Stellar Populations of Lyman Alpha Emitters at $2<z<6$ in the VIMOS Ultra Deep Survey

Hathi+ 2016, A&A, in press (arXiv:1503.01753) and Hathi+ 2016 (in prep.)

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<u>Collaborators</u>

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VUDS | VIMOS Ultra Deep Survey

Motivation

- To better understand the range of physical properties in high-z galaxies and its evolution with redshift we need large samples

  Lack of statistics -- objects with multi-wavelength photometry and spectroscopy

- Lyα emitters (and their properties) could have strong implications on the reionization process

Stellar population studies of Lyα emitters at z~>2 are based on 'UV-selected' or 'NB-selected' Lyα emitters

e.g., Shapley+ 2001, 2003; Erb+ 2006, Gawiser+ 2006, Pentericci+ 2007, Verma+ 2007, Kai+ 2008, Reddy+ 2008, Finkelstein_S+ 2009, Kornei+ 2010, Guaita+ 2011, Berry+ 2012, Vargas+ 2014, Hagen+ 2014, Finkelstein_K+ 2015

These studies cover limited/specific redshift range and Results vary based on the selection method, and luminosities probed

Our goal is to use the 'UV-selection' approach on ~4000 star-forming galaxies (SFGs) ($\sim > L^*_{UV}$) over a large redshift range ($2<z<6$) to investigate stellar populations of Lyα emitters

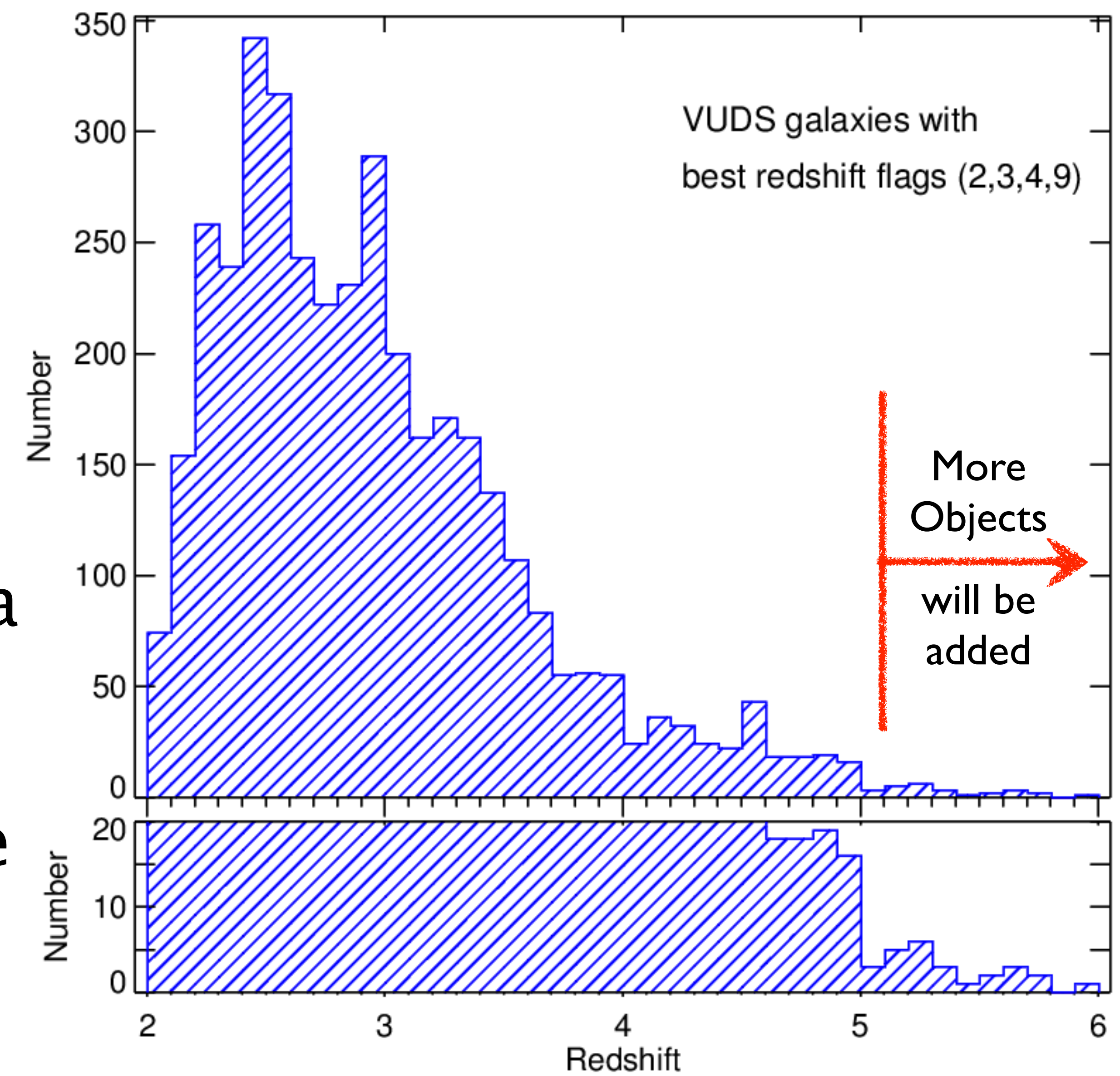
VIMOS Ultra Deep Survey (VUDS)

[Le Fèvre+ 2015, A&A, 576, A79]

- A large (1 deg^2, 3 fields, ~10,000 galaxies) and deep (640 hours, 14h per exposure) VIMOS spectroscopic survey

- ECDFS, VVDS-02h, COSMOS fields with extensive multi-wavelength data

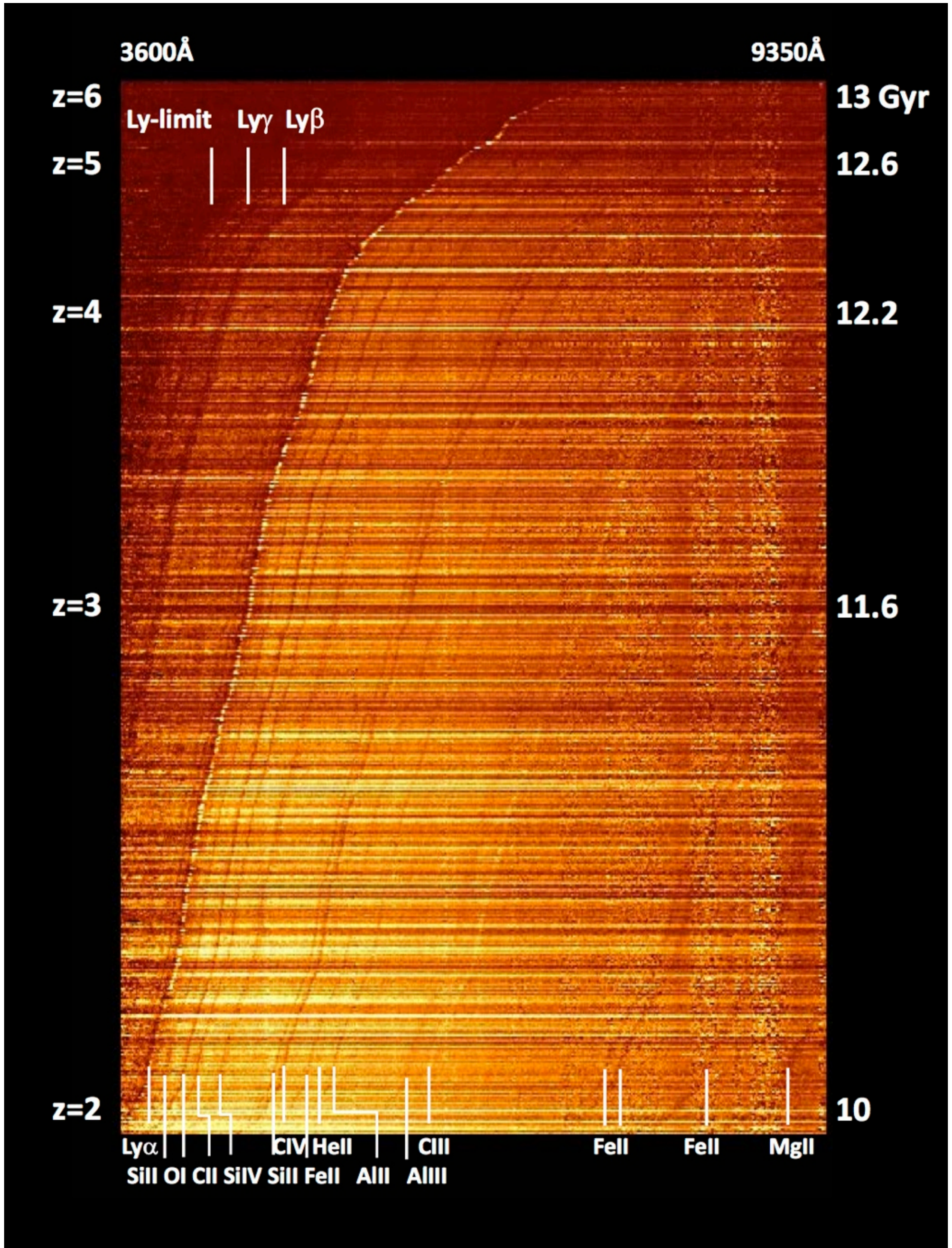
- VUDS covers full wavelength range from ~3600Å to 9500Å (Lyα line visible at 2<z<~6.5)

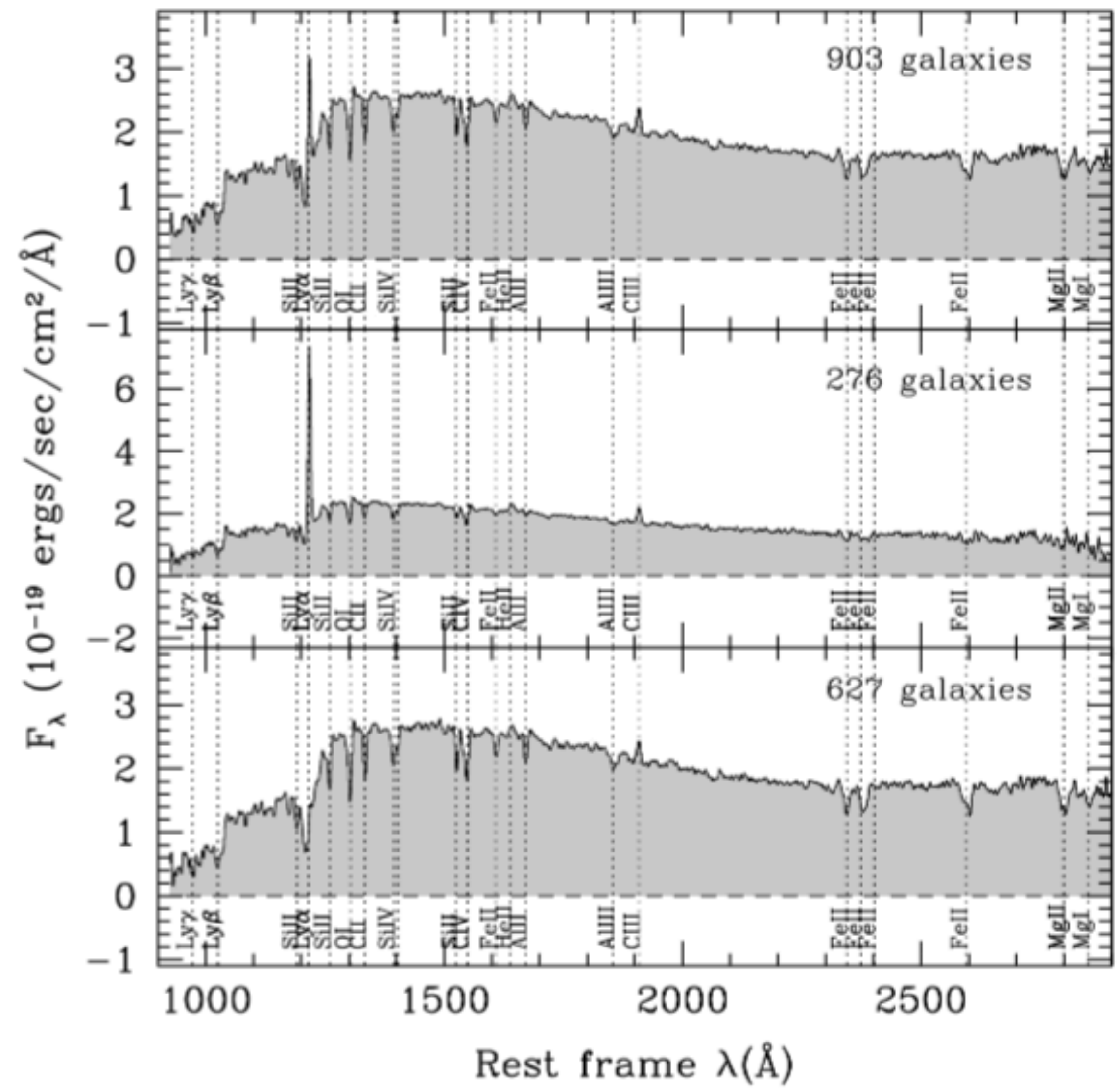


- Target selection based on photometric redshifts and broad-band colors (i_{AB}<~25 mag) ➡ continuum-selected sample

VUDS Spectra

[Le Fèvre+ 2015, A&A, 576, A79]



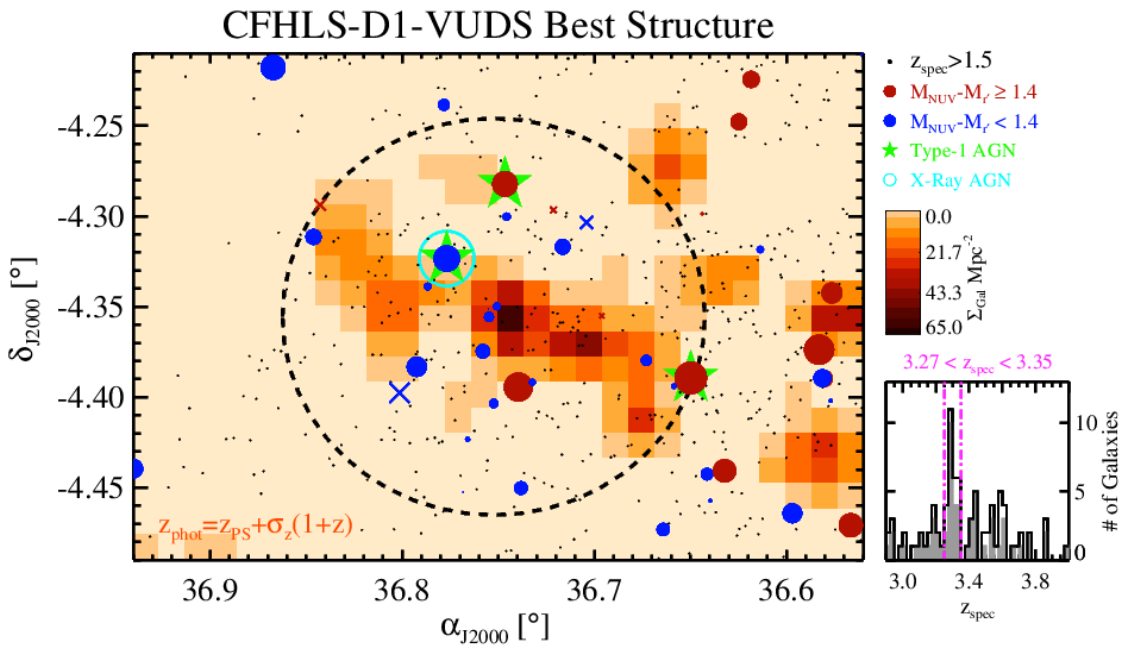


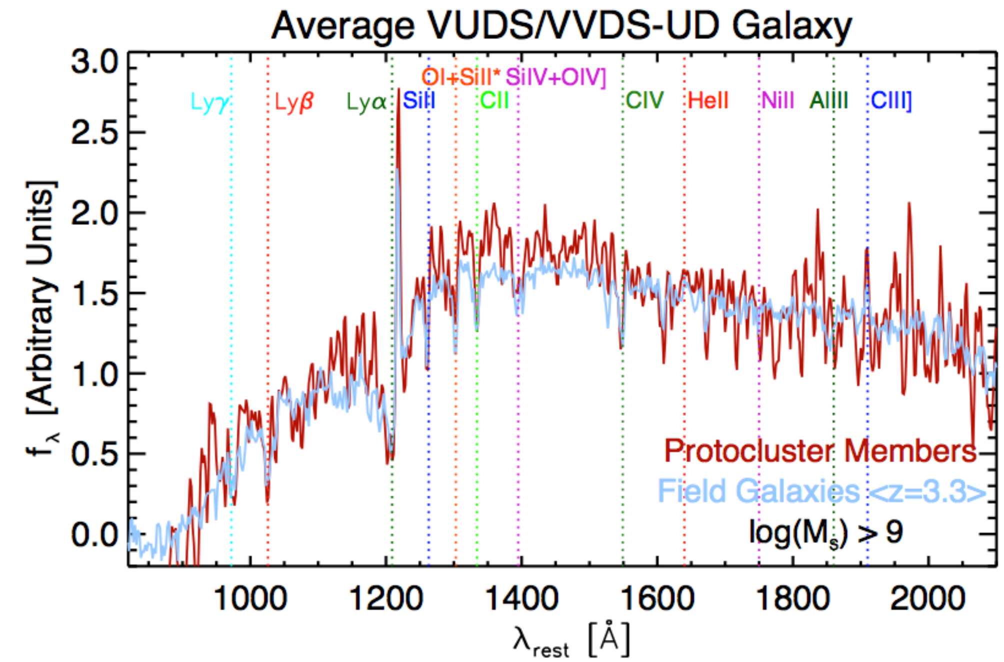
- These spectra gives access to a range of ISM/Nebular spectral features and physical properties for each individual galaxy.

- With large numbers, the average spectral properties can be obtained using high signal-to-noise stacked spectra.

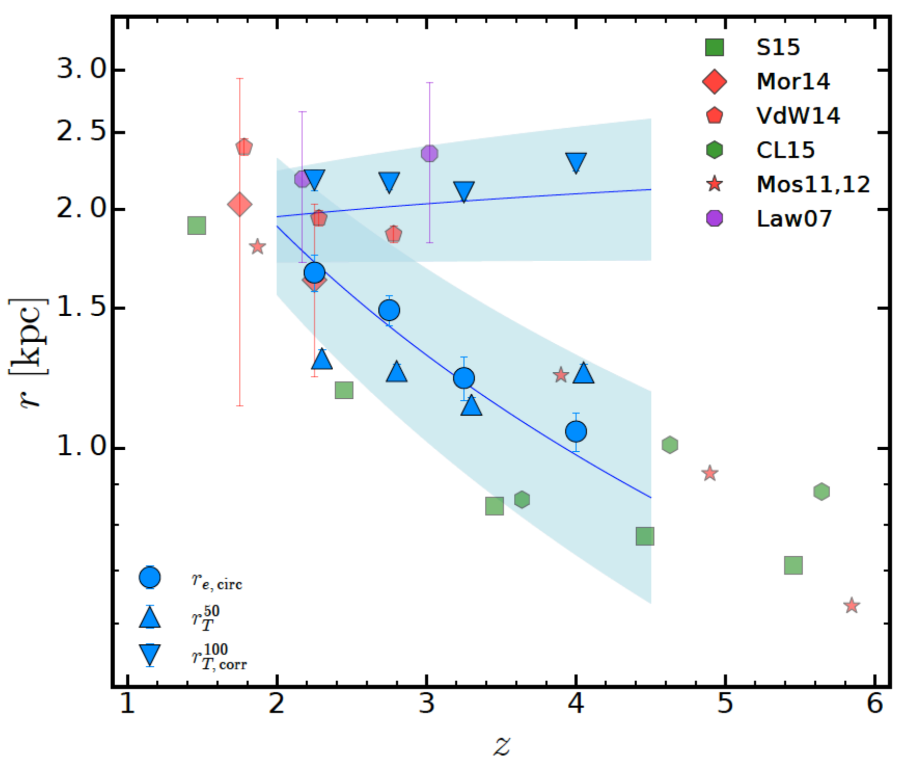
VUDS Science

Proto-clusters at z~>3 and environmental dependence
[Lemaux+ 2014, A&A, 572, A41; Cucciati+ 2014, A&A, 570, A16]

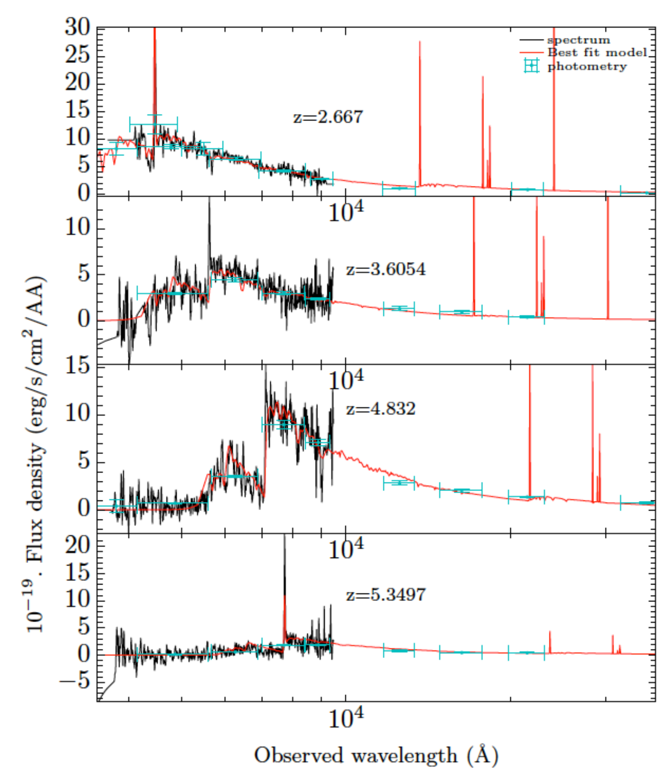




Galaxy Sizes
Ribeiro+ 2016, A&A, arXiv: 1602.01840



Thomas+ 2016, A&A, arXiv: 1602.01841

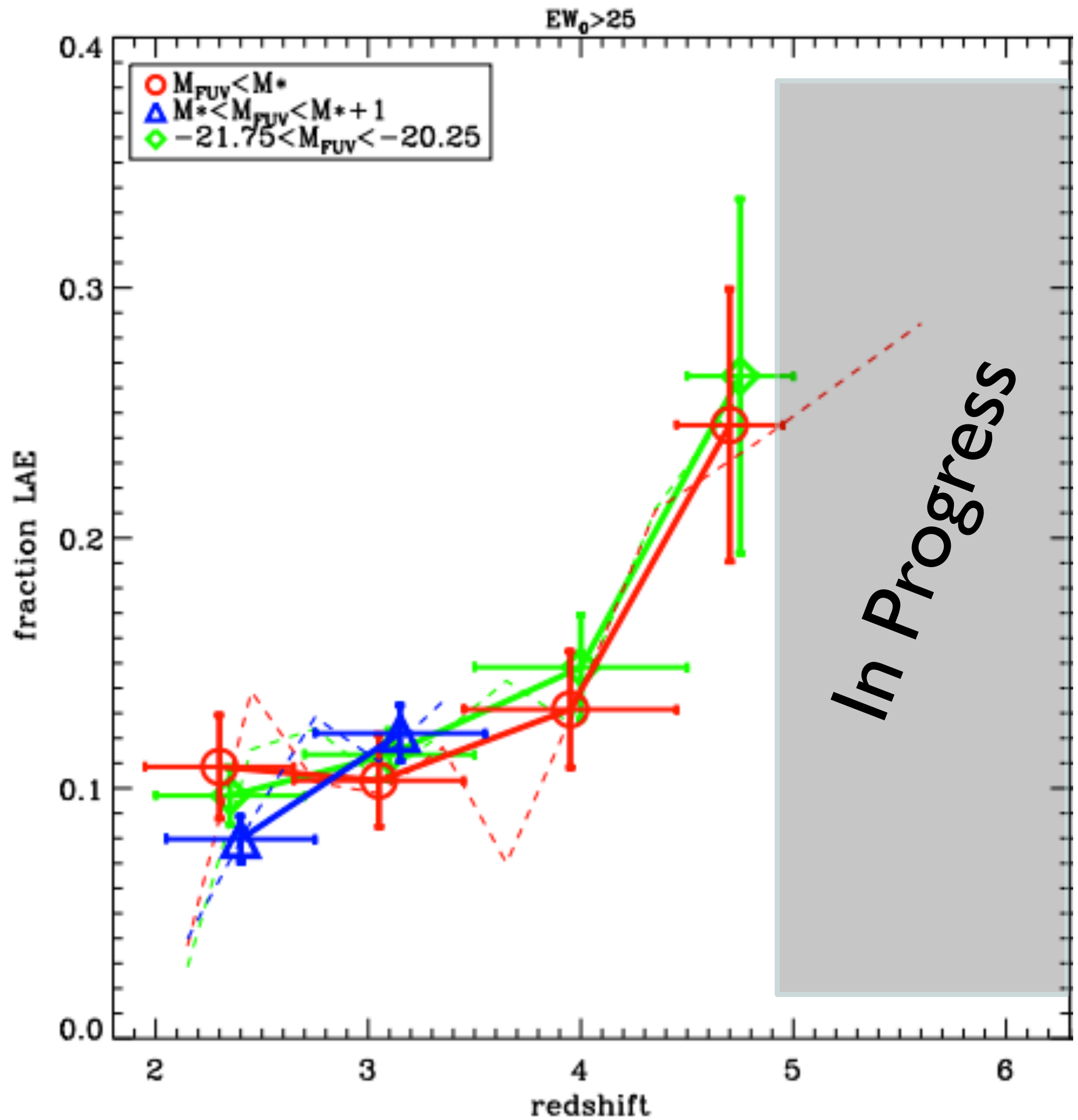


Spectral energy distribution fitting combining both spectra and photometry

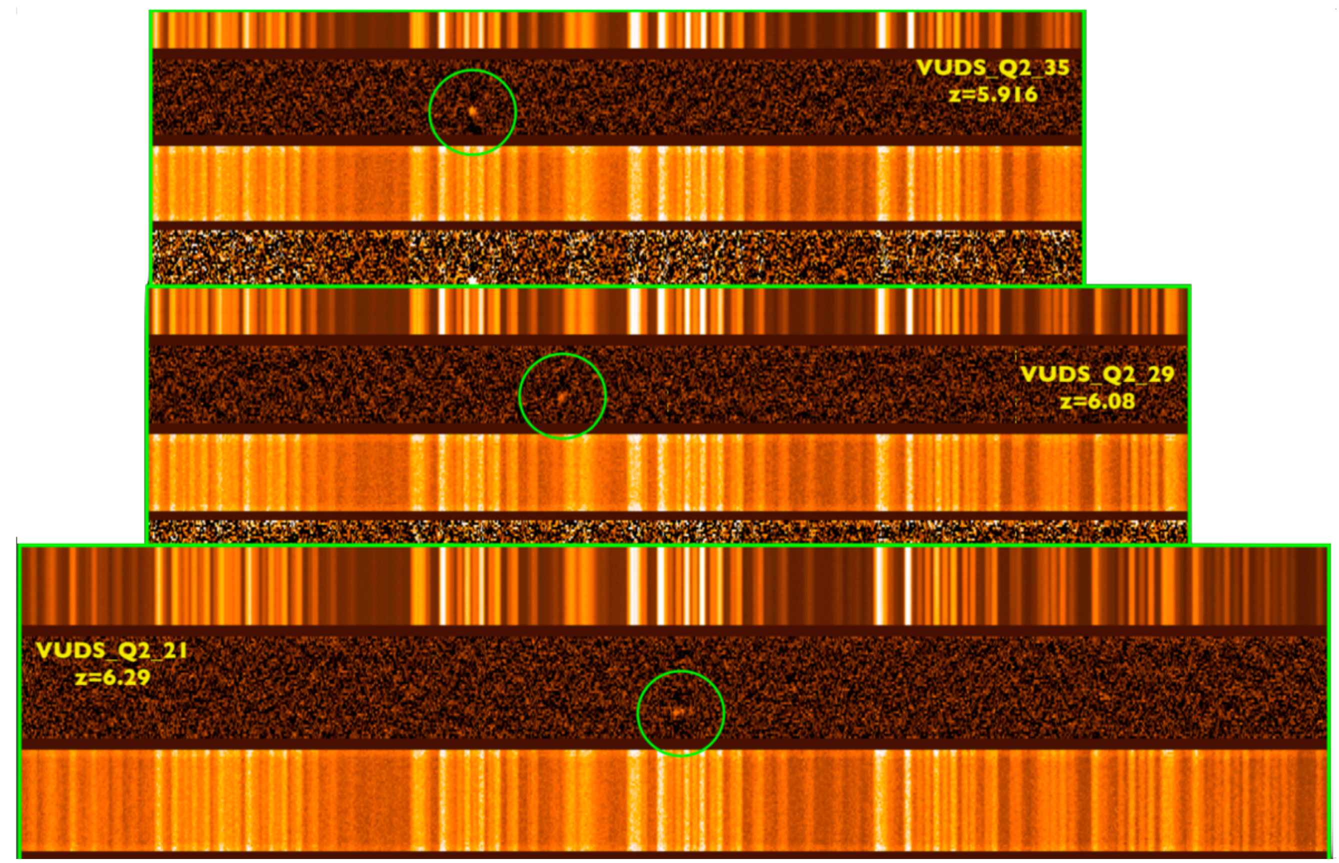
See Romain Thomas's Talk on Friday

Lyα Fraction versus Redshift

[Cassata+ 2015, A&A, 573, A24]



Ongoing work: Identification of LAEs up to z~6.5



Credit: E.Vanzella

SFGs at 2<z<6 from VUDS show increasing Lyα fraction with the redshift (true for different EW cuts)

This is consistent with Stark et al. and other studies at these redshifts
One possible reason is that more Lyα escapes from less dusty galaxy

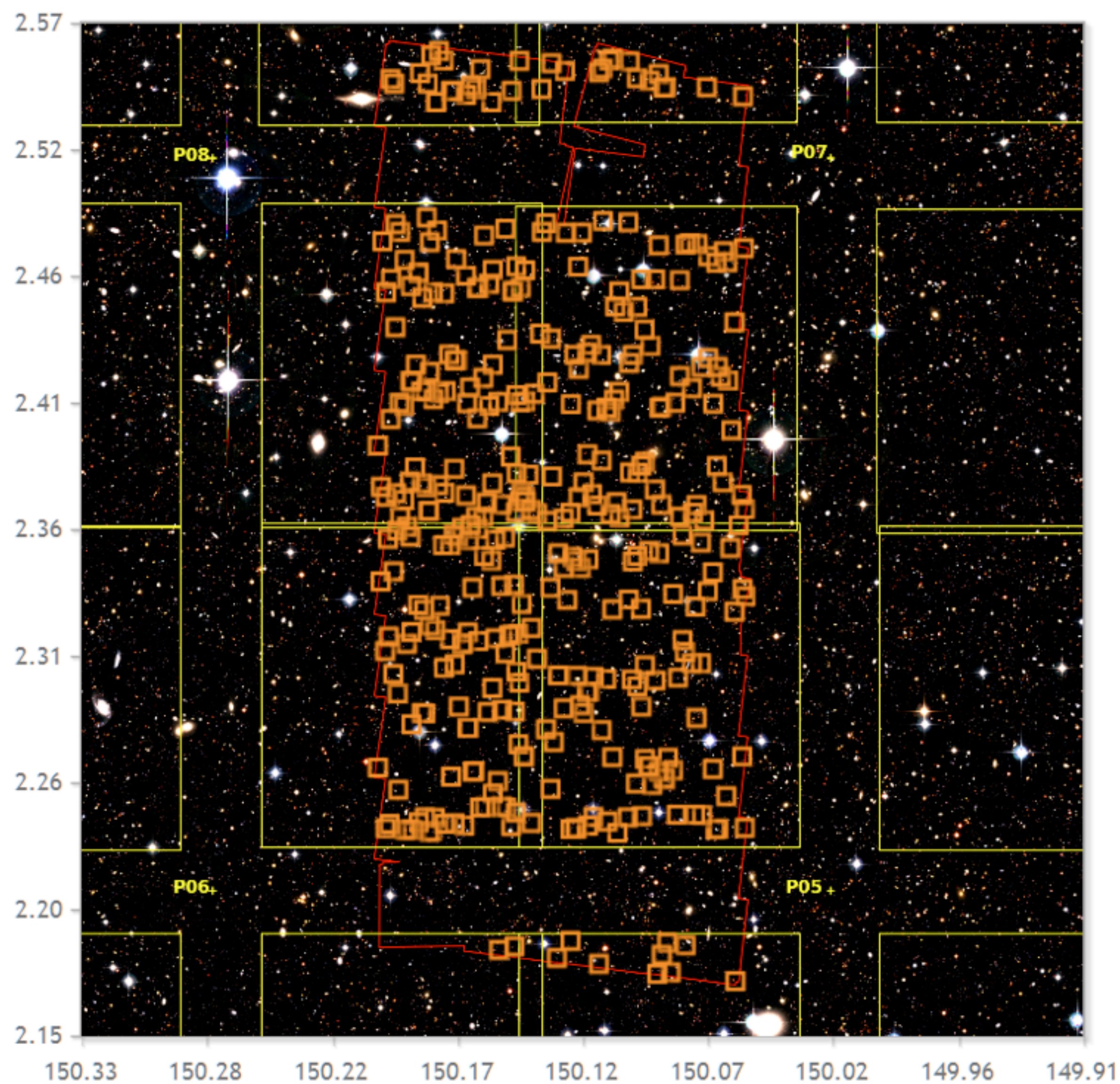
VUDS-DR1: Public data release

[Tasca+ 2016, A&A, arXiv:1602.01842]

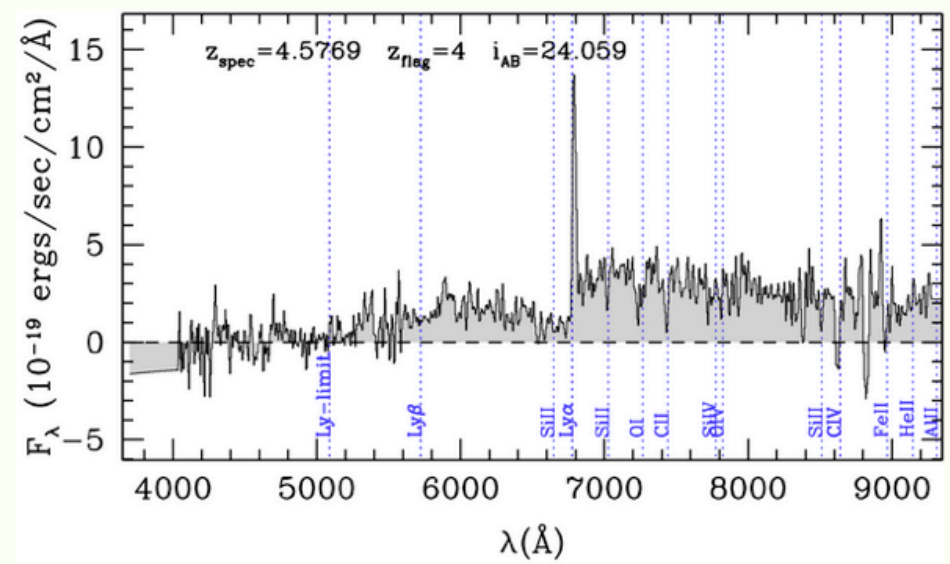
~700 galaxy spectra to z_{spec}<6 in CANDELS

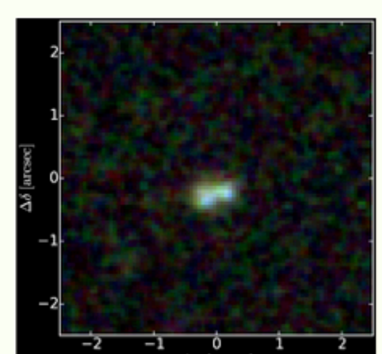
http://cesam.lam.fr/vuds/DR1/

VUDS data matched to:
CANDELS-COSMOS
CANDELS-ECDFS



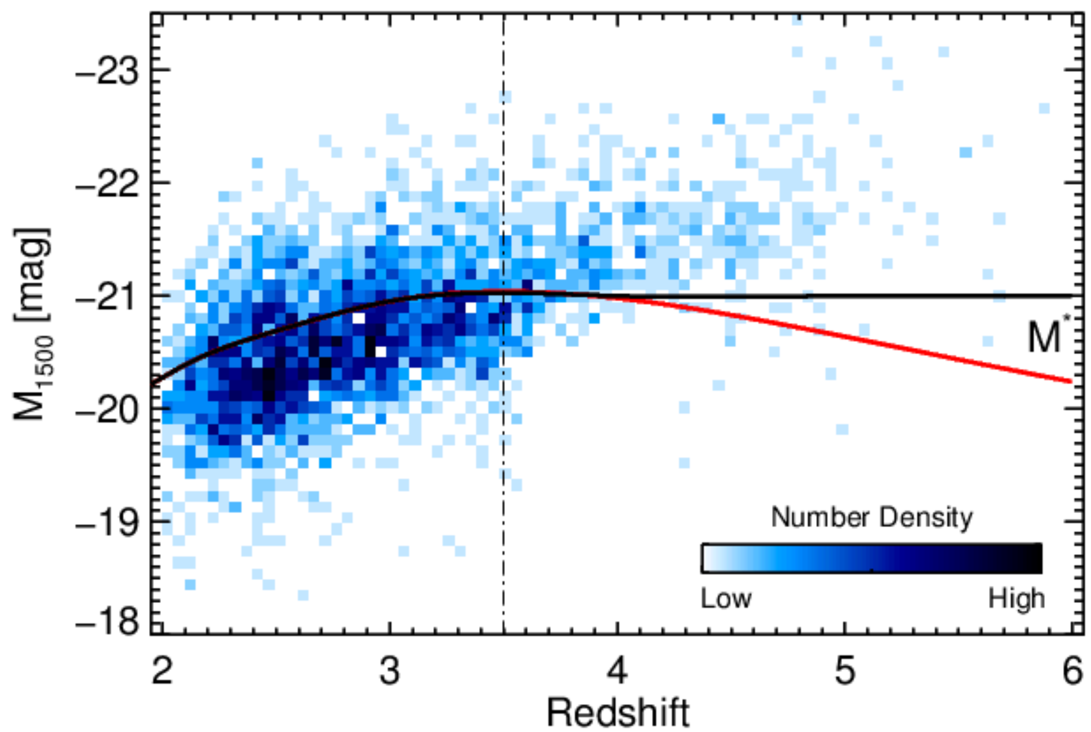
VUDS Identification	Alpha (J2000)	Delta (J2000)
5101244930	+10:00:47.66	+02:18:02.3





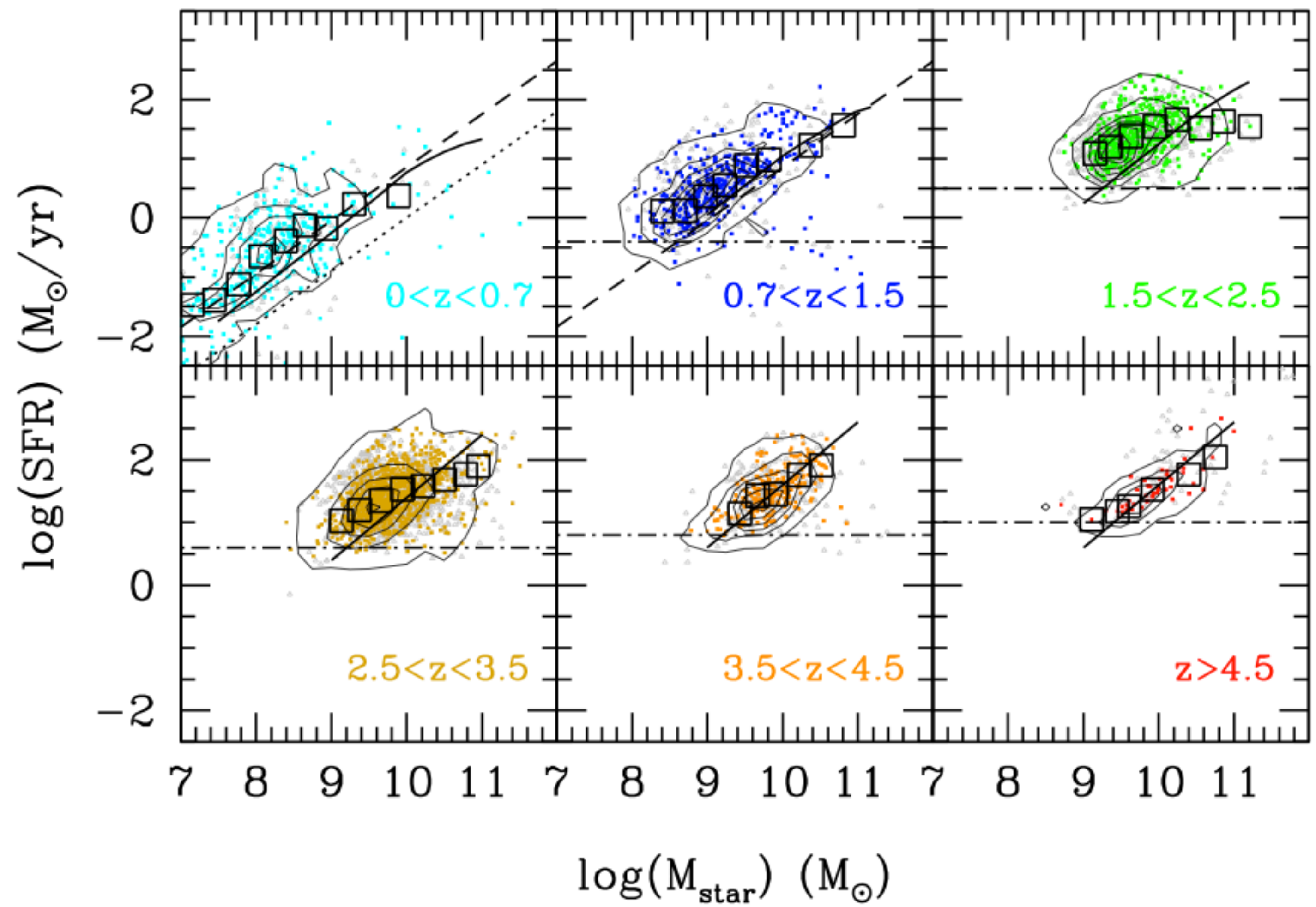
CANDELS Identification 10102
log(SFR) 1.38899 (SFR in M_sun/yr)
log(M*) 9.804 (M* in M_sun)
Age 0.424027 (in 10^9 yr)

Properties of VUDS SFGs at 2<z<6



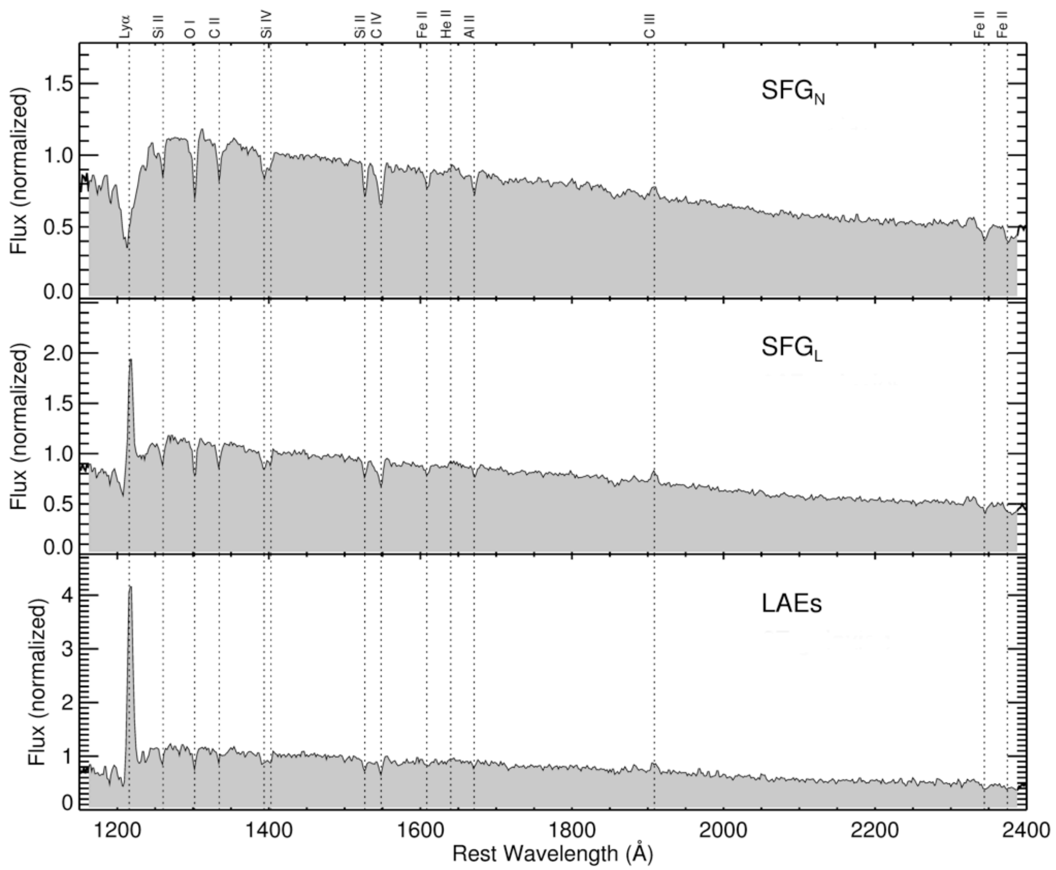
SFGs have UV luminosities ~>L*
(M*±1 for z<~3.5,
~M* and brighter for z>3.5)

[Tasca+ 2015, A&A, 581, A54]



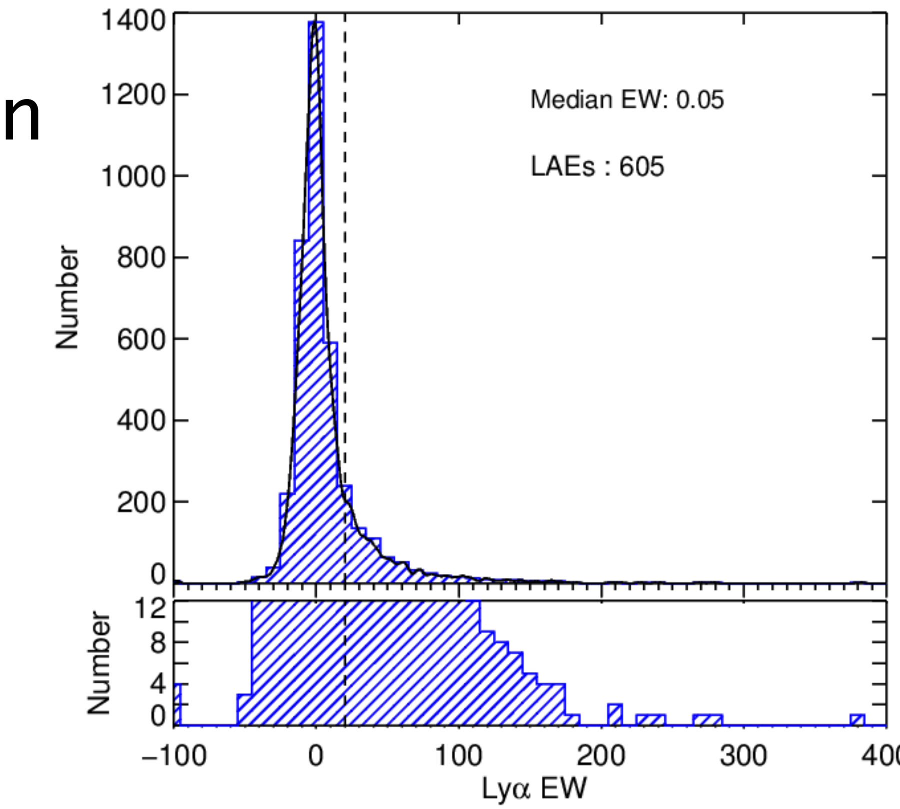
- SFGs (z~>2) spans a large range in SFR (~3 to 300 M$_\odot$/yr) and stellar mass (~5x10^8 to 10^{11} M$_\odot$)
- VUDS galaxies are 'normal' SFGs, populate the 'MS' but we see a large scatter (SFH effect; Cassara+ 2016, A&A, submitted)

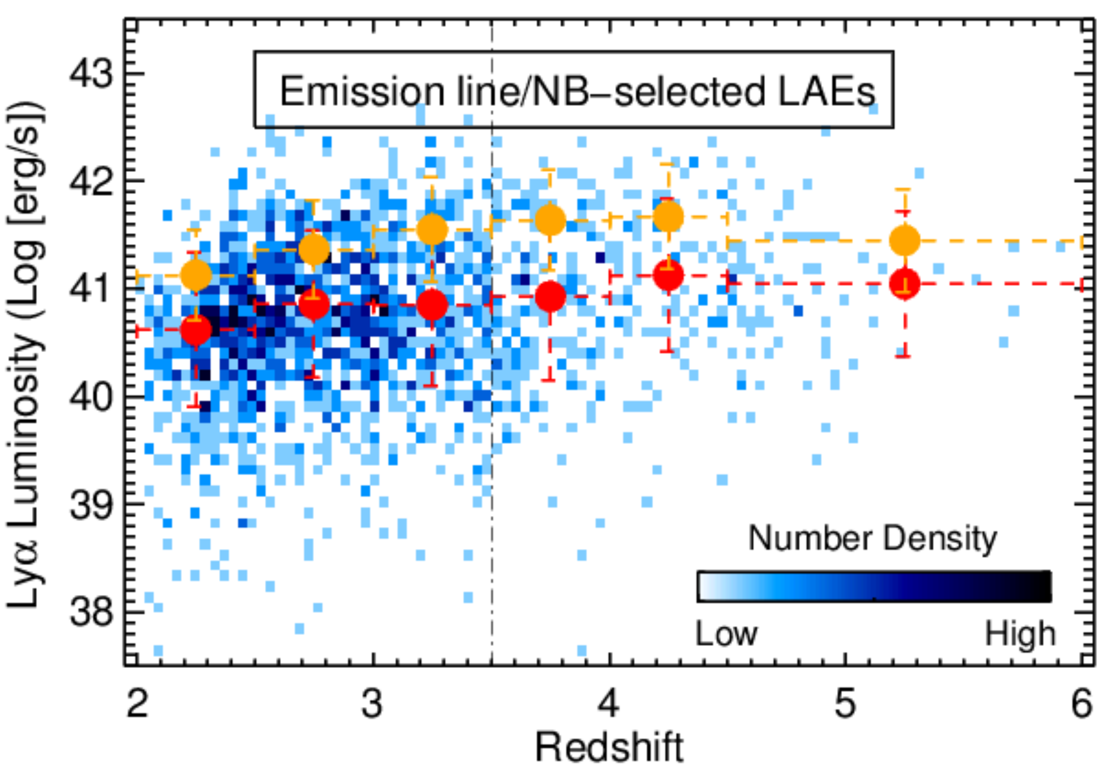
Lyα in SF Galaxies at 2<z<6



We divide SFGs in 3 groups:

SFG_N (EW≤0Å),
SFG_L (EW>0Å),
and
LAEs (EW≥20Å)

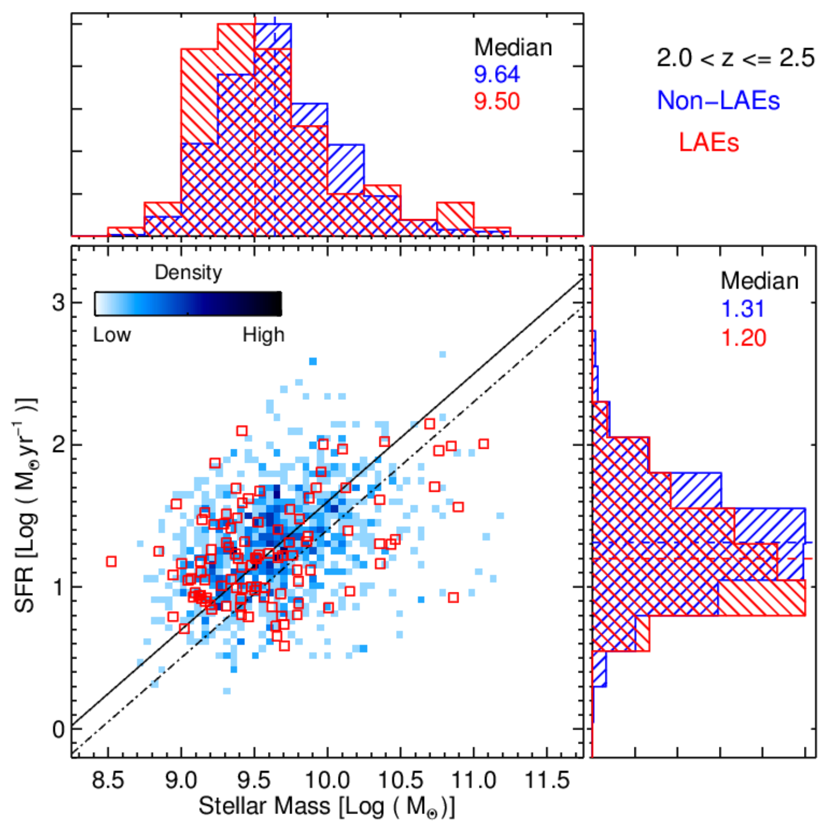




- Rest Lyα EW range from strong absorbers (−50Å) to strong emitters (~200Å)
- Median Lyα luminosity is ~10^{41} erg/s for LAEs (~an order of magnitude lower than typical NB LAEs)

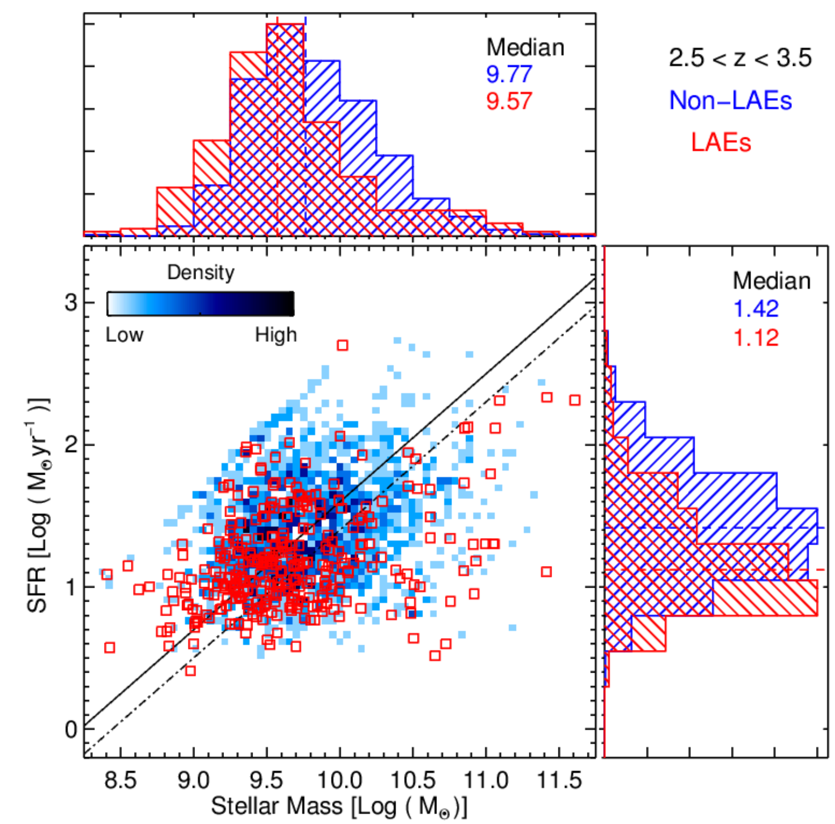
Stellar Populations of LAEs (and non-LAEs)

[Hathi+ 2016, A&A, arXiv:1503.01753 and Hathi+ 2016, in prep.]

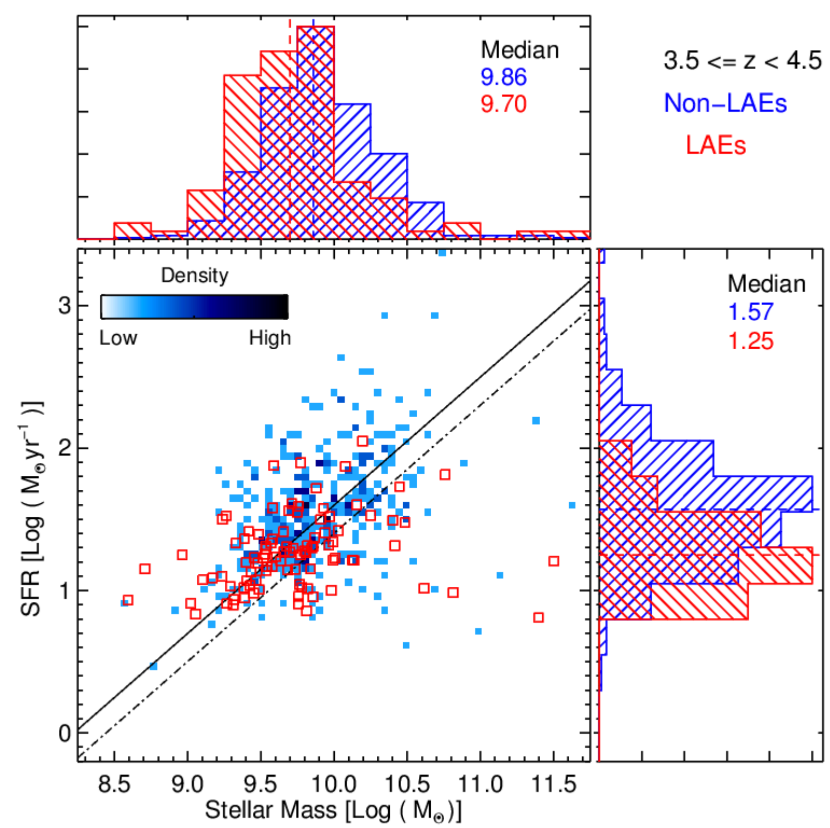


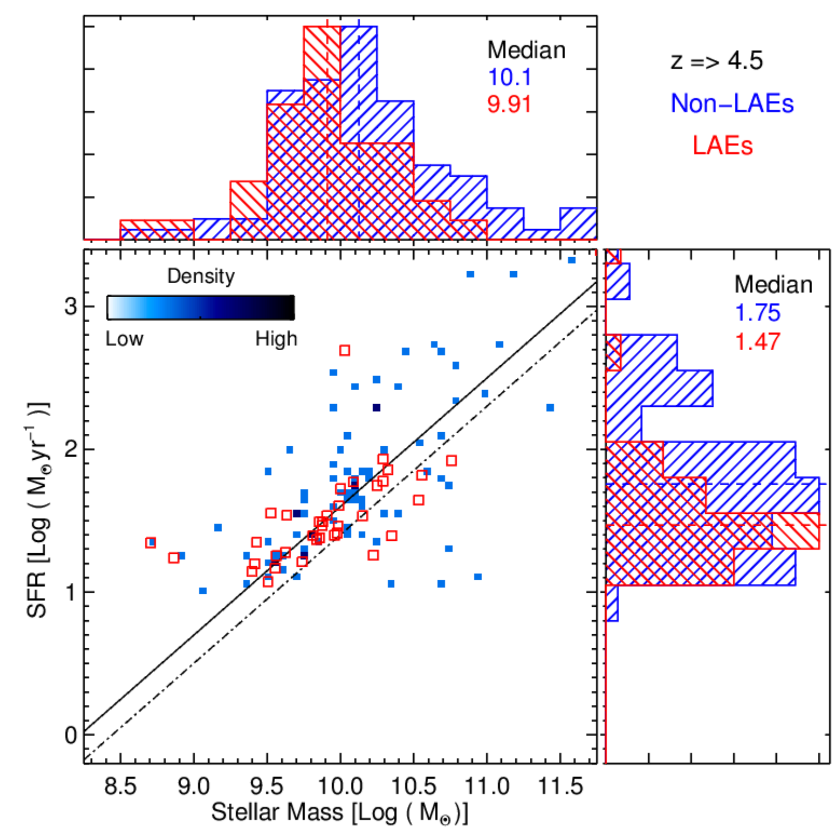
SFR vs Stellar Mass in 4 redshift bins for LAEs and non-LAEs

Difference between LAEs and non-LAEs is ≲0.3 dex or factor of 2 at all redshifts

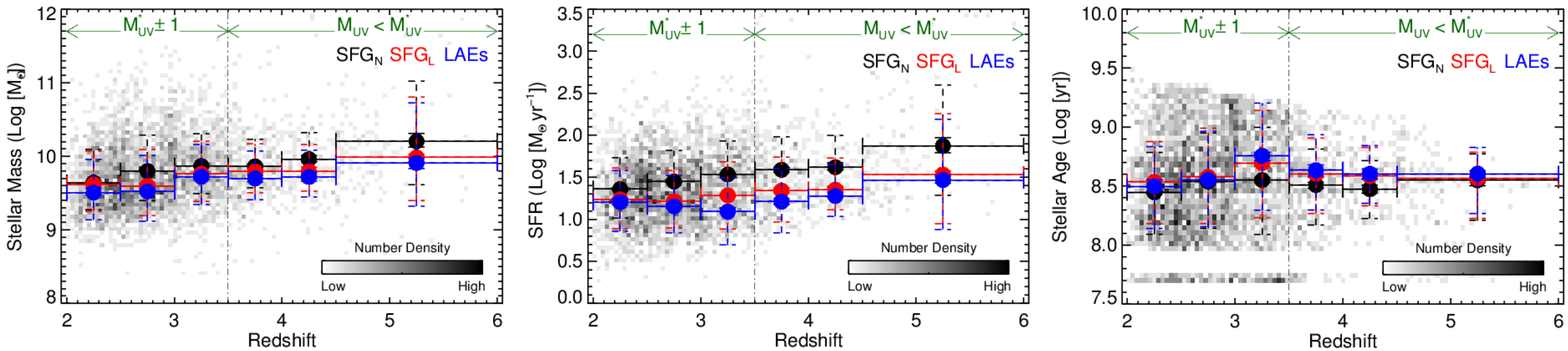


Using the VUDS spectroscopic redshifts, we perform SED fitting on the multi-wavelength photometry using the code Le Phare (Ilbert et al. 2006, 2013) to obtain M_{star}, SFR, E(B-V), Stellar age





Stellar Populations of LAEs (and non-LAEs)

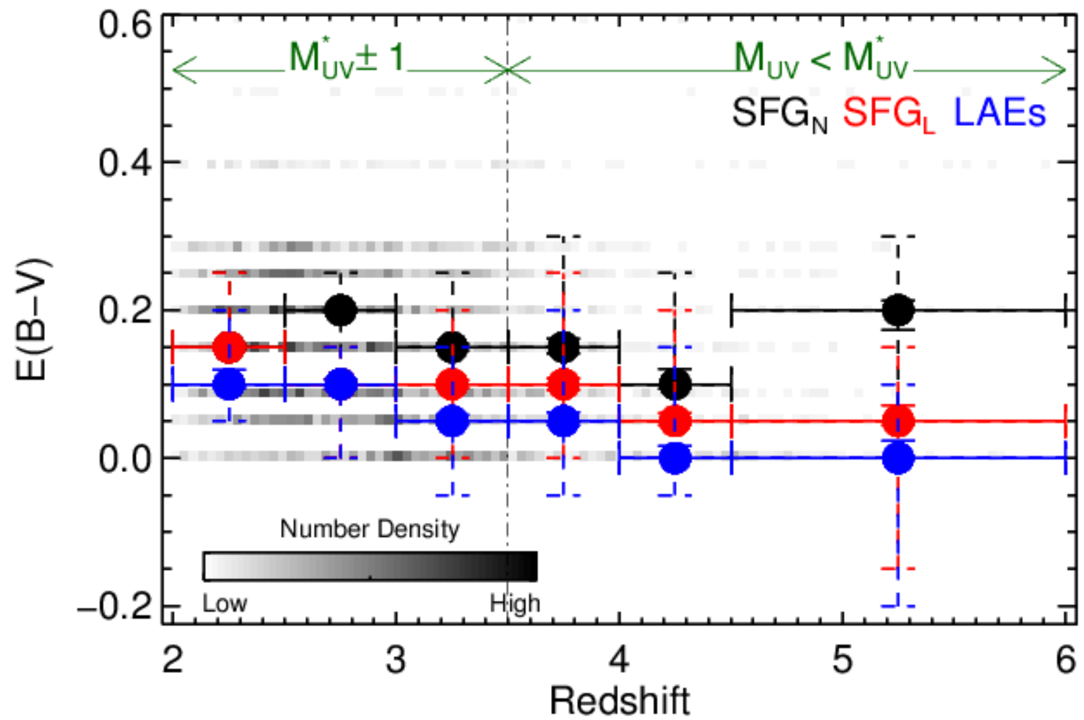


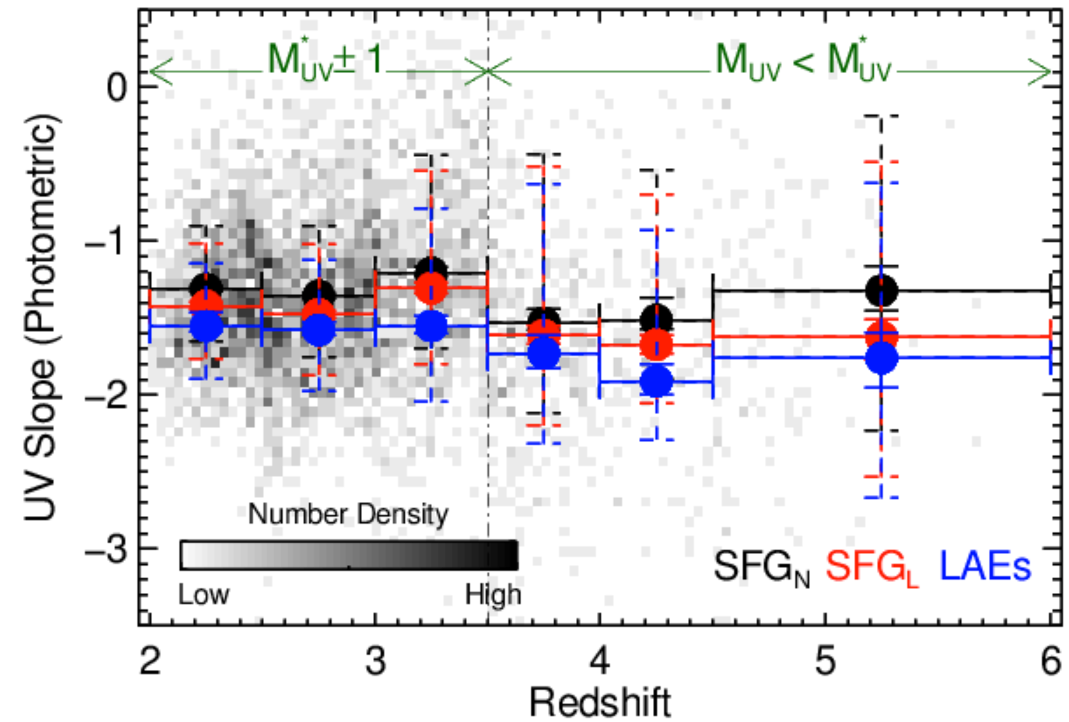
- At all redshifts (z≥2), LAEs and non-LAEs have small differences in SED-based stellar properties (stellar mass and SFRs). On average, Lyα emitters are less massive and less star-forming

- At 2<z<3.5, galaxies cover luminosities around M*±1 mag while at z≥3.5, all galaxies are ~M^* or brighter
but

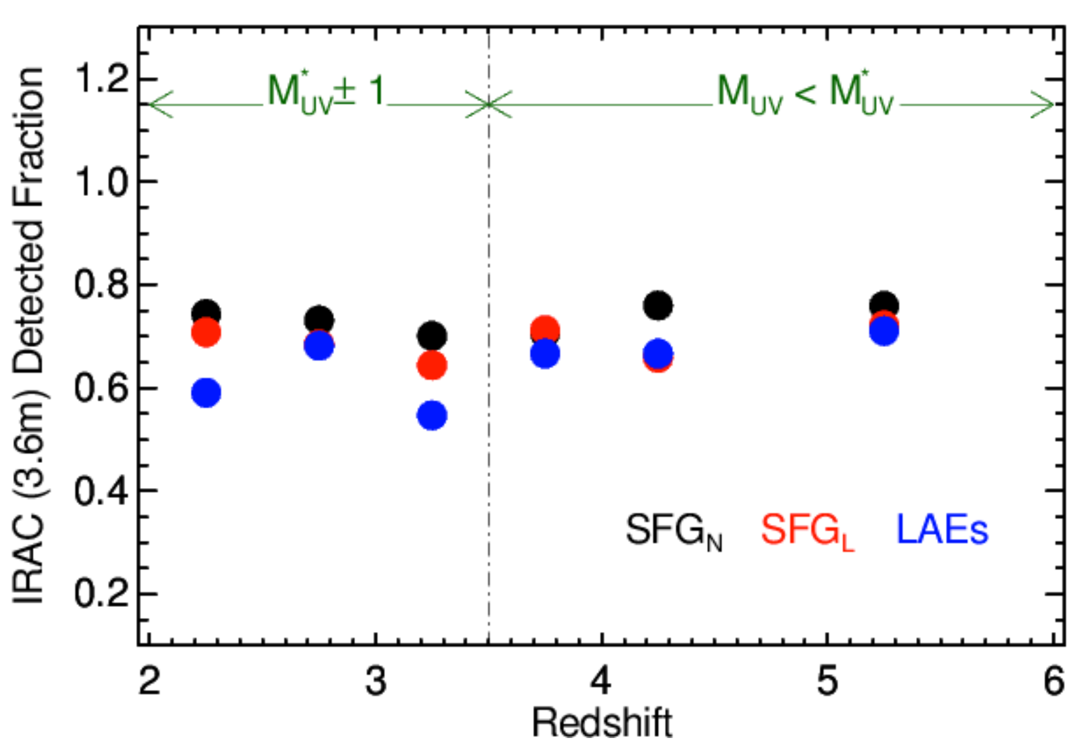
A similar trend in SED-based stellar parameters is observed between Lyα emitters and non-emitters for a sample with $M_{1500} \leq -21$ mag (and also for fixed and evolving stellar mass cut)

Stellar Populations of LAEs (and non-LAEs)





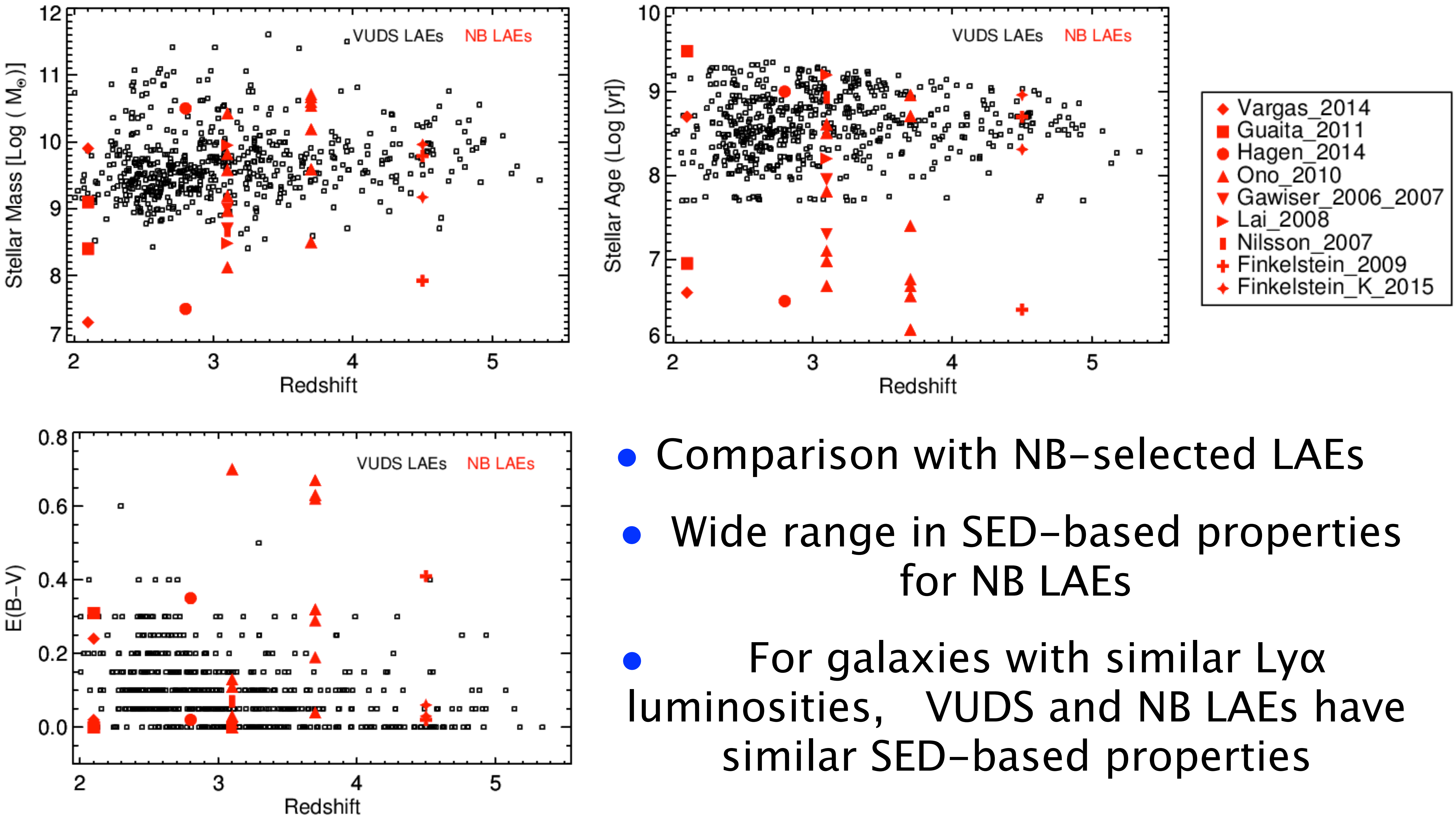
Significant difference between LAEs and non-LAEs is the dust content as seen in E(B-V) and β_{phot}



- Spitzer/IRAC 3.6μm (or 4.5μm) detection down to ~25 AB mag
- ~>50% of LAEs are IRAC-detected (compared to ~20-30% NB LAEs)

➡ UV-selected LAEs are more evolved than NB-selected LAEs

VUDS LAEs and Narrow-Band LAEs



- Comparison with NB-selected LAEs
- Wide range in SED-based properties for NB LAEs
- For galaxies with similar Lyα luminosities, VUDS and NB LAEs have similar SED-based properties

➡ Comparison of LAEs and non-LAEs (or comparison between UV-selected and NB-selected LAEs) have to be made at similar luminosities

Summary

For VUDS LAEs (and non-LAEs) at $2<z<6$ selected based on their UV magnitudes and covering $\sim>L^{*}_{UV}$ luminosities, we find that

- On average, Lyα emitters and non-Lyα emitters have small differences in SED-based stellar properties.

LAEs are less dusty (and less star-forming, less massive) compared to non-LAEs.

- Higher fraction of VUDS LAEs have Spitzer detection compared to NB LAEs => continuum selected LAEs are more evolved

- For similar Lyα luminosities, VUDS LAEs and NB LAEs have similar properties

- Future studies will focus on other rest-UV spectral features which will help us to better understand ISM properties of LAEs (and its evolution) at $z<\sim6$

LAEs are diverse populations and their properties depend on various things (e.g., sample selection, range of luminosities/stellar masses/EWs probed)

Thank You!