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Monitoring the variable mini-BAL system in the quasar UM675

UM675に見られるmini-BALの時間変動について

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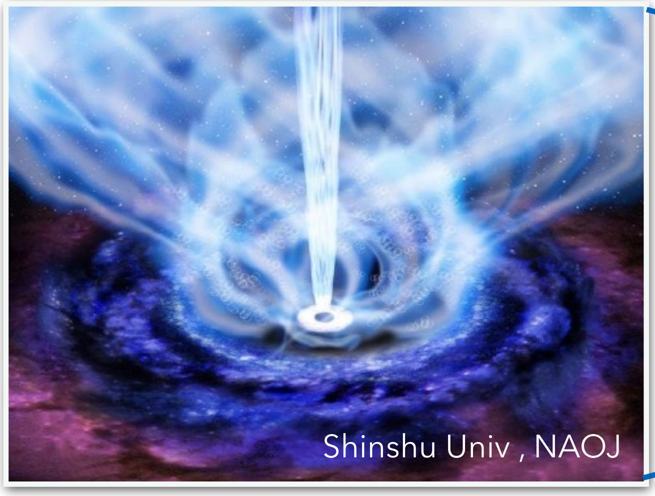
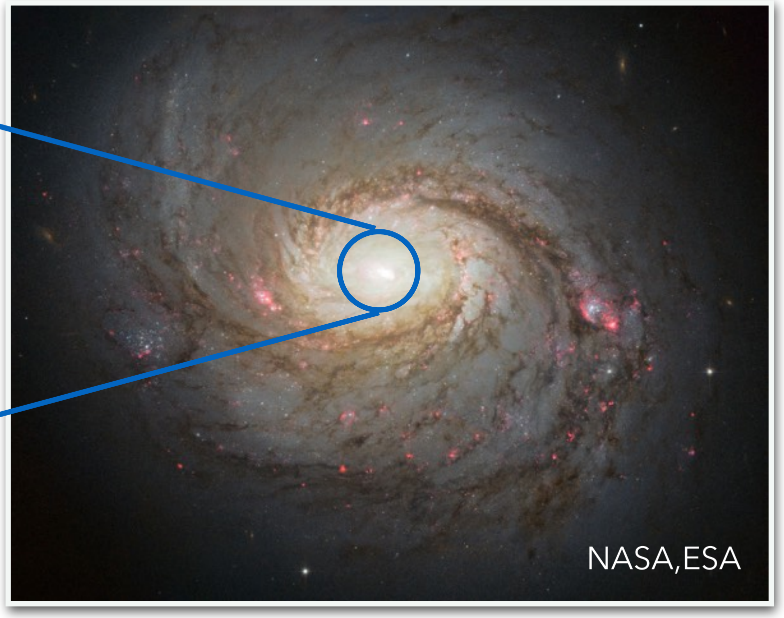
Introduction

AGN outflow wind





- AGN outflow

  -> It is blown wind from accretion disk by radiation or magnetic pressure.

Why AGN outflow wind is important?

- It promotes gas accretion by drawing out angular momentum.

-> leading to the **co-evolution of SMBH** (e.g., Murray et al. 1995)

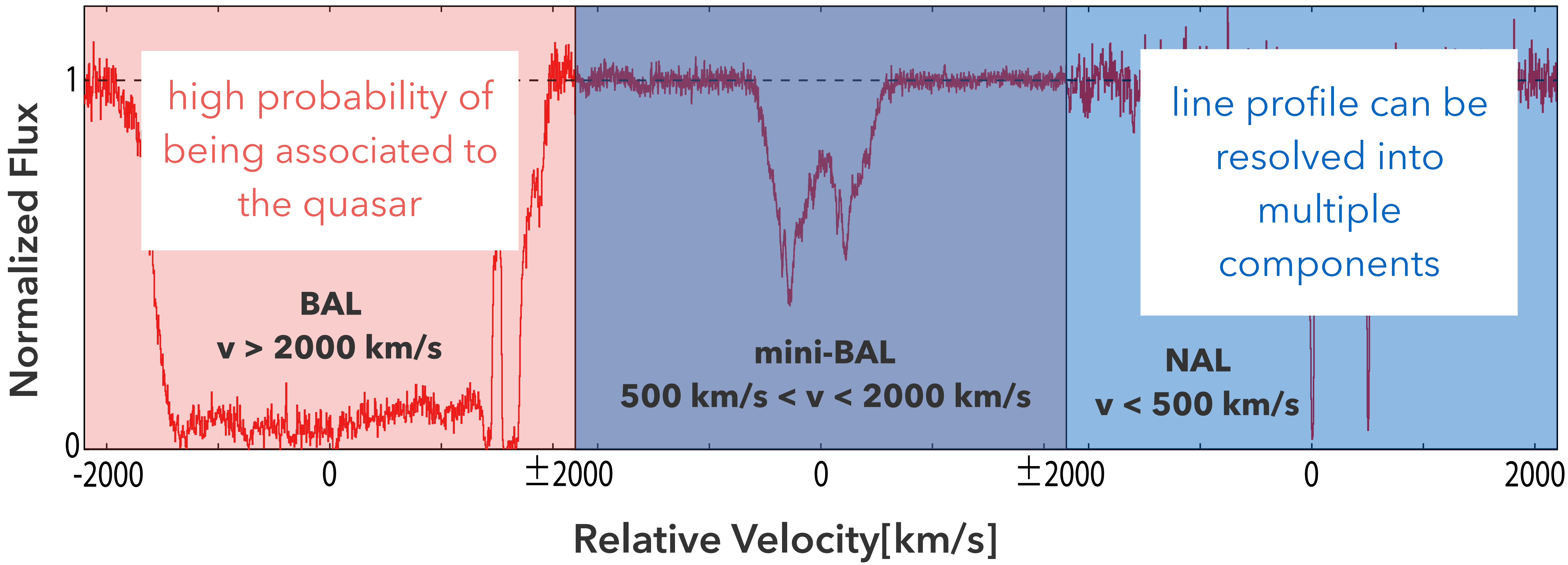
- It distributes heavy elements to host galaxy and inter-galactic region.

-> leading to cosmic **chemical evolution** (e.g., Dunn et al. 2012)

- It releases energetic gas.

-> **suppressing star formation rate** (e.g., Di Matteo et al. 2005)

Classification of absorption line



mini-BAL is intermediate class between BAL and NAL.

mini-BALs have the advantages of both BALs and NALs!

variability in outflow absorption line

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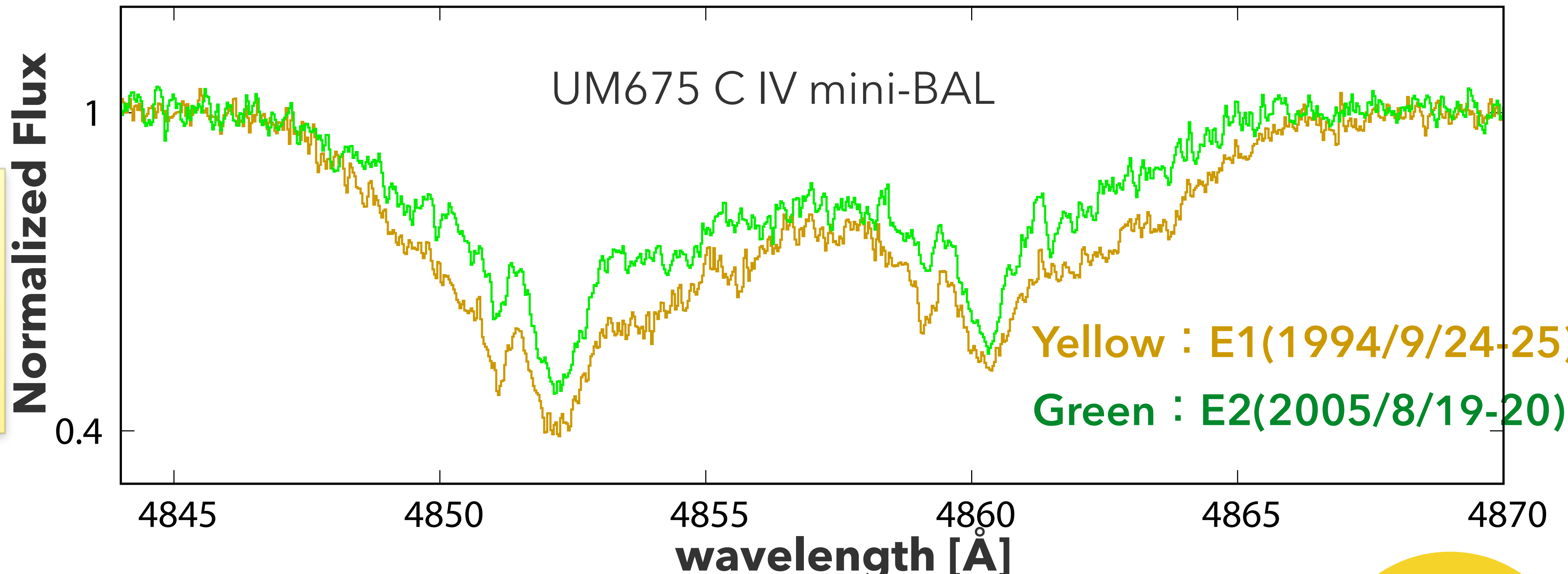
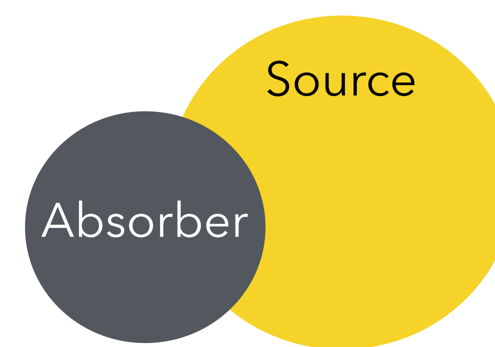


- **plausible scenarios in variability**

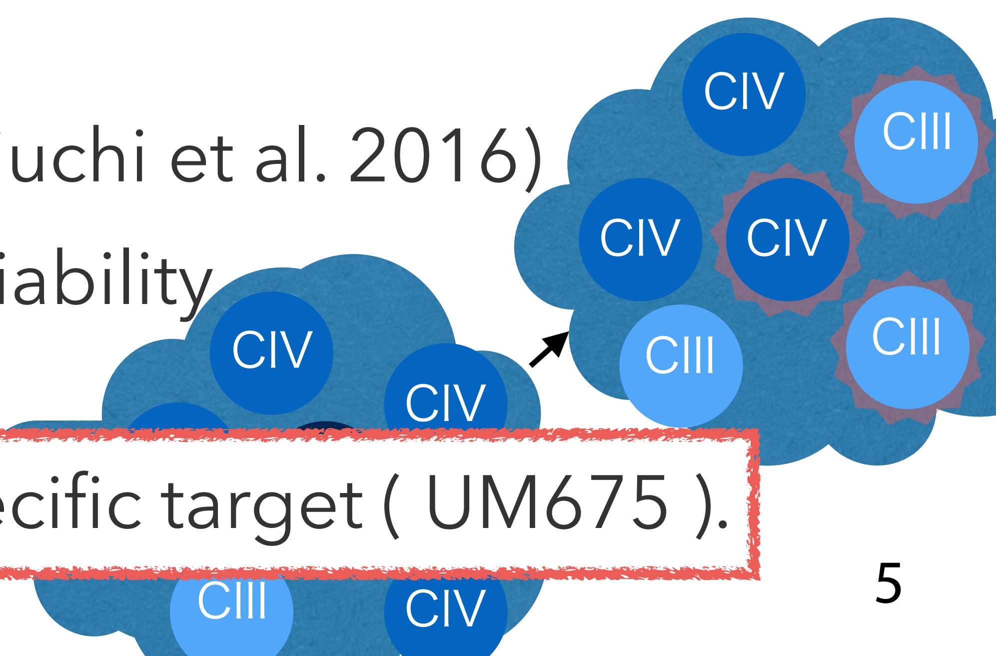


(i) Gas motion scenario (e.g., Hamann et al. 2008)

absorber moves through our line of sight.

(ii) Variable Ionization scenario (VIS; e.g., Horiuchi et al. 2016)

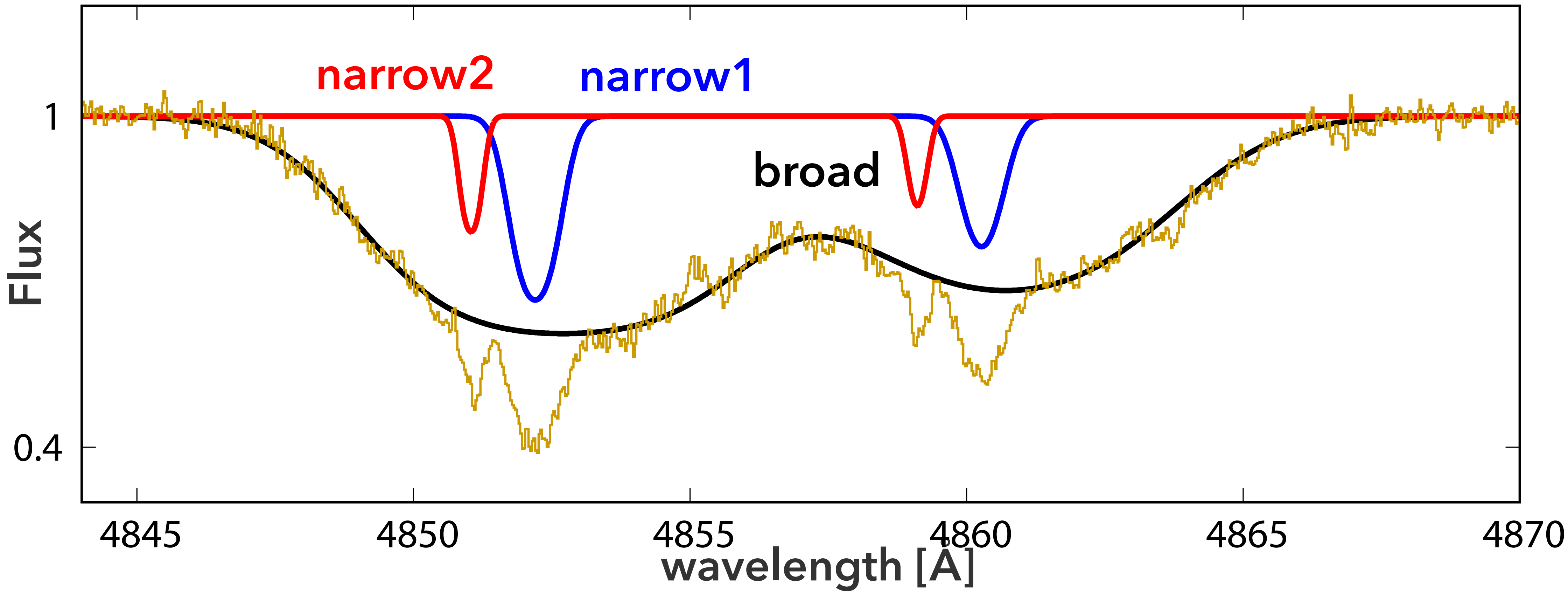
ionization fraction varies due to quasar variability



In this study we verify these scenarios for a specific target (UM675).

Analysis

mini-BAL quasar UM675



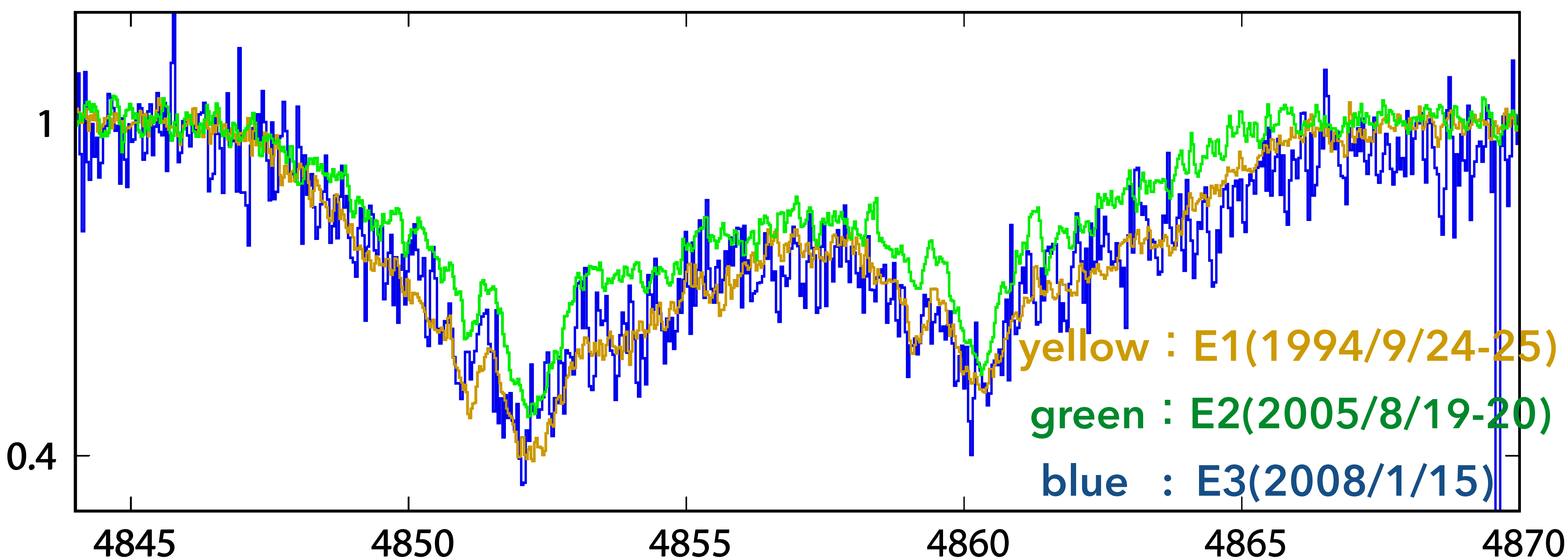
- z_{em} ~ 2.147, relatively bright QSO (L_{bol} ~ 10^{47} erg/s), Radio loud
- Lya, C IV, and N V mini-BALs at z_{abs} ~ 2.134 (v_{ej} ~1,500 km/s)
  - 2 narrow C IV components with FWHM $\lesssim$ 50km/s in mini-BAL

In this study, we monitor physical parameters of both broad and narrow components of the mini-BAL system by applying model fitting, and find a possible model for time variability.

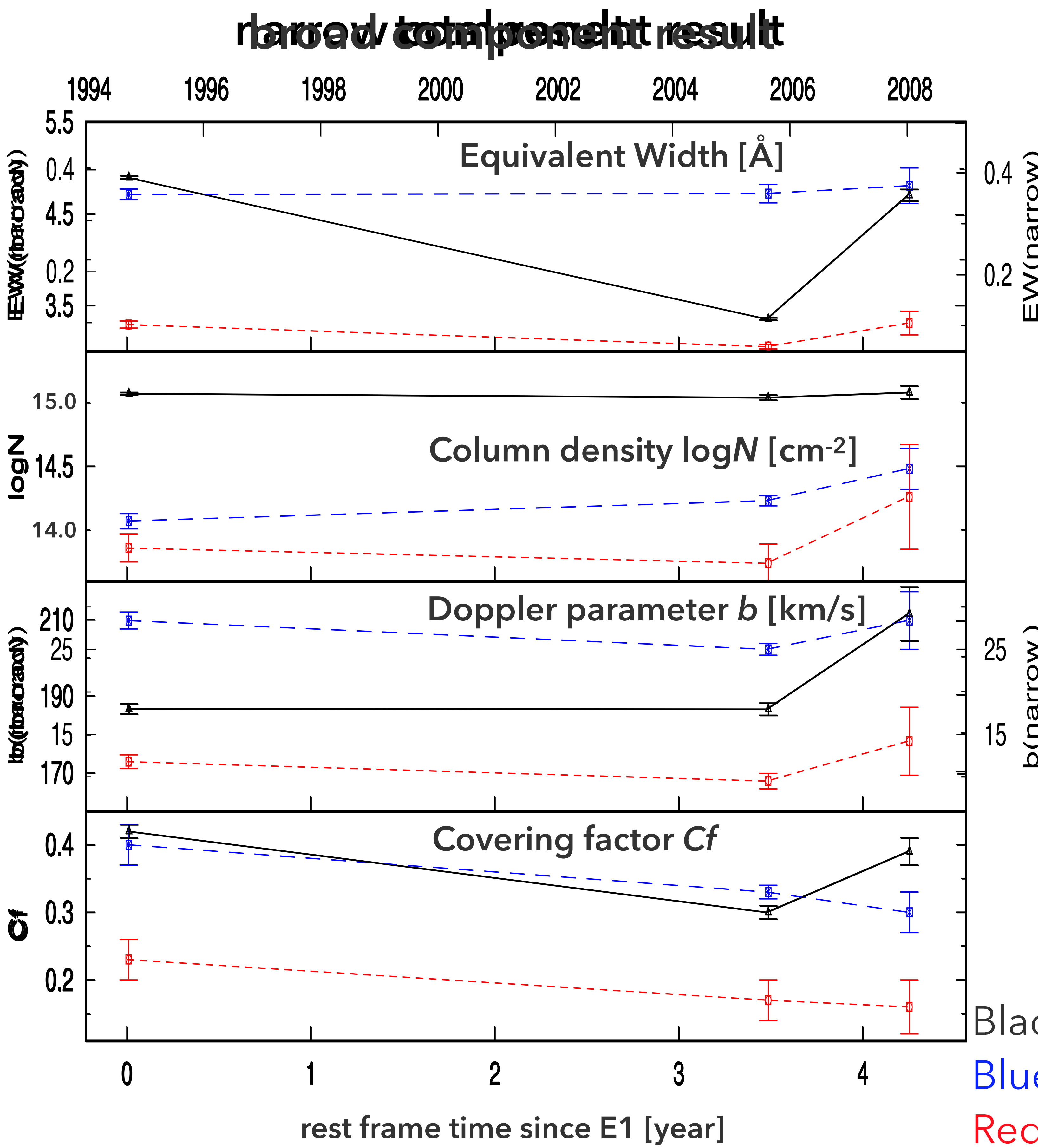
Voigt profile fitting of the C IV mini-BAL in UM675

Date list	Epoch1	Epoch2	Epoch3
Observed data	1994/09/24-25	2005/08/19-20	2008/01/15
Time delay since E1 [year]	0	3.7	4.2
Telescope/Insturment	KecK/ HIRES	Subaru/ HDS	Keck/ HIRES
S/N(λ~4800Å) [/pixel]	~ 40	~ 40	~10
spectral resolution	34000	36000	47000

Time variability of the C IV mini-BAL in UM675



Monitoring line parameters of the absorbers



logN is very stable

⇒homologous absorber

EW and Cf vary together

⇒ absorption strength depends on Cf

We only consider the time variability between E2 and E3.

Black : broad

Blue : narrow1

Red : narrow2

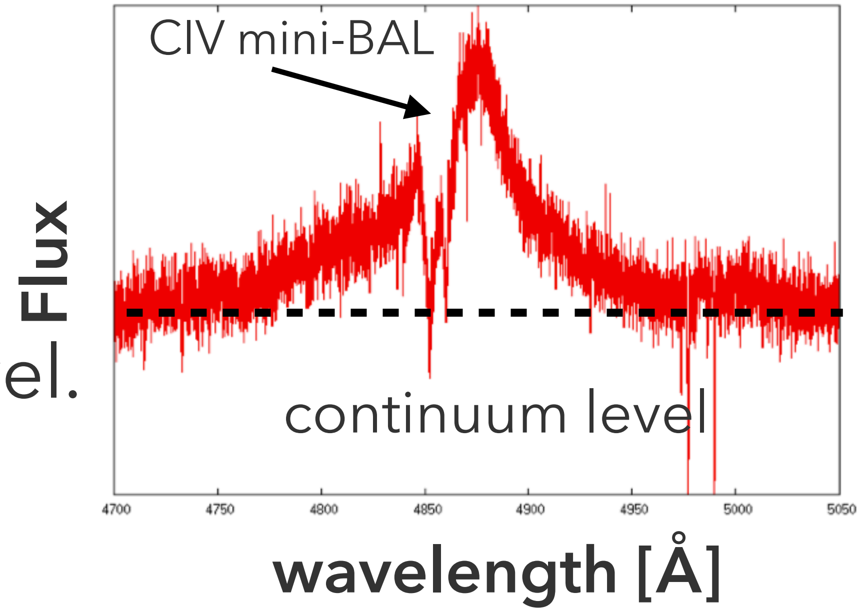
Discussion

(1) Gas motion scenario

- **Working model**
  - square-shaped source and absorber.
  - comparable sizes of source and absorber.
  - absorber is moving in Kepler motion.
  - $M_{BH} \sim 2 \times 10^9 M_\odot$ (Coatman et al. 2016)

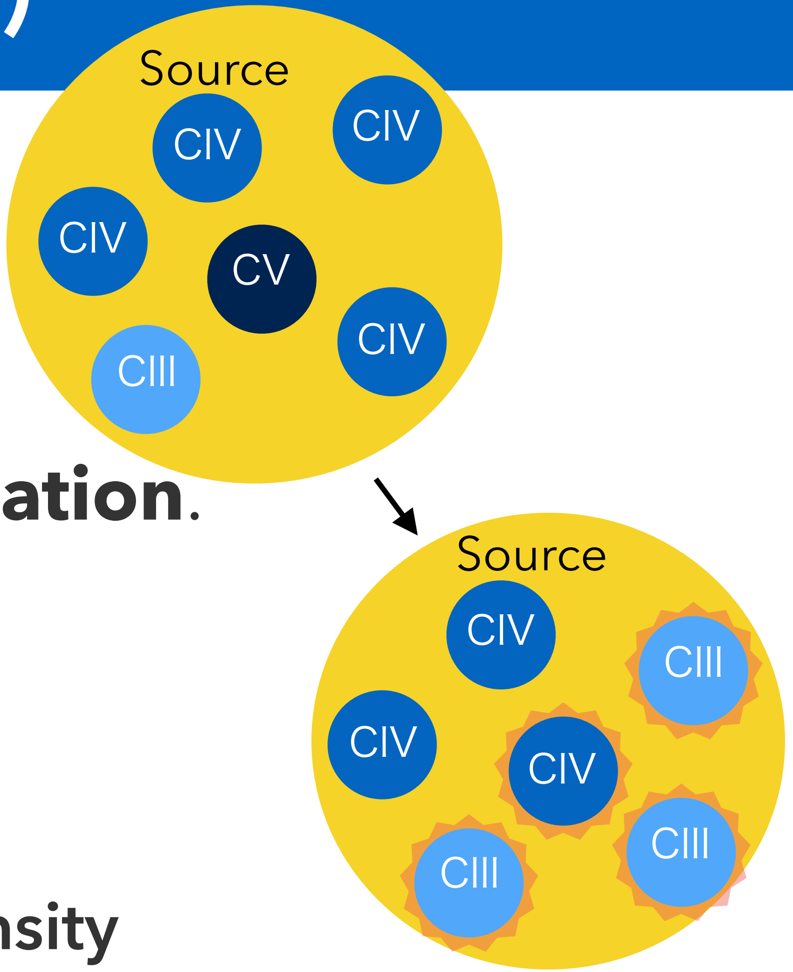
- **Background source**
  - BLR + Continuum
    - absorption is deeper than continuum level.

    $R_{BLR} \sim 0.1$ pc (Lira et al. 2018)



※absorber is located in front of BLR

(2) Variable Ionization scenario (VIS)



- **Recombining VIS**
  - assuming variability is caused by only **recombination**.
  - (variability time) ≳ (recombination time)

E2-E3

- absorption strength -> strong
- CV -> CIV dominante

electron density

$$n_e \gtrsim \frac{1}{\alpha t_{var}} \quad (n_V \gtrsim n_{IV})$$

- **Ionizing VIS**
  - assuming variability is caused by **ionization**.
  - Because ionization is complicated , we only focus qualitative discussion.

Constraints on physical parameters

	electron density n_e [cm^{-3}]	source - gas distance r [pc]	thickness d [pc]	propriety of (n_e ,r ,d)	consistency of variability and each scenario
Gas motion (BLR + cont.)	$\gtrsim 1.2 \times 10^{10}$	$\lesssim 0.09$	$\lesssim 2 \times 10^{-11}$	✖	○
VIS (Recombination)	$\gtrsim 1.5 \times 10^{4}$	$\lesssim 1900$	$\lesssim 1.4 \times 10^{-5}$	○	△ ($n_e^{narrow} \ll n_e^{broad}$)
VIS (Ionization)	**difficult to estimate**				△ ($n_e^{narrow} > n_e^{broad}$)

Ionization parameter U

$$U = \frac{(\text{UV photon density})}{(\text{electron density})} = \frac{Q}{4\pi r^2 c} \Big/ n_e$$

UV proton fluctuation ΔQ

$$n_e^{narrow} > n_e^{broad}$$
$$\downarrow$$
$$\Delta U^{narrow} < \Delta U^{broad}$$

narrow absorber's ionization state is more stable than broad one's

Summary

- We performed Voigt profile fitting for the CIV mini-BAL to monitor physical parameters of broad and narrow components using high-resolution (R~40,000) spectra taken with 8-10m class telescopes.
- **Broad component showed an obvious variability ($\gtrsim 3\sigma$) , while narrow ones don't ($\lesssim 2\sigma$)**
- For broad component we considered two scenarios (i.e., gas motion scenario and variable ionization scenarios) as the cause of time variability.
- **Gas motion scenario is less likely because it requires.**
- **In VIS this result is possible, but it gives only weak constraints or only qualitative evaluation.**
- **Future work**
  - We'll consider ionizing VIS using Cloudy and apply the same analyses for other target's.