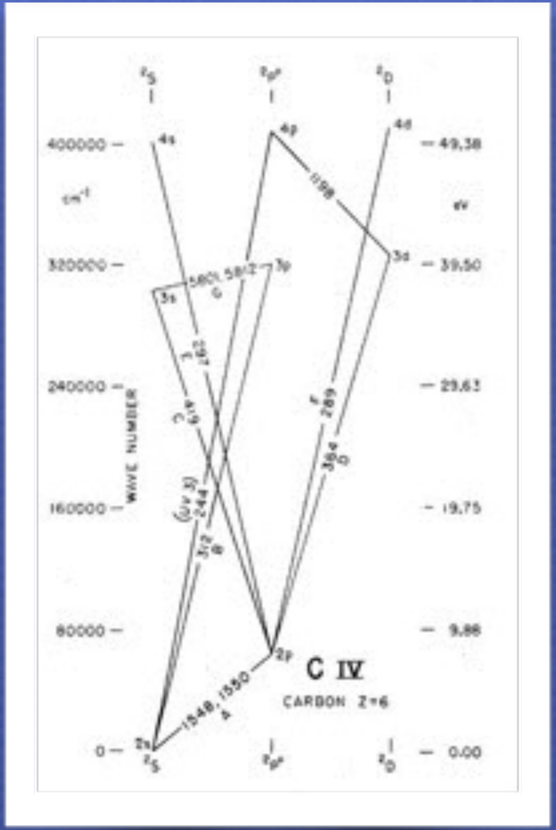
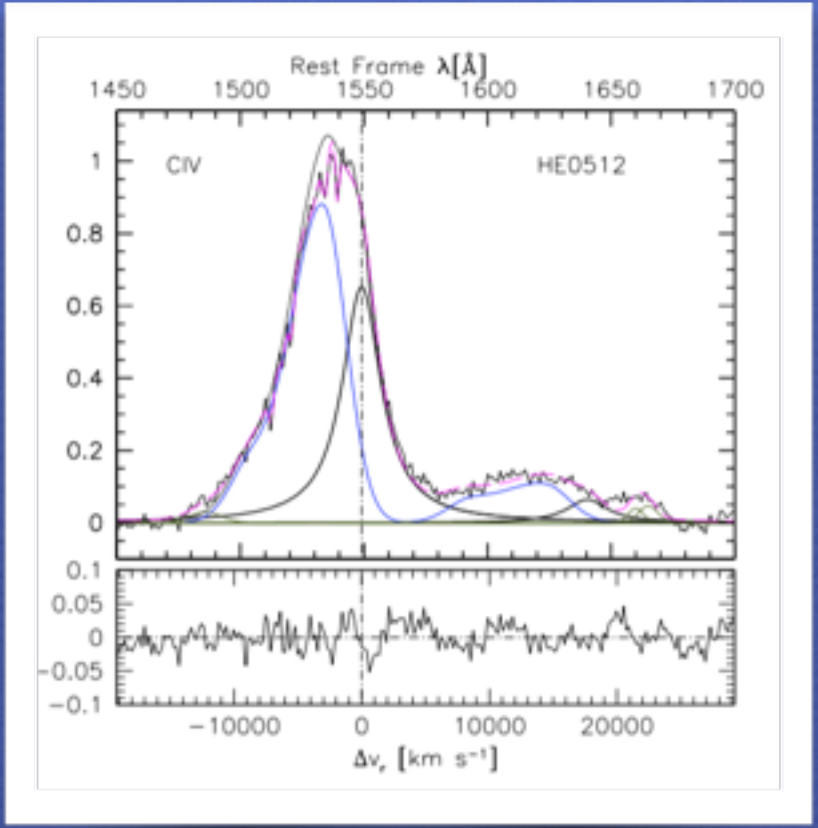
# THE MOST POWERFUL QUASAR OUTFLOWS AS SEEN FROM THE CIV λ1549 RESONANCE LINE (in emission)





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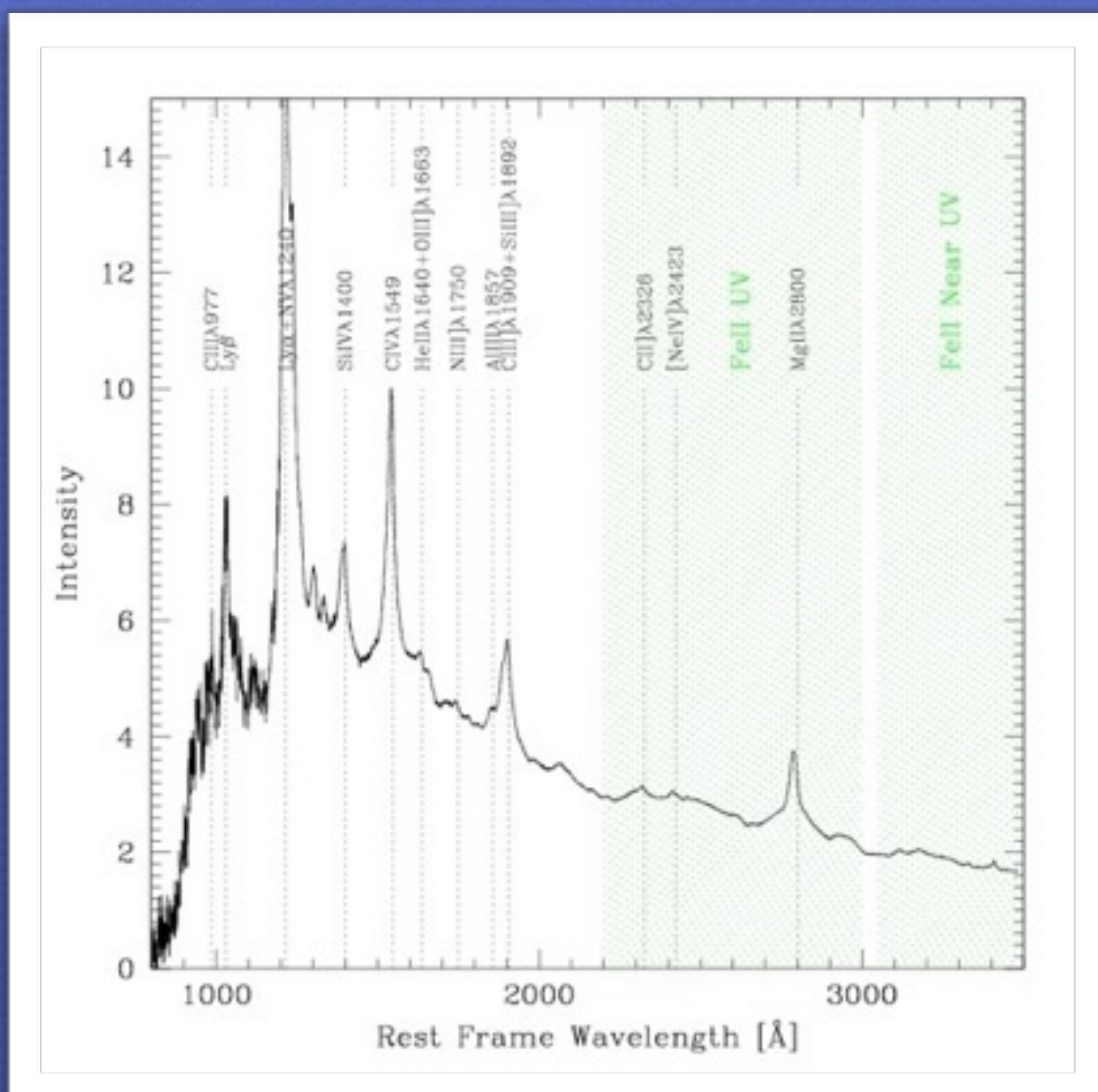
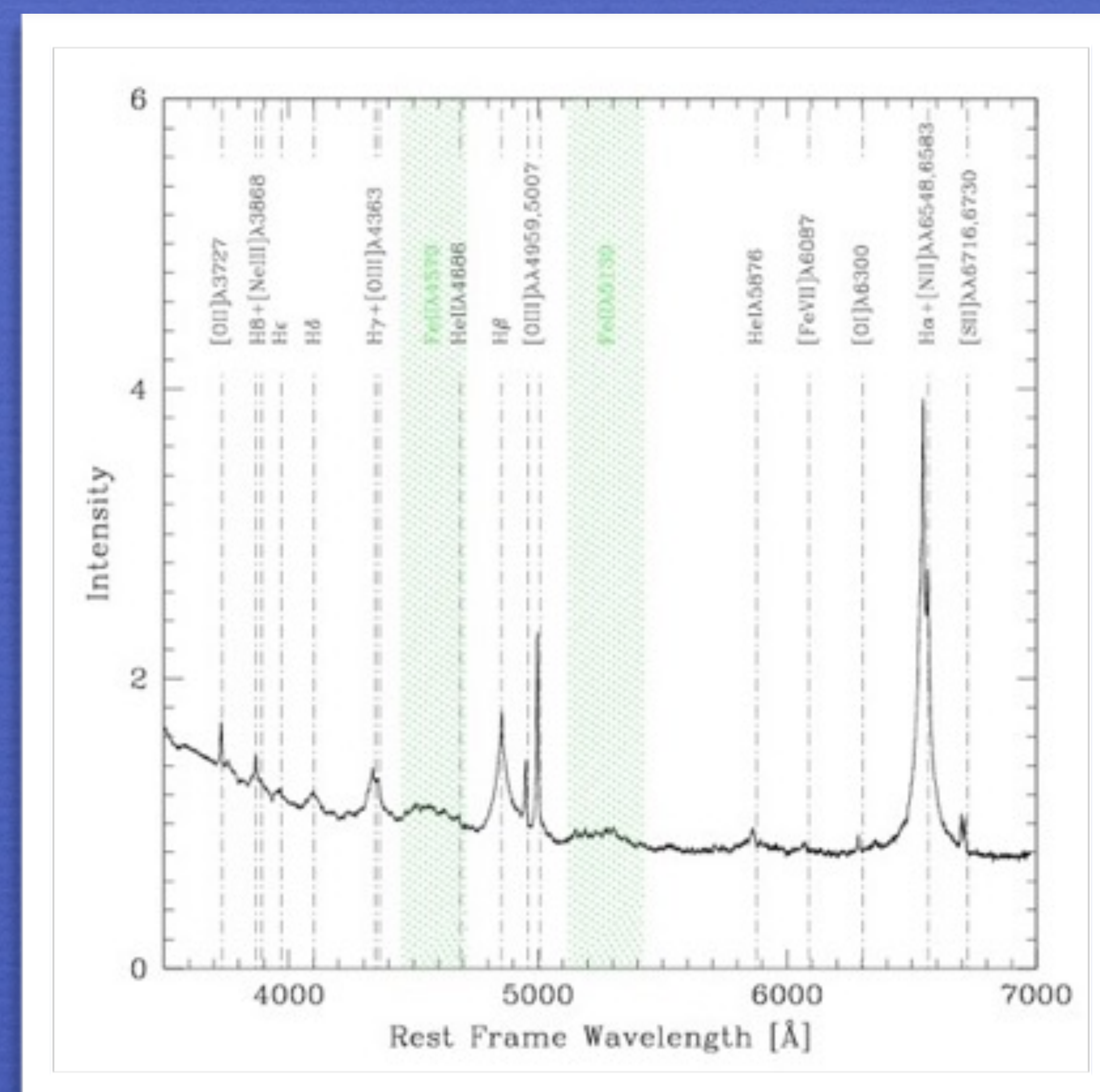
# Quasars' optical and UV spectrum

broad and narrow lines emitted by ionic species over a wide range of IPs

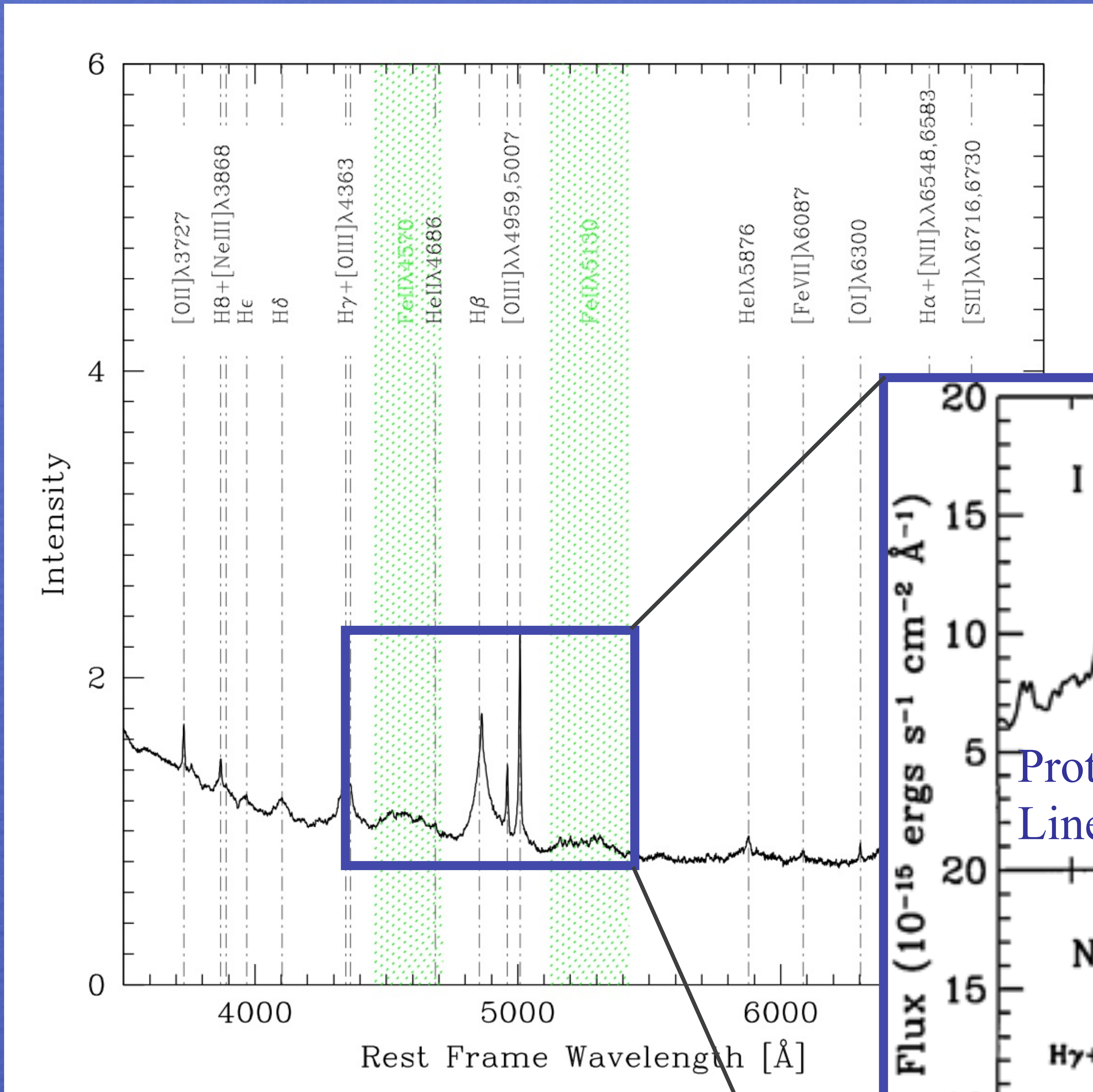
| | Broad | Narrow |
|---|---|---|
| High Ionization | CIVλ1549, HeII | [OIII]λλ4959,5007, HeII,NeIII |
| Low Ionization | Balmer (Hβ), FeII, MgIIλ2800, CaII IR Triplet) | Balmer, [OI]λ6300, |

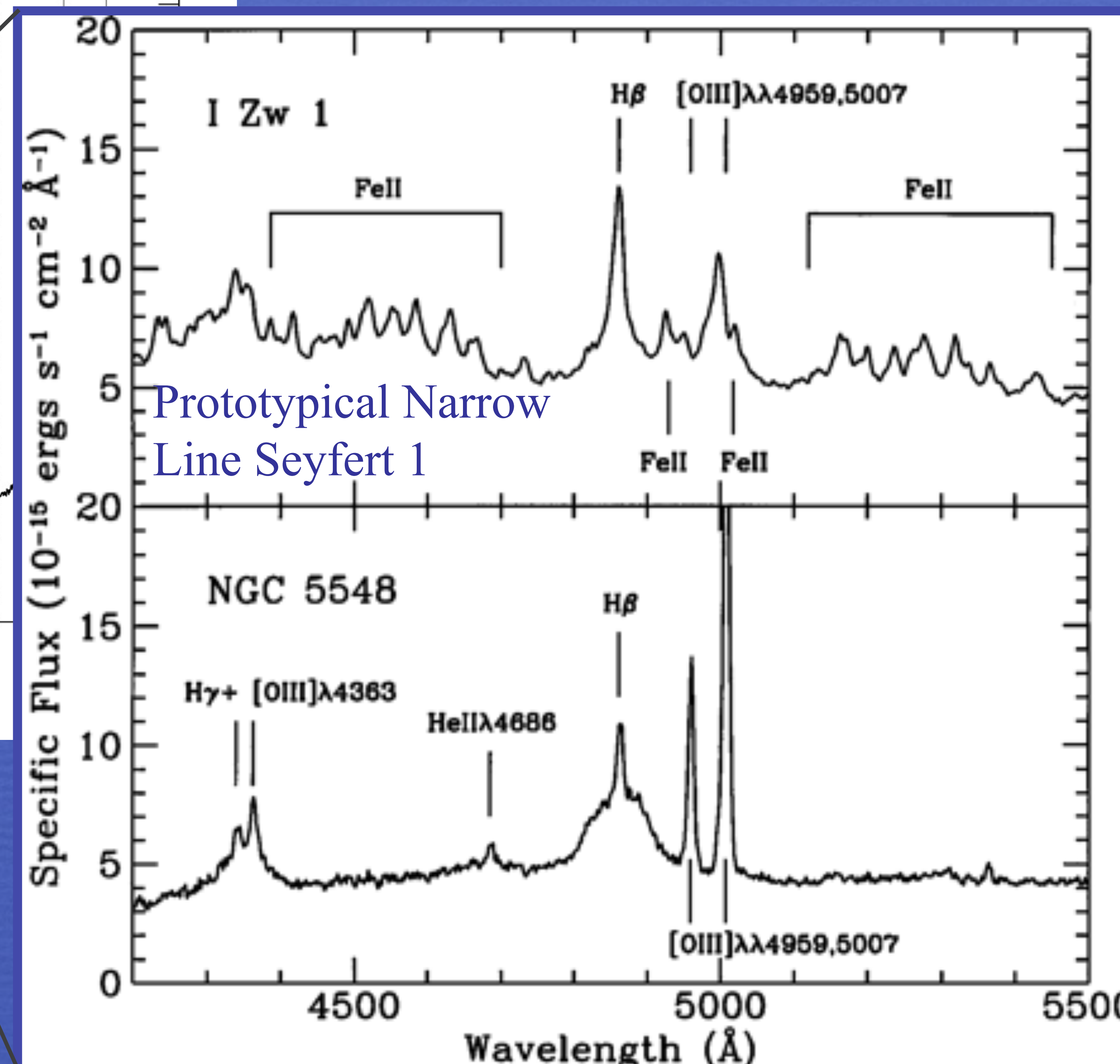



The composite quasar spectrum from the Sloan DSS (Van den Berk et al. 2001; Marziani et al. 2006)

# Quasars do not all show the same spectrum!

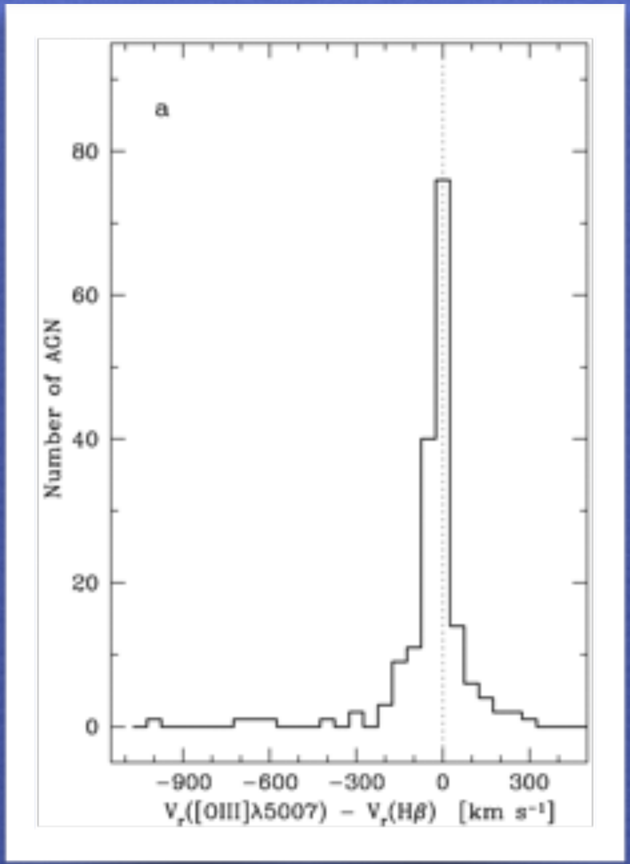


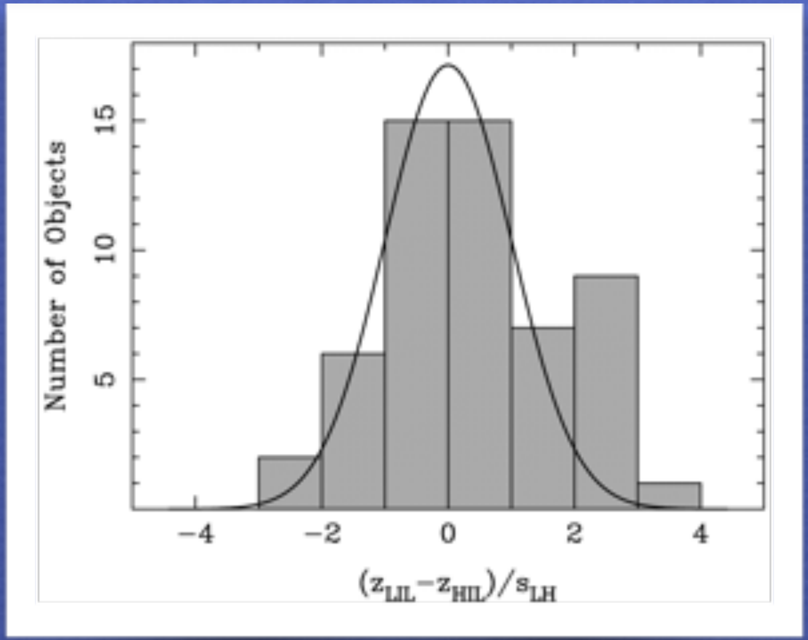

Widely different line profiles, intensity ratios, ionization level

# Lines do not all show the same profiles!

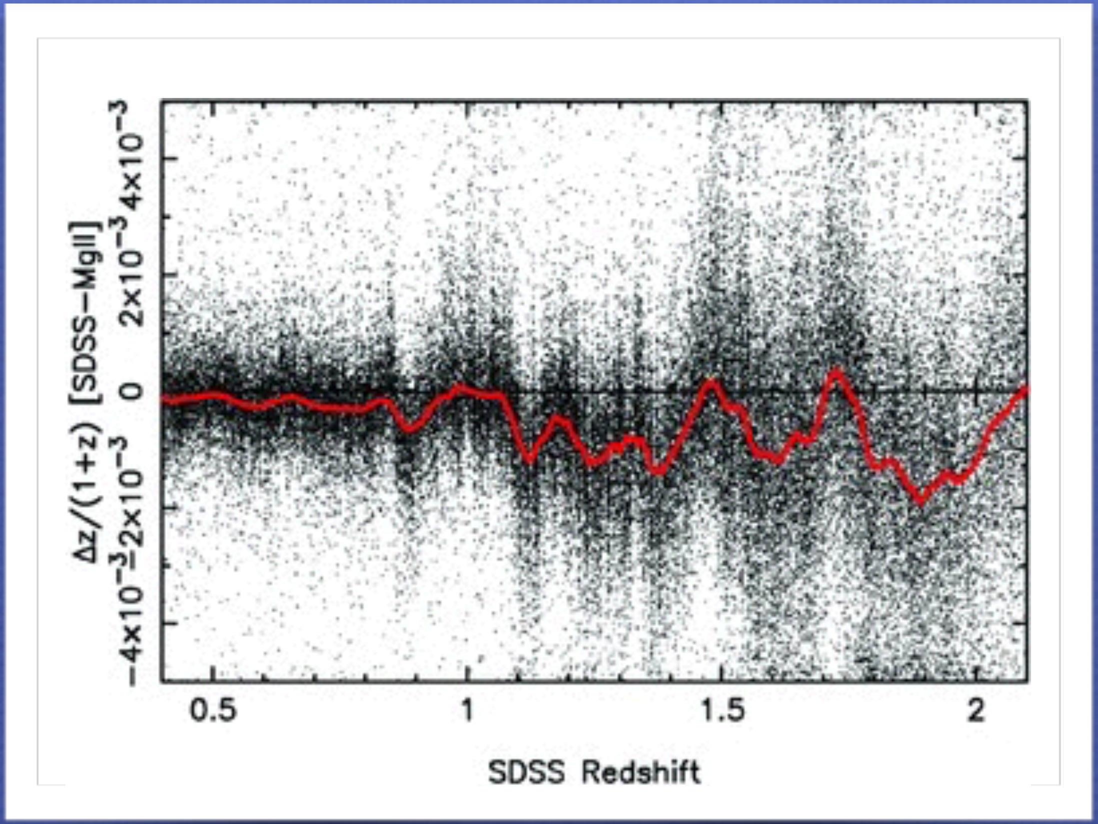
## Internal emission line shifts involve both broad and narrow linesl




Zamanov et al. 2002




Eracleous & Halpern 2003
c.f. Hu et al. 2008




Hewett and Wild 2010

Narrow low-ionization lines such as narrow Hβ and [OII]λ3727 best for systemic redshift

Quasar systemic redshift more uncertain if $z>1$

# Internal emission line shifts

## HIL blueshifts provide evidence of outflow require rest frame knowledge and proper contextualisation

TABLE 1

PUBLISHED EMISSION-LINE VELOCITY SHIFTS

| Line − Reference Line | Velocity[a] (km s$^{-1}$) | N[b] | σ (km s$^{-1}$) | Reference |
|---|---|---|---|---|
| **High Ionization − Low Ionization** | | | | |
| C IV − [O II] λ3727 ........ | 40 ± 70 | 13 | 230 | 1 |
| C IV − Hα ............. | −1140 ± 290 | 17 | 1180 | 2 |
| C IV − O I λ1304 ...... | −560 ± 120 | 23 | ... | 3 |
| C IV − O I λ1304 ...... | −1290 ± 180 | 19 | 800 | 4 |
| C IV − C II λ1335 ...... | −1320 ± 400 | 7 | 1046 | 4 |
| C IV − Mg II ........... | −565 ± 100 | 17 | ... | 3 |
| C IV − Mg II ........... | −460 ± 110 | 15 | 410 | 1 |
| C IV − Mg II ........... | −980 ± 180[c] | 26 | 930 | 5 |
| C III] − Mg II .......... | −600 ± 90 | 44 | 600 | 4 |
| C III] − Hα ............ | −880 ± 230 | 16 | 920 | 2 |
| Lyα − Hα ............. | −1770 ± 370[d] | 11 | 1230 | 2 |
| **High Ionization − High Ionization** | | | | |
| C IV − C III] ........... | 120 ± 150 | 65 | 1200 | 4 |
| C IV − C III] ........... | −530 ± 110 | 25 | 570 | 5 |
| C IV − Lyα ............ | −400 ± 100 | 55 | ... | 3 |
| C IV − N V ............ | −170 ± 100 | 26 | ... | 3 |
| **Low Ionization − Low Ionization** | | | | |
| Mg II − [O II] .......... | −200 ± 170 | 22 | 810 | 4 |
| Mg II − [O II] .......... | 380 ± 80 | 12 | 270 | 1 |
| Mg II − Hα ............ | −140 ± 120 | 17 | 510 | 2 |
| O I − Hα .............. | −390 ± 470 | 4 | 930 | 2 |
| [O III] − Hβ ........... | −220 ± 150 | 23 | 730 | 4 |
| [O II] − [O III] ......... | 100 ± 130 | 6 | 310 | 4 |

[a] Mean velocity of first ion in the reference frame of the $z$ given by second ion, $\pm\sigma/\sqrt{N}$.

[b] Number of QSOs.

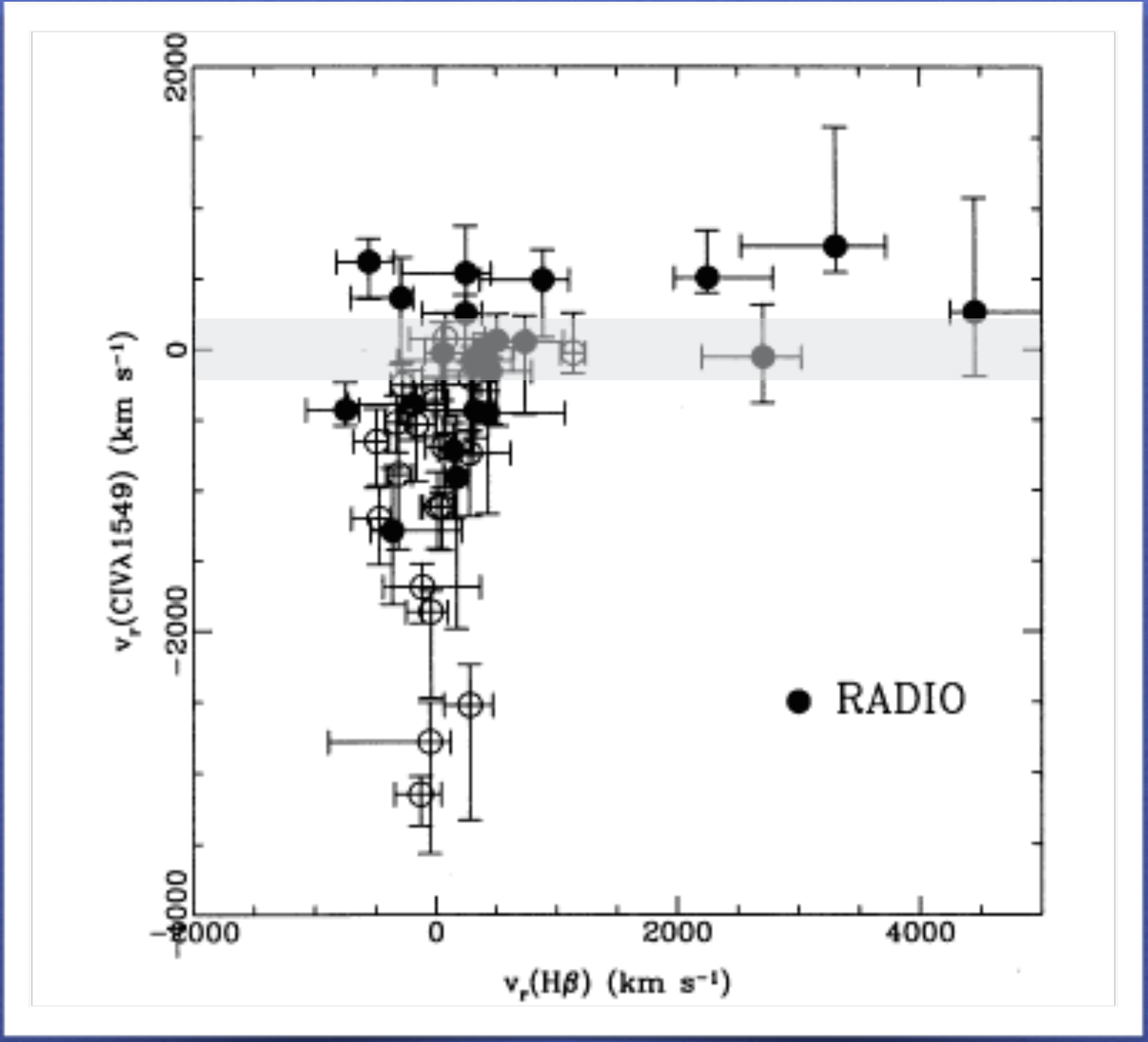
[c] Reduces to −780 when two QSOs with −4400 and −2500 are excluded.

[d] Reduces to −1420 when one outlier value of −5200 is excluded.

REFERENCES.—(1) Junkkarinen 1989; (2) Espey et al. 1989; (3) Gaskell 1982; (4) Wilkes 1986; (5) Corbin 1990—excluding BAL QSOs.

Tytler & Fan 1992; Gaskell 1982

A first contextualisation (radio quiet vs. radio loud)




Sulentic et al. 1995

(4D)Eigenvector 1 quasar contextualization at low-$z$

Interpretation of the CIV$\lambda$1549 emission line profile
evidence of outflows

analysis of the CIV$\lambda$1549 line at high-$z$ and very high $L$
*with coverage of Hβ-spectral range*

extreme outflows
(weak lined quasars, (WLQ)s, extreme Pop. A quasars)

feedback on host galaxy?

# 4DE1 contextualization

# Organizing quasar spectral diversity — Quasars' (4D) Eigenvector 1

Boroson & Green 1992; see also Gaskell et al. 1999

Originally defined by a Principal Component Analysis of PG quasars, and associated with an anticorrelation between strength of FeIIλ4570 and width of Hβ

Found in several independent samples

(Dultzin-Hacyan et al. 1997; Shang et al. 2003, Yip et al.2004, Sulentic et al. 2000, 2007, Kruzcek et al 2011 Tang et al. 2012); Recently confirmed by an analysis of SDSS data (Shen & Ho 2014, Sun & Ho 2015)

Found for multi-dimensional parameter spaces

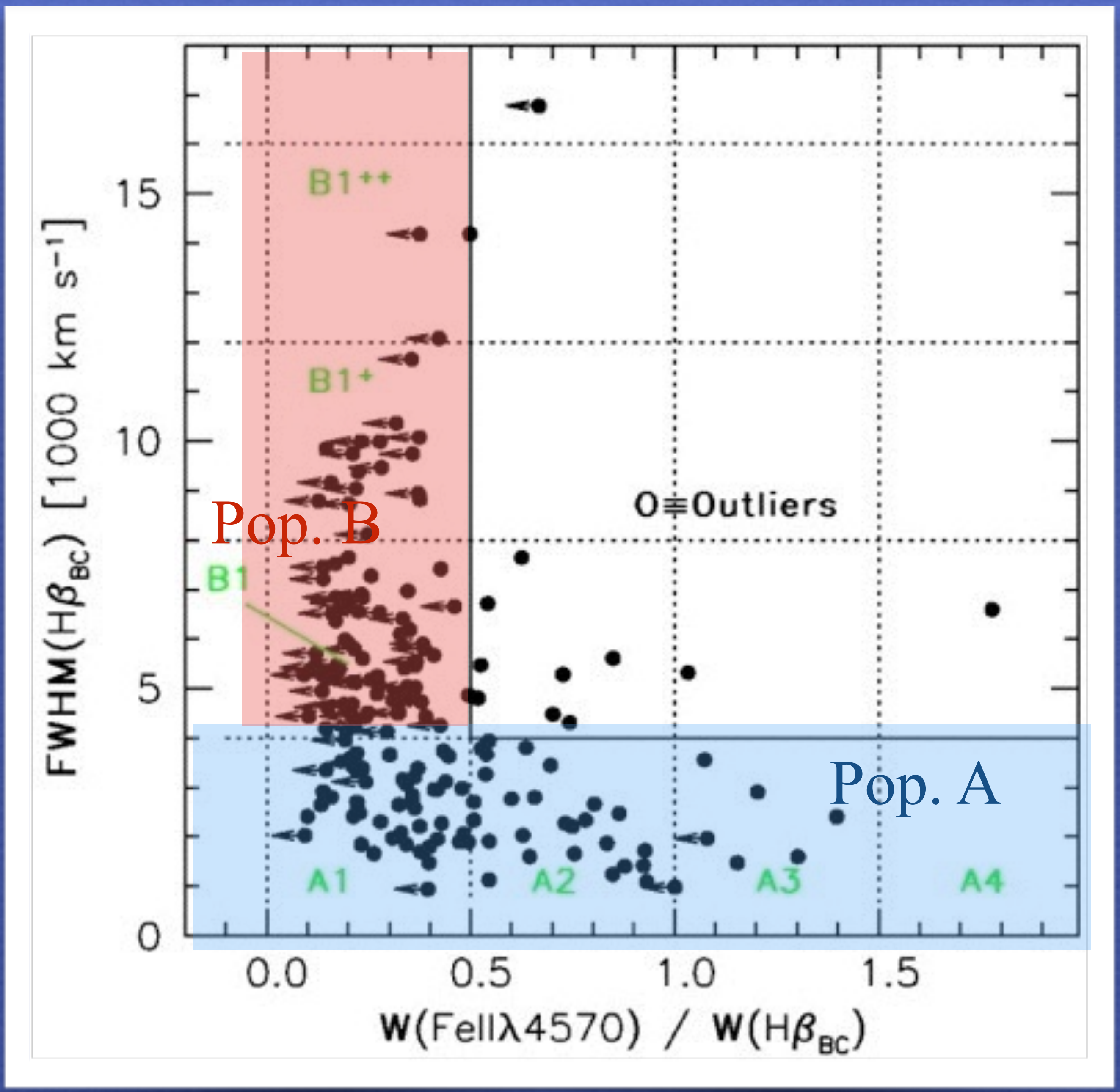
(Kuraszkiewicz et al. 2008; Mao et al. 2009; Grupe 2004, Wang et al. 2006; Bachev et al. 2004; Sulentic et al. 2007)

The 4DE1 space of Sulentic et al. includes CIVλ1549 line shift and soft-X ray photon index

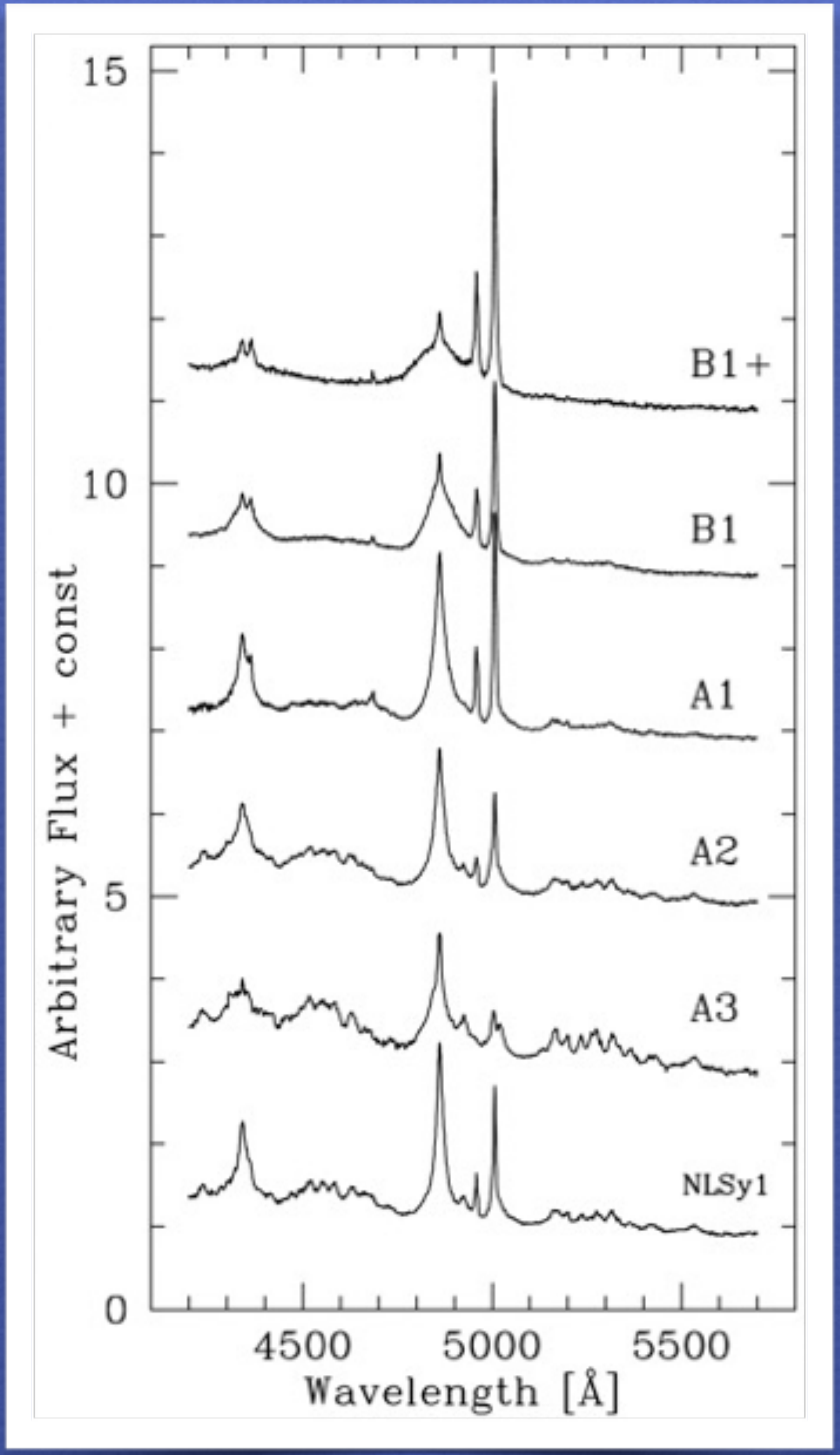
Eigenvector 2: luminosity effects "Baldwin effect(s)"

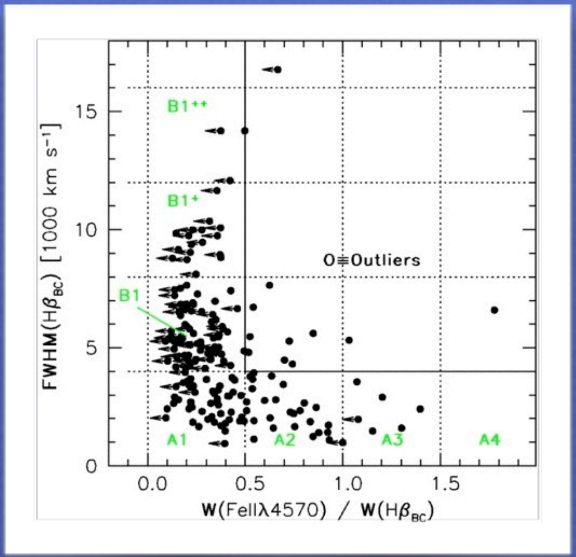
e.g. Balwin et al. 1978, Bian et al. 2005

# Optical plane of Eigenvector 1: Spectral types in bins along a 1D sequence; Population A and population B

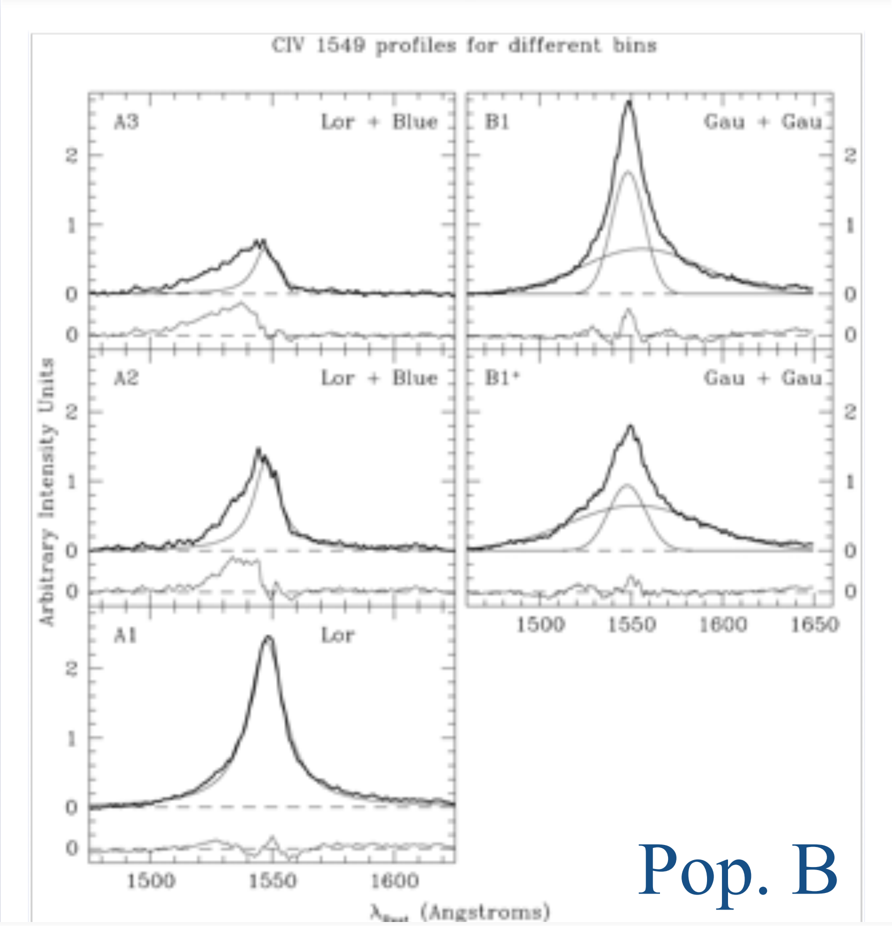



Sulentic et al. 2002



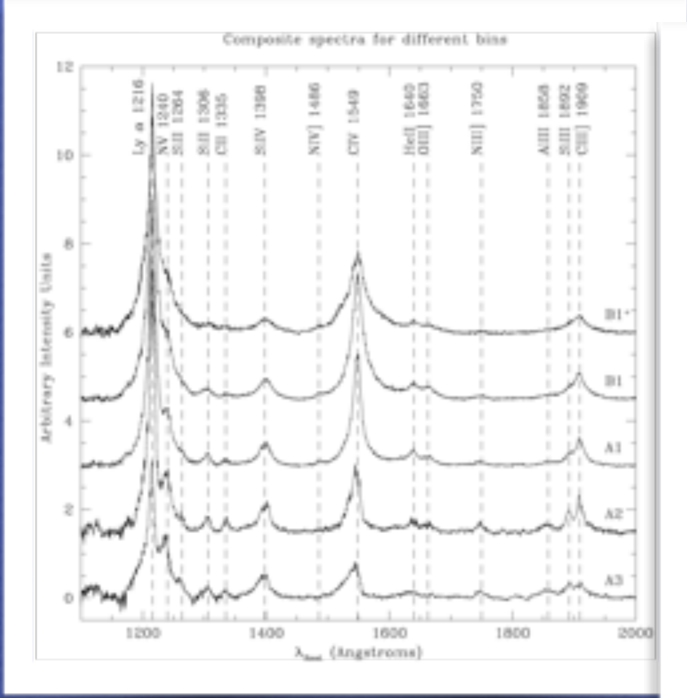


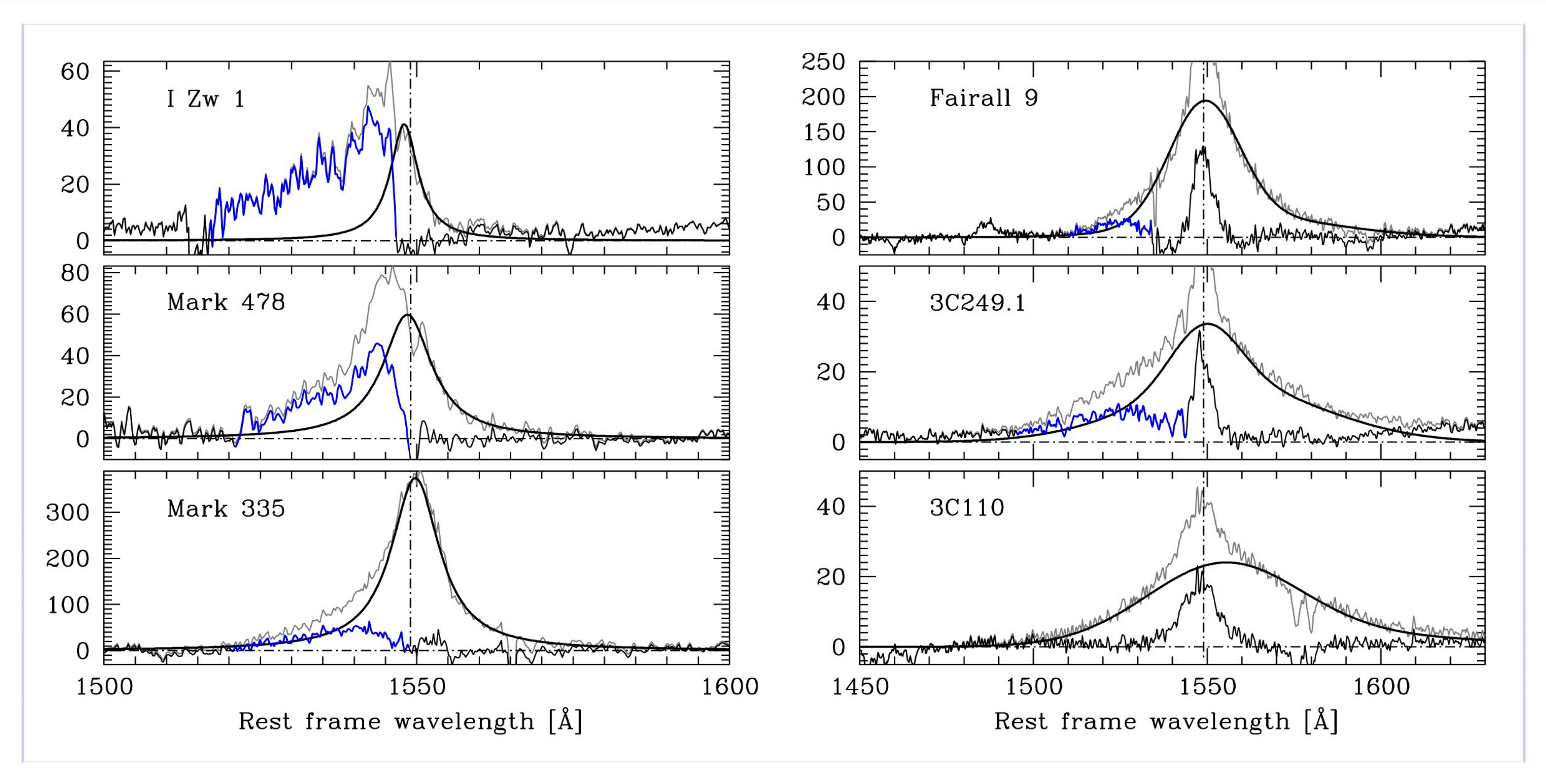

# UV correlates of Eigenvector 1: UV diagnostic ratios and CIV 1549 profile: blueshifted excess




Pop. A

Pop. B




Bachev et al. 2004,
Marziani e al. 2010

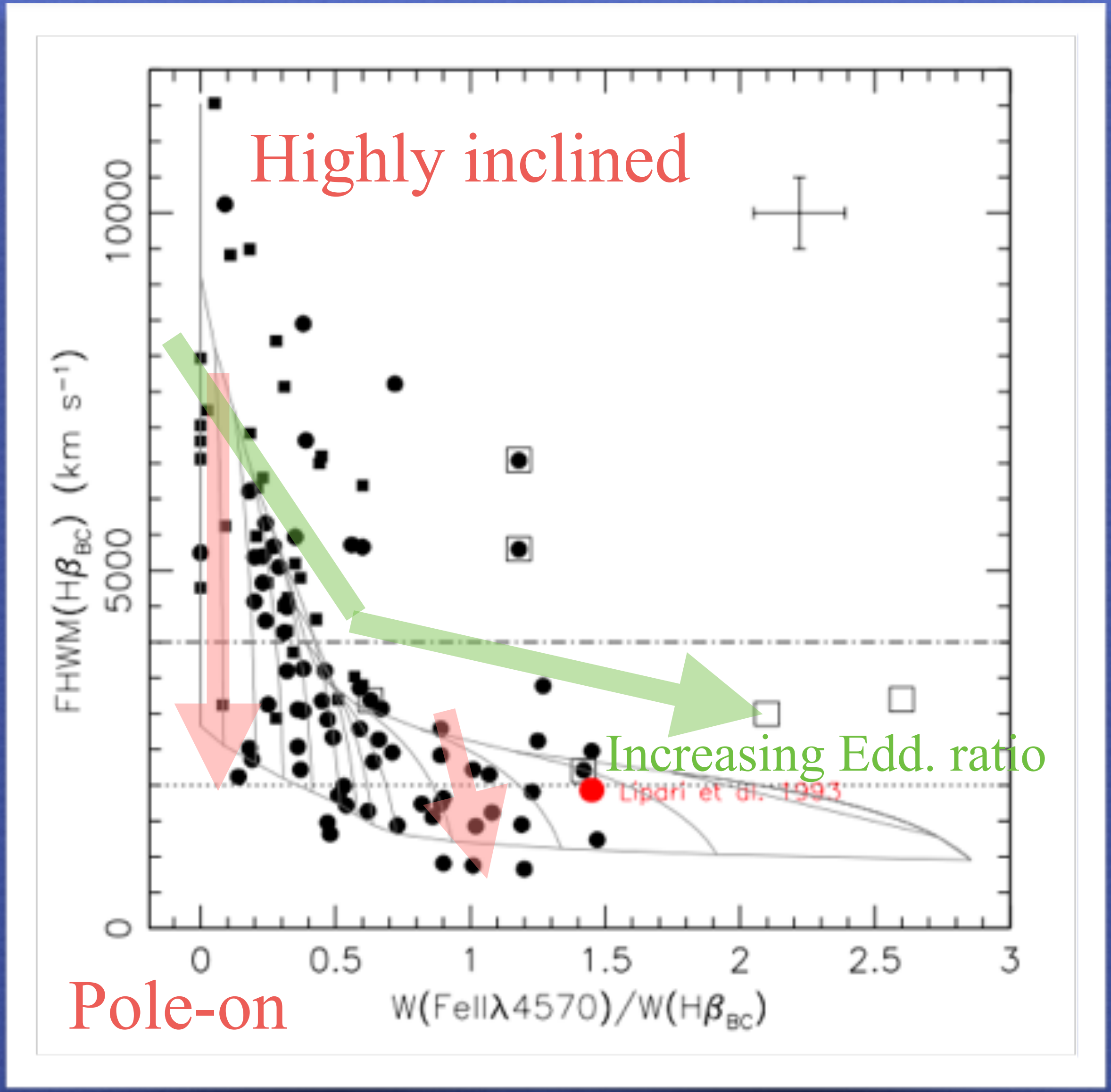
# Optical plane of 4DE1: a sequence of Eddington ratio

with significant orientation and black hole mass effects

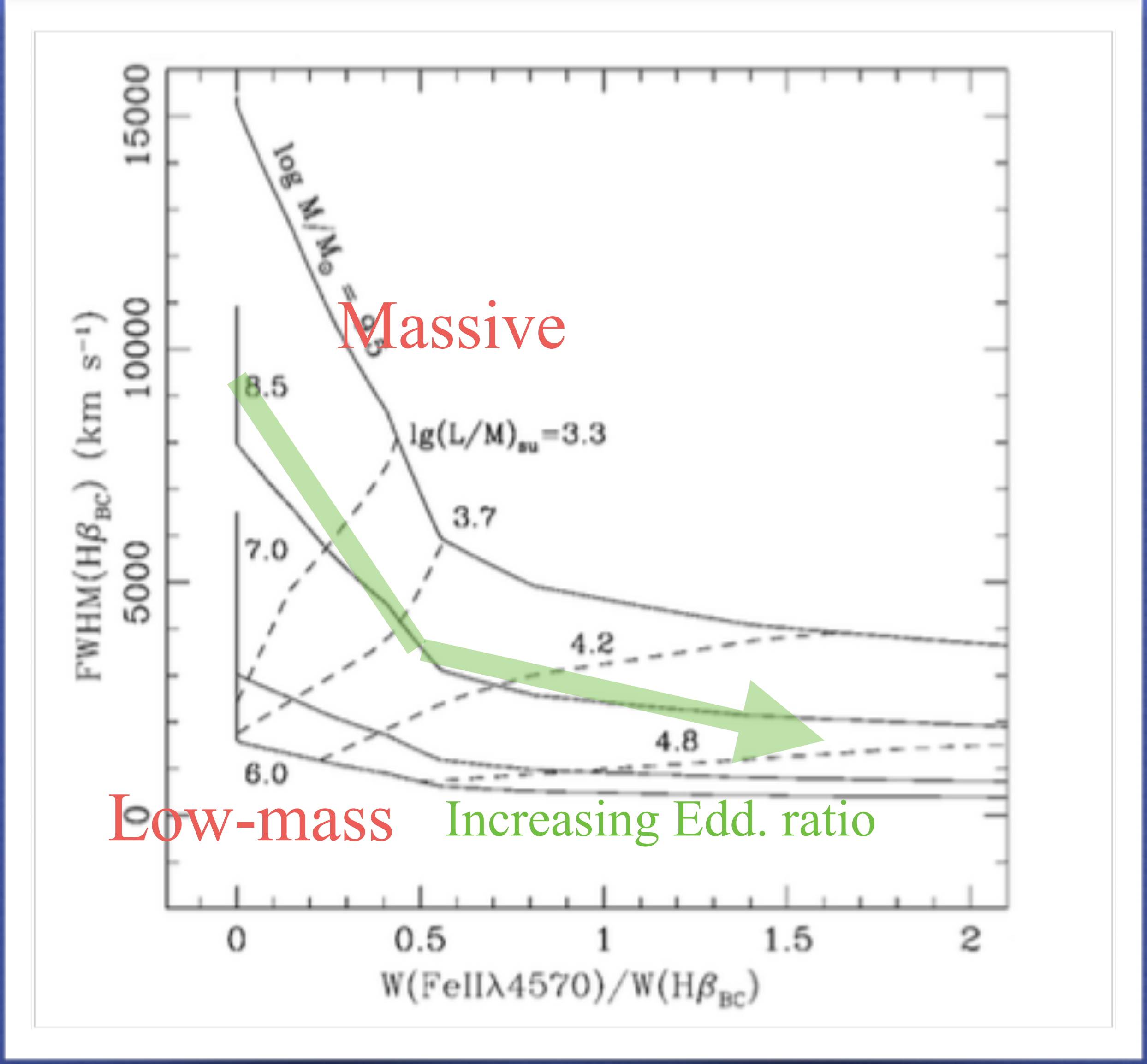
Ionization parameter $U = \frac{\int_{\nu_0}^{+\infty} \frac{L_\nu}{h\nu} d\nu}{4\pi r_{\rm BLR} n_{\rm e} c}$ written as a function of $L/M_{\rm BH}$ and $M_{\rm BH}$

assuming virial broadening, FeII and line width orientation dependence, $L \propto r^{a}$

Fixed black hole mass




Varying black hole mass, average orientation

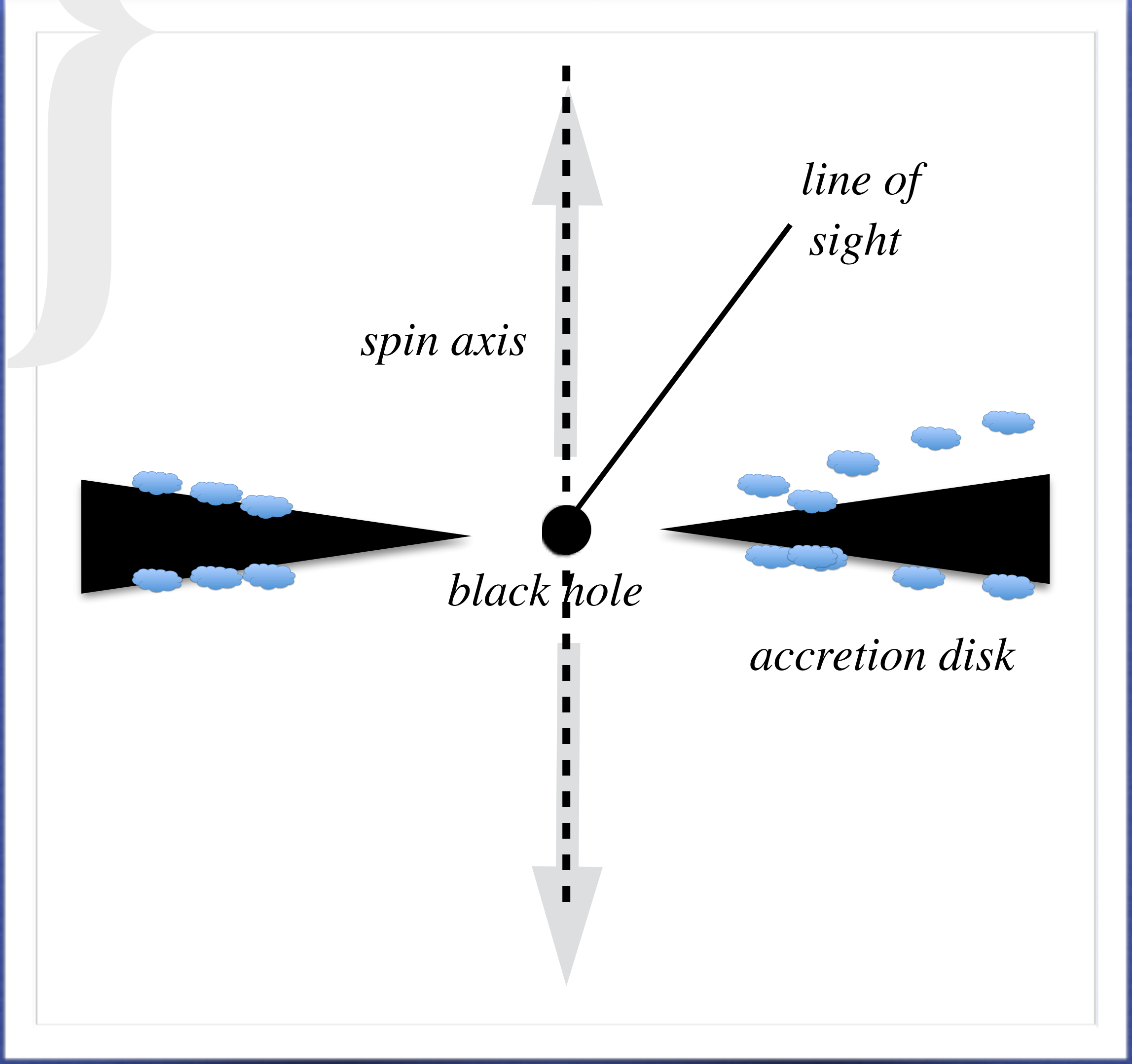



Marziani et al. 2001; Zamanov & Marziani 2002, cf. Shen & Ho 2014, Sun & Shen 2015

# The 4D Eigenvector 1 space of quasars

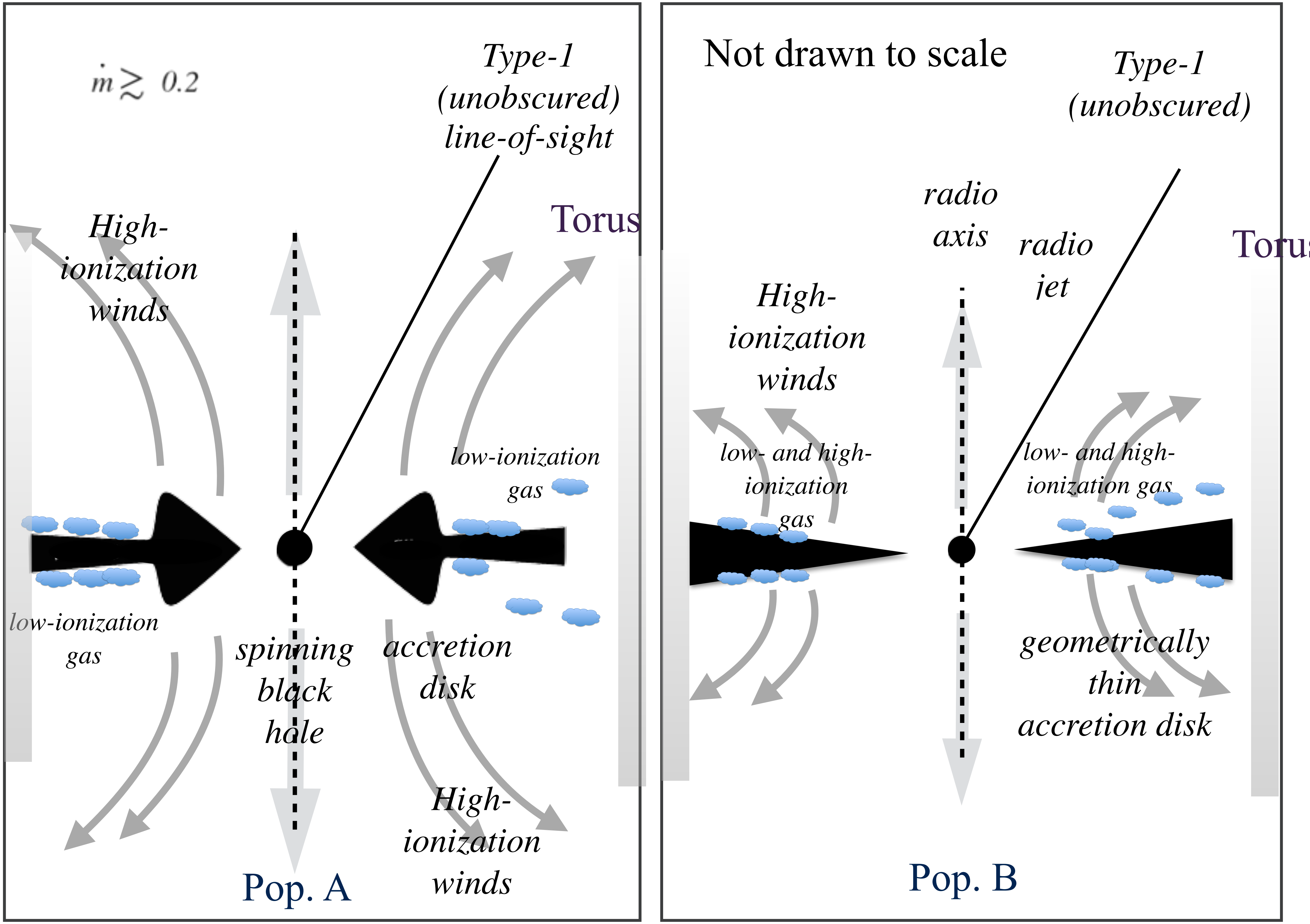
| Observed parameter | Physical interpretation | Accretion-related parameters |
| --- | --- | --- |
| $R_{FeII}$=I(FeII)/ I(Hβ) | ionization degree *col. density, Z* | $L/L_{Edd}$ |
| FWHM(Hβ) | velocity field of low-ionization gas | $L/L_{Edd}$, $M_{BH}$, orientation |
| CIVλ1549 Shift | velocity field of high-ionization gas | $L/L_{Edd}$, orientation |
| $\Gamma_{soft}$ (0.2-2 KeV) | Compton thick / accretion disk emission? | $L/L_{Edd}$ |

Optical plane of 4DE1

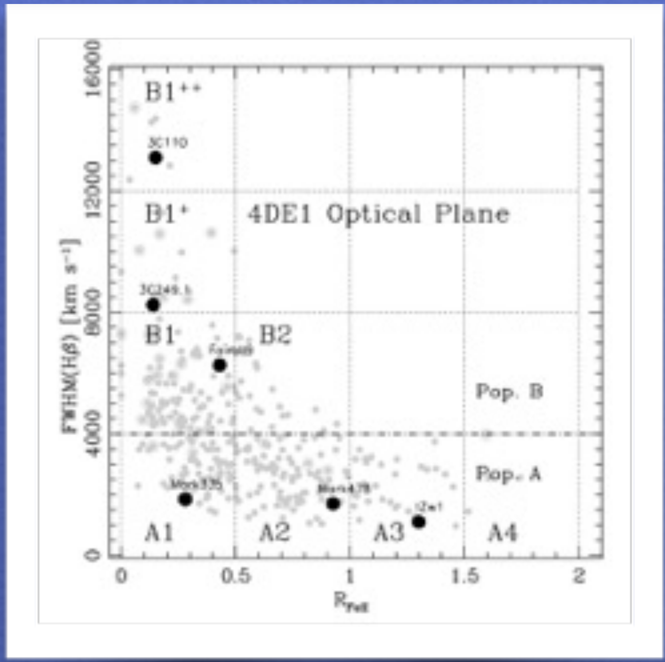


# Pop. A/B transition: geometrically thick/thin disk?

Abramowicz et al. 1988, Shakura & Sunyaev 1973



# Interpretation of the CIV$\lambda$1549 emission line profile

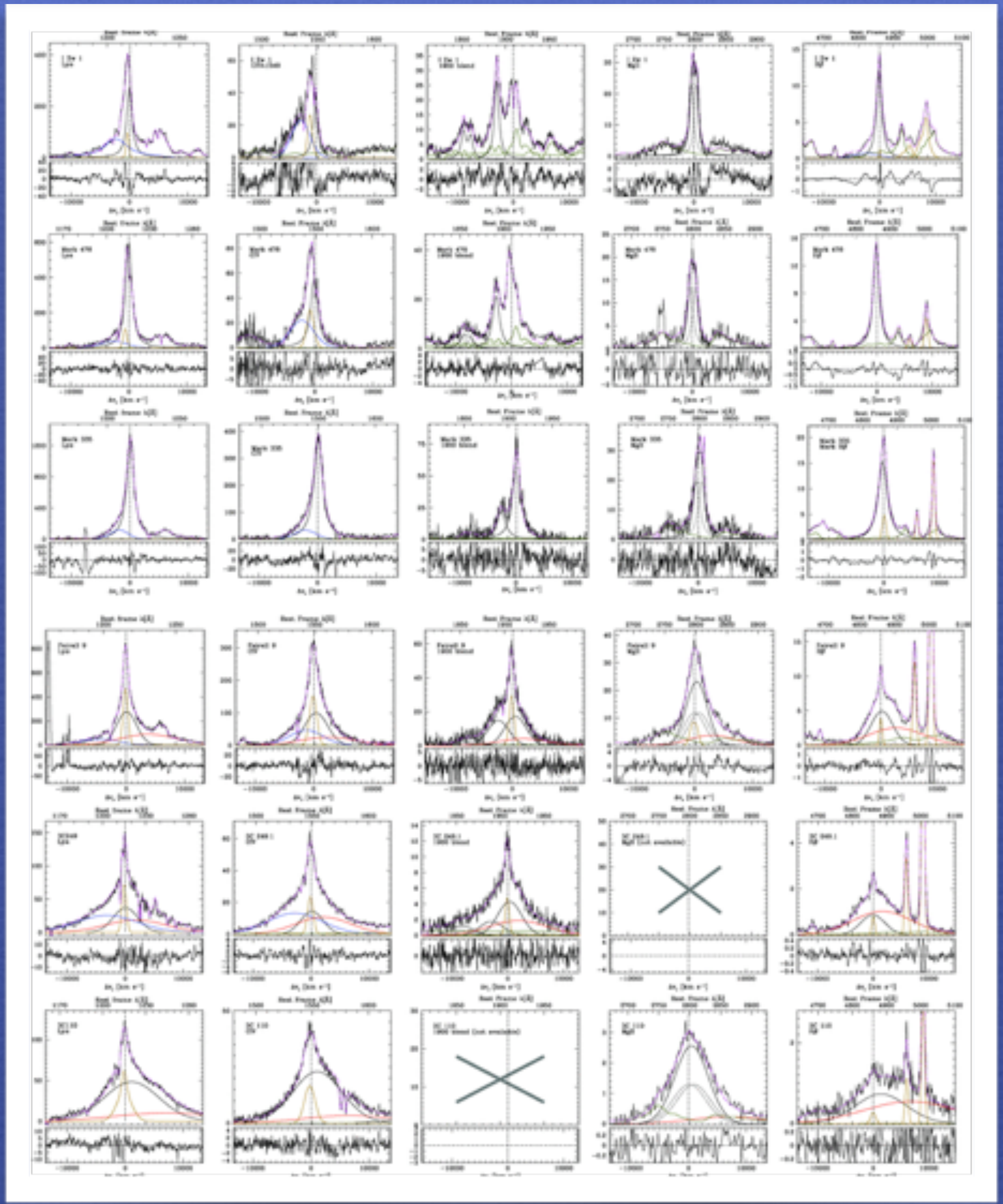



# Strongest emission lines along the 4DE1 sequence can be empirically reproduced by three main components

Blueshifted component (BLUE): strong in Lyα, CIVλ1549, HeIIλ1640

"Broad Component"(BC) strong in all low ionization lines: FeII, MgIIλ2800, Hβ

"Very Broad Component" (VBC FWHM~10000 km $s^{-1}$) redshifted: strong in Lyα, CIVλ1549, HeII, Balmer lines absent in FeII



Marziani et al. 2010

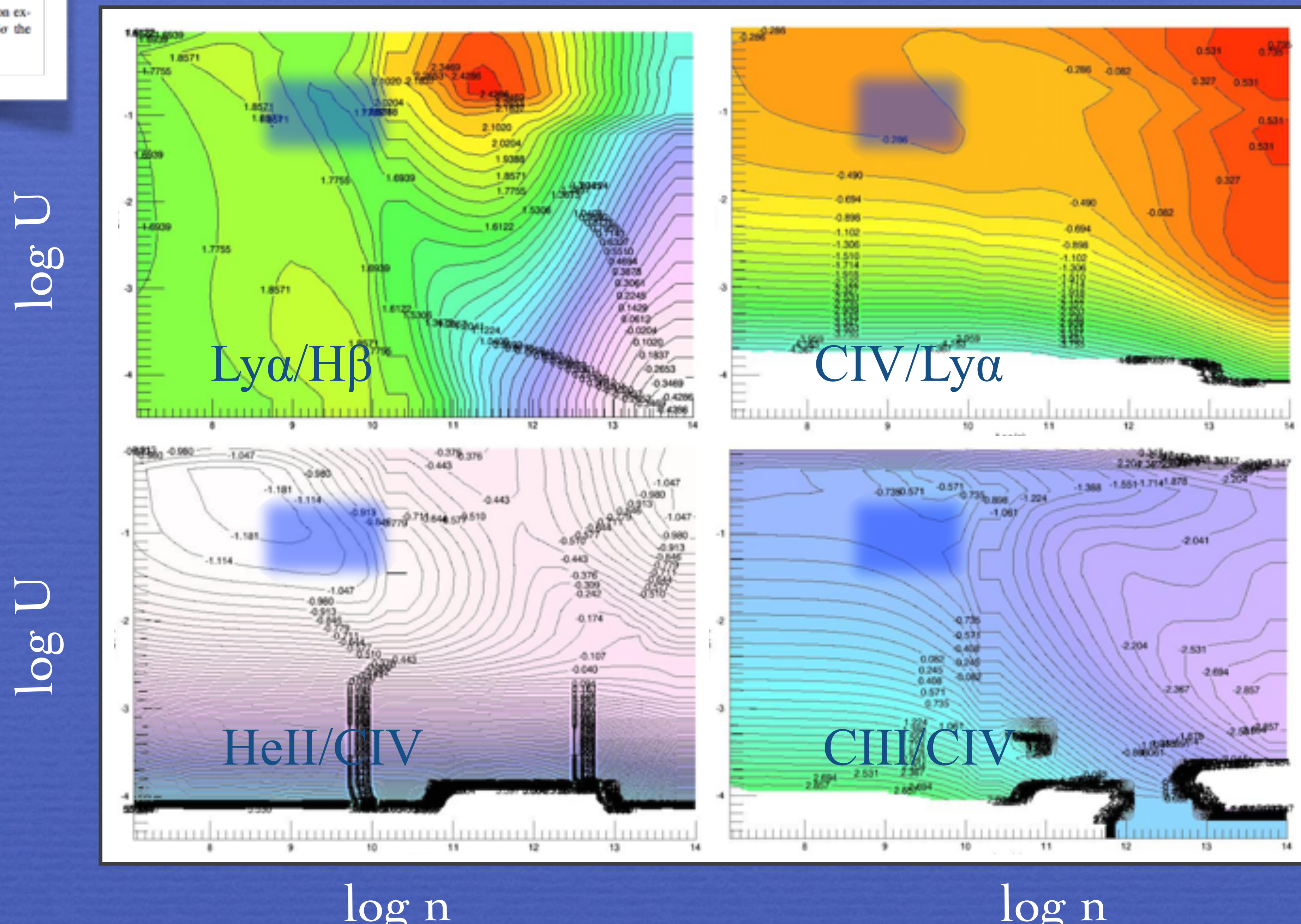
# Blueshifted component physical conditions

Results of Cloudy 08.00 (Ferland et al. 1998,2013) simulations as a function of density and ionization parameter $U$

**Table 4.** BLUE: FWHM ~ 7000 km s$^{-1}$, $\Delta v_r$ ~ −3000 km s$^{-1}$.

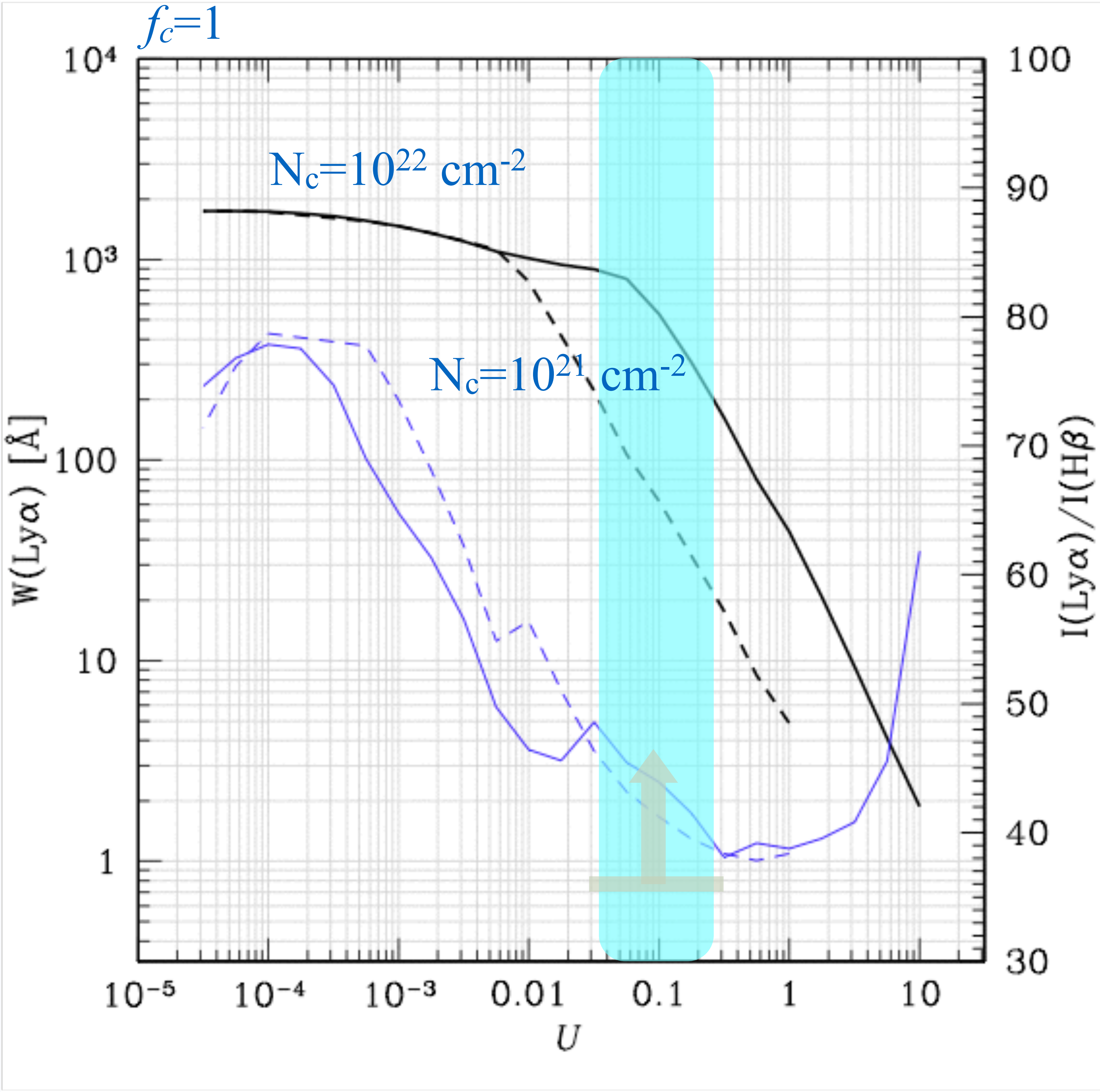
| Sp. T. | Name | Intensity ratio C IV/Lyα | He II/C IV | Hα/Hβ | Lyα/Hβ[b] | $W$[a] Lyα |
|---|---|---|---|---|---|---|
| A3 | I Zw 1 | 0.25 | 0.41 | 4.2 | ~18 | 60 |
| A2 | Mrk 478 | 0.66 | 0.17 | – | ≳46 | 15 |
| A1 | Mrk 335 | 0.45 | 0.67 | – | ≳32 | 16 |
| B1 | Fairall 9 | 1.05 | 0.14 | – | ≳46 | 30 |
| B1$^{+}$ | 3C 249.1 | 0.59 | 0.17 | – | ≳32 | 53 |
| B1$^{++}$ | 3C 110[c] | – | – | – | – | 0 |

[a]EW in Å.
[b]Lower limits to Lyα/Hβ are estimated by the maximum contribution expected by a component of the same shift and width if peaking at 3σ the noise level. See the text for a detailed explanation.
[c]Consistent with 0 intensity in all lines.




BLUE consistent with high ionization ($U$~$10^{-1\pm0.5}$)

and moderate density ($n_H$~$10^{9.5\pm0.5}$ cm$^{-3}$)




# Blueshifted component: large Lyα/Hβ>30

Very different from the other components for which Lyα/Hβ ~ 5 – 10

Matter bounded emitting region?

# Interpretation of the heuristic decomposition of the broad profiles: "stratification"

**broad component** → lower ionization **Broad Line Region**

line broadening predominantly virial; FeII, CaII emission

**very broad component** →

high-ionization inner **Very Broad Line Region (VBLR)**

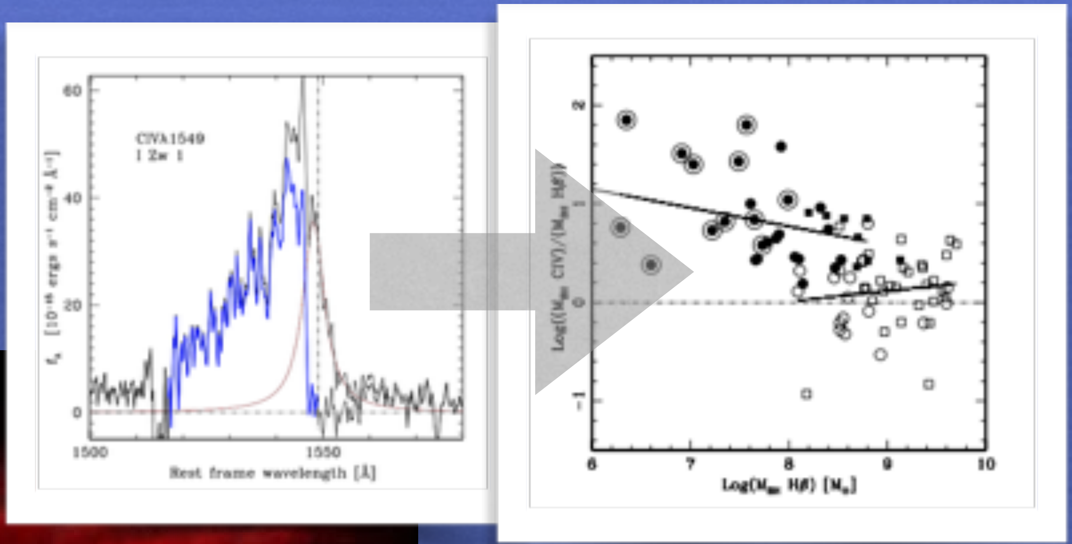
emitting no FeII and showing lower continuuum responsivity

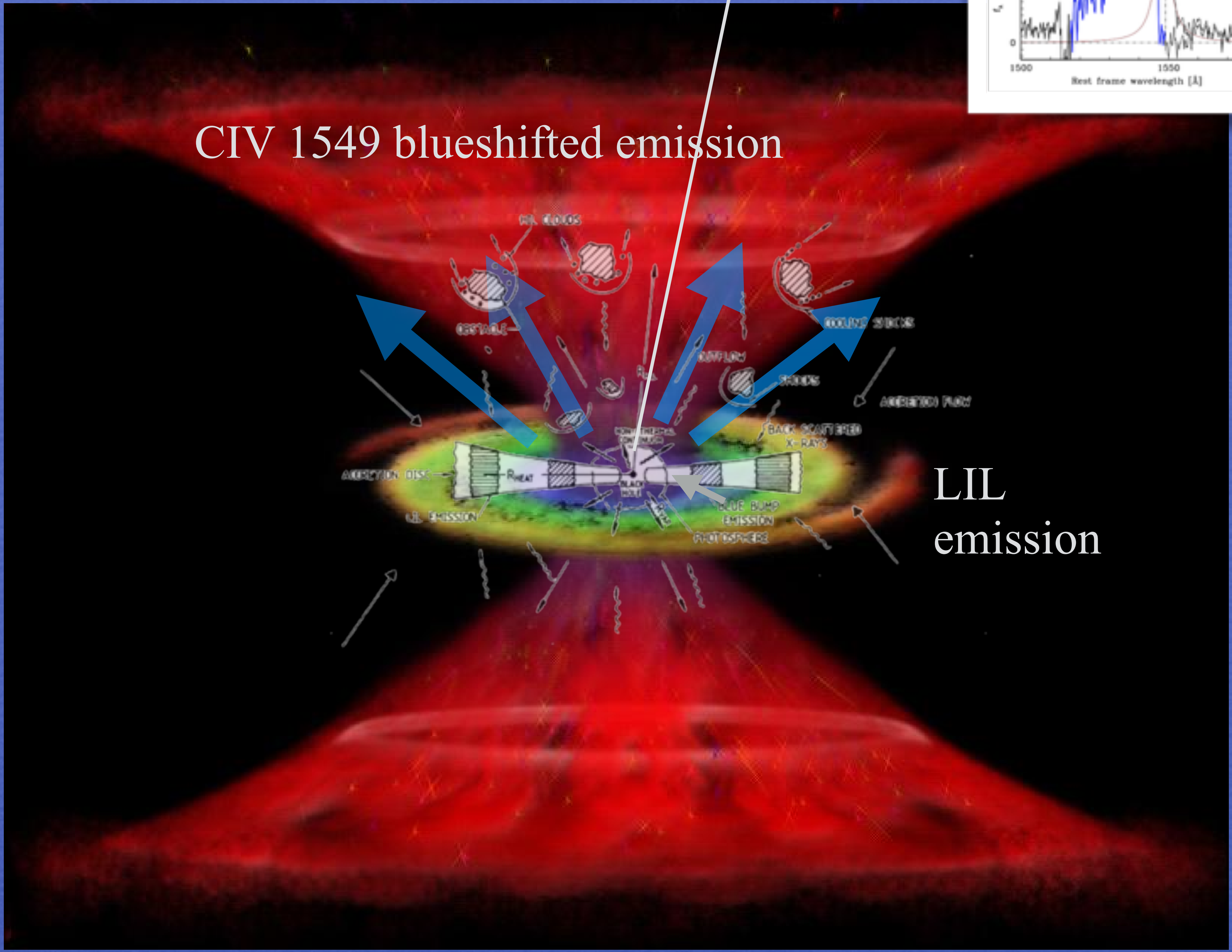
(Snedden & Gaskell 2007; Goad & Korista 2014).

**blueshifted component → outflow/wind**

line-of-sight

# Heuristic model(s)





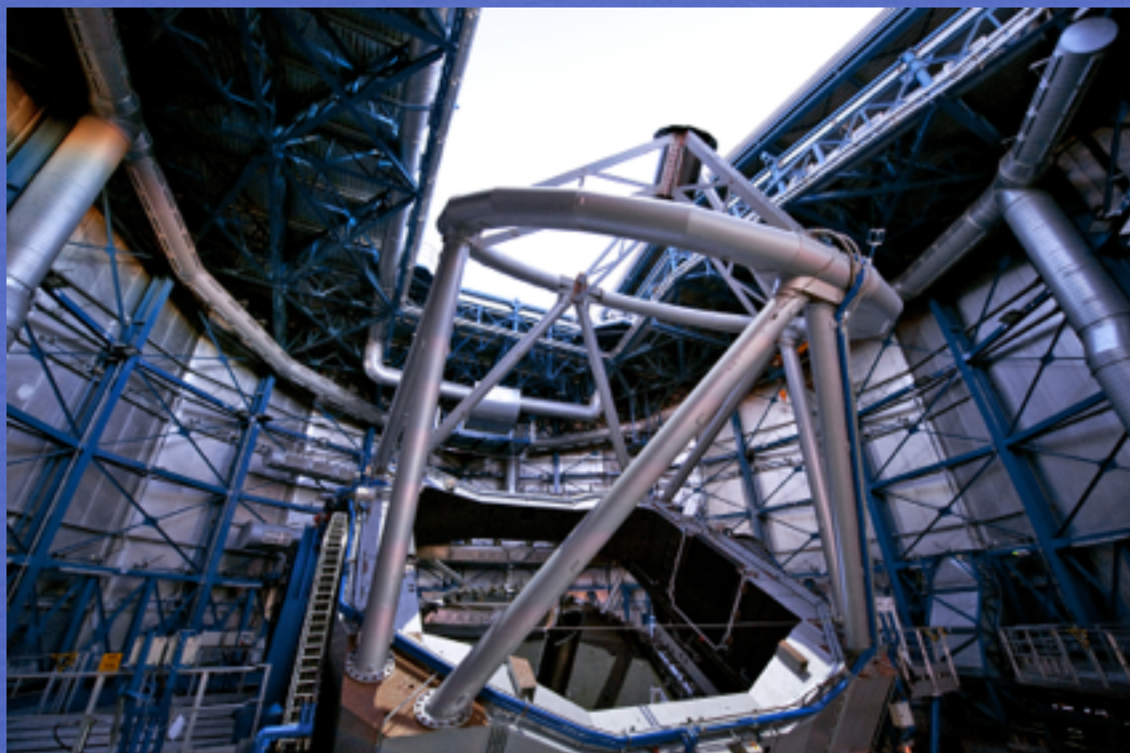

Explains most striking observations of blueshifts in Pop. A sources

Elvis 2000; Collin-Souffrin et al. 1986

# Analysis of CIV$\lambda$1549 at high-$z$ and high-$L$

*maximizing luminosity effects*

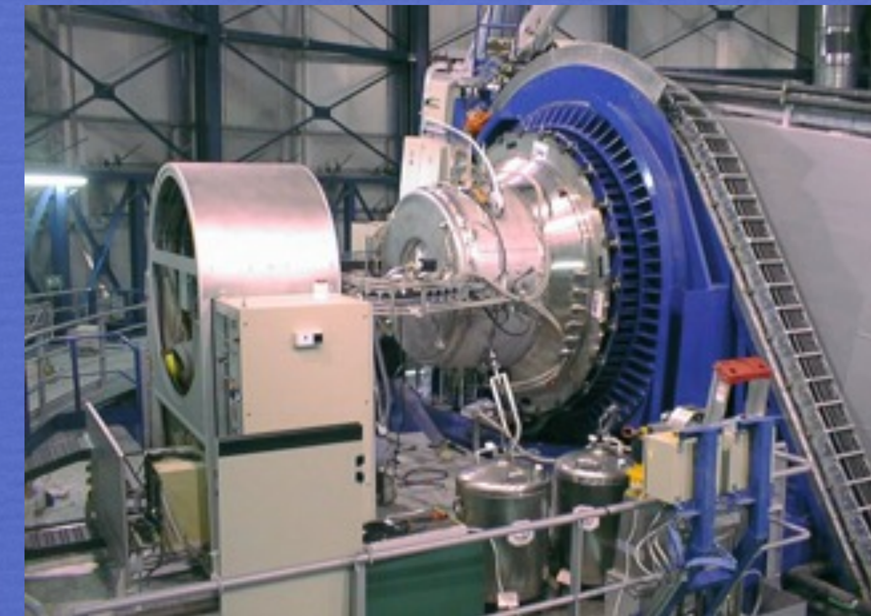
## ESO VLT



## ISAAC

$R = \lambda/\delta\lambda \sim 1000$

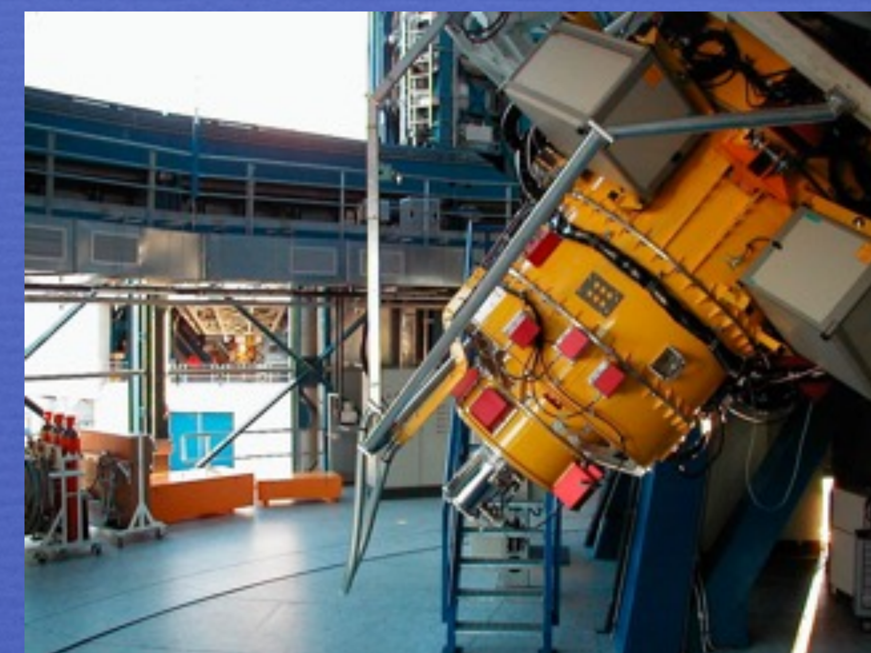
sZ,J,H,K



## FORS

$R = \lambda/\delta\lambda \sim 1000 - 1500$

optical

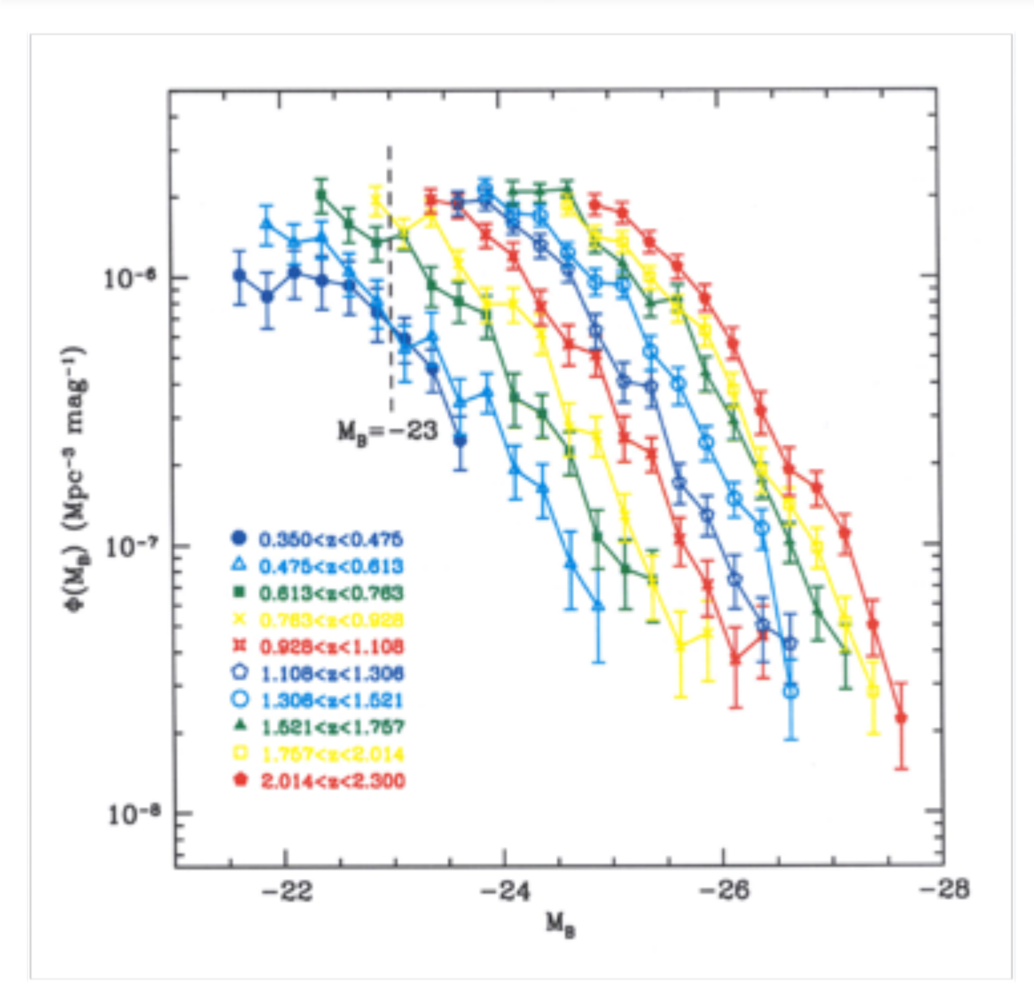


## Galileo TNG


## Dolores

$R = \lambda/\delta\lambda \sim 500$

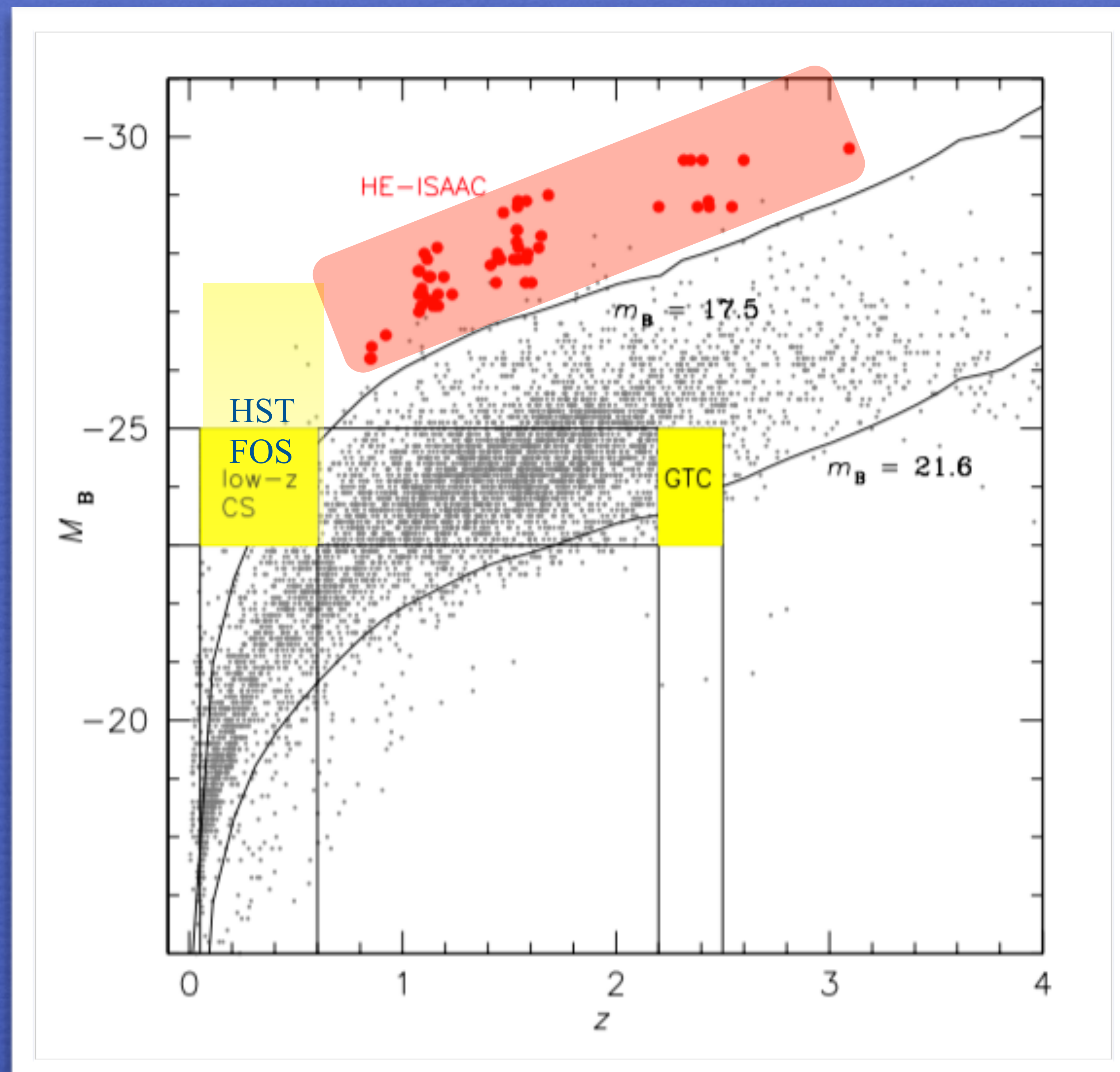
optical




Boyle et al. 2000

# The sample at high luminosity

## Rare, extremely luminous quasars




## A control sample at low *z* and luminosity

## 130 HST/FOS CIV observations

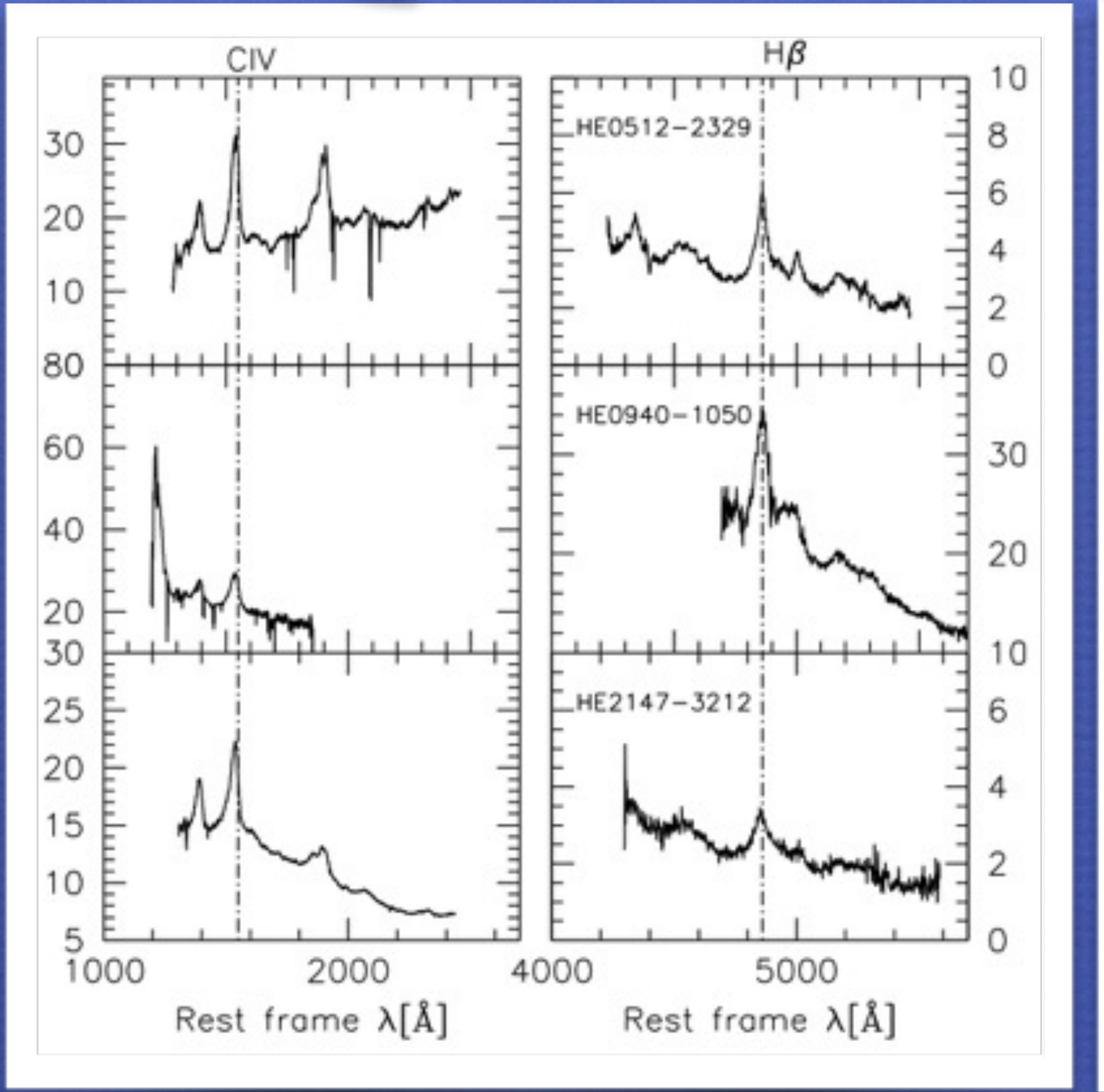
Sulentic et al. 2007

| Name | $m_B$ | $z$ | $M_B$ | $\log R_K$ |
|---|---|---|---|---|
| HE0035-2853 | 17.03 | 1.6377 | -28.1 | < 0.21 |
| HE0043-2300 | 17.06 | 1.5402 | -27.9 | 2.03 |
| HE0058-3231 | 17.14 | 1.5821 | -27.9 | < 0.24 |
| HE0109-3518 | 16.44 | 2.4057 | -29.6 | < -0.04 |
| HE0122-3759 | 16.94 | 2.2004 | -28.8 | < 0.35 |
| HE0203-4627 | 17.34 | 1.4381 | -27.5 | 2.07 |
| HE0205-3756 | 17.17 | 2.4335 | -28.9 | 1.06 |
| HE0248-3628 | 16.58 | 1.5355 | -28.4 | 0.55 |
| HE0251-5550 | 16.59 | 2.3505 | -29.6 | < 0.23 |
| HE0349-5249 | 16.13 | 1.5409 | -28.9 | 0.76 |
| HE0359-3959 | 17.09 | 1.5209 | -27.9 | 0.22 |
| HE0436-3709 | 16.84 | 1.4447 | -27.9 | < 0.38 |
| HE0507-3236 | 17.36 | 1.5759 | -27.5 | < 0.50 |
| HE0512-3329 | 17.03 | 1.5862 | -28.0 | < 0.36 |
| HE0926-0201 | 16.23 | 1.6828 | -29.0 | < -0.37 |
| HE0940-1050 | 16.96 | 3.0932 | -29.8 | < 0.10 |
| HE1039-0724 | 17.16 | 1.4584 | -27.9 | < 0.20 |
| HE1104-1805 | 16.45 | 2.3180 | -29.6 | < 0.09 |
| HE1120+0154 | 16.31 | 1.4720 | -28.7 | -0.57 |
| HE1347-2457 | 16.83 | 2.5986 | -29.6 | -0.68 |
| HE1349+0007 | 16.83 | 1.4442 | -28.0 | -0.18 |
| HE1409+0101 | 16.92 | 1.6497 | -28.3 | 0.40 |
| HE2147-3212 | 16.84 | 1.5432 | -28.1 | < 0.14 |
| HE2156-4020 | 17.39 | 2.5431 | -28.8 | -0.09 |
| HE2202-2557 | 16.71 | 1.5347 | -28.2 | 1.56 |
| HE2349-3800 | 17.46 | 1.6040 | -27.5 | 1.89 |
| HE2352-4010 | 16.05 | 1.5799 | -28.9 | < 0.25 |
| HE2355-4621 | 17.13 | 2.3825 | -28.8 | < 0.70 |

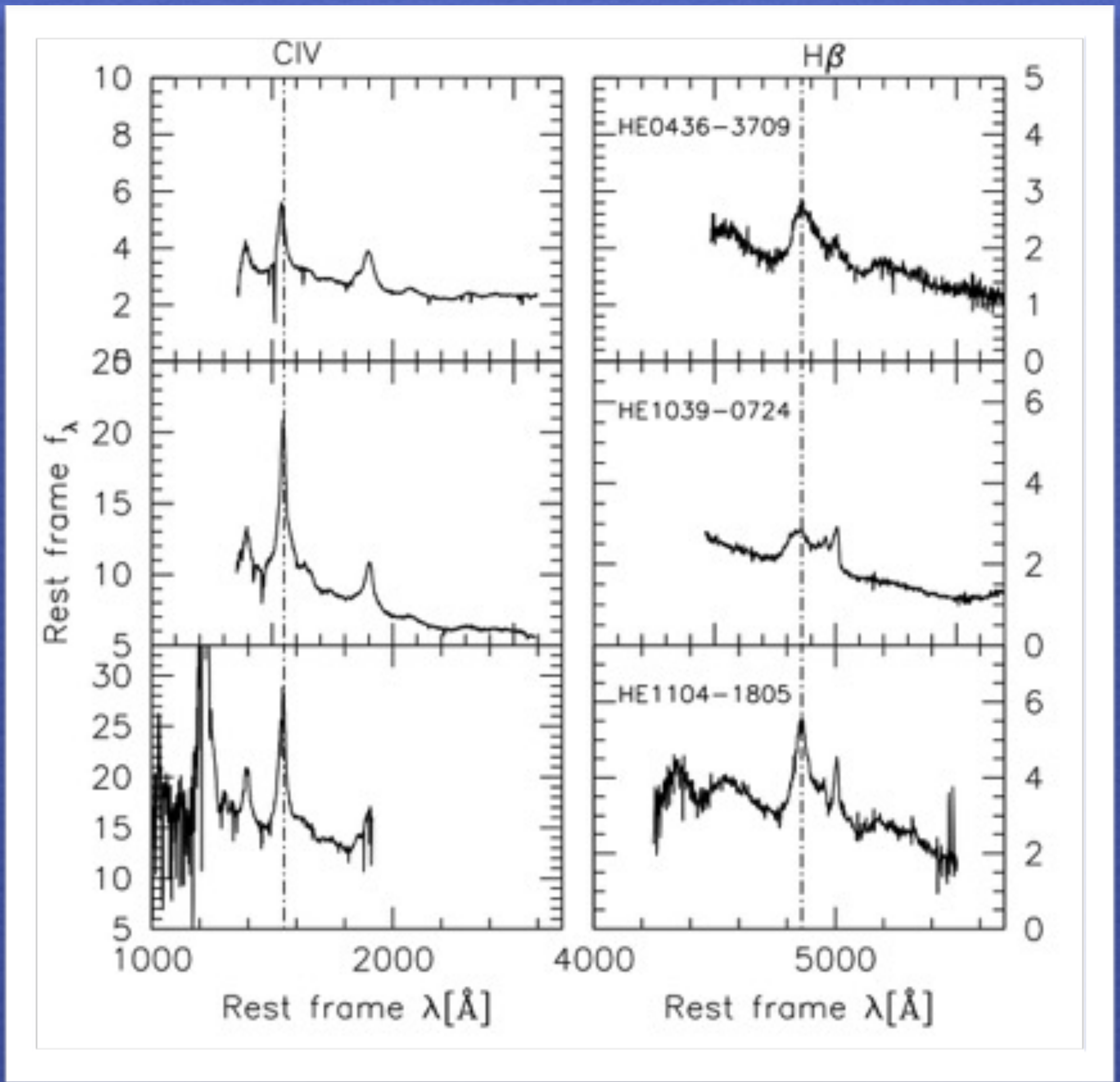
# The sample at high luminosity

52 HE quasars observed with ISAAC in the Hβ spectral range (yielding reliable rest frames), for 32 CIV was observable from ground (28 actually observed)

Pop. A

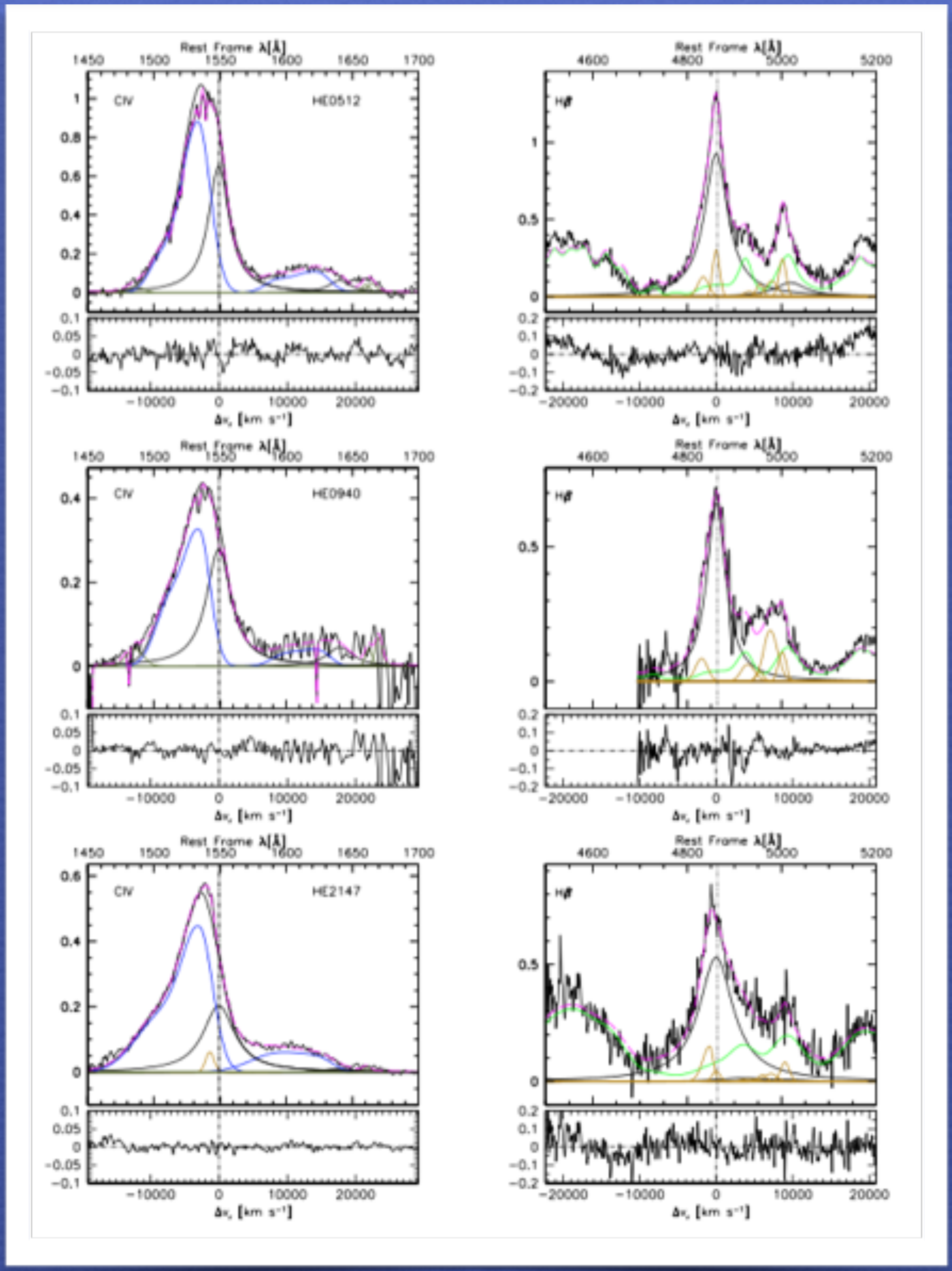



Pop. B

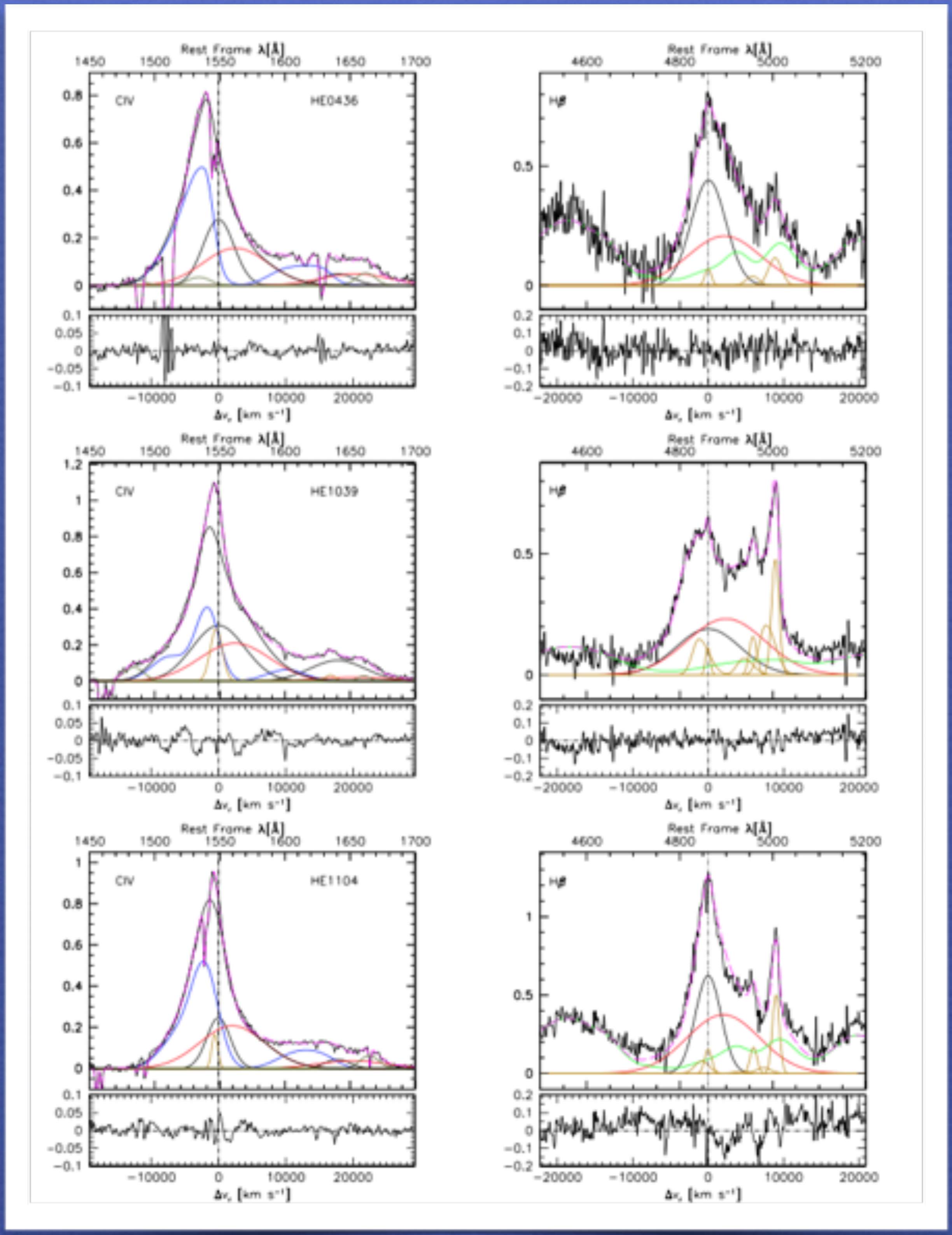


# CIVλ1549: high amplitude blueshifts

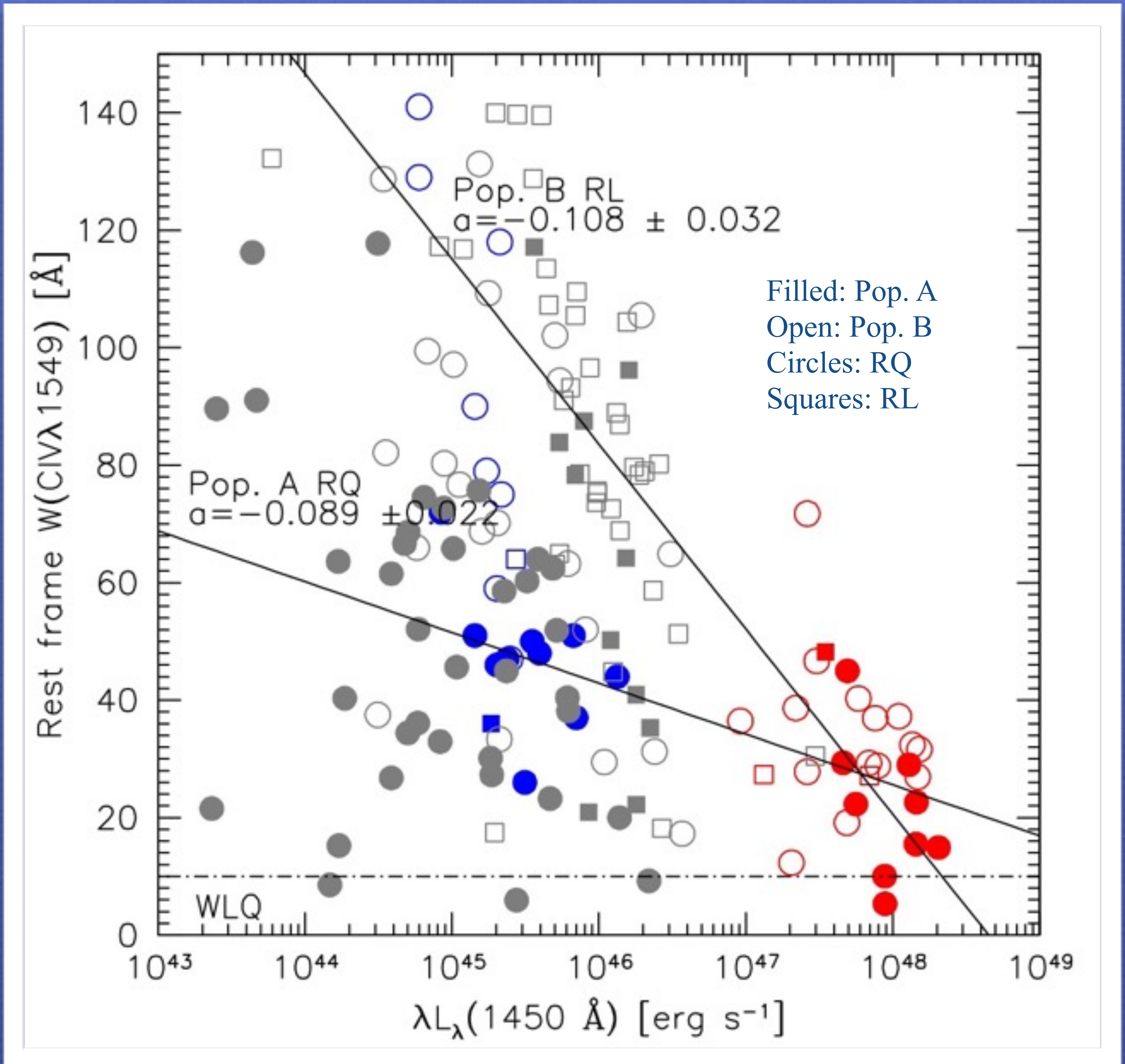
Pop. A




Pop. B



# The "Baldwin effect"




Consistent with Bian et al. (2005)

Still explainable by a dependence on Eddington ratio and selection effects

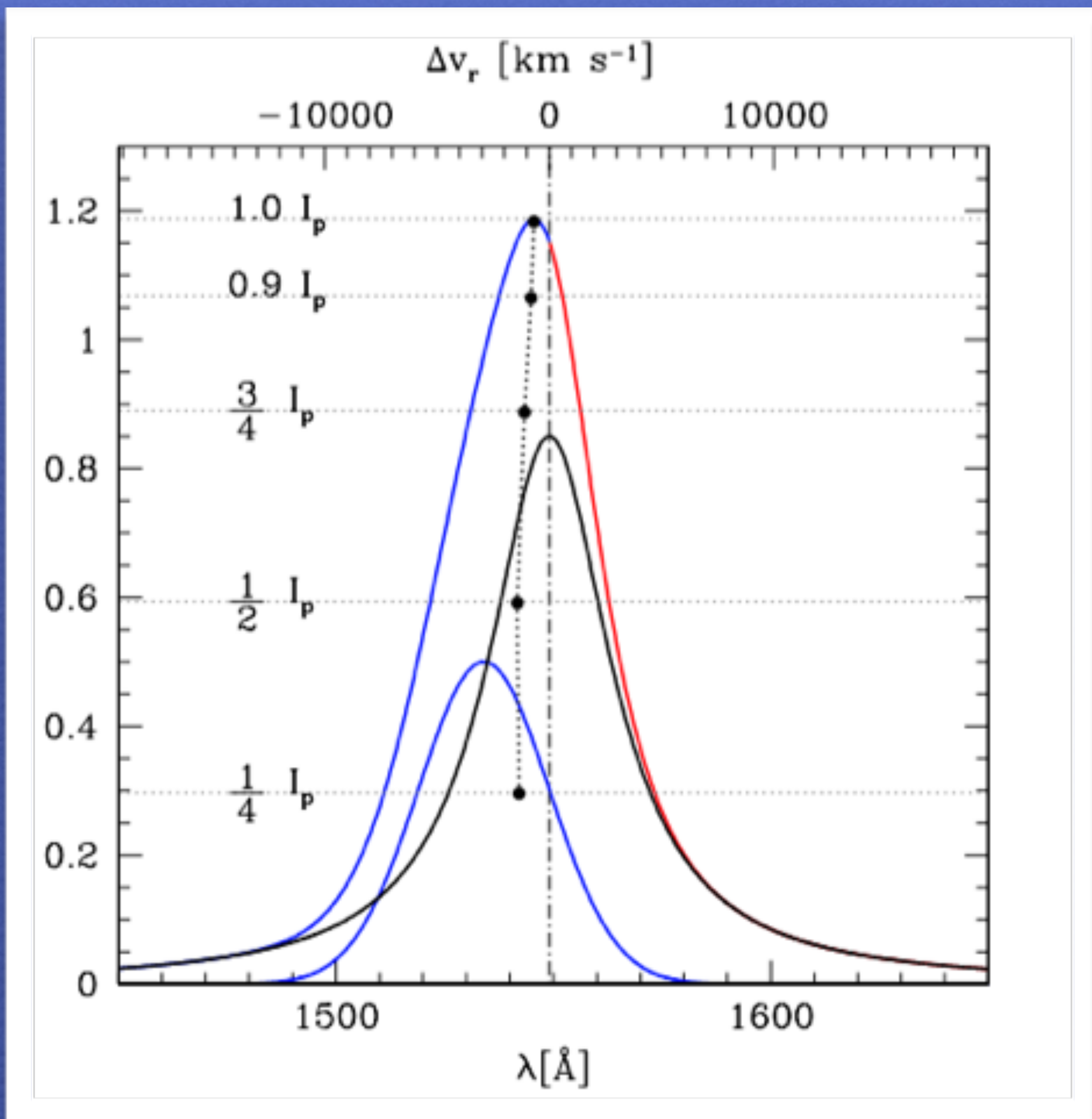
Bachev et al. 2004; Baskin & Laor 2005
Sulentic et al. 2007; Marziani et al. 2008

# CIVλ1549 line profile parameterisation

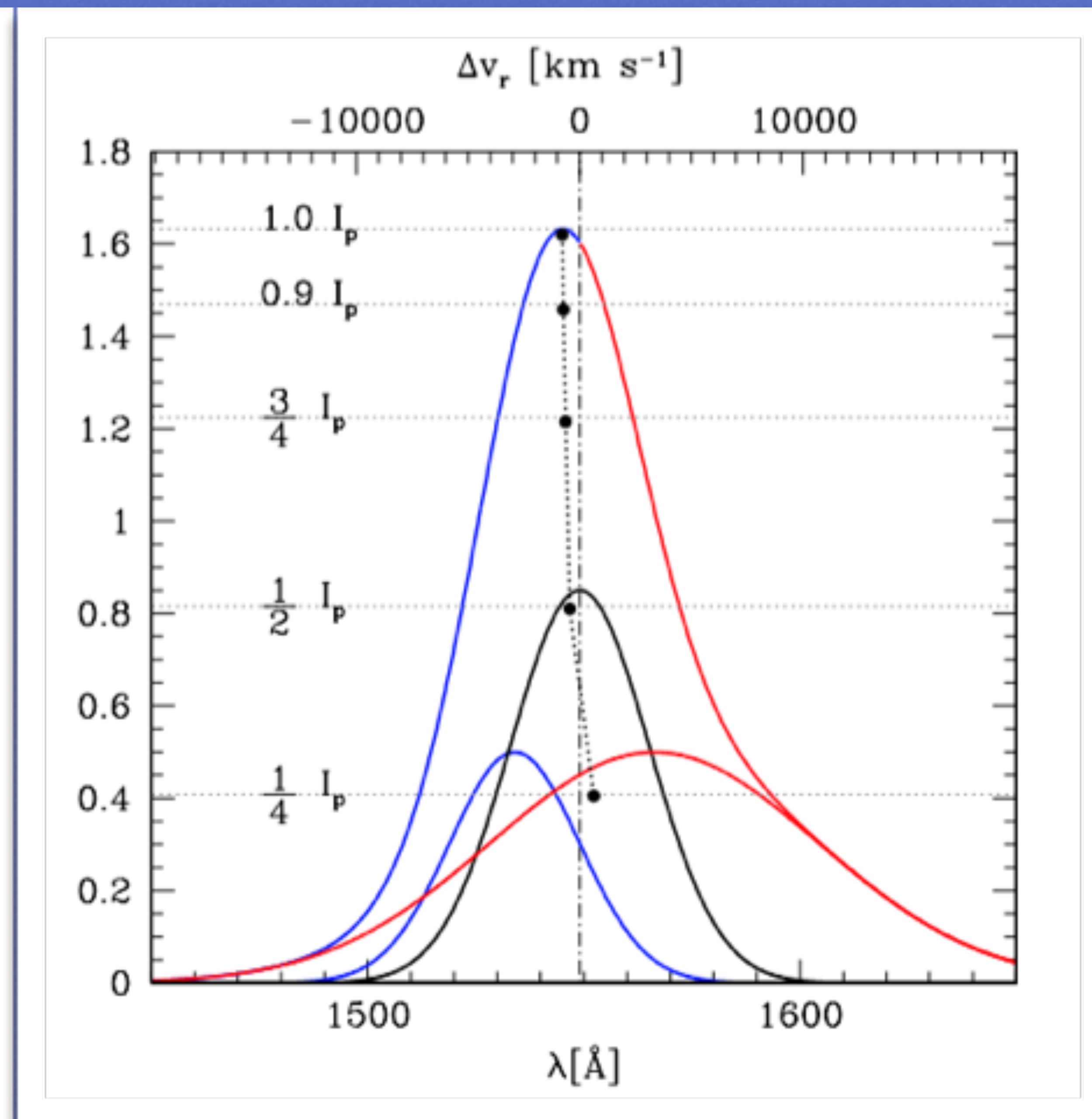
$$c\left(\frac{i}{4}\right) = \frac{\lambda_B(i/4) + \lambda_R(i/4)}{2} - \lambda_0 \ \forall i = 0, \ldots 4$$

$$AI\left(\frac{i}{4}\right) = \frac{\lambda_B(i/4) + \lambda_R(i/4) - 2 \cdot \lambda_P}{\lambda_R(i/4) - \lambda_B(i/4)} \ \forall i = 0, \ldots 4$$

Pop. A




Pop. B

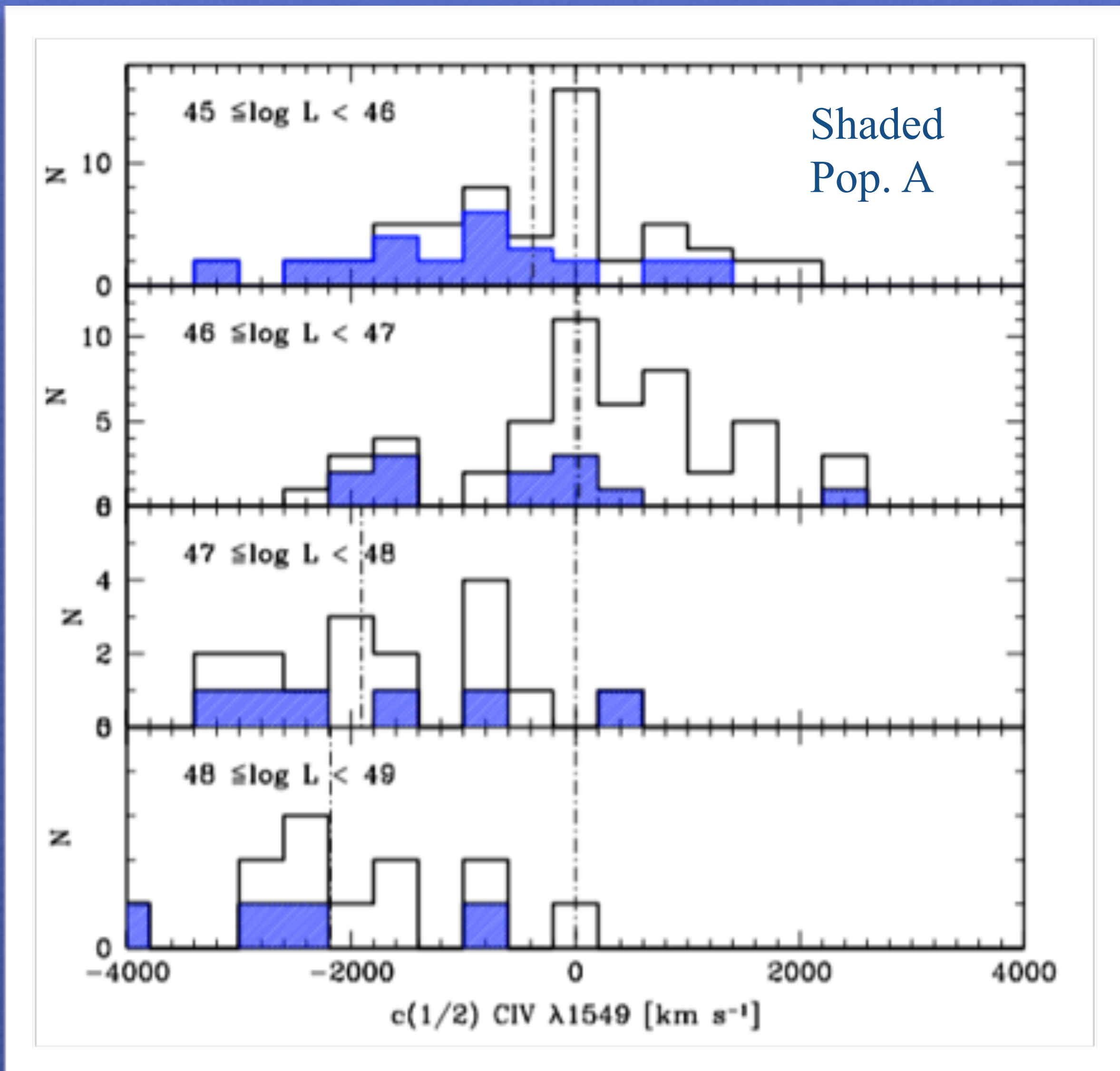


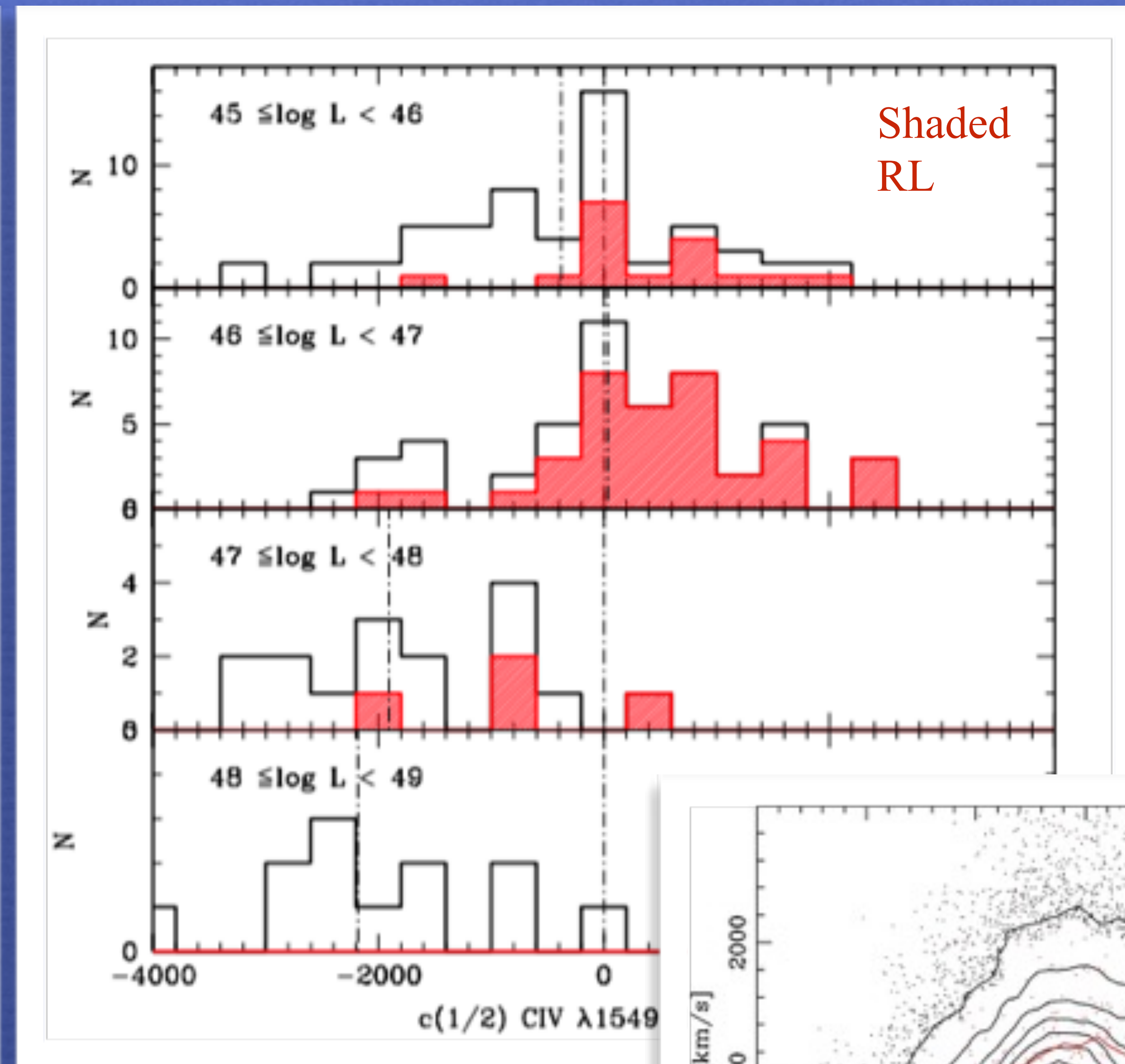

line centroids at fractional intensity
independent from multi-component decomposition

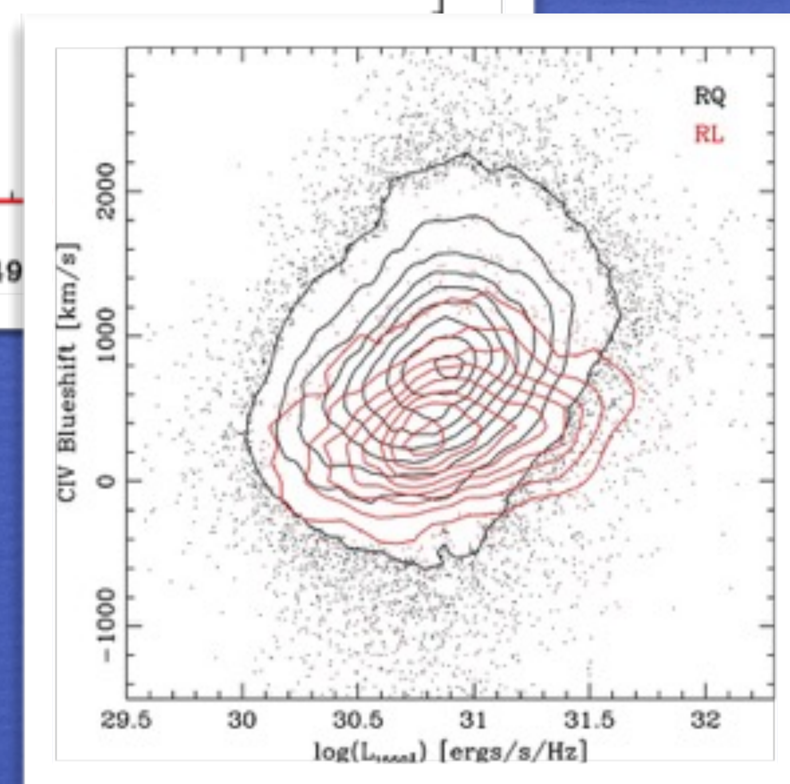
# Blueshift distribution as a function of luminosity

All and Pop. A; FOS + HE

All and RL; FOS + HE




Richards et al. 2011

Consistent with result from SDSS

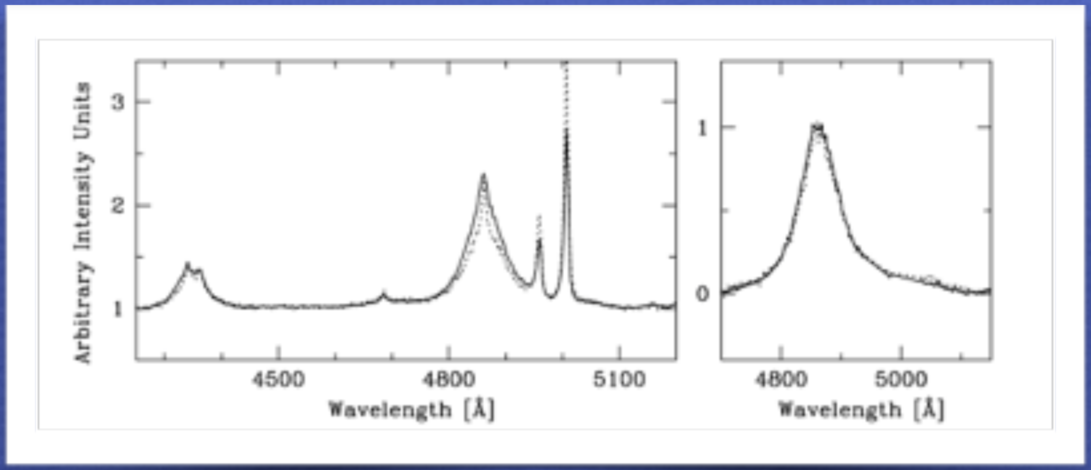
# Contextualization for High Ionization Lines

HIL < Pop. A, Pop. B

Pop. B < RQ, RL

LIL < Pop. A, Pop. B

No strong effect of Radio Loudness on LIL profiles, only on HILs.

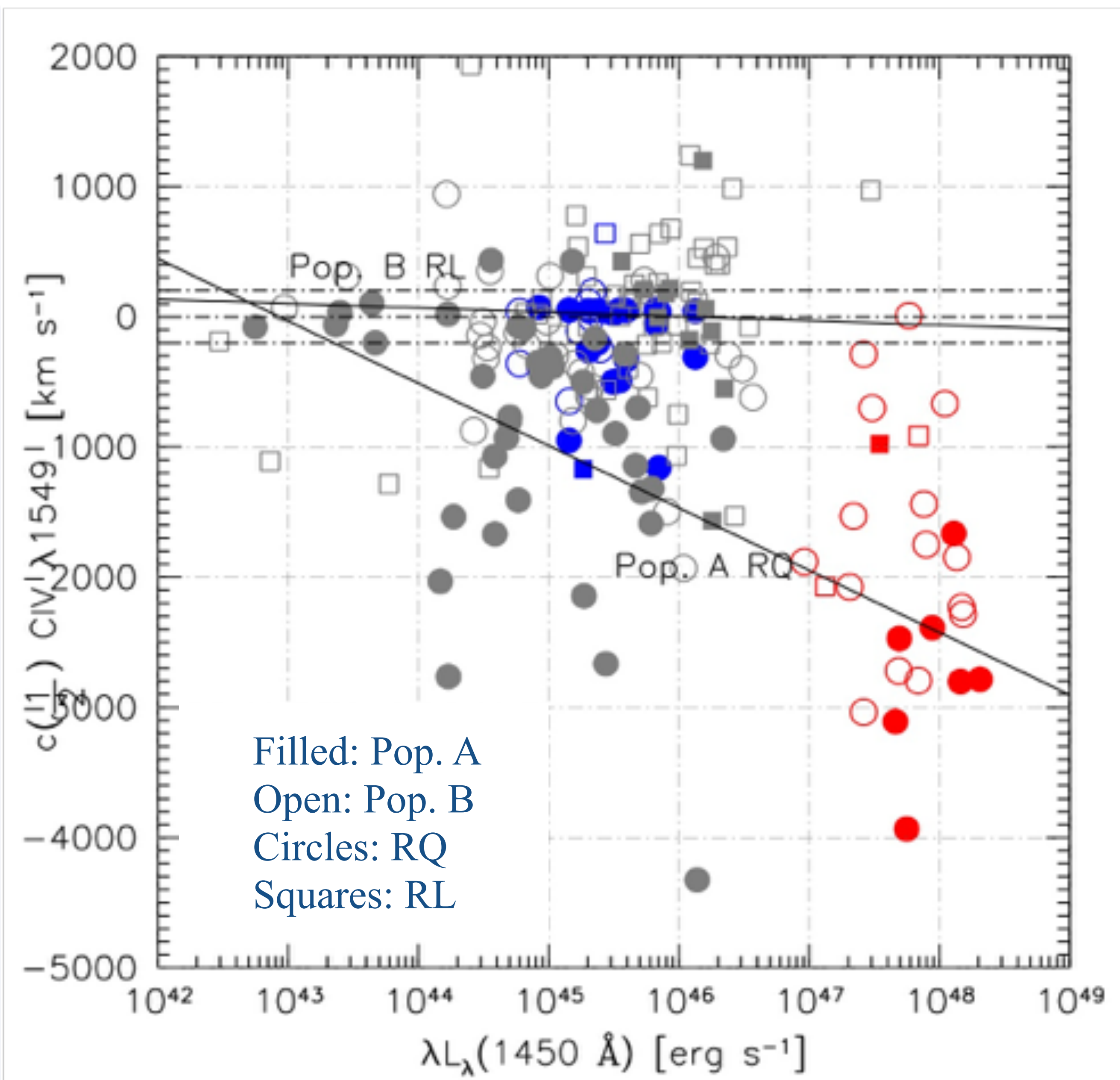


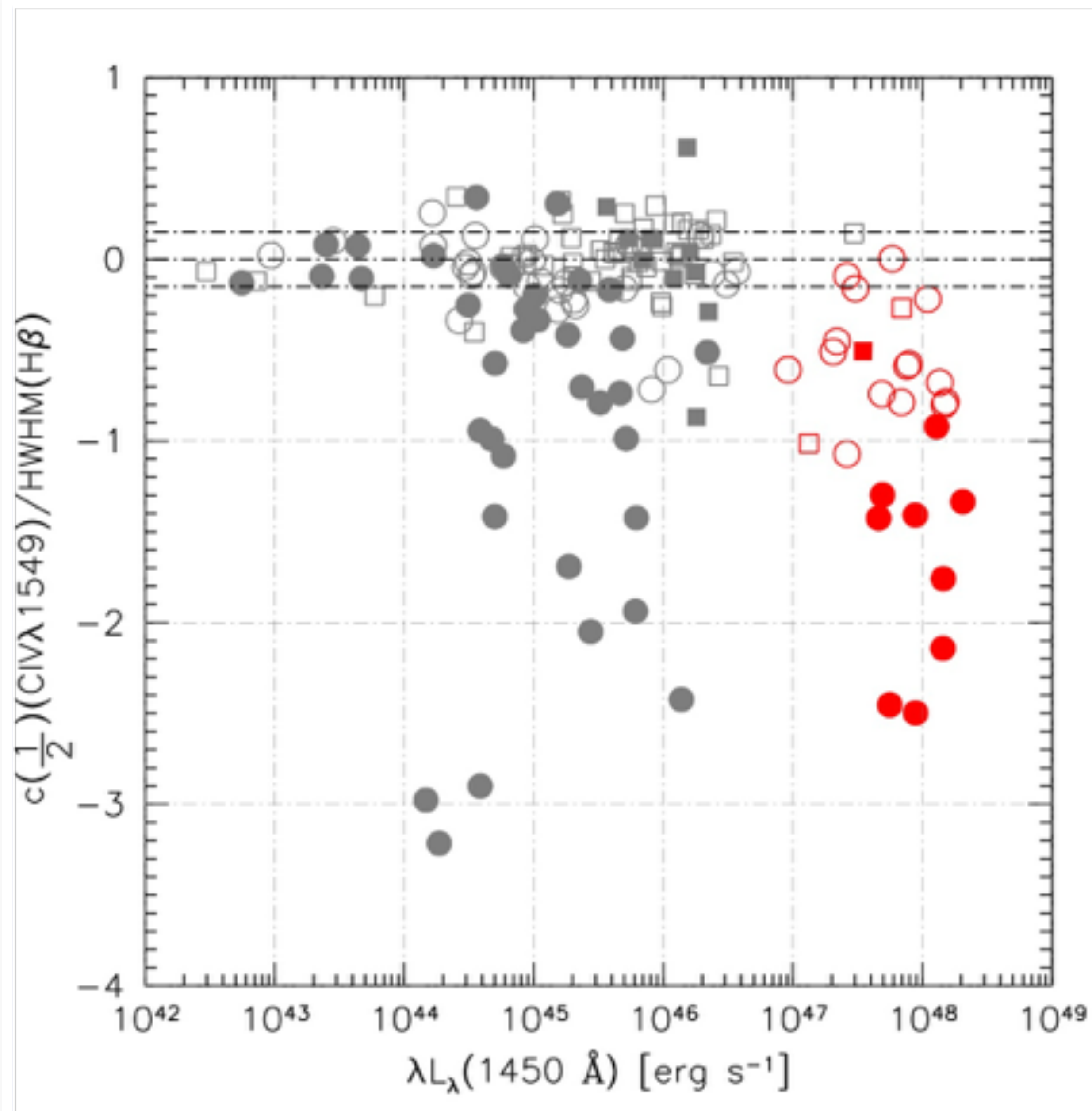

Hβ RL vs RQ
Pop. B

# Large blueshifts are apparently more frequent at high *L* but shift amplitudes at lower *L* are comparable

$$\frac{c\left(\frac{1}{2}\right)}{HWHM(H\beta)}$$

"Dynamical relevance" of CIVλ1549 shift



# Blueshift trends are consistent with a radiation-driven wind

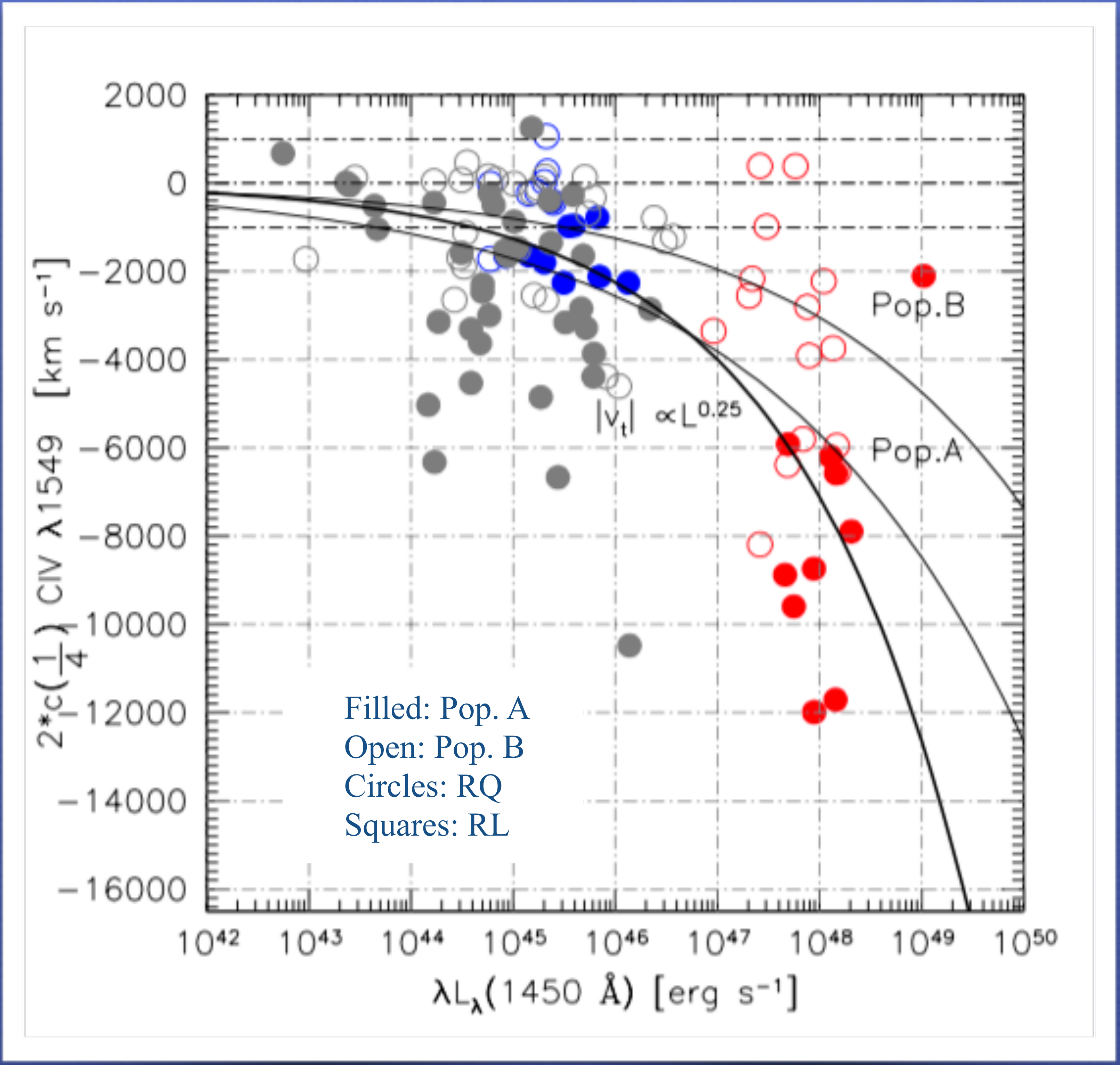
Using 2×c(1/4) as a proxy of terminal velocity

Assuming:

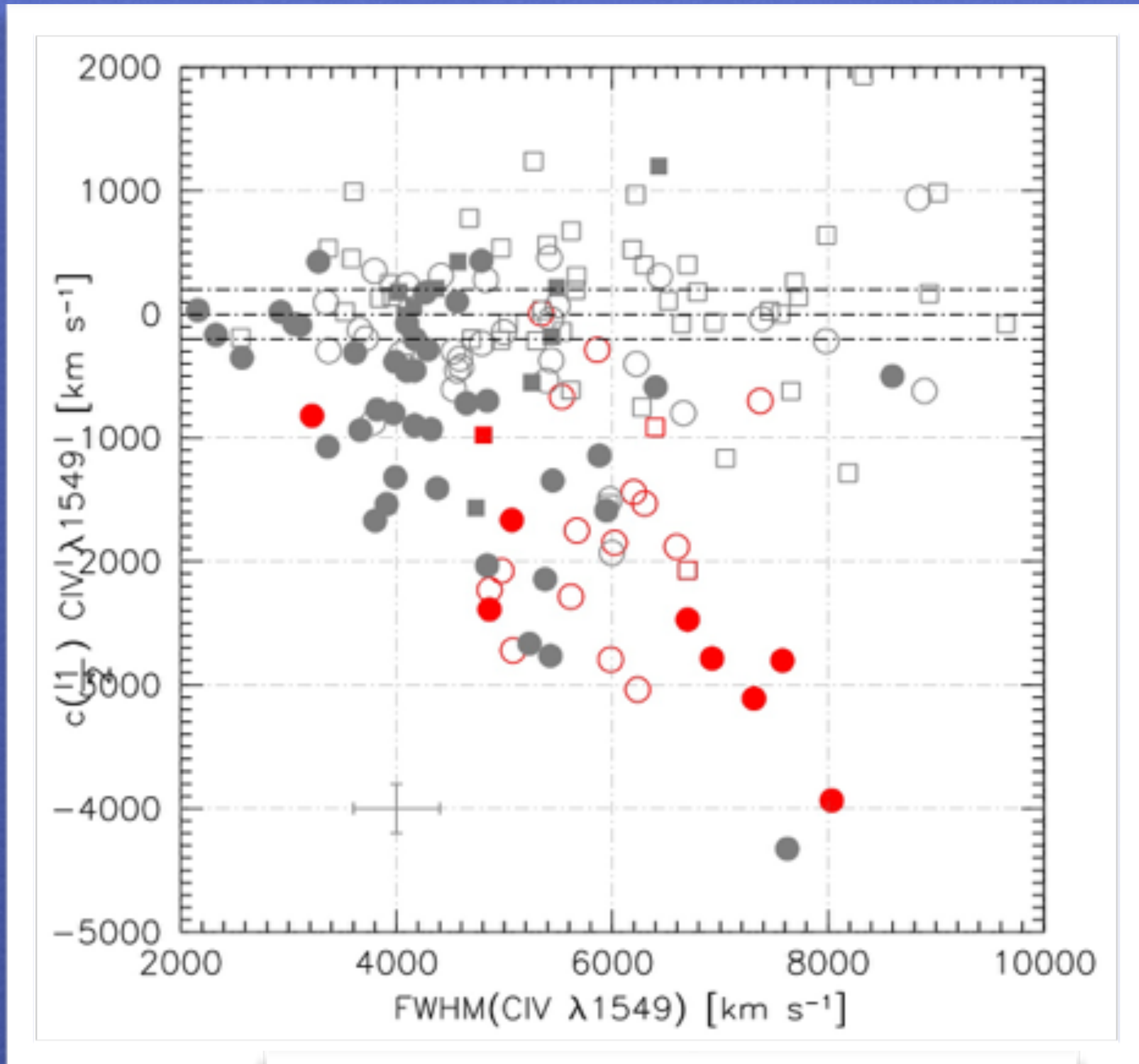
$$v_t \sim v_K \sqrt{\mathcal{F} \frac{L}{L_{\rm Edd}}}$$

$$v_t \propto L^{1/4}$$

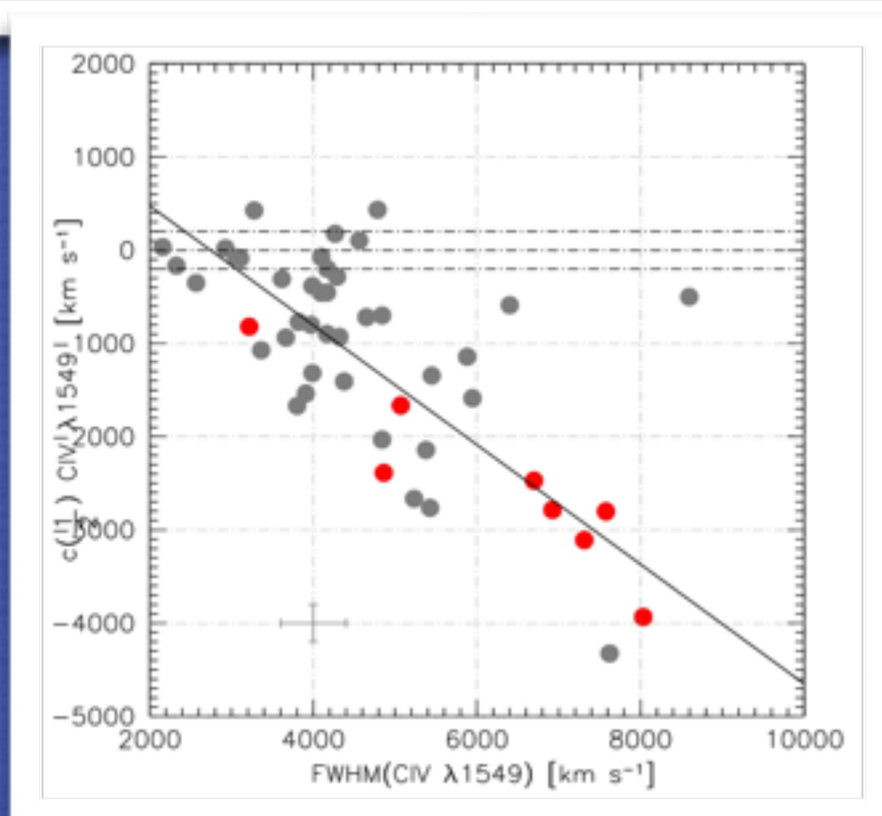
Laor & Brandt 2002



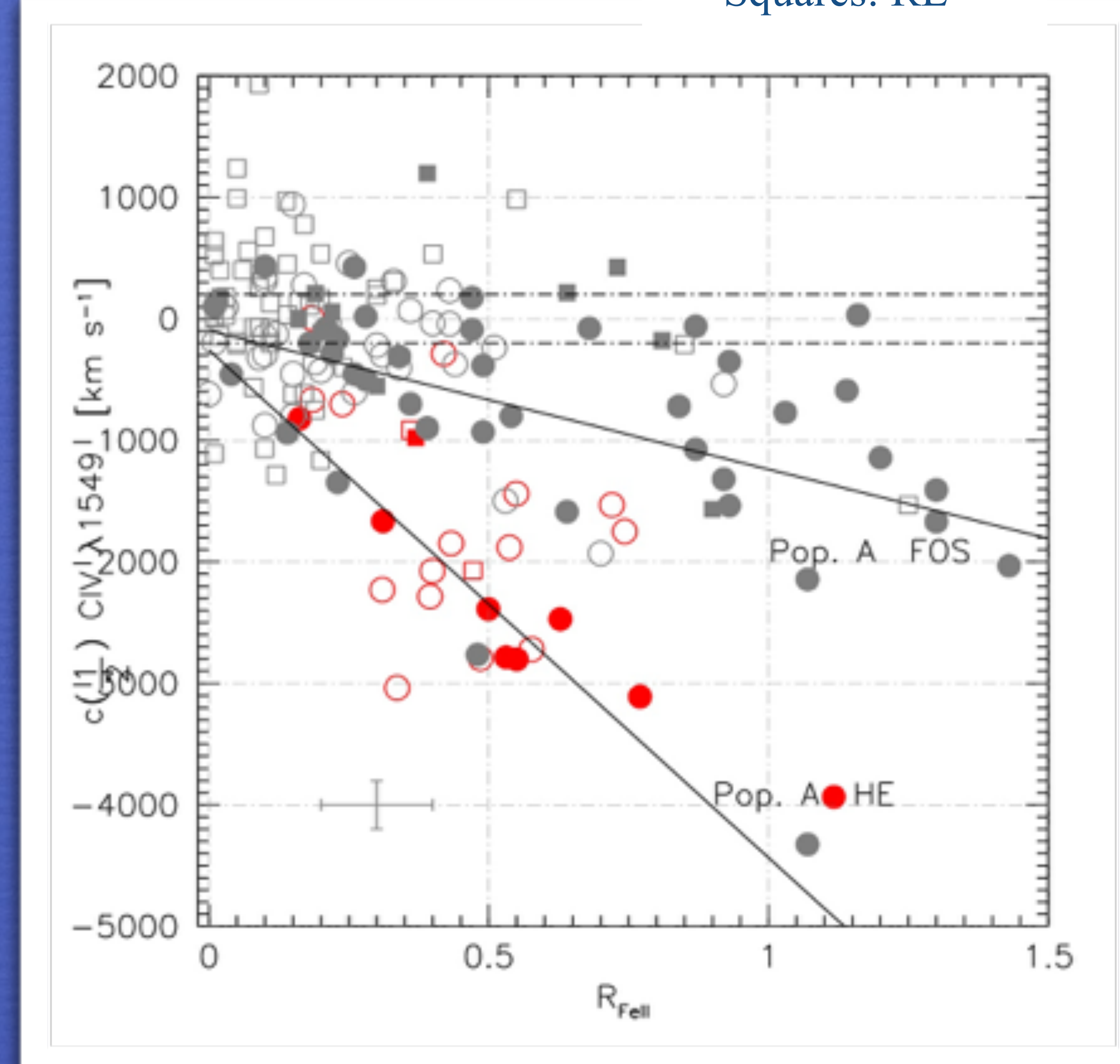
# Correlations with 4DE1 parameters FWHM(Hβ) $R_{FeII}$=F(FeIIλ4570)/F(Hβ)




Filled: Pop. A
Open: Pop. B
Circles: RQ
Squares: RL



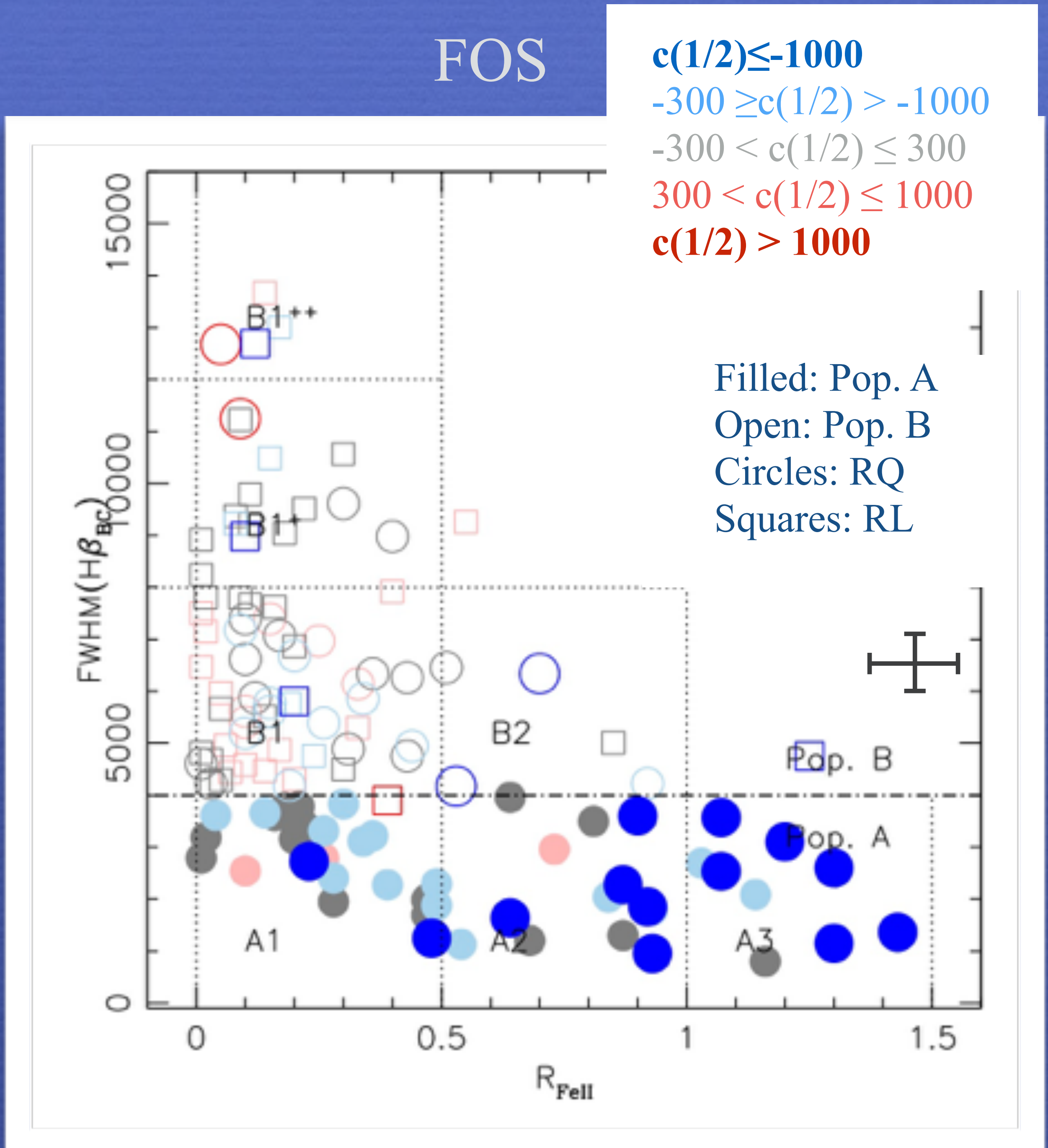

Pop. A RQ only



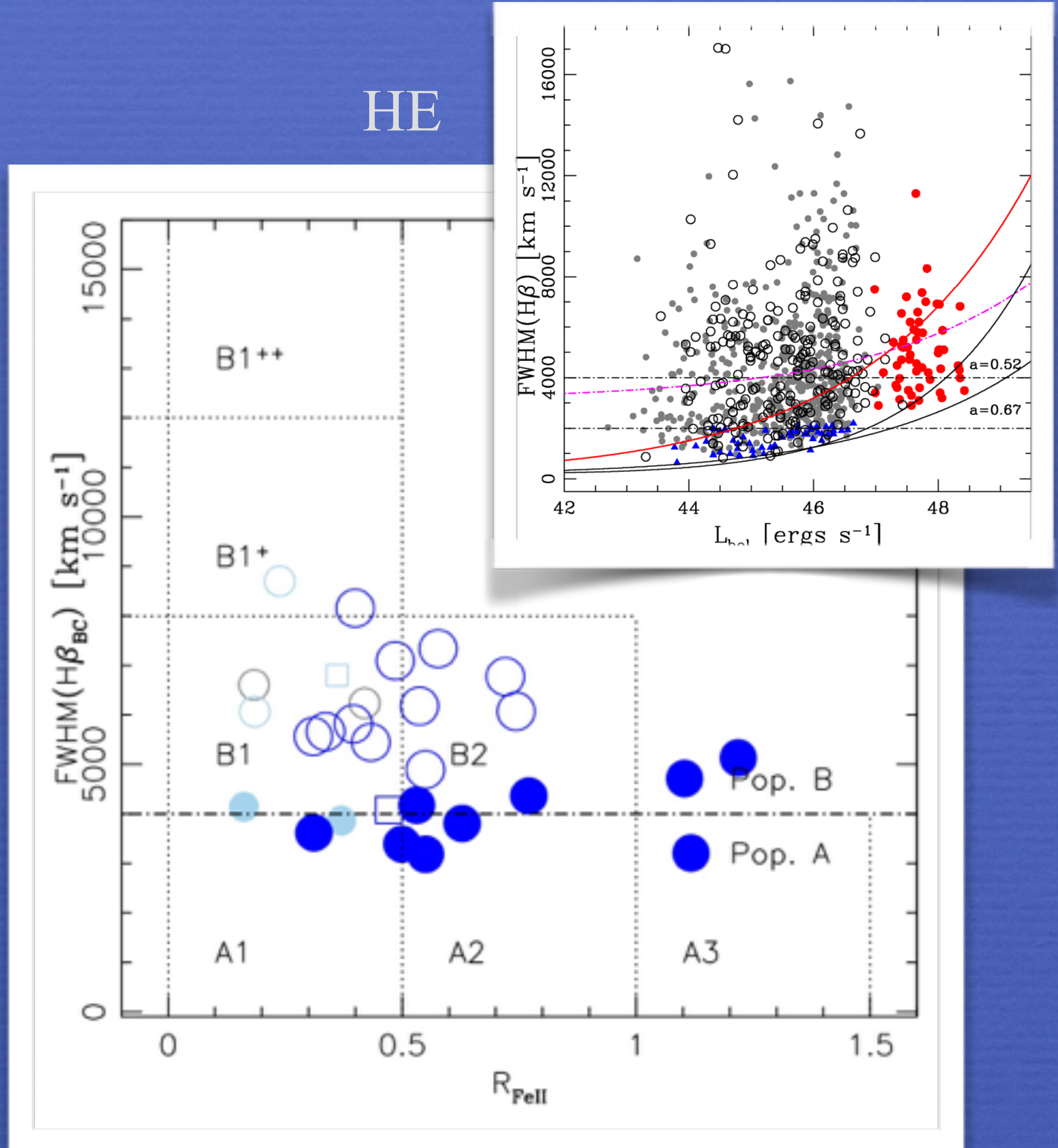
# High-L HE quasars in the optical plane of the 4DE1

Luminosity (Mass) effect visible in a systematic increase of the minimum FWHM possible for a sub-Eddington radiator

FOS




HE



# Virial Black Hole Mass & Eddington ratio

geometry
dynamics

$$M_{\rm BH} = \frac{f r (\delta v)^2}{G}$$

$r_{\rm BLR}$

FHWM
σ
FWZI

Keplerian velocity field: the BLR dynamics dominated by the gravity of a central mass; $v \propto r^{-1/2}$

valid for low-ionization lines

Hβ and MgII λ2800

$$M_{\rm BH}(H\beta) = 1.05 \times 10^8 \left[\frac{L_{5100}}{10^{46}\,{\rm ergs\,s^{-1}}}\right]^{0.65} \left[\frac{{\rm FWHM}(H\beta)}{10^3\,{\rm km\,s^{-1}}}\right]^2 M_\odot.$$

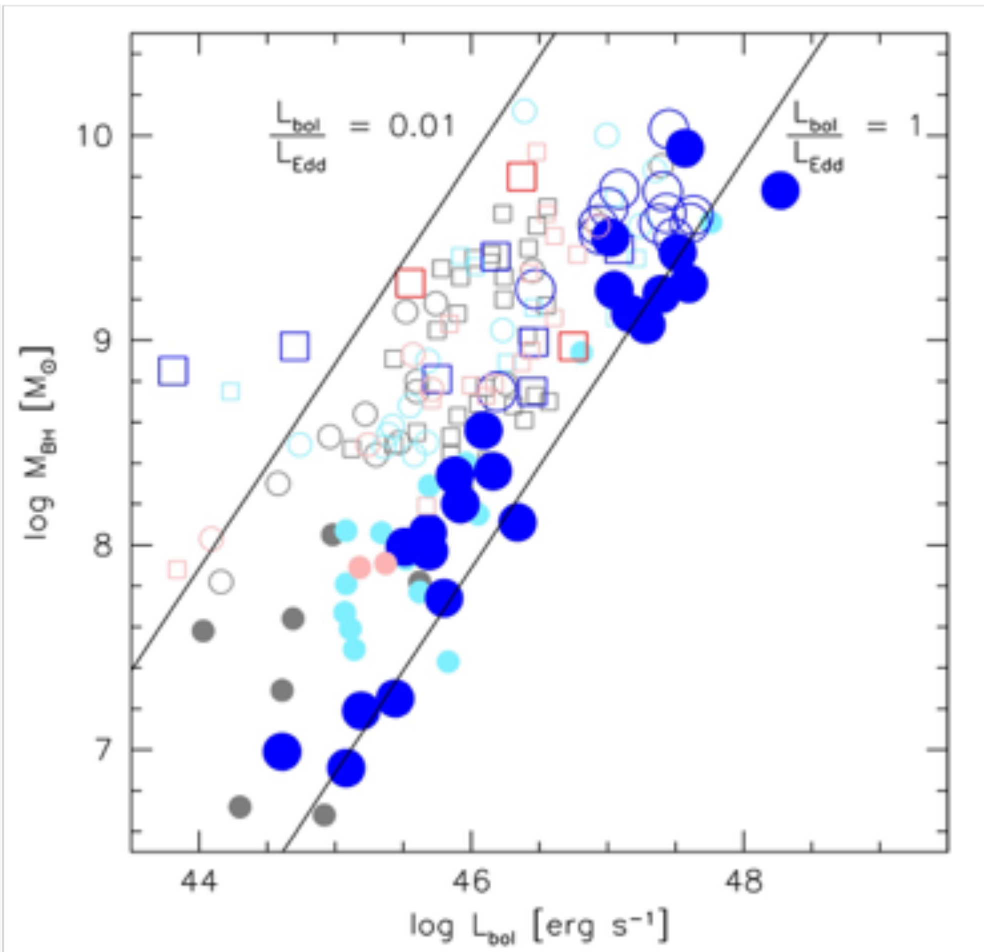
for large samples: $r \propto L^{1/2} \longrightarrow M_{\rm BH} = M_{\rm BH}(L, {\rm FWHM})$

(Vestergaard & Peterson 2006; Trakhtenbrot & Netzer 2012)

$$\text{Eddington ratio} = \frac{L_{\rm bol}}{L_{\rm Edd}} \propto \frac{\lambda L_\lambda \times {\rm B.C.}}{M_{\rm BH}}$$

Bolometric correction not trivial especially at high $L$

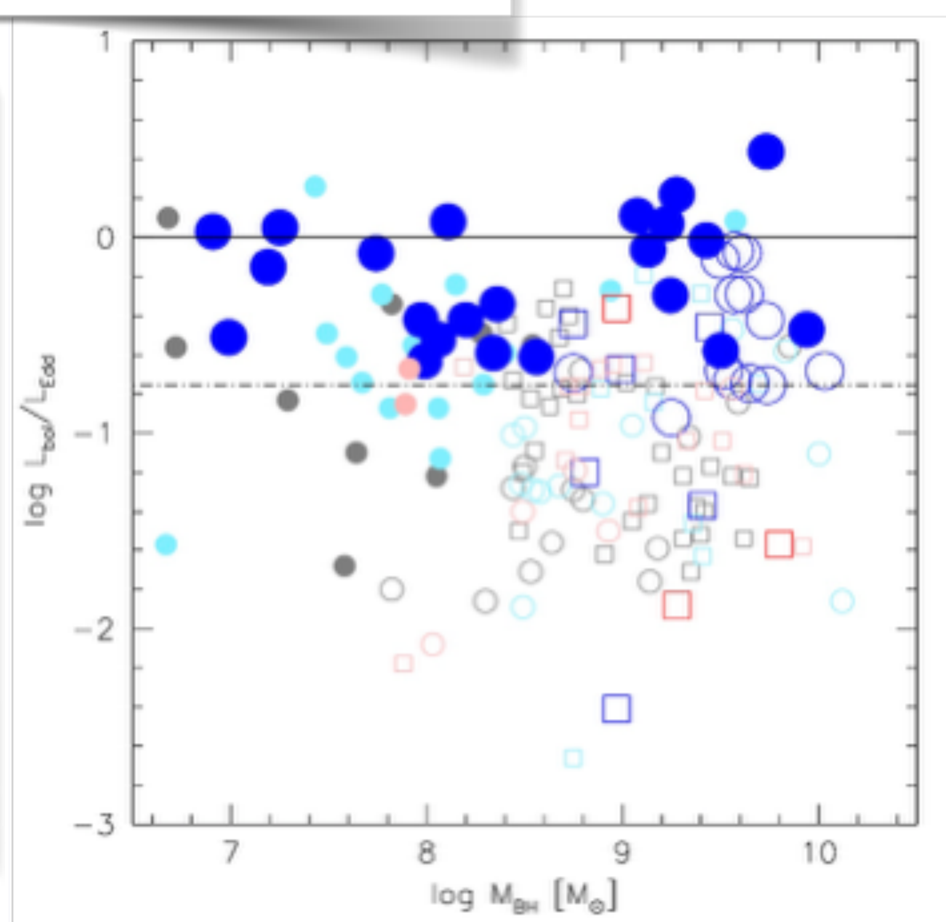
(Richards et al. 2006; Runnoe et al. 2013)

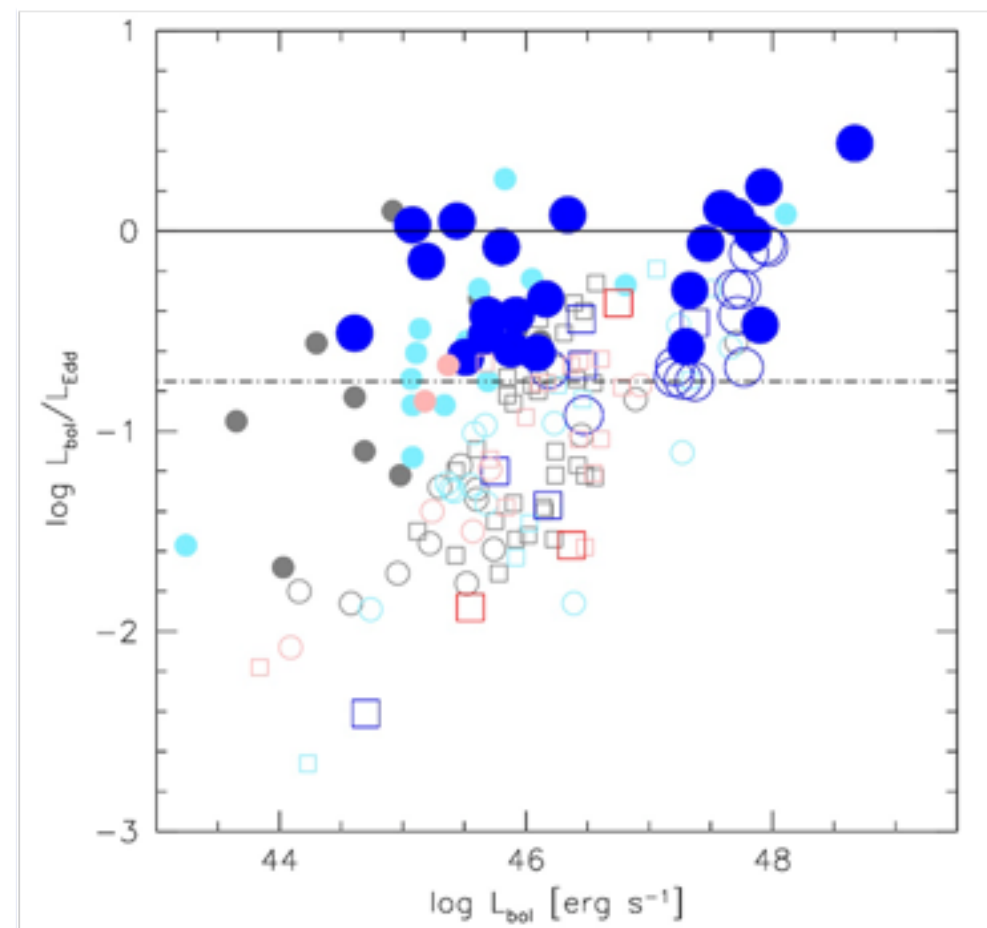



Largest CIVλ1549 blueshifts are observed at high $L/L_{EDD}$ but not necessarily at high $M_{BH}$ or high $L$

**c(1/2)≤-1000**
-300 ≥c(1/2) > -1000
-300 < c(1/2) ≤ 300
300 < c(1/2) ≤ 1000
**c(1/2) > 1000**

Filled: Pop. A
Open: Pop. B
Circles: RQ
Squares: RL



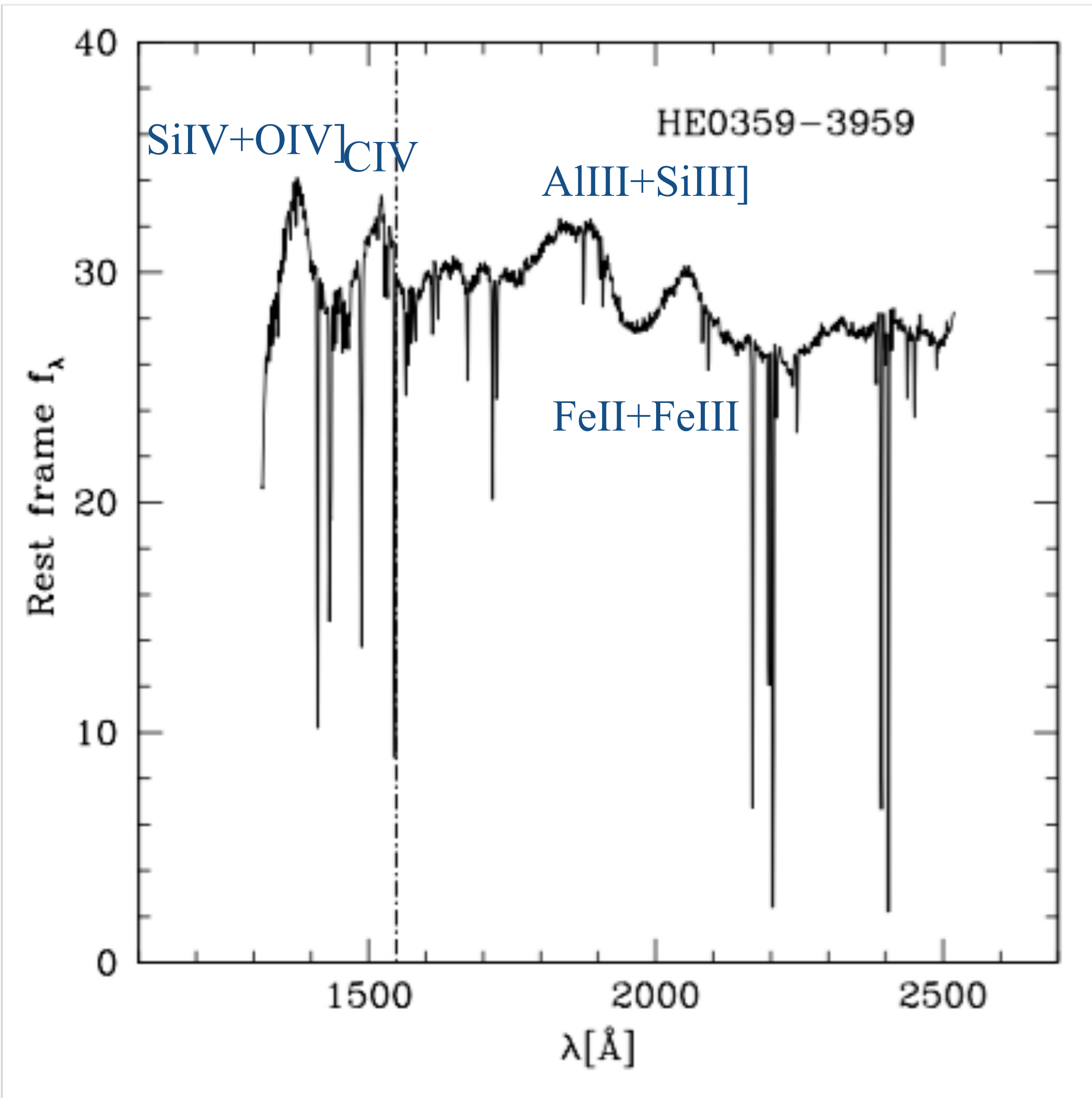



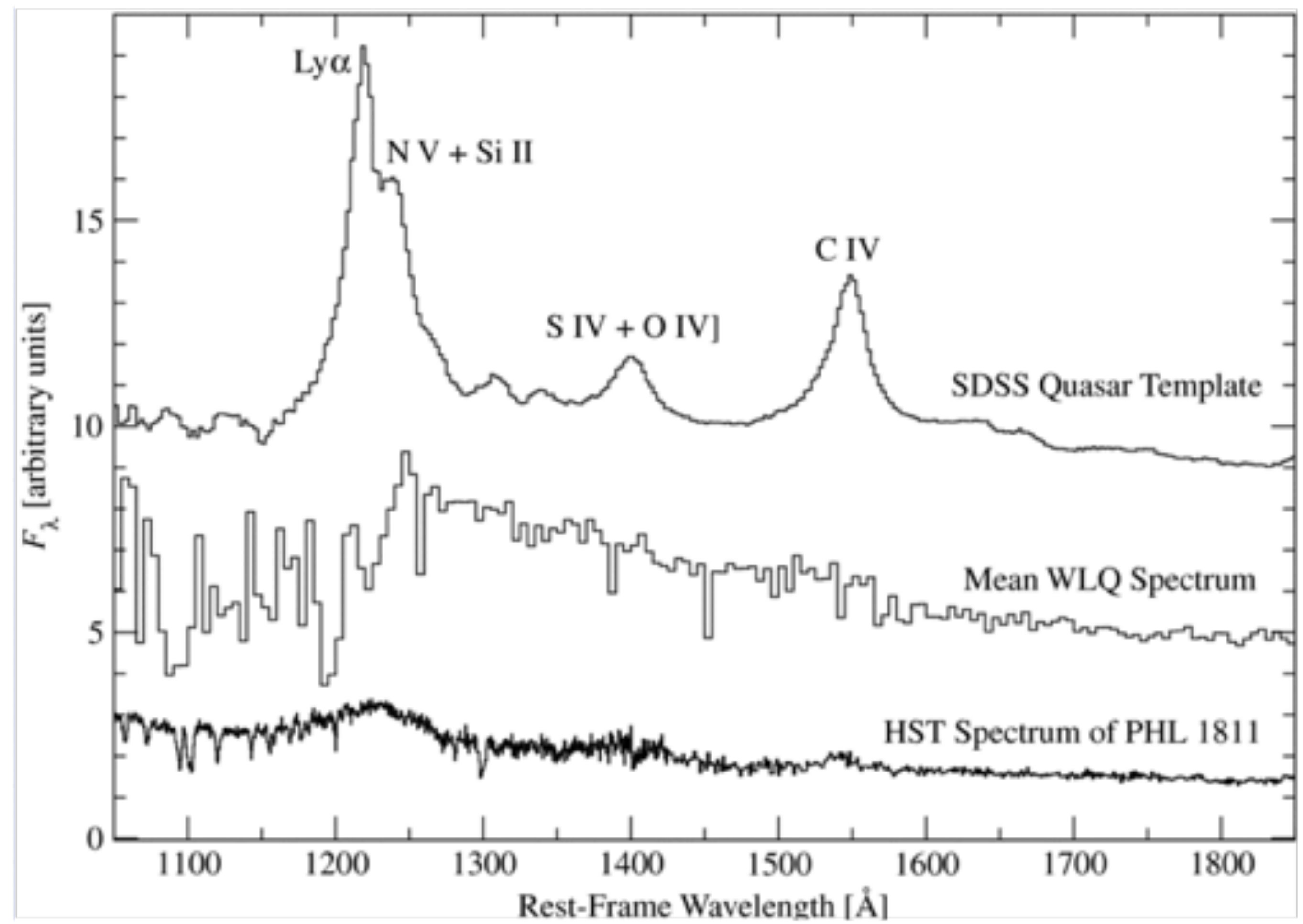
# Extreme outflows in extreme quasars

# Weak Lined Quasars (WLQs)

Low equivalent width of CIVλ1549 (≤10 Å) and Lyα (≤16 Å)

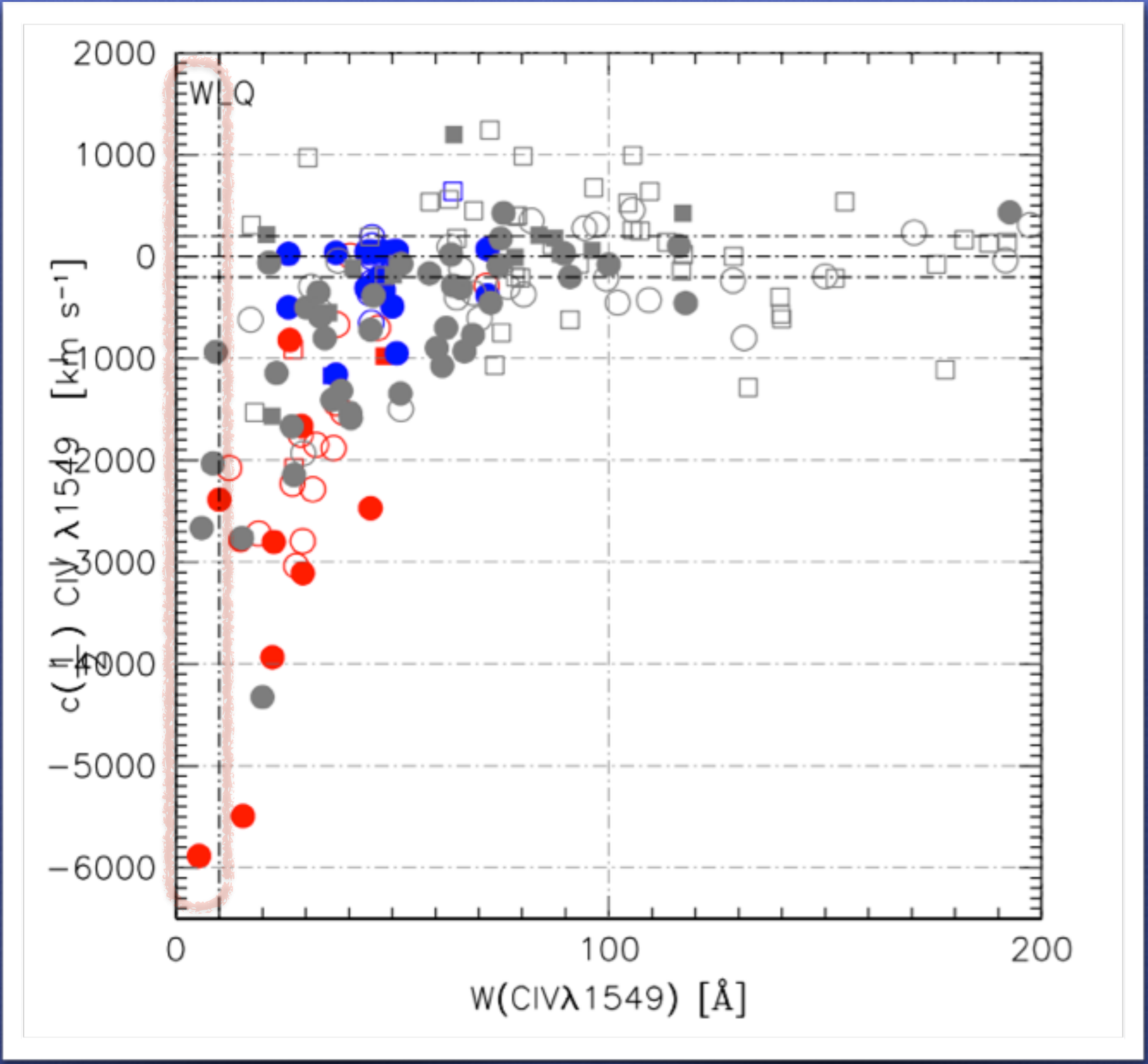
Diamond-Stanic et al. 2009




Shemmer et al. 2009

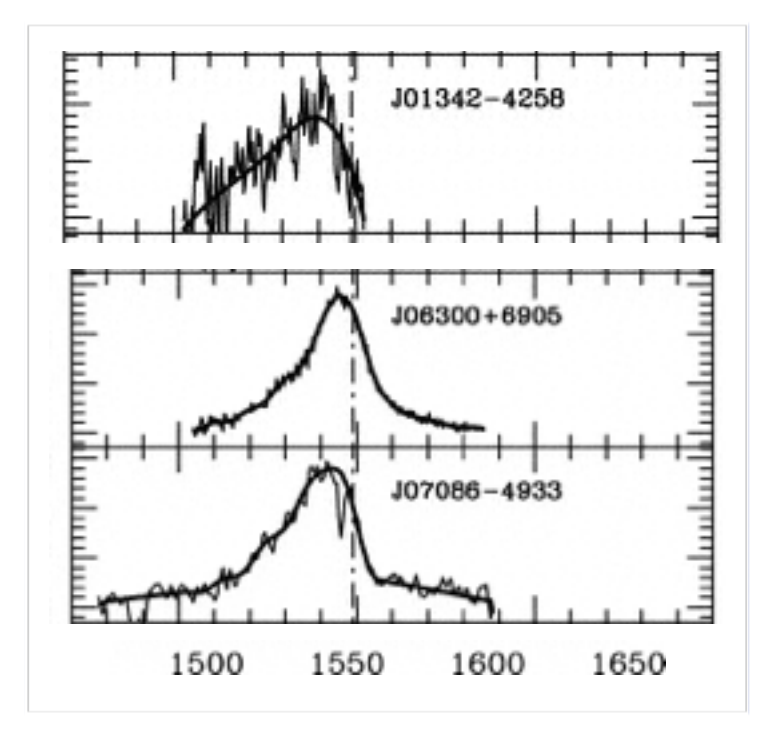
# $W$(CIVλ1549) vs CIV shift

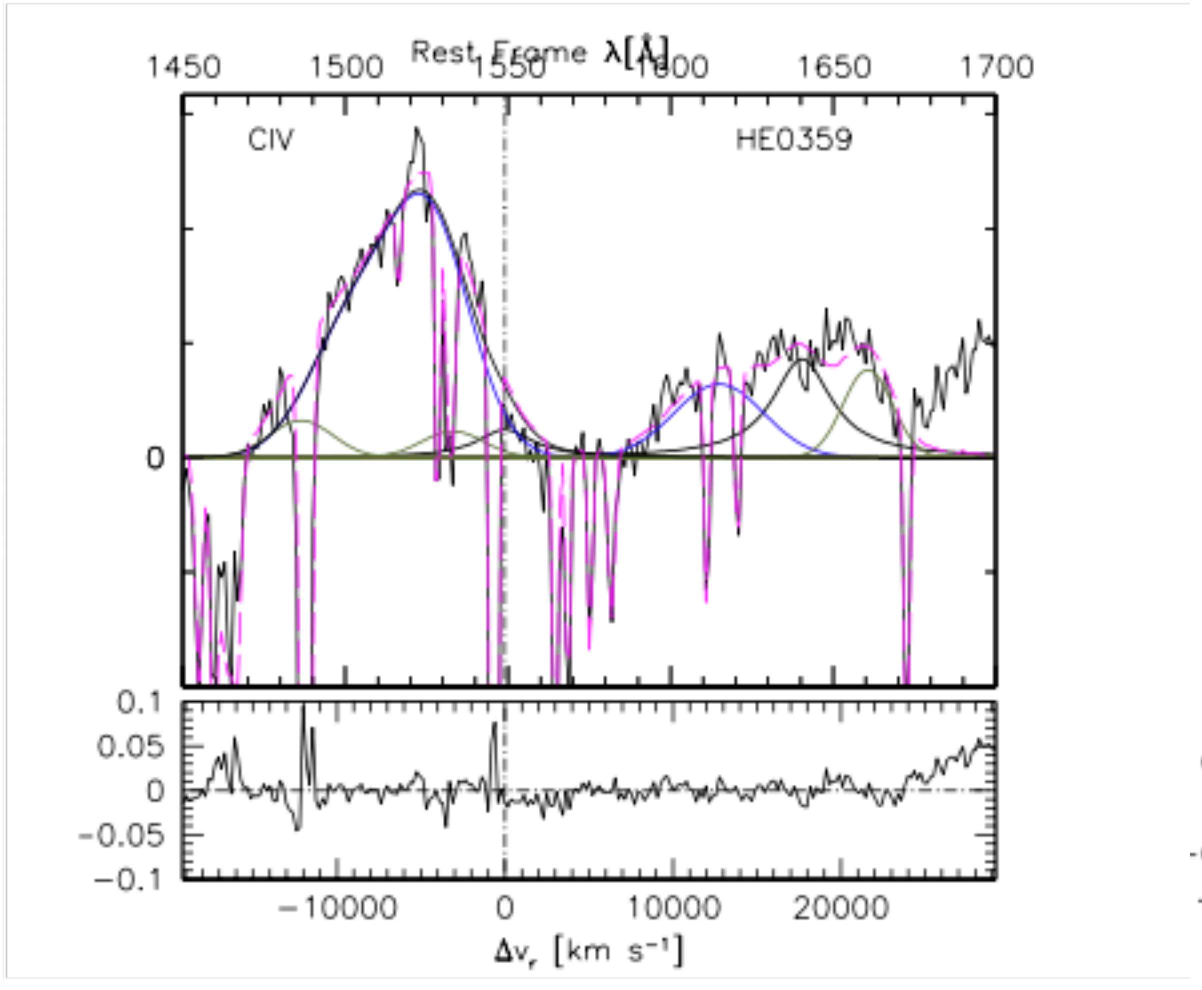


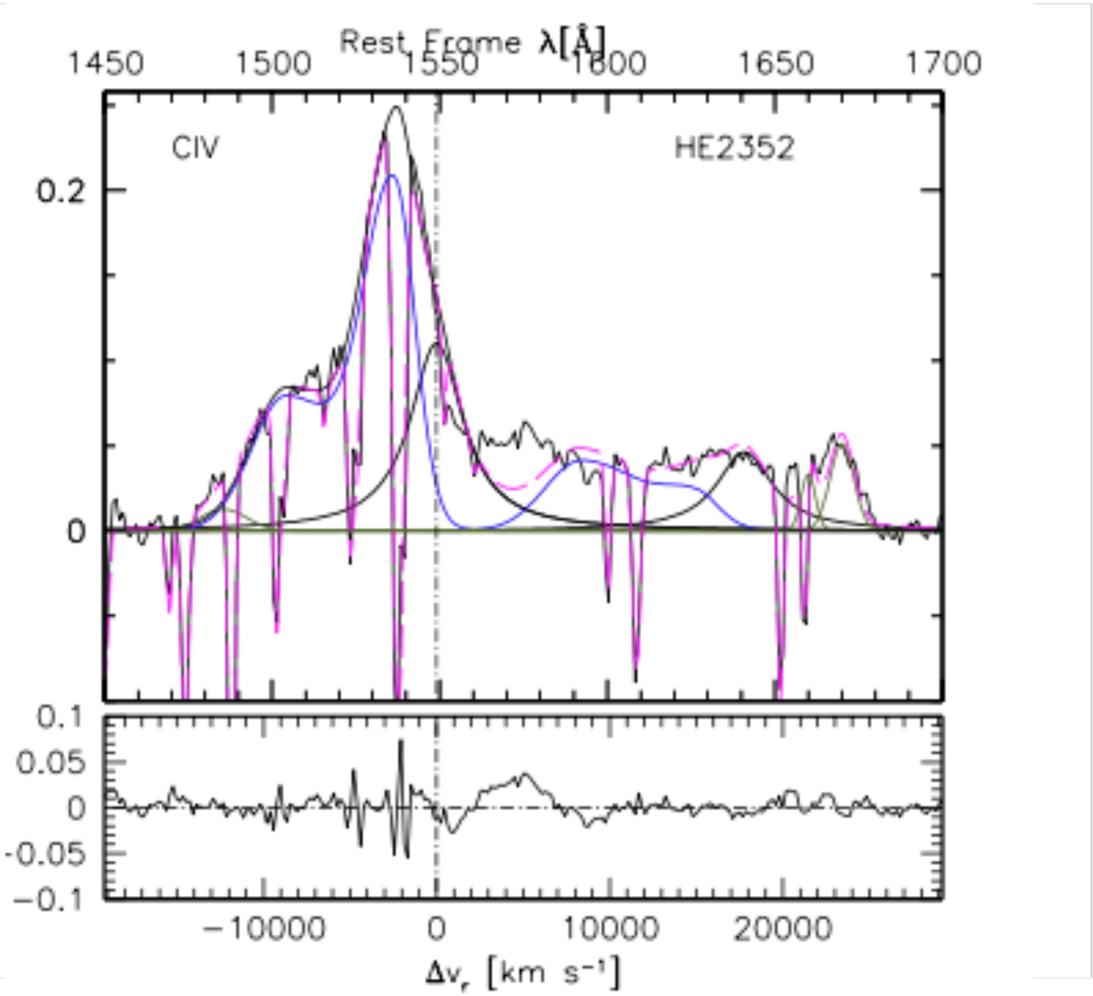

**c(1/2)≤-1000**
-300 ≥c(1/2) > -1000
-300 < c(1/2) ≤ 300
300 < c(1/2) ≤ 1000
**c(1/2) > 1000**

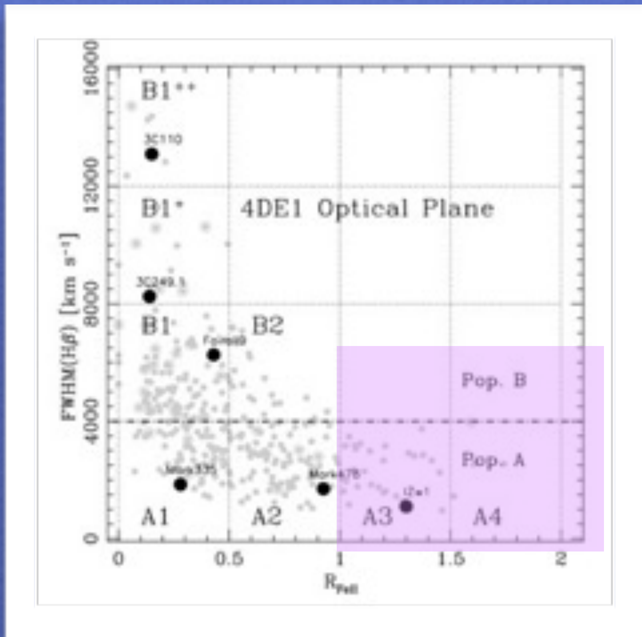
Filled: Pop. A
Open: Pop. B
Circles: RQ
Squares: RL

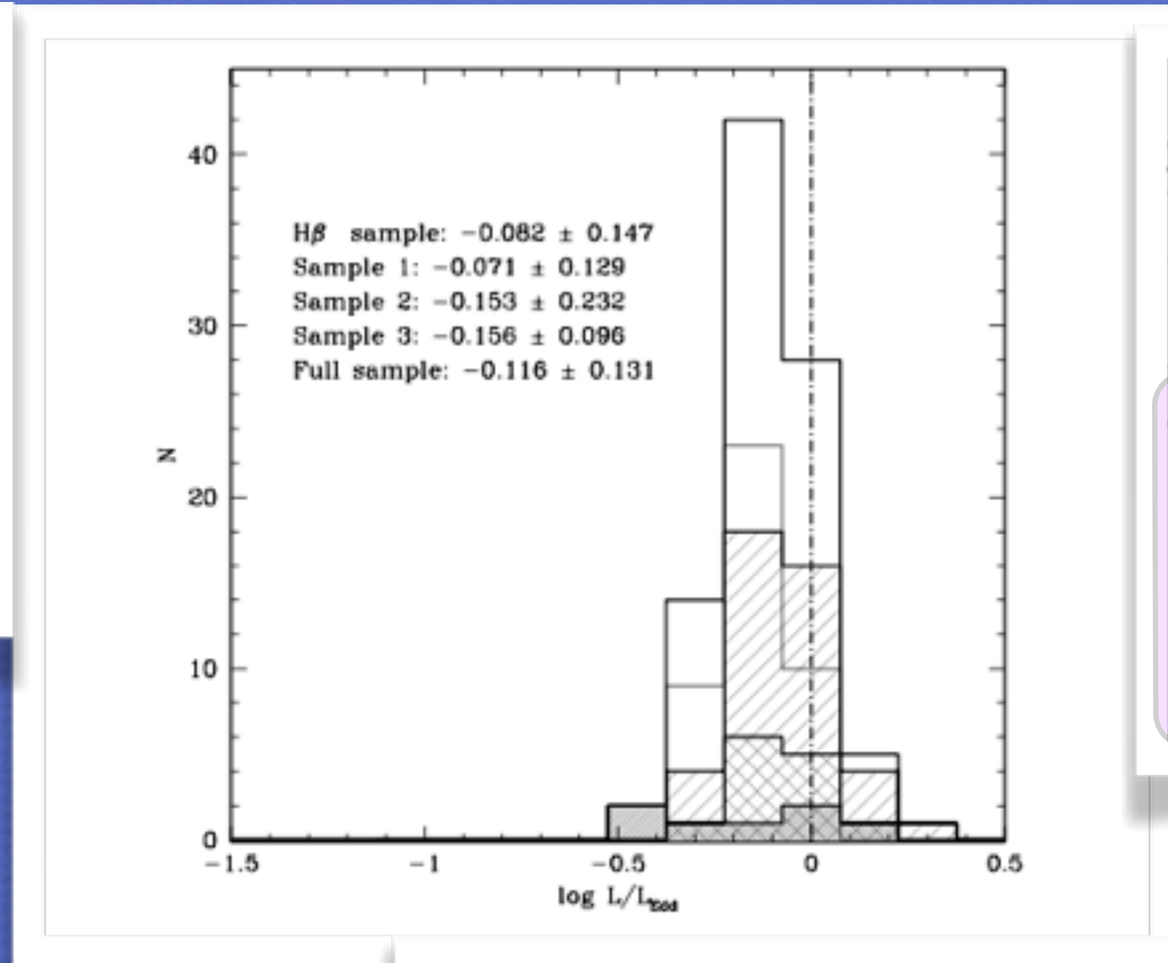
# CIVλ1549 profiles show extreme blueshifts

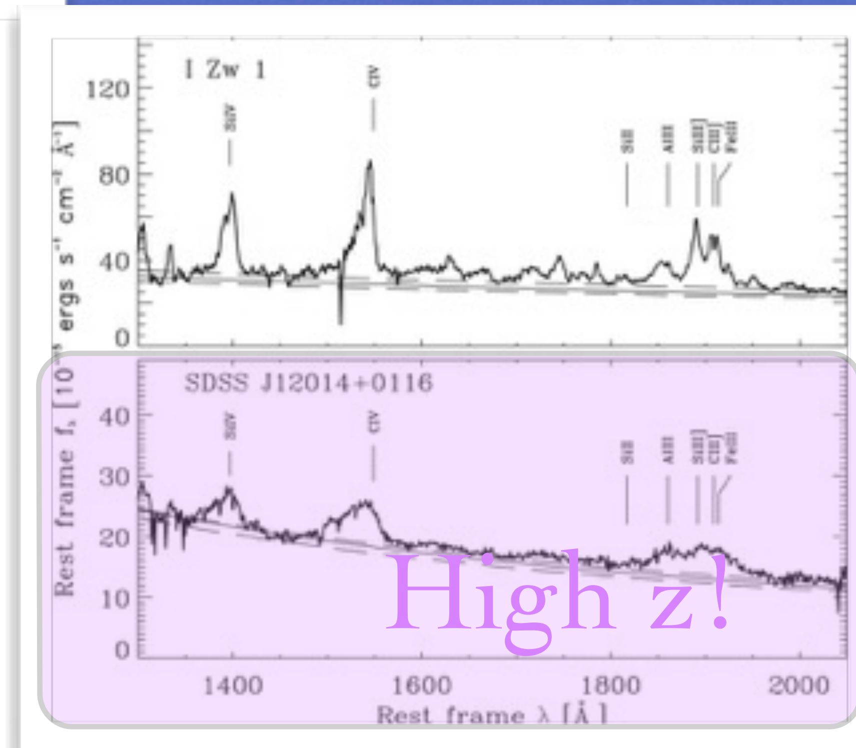


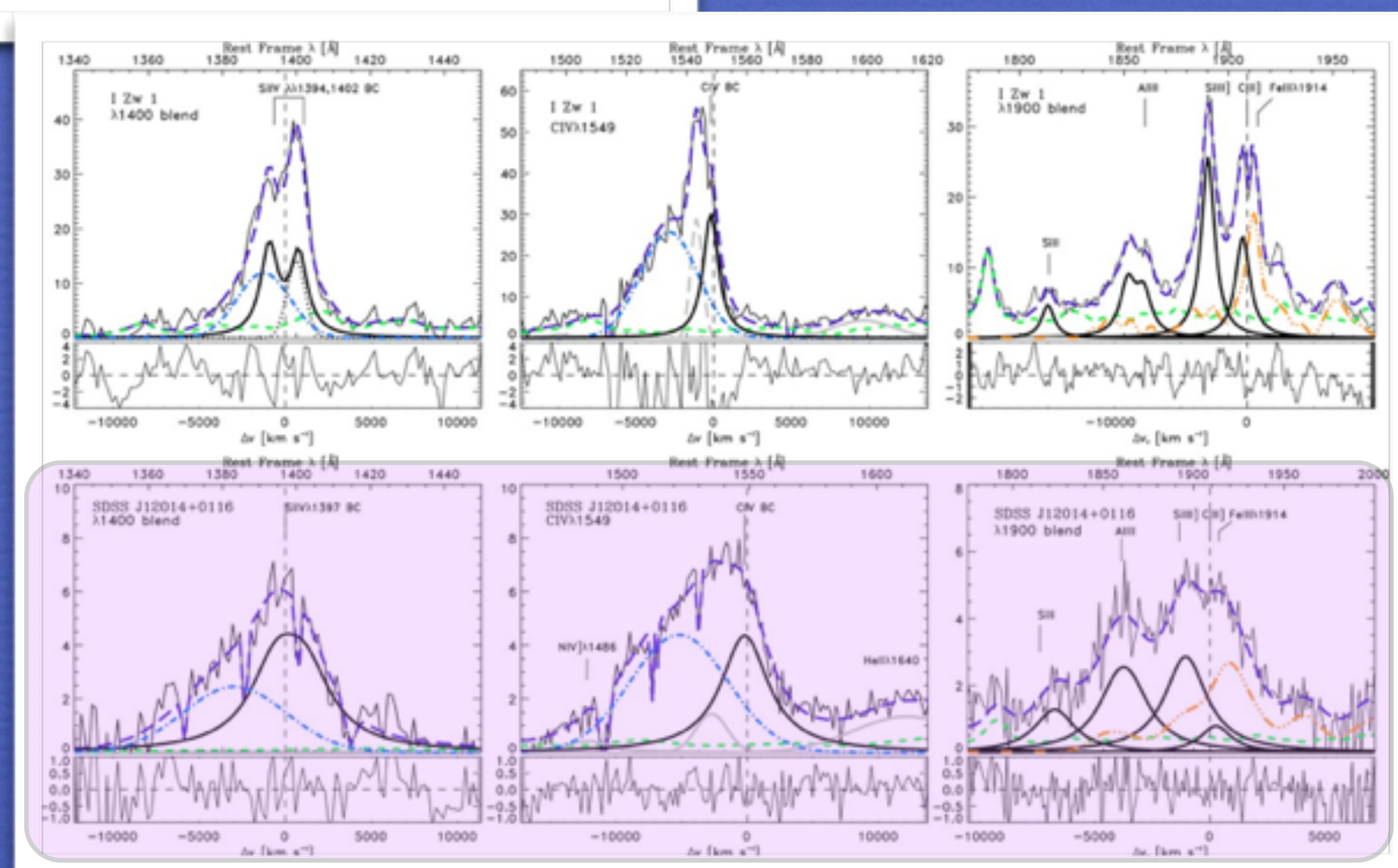





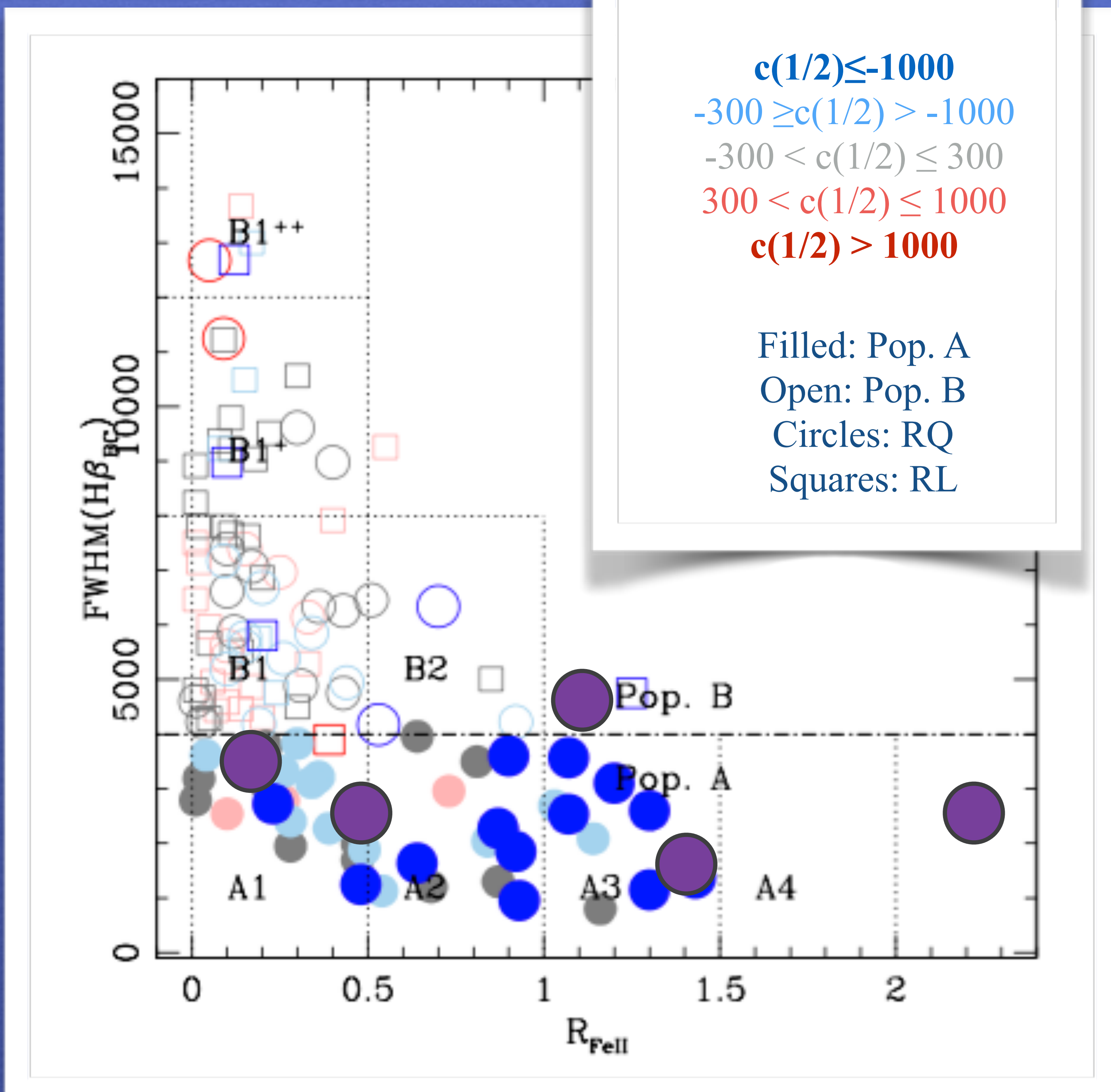




UV spectrum consistent with extreme A quasars revealed at both high and low luminosity, radiating at high Eddington ratio

(Dultzin et al. 2011; Negrete et al. 2012
Marziani & Sulentic 2014)

# WLQs in the optical plane of 4D Eigenvector 1

## Most —all of the ones at high-*z* — are extreme Pop. A sources with $R_{FeII} > 1$, with CIV showing extreme outflow velocities



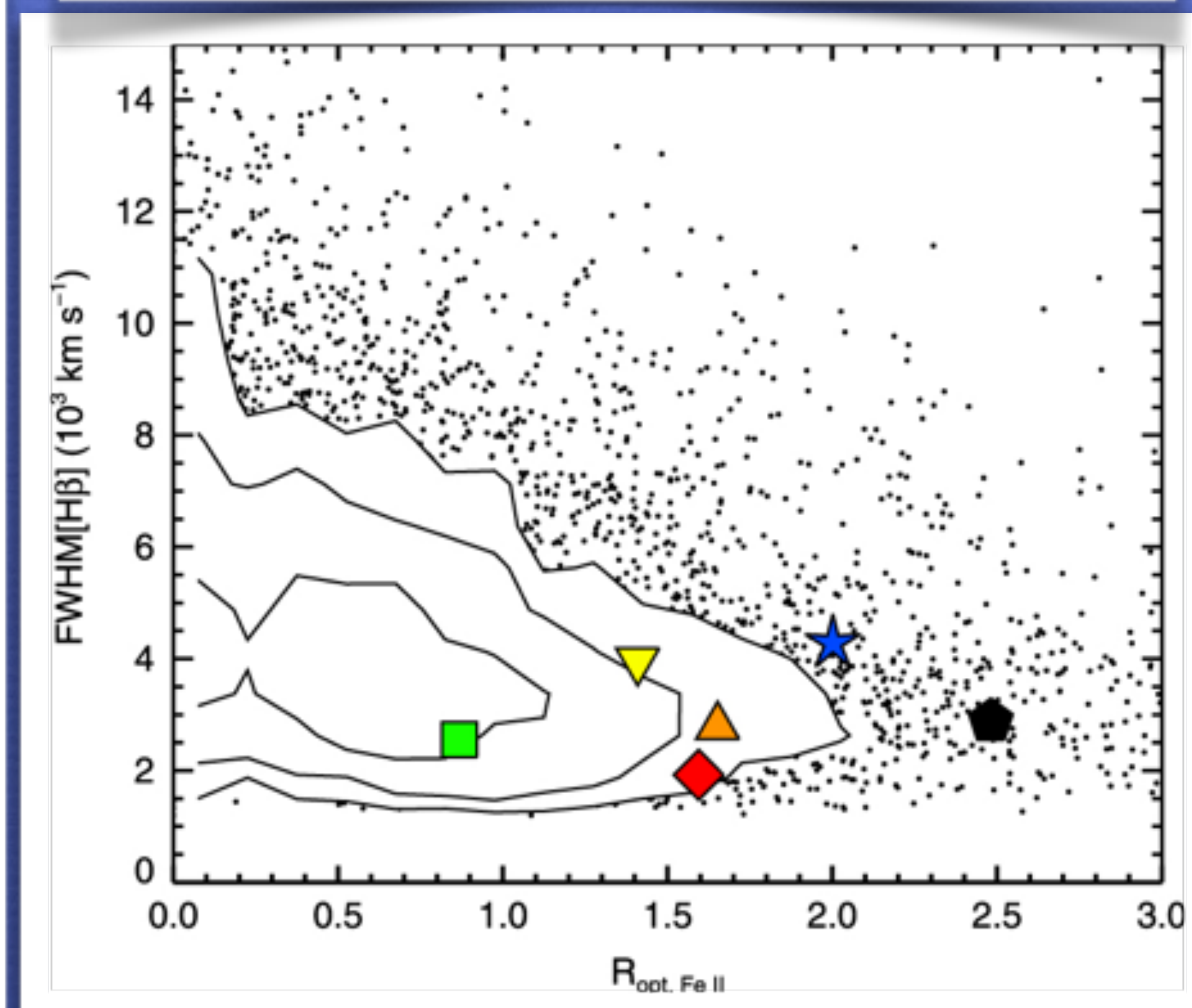

**c(1/2)≤-1000**
-300 ≥c(1/2) > -1000
-300 < c(1/2) ≤ 300
300 < c(1/2) ≤ 1000
**c(1/2) > 1000**

Filled: Pop. A
Open: Pop. B
Circles: RQ
Squares: RL

**Table 4**
Line Luminosities and Blueshifts

| Name | log L[Hα] (erg s$^{-1}$) | log L[Hβ] (erg s$^{-1}$) | log L[Mg II] (erg s$^{-1}$) | log L[C IV] (erg s$^{-1}$) | Δv[Mg II] (km s$^{-1}$) | Δv[C IV] (km s$^{-1}$) |
|---|---|---|---|---|---|---|
| J0836 | $44.29^{+0.21}_{-0.06}$ | $43.71^{+1.09}_{-0.19}$ | $43.56^{+0.09}_{-0.06}$ | $43.54 \pm 0.07$ | $197 \pm 216$ | $2266 \pm 191$ |
| J0945 | $44.64 \pm 0.05$ | $44.02 \pm 0.08$ | $44.29 \pm 0.02$ | $43.75 \pm 0.12$ | $1281 \pm 183$ | $5485 \pm 380$ |
| J1321 | $43.89^{+0.03}_{-0.04}$ | $43.32^{+0.39}_{-0.09}$ | $43.48^{+0.11}_{-0.02}$ | $43.95^{+0.28}_{-0.06}$ | $202 \pm 188$ | $396 \pm 189$ |
| J1411 | $44.03^{+0.03}_{-0.06}$ | $43.52 \pm 0.20$ | $43.34 \pm 0.06$ | $43.60^{+0.18}_{-0.06}$ | $-136 \pm 181$ | $3142^{+370}_{-208}$ |
| J1417 | $44.15^{+0.05}_{-0.03}$ | $43.45 \pm 0.11$ | $43.88 \pm 0.02$ | $43.55^{+2.38}_{-0.23}$ | $624 \pm 180$ | $5321^{+4178}_{-812}$ |
| J1447 | $43.99^{+0.03}_{-0.03}$ | $43.41^{+0.51}_{-0.07}$ | $43.56^{+0.09}_{-0.02}$ | $43.89^{+0.50}_{-0.15}$ | $1 \pm 185$ | $1319^{+766}_{-381}$ |

**Note.** Δv[Mg II] and Δv[C IV] are line of sight blueshifts of the peaks of the Mg II and C IV profiles, respectively. Δv is based on the observed wavelength of each line center (expected to be at rest-frame 2800 Å for Mg II and 1549 Å for C IV) compared to the systemic redshifts in Table 1. Blueshifts are defined to be positive for approaching motions.




Plotkin et al. 2015

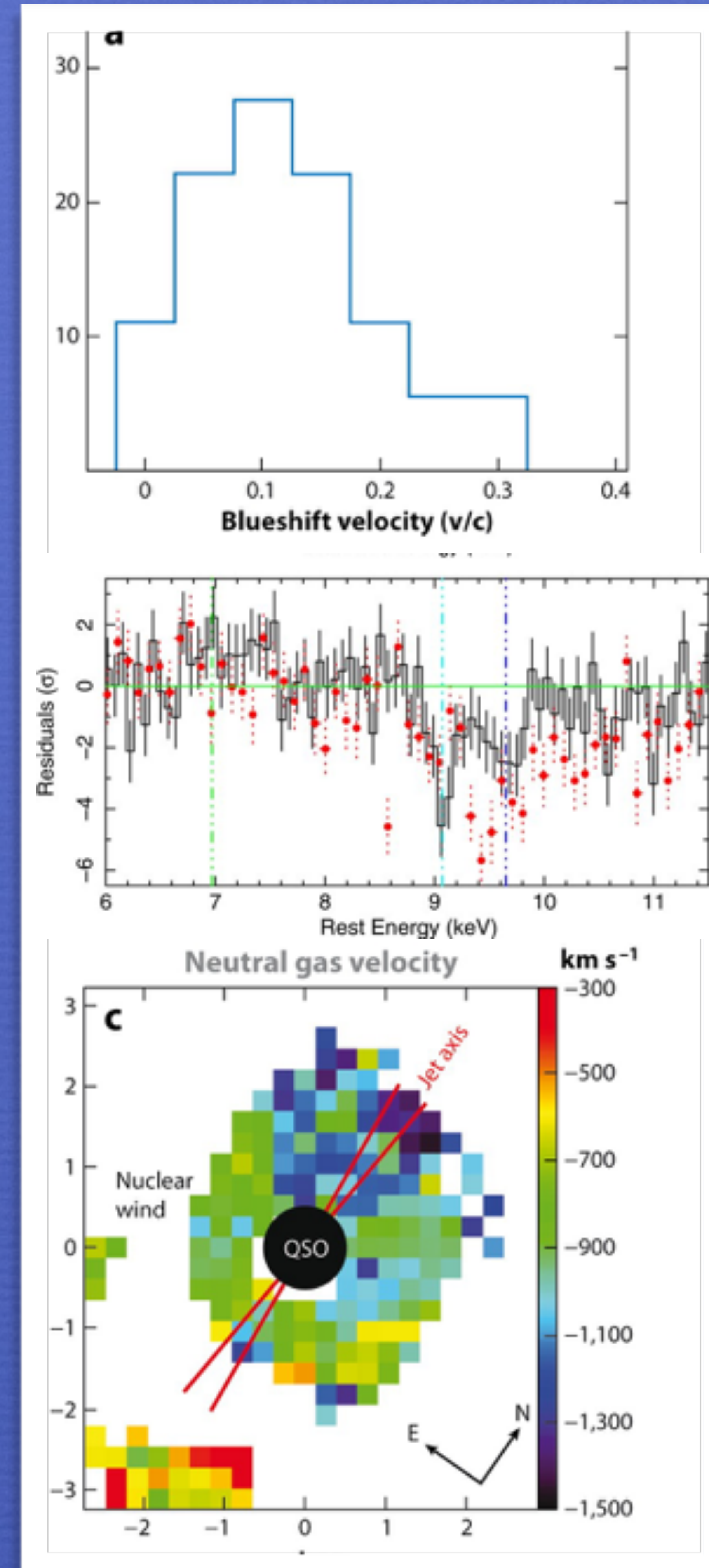
# The most powerful outflows: feedback?

# The observational evidence of the active nucleus feedback is still debated

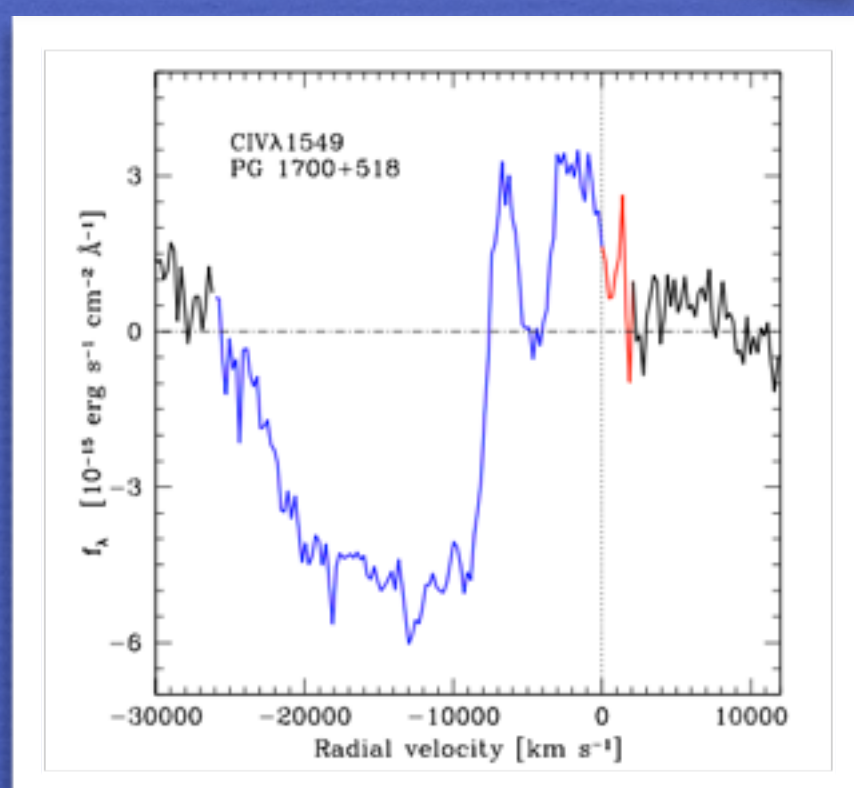
UFO

**Table 1** Observational evidence for AGN feedback

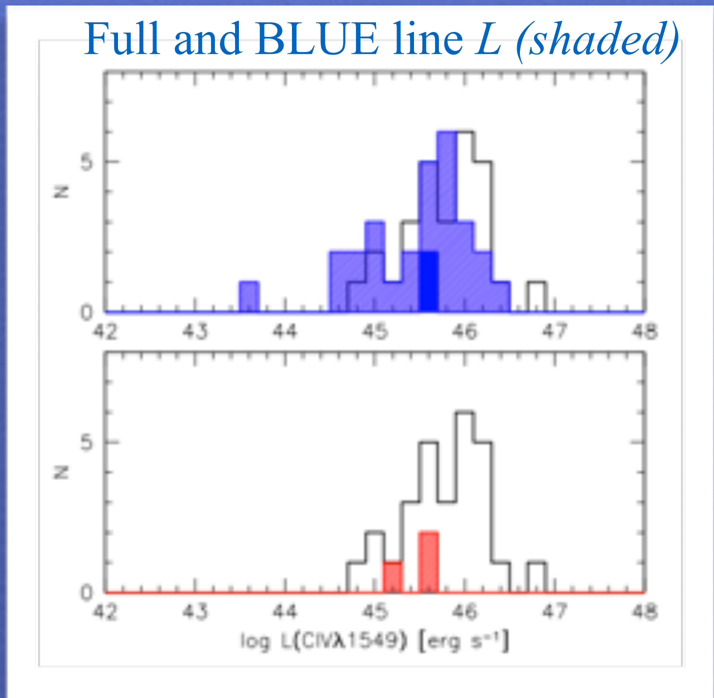
| Evidence | Quality |
|---|---|
| High-velocity broad absorption lines in quasars | Strong |
| Strong winds in AGN | Strong |
| 1,000 km s$^{-1}$ galactic outflows | Strong |
| Bubbles and ripples in brightest cluster galaxies | Strong |
| Giant radio galaxies | Strong |
| Lack of high star-formation rate in cool cluster cores | Indirect |
| *M*–*σ* relation | Indirect |
| Red and dead galaxies | Indirect |
| Lack of high lambda, moderate $N_H$, quasars | Indirect |
| Steep *L*–*T* relation in low *T* clusters and groups | Indirect |




Large Balnicity index BAL QSOs are a minority of quasars

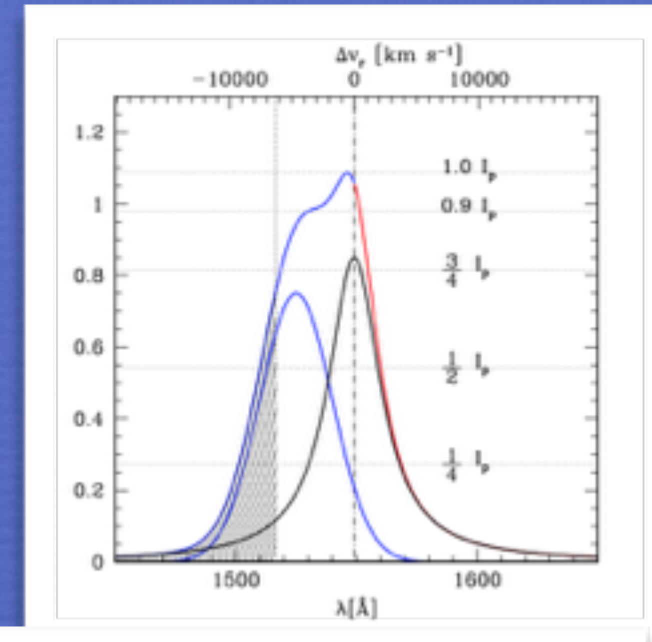



Fabian 2012; Rupke & Veilleux 2011; Tombesi et al. 2010; Reeves et al. 2009




# CIVλ1549 blue component

a fraction of the line emitting gas is above the expected projected escape velocity at r ~ 1000 $R_g$.




King & Pounds 2015; Faban 2012; Cano.Diaz et al. 2014

The **mass of ionised gas** emitting CIVλ 1549 can be written as, under the assumption of constant density:

$$M^{\rm ion}_{\rm out} = 9.5\ 10^2\ L_{45}({\rm CIV}) \left(\frac{Z}{5Z_\odot}\right)^{-1} n_{\rm g}^{-1}\ M_\odot$$

The **mass outflow rate** at a distance $r$ (1 pc) can be written as, if the flow is confined to a solid angle of $\Omega$:

$$\dot{M}^{\rm ion}_{\rm out} = \rho\ \Omega r^2 v = \frac{M^{\rm ion}_{\rm out}}{V}\Omega r^2 v \approx 15 L_{45} v_{5000} r_1^{-1} {\rm M}_\odot\ {\rm yr}^{-1}$$

The **outflow kinetic power**, with outflow $v$ in units of 5000 km $s^{-1}$, is:

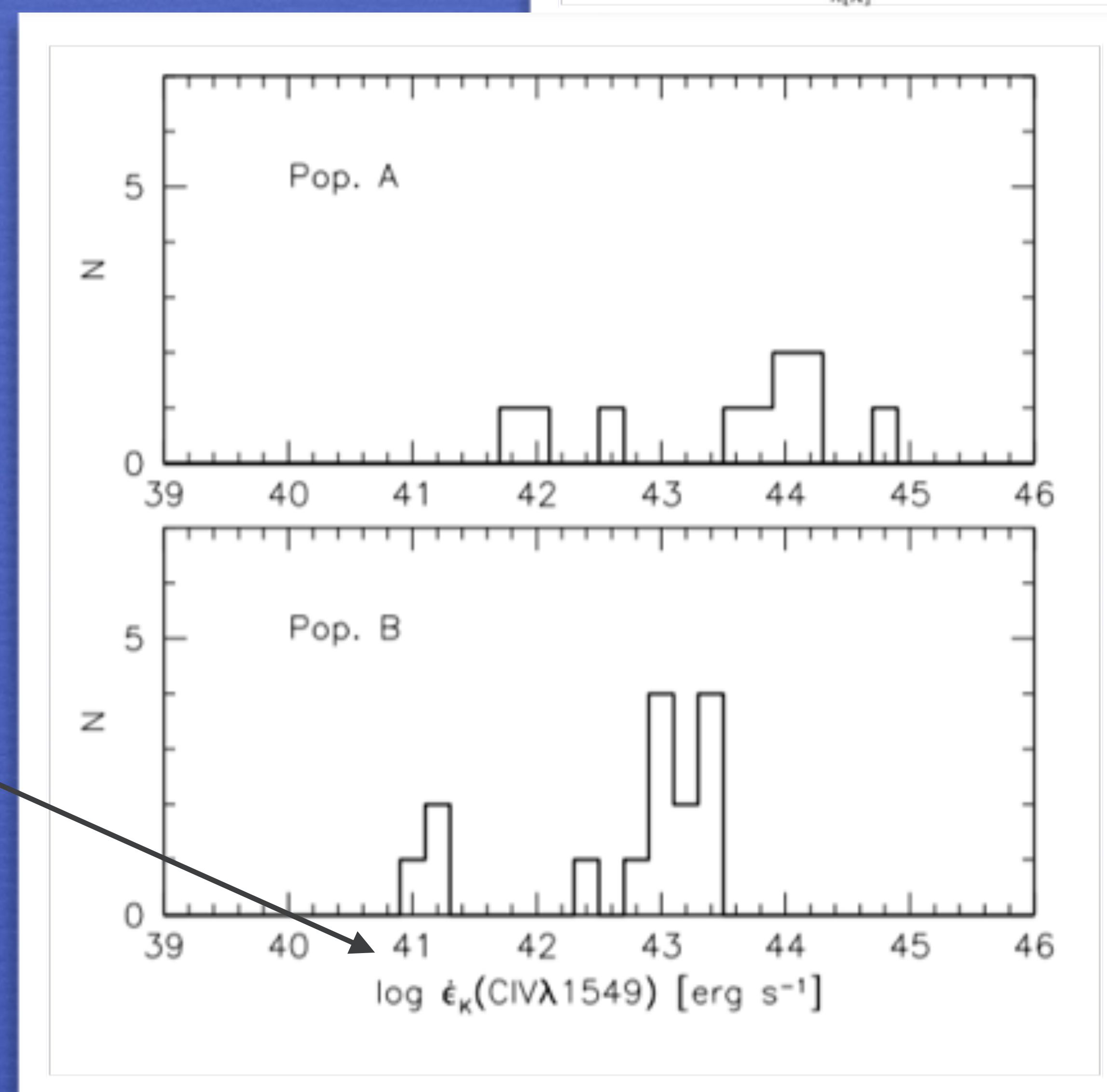
$$\dot{\epsilon} = \frac{1}{2}\dot{M}^{\rm ion}_{\rm out} v^2 \approx 1.2 \cdot 10^{44} L_{45} v^3_{5000} r_1^{-1} {\rm erg\ s}^{-1}.$$

The **total energy expelled over a duty cycle** of $10^8$ yr is

$$\int \dot{\epsilon} dt \approx 3.6 \cdot 10^{59} L_{45} v^3_{5000} r_1^{-1} \tau_8\ {\rm erg}.$$

This value can be compared to the **binding energy of the gas in a massive bulge/spheroid**:

$$U = \frac{3GM^2_{\rm sph} f_{\rm g}}{5R_{\rm e}} \approx 2 \cdot 10^{59} M^2_{\rm sph,11} f_{\rm g,0.1} R^{-1}_{\rm e,2.5kpc} {\rm erg}$$



# Conclusions

4DE1 provides an interpretation framework at extreme luminosity.

The CIV analysis reveals blueshifted emission associated with quasars outflows in RQ quasars, with high amplitude shifts being frequent at high L.

"Unexpected" luminosity effects are not seen: larger CIV shifts are expected for a radiation driven wind. The outflow phenomenology is self-similar over a wide range of L.

The CIV blueshift-dominated profile in the most luminous sources supports the idea that the outflow may be at the origin of galactic-scale feedback effects.