



Extreme nature of blue-excess dust-obscured galaxies revealed by optical spectroscopy

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Dust-Obscured Galaxies

very
red

- **definition**

$$R - [24] \geq 14.0 \text{ [vega mag]}$$

Dey+08

$$i - [22] \geq 7.0 \text{ [AB mag]}$$

Toba+15

rare

- **number density**

$$\log \phi = -6.59 \pm 0.11 \text{ [Mpc}^{-3}\text{]}$$

Toba+15

far

- **redshift**

$$z = 1 - 2$$

Dey+08, Toba+15



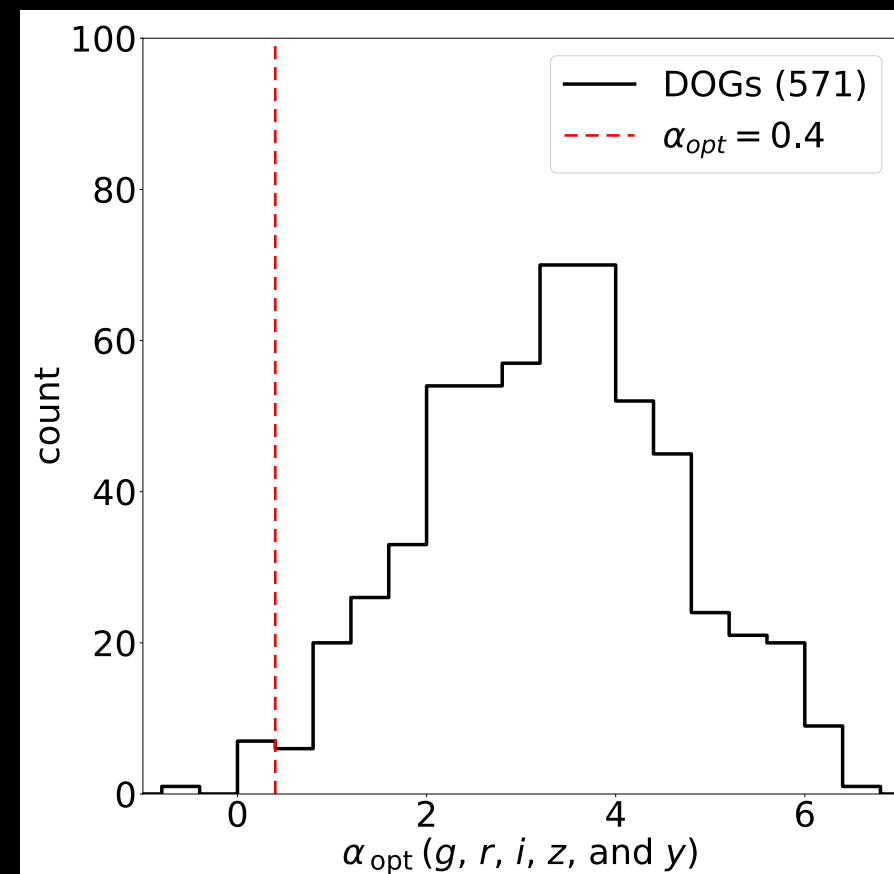
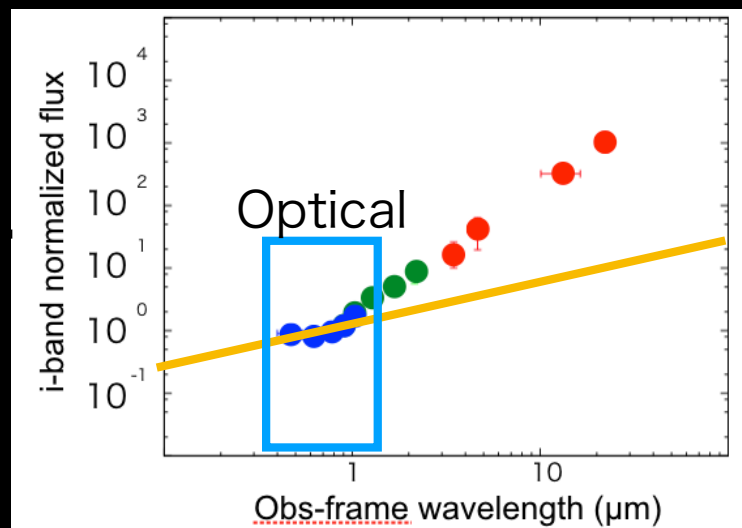
The Blue-excess DOGs

In Noboriguchi+19

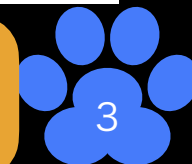
the definition of **blue-excess DOGs (BluDOGs)** is

as follows: $\alpha_{\text{opt}} < 0.4$,

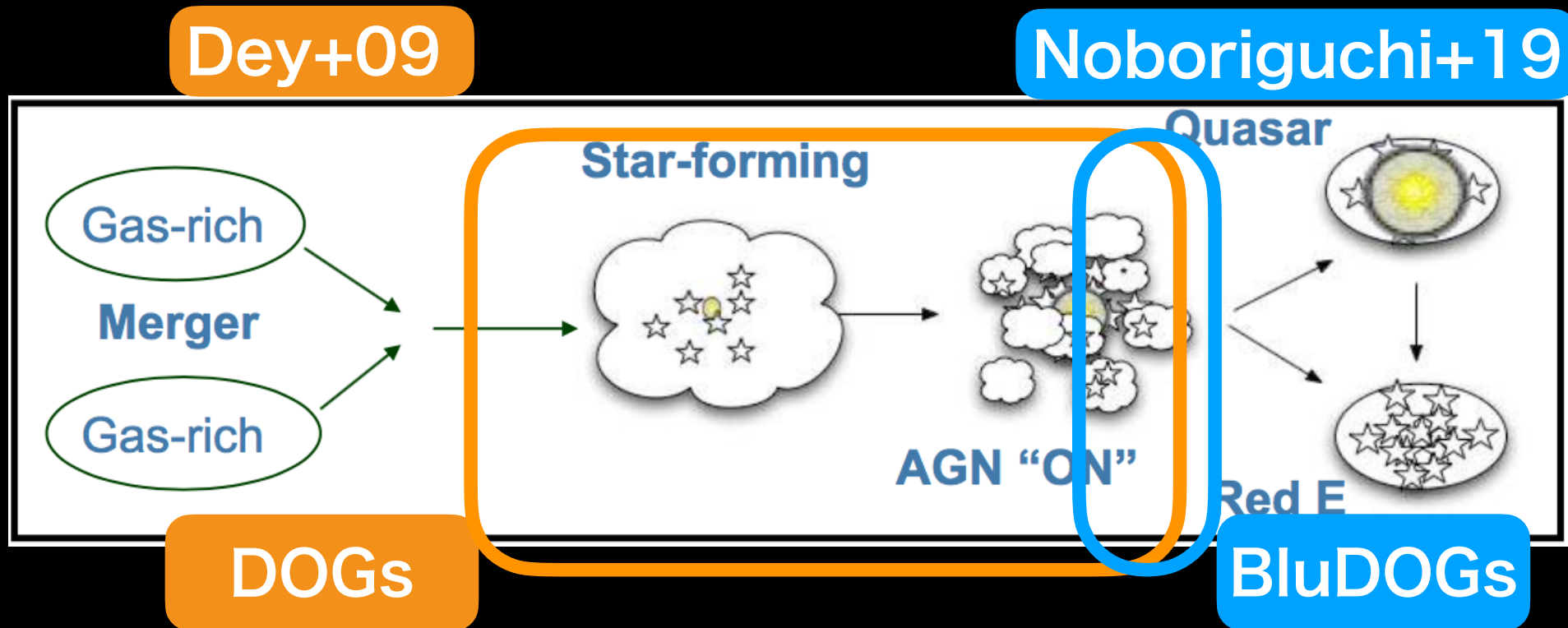
where α_{opt} is a slope of $\log f_{\text{opt}} = \beta + \alpha_{\text{opt}} \times \log \lambda_{\text{opt}}$ for the 5 HSC bands.



We selected **8 BluDOGs** out of 571 DOGs.



The major merger scenario



DOGs are thought to be important objects to understand the formation and evolution of quasars. BluDOGs might be experiencing the blowing-outflow phase.

What is the origin of blue excess of BluDOGs?

However...

The origin of the blue excess is still unknown.

Possibilities

- The **leaked AGN light**
- **Stellar UV light** from starbursts
- Other?

In this work

We executed
spectroscopic observations for the BluDOGs
using Subaru FOCAS and ESO VLT FORS2.

Spectroscopic observation

VLT FORS2

ESO VLT/FORS2

Diameter (VLT)

D ~ 8-m

Spectral resolution (FORS2)

R ~ 1500

Grism

GRIS_600RI

Slit width

0.7 arcsec

Coverage wavelength

5200 - 9200 Å



<https://www.eso.org/sci/facilities/paranal/instruments/fors.html>

Spectroscopic observation

Subaru FOCAS

Subaru FOCAS

Diameter (Subaru)

$D \sim 8\text{-m}$

Spectral resolution (FOCAS)

$R \sim 800$

Grism & Filter

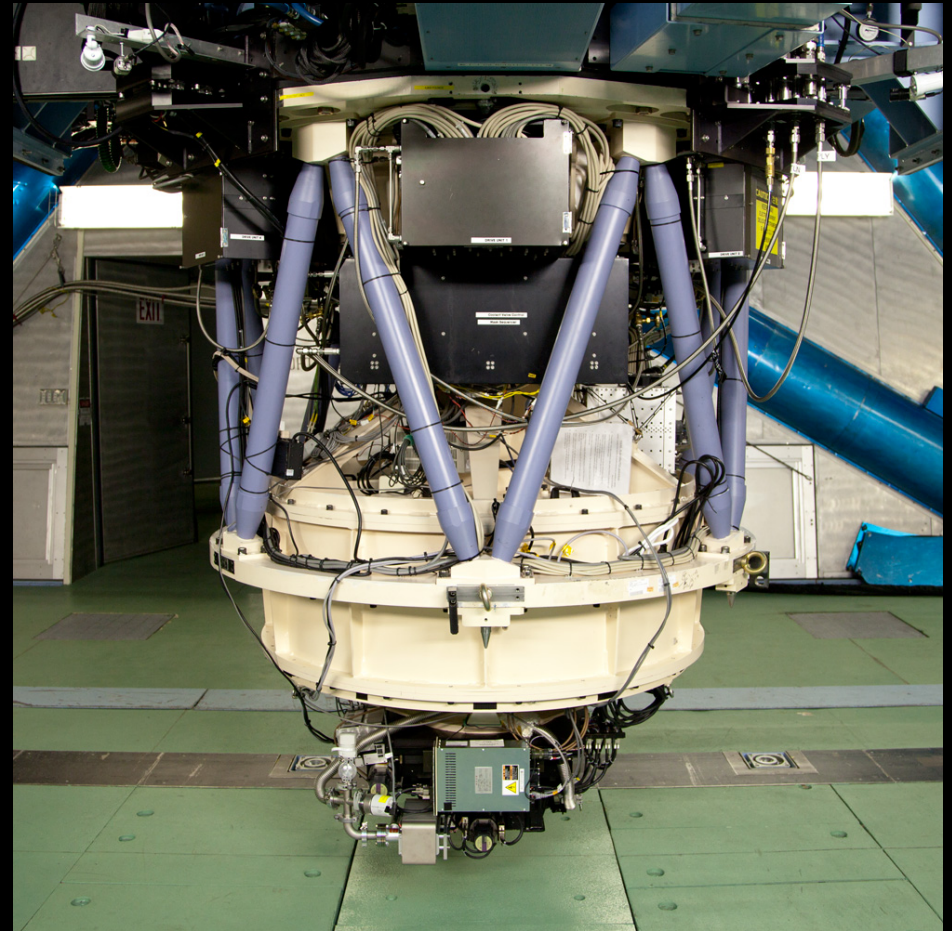
300B SY47

Slit width

0.8 arcsec

Coverage wavelength

4700 - 9200 Å



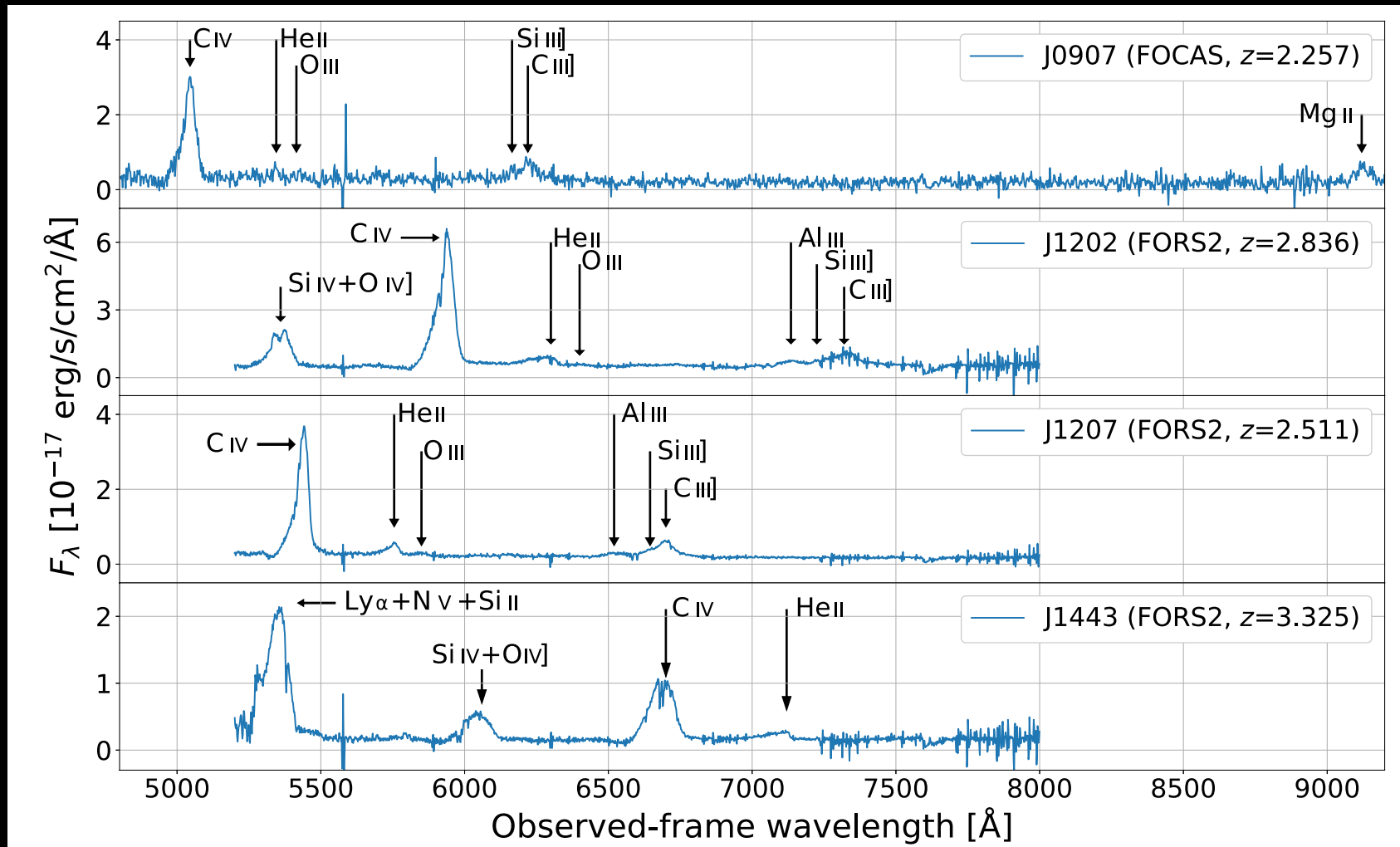
<https://www.subarutelescope.org/Introduction/instrument/FOCAS.html>



The spectra of BluDOGs

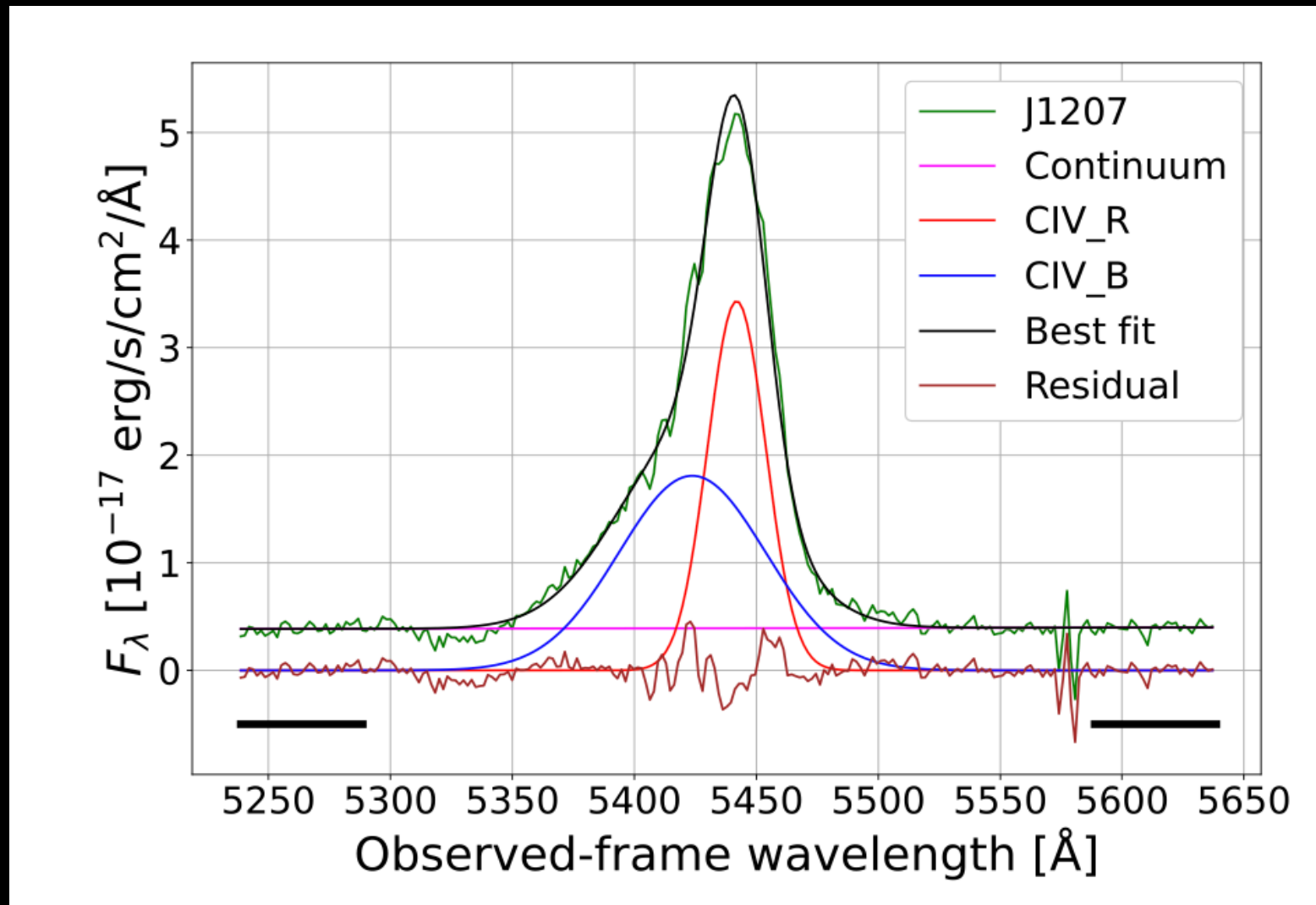
Their spectra show the two features.

- Strong broad lines
- A large equivalent width of the C_{IV}



CIV emission line

The CIV line has a blue tail, suggesting that there are outflow around the nucleus region.



The spectra of BluDOGs

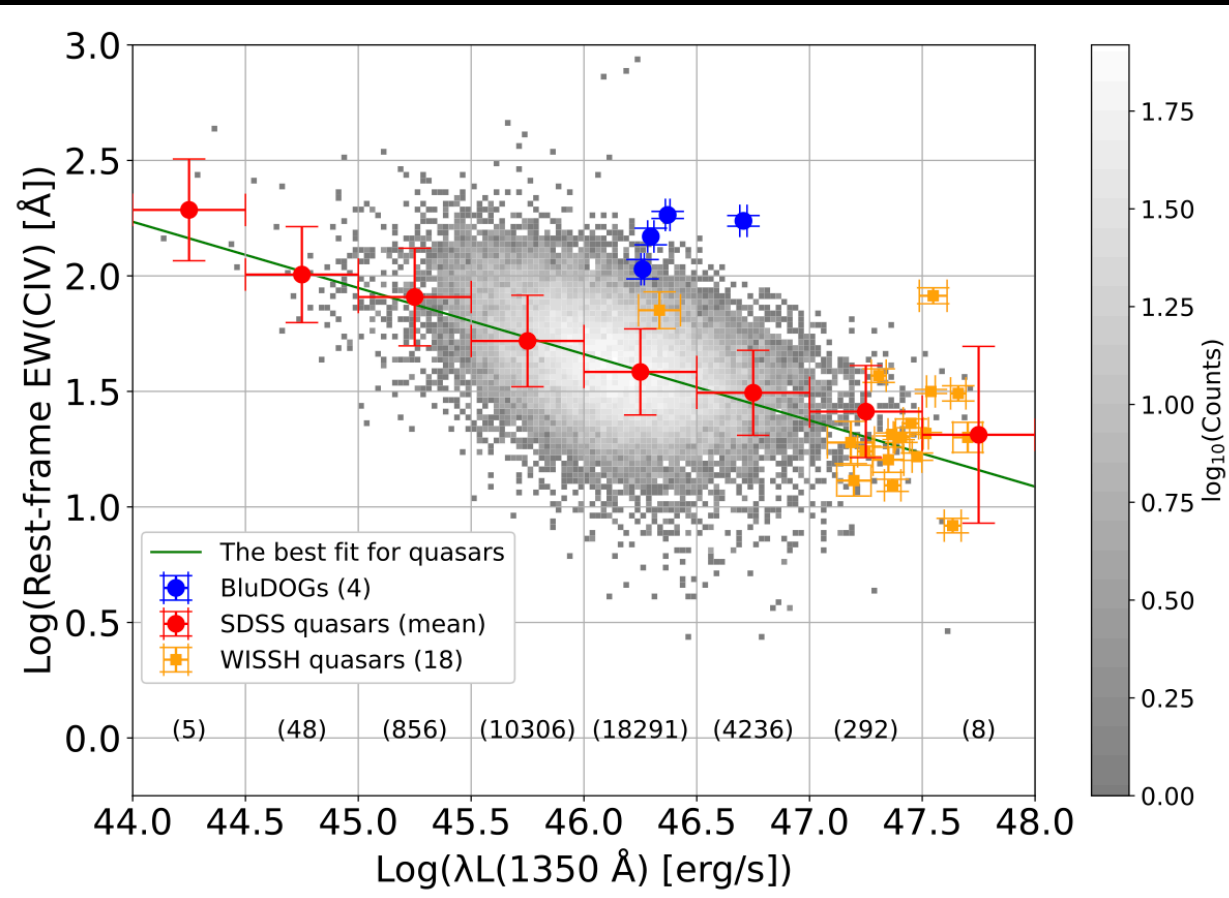
name	EWrest(CIV) [Ang.]	spec-z
J0907 (Subaru/FOCAS)	148	2.257
J1202 (VLT/FORS2)	184	2.836
J1207 (VLT/FORS2)	173	2.511
J1443 (VLT/FORS2)	107	3.325

Their rest-frame EWs are about 150 Å.

The origin of their blue excess is the broad emission lines with large equivalent widths.



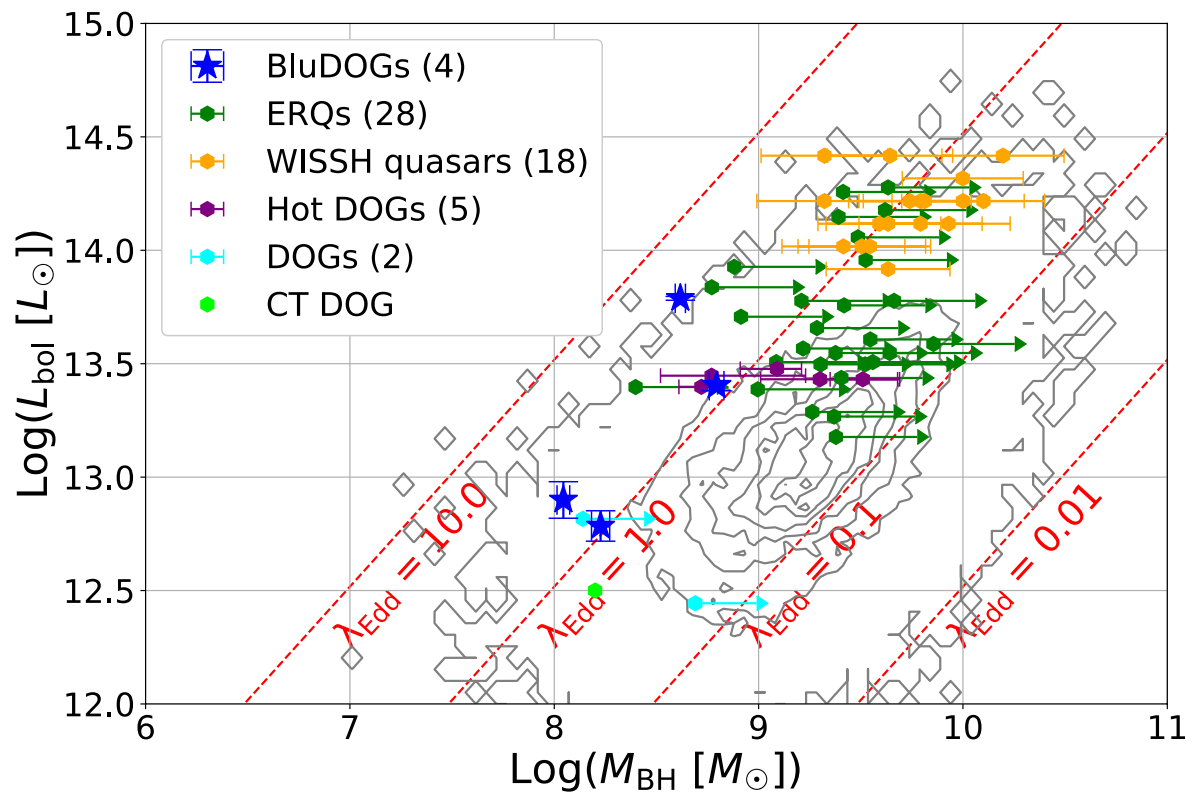
Baldwin effect



- SDSS quasar (Shen+11)
- WISSH quasar (Vietri+17)

The origin of the large CIV EWs are not Baldwin effect.

M_{BH} vs. L_{bol}



- Extremely red quasar (ERQs; Perrotta+19)
- WISSH quasar (Vietri+17)
- Hot DOGs (Wu+18)
- DOGs (Melbourne+11,12)
- Compton-thick DOG (Toba+20)

This suggest that the SMBH growth in the BluDOGs is more rapid than AGNs in comparison sample.

Summary

- We executed spectroscopic observations of 4 BluDOGs identified by Subaru HSC.
- **The CIV line profiles show the blue tail.**
- We suggest that the BluDOGs have outflows around the nucleus region.
- **Their Eddington ratios are higher than one.**
- We suggest that BluDOGs may represent the blowing-outflow phase.