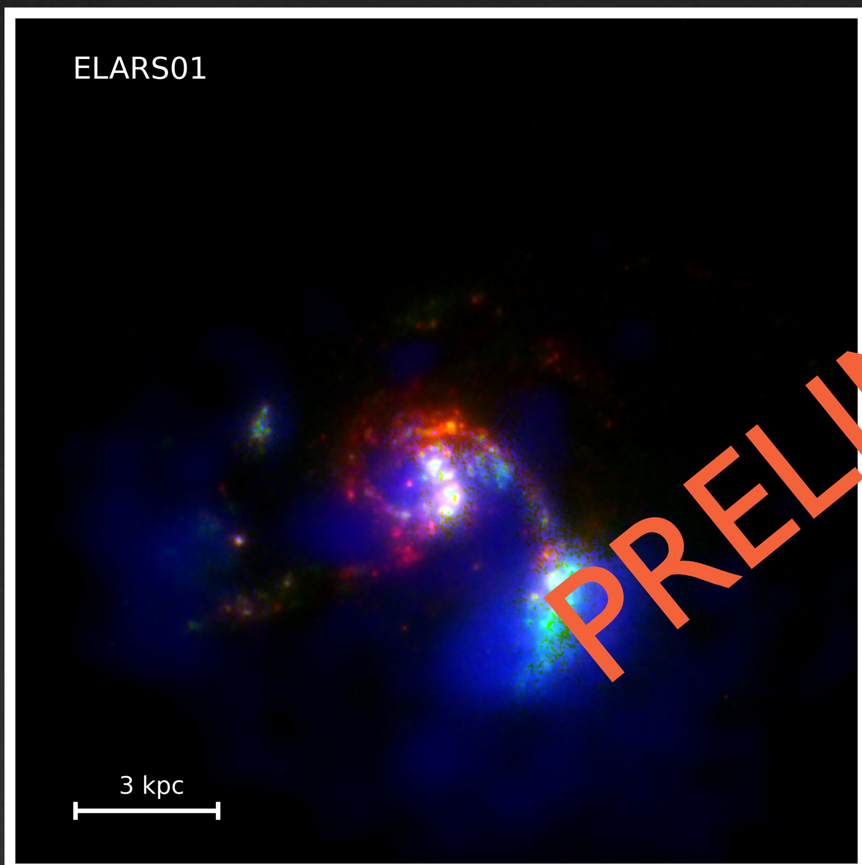


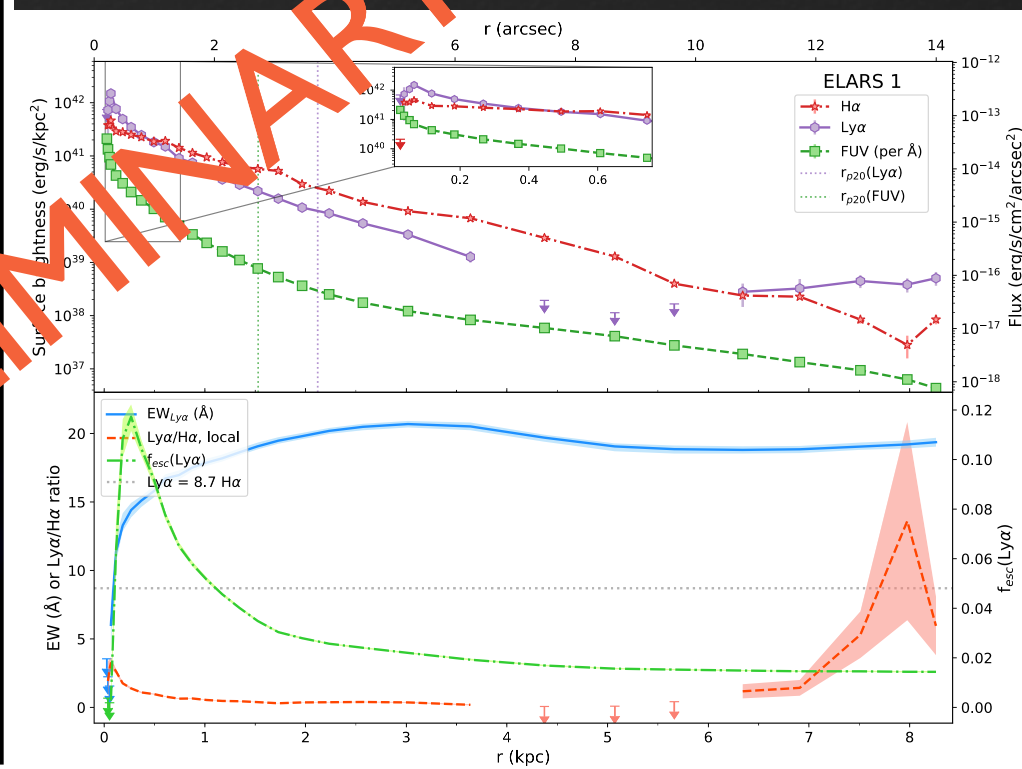



# ELARS01/NGC 6090

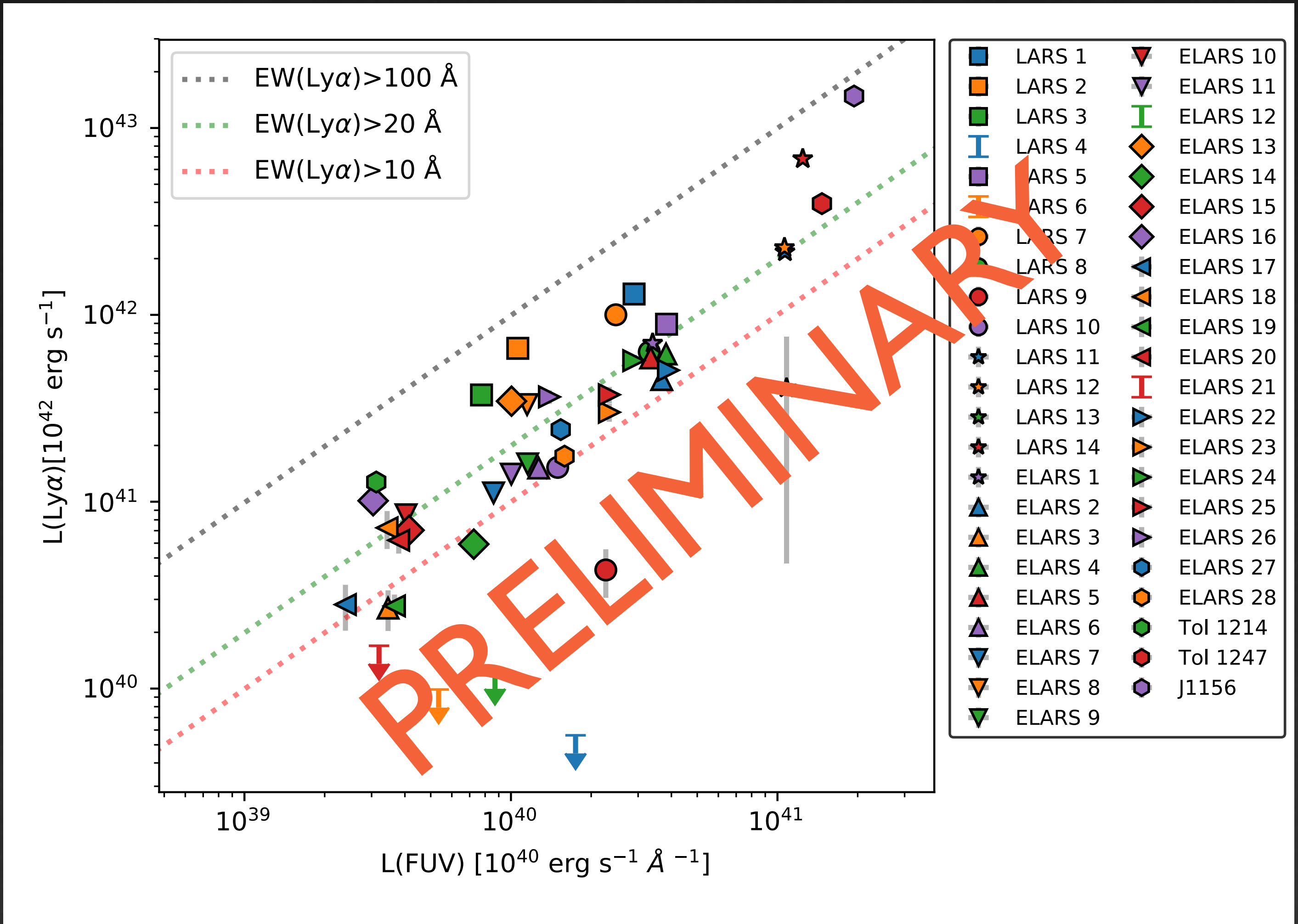
Galaxy merger and LIRG. Contains significant amounts of dust, but Lyα manages to escape even in the center of the system, maybe because of a patchy ISM structure.

| | |
|---|---|
| EW(Hα) | 120 Å |
| EW(Lα) | 20 Å |
| $f_{esc}$(Lα) | 0.02 |
| $M_\star$ | 3e10 $M_\odot$ |
| L(FUV) | 4.0e40 erg/s/Å |
| $E(B-V)_n$ | 0.32 |



# Lyα spatial distribution and escape




Escape fractions may be severely underestimated when using smaller apertures.

The fraction of net Lyα emitters in LARS/ELARS is:

**38(15)/45** for a mask designed to include all Lyα (with EW(Lyα)>20)

**32(13)/45** for a 2×$r_{p20}$ radius aperture (with EW(Lyα)>20)

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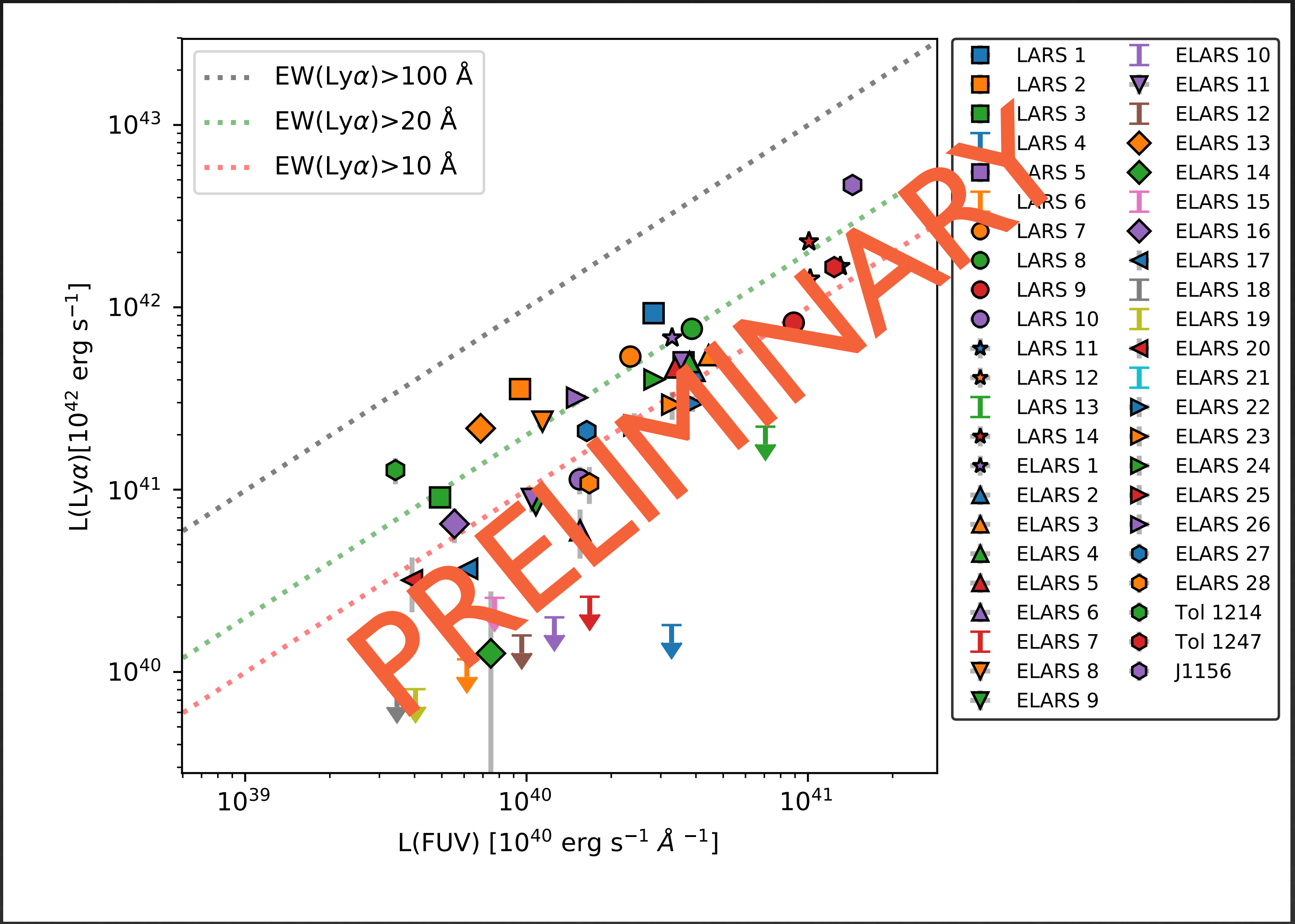


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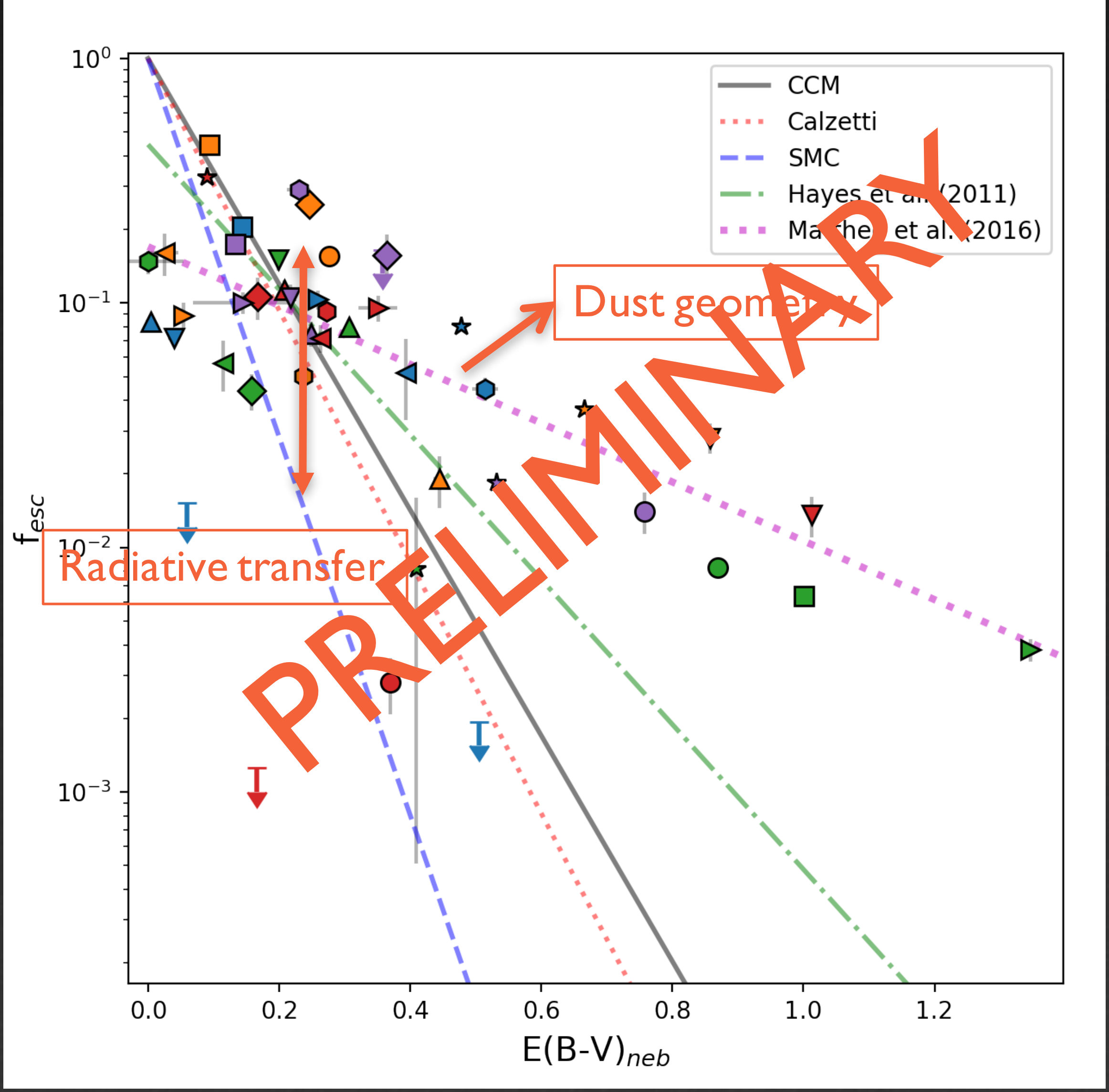
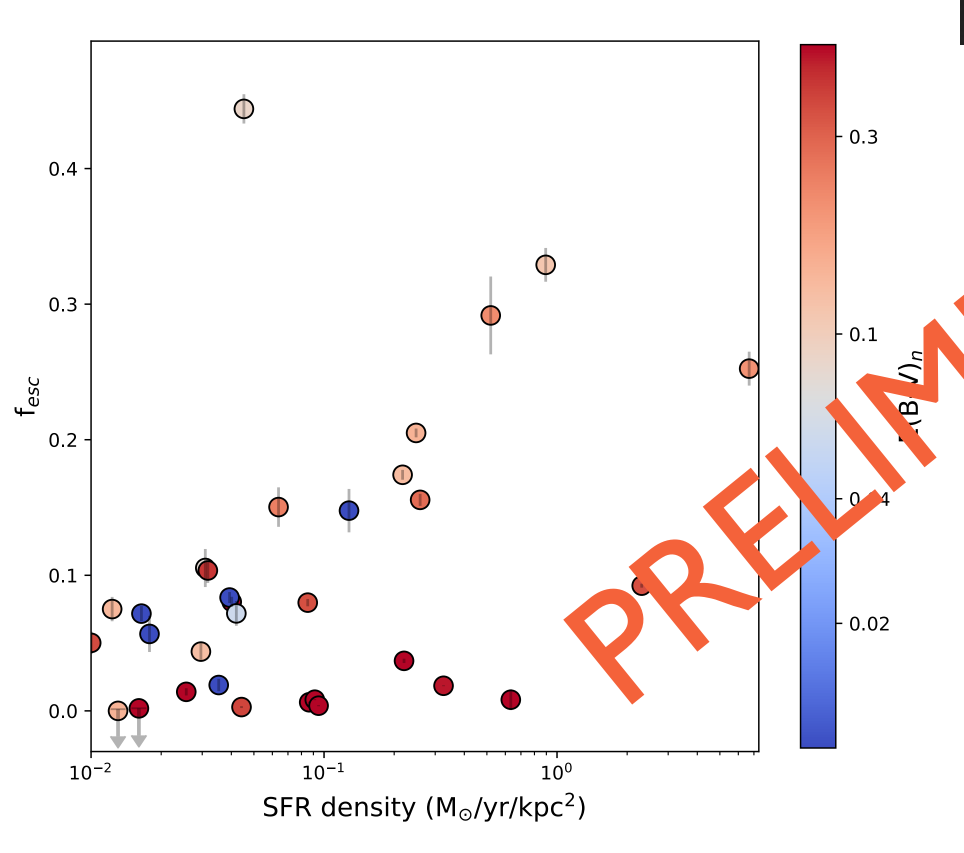
# How dust affects the escape fraction.

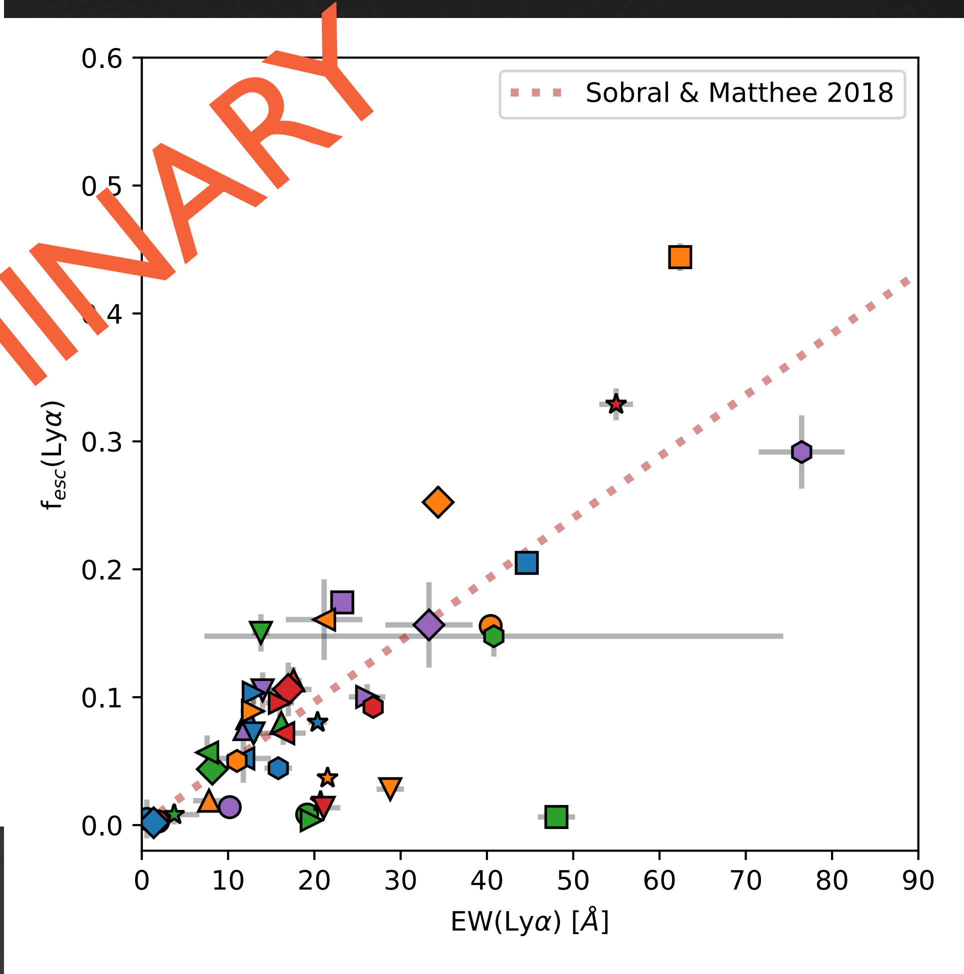



The escape of Lyα is directly affected by both dust content and radiative transfer effects.

A clumpy dust distribution might help explain unexpectedly high escape fractions found for LARS. Also, see Bridge et al. (2018)

# Lyα escape and star formation rate/EW(Lyα)



# Summary

- LARS+eLARS is a sample of 45 star-forming galaxies at $z<0.3$ with multi-wavelength observations available. The back-bone is the FUV-optical HST observations.

- Ly$\alpha$ escape is mediated not by a single parameter, but by many different factors. Dust and neutral gas and how these components are distributed, as well as gas kinematics are important.

All of the LARS data will be released to the community very soon. Downloading and exploration of the data on a dedicated website…