Gas outflow in local Type 1 AGNs

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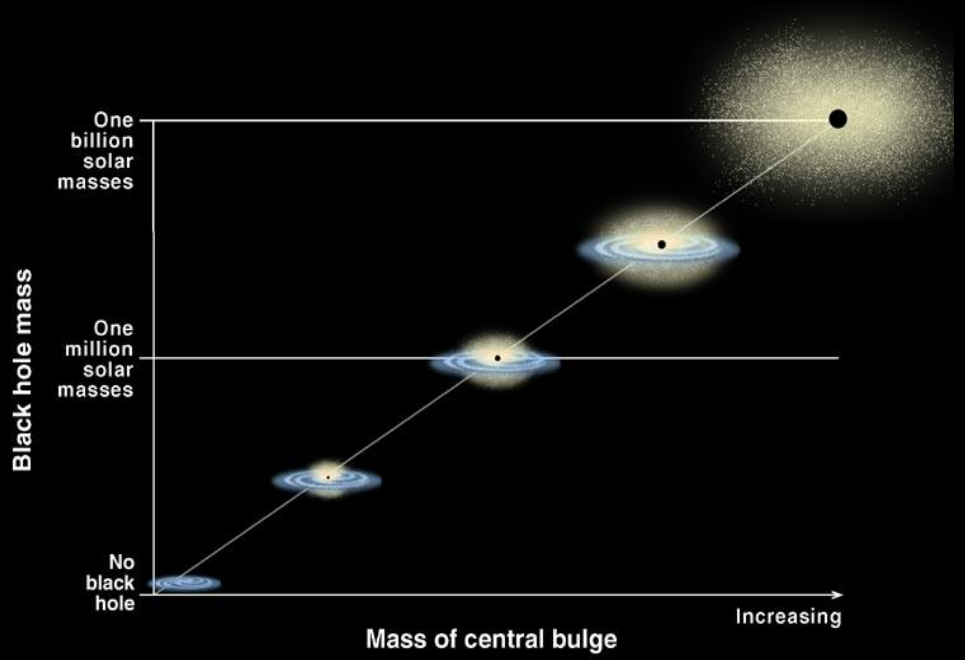
Galaxy-Black Hole co-evolution

- The several scaling relations between SMBHs and their host galaxies (M_{BH}-M_{bulge}, M_{BH}-L_{bulge}, M_{BH}-σ_* relation)

  → Co-evolution

- Co-evolution mechanism is unknown.



Magorrian +1998

Active Galactic Nucleus (AGN)

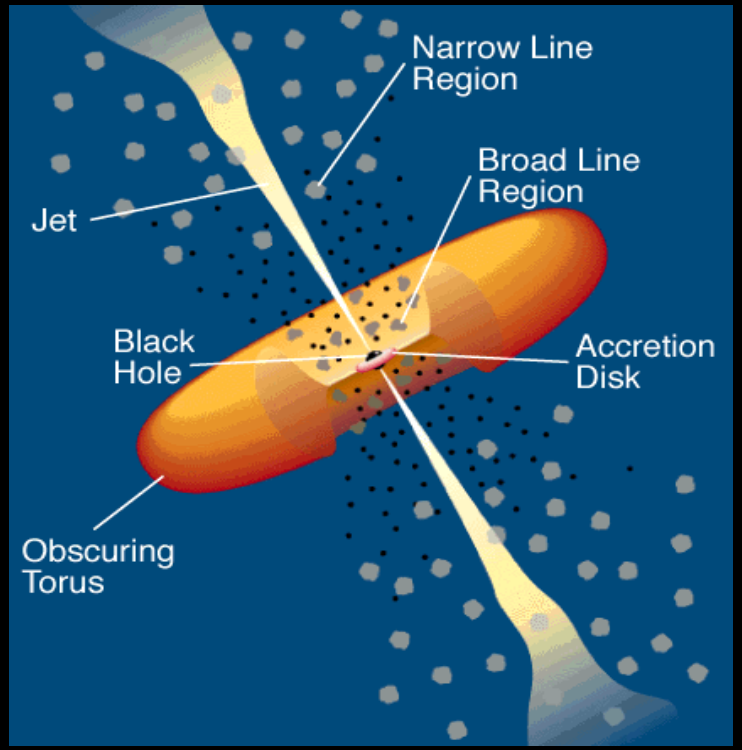
Urry & Padovani 1995

- AGN is turned on when materials accretes to SMBH

  → BH growth

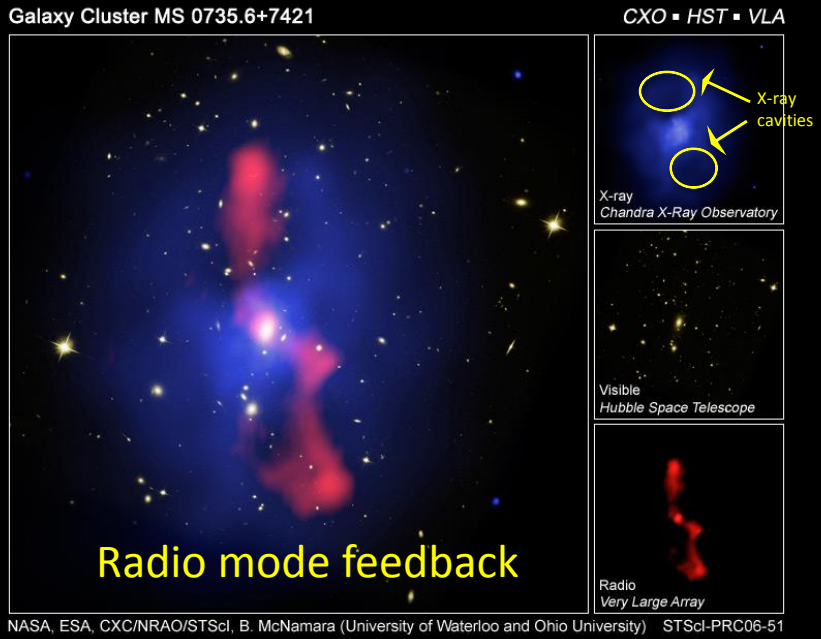
- Powerful activities and huge energy from AGN

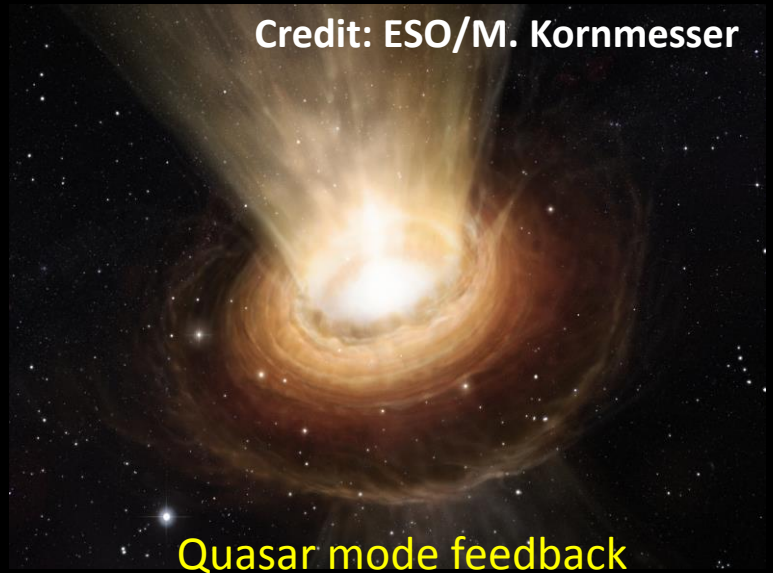
  → AGN feedback



AGN feedback

- AGN feedback can be a key to understand co-evolution affecting star formation in host galaxies (Silk & Rees 1998; Crenshaw et al. 2003, Di Matteo et al. 2005, McNamara& Nulsen 2007).



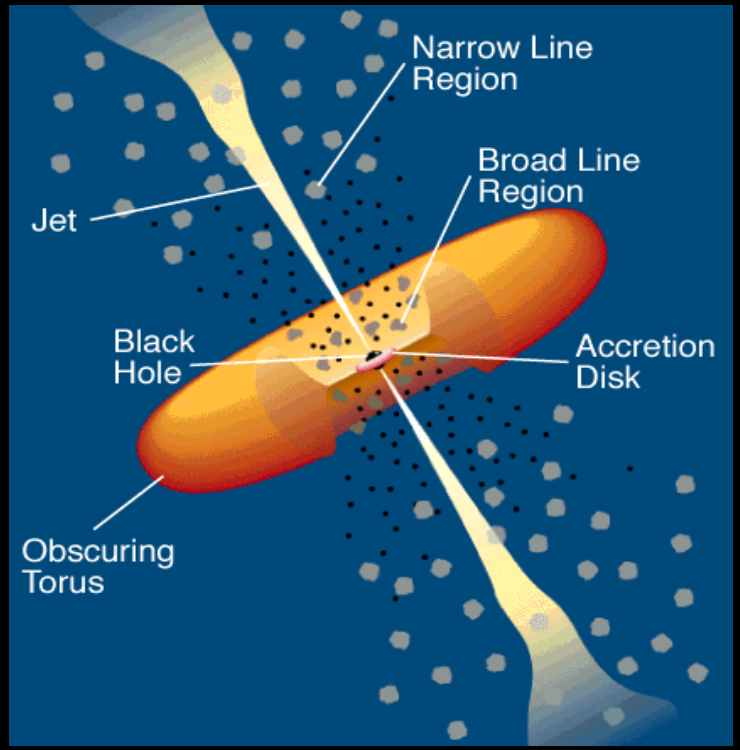


Gas outflow

- Shown in Broad Line Region (BLR) and Narrow Line Region (NLR)

- Seen as emission lines and absorption line (Sulentic et al. 2000, Crenshaw et al. 2003, Wang et al.2011, Bae & Woo 2014)
  - Due to viewing angle

Urry & Padovani 1995

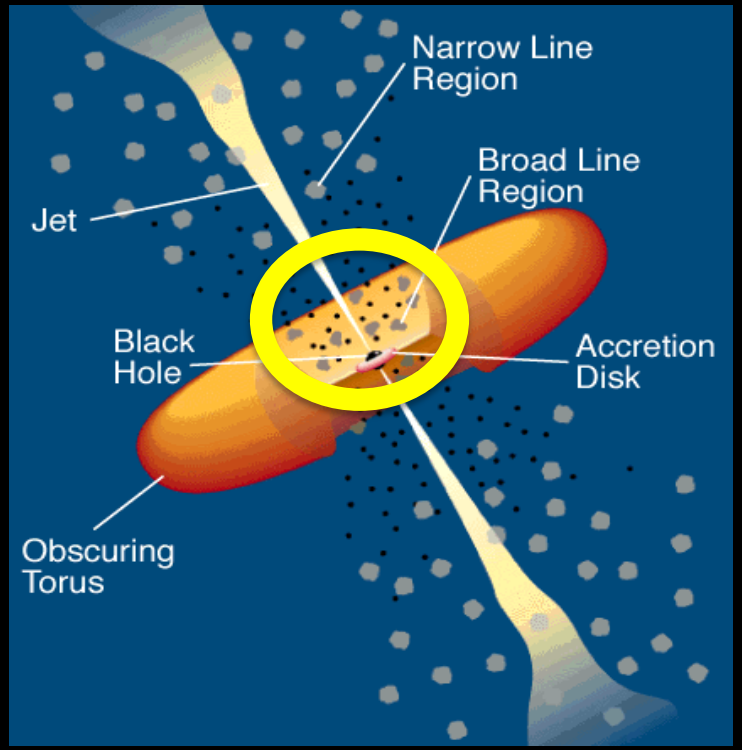


Gas outflow at BLR

- BLR is the best region to investigate AGN gas outflow (~0.1pc)

- High ionization lines (i.e., CIV 1549A) are the most affected by outflow.

Urry & Padovani 1995



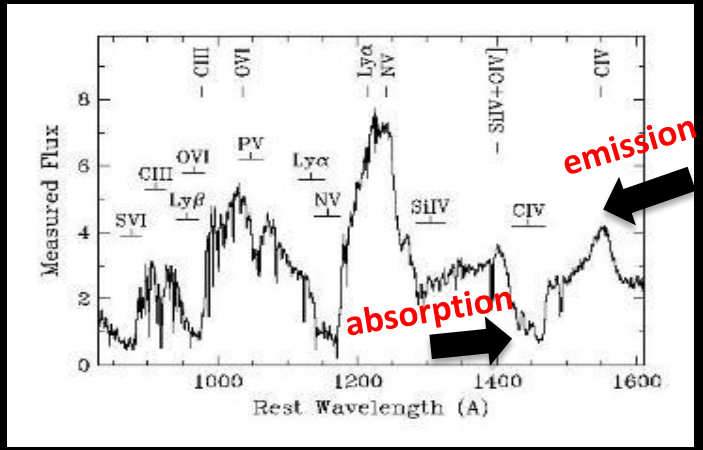
Gas outflow with CIV

- BAL (broad absorption line)

- BEL (broad emission line)
  - Blue shift : radio quiet quasar
  - Asymmetry : radio loud quasar

(Marziani et al. 1996, Sulentic et al. 2000, Richards et al. 2002, Marziani et al. 2006, Richards et al. 2011)

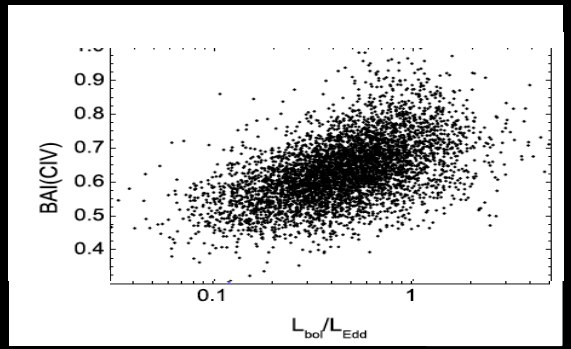
PG 1254+007 (Hamann 1998)



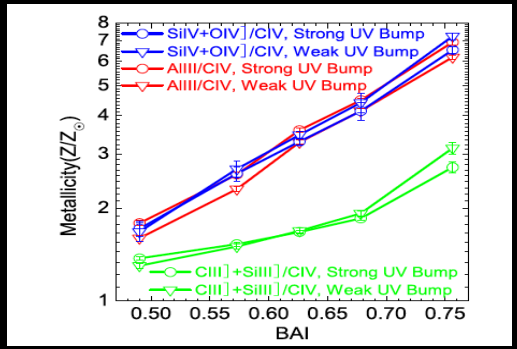
BAI- Eddington ratio- metallicity

- BLR gas outflow indicator: Blueshift and Asymmetry index (BAI)
- ~6000 SDSS QSOs at 1.7<z<2.2 (Wang et al 2011) ,~12000 SDSS QSOs at 1.7< z< 4 (Wang et al. 2012)
- Possible connection between past star formation, accretion activity and gas outflow

Wang et al. 2011



Wang et al. 2012



Previous works & Purpose

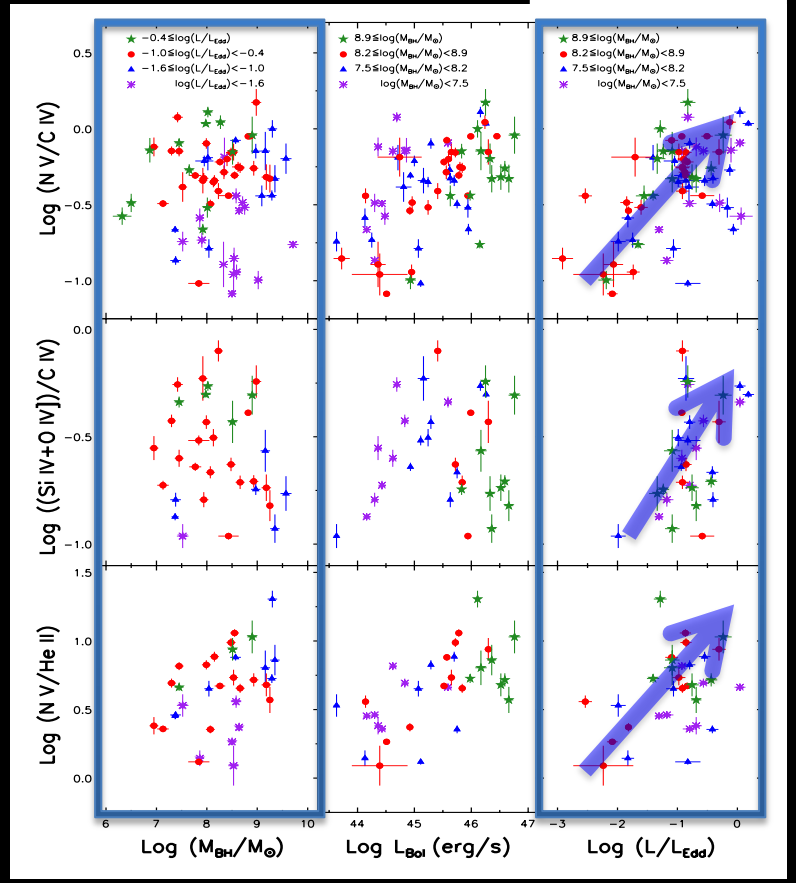
- L/L_{Edd}-Z_{BLR} relation, while little M_{BH} and Z_{BLR} relation found from 70 PG QSOs (z<0.5) using rest frame UV spectra (HST & IUE)

  → Past star formation – current AGN activities relation?

- UV spectra enable us to study AGN outflow for local AGNs.

- We could investigate cosmic evolution.

Shin+2013



Sample & Data

- Initial sample: 70 Palomar Green (PG) Type1 QSOs from Shin+2013 : Most luminous object in local (z<0.5)

- Having UV spectra (HST and IUE) and Optical spectra (SDSS DR7)

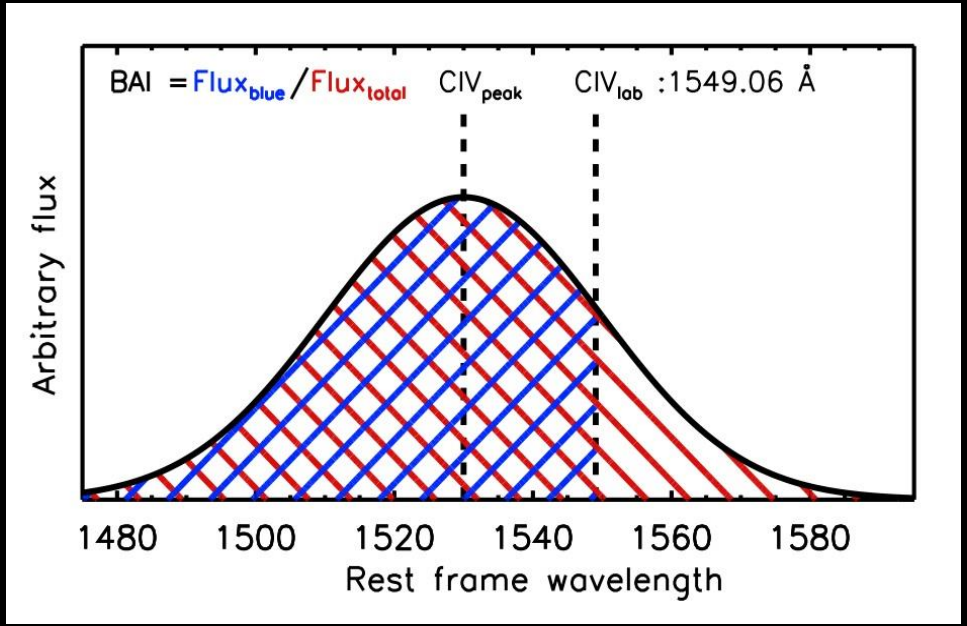
  → 28 PG QSOs

- + Six Markarian AGNs (from Veron-cetty 13_{th} catalog)

  → 34 PG QSOs and Markarian AGNs

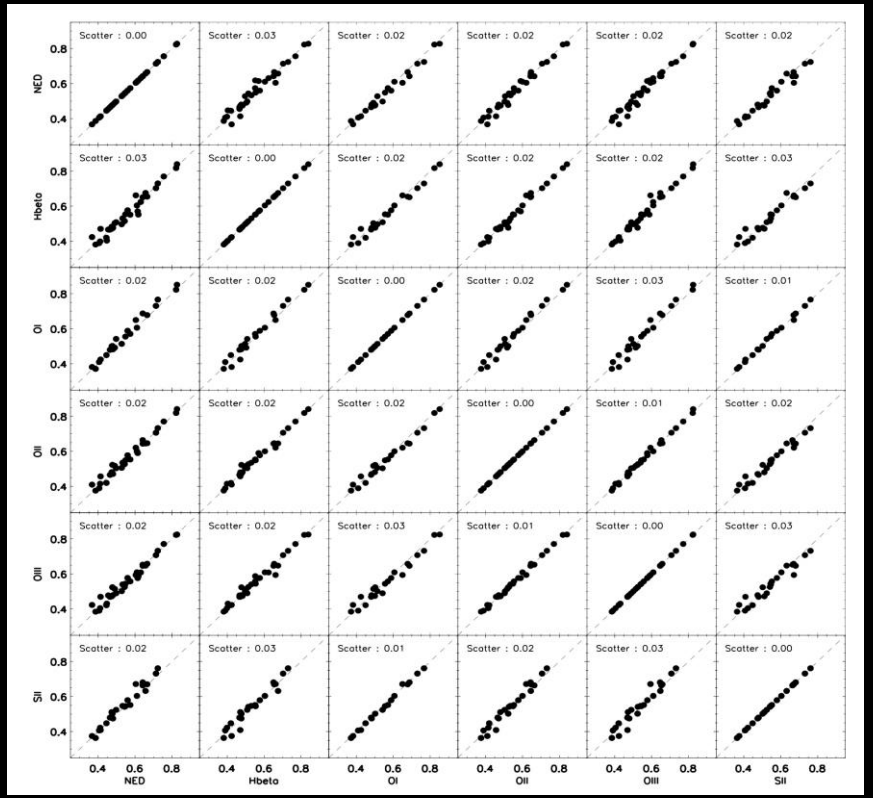
Blueshift and asymmetry index (BAI)

- Combination of blue shift and asymmetric effect of CIV1549 (proposed by Wang+2011)
- BAI=$Flux_{Blue}/Flux_{Total}$
- Highly depended on redshift



Redshift determination

- Redshift is important to determine C IV laboratory center, 1549.06A.
- We used narrow emission line for measuring redshift (Nagao et al. 2011)
  - SII 6718.29A, 6732.67A,
    OI 6302.05A, 6365.54A,
    OII 3728.48A, OIII 5008.24A, and
    Hβ narrow component 4862.68A



AGN properties and Metallicity

- AGN proeprties
  - AGN luminosity: L_{5100A}
  - Black hole masses from single epoch method (with $\sigma_{H\beta}$ and L_{5100})

$$M_{\rm BH} = 10^{7.370}\, M_\odot \left(\frac{\sigma_{\rm H\beta}({\rm SE})}{1000\,{\rm km\,s^{-1}}}\right)^{2.212} \left(\frac{\lambda L_{5100,n}}{10^{44}\,{\rm erg\,s^{-1}}}\right)^{0.518}$$

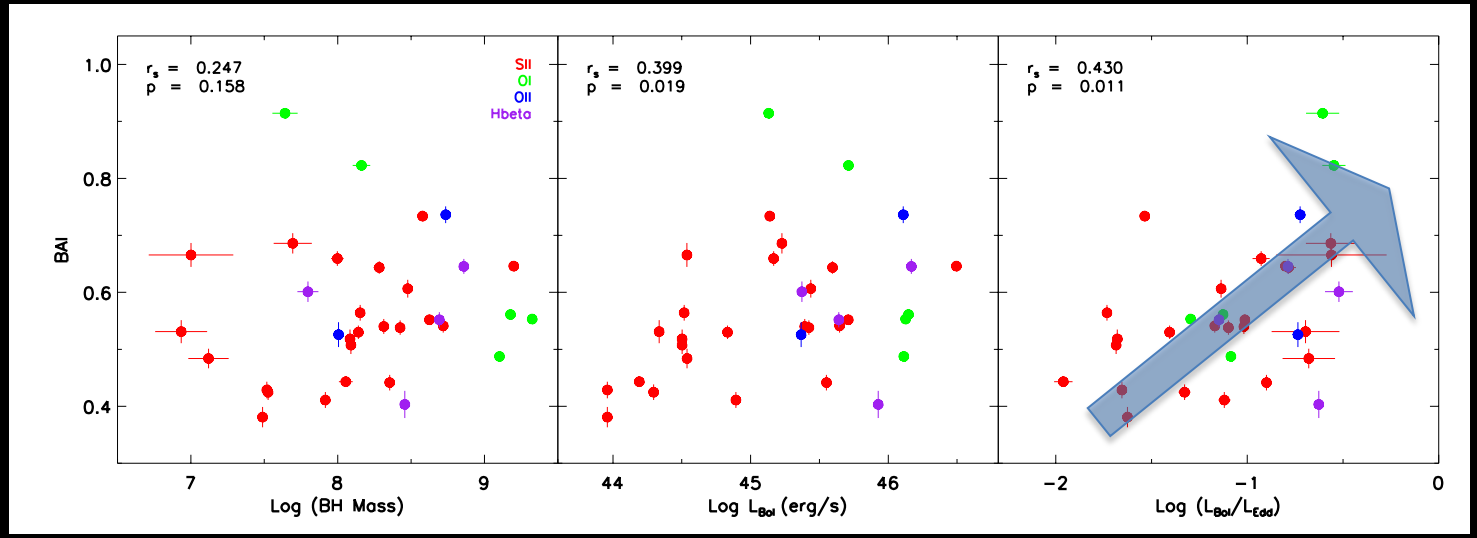
Park+ 2012

  - Eddington ratio : $L/L_{Edd} = L_{Bol}/(1.25\times10^{38}\times M_{BH})$

- BLR gas metallicity : NV/CIV, SiIV+OIV/CIV, and NV/HeII
  (Hamann & Ferland 1992,1993 and Nagao et al. 2006)

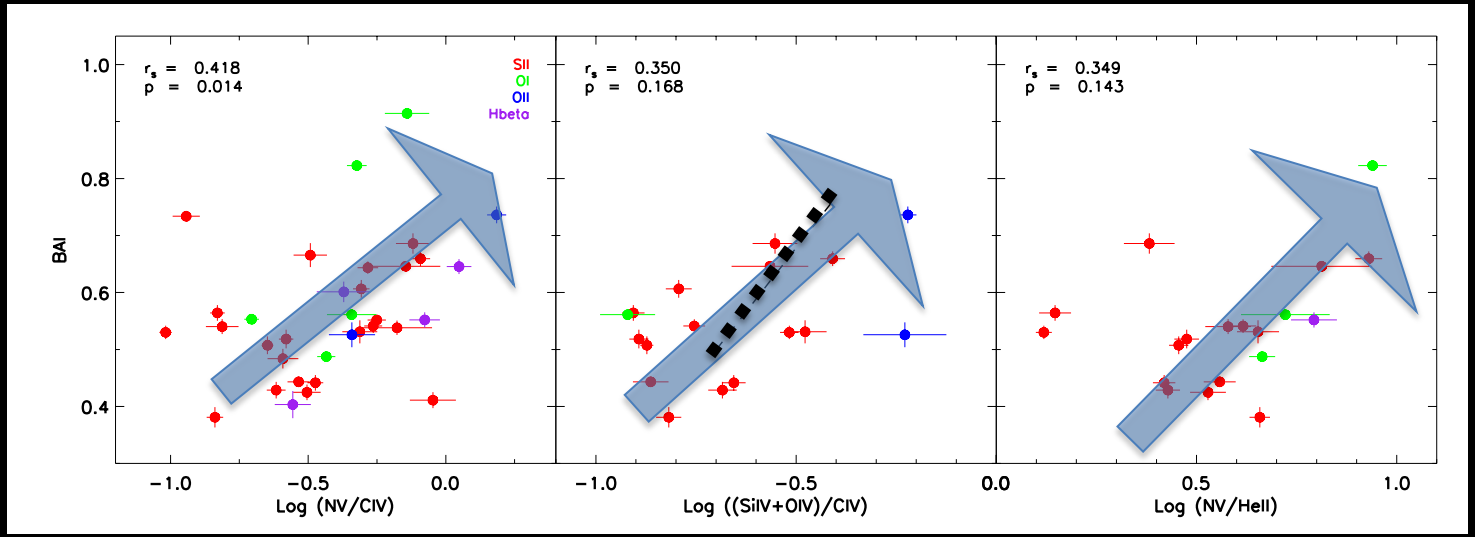
BAI-AGN properties

- BAI correlates with Edd ratio assuming accretion activities and outflow relation.



BAI-AGN metallicity

- BAI correlates with metallicity indicators.



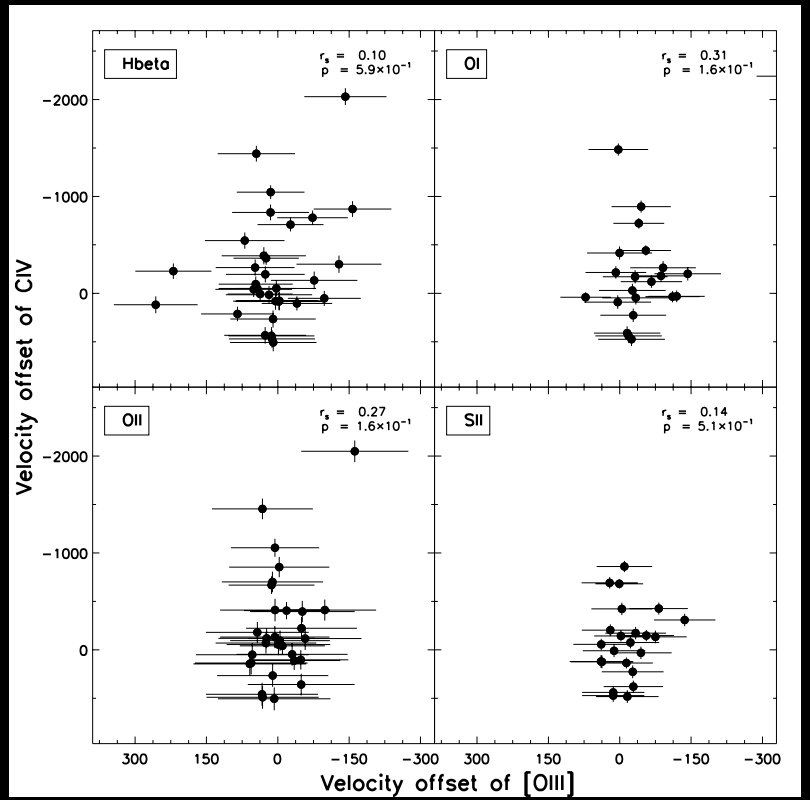
Discussion and Summary

- We studied AGN gas outflow for local AGNs at $z<0.5$.

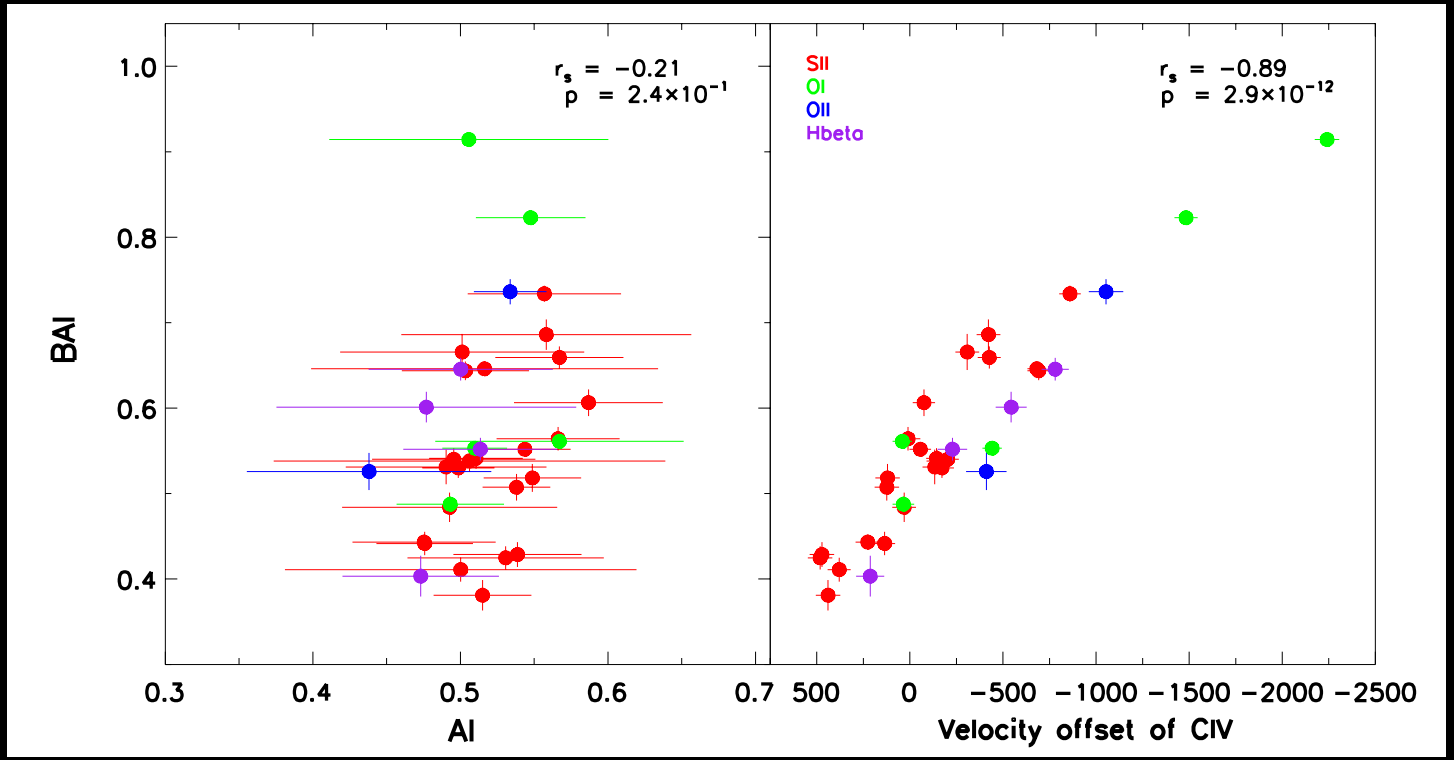
- There are possible connections between AGN outflow, Eddington ratio, and AGN metallicity.

- Global properties (black hole mass) and cosmic evolution may not affect AGN activities.

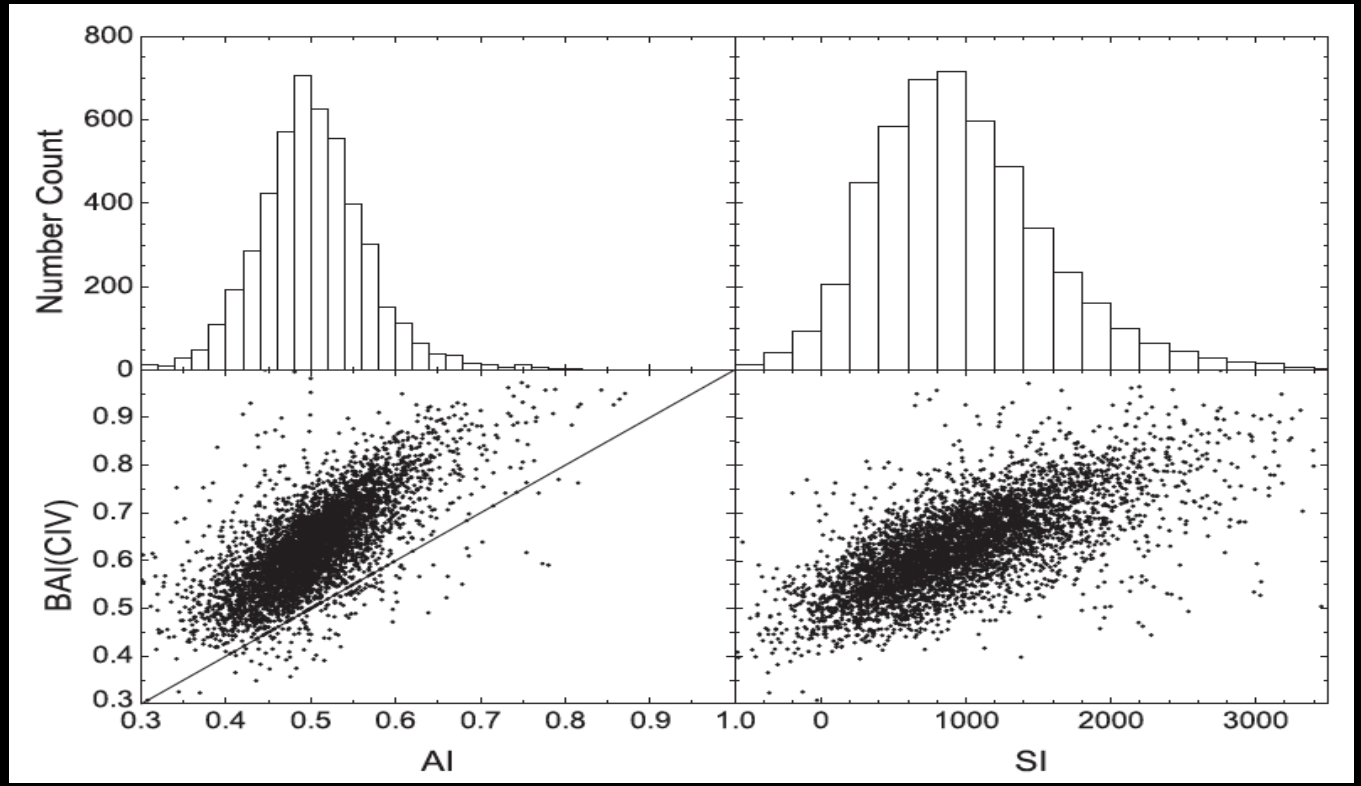
Discussion BLR- and NLR- outflow



Outflow indicators



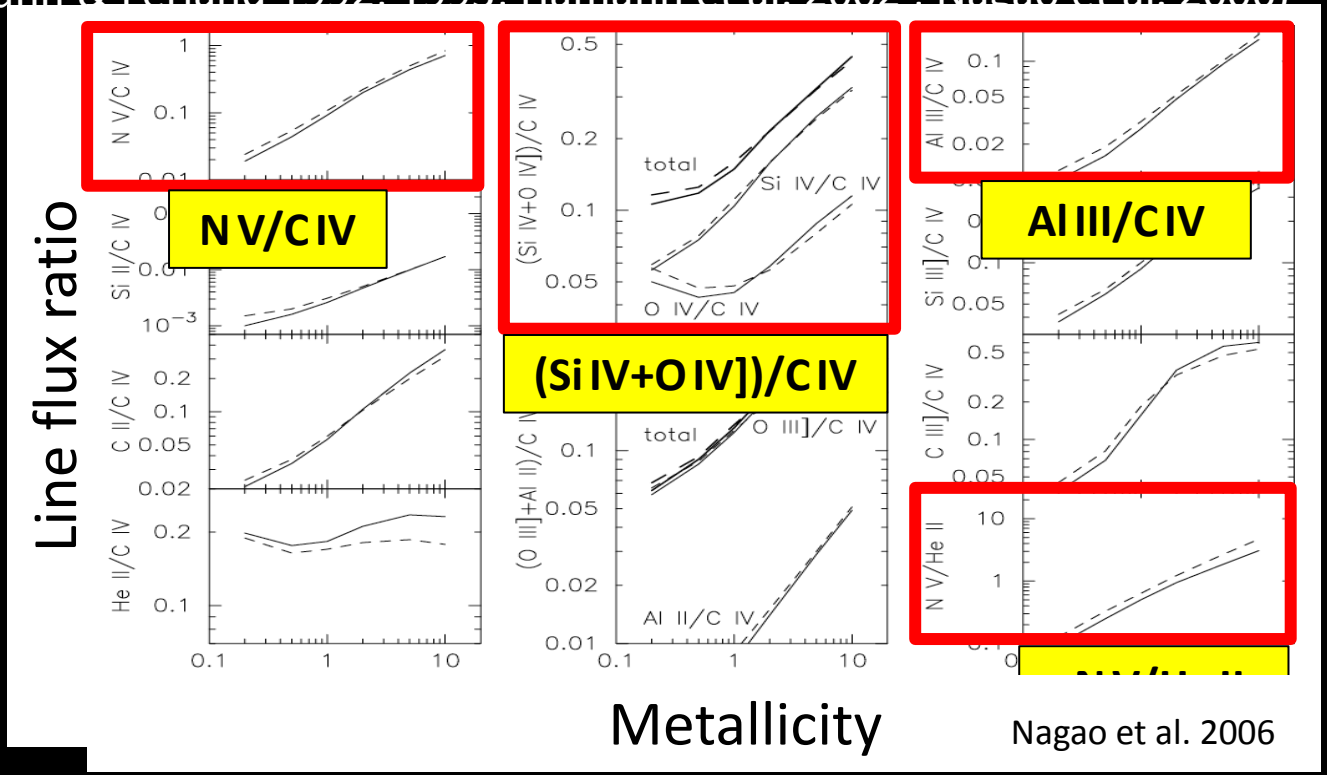
Asymmetry and blue shift



BLR metallicity

UV broad emission line flux ratio → BLR metallicity

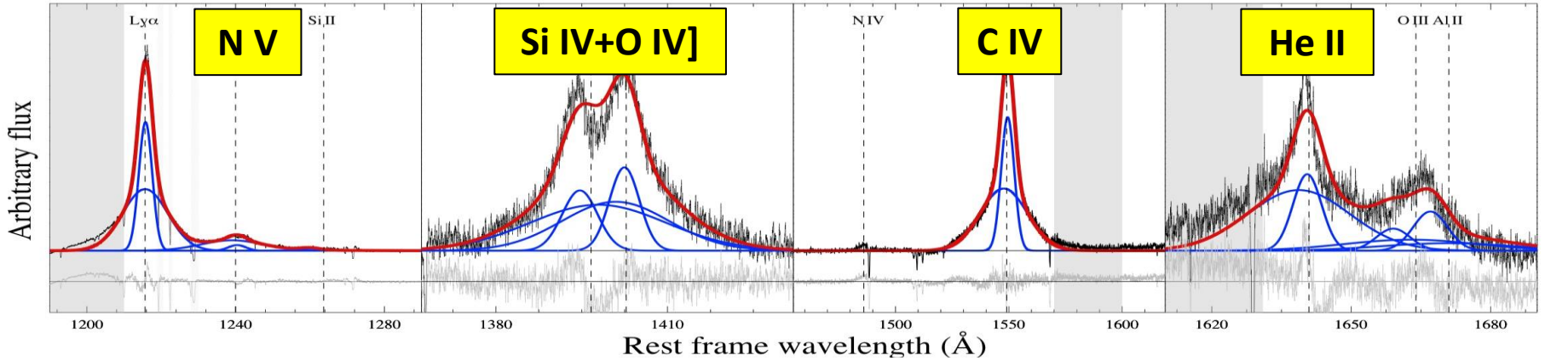
(Hamann & Ferland 1992, 1993; Hamann et al. 2002 ; Nagao et al. 2006)



Nagao et al. 2006

Measurement

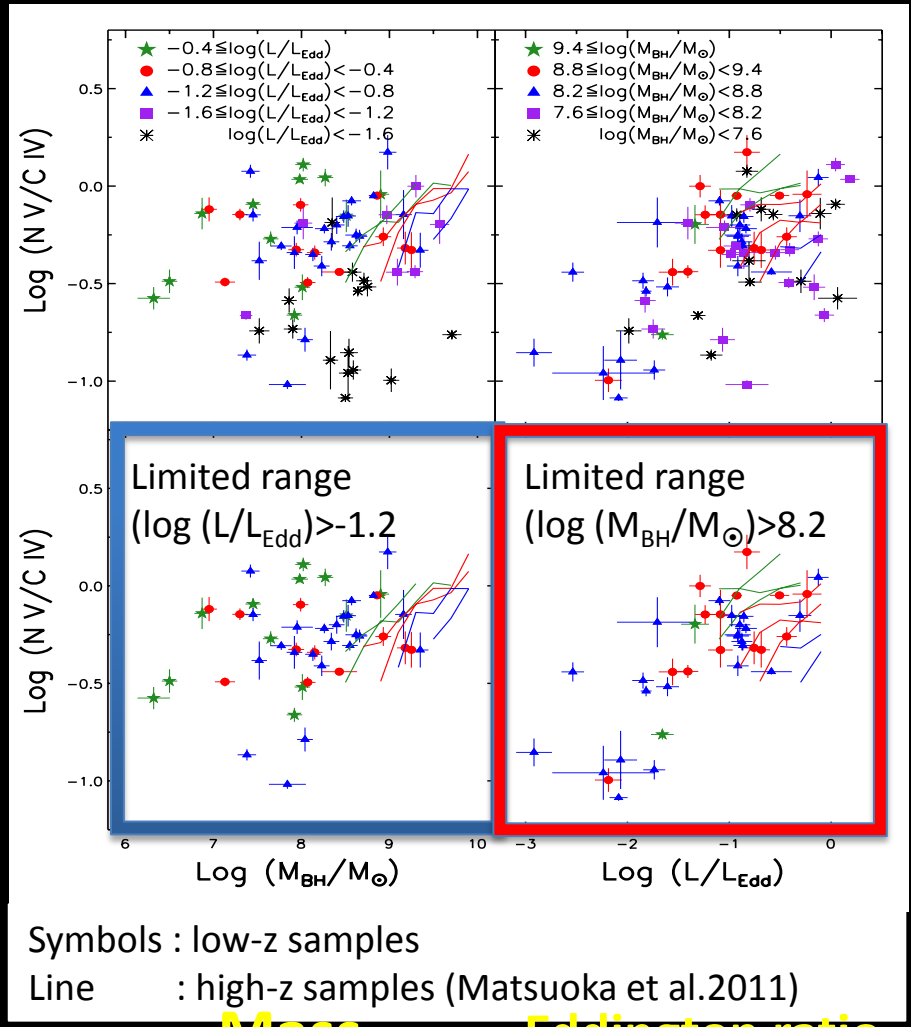
- To fit accurately, we use multi component fitting method.
- We adopted double gaussian line profile.



PG0003+199 observed by HST/COS

Result

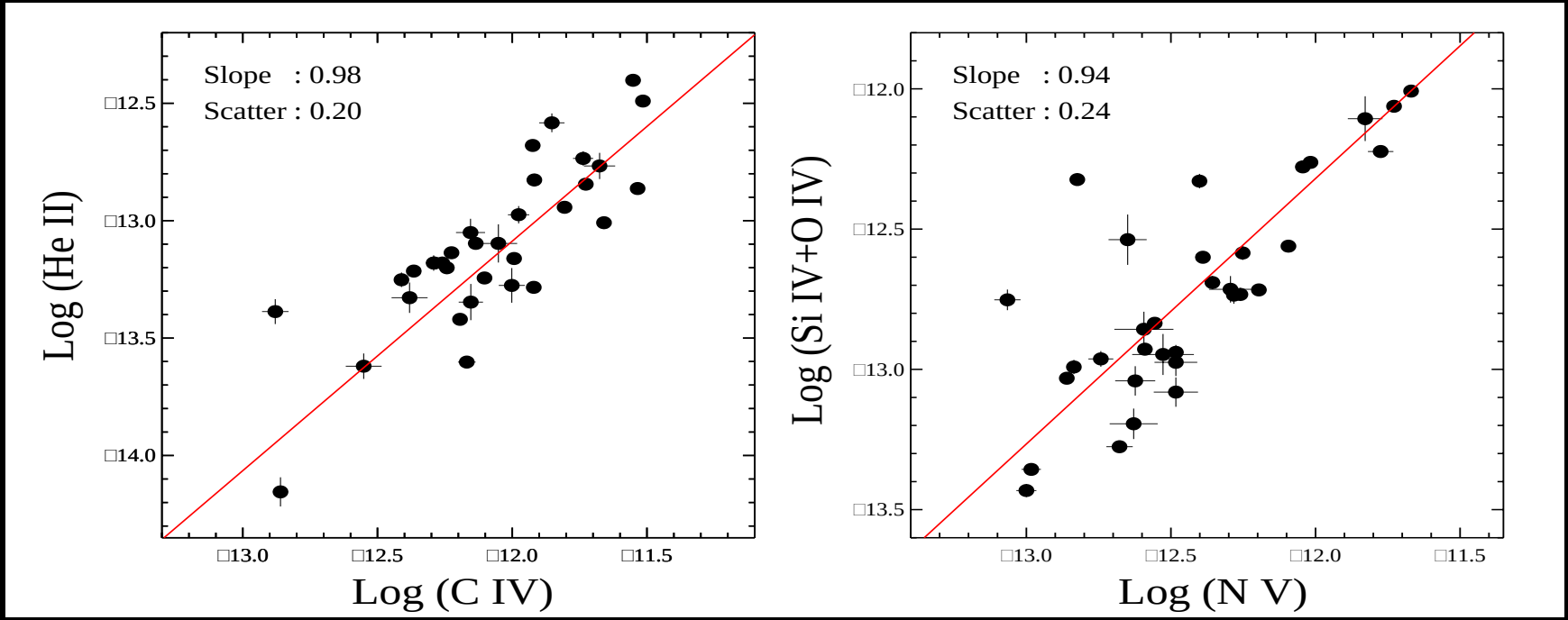
- We compare our result (symbols) with result of high-z quasars (lines) using strong line ratio NV/CIV .
- We limited dynamical range to match high-z result.
- There is weak correlation between M_{BH} and Z_{BLR} in low-z.



Metallicity

Mass **Eddington ratio**

Comparison of emission line fluxes



Comparison among metallicity indicators