National Astronomical Observatory of Japan

DAWN

Escape of Lyman radiation from galactic labyrinths:

A Hard Ionising Spectrum in z=3 Lyman Alpha Emitters

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(NAOJ → DAWN, Copenhagen)

In collaboration with

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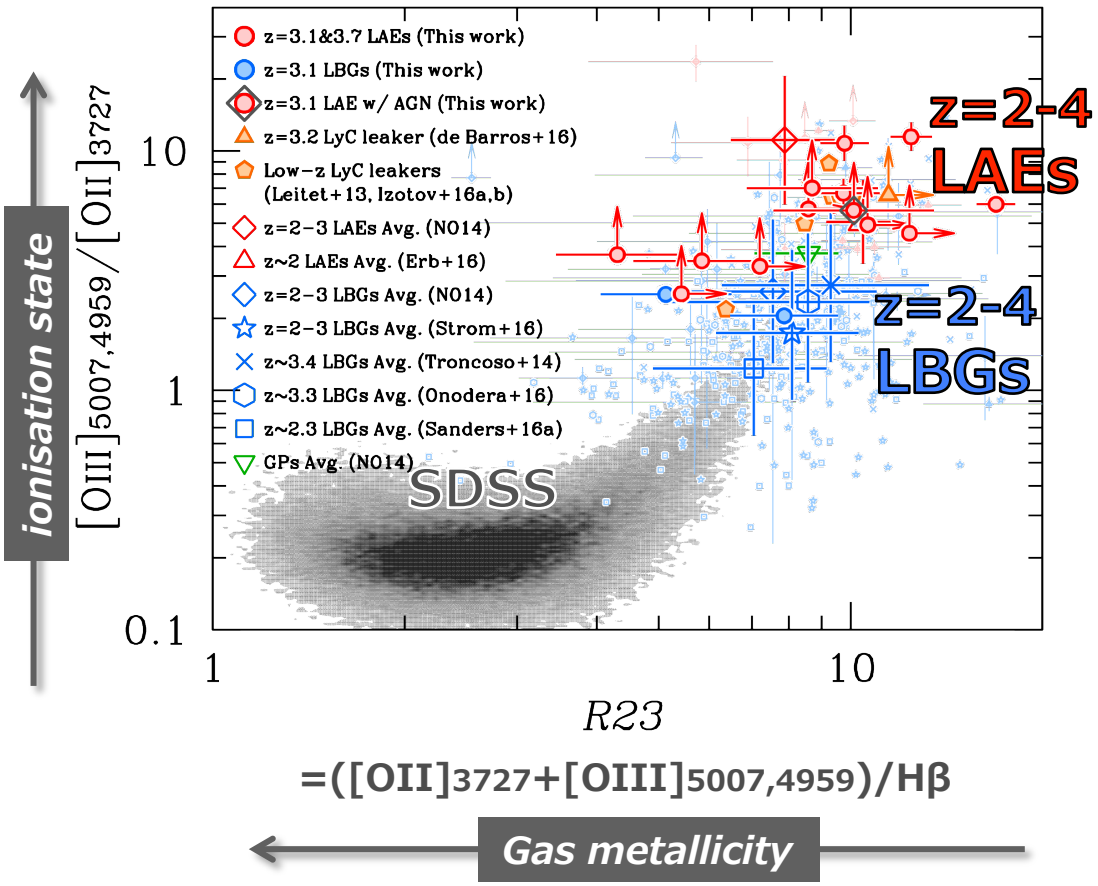
D. P. Stark (U. Arizona),
A. K. Inoue (Osaka Sangyo U.), I. Iwata (Subaru/Halifax)

Lyα emitters (LAEs):

Highly Ionised



Nakajima et al. 2016

See also Nakajima & Ouchi 2014, Erb+2016, Trainor+2016
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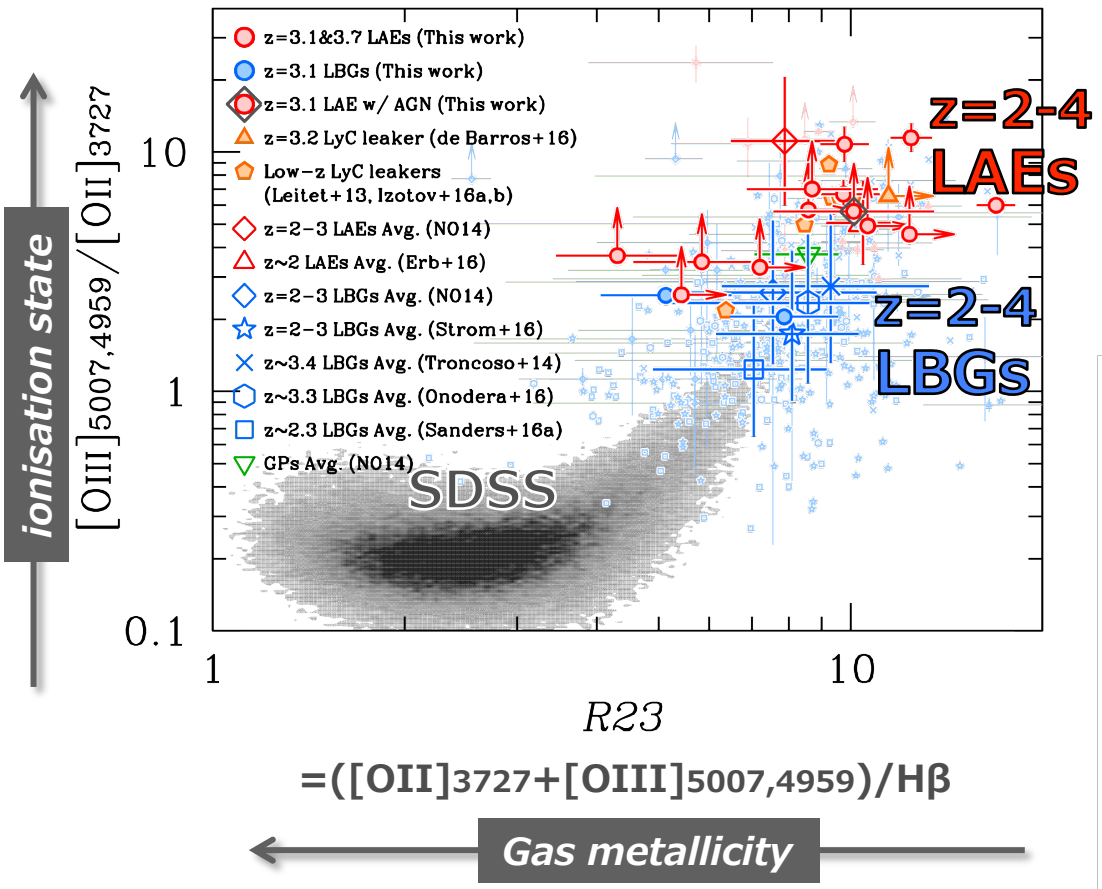

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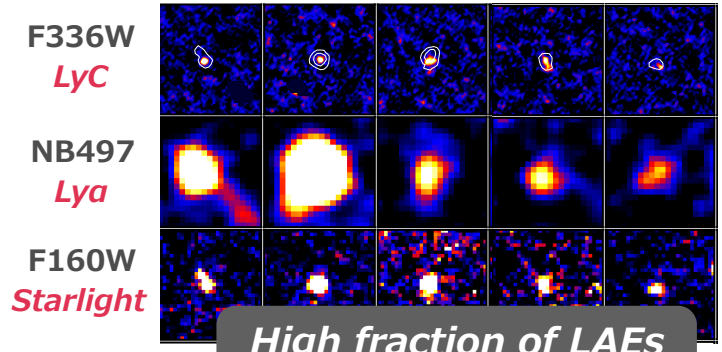
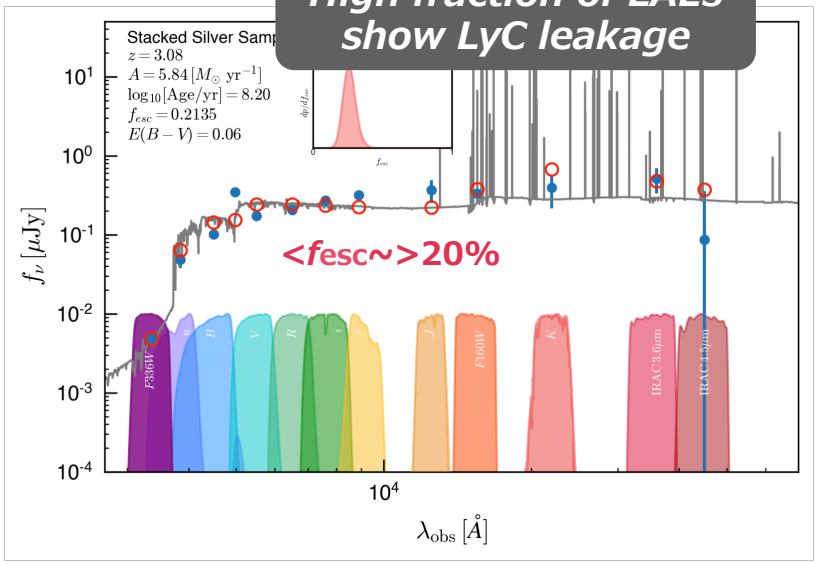
Escape of LyC photons



High fraction of LAEs show LyC leakage



Fletcher, KN et al. 2018 *(LACES)*

See also Iwata+2009, Mostardi+2013,2015,
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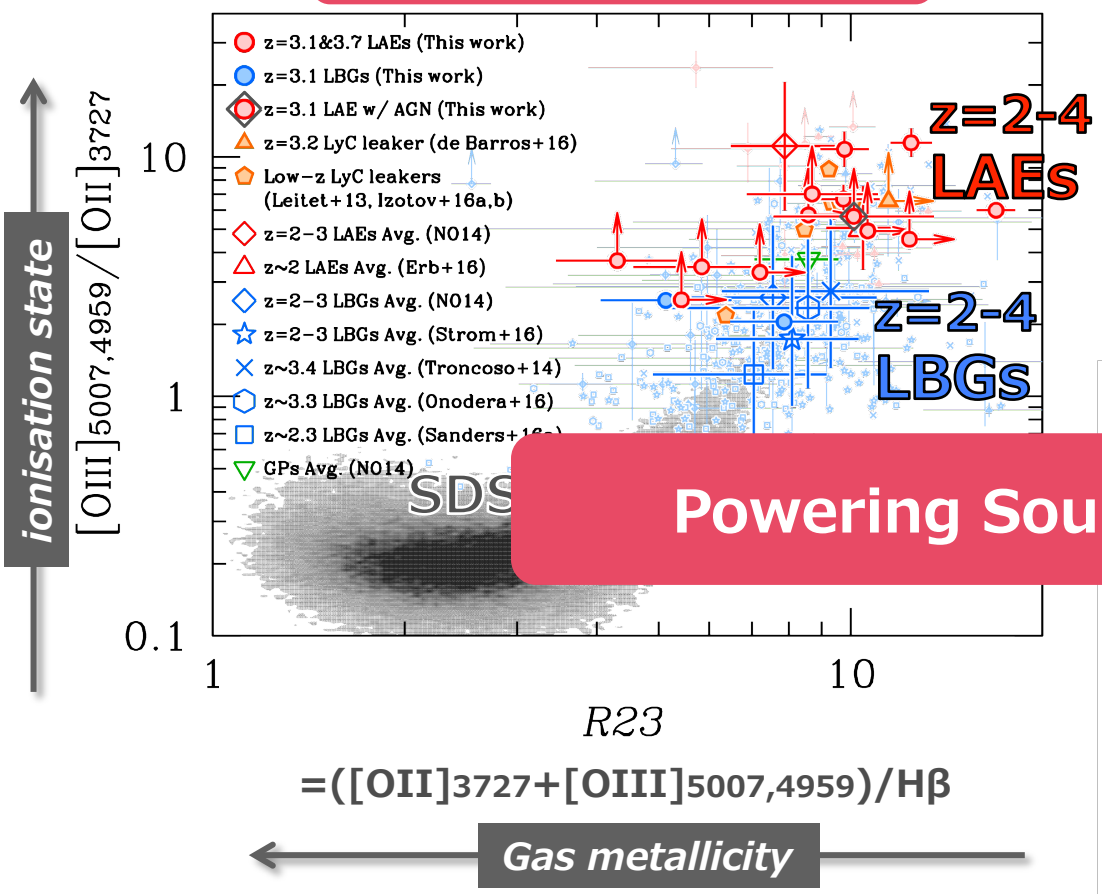

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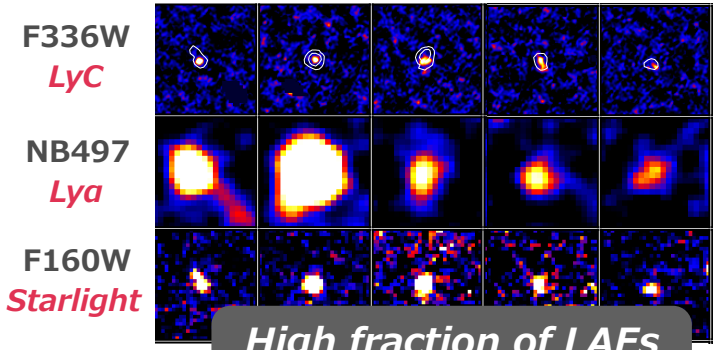

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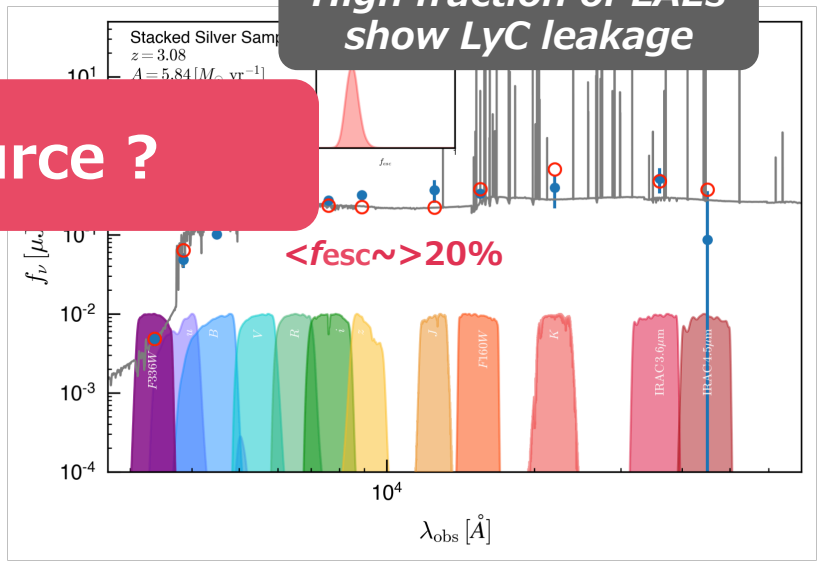

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Powering Source ?

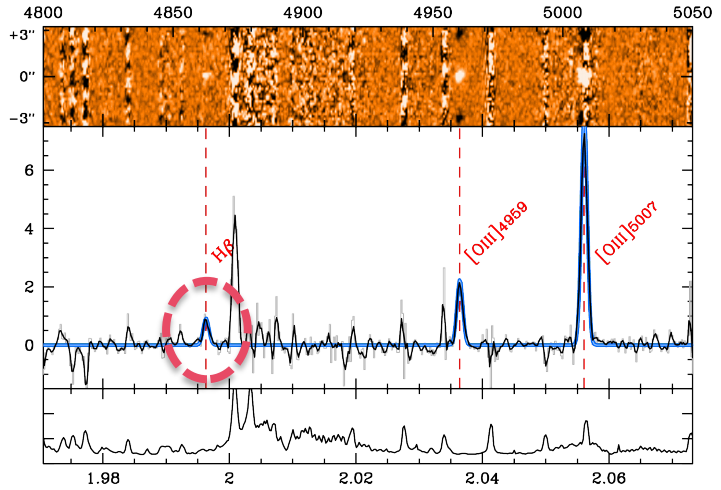
Efficiency of ionising photon production, $\xi_{\rm ion}$

$$\xi_{\rm ion} = \dot{n}_{\rm ion} / L_{\rm UV}$$

Efficiency of ionising photon production, ξ_{ion}

$$\xi_{ion} = \dot{n}_{ion} / L_{UV}$$

z=3.1 LAE's MOSFIRE K spectrum



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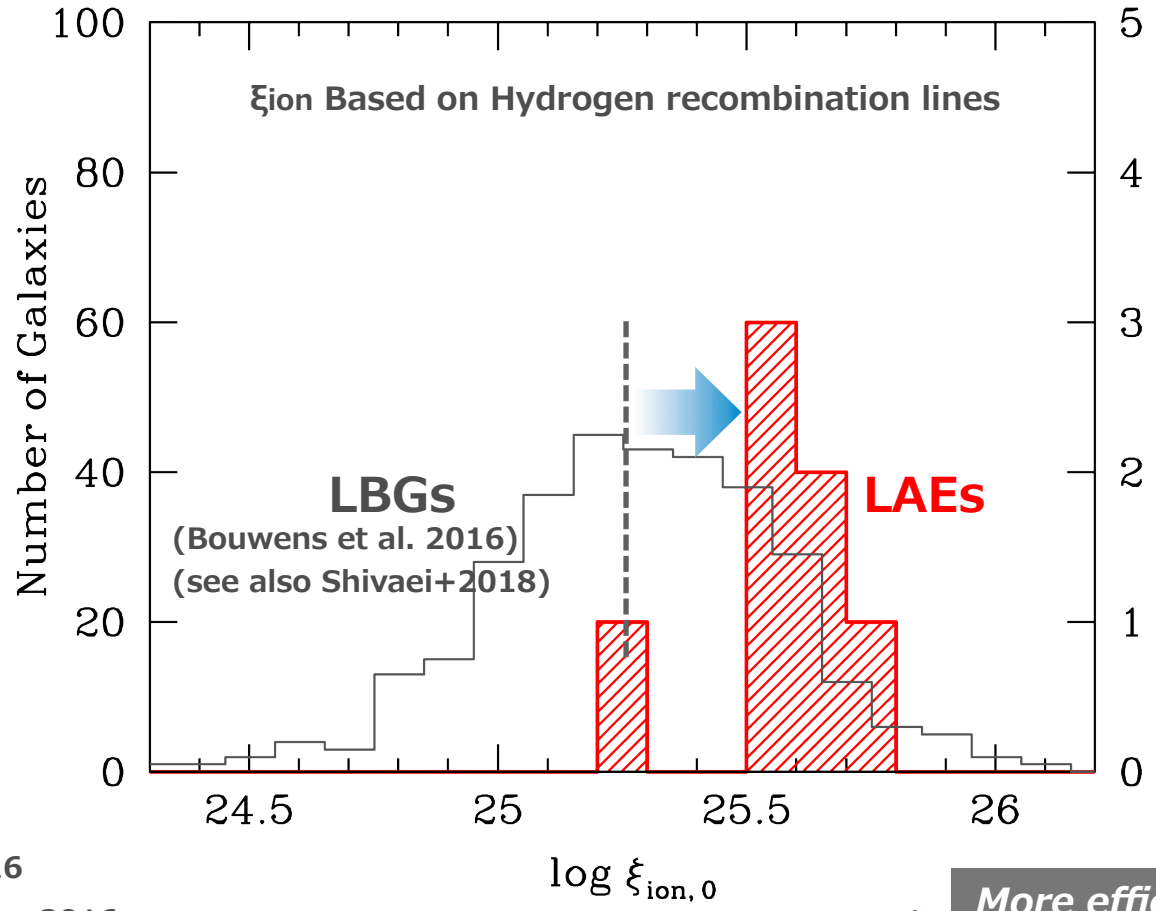

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More efficient production of ionising photons

Efficiency of ionising photon production, ξ_{ion}

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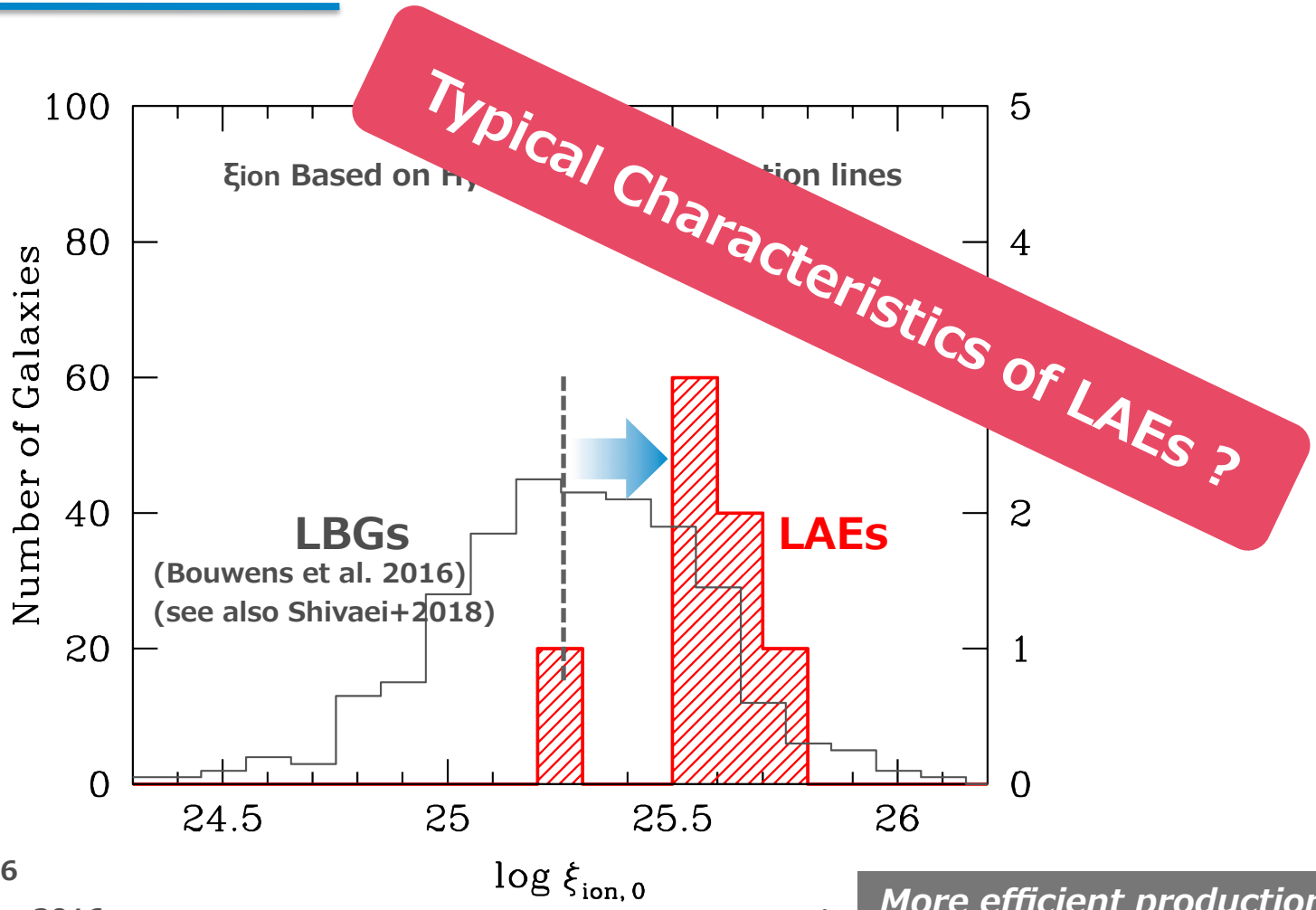

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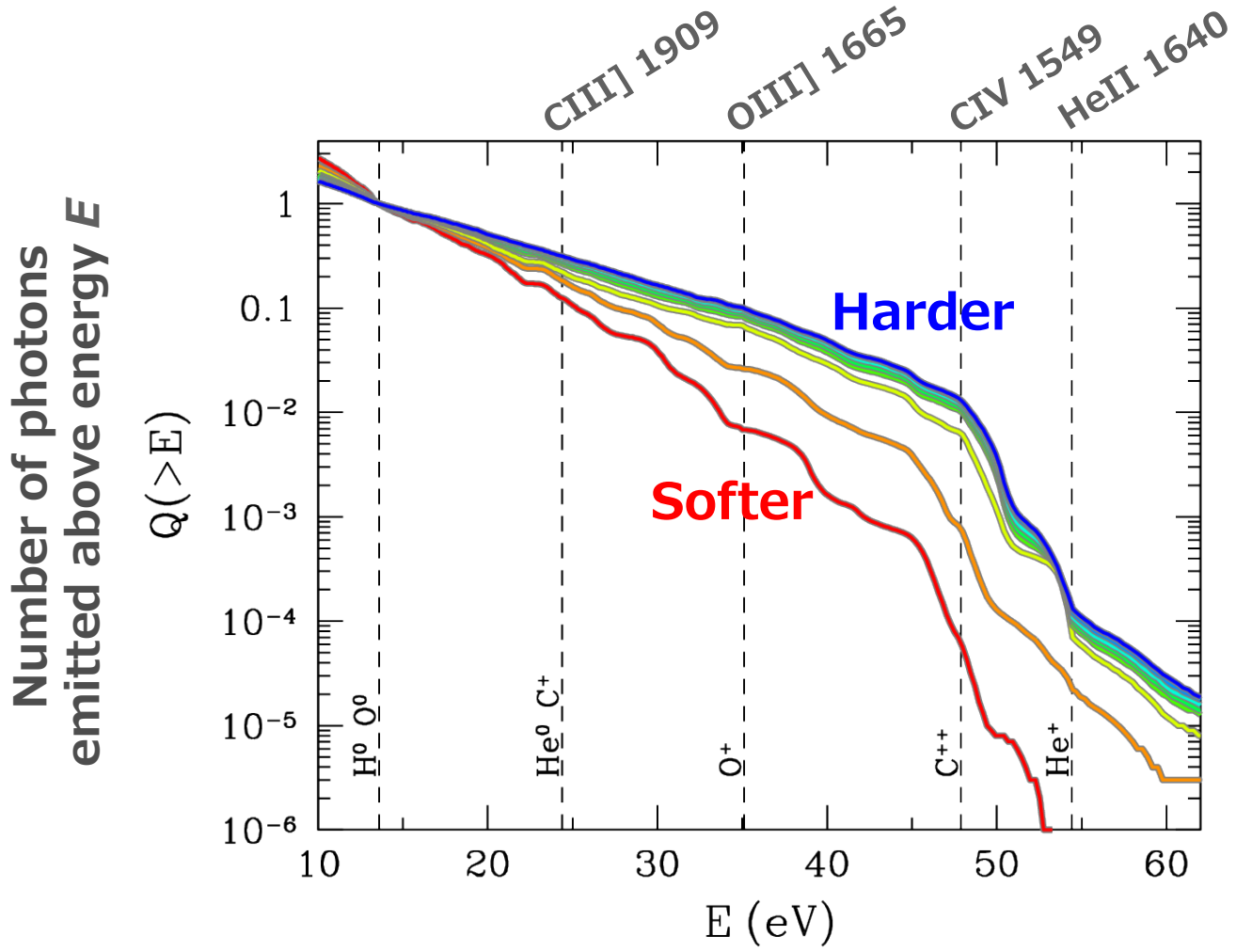
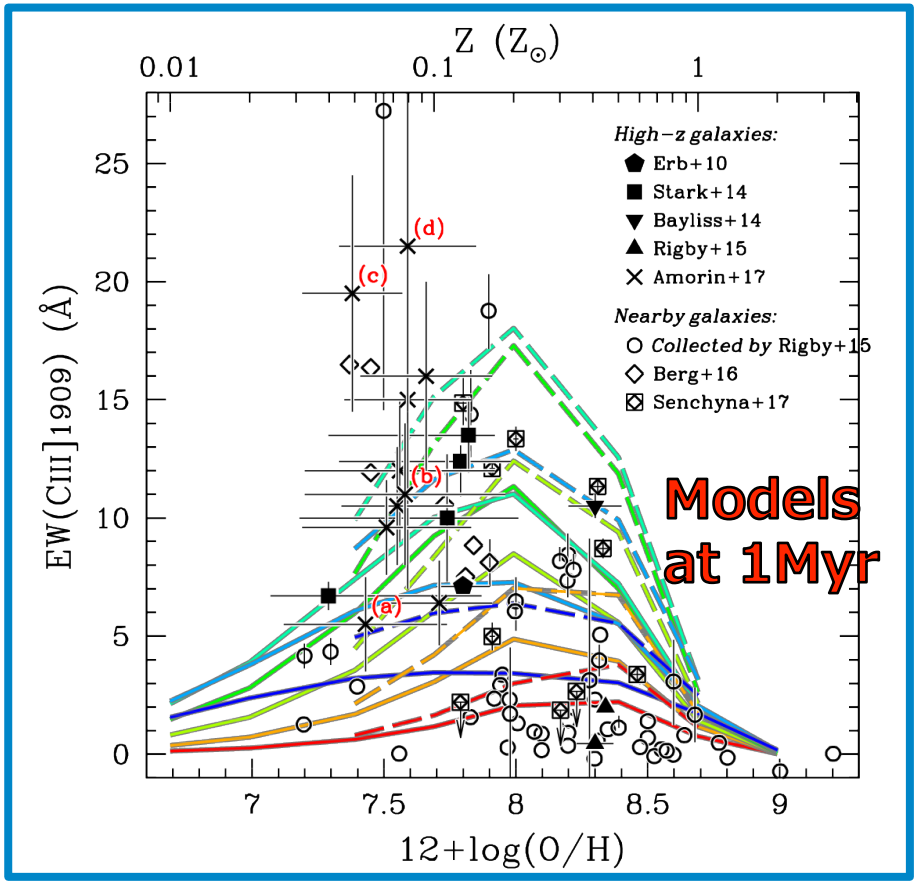
Nature of Ionising Spectrum Examined by UV Emission lines

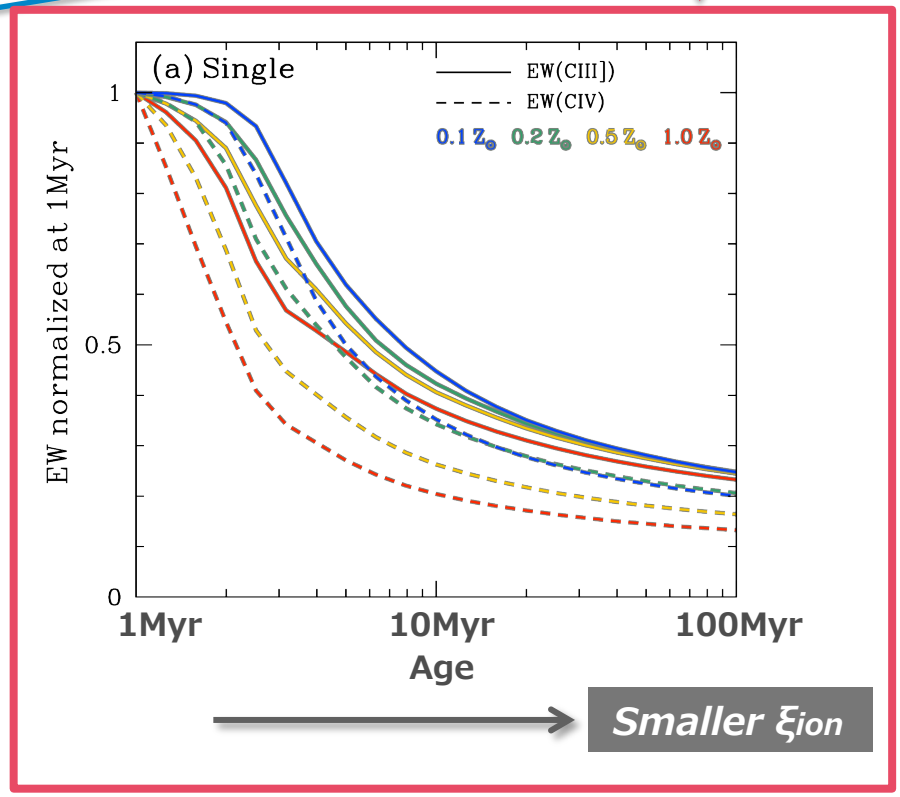


Nakajima et al. 2018a (A&A) *in collaboration with VUDS*

UV line Diagnostics of ξion

$$EW(CIII]) = \frac{Flux(CIII])}{f_{\lambda,1909}} \propto \frac{N_{ion}(>24.4eV)}{L_{UV}} = f(Z,U,\xi_{ion}(age))$$





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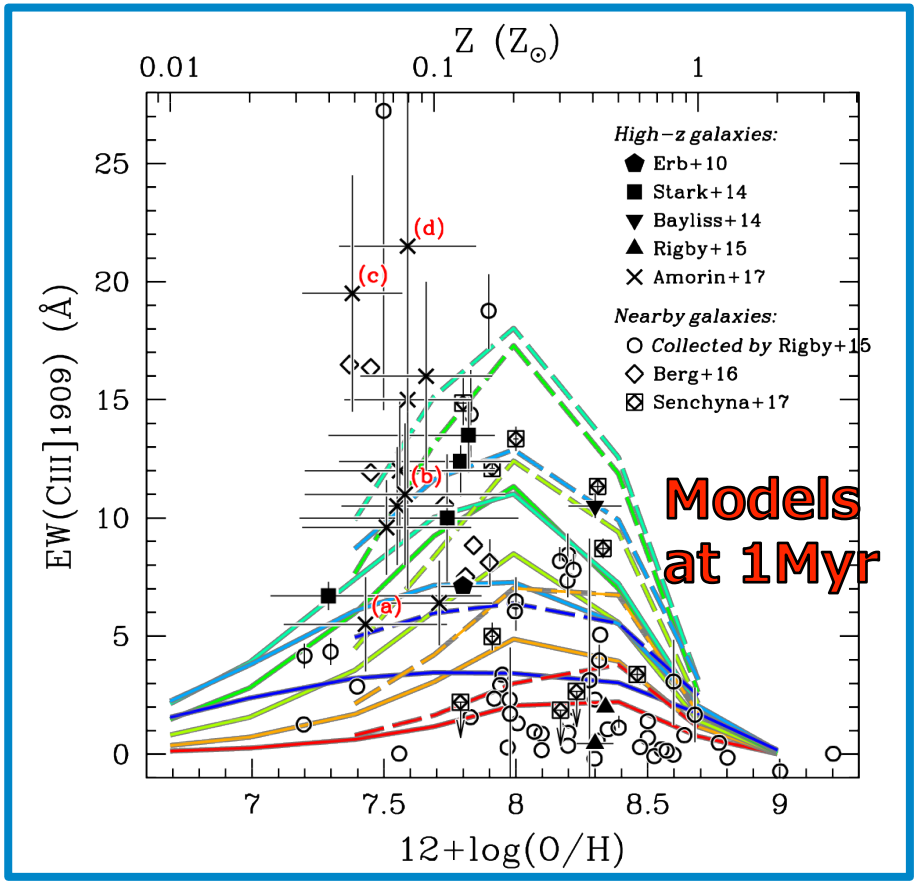

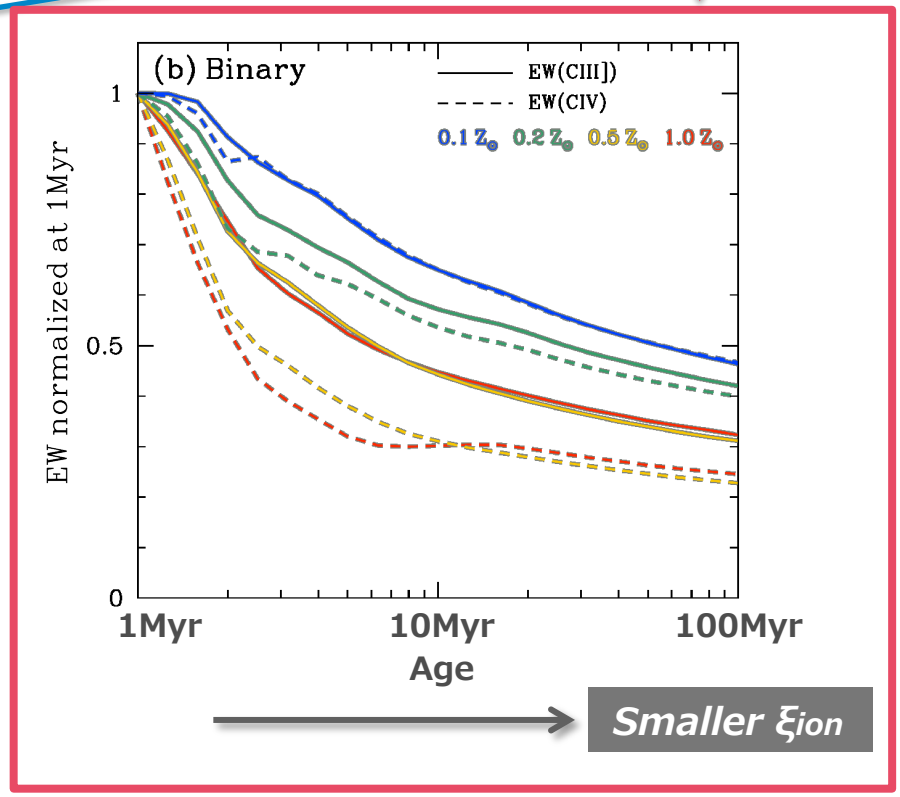

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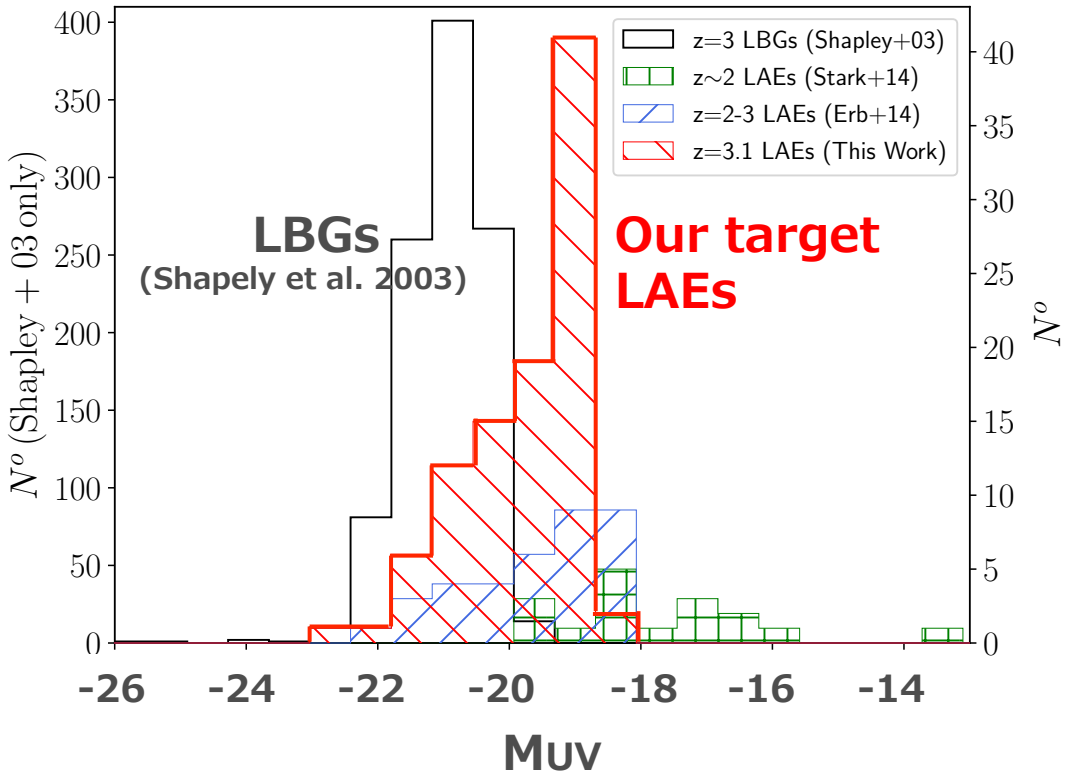
VLT/VIMOS (11hrs) Observation Identifying Lyα from 70 Faint z=3 LAEs



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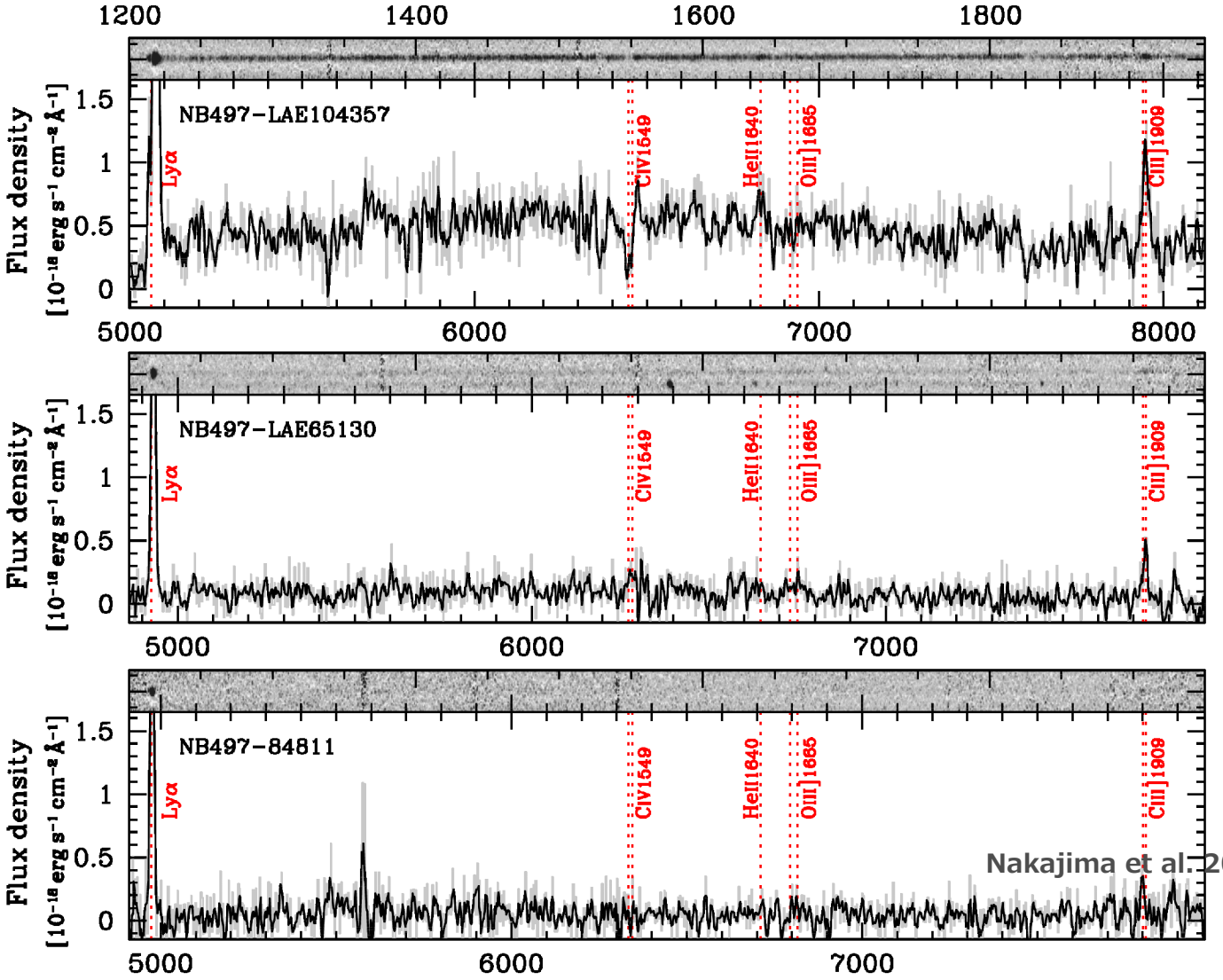

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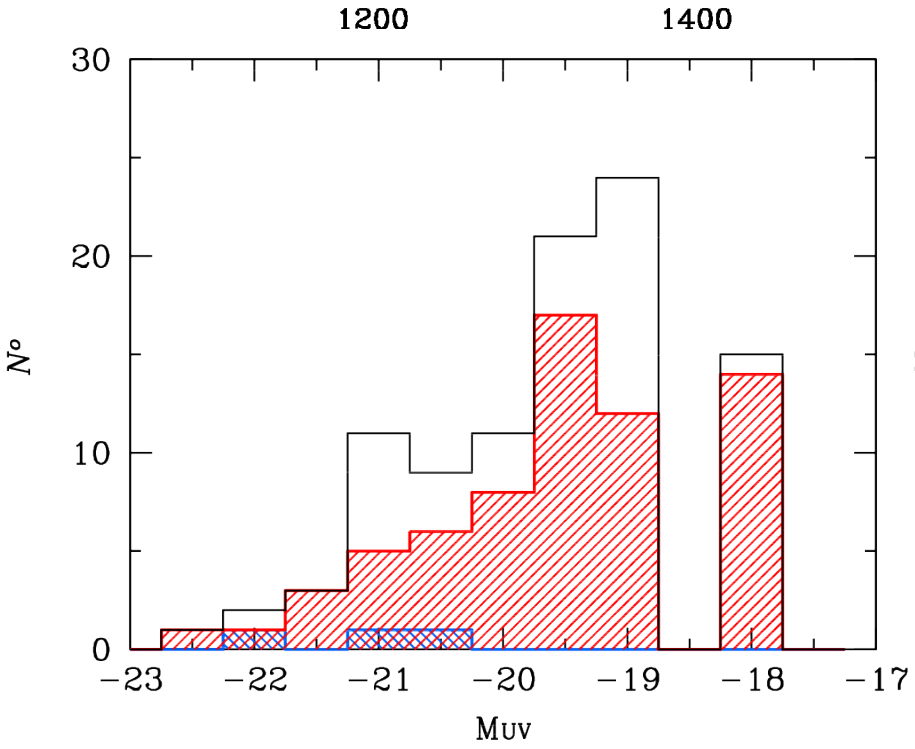
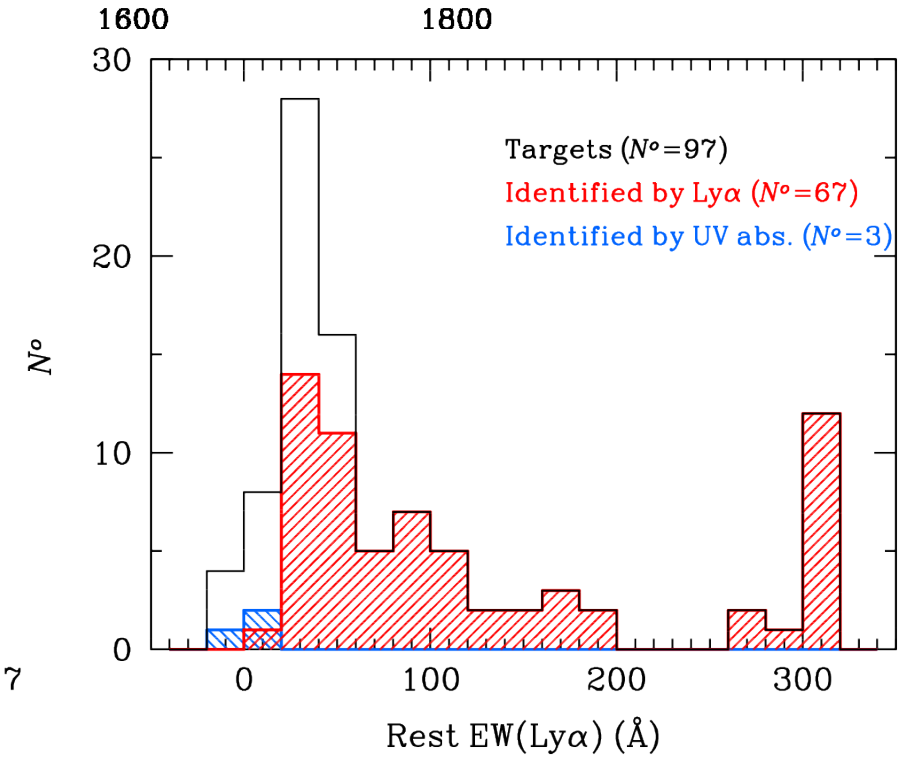
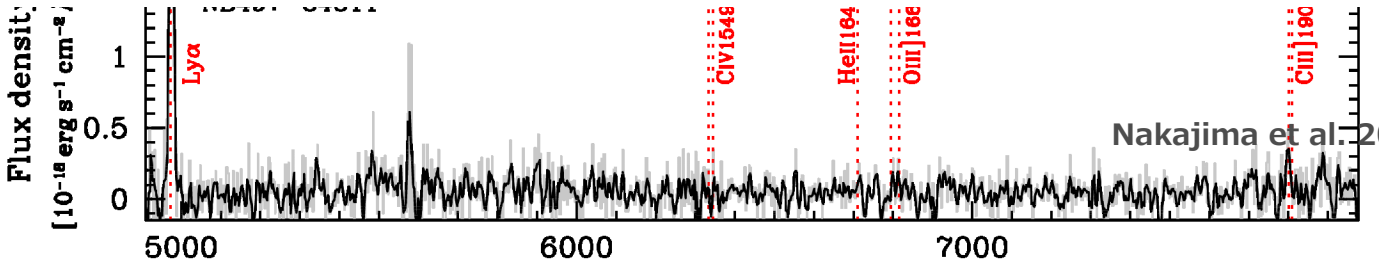
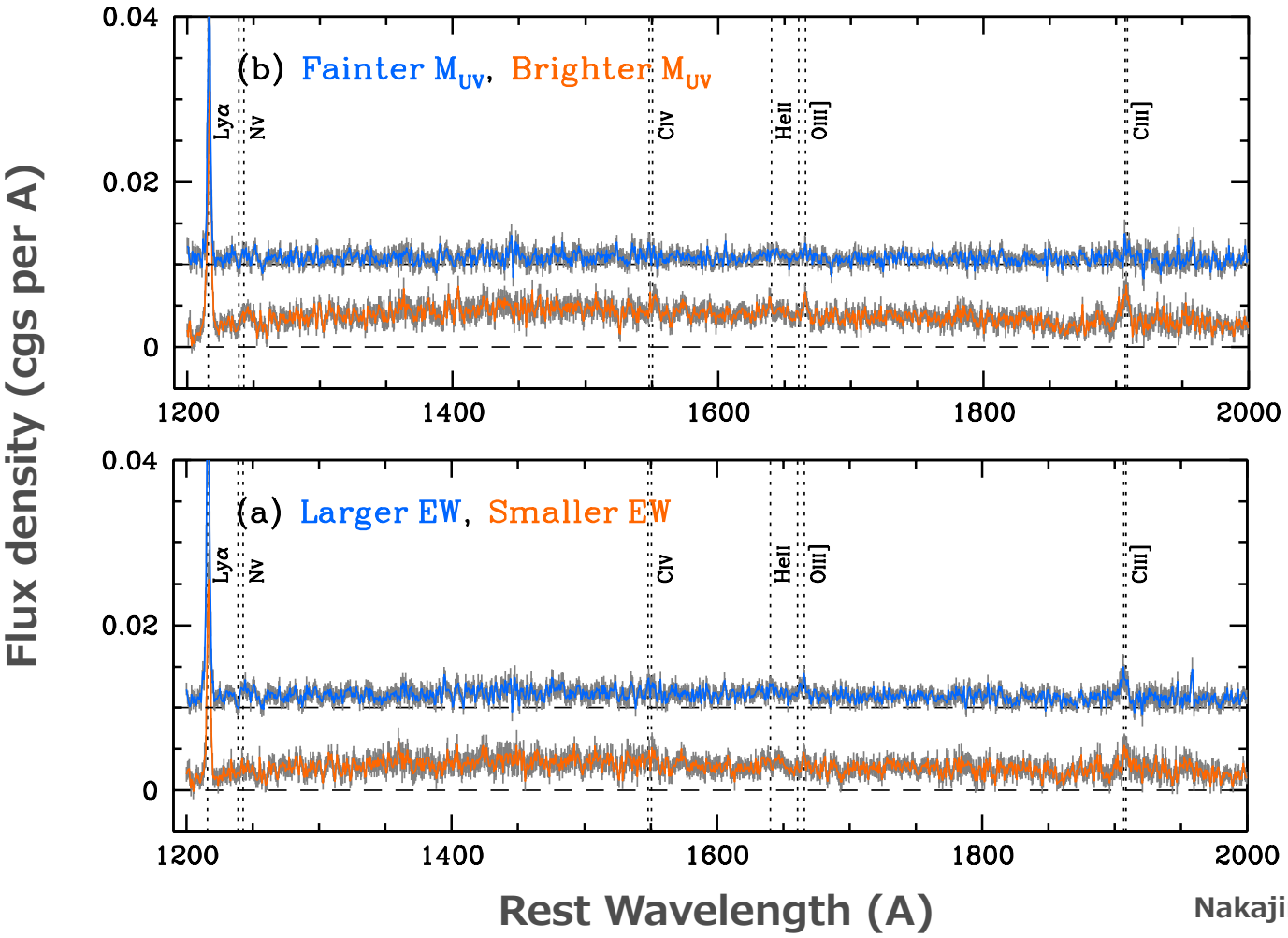






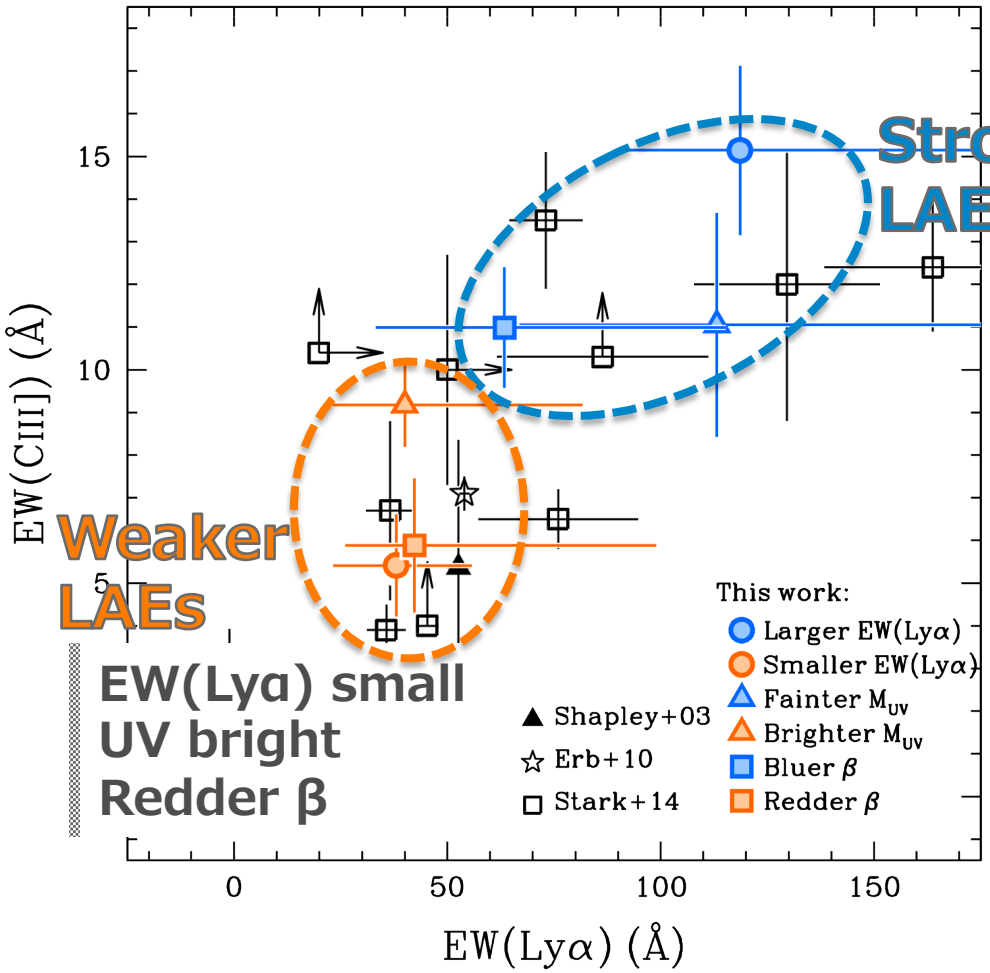
Nakajima et al. 2018b (MNRAS)

VLT/VIMOS (11hrs) Observation
Identifying UV lines in Stacks of 70 z=3 LAEs



Nakajima et al. 2018b

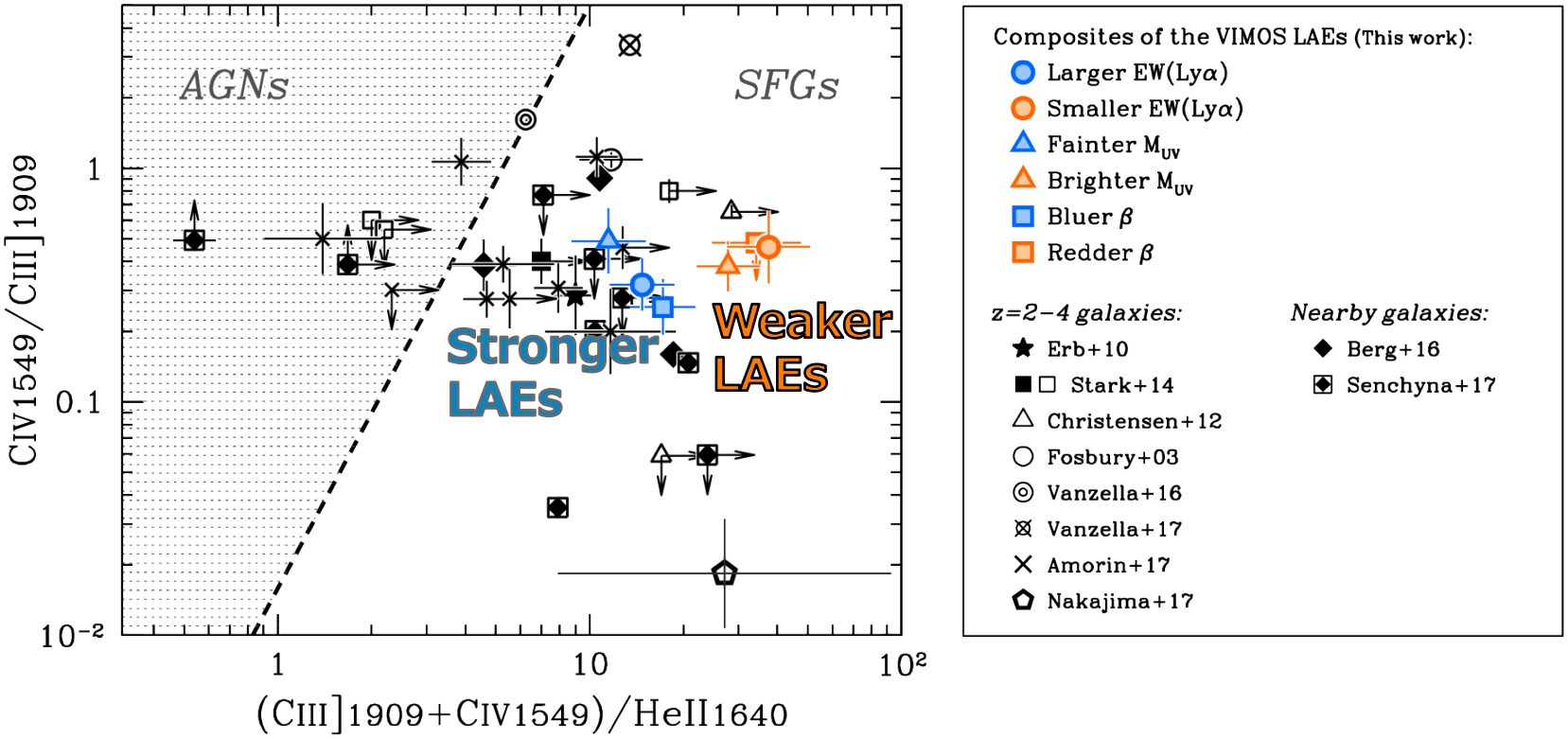
Strong CIII] Associated with Strong Lyα



Nakajima et al. 2018b

See also F. Marchi's Talk

Stronger LAEs Characterised by Lower metallicity



Nakajima et al. 2018b

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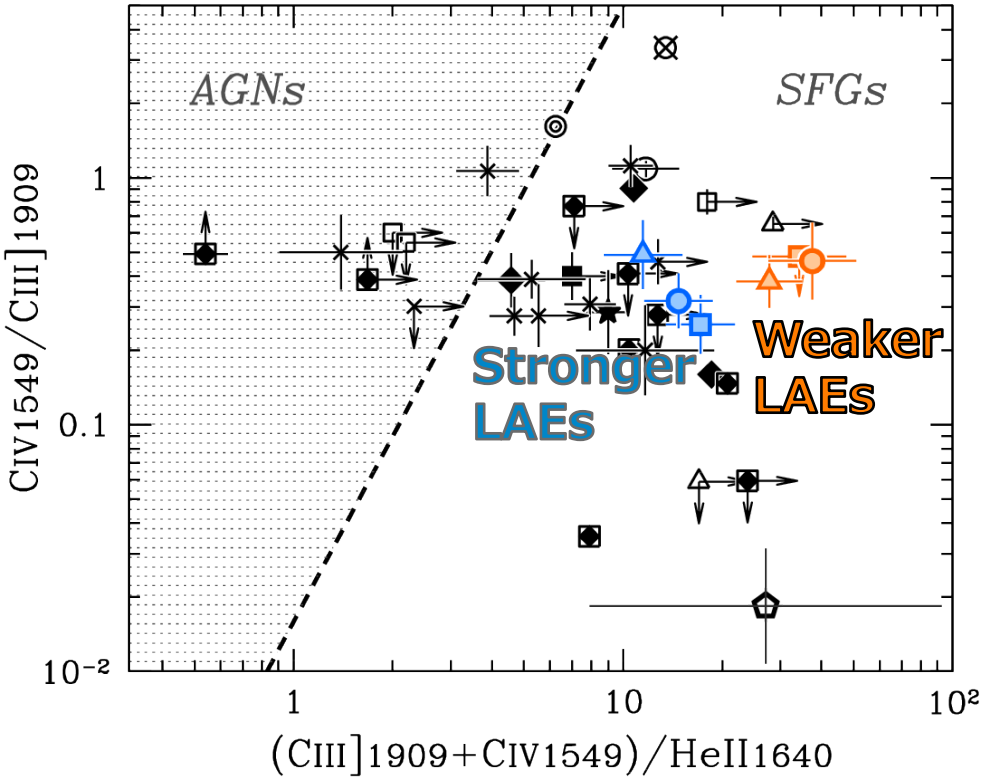
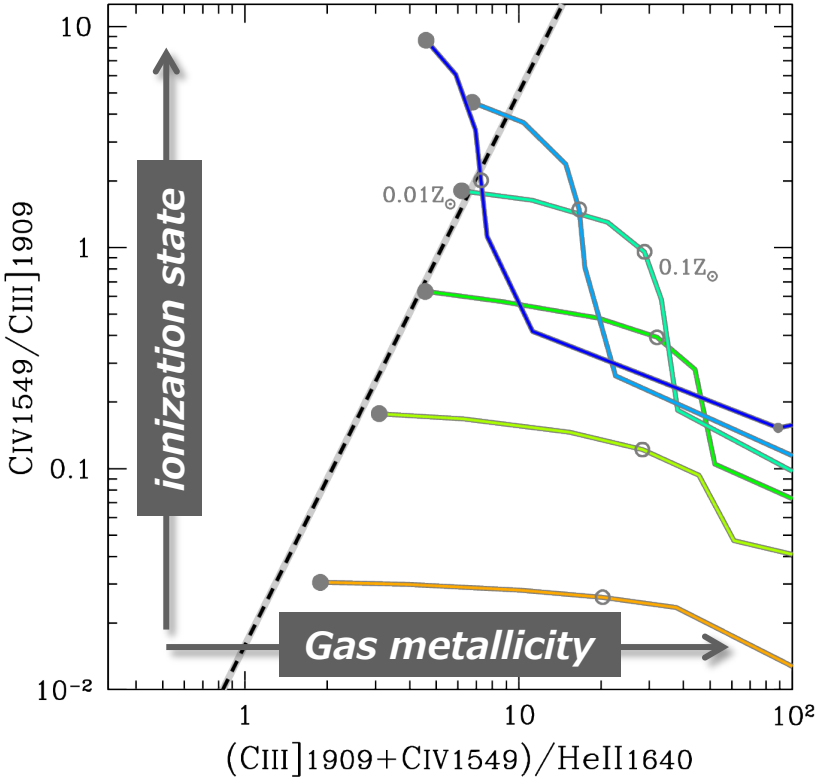


Nakajima et al. 2018b

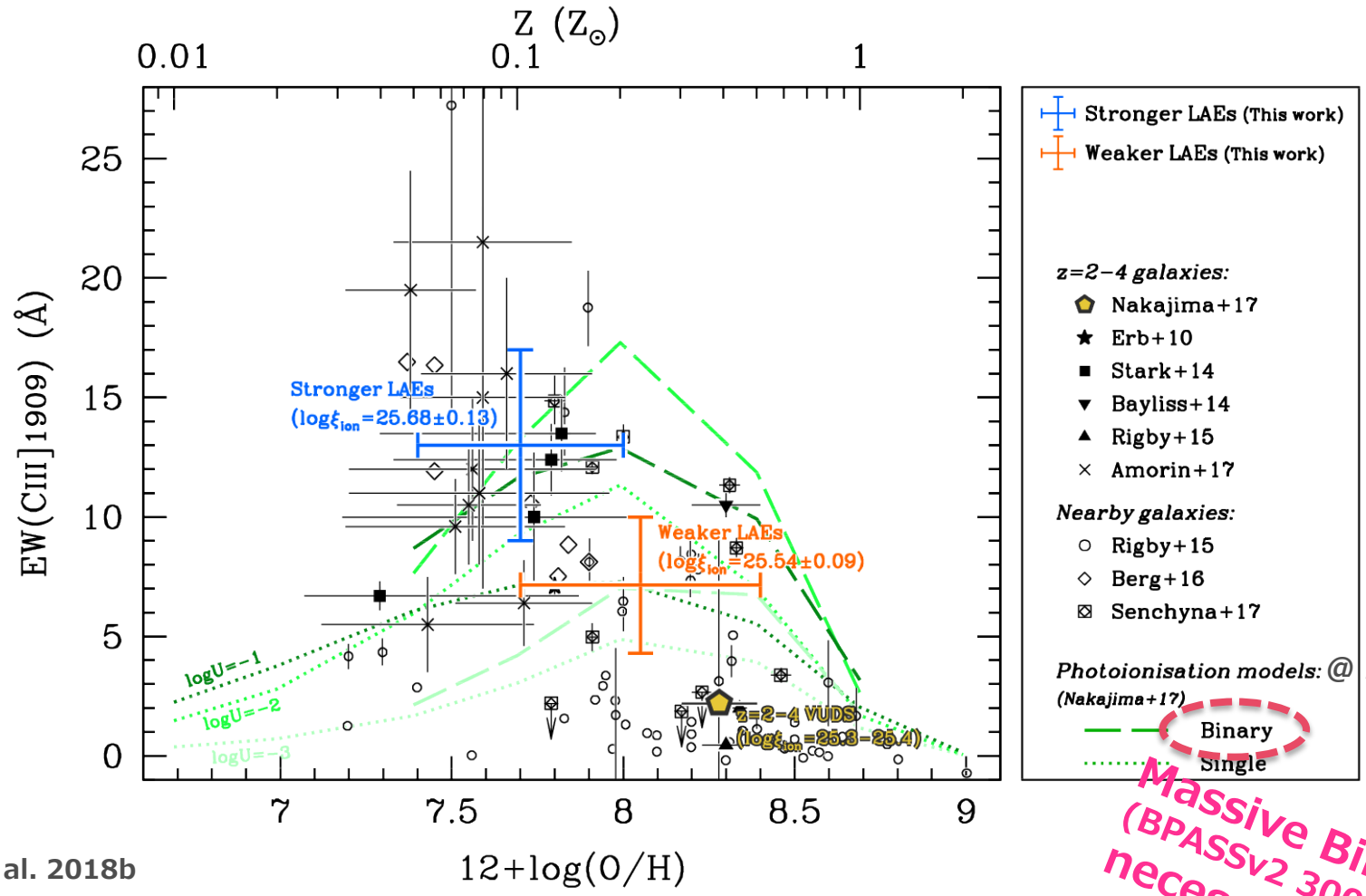


Nakajima et al. 2018a

Stronger LAEs: Z = 0.05 – 0.2 Z_{sun}

Weaker LAEs: Z = 0.1 – 0.5 Z_{sun}

LAEs' Hard ξion Confirmed with UV line analysis



Massive Binary (BPASSv2 300Msun) necessary!

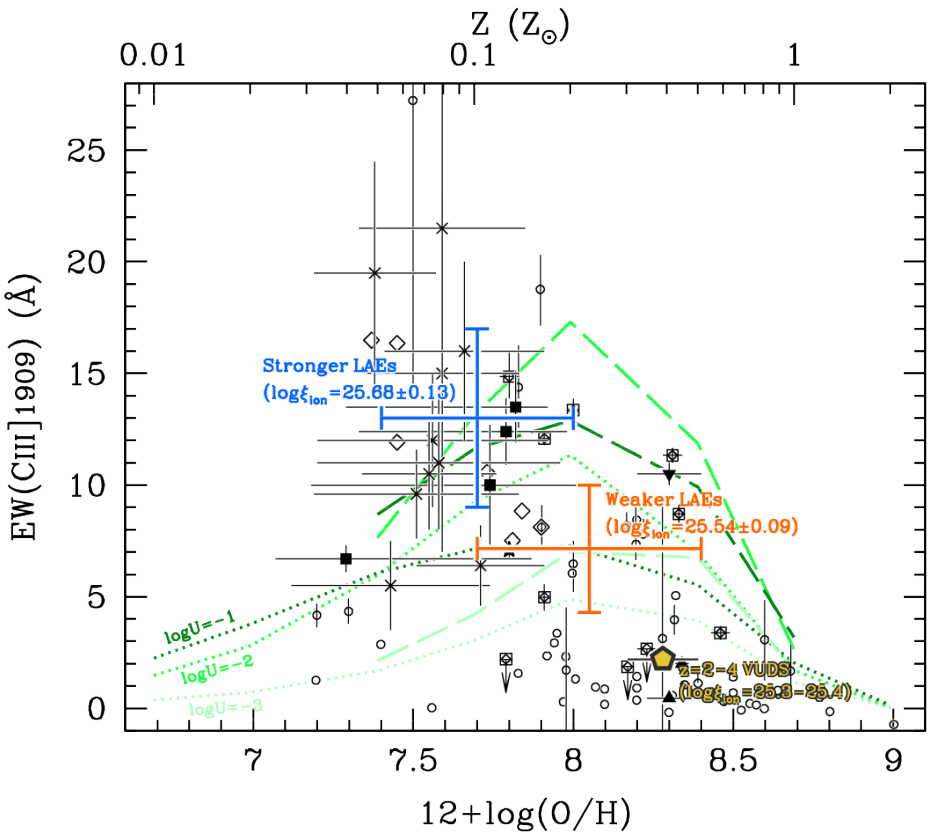
Nakajima et al. 2018b

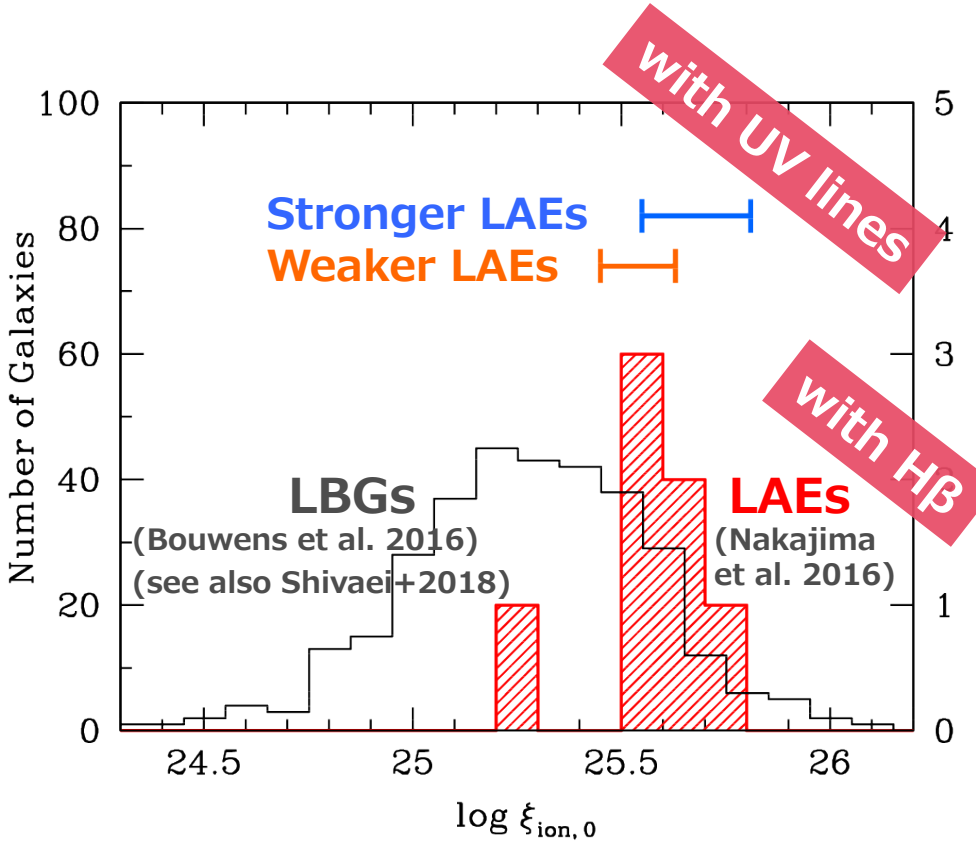
See also Schaerer+2018

Stronger LAEs: log ξion = 25.68±0.13

Weaker LAEs: log ξion = 25.54±0.09

LAEs' Hard ξion Confirmed with UV line analysis





Nakajima et al. 2018b

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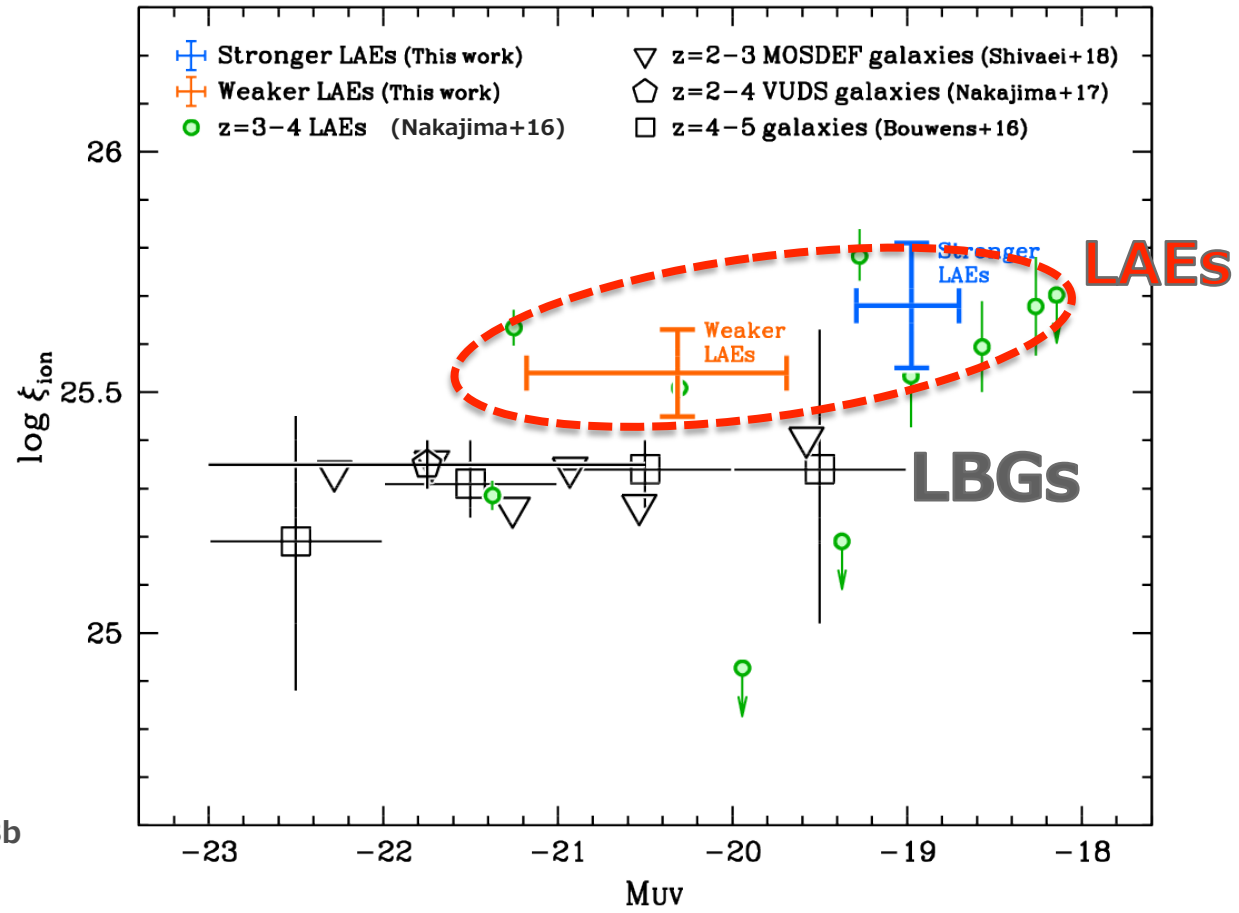
LAEs' Hard ξion for given UV luminosity



Nakajima et al. 2018b

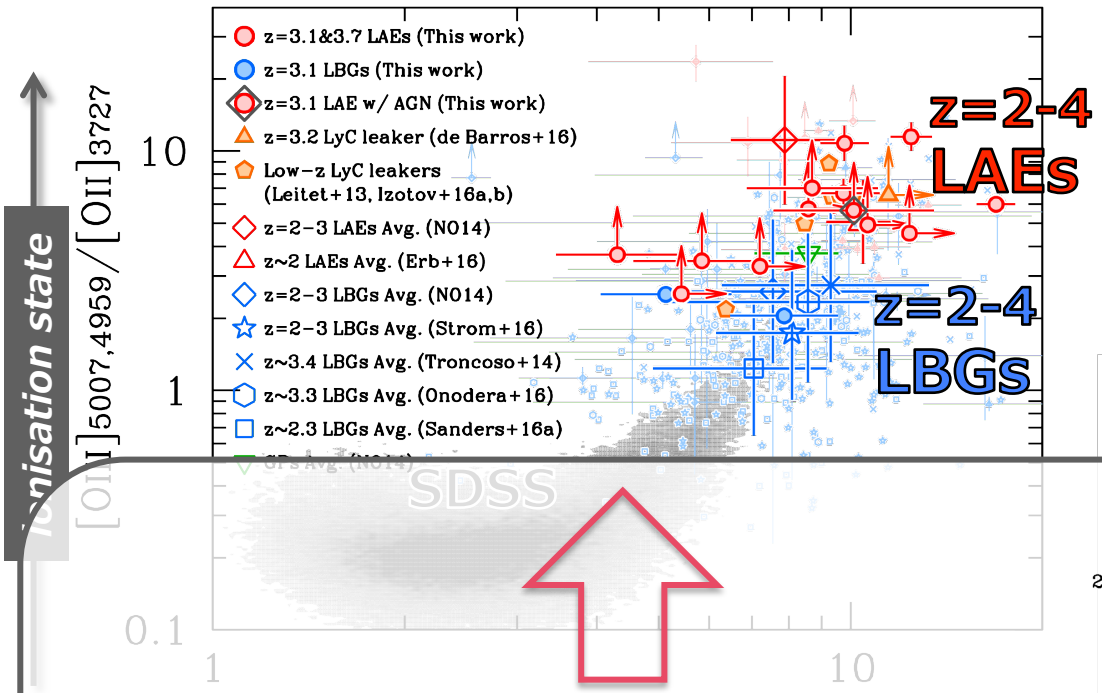
LBGs: Uniform ξion (~25.2--25.4), independent of MUV, *z*

LAEs: Larger ξion (~25.5--25.7), particularly for faintest LAEs

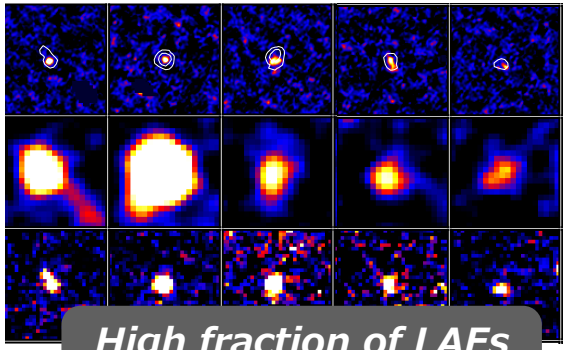
→ Highly Ionised & Escape of LyC photons in LAEs

Summary: Lyα emitters (LAEs):

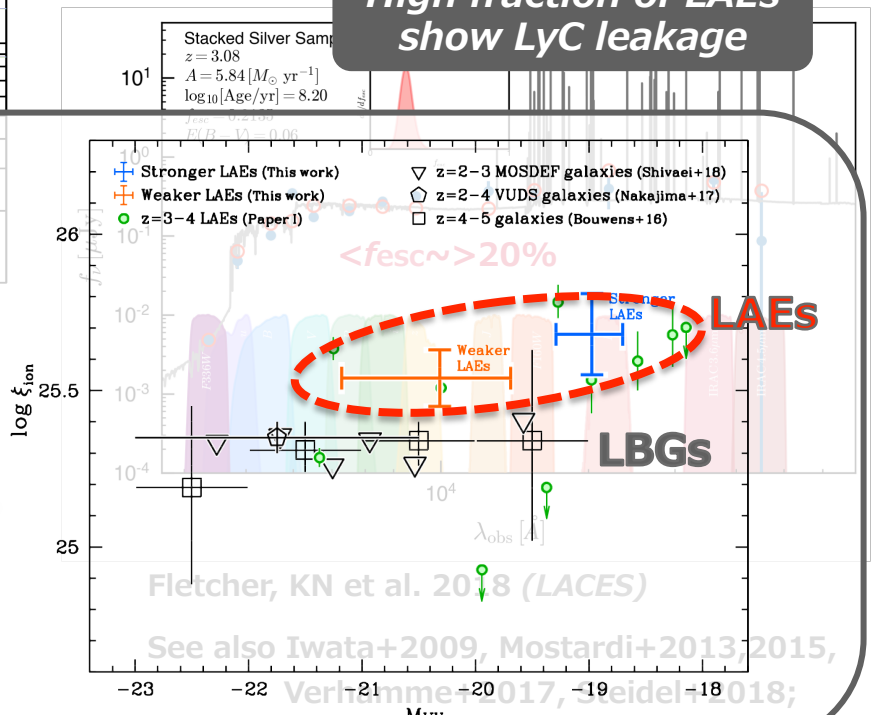
Highly Ionised



Escape of LyC photons



High fraction of LAEs show LyC leakage



Efficiently Producing Ionising photons

- Young, metal-poor Stel. Pop.
- Massive Binary systems

Nakajima et al. 2016

See also Nakajima & Ouchi 2014, Erb+2016, Trainor+2016 Kojima+2017; D. Erb's & R. Trainor's Talks

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