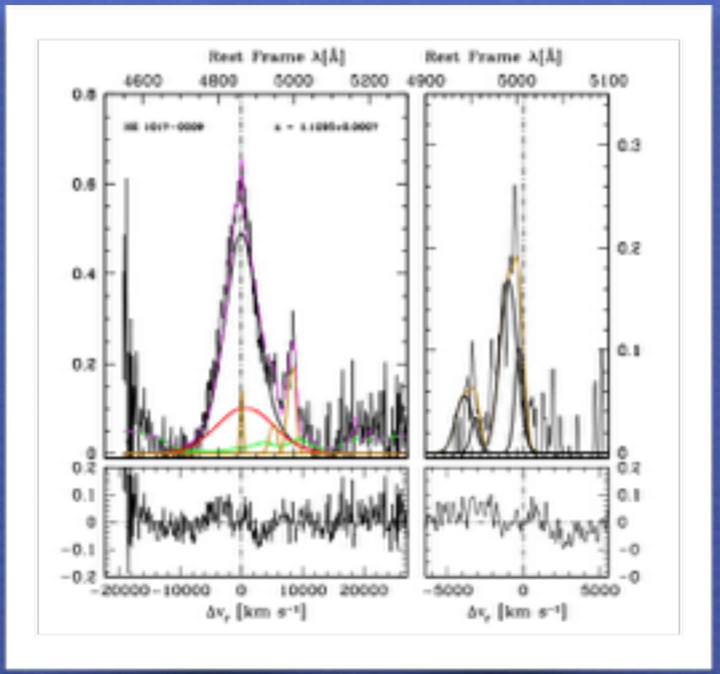
“BLUE OUTLIERS” AMONG HIGH REDSHIFT QUASARS



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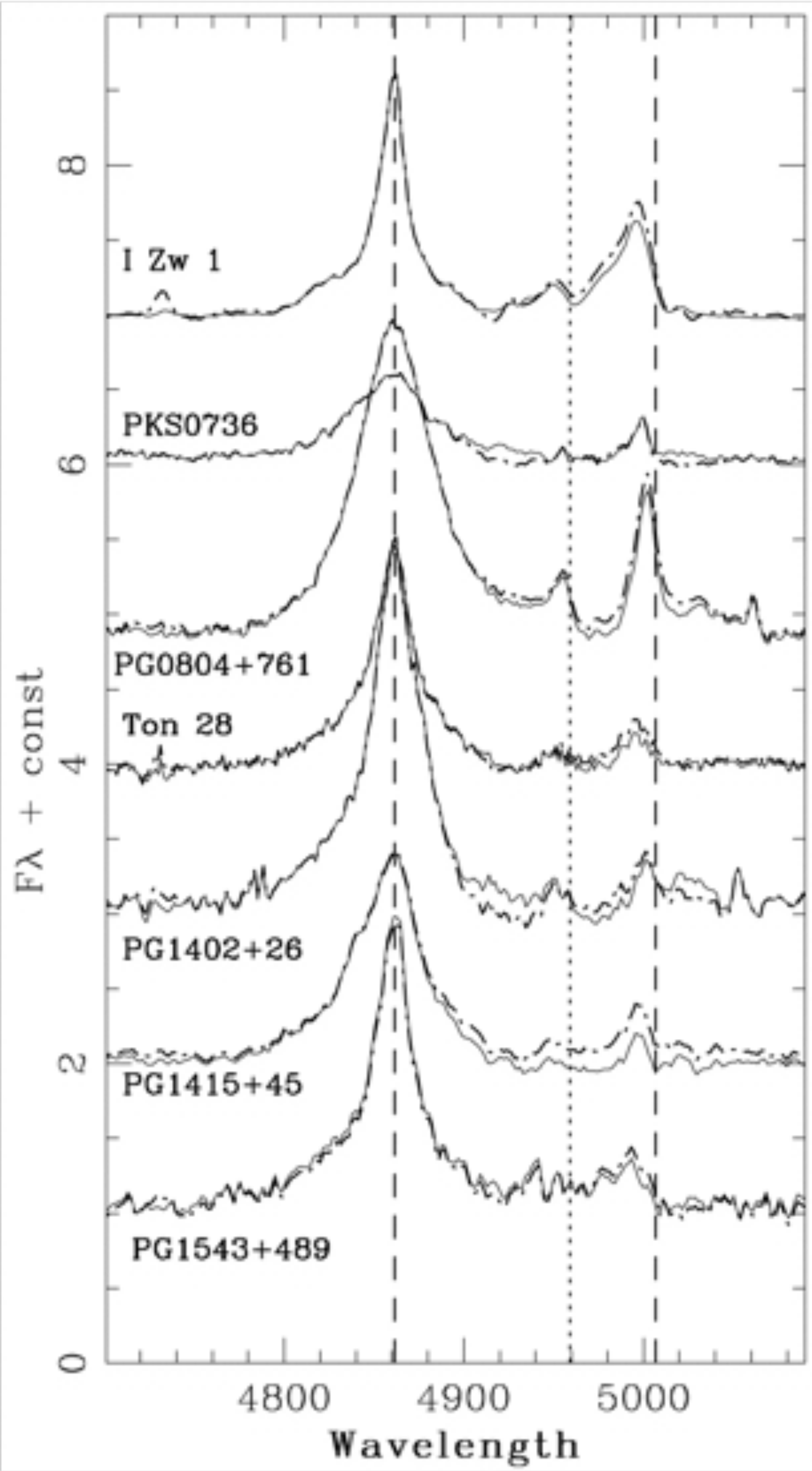
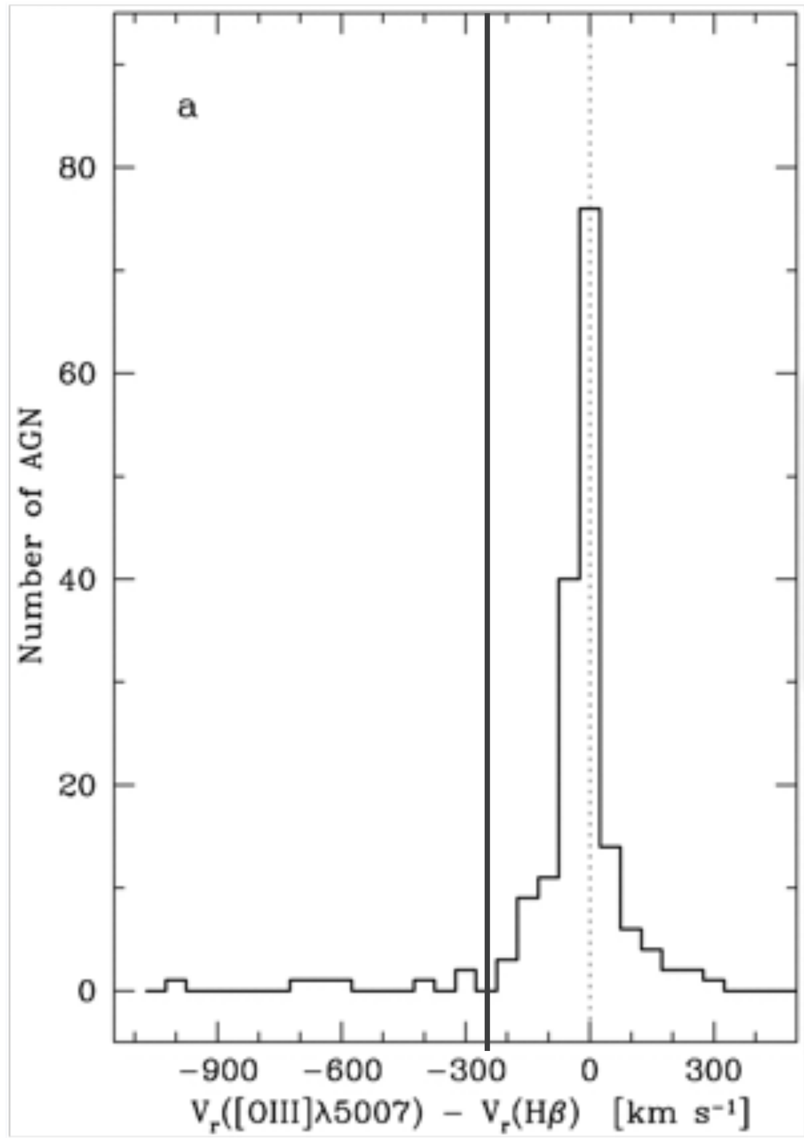
"Blue outliers:" the original picture (c.a. 2002)



Zamanov et al. 2002

Blue outliers: type-1 AGN whose [OIII]λ5007 is displaced to the blue by more than 250 km s^{-1}

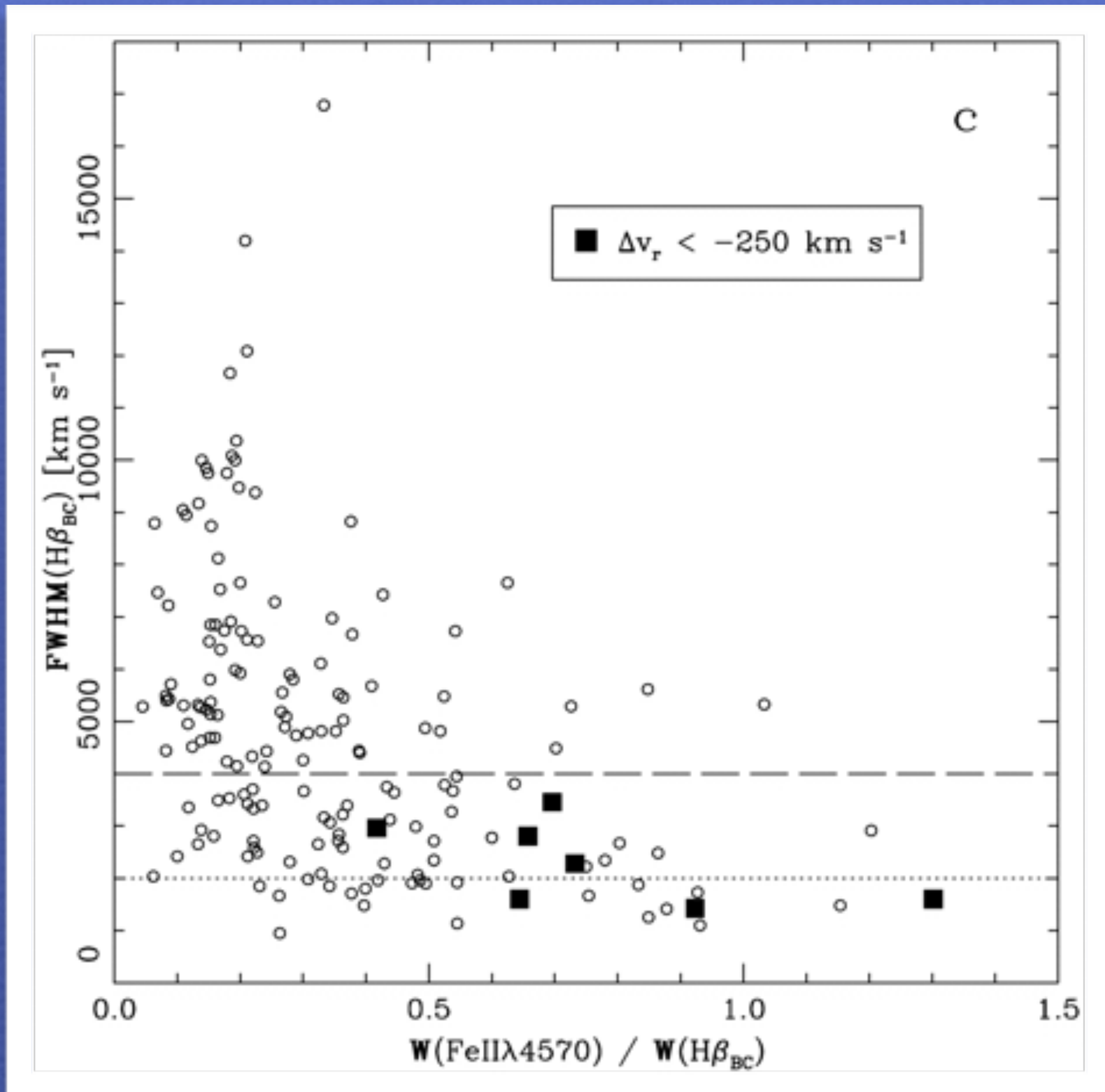


Real "statistical outliers" from the modified Z score

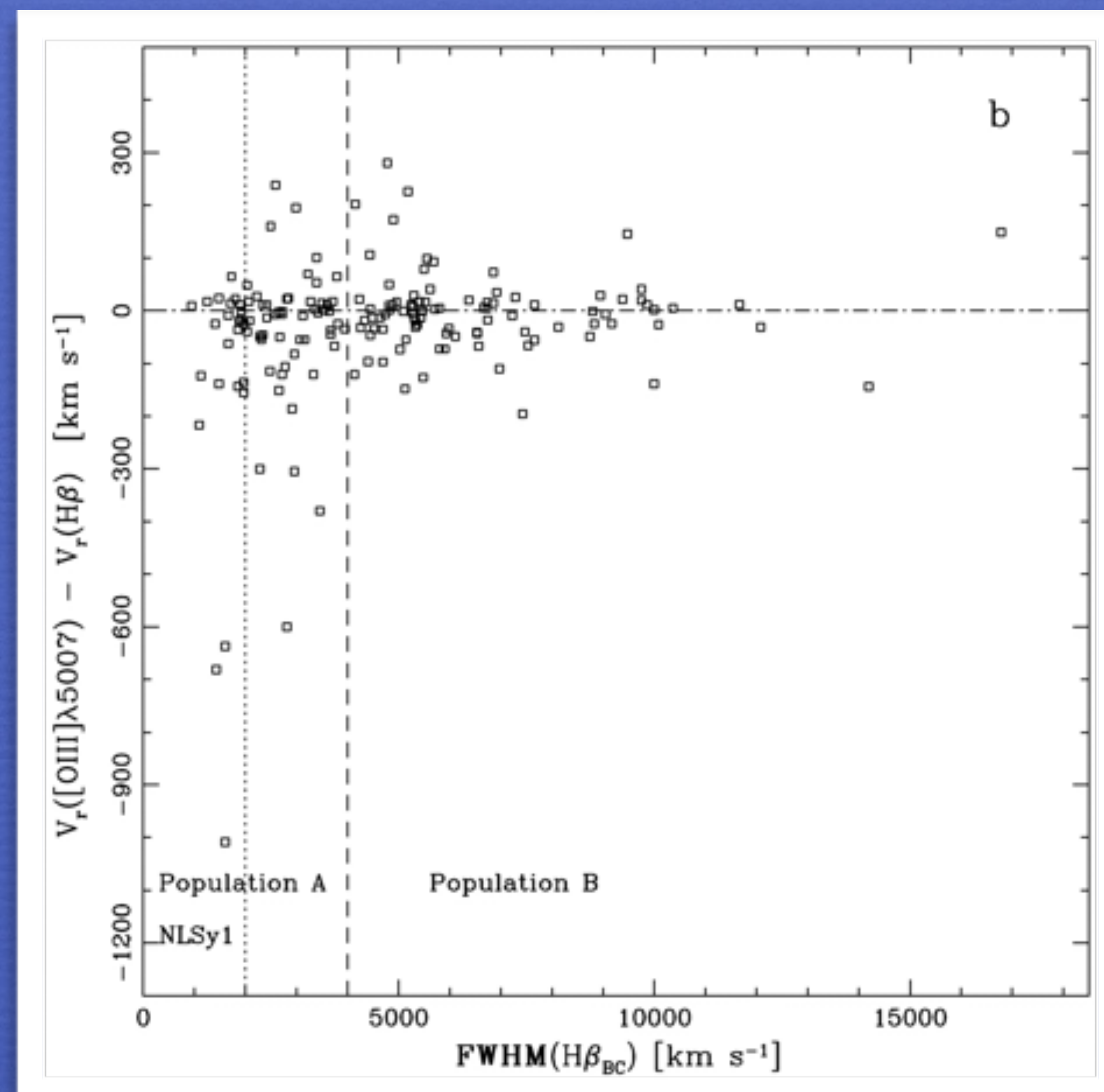
$$Z_i = 0.6745 \frac{v_i - \langle v \rangle}{\langle |v_i - \langle v \rangle| \rangle}$$

Iglewicz and Hoaglin 1993

Usually of low EW
W≲20 Å



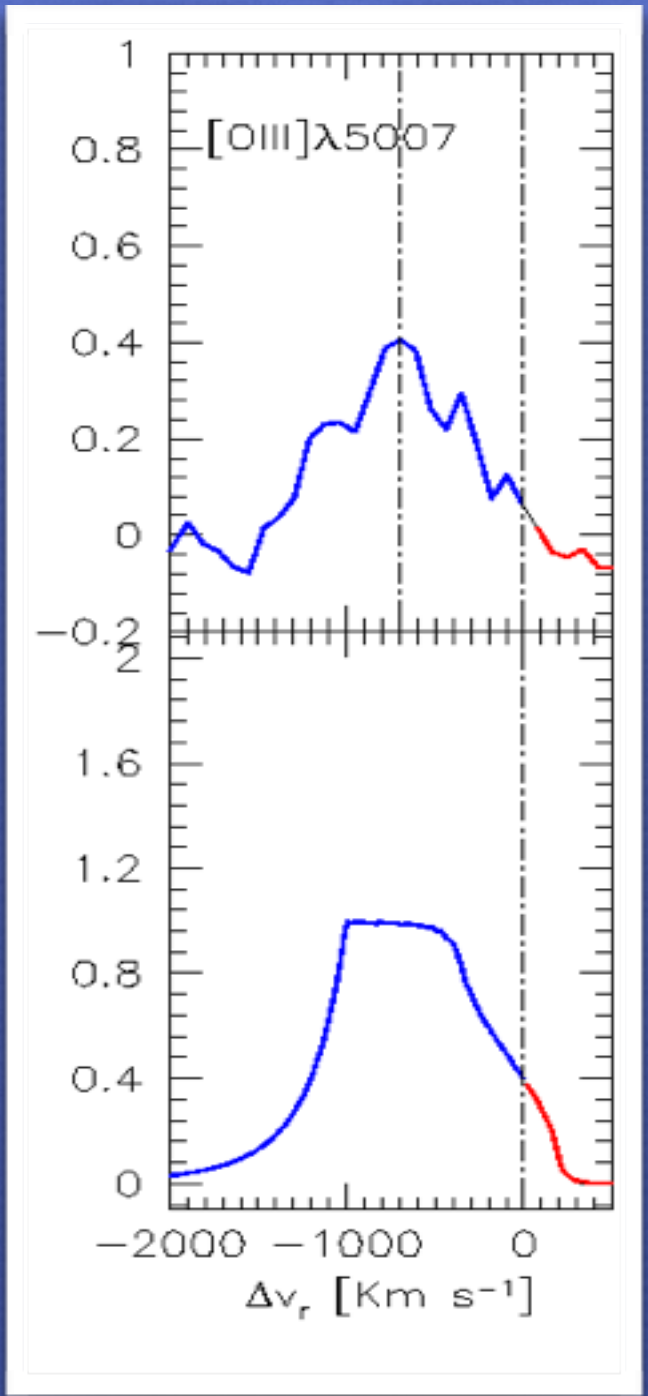
Blue outliers in the 4D eigenvector 1 context

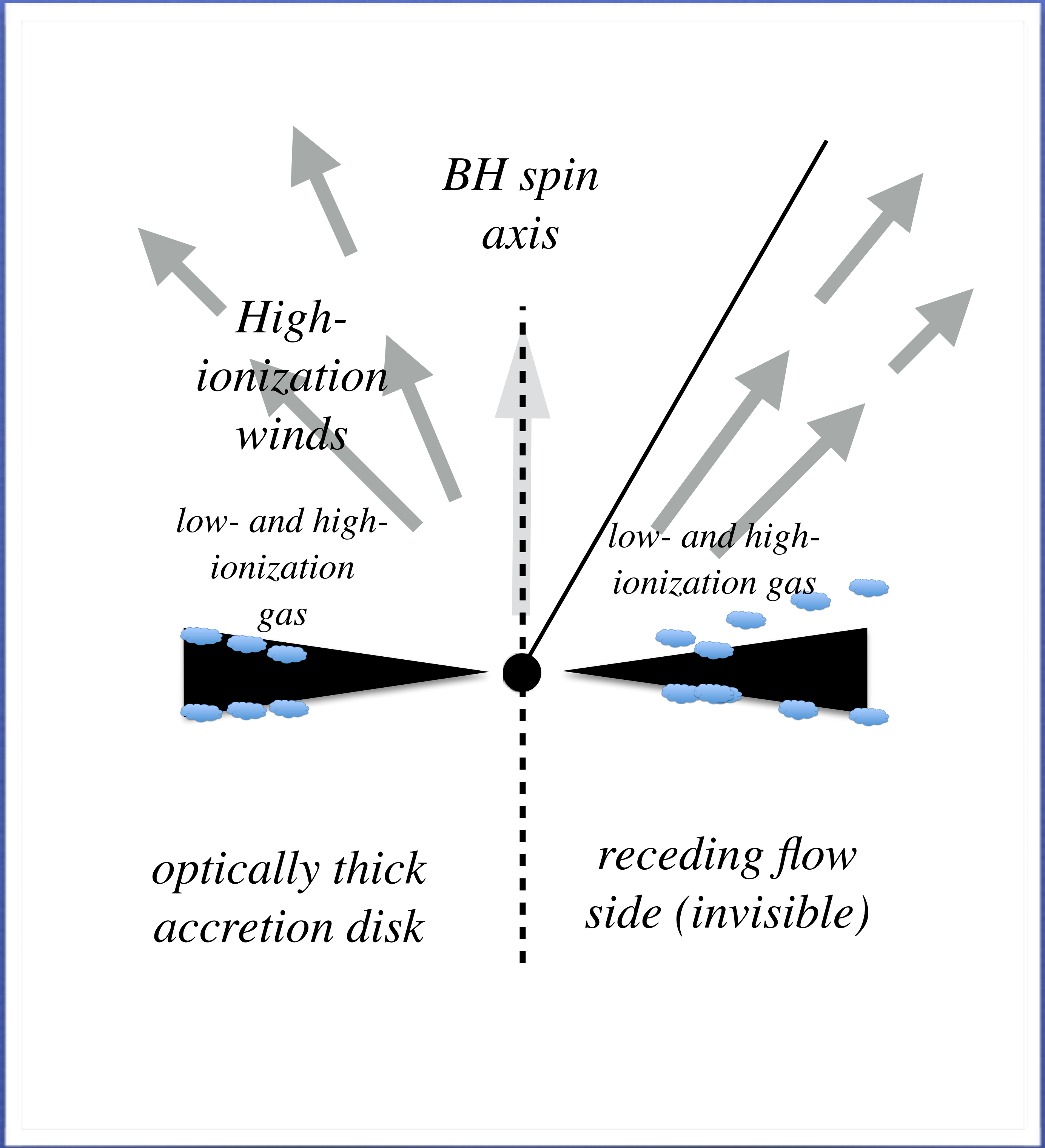


Population A sources: larger Eddington ratio outflow/wind evidence

Physical interpretation: outflow

Ton 28

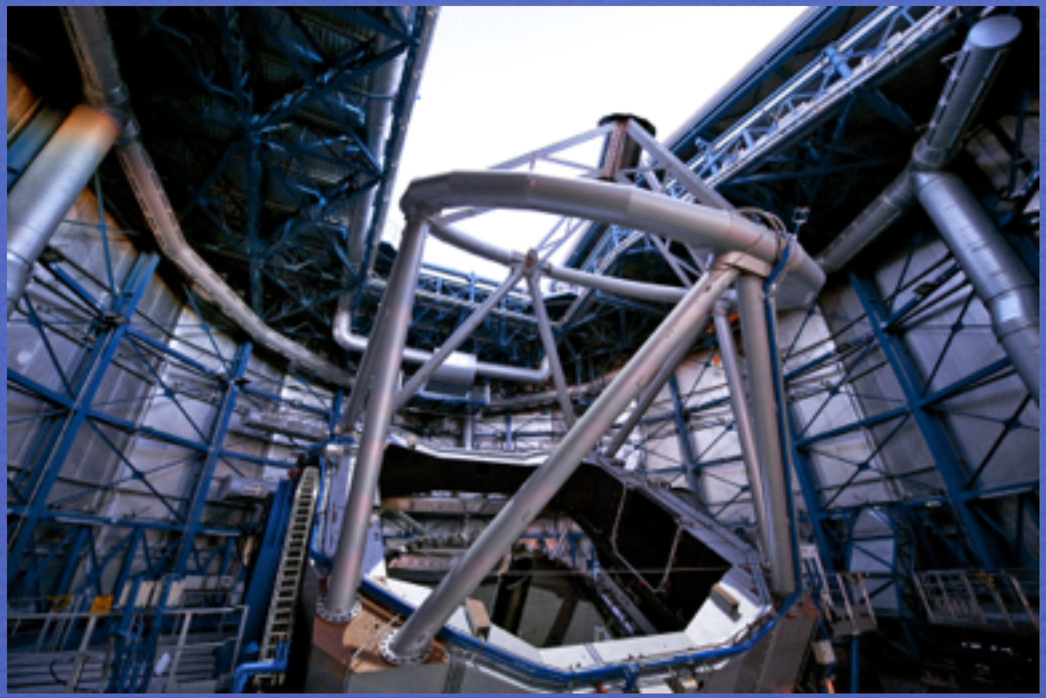




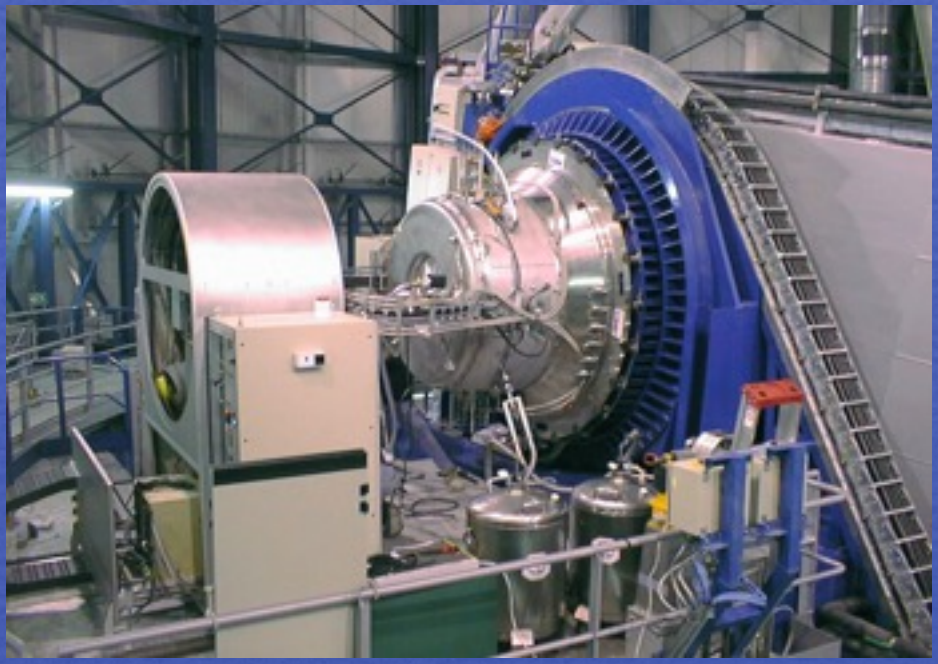
Wide opening angle radial flow, with velocity field $v = f v_{esc}(r) \propto r^{-3/4}$ ($f>1$) *roughly* accounts for [OIII] profile; compact NLR

Progressing to intermediate / high-z

52 luminous quasars in the redshift range $0.9 \lesssim z \lesssim 3.1$ (most $1 \lesssim z \lesssim 2$) of the Hamburg-ESO survey observed in the Hβ spectral range

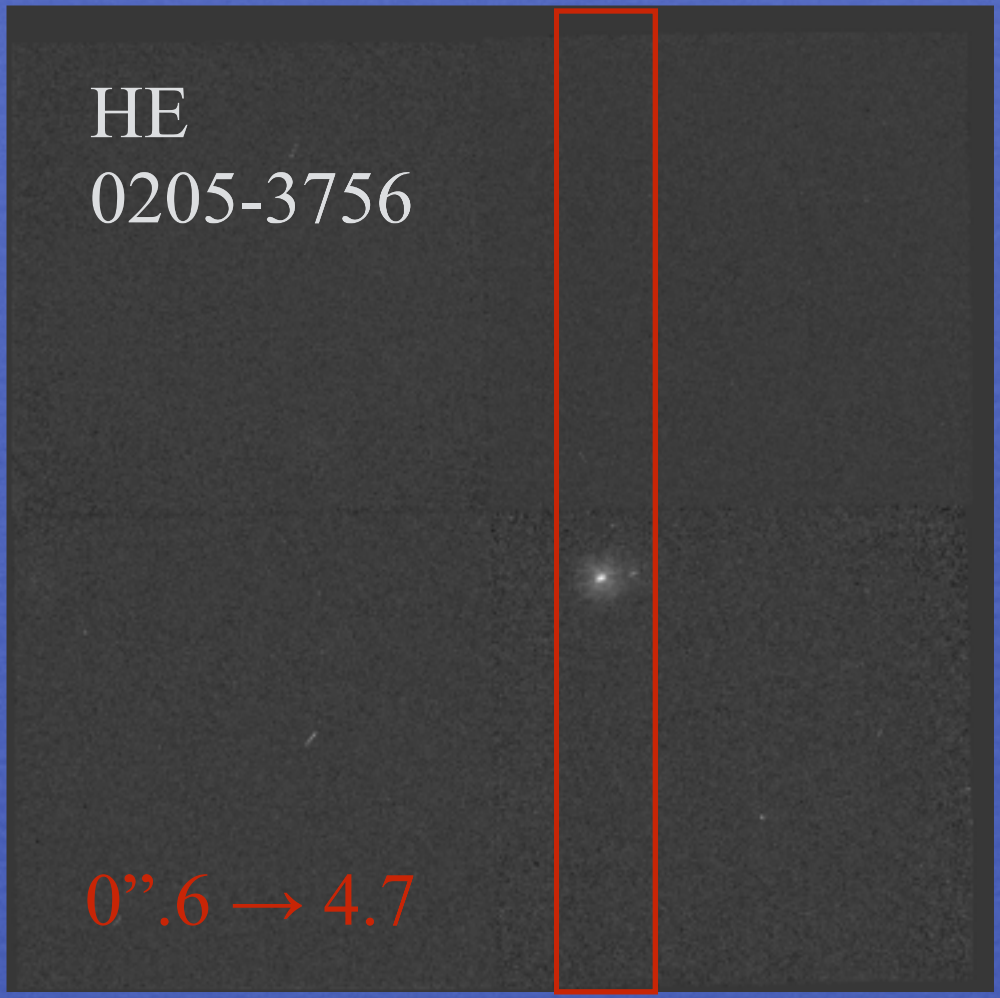


ESO VLT

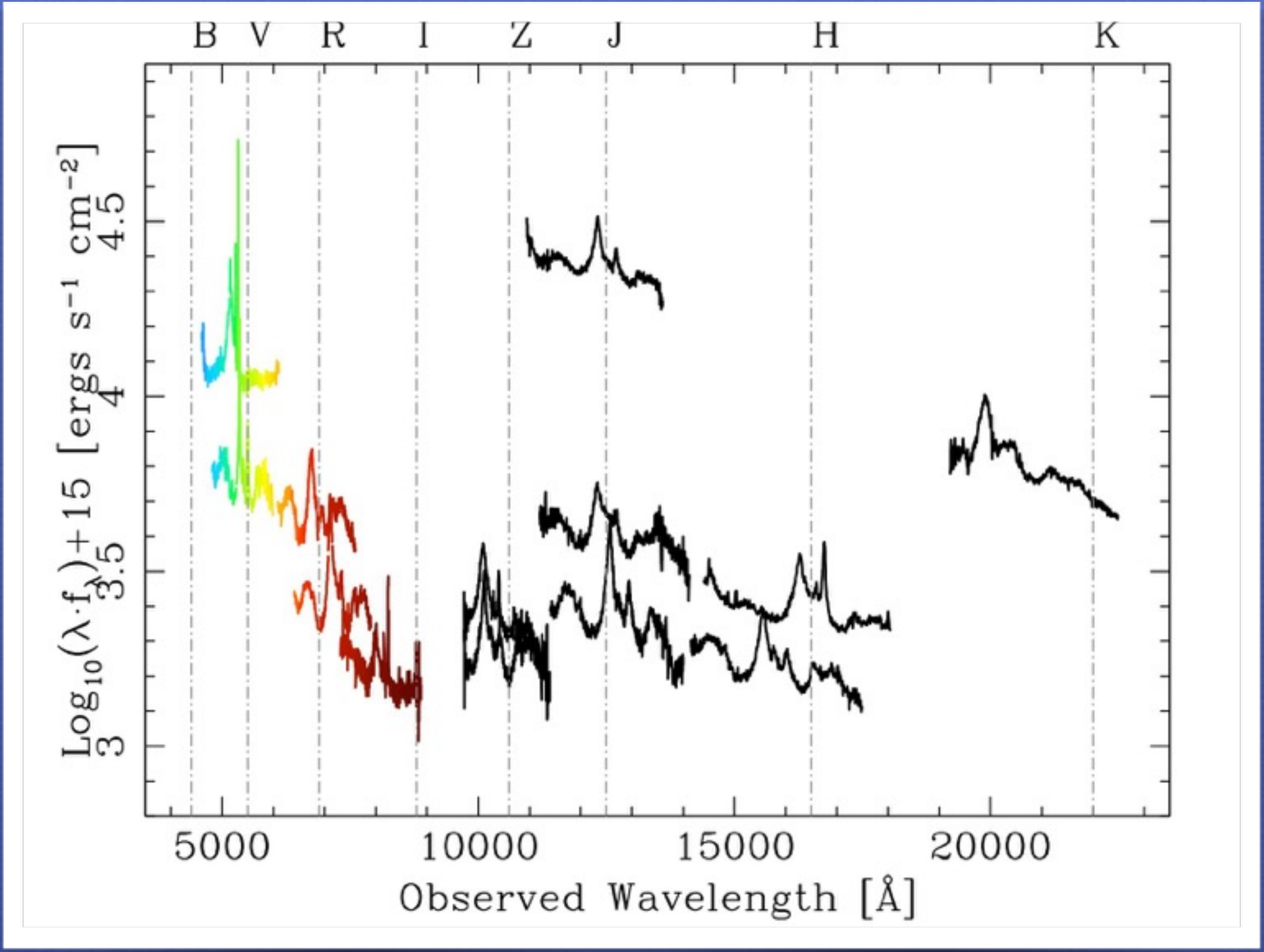


ISAAC

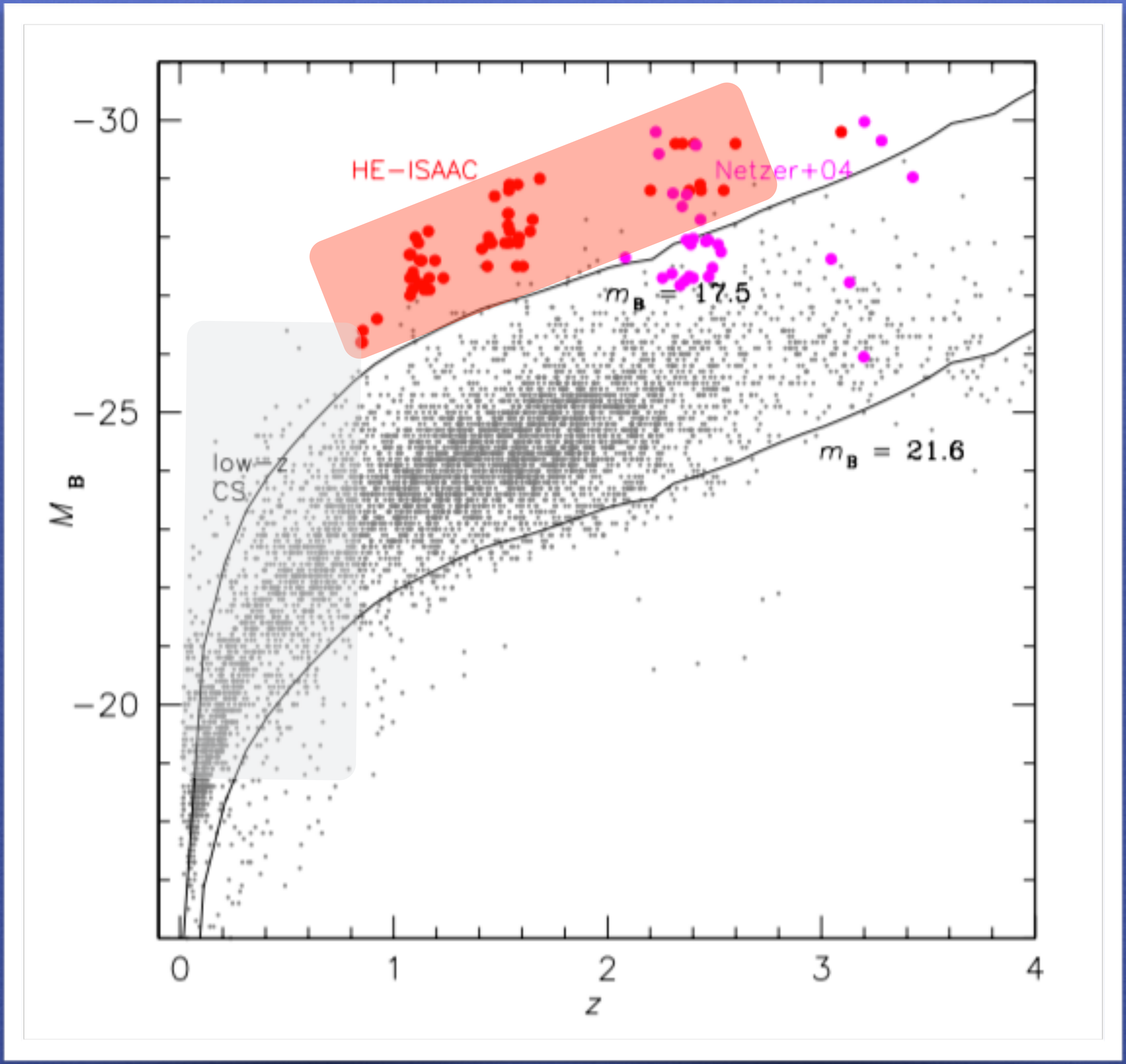
$R = \lambda/\delta\lambda \sim 250$
sZ,J,H,K



IR spectra have resolution and S/N similar to the ones of low-*z* quasars



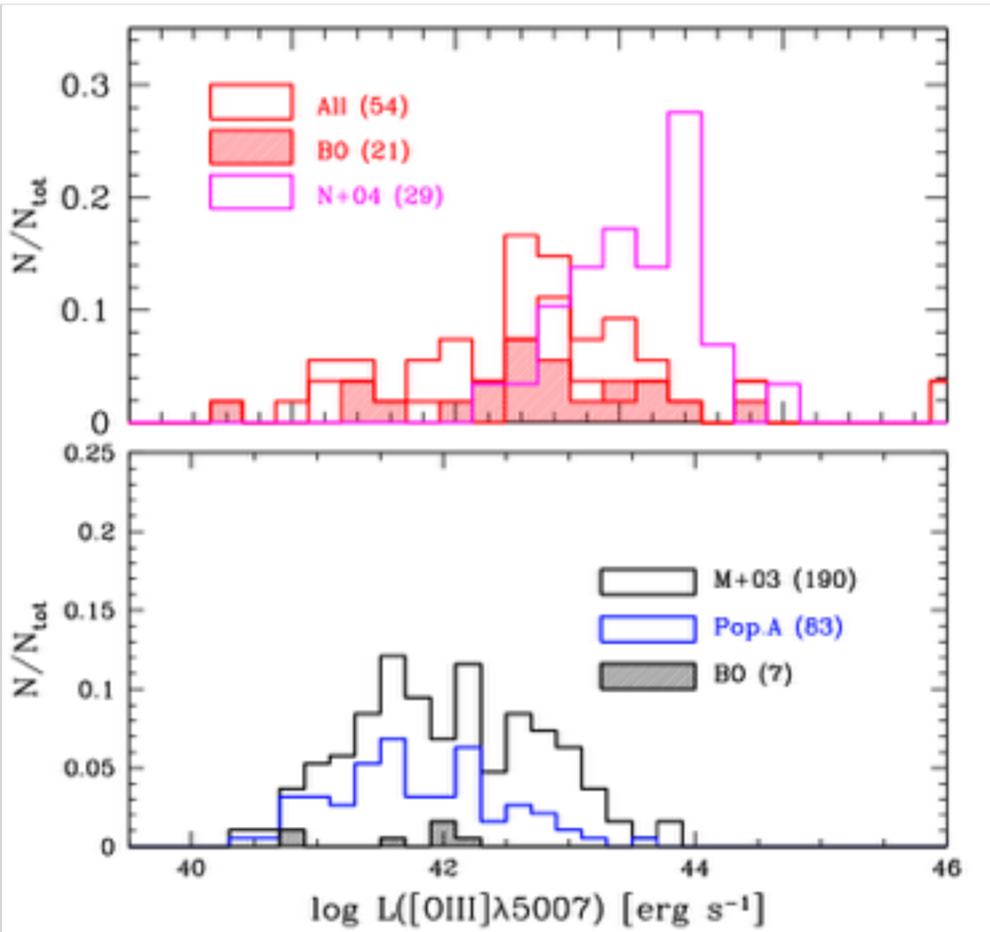
The HE-ISAAC sample: extremely high L sources

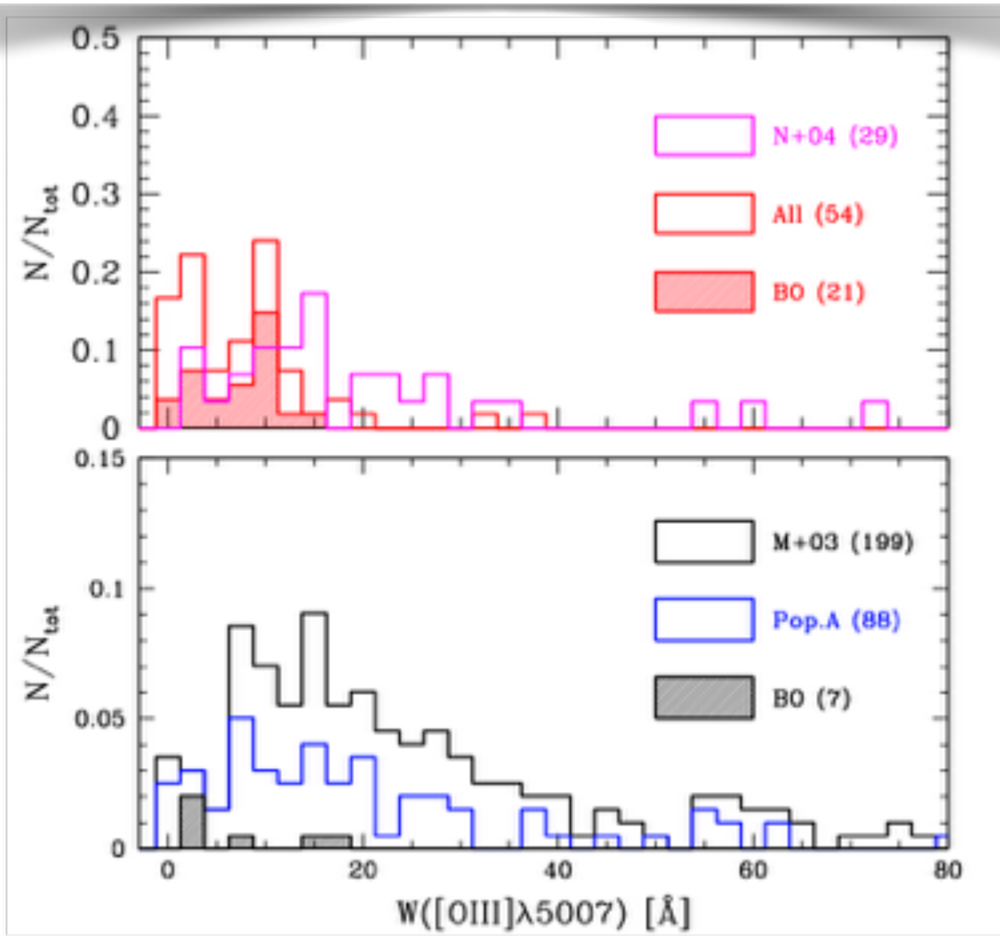


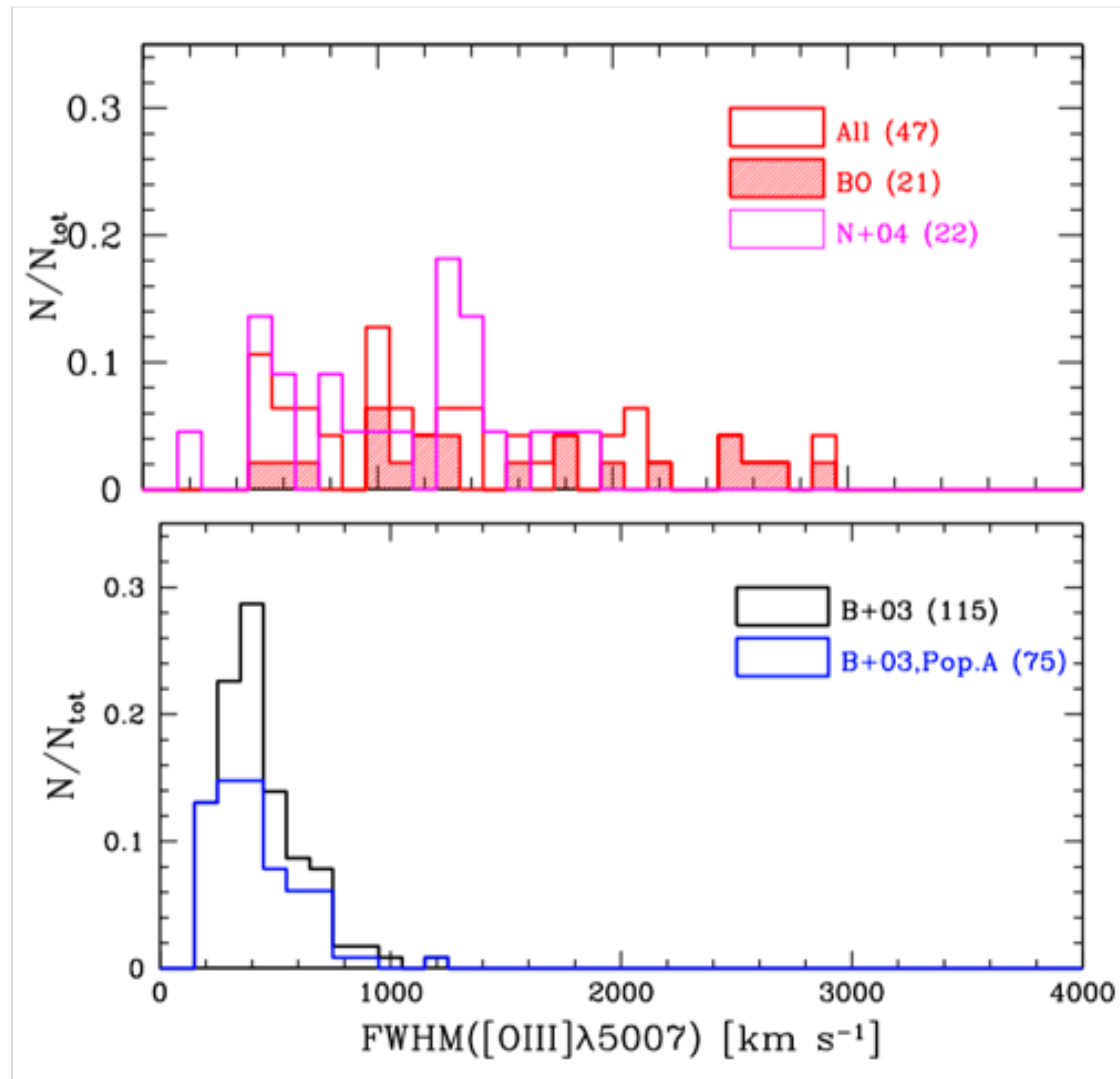
Netzer et al. (2004) and Shemmer et al. (2004) data can be used for a high-z comparison;

Marziani et al. 2003 for low-z

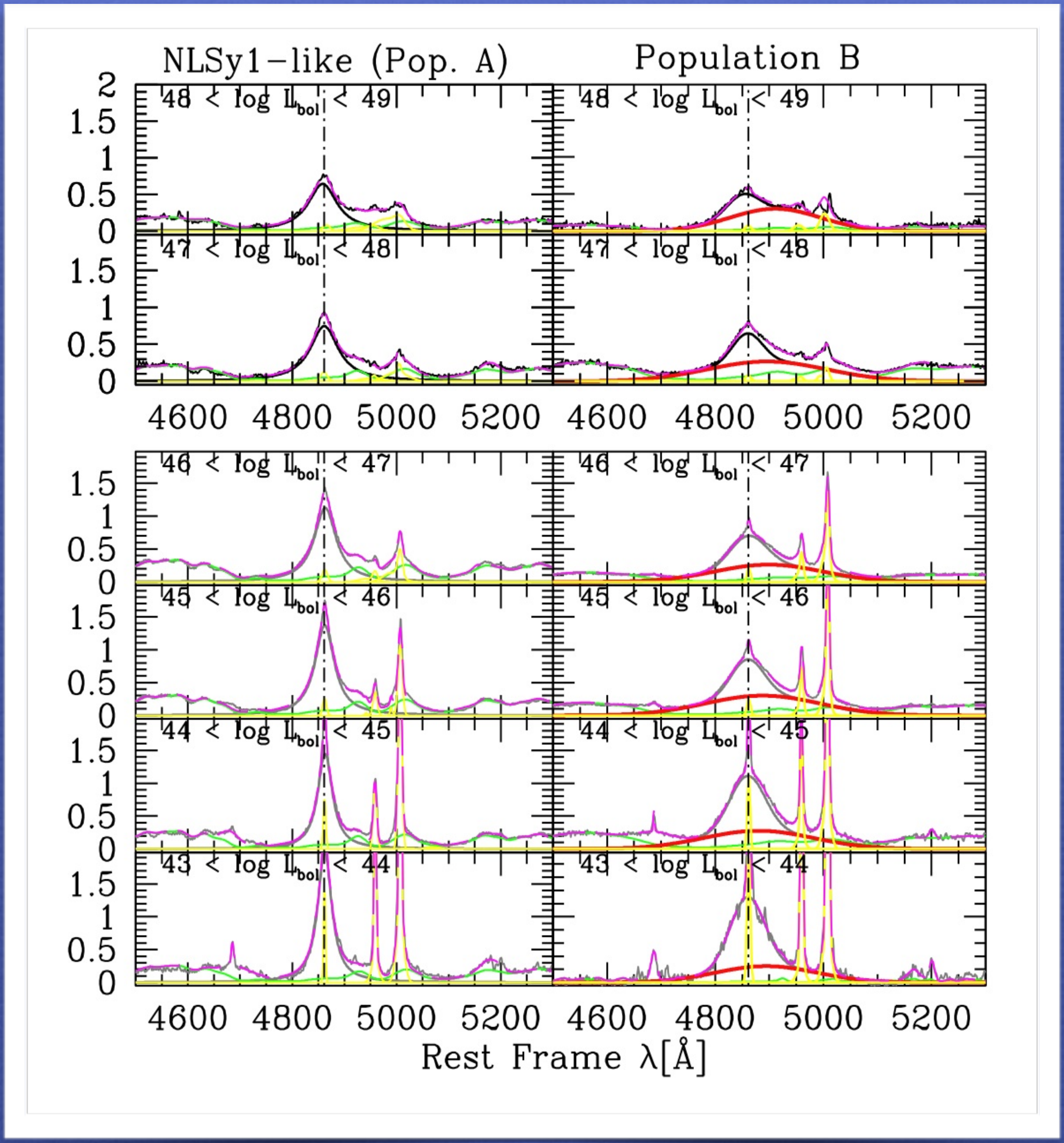
HE ISAAC sample: consistent with other high z sample; both remarkably different with respect to low-z







Luminosity trends: median composite spectra



HE

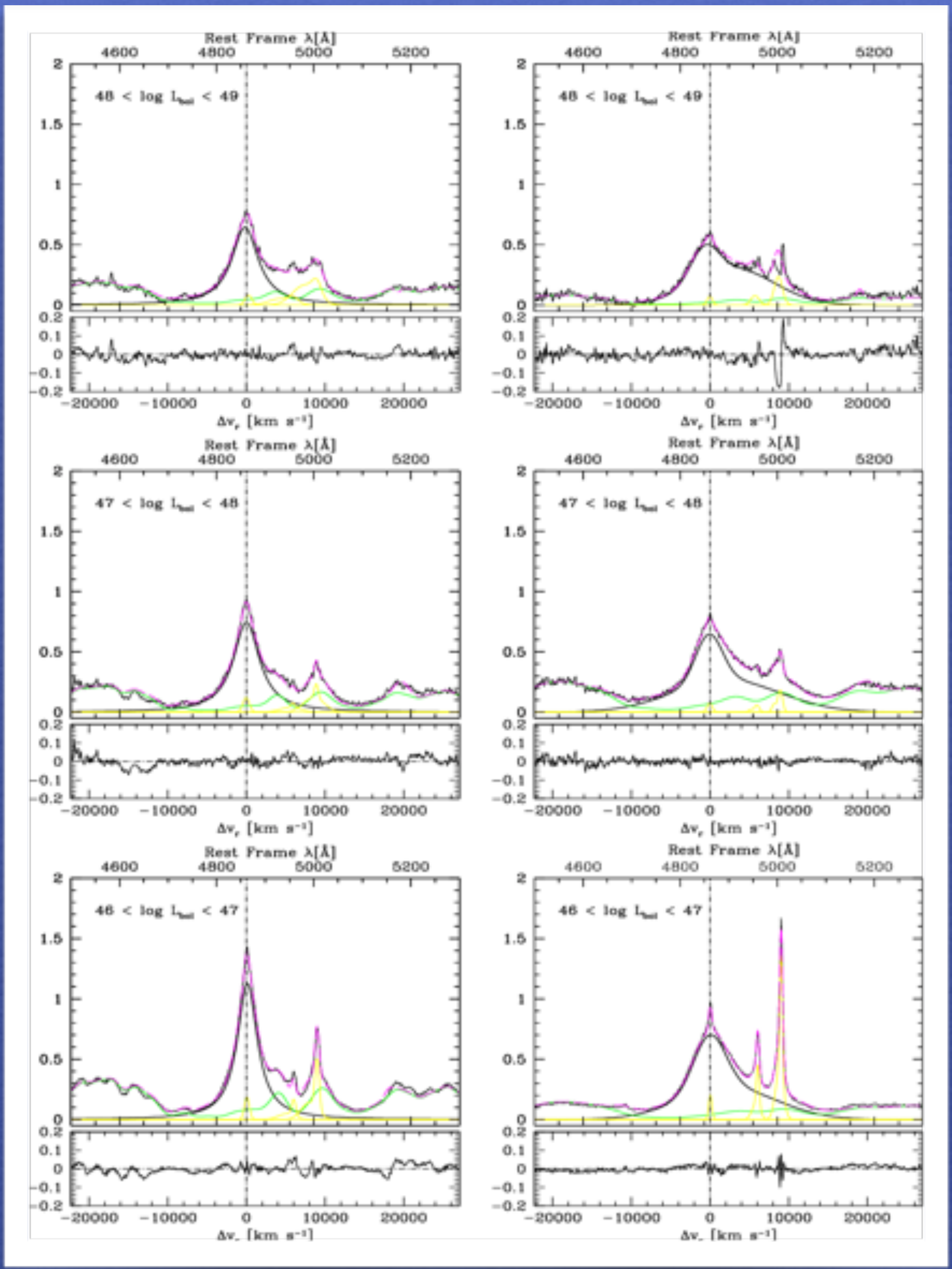
The A/B distinction is preserved over a very wide luminosity range

A "Baldwin effect" in [OIII] is evident in both Pop. and B sources.

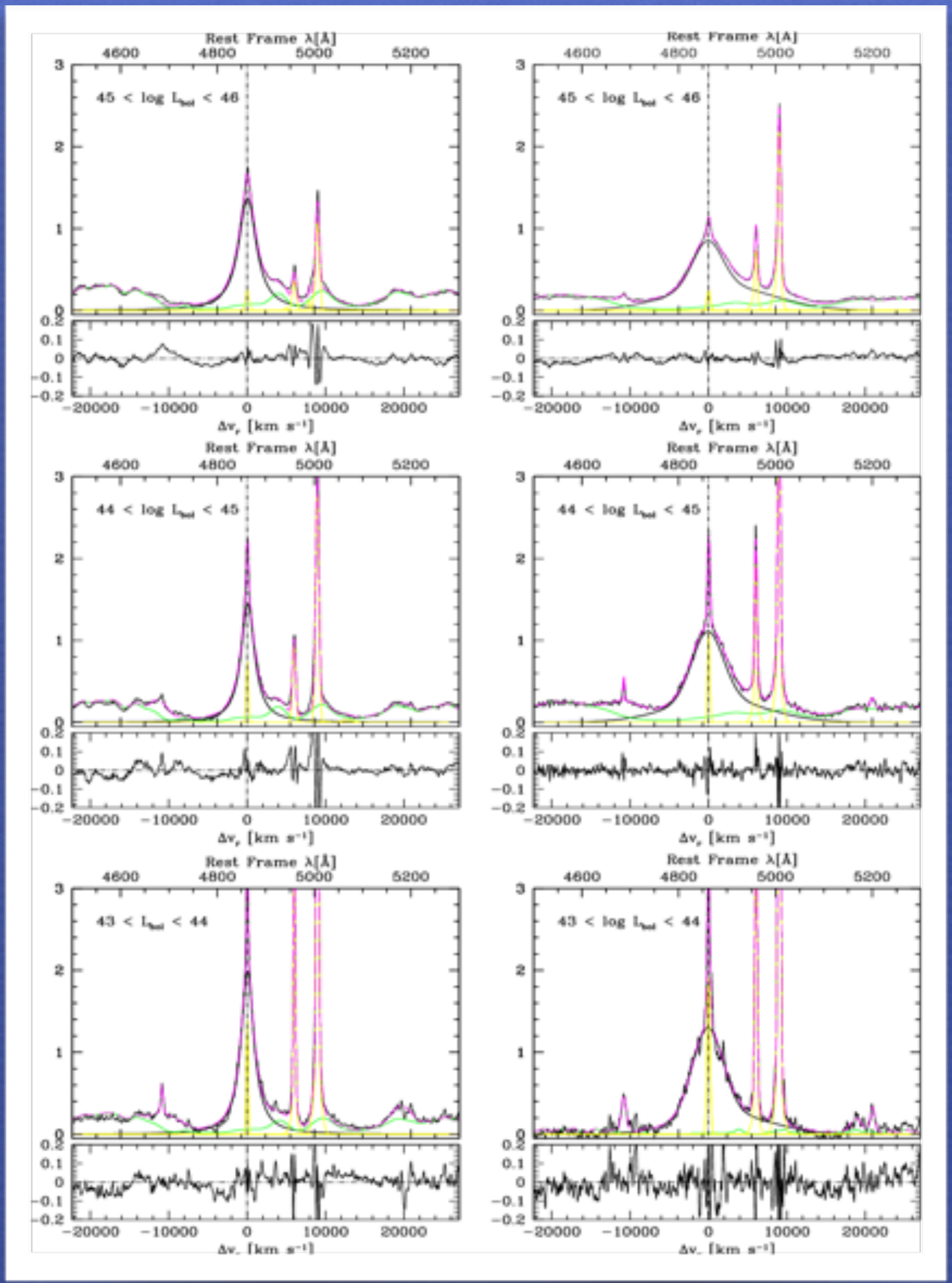
SDSS,
Zamfir et al. 2010

Luminosity trends: [OIII]λλ4959,5007 becomes less prominent and broader with *L*

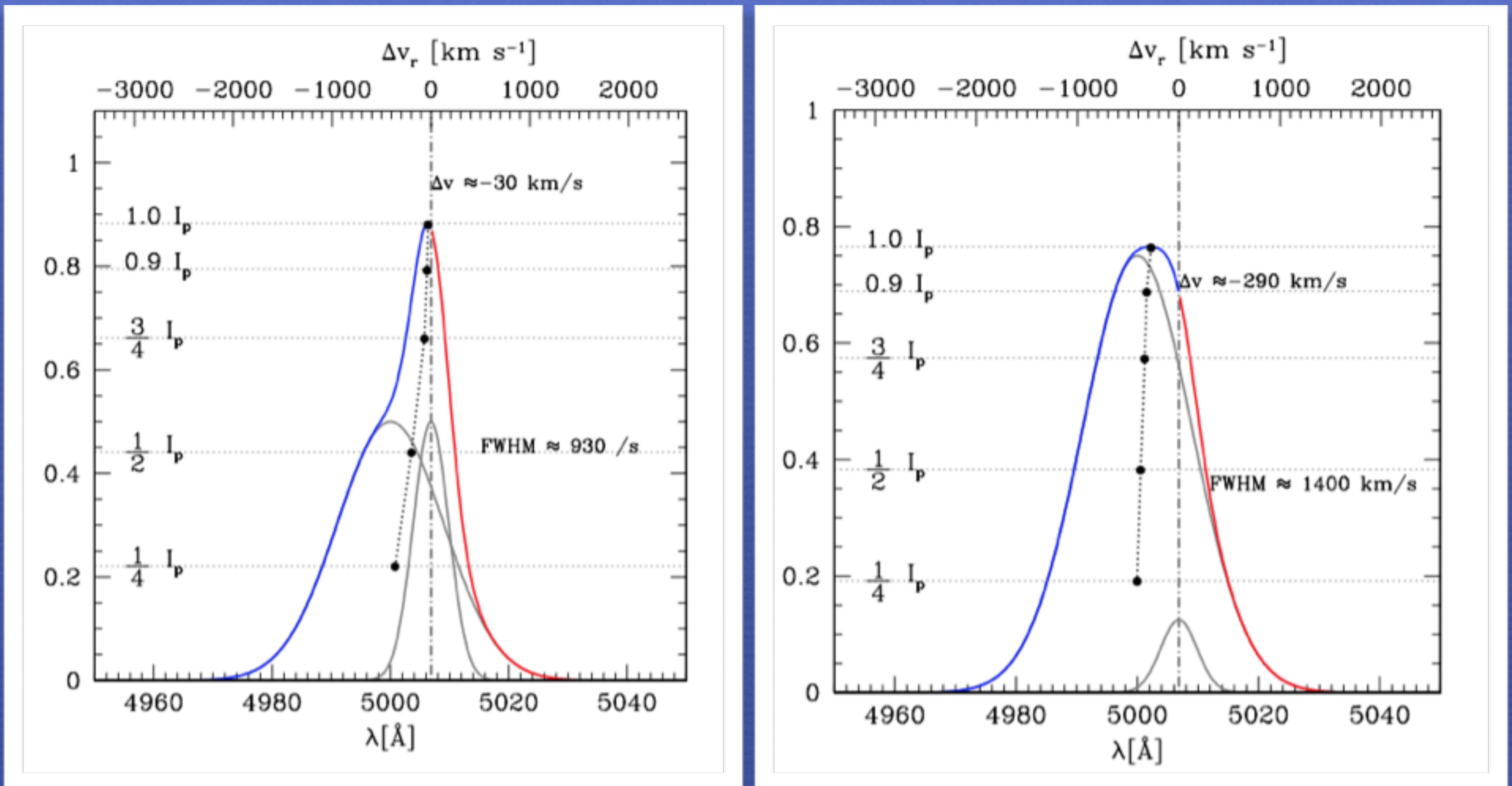
Pop. A Pop. B



Pop. A Pop. B



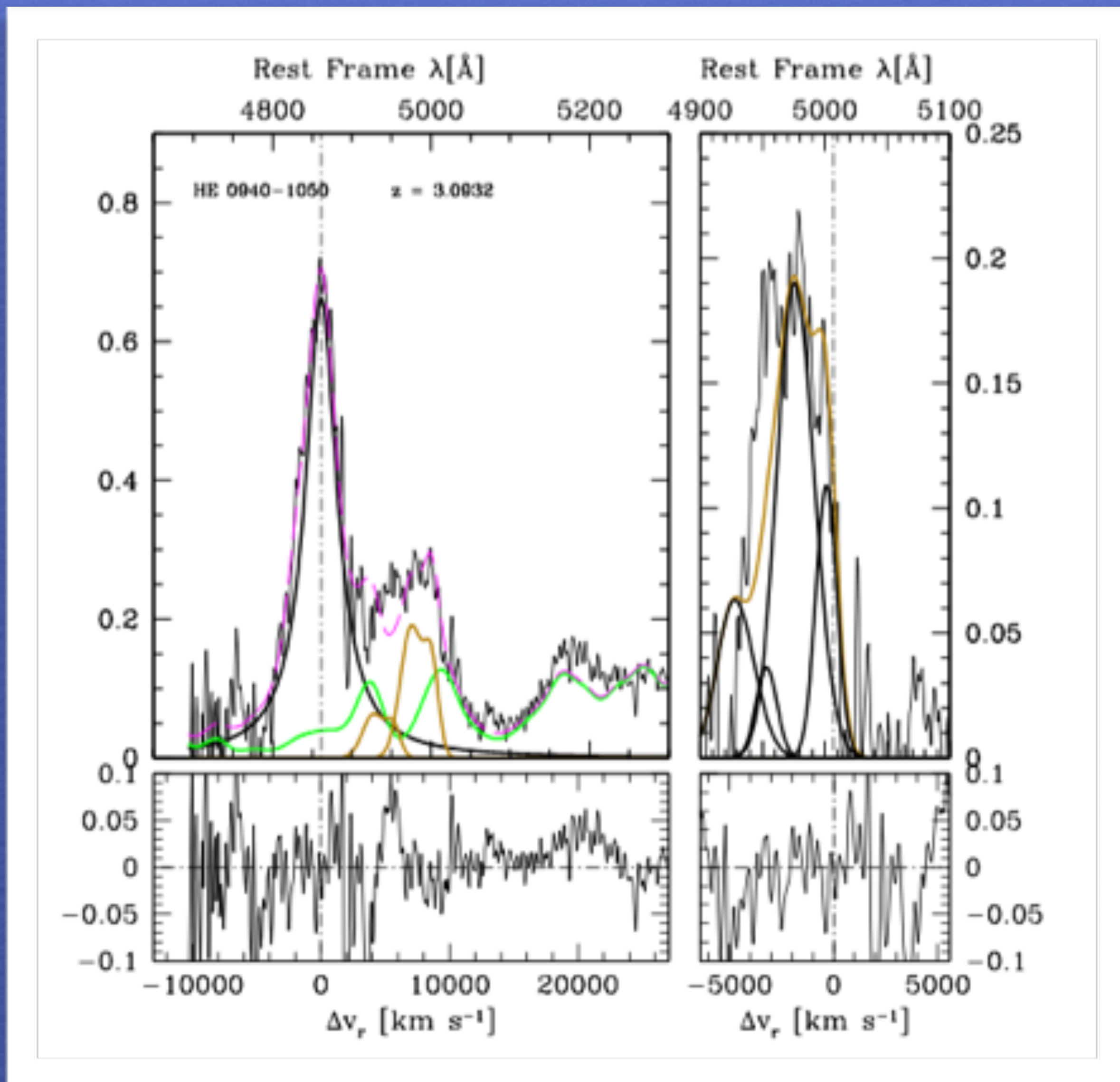
[OIII]λ5007 line profile parameterisation

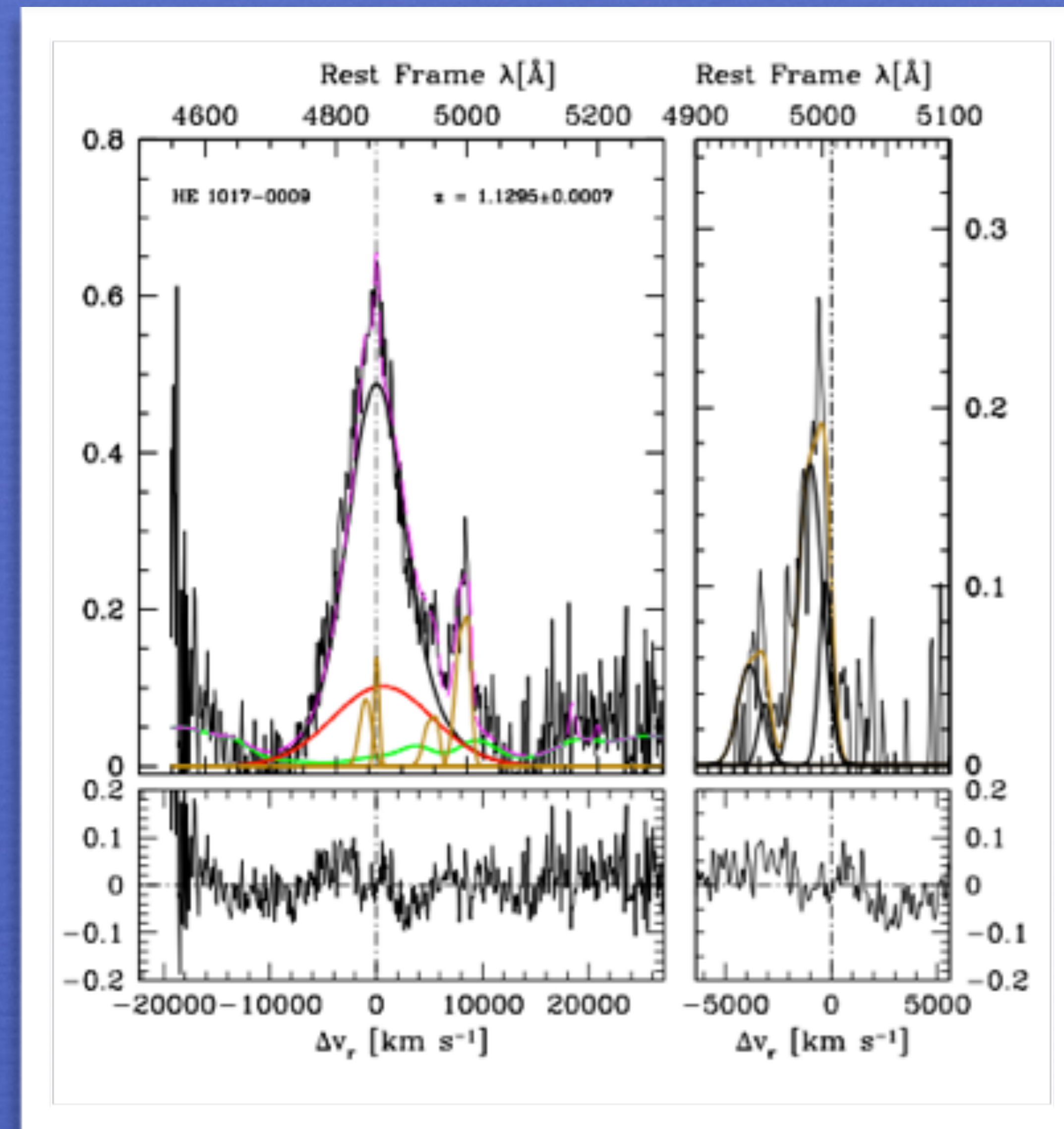


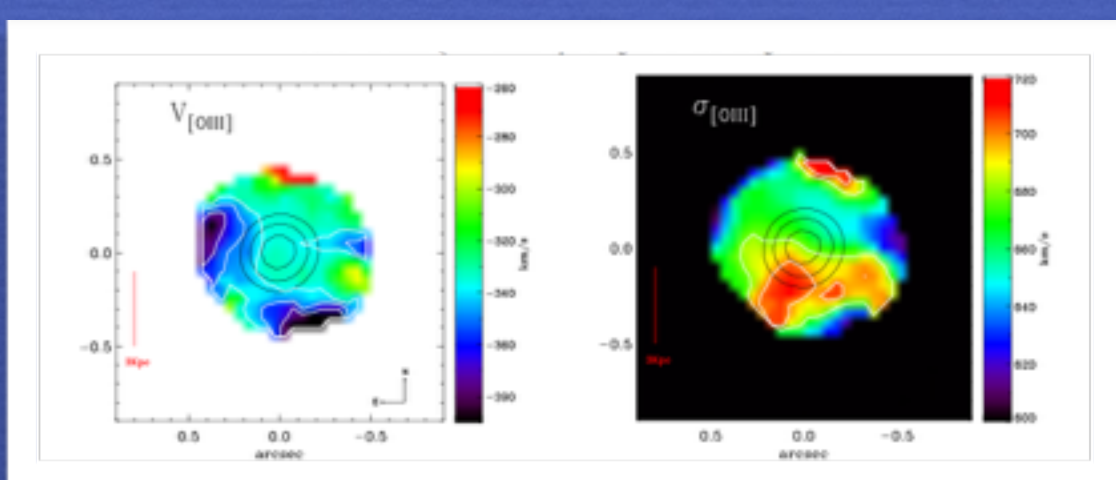
line centroids at fractional intensity
core and semibroad component decomposition

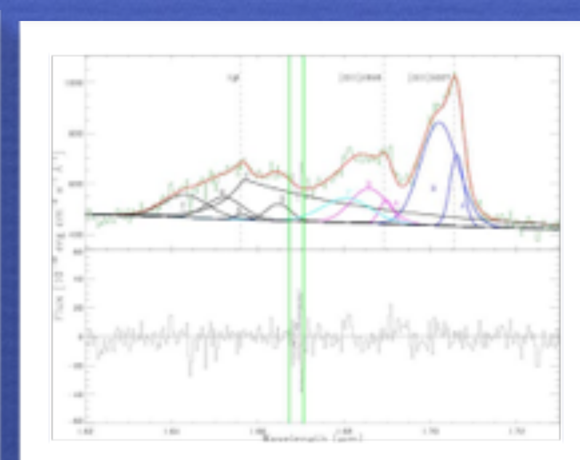
(Zhang et al. 2011; Marziani et al.)

Pop. A and B at high *z*





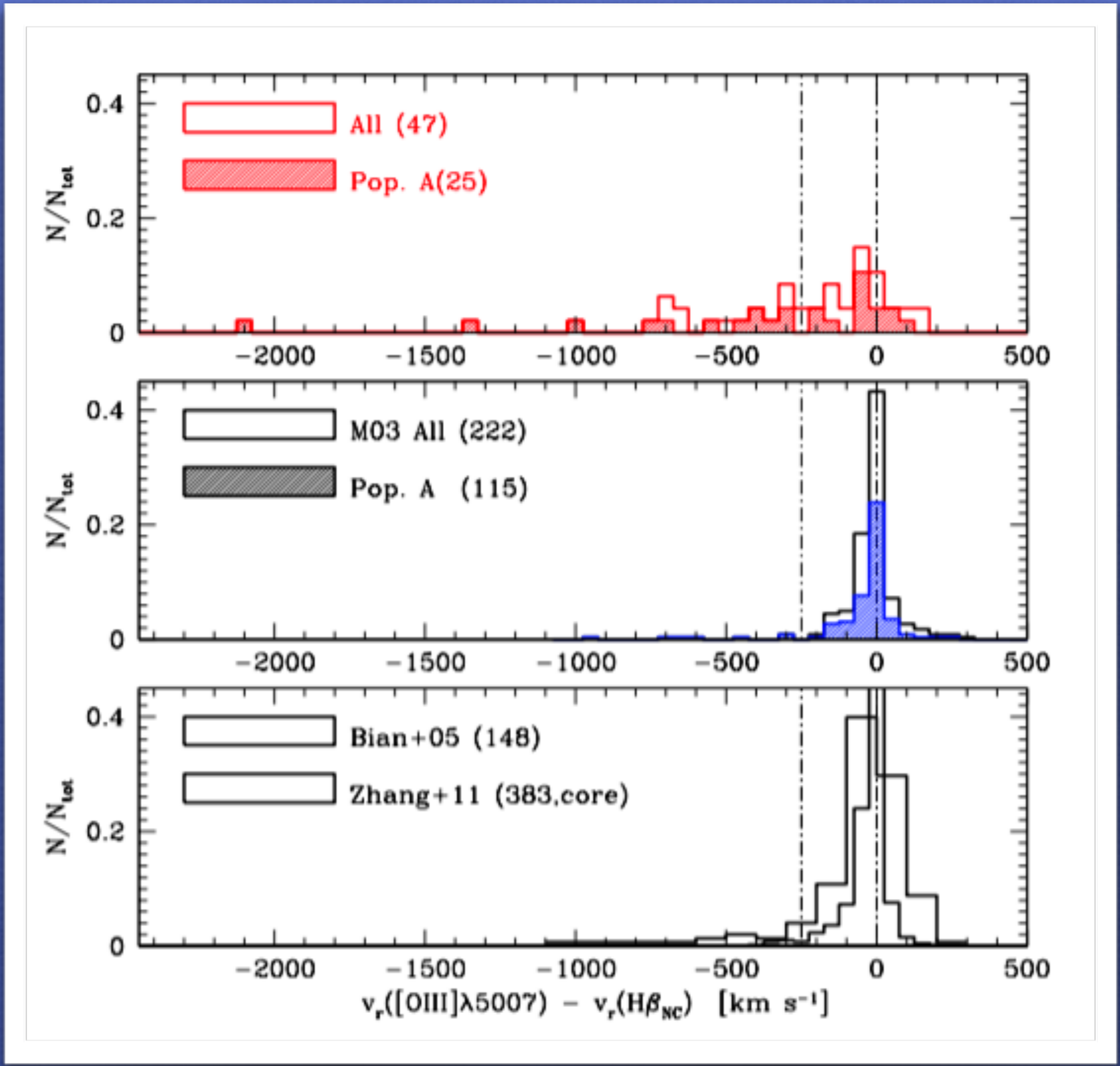




Spatially resolved outflow in 2QZ0028-28 (*z*=2.4)

Cano-Díaz et al. 2012

Blue outliers are rare (but not extremely so) at low *z*; they are much more frequent in the high *z* and *L*

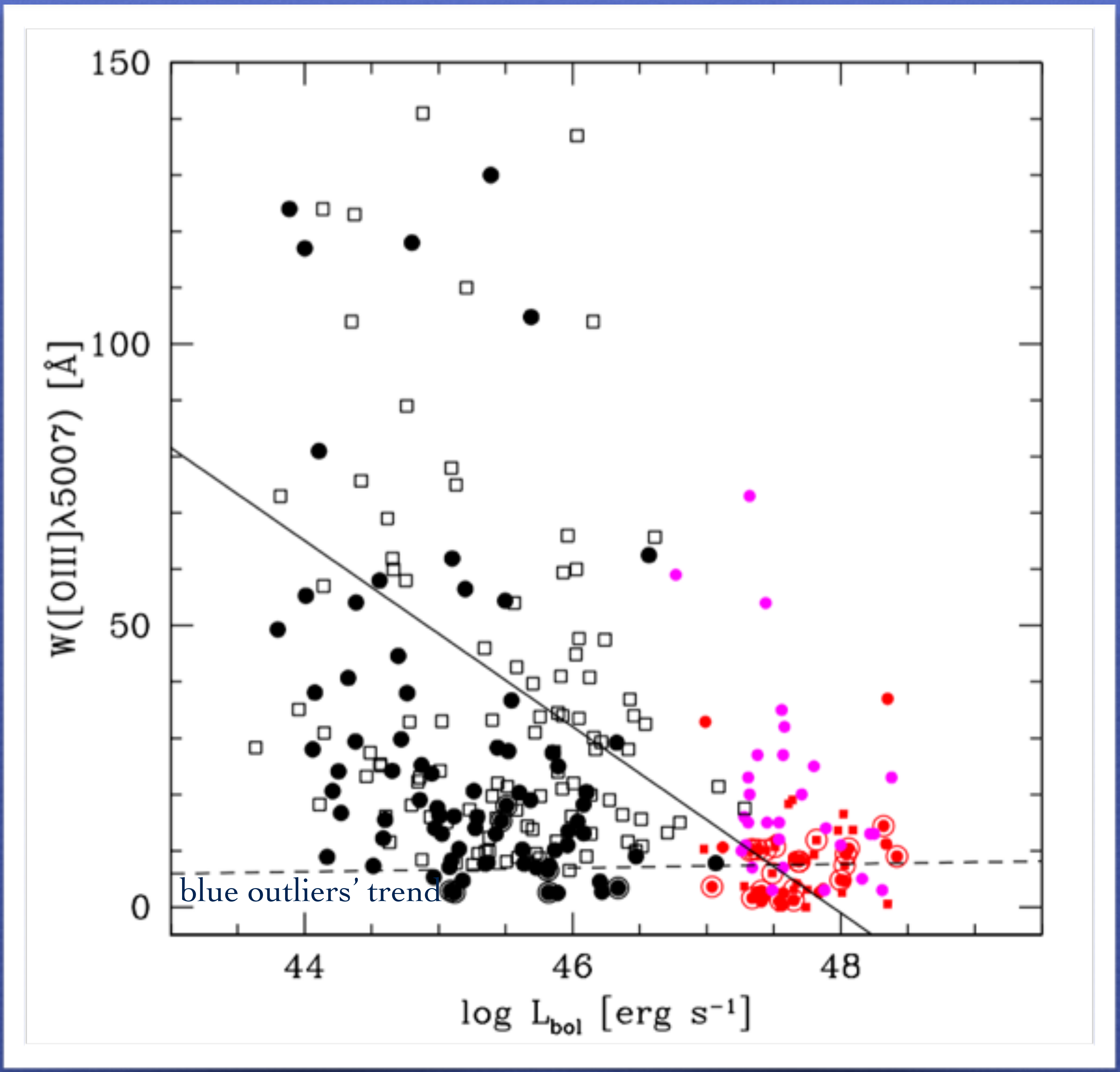


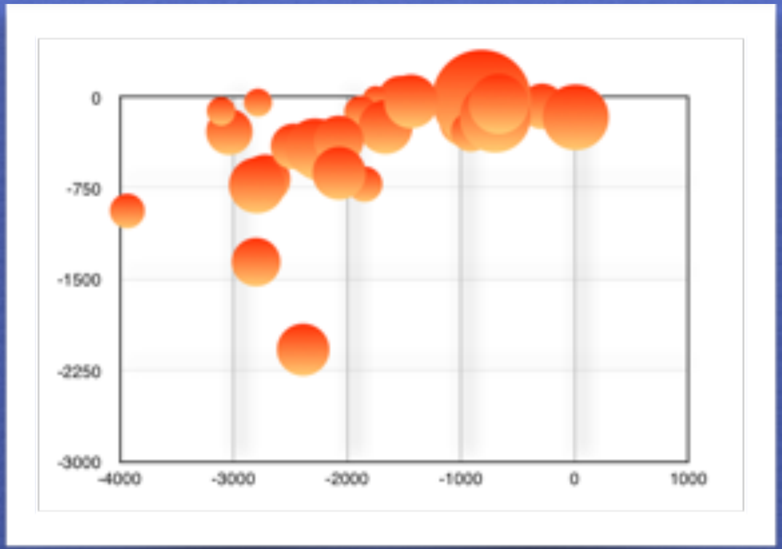
Until 2008 (Komossa et al. included) only 27 sources quilfied as BO; Zhang et al. (2011) identify at least 9; 21 are added by the HE sample

BOs are about 5% in the samples of Marziani et al. 2003 and Bian et al. 2005

No [OIII]Baldwin effect for the blue outliers

c.f. Zhang et al. 2011 anti-Baldwin effect on the semibroad component

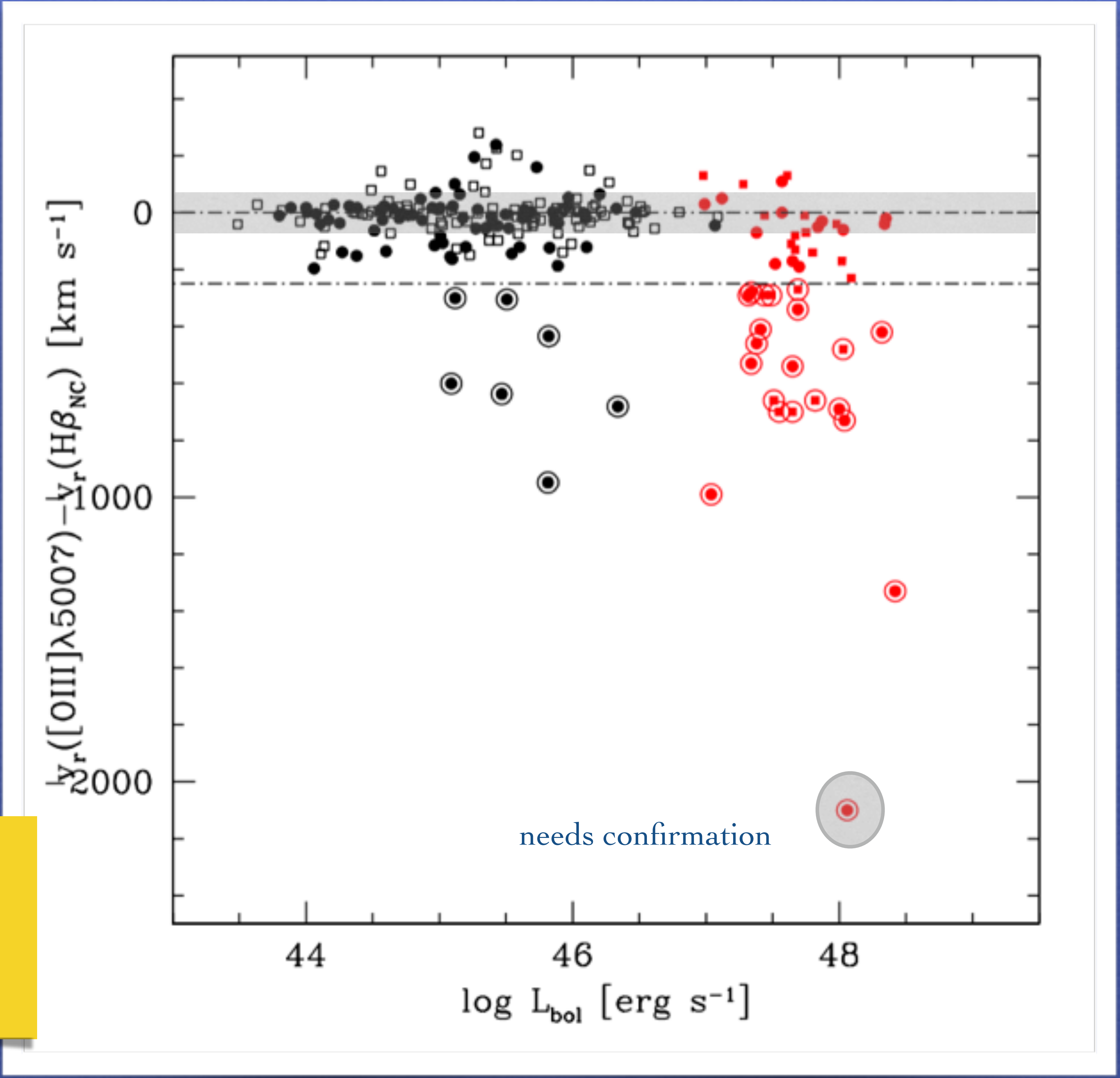




Very low EW does not imply BO status in the HE sample

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

Blue outliers are more frequent at high *L* but shift amplitudes are comparable

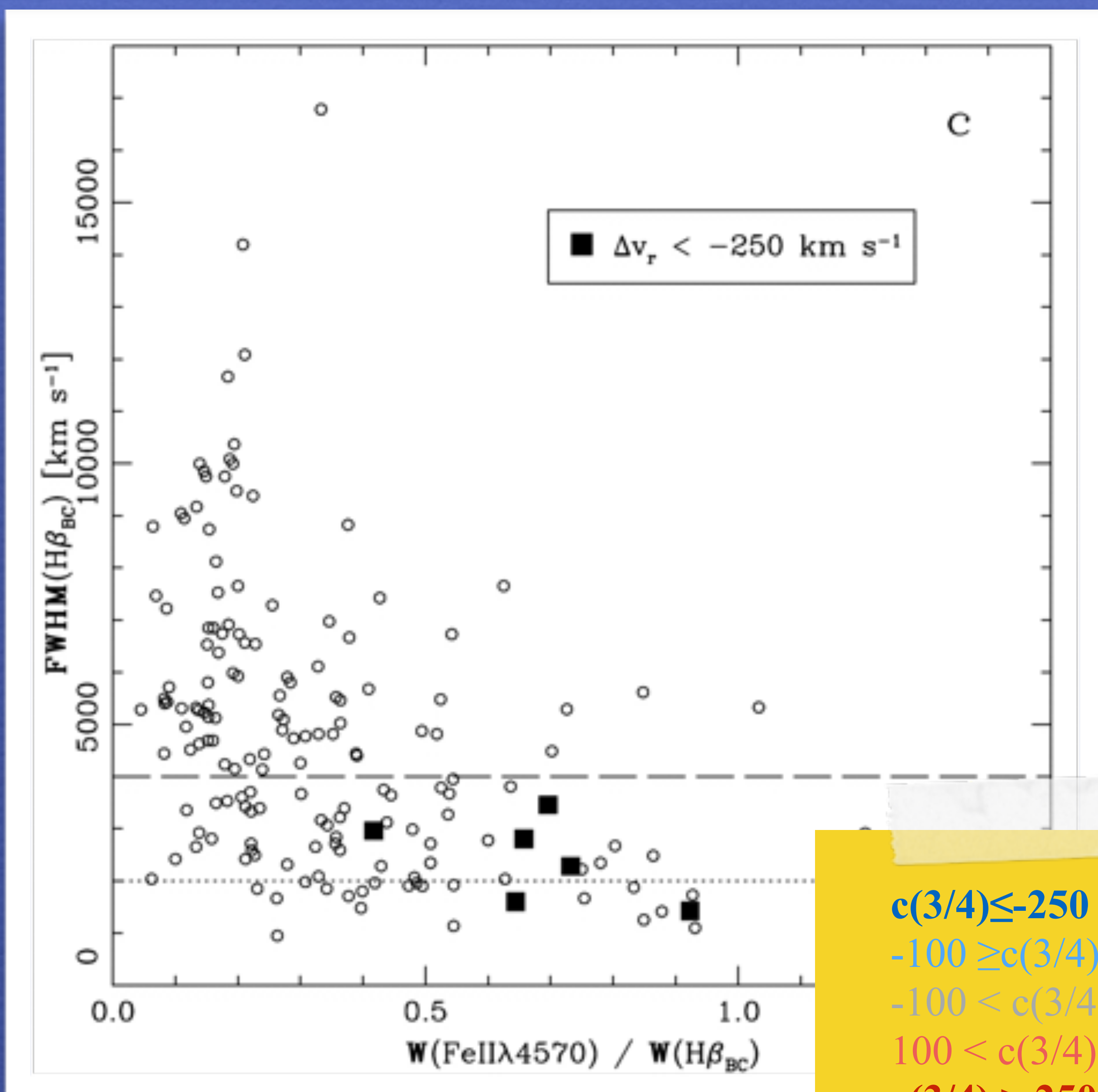


Filled: Pop. A
Open: Pop. B
Circles: RQ
Squares: RL

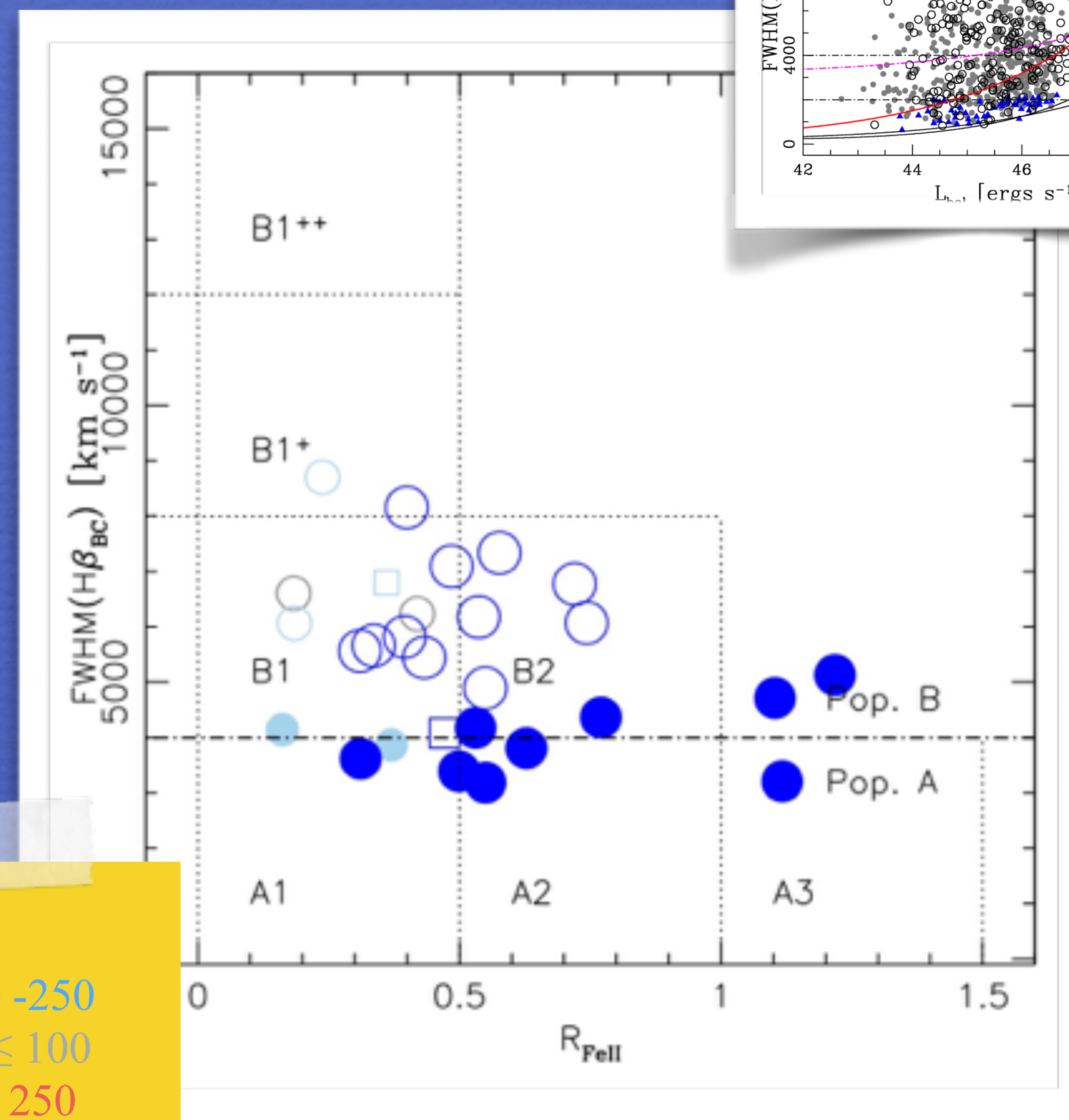
High-L HE quasars in the optical plane of the 4DE1

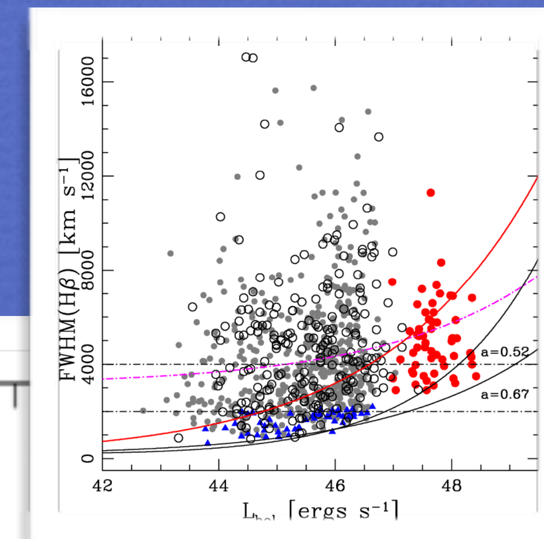
Luminosity (Mass) effect visible in a systematic increase of the minimum FWHM possible for a sub-Eddington radiator

M03 - low *z*

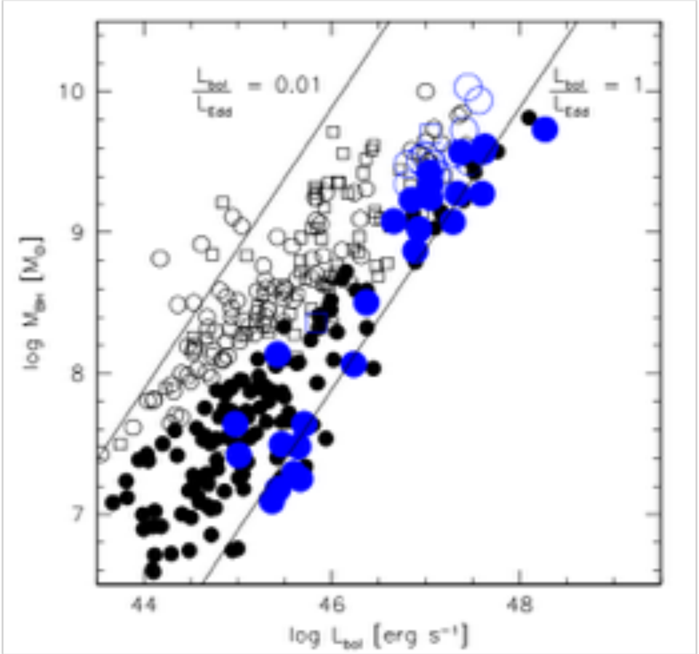


HE



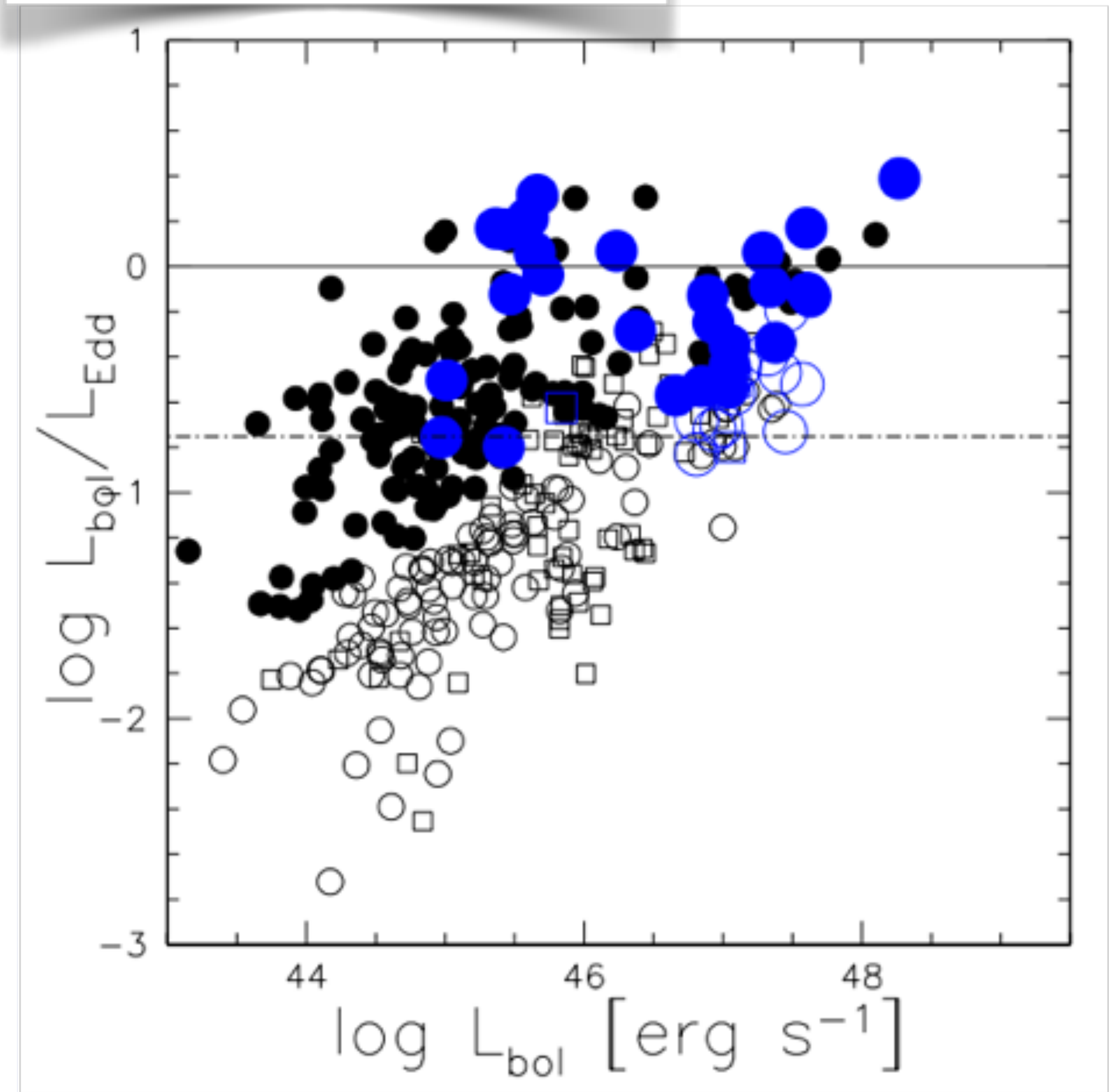


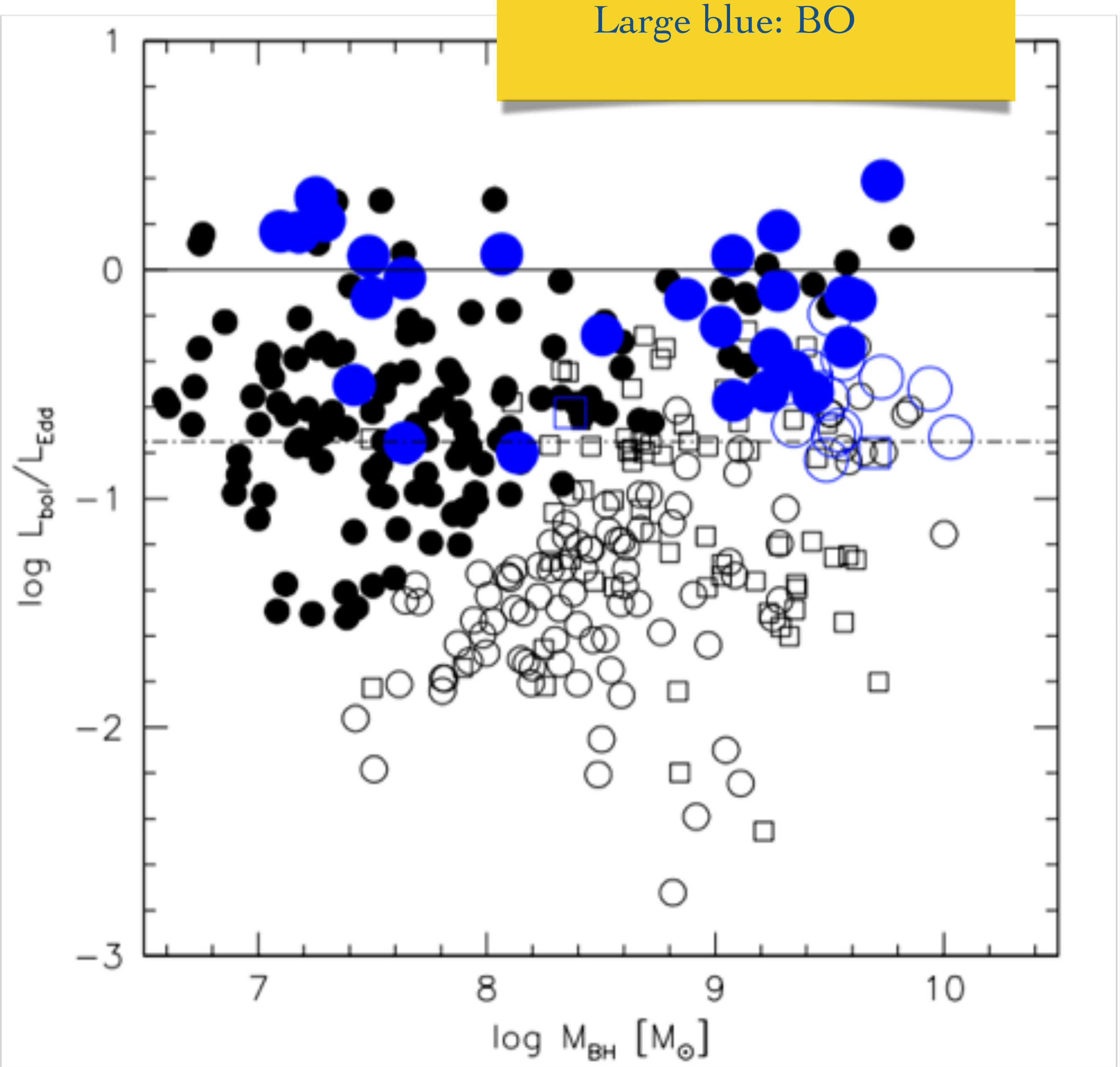
c(3/4)≤-250
-100 ≥c(3/4) > -250
-100 < c(3/4) ≤ 100
100 < c(3/4) ≤ 250
c(3/4) > 250

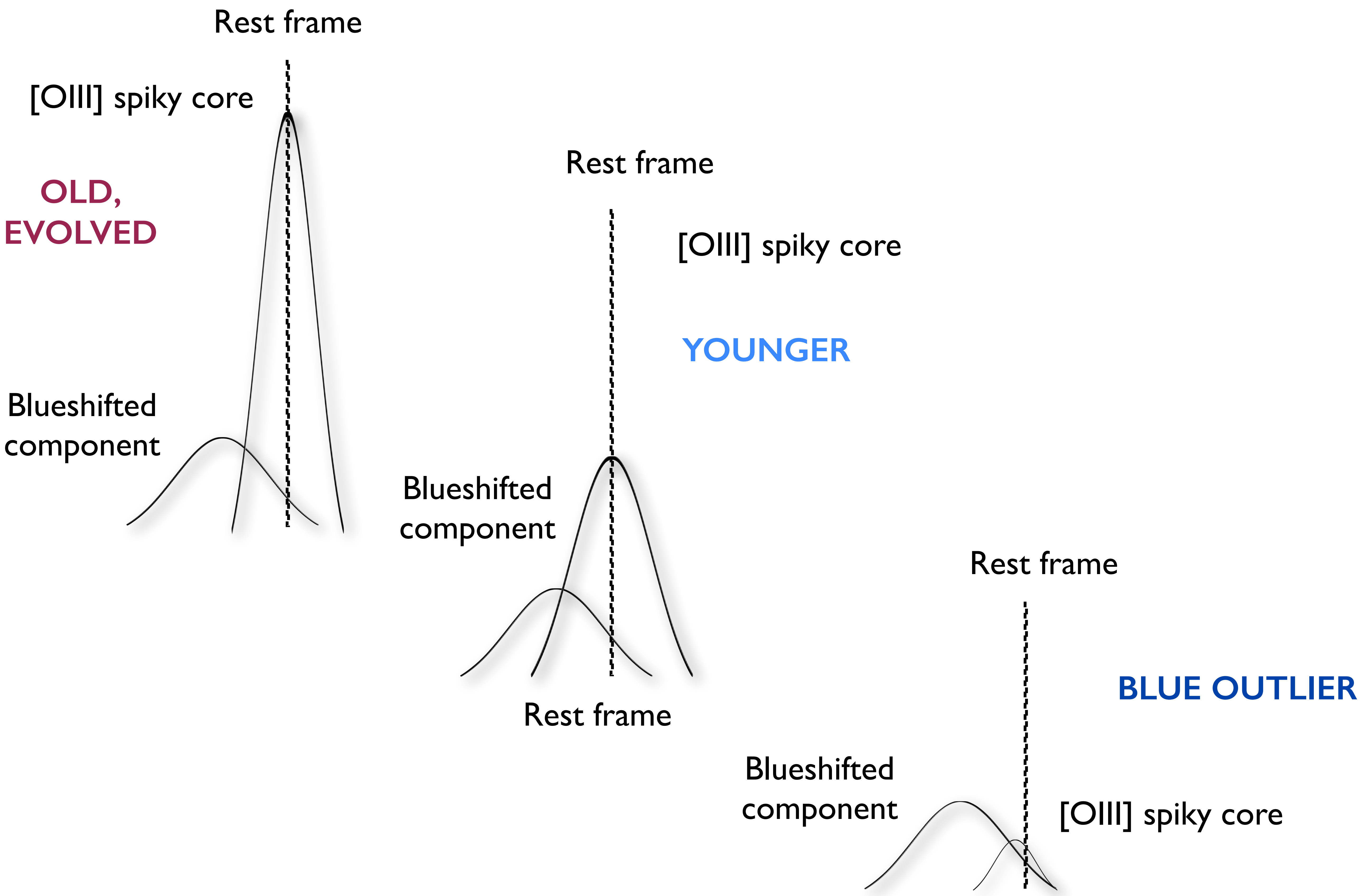


They are high L/L_{EDD} radiators but not necessarily high M_{BH} or high L

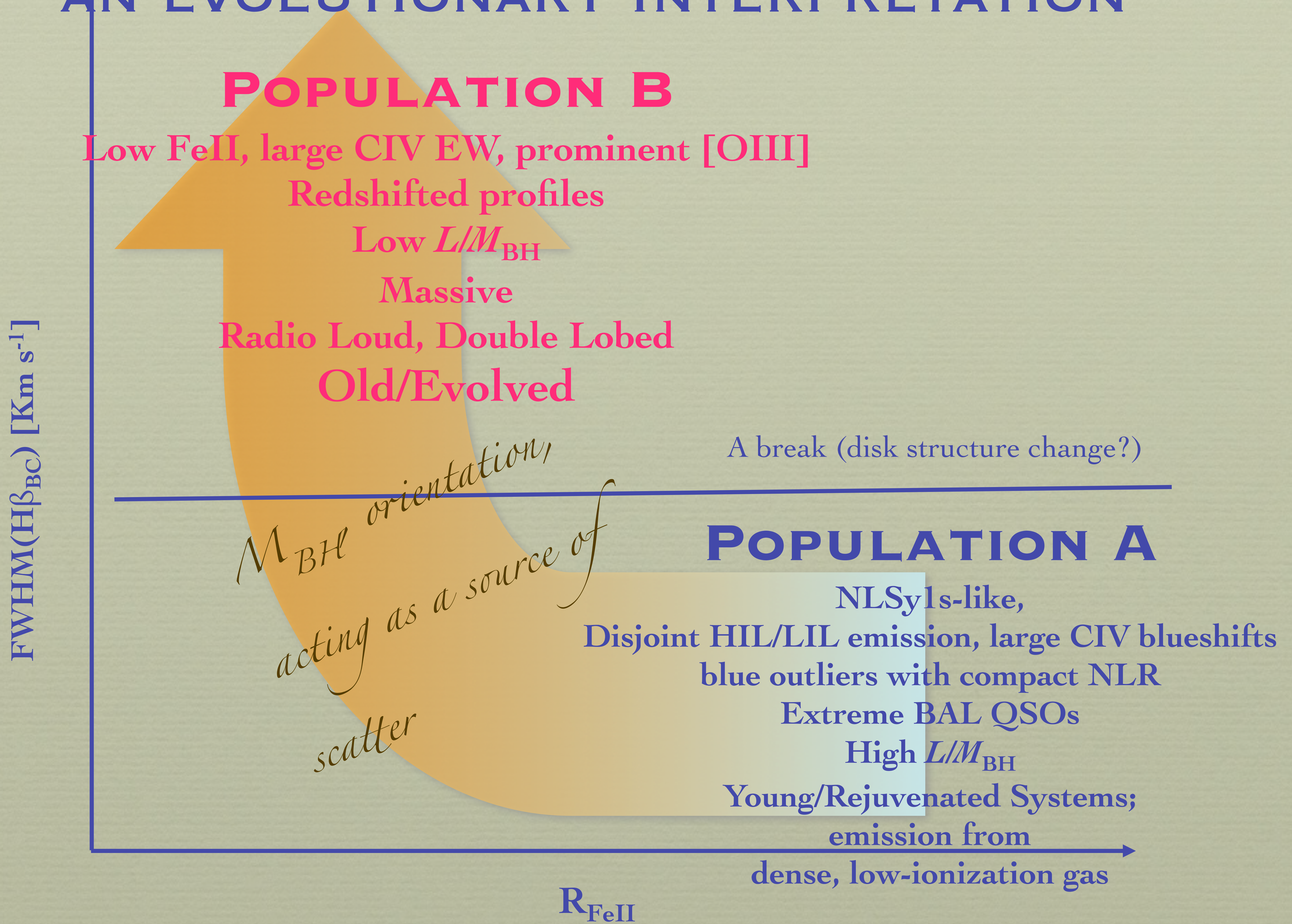
Filled: Pop. A
Open: Pop. B
Circles: RQ
Squares: RL
Large blue: BO






Rest frame
[OIII] spiky core
OLD, EVOLVED
Blueshifted component
Rest frame
[OIII] spiky core
YOUNGER
Blueshifted component
Rest frame
Rest frame
BLUE OUTLIER
Blueshifted component
[OIII] spiky core

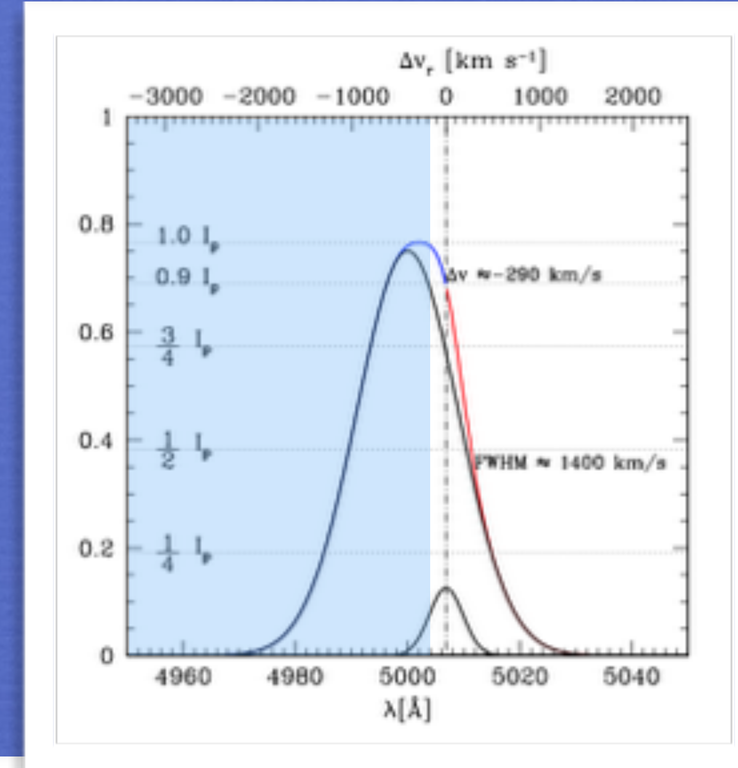
The Eigenvector 1 of quasars: an evolutionary interpretation



Massive outflows

In BOs [OIII]5007 is almost fully blueshifted, and very high luminosity. The line emitting gas is above the expected escape velocity at r ~ 1 kpc.

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



The **mass of ionised gas** emitting [OIII]λ5007 can be written as, under the assumption of constant density:

$$M^{\rm ion}_{\rm out} = 4.2\ 10^7\ L_{44}([{\rm OIII}]) \left(\frac{Z}{Z_\odot}\right)^{-1} n_3^{-1}\ M_\odot$$

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

$$\dot{M}^{\rm ion}_{\rm out} = \rho\ \Omega r^2 v = \frac{M^{\rm ion}_{\rm out}}{V} \Omega r^2 v \approx 135 L_{44} v_{1000} r^{-1}_{\rm 1kpc} {\rm M}_\odot\ {\rm yr}^{-1}$$

The **outflow kinetic power**, with outflow v in units of 1000 km s^{-1}, is:

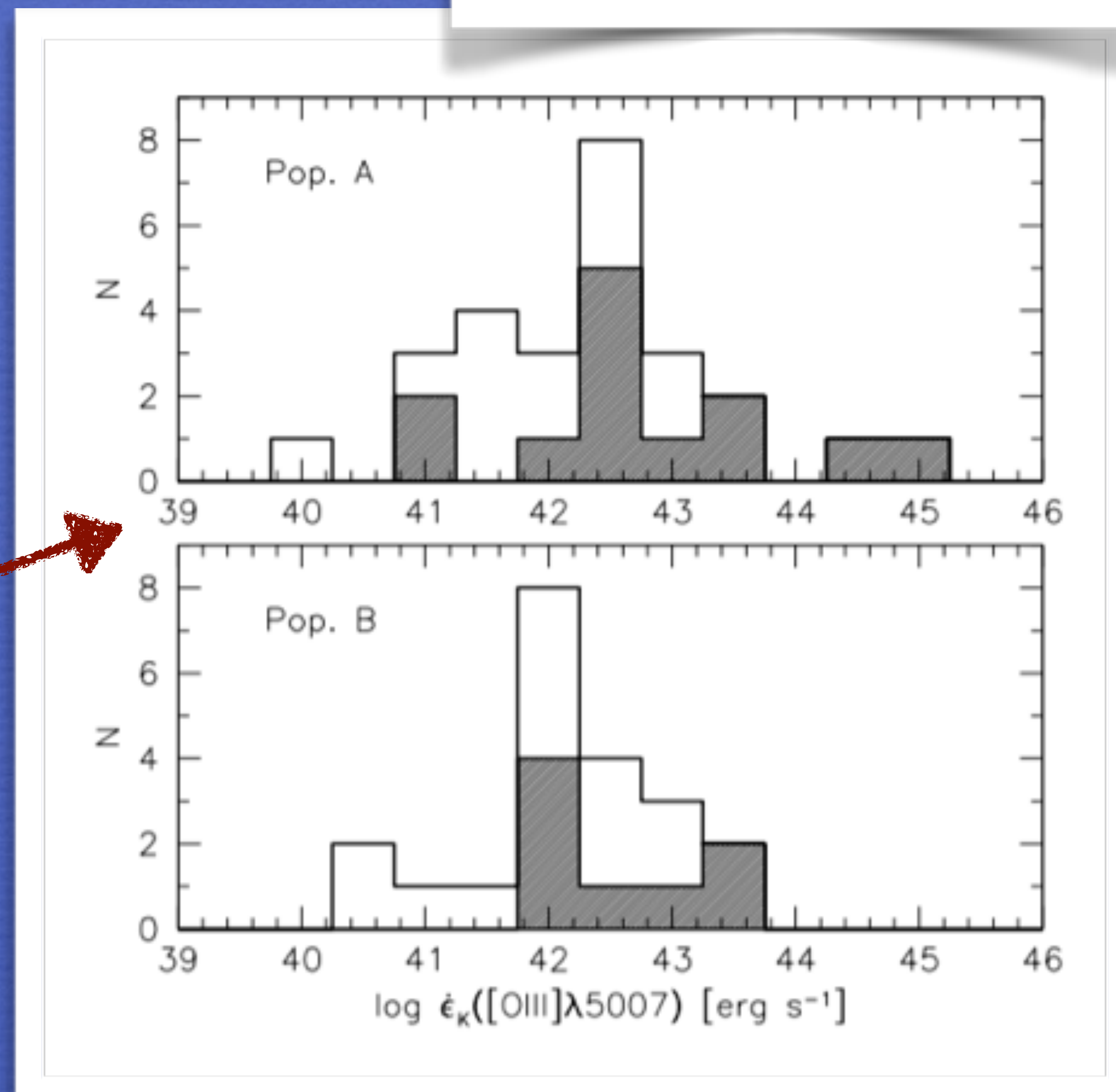
$$\dot{\epsilon} = \frac{1}{2}\dot{M}^{\rm ion}_{\rm out} v^2 \approx 4.3 \cdot 10^{43} L_{44} v^3_{1000} r^{-1}_{\rm 1kpc} {\rm erg\ s}^{-1}.$$

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

$$\int \dot{\epsilon} dt \approx 1.35 \cdot 10^{59} L_{45} v^3_{1000} r^{-1}_{\rm 1kpc} \tau_8\ {\rm erg}.$$

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

Blue outliers are more frequently found at intermediate z than at low z

In the context of 4DE1, BOs are more frequently Pop.A sources

They represent a self-similar phenomenon that spans 4 dex in luminosity. They are high $L/L_{\rm EDD}$ but not necessarily high $M_{\rm BH}$ or high L

They are signatures of an outflow process that can have a significant feedback effect on the host galaxy, at least at the highest derived kinetic powers.