The Lyman Alpha Reference Sample(s) - update and recent developments: Tol1214-277 & SAFE

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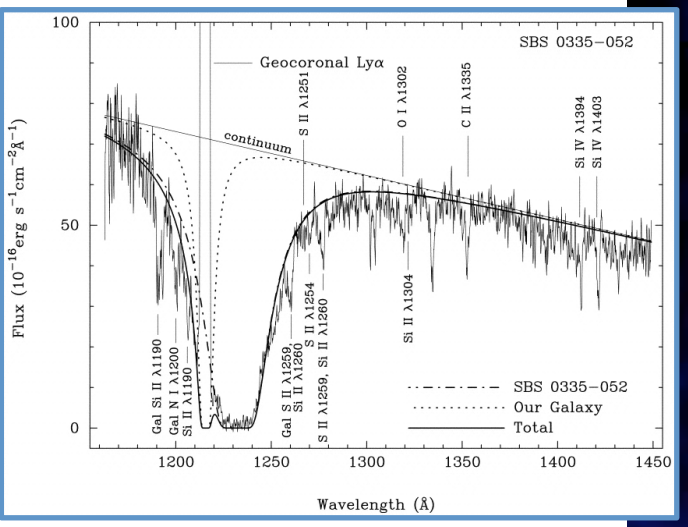
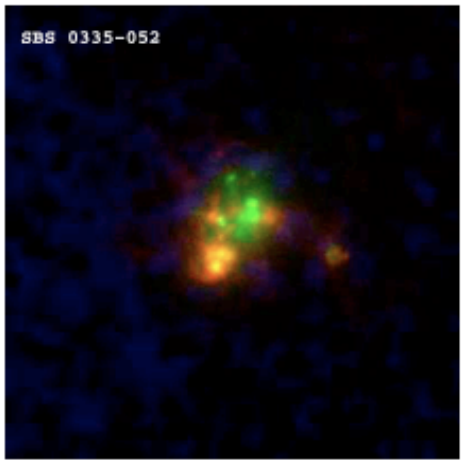
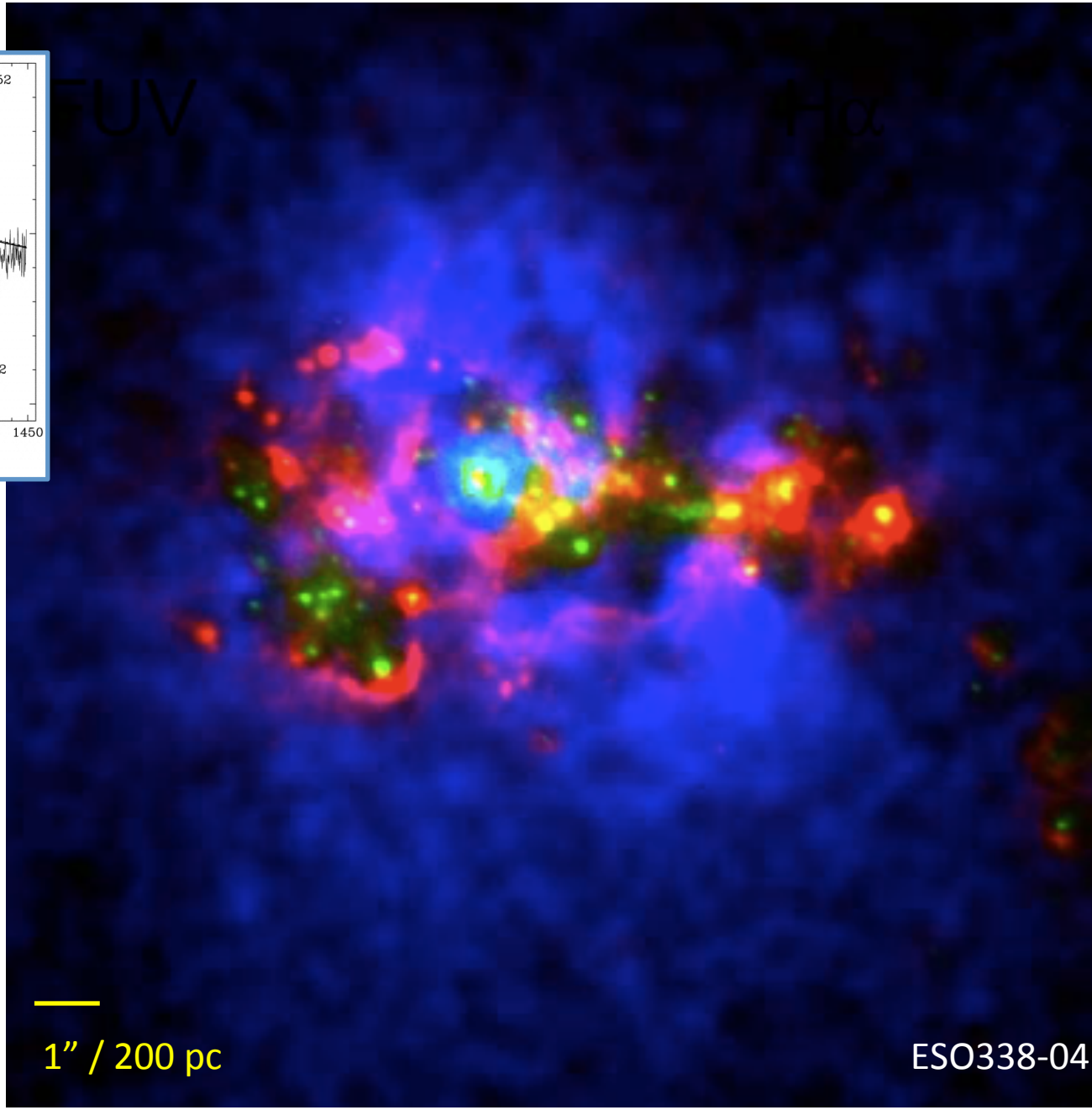
LARS
LYMAN ALPHA REFERENCE SAMPLE

In collaboration with the LARS team (Hayes, Bridge, Runnholm, Verhamme, Gronke, Rivera-Thorsen, Finley at this conference + many more….)



SBS0335-052, GHRS, TI+97



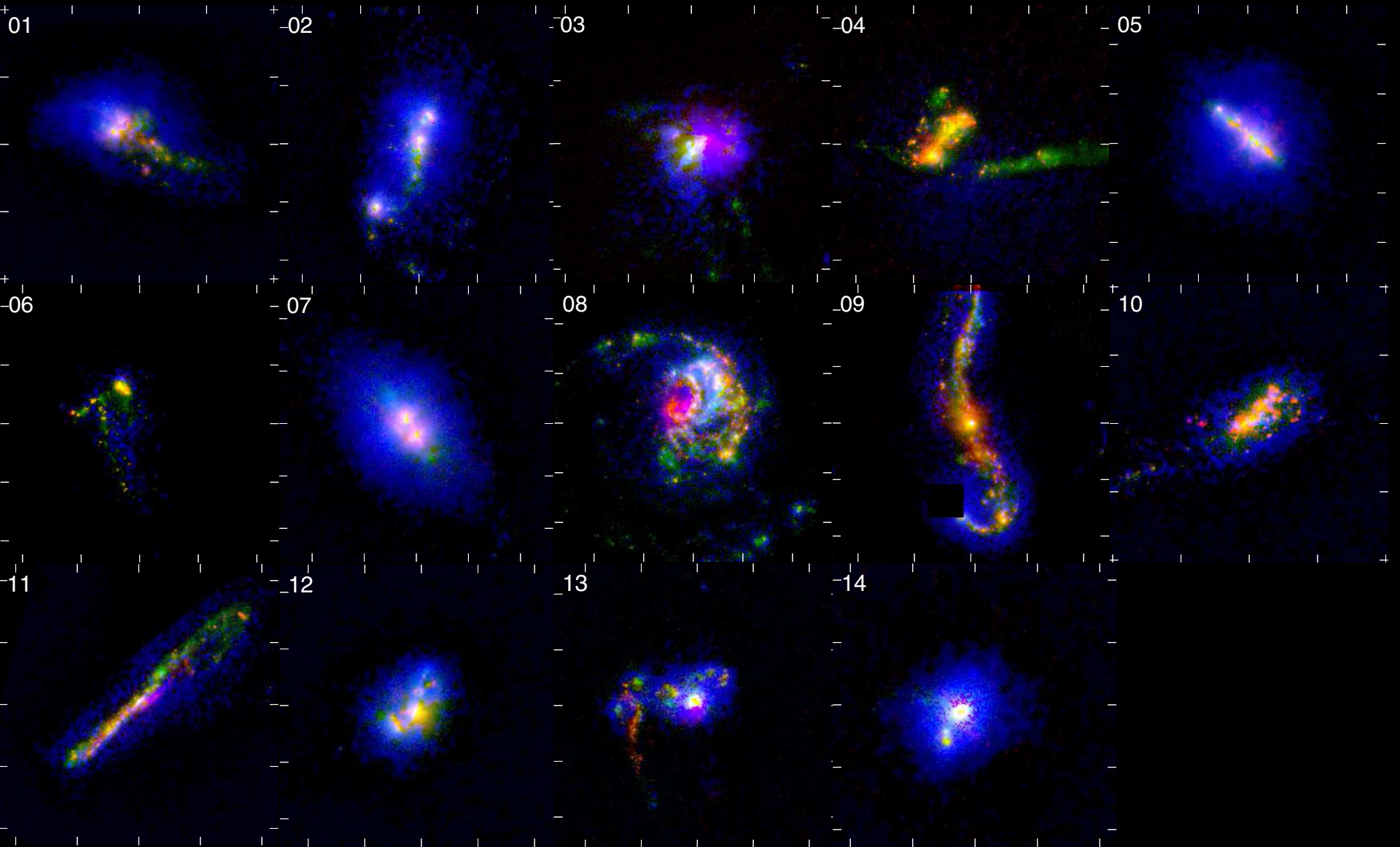


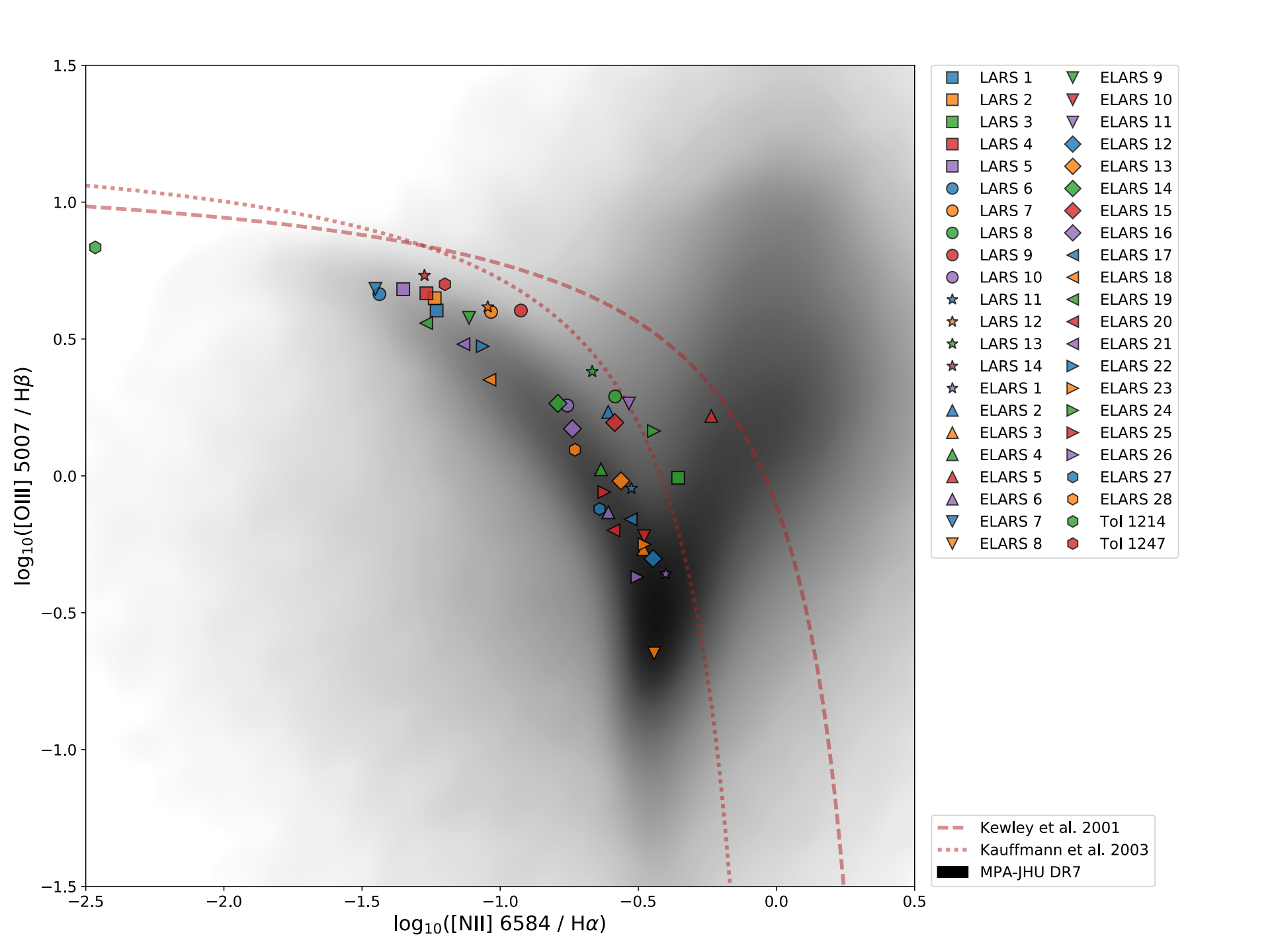
Hayes+2005, Ostlin+2009

Why LARS ?

- Study Lyα at low z where sources are brighter and better resolved
- Unbiased sample, UV and Hα selected from GALEX+SDSS: where do we find Lyα and not? (see Hayes talk)
- Original LARS: 14 galaxies with EW(Hα)>100Å
- eLARS: improve statistcs and add 'normal' galaxies (EW>40Å)
- Ancillary data:
  - VLA: HI masses (D/C) and distribution (B/A)
  - IFU Hα kinematics (MUSE and PMAS)
  - CO, FIR, etc
- In progress: LyC leakers, ULIRGs -> 55 galaxies

LARS sample as seen by HST. Blue = Lyα, Green = UV continuum, Red = Hα
Due to scattering, Lyα is more extended and emerges in form of diffuse halo




1.5
1.0
0.5
0.0
−0.5
−1.0
−1.5
−2.5
−2.0
−1.5
−1.0
−0.5
0.0
0.5
log10([OIII] 5007 / Hβ)
log10([NII] 6584 / Hα)
LARS 1
LARS 2
LARS 3
LARS 4
LARS 5
LARS 6
LARS 7
LARS 8
LARS 9
LARS 10
LARS 11
LARS 12
LARS 13
LARS 14
ELARS 1
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ELARS 20
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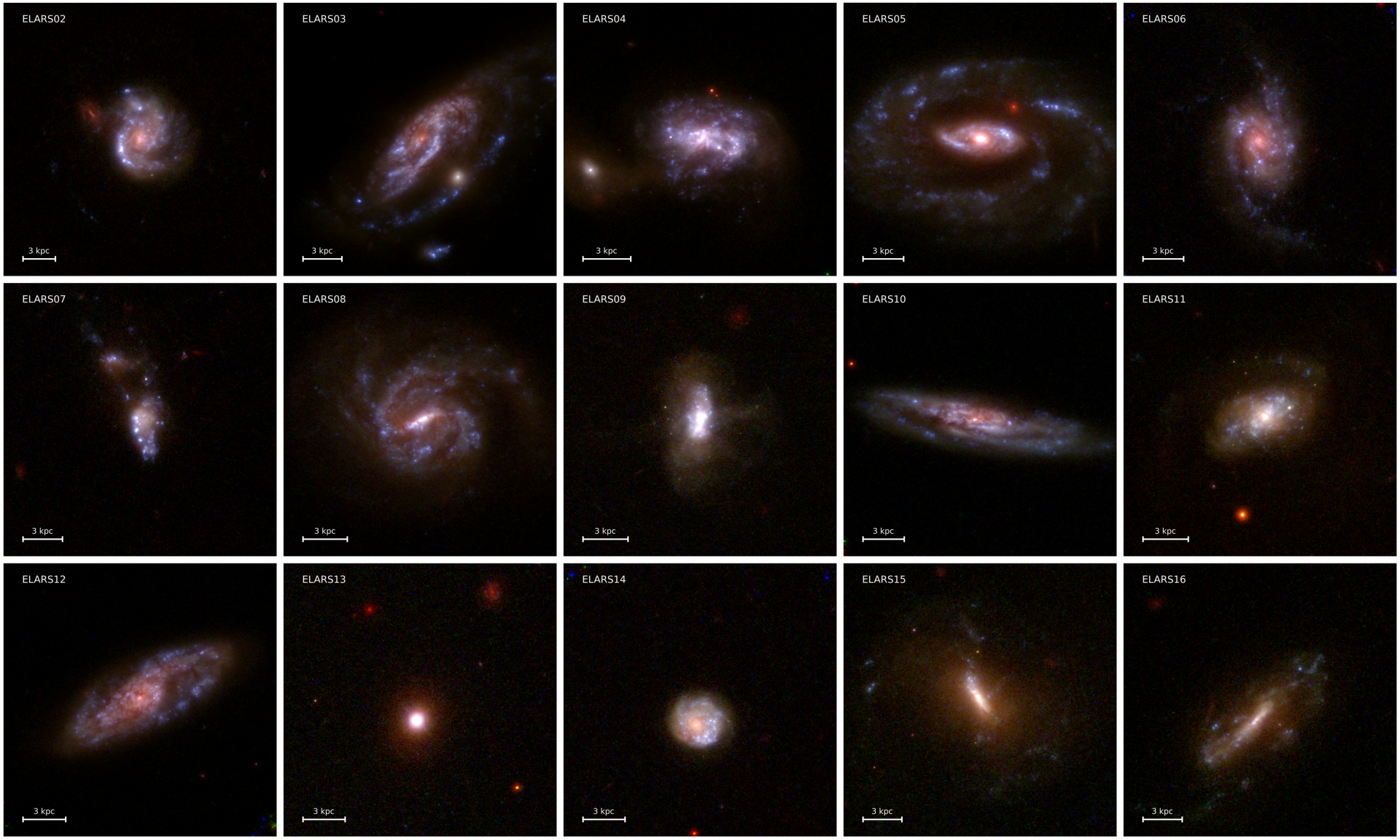
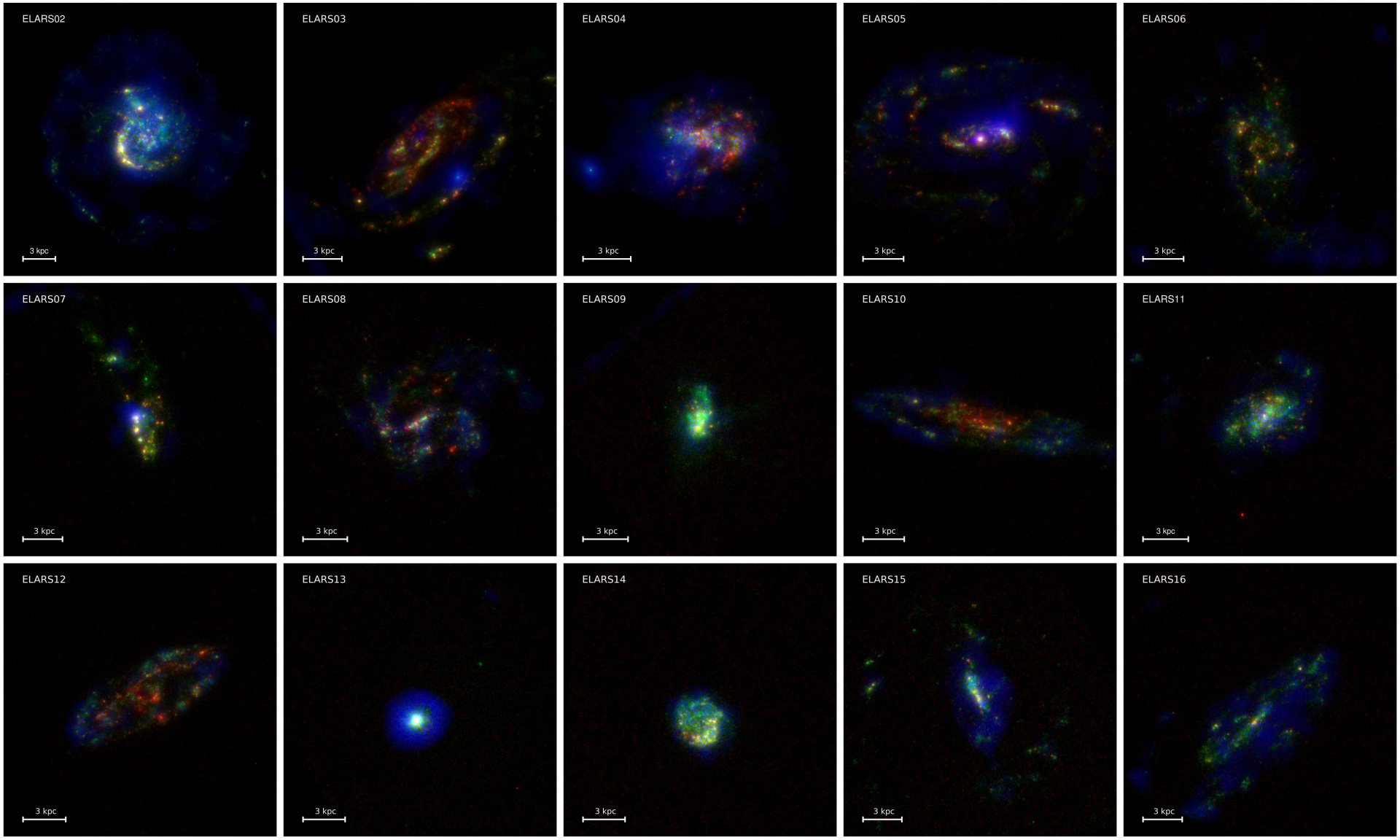
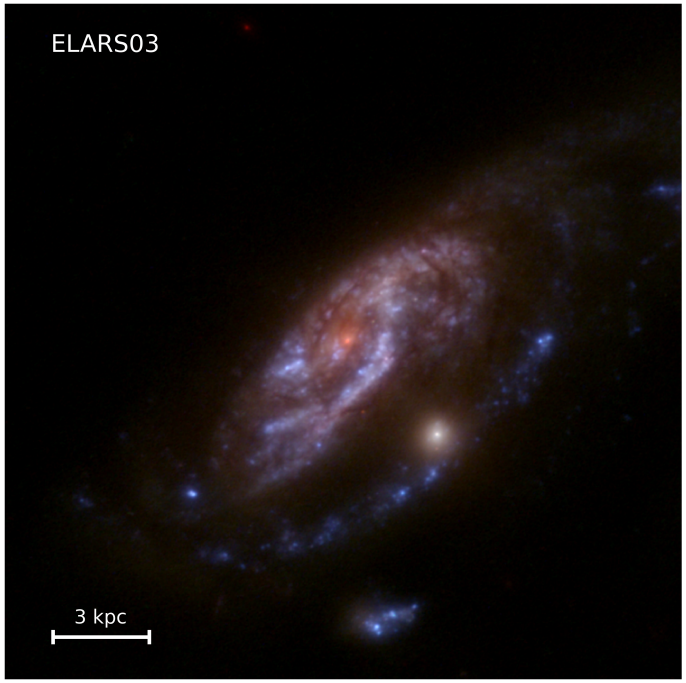
ELARS 22
ELARS 23
ELARS 24
ELARS 25
ELARS 26
ELARS 27
ELARS 28
Tol 1214
Tol 1247
Kewley et al. 2001
Kauffmann et al. 2003
MPA-JHU DR7

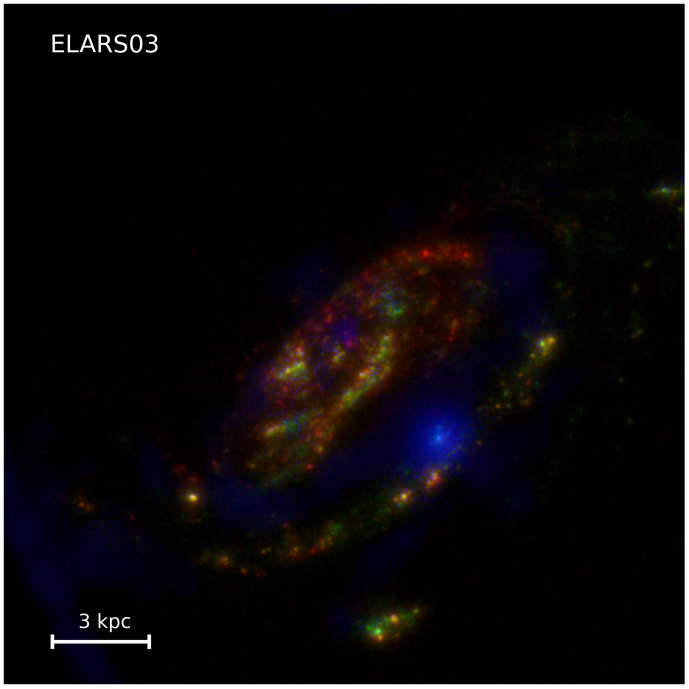
eLARS 2-16 (F336W, F438W, F775W)



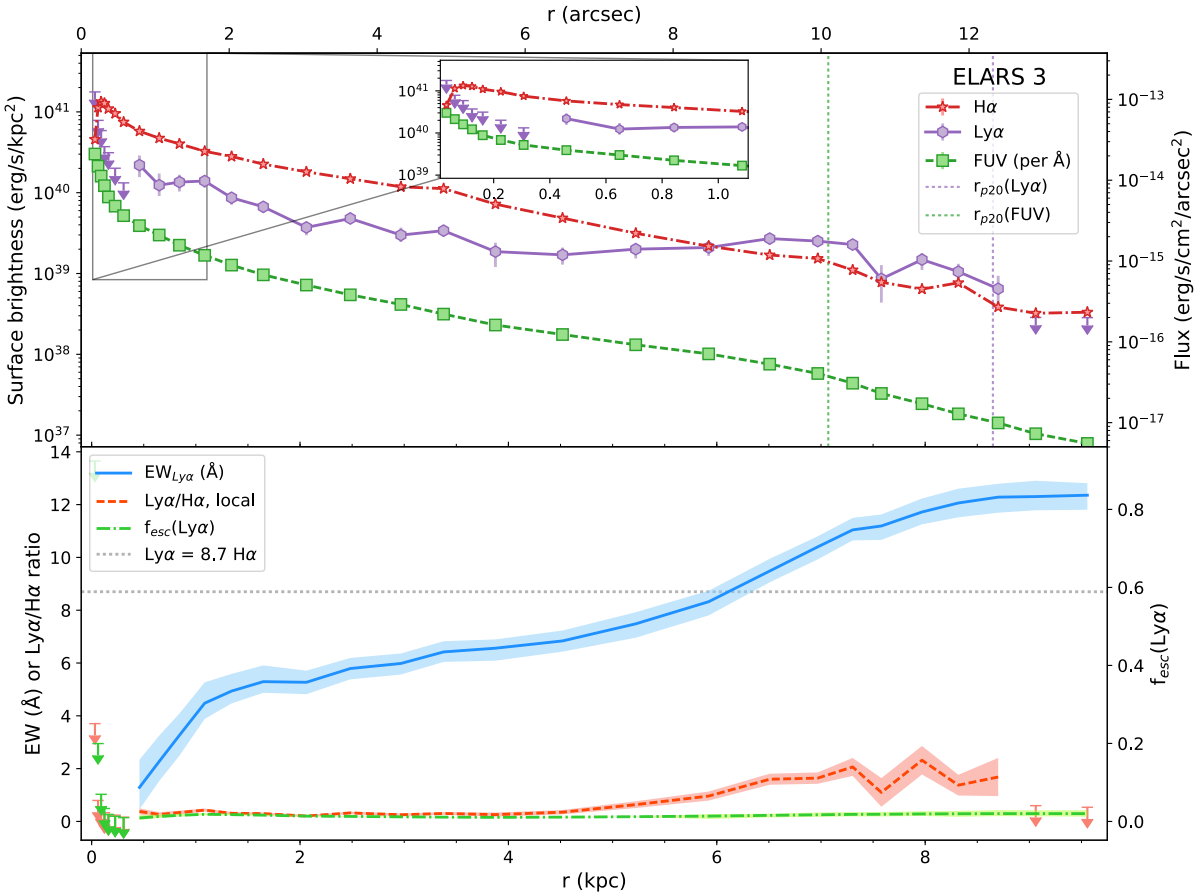
eLARS 2-16 (Hα, FUV, Lyα)



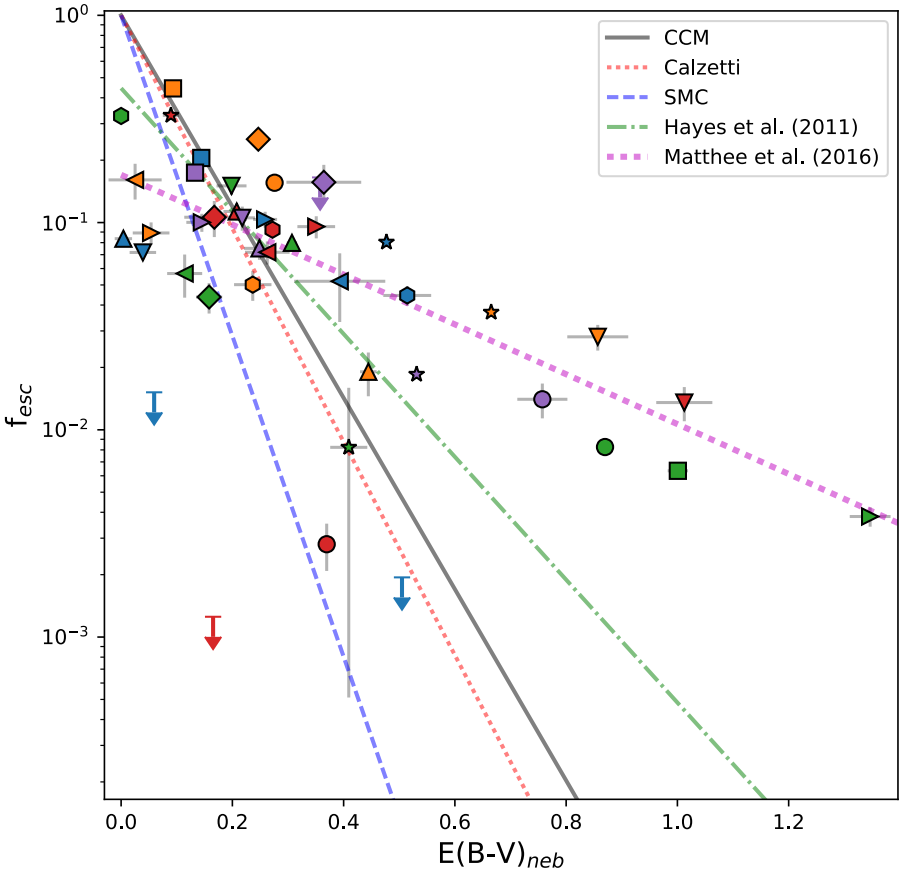


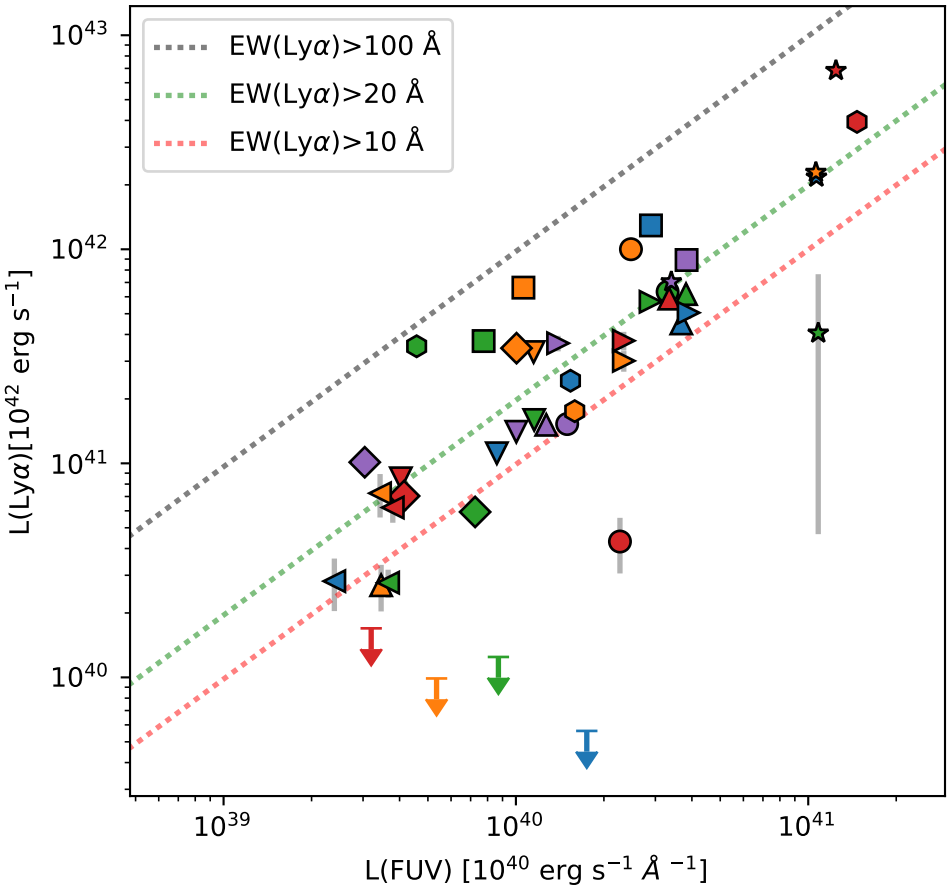


Radial flux distributions: eLARS3 NB definition of f_{esc}

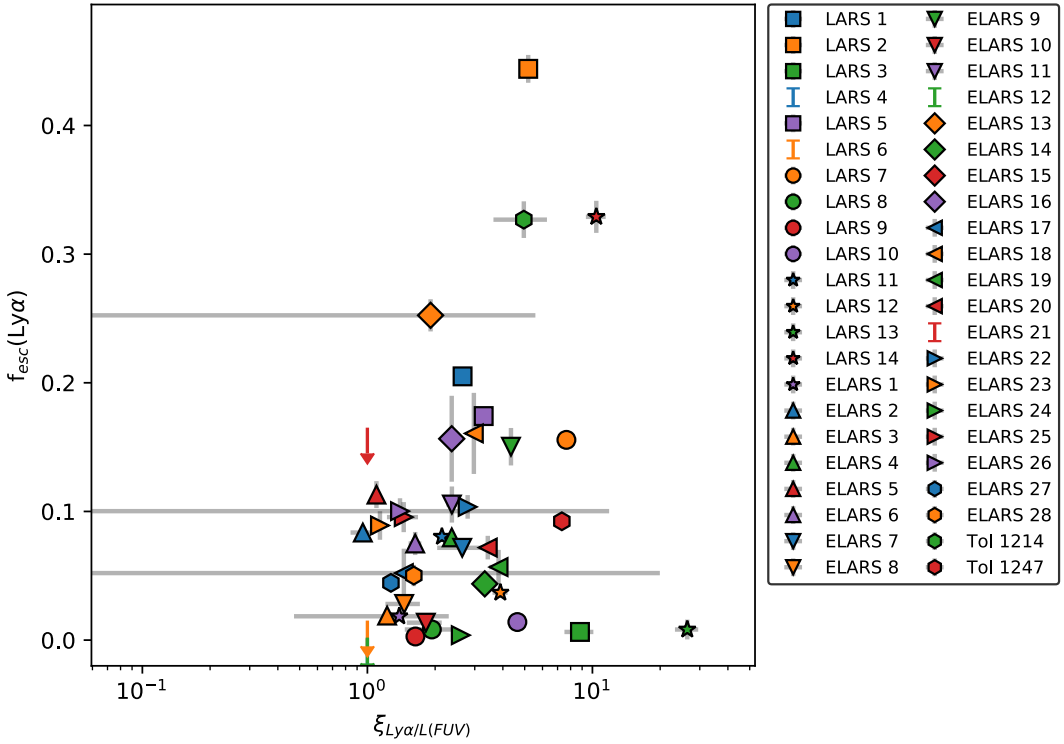


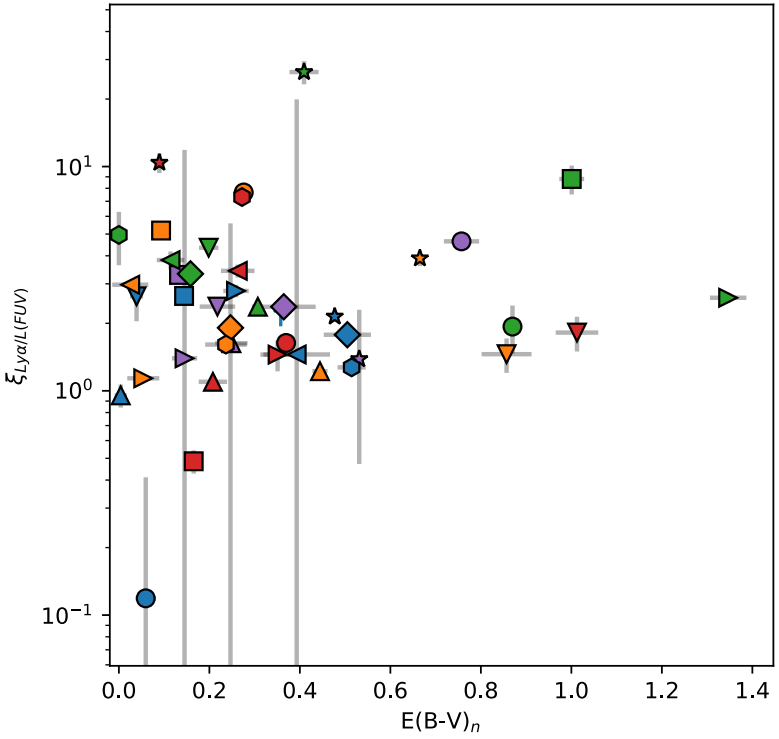
LARS Combined sample (44 galaxies)



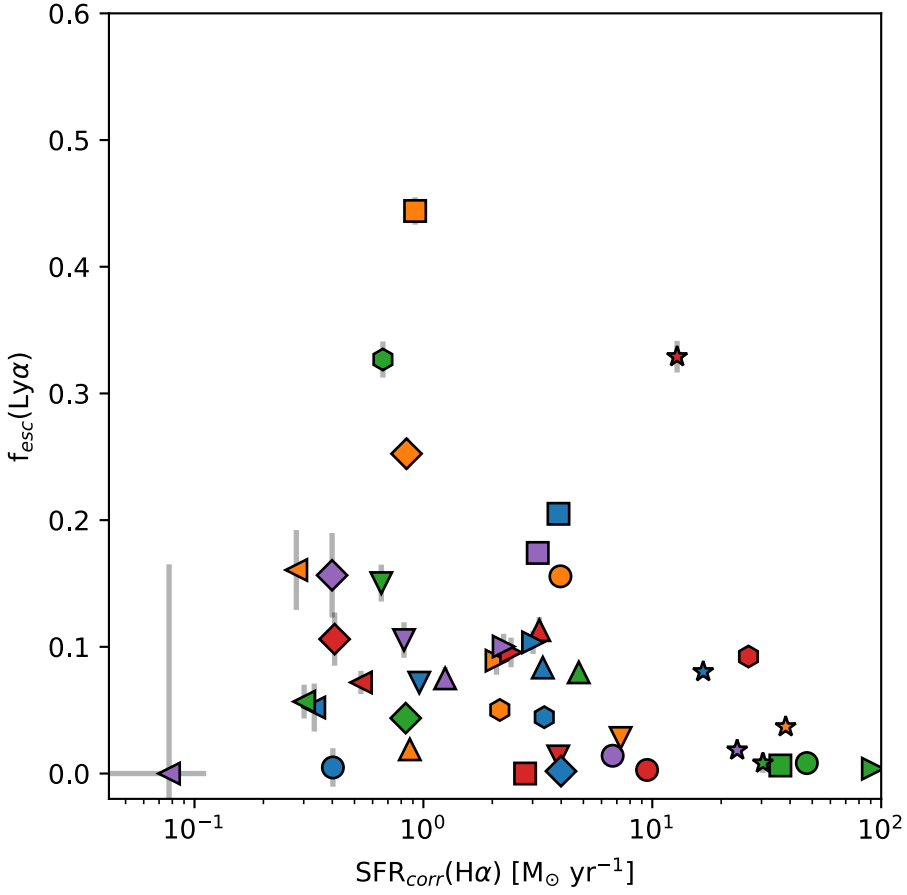


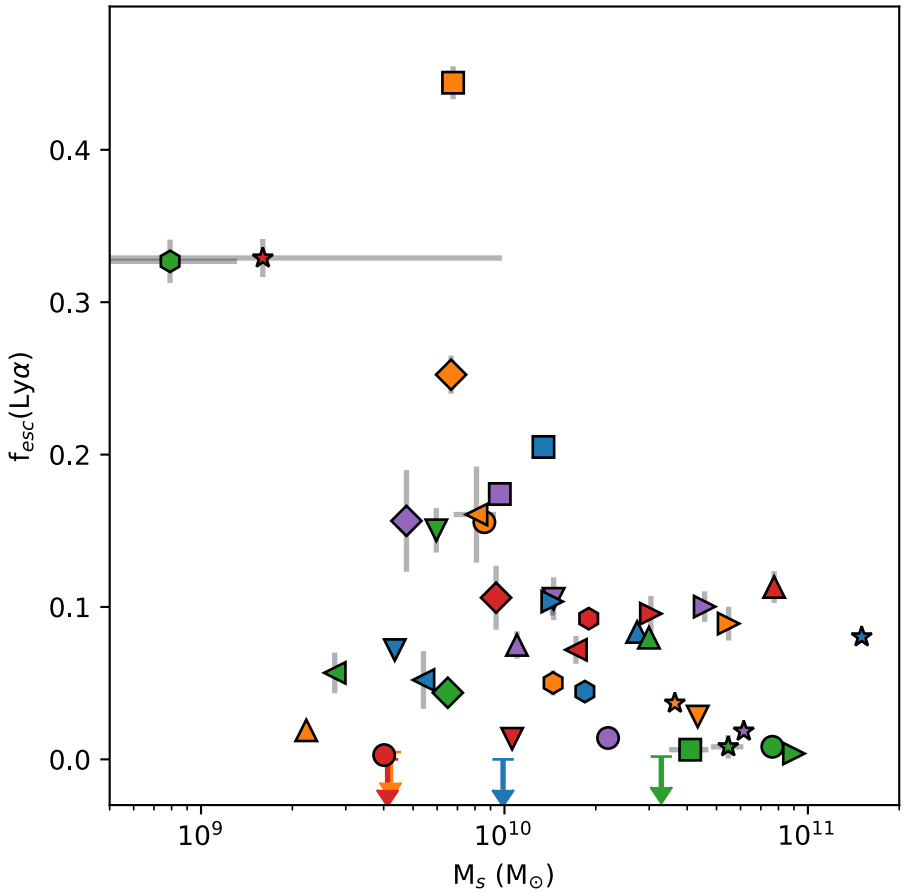
LARS Lyα halo sizes: $\zeta = r_{Ly\alpha} / r_{FUV}$



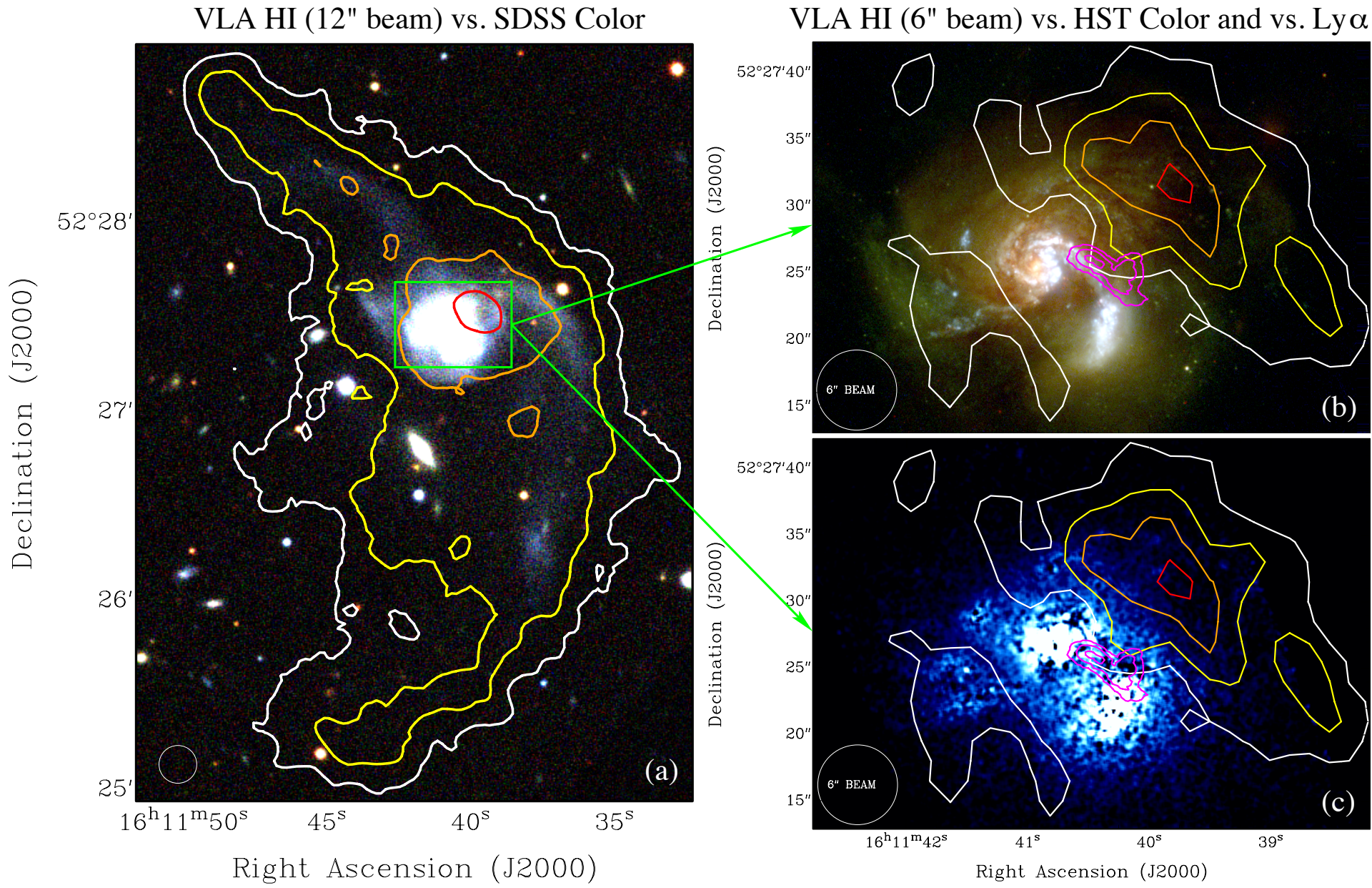


LARS+ f_{esc} vs SFR and $M_\star$





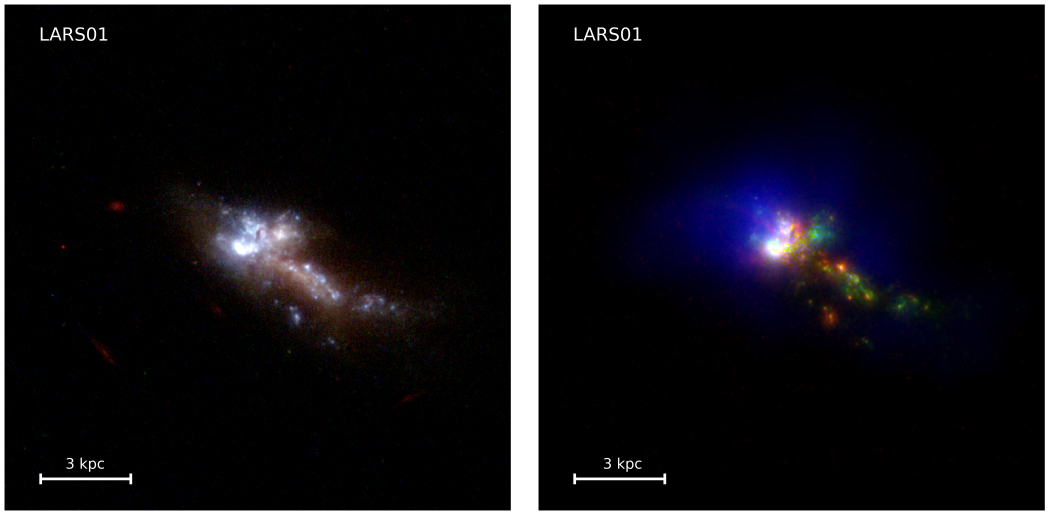
eLARS1 (NGC6090) neutral and molecular gas

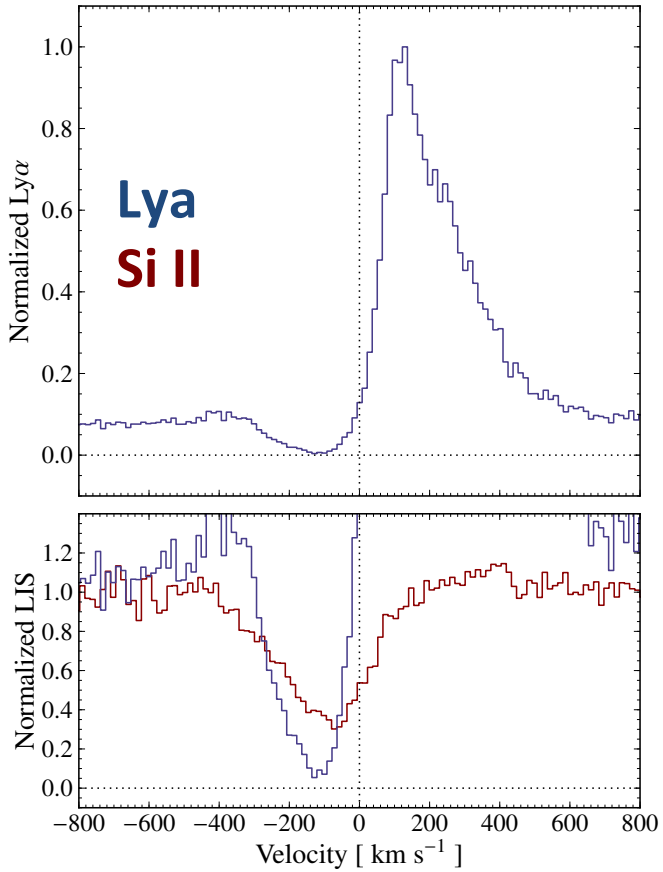


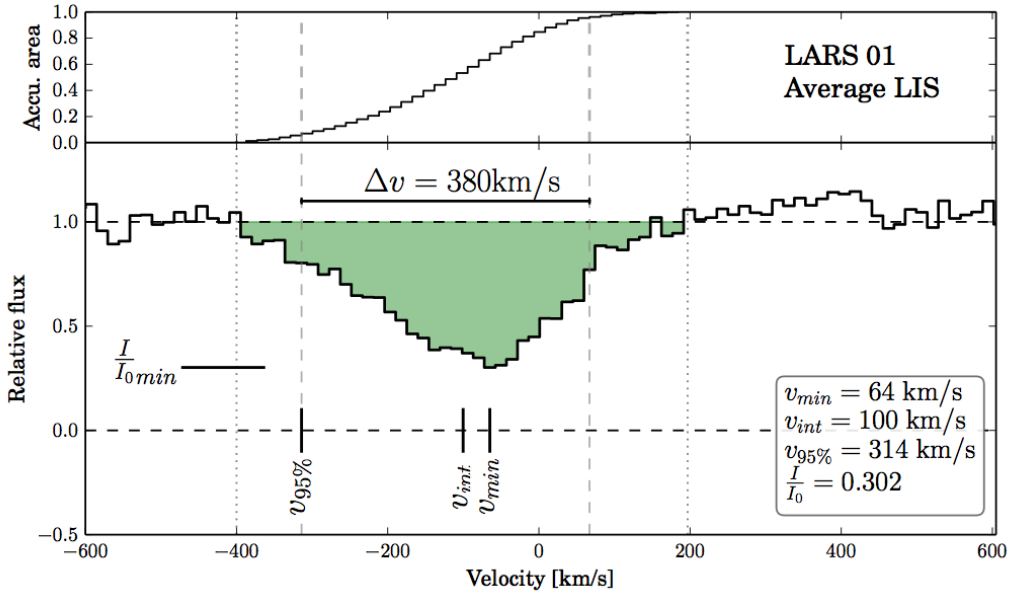
Cannon, Pushnig

Lya and the structure of the HI

LARS1
-> Clumpy outflowing ISM



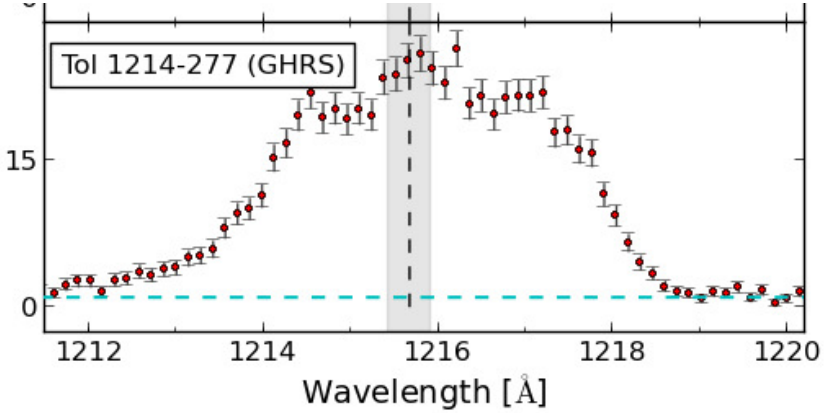


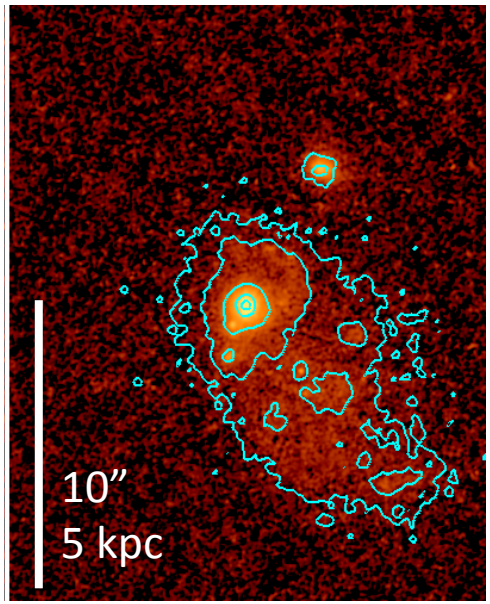


Rivera-Thorsen+2015

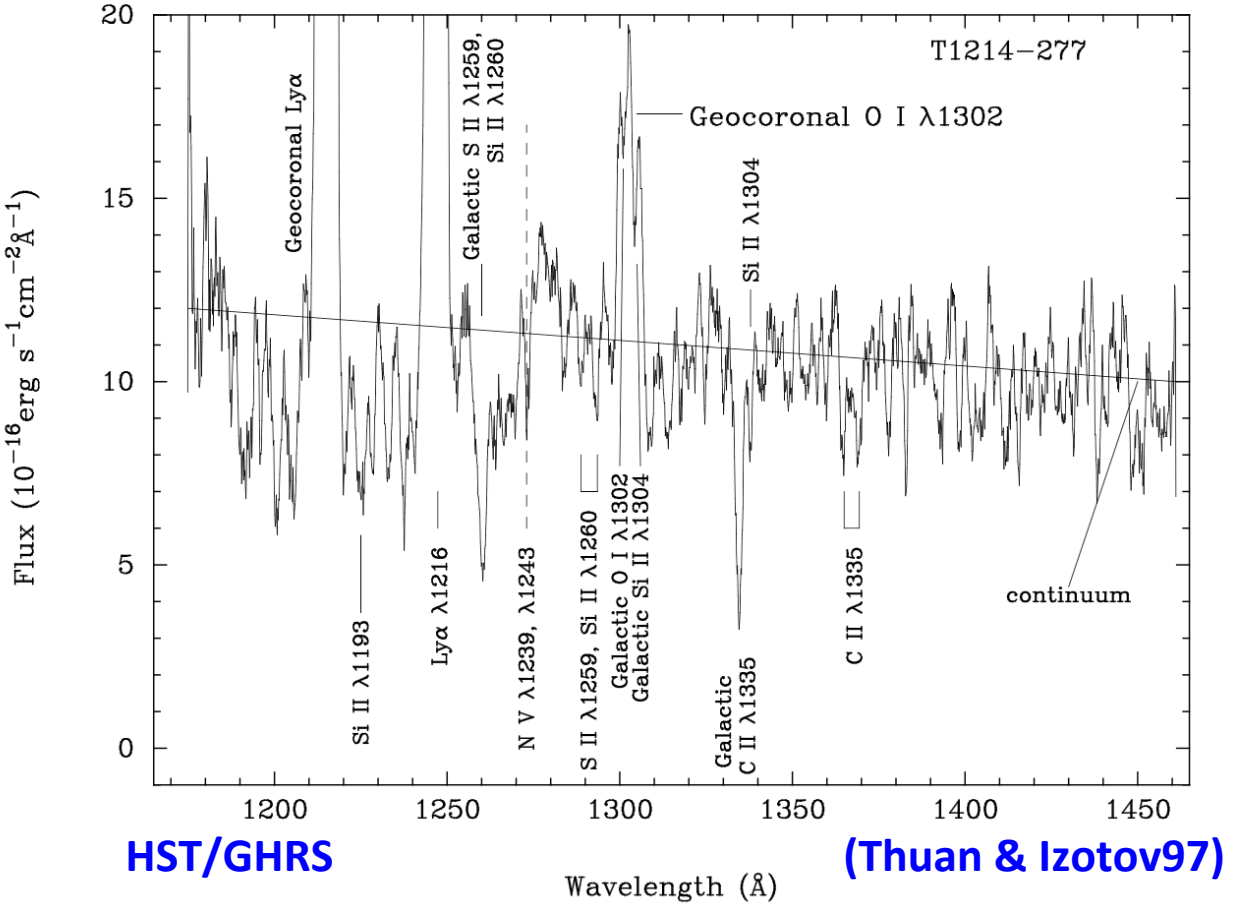
Tol 1214-217 (Tololo 21) – another odd ball?

z=0.026, [O/H]=5% ⊙, M_{FUV}=-16
Lowest Z Lyα emitter
'symmetric Lyα profile'
Cometary BCG





HST/F775W



HST/GHRS (Thuan & Izotov97)

Tol 1214-217 (Tololo 21)

GHRS (Thuan & Izotov 1997, Verhamme 2015) R=1000

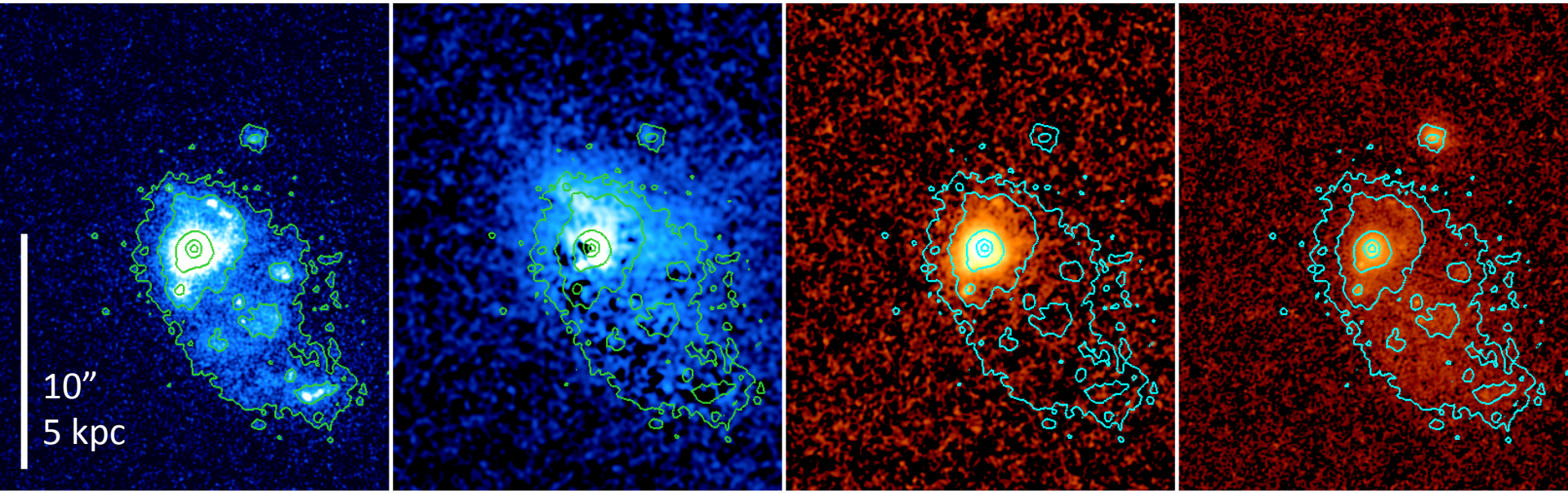
- Lyα 'symmetric' and centered at systemic velocity -> Lyman continuum escape?

- Forero-Romero+2017

Reobserve with HST !

HST/COS/G140M targetting Lyα and ISM absorption lines (e.g. SiII, SiIV)

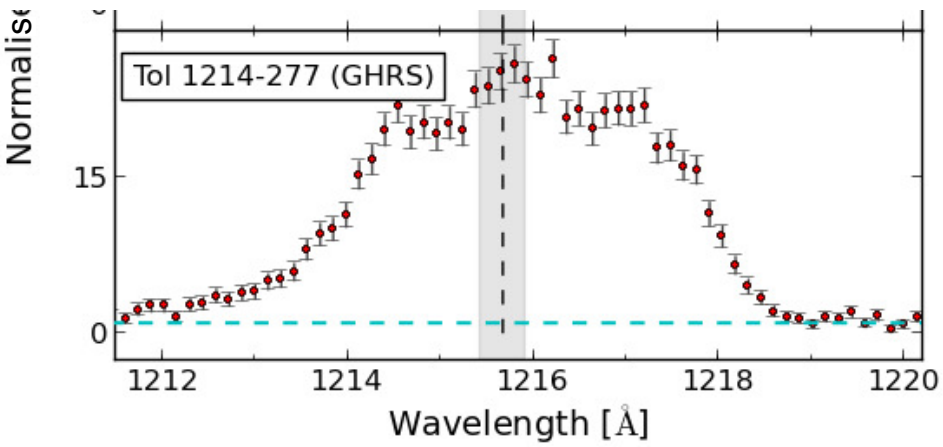
HST imaging in Lyα, Hα, Hβ, [OII], [OIII], FUV, u, b & i (ACS/SBC and WFC3/UVIS)



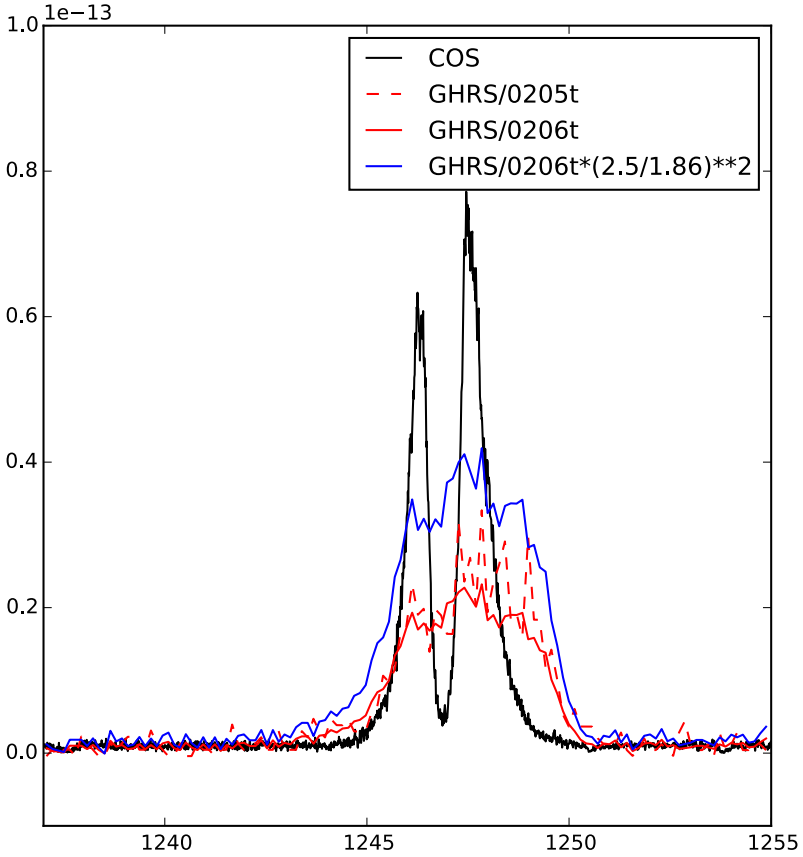
1500 Å Lyα [OIII]5007 *i* (F775W)

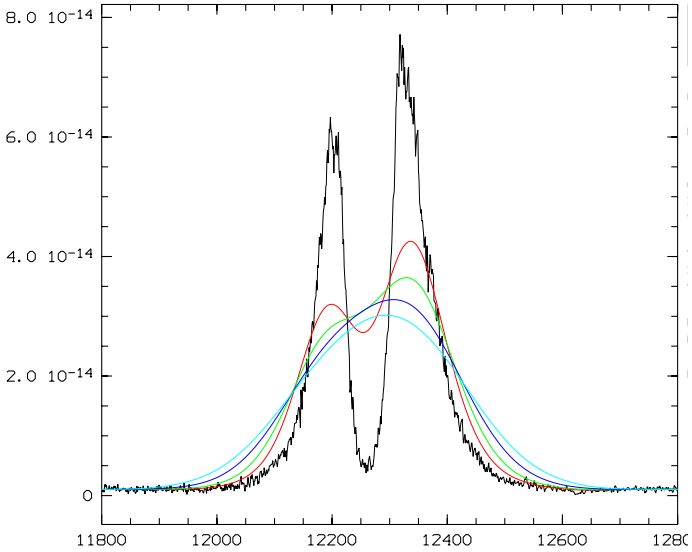
1500 Å contours in all images

Tol 21: only symmetric Lya in local universe…?



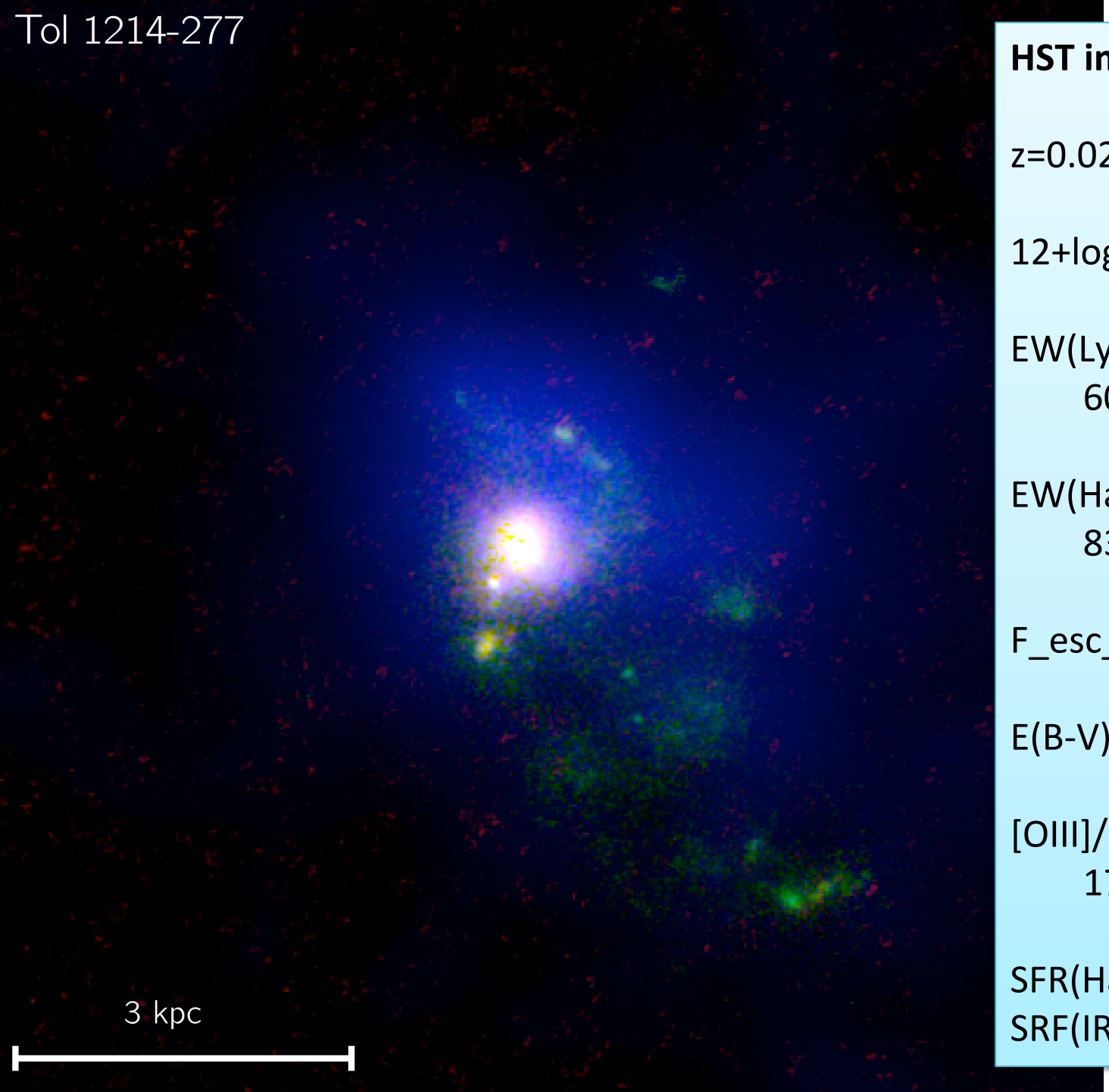
Comparison COS vs GHRS →





← **Smothing the COS spectrum to GHRS resolution**

- Odd spectrum caused by low R and poor S/N



HST imaging & COS spec

z=0.026

12+log(O/H)=7.6

EW(Lya)=100 Å COS
60 Å global

EW(Ha)=1231 Å COS
835 global

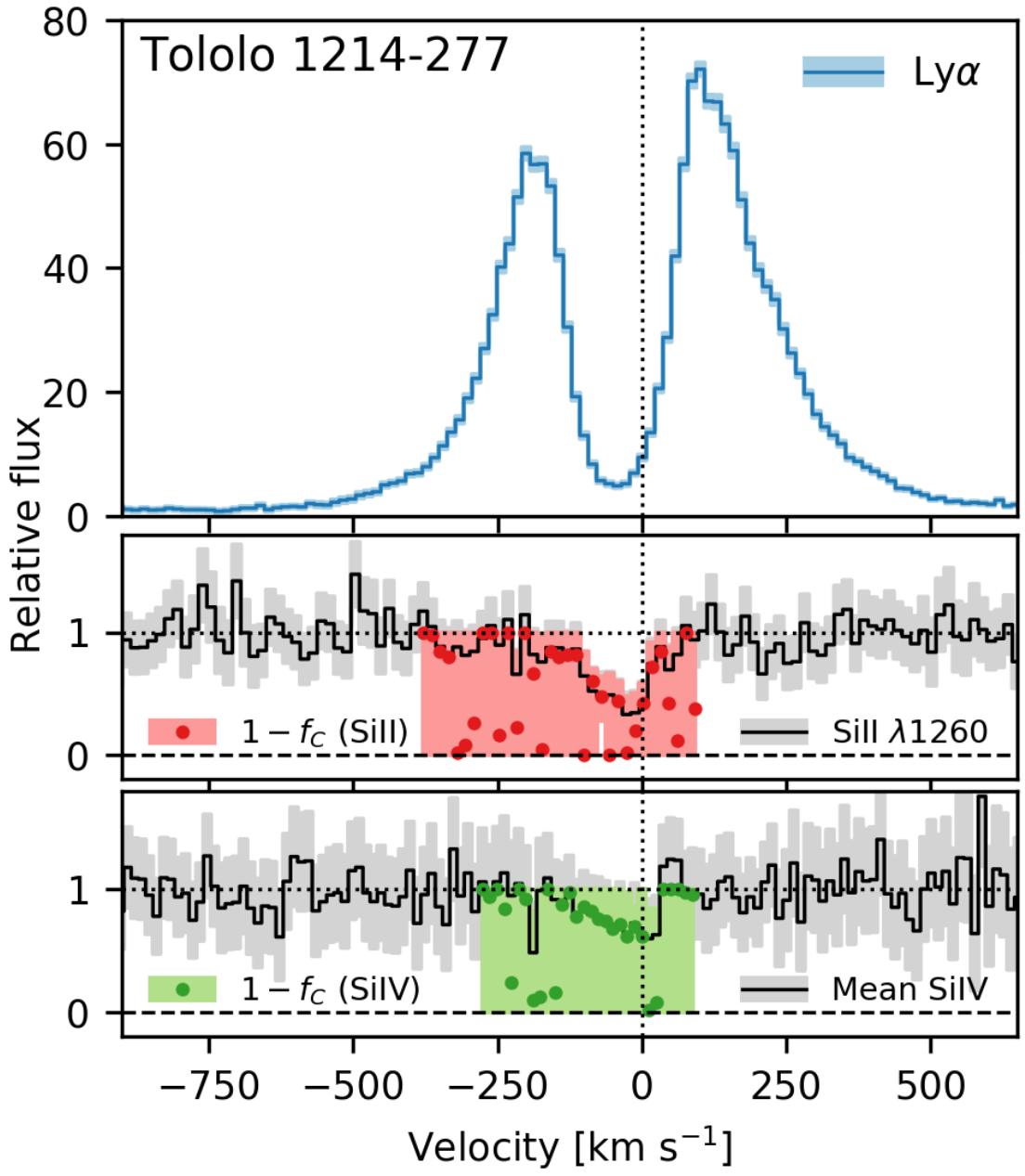
F_esc_Lya=63% global

E(B-V)=0.0 everywhere

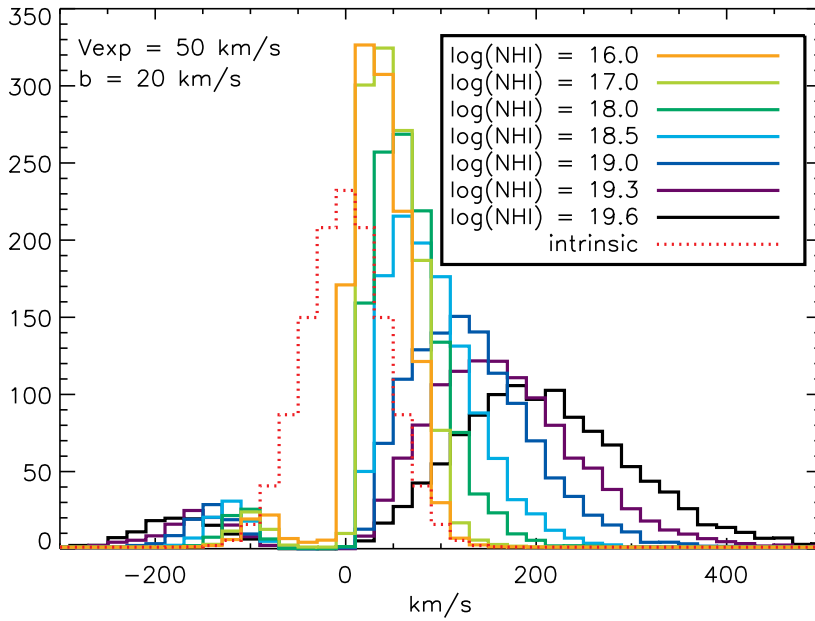
[OIII]/[OII]=19.3 COS
17.7 global

SFR(Ha)=0.92 Msun/yr
SRF(IR)=0.16 Msunlyr

Comparing Lyα and ISM absorption lines



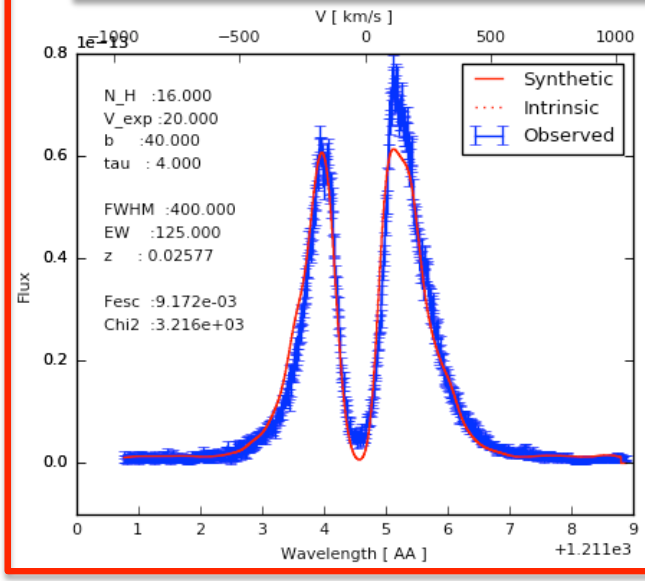
Homogeneous shell models (Verhamme)

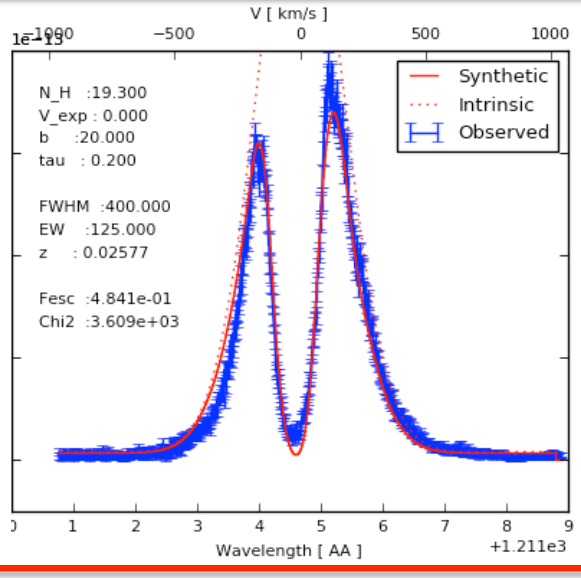


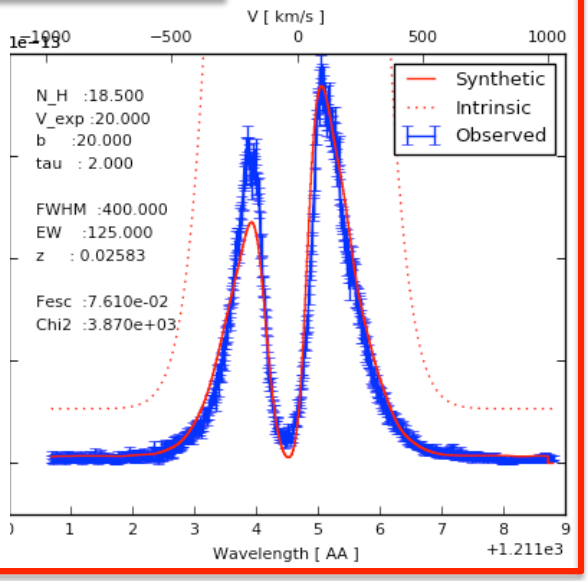
V_min_Lyα= -43 km/s
V_min_SiII ≈ -30 km/s
V_red = 99 km/s
V_blue = -199 km/s
FWHM_red= 160 km/s
FWHM_blue = 150 km/s
R(Lyα)≈3000
-> FWHM_intrinsic ≈ 120 km/s
(FWHM Hα = 59 km/s)

Tol 21: radiative transfer modelling

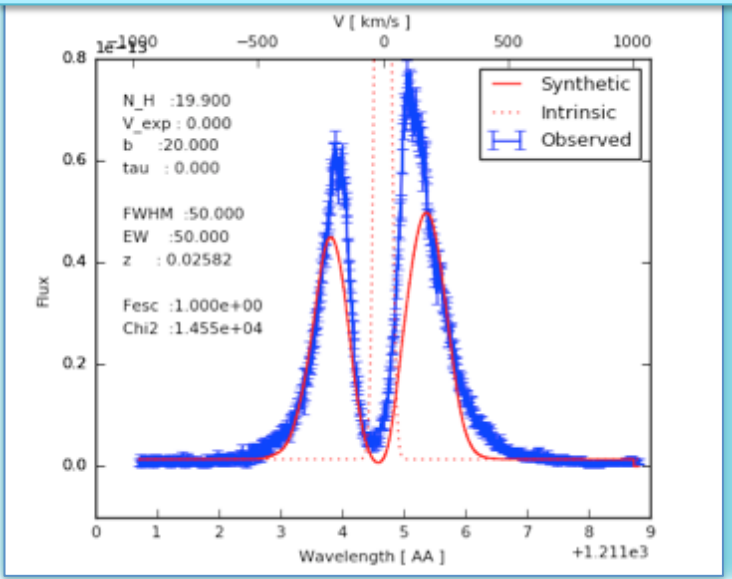
Best fit shell models, with only z fixed (Verhamme). NB FWHM=400 vs 50



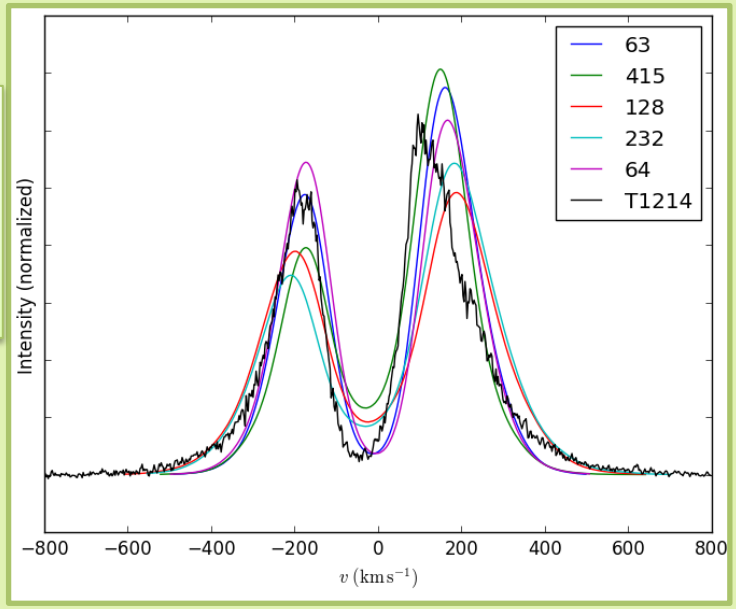




Best fit shell model, w correct FWHM



Clumpy shell model (Gronke) correct FWHM (in progress)



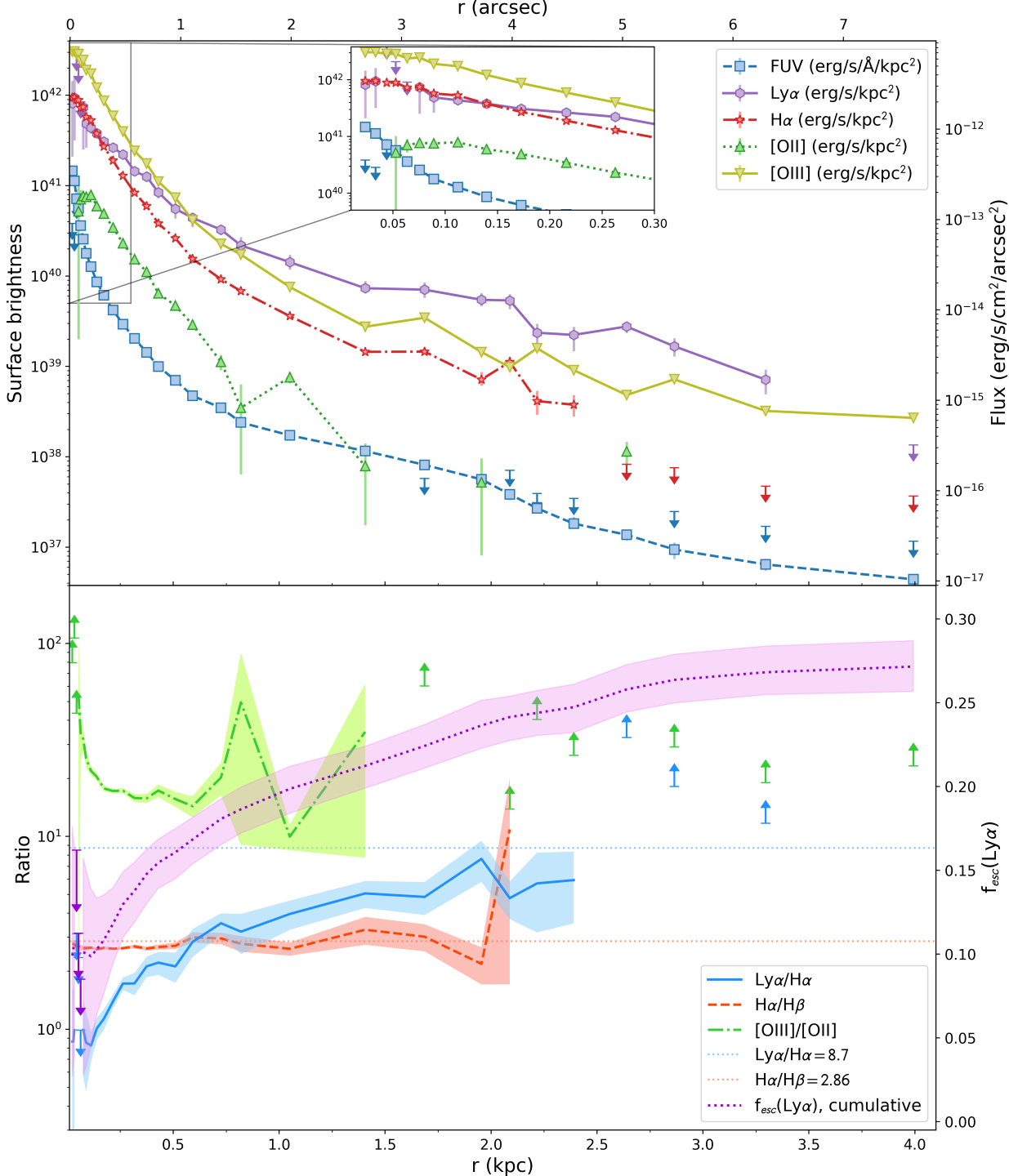
Tol1214-277
Radial luminosity profiles

No dust, still moderate Lyα

Extreme O_{32}

+ small Lyα peak separation
+high EW blue/red

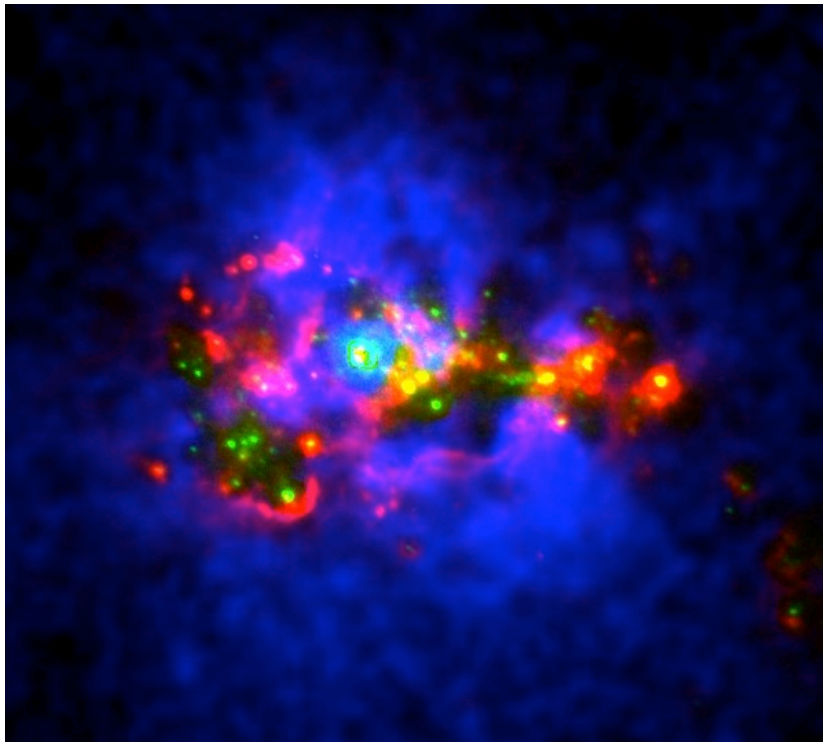
-> probable LyC leaker

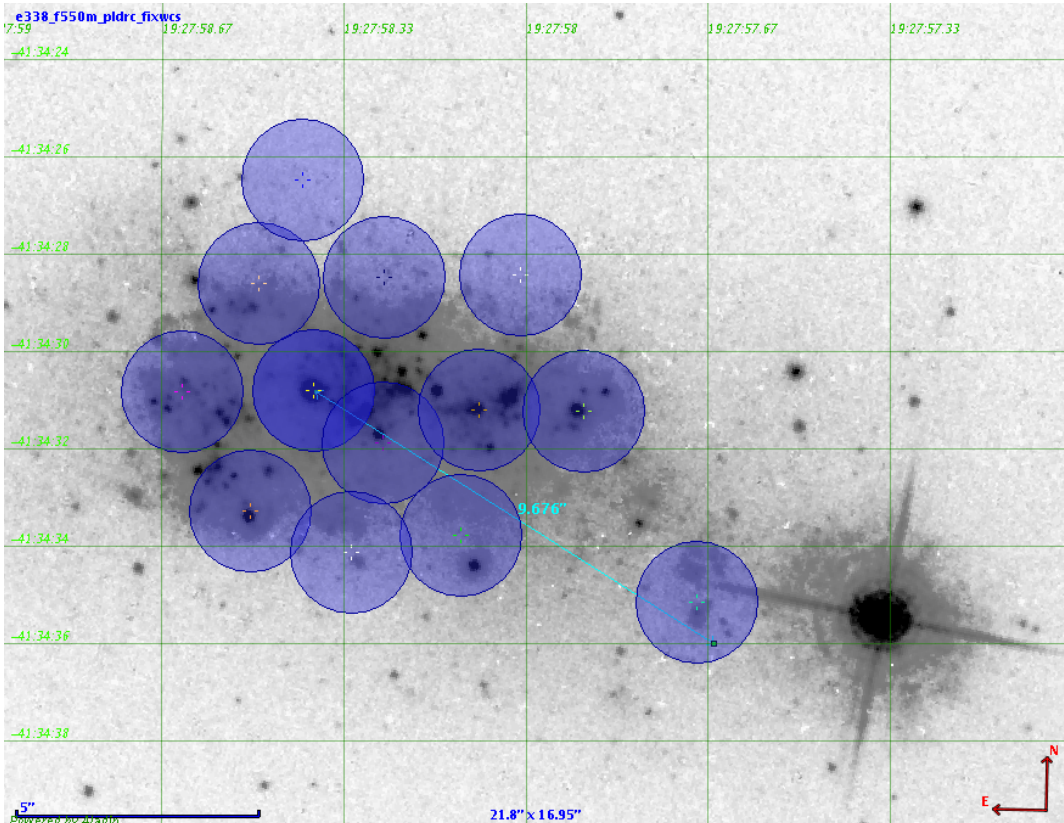


SAFE: **S**tar clusters lyman **A**lpha and **F**eedback in **E**so338-04

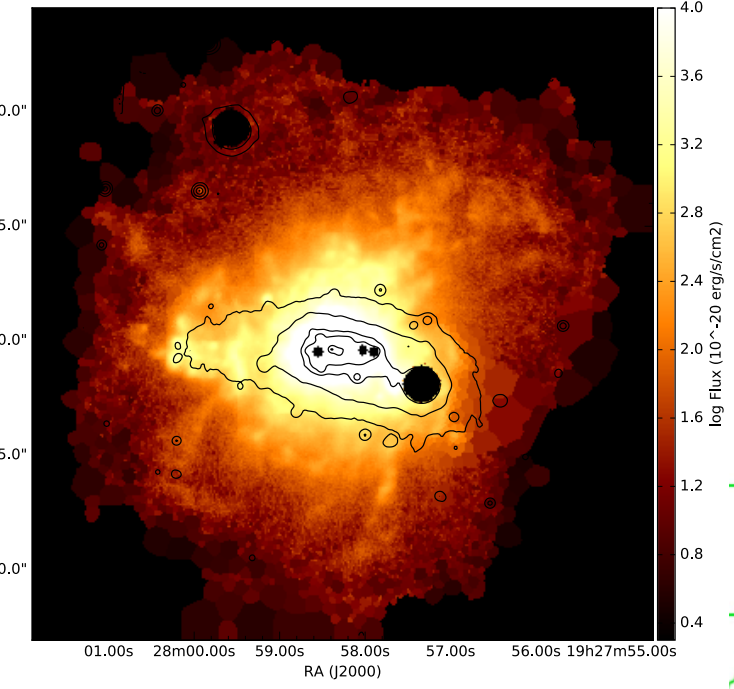
- COS spectra in LARS (and other studies) give Lyα spectra and ISM kinematics along <u>one</u> LOS
- ESO 338-04 has many star clusters UV bright enough to enable multiple pointings

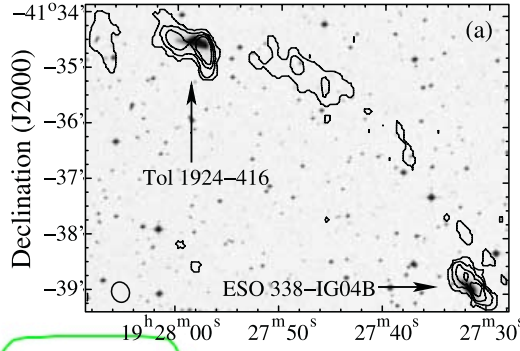
-> multiple sight line ISM + Lya study: COS + STIS (HSTCy24)

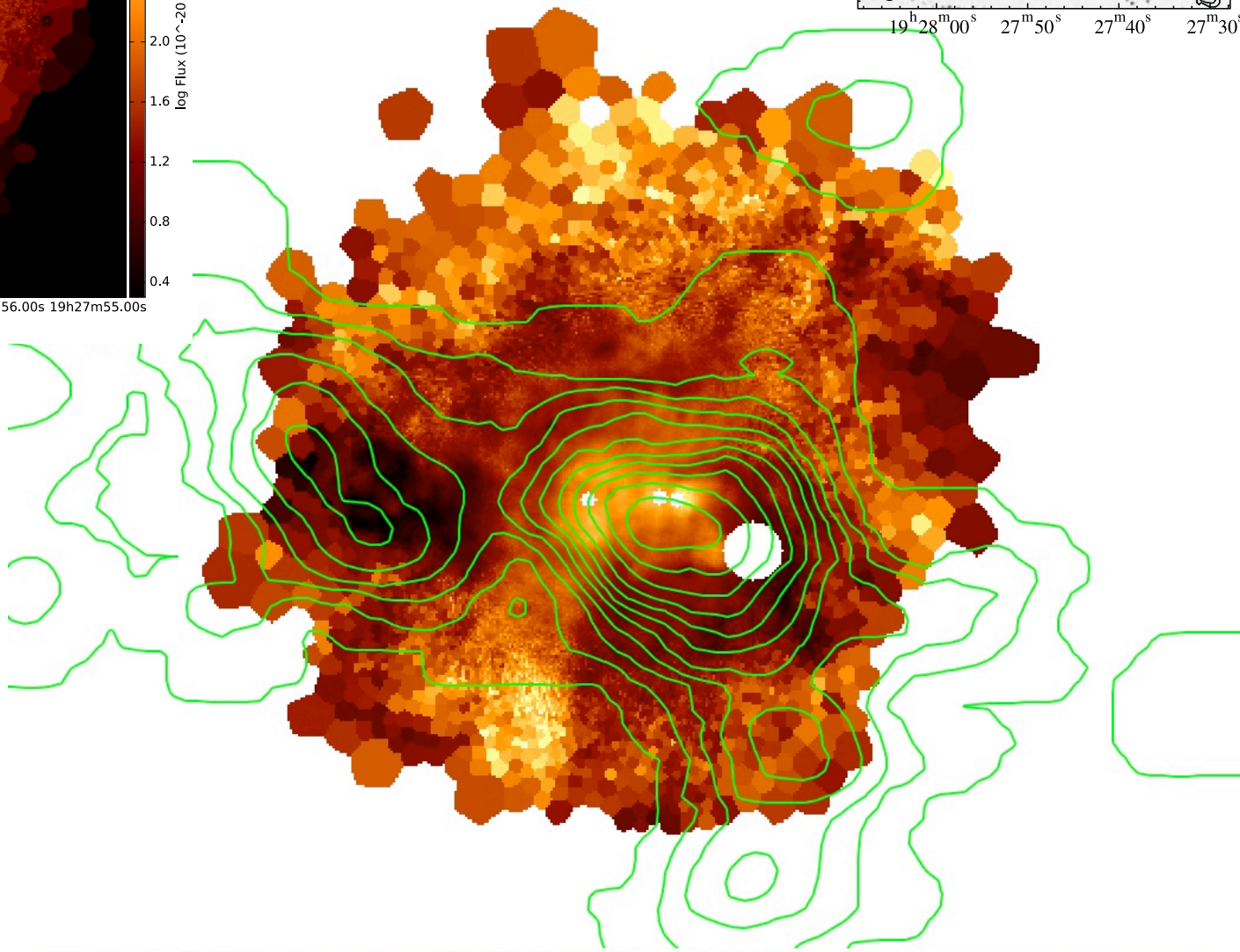




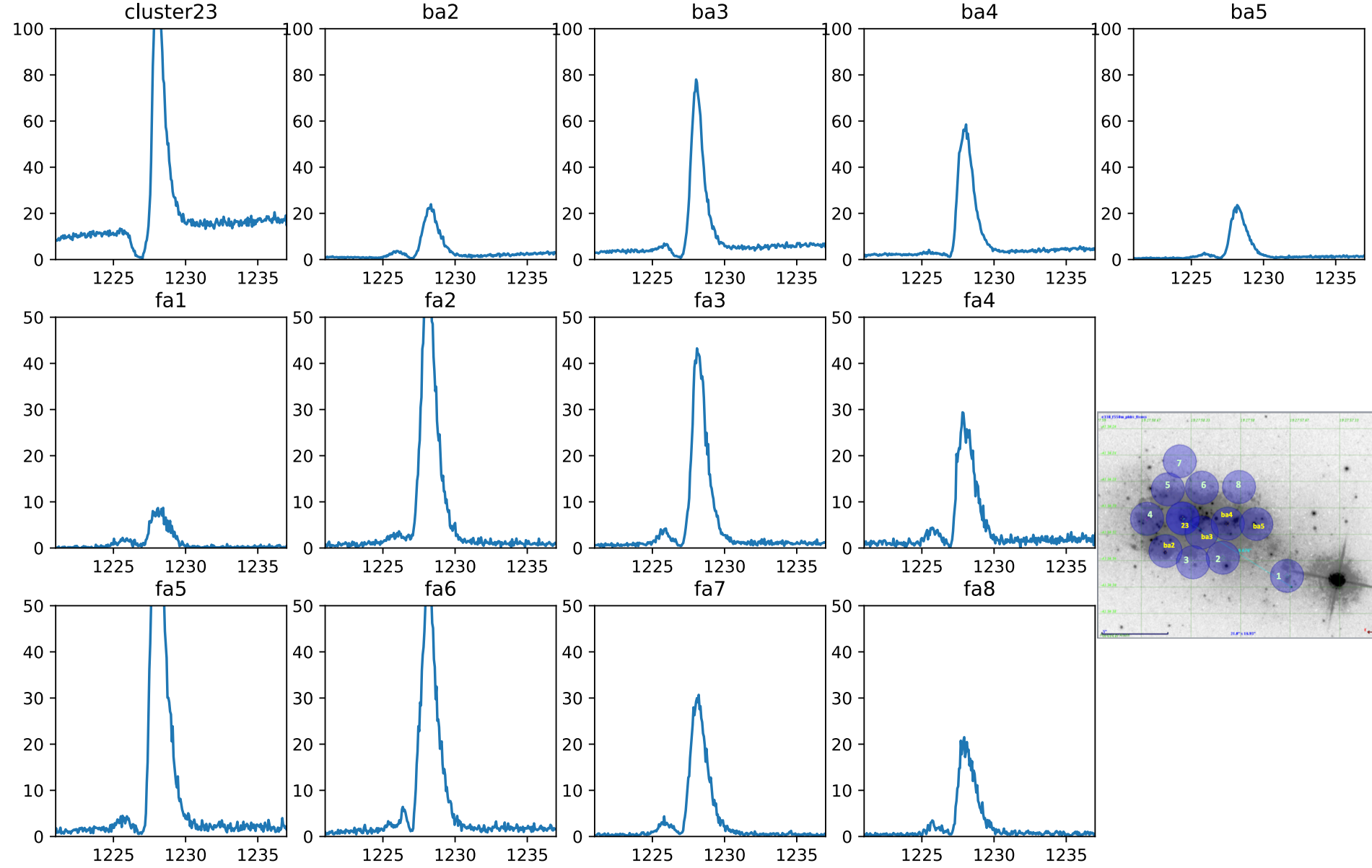
VLA HI contours
Overlaid on MUSE OIII/Hα map







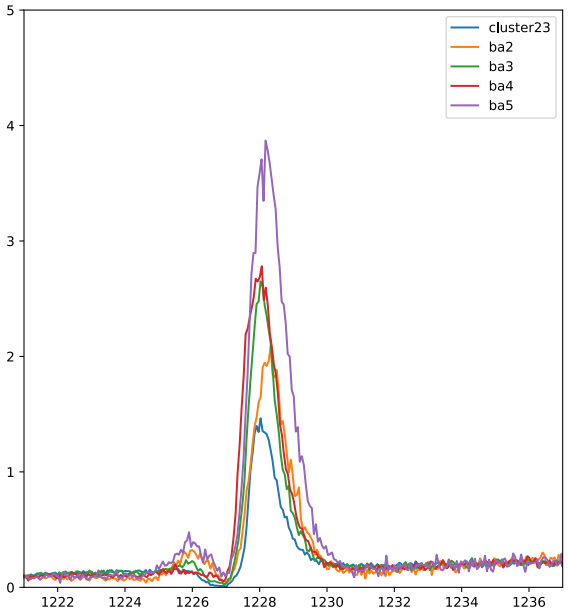
SAFE Lyα spectra

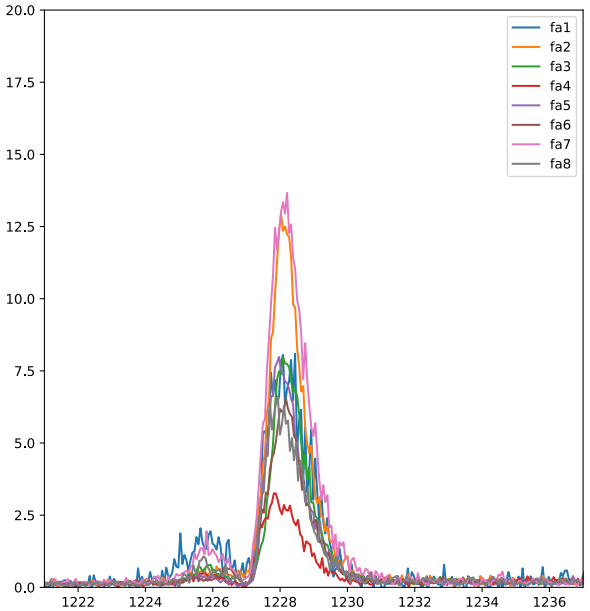


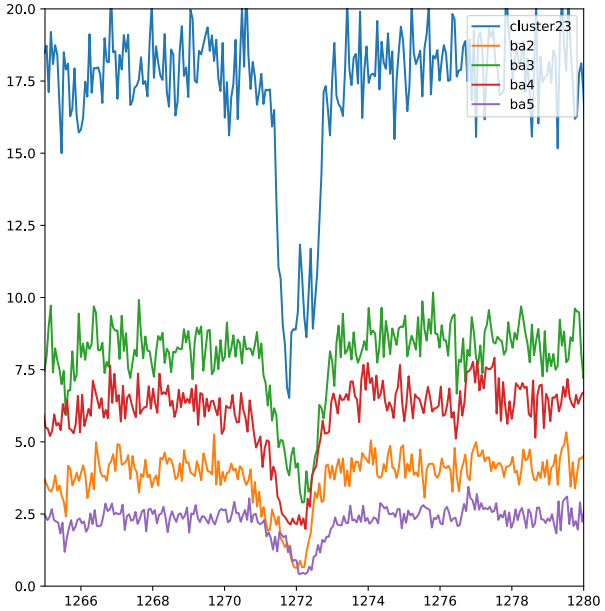
SAFE
5 UV bright signtlines

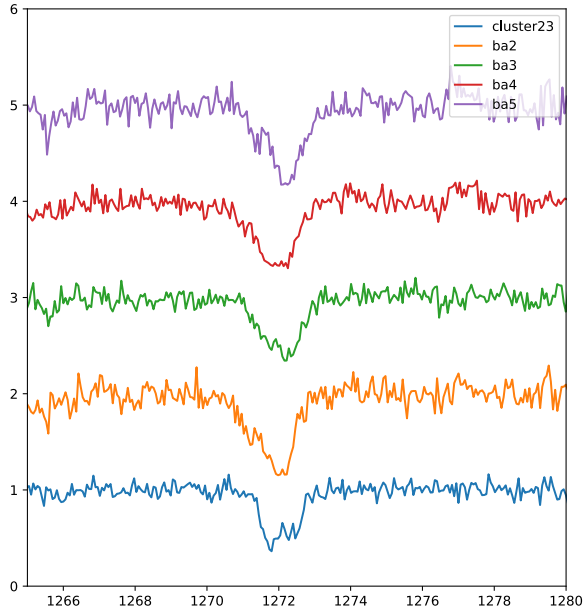
Comparison of Lyα and SiII 1260 line

In progress.









Summary

- LARS+eLARS data products soon to be released
- Tol1214-277 turns out to be an ordinary LAE but is probably leaking LyC
- SAFE will allow the first tomographic Lyα + ISM tomography of a Lyα galaxy in the local universe