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HIGHLY ACCRETING QUASARS AT HIGH REDSHIFT

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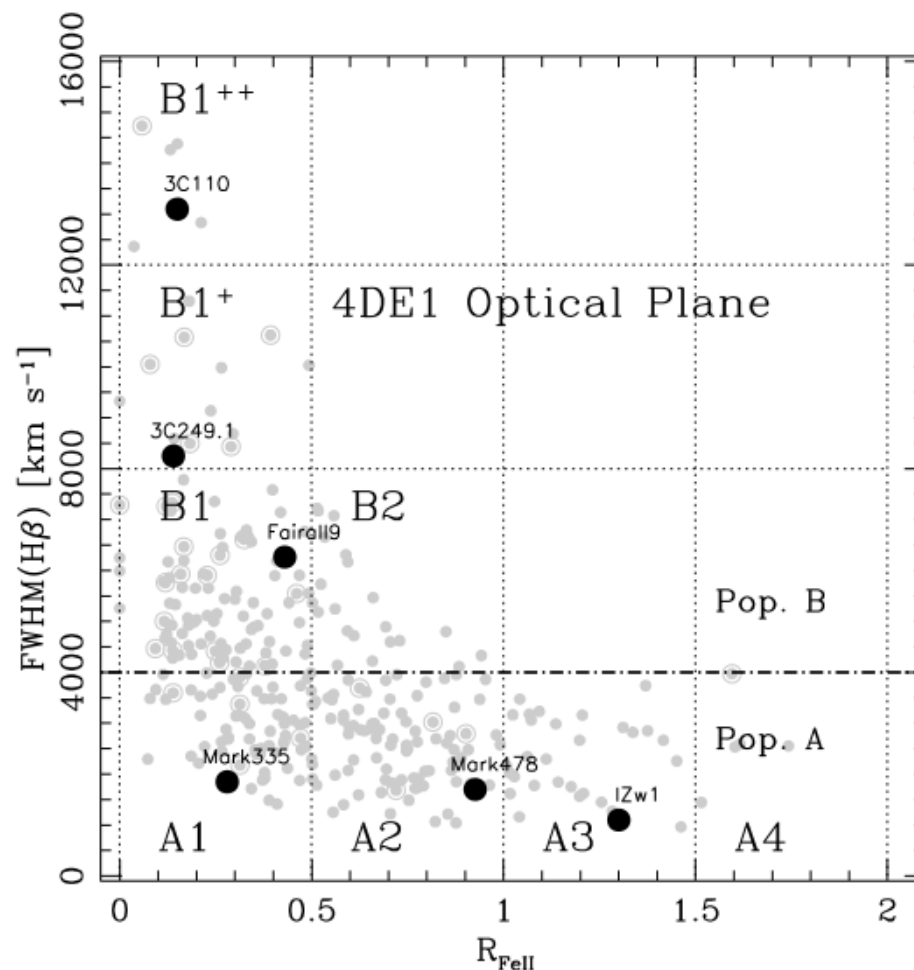


4D Eigenvector 1 formalism

The 4D Eigenvector 1 (4DE1) parameter space offers a formalism to distinguish and classify type 1 AGN considering their spectral properties (Boroson & Green 1992; Sulentic+ 2000; Marziani+ 2001, 2003; Sulentic+ 2007; Zamfir+ 2010). It is based on four parameters:

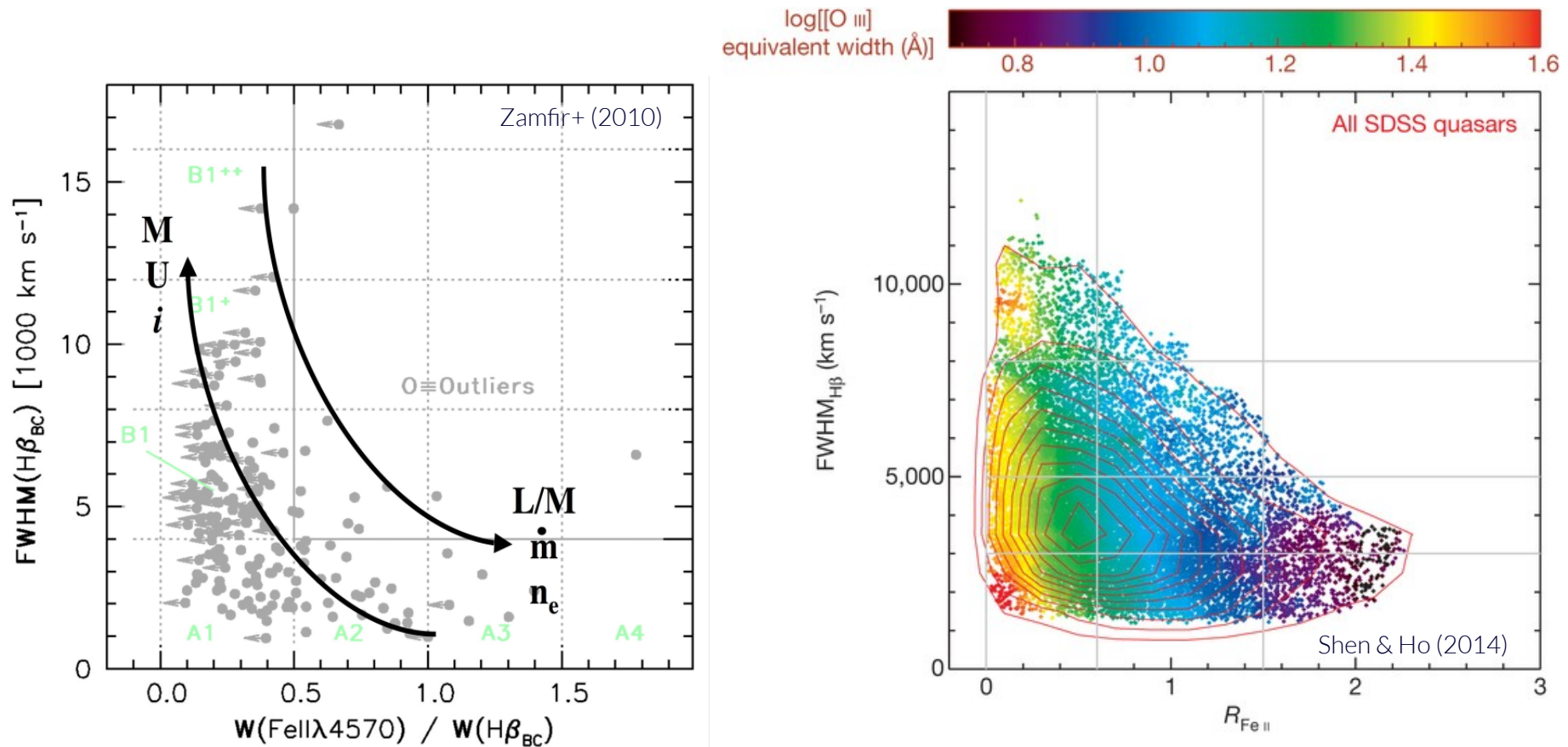
- 1) $\text{FWHM}(\text{H}\beta_{\text{BC}})$
- 2) $R_{\text{FeII}} = I(\text{Fe II } \lambda 4570) / I(\text{H}\beta_{\text{BC}})$
- 3) Γ_{soft} : spectral index of soft X-ray
- 4) $\text{CIV}\lambda 1549$ profile shift

In the optical plane, the type 1 AGN occupy a well defined sequence, mainly driven by the Eddington ratio, L/L_{EDD} (Marziani+ 2001).



4D Eigenvector 1: an evolution diagrama for type 1 AGN

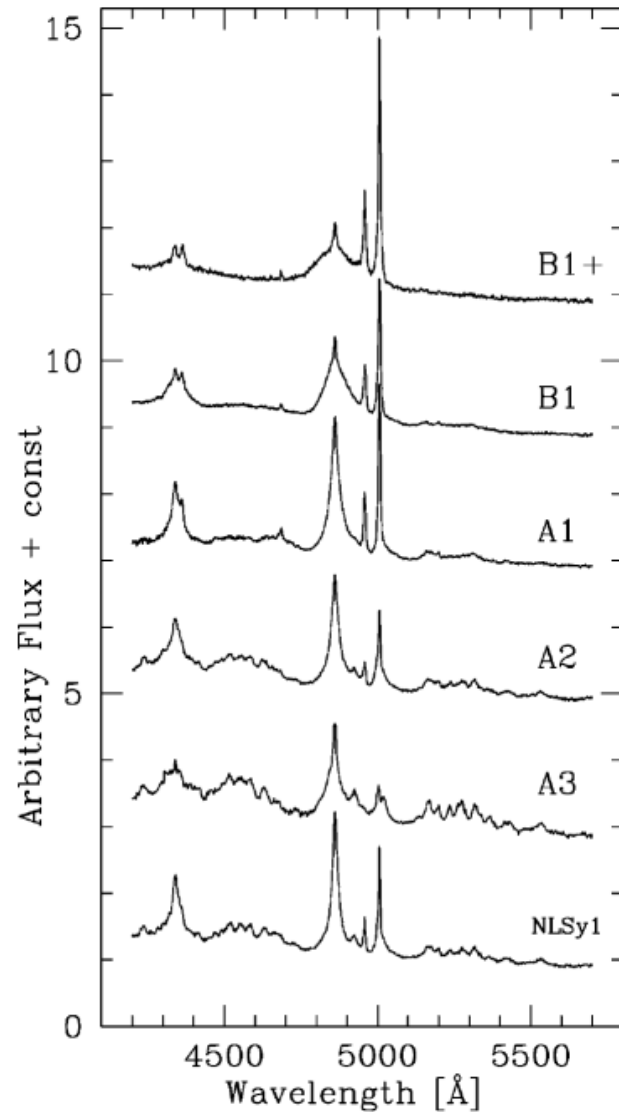
4DE1 also gives information about the variation of the physical parameters and the orientation. Then, 4D Eigenvector 1 could be considered as an evolution diagraman for type 1 quasars (Sulentic, Marziani & Dultzin 2000; Marziani+ 2010; Zamfir+ 2010). **See Marziani's talk.**



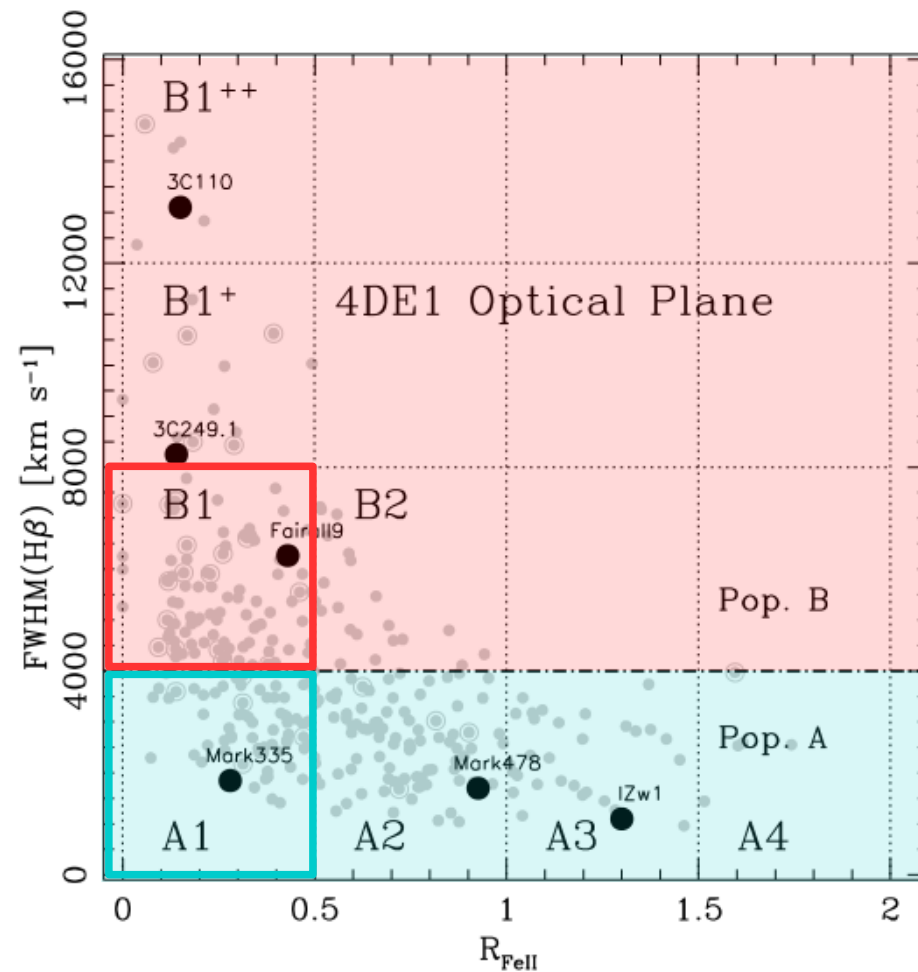
These results were confirmed by Shen & Ho (2014) using the SDSS quasars.

4D Eigenvector 1: Population A and B

Along the 4DE1, we can find a change in the spectral properties of the AGN, suggesting the existence of two kind of populations: **A** and **B**



Sulentic+ (2002)

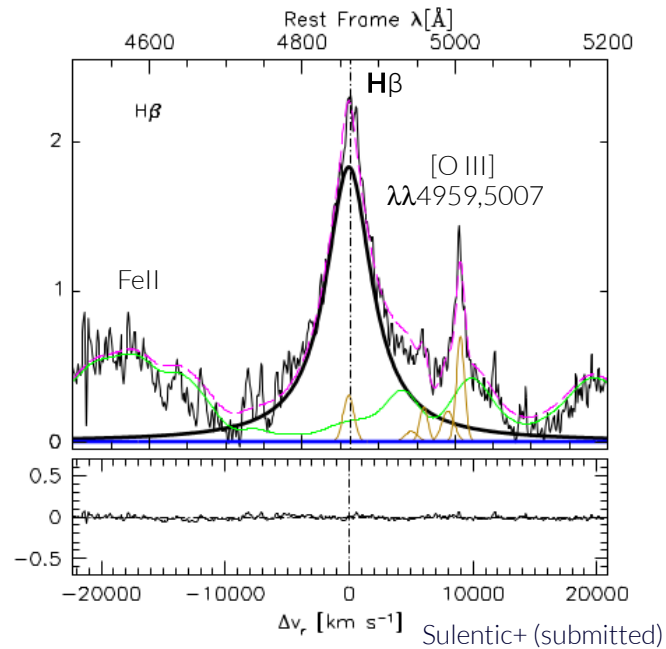


Marziani+ (2010)

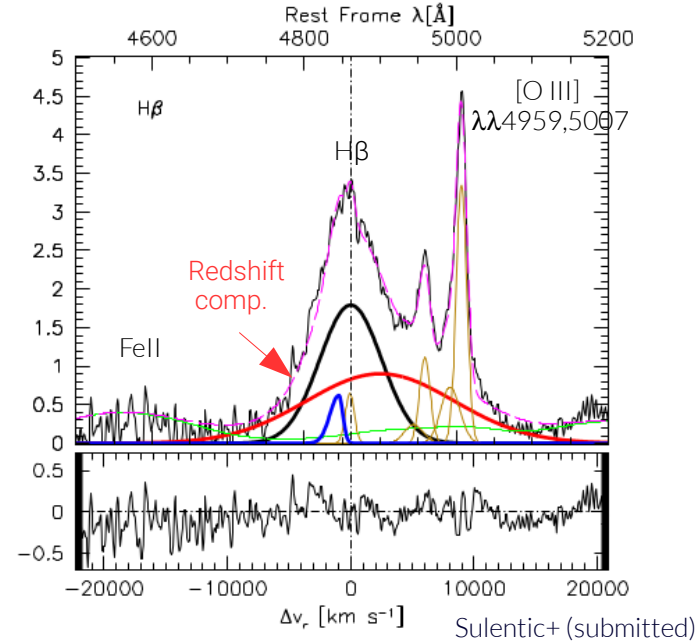
4DE1 along the spectral range

Pop. A1

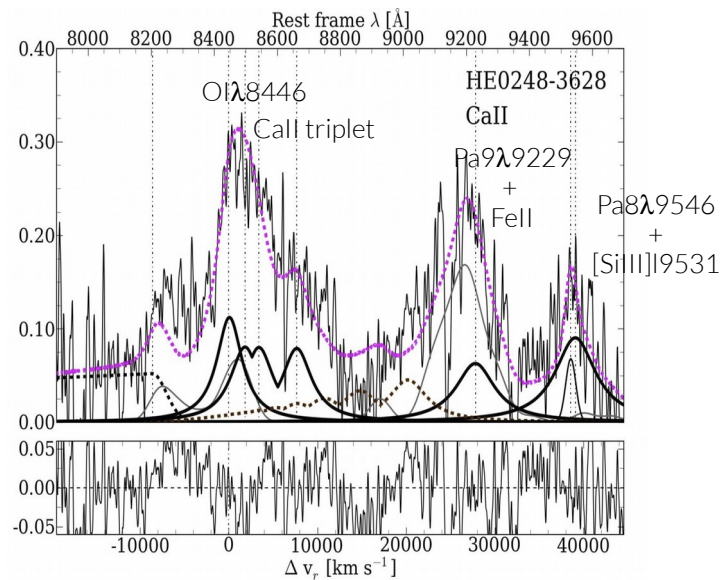
Opt



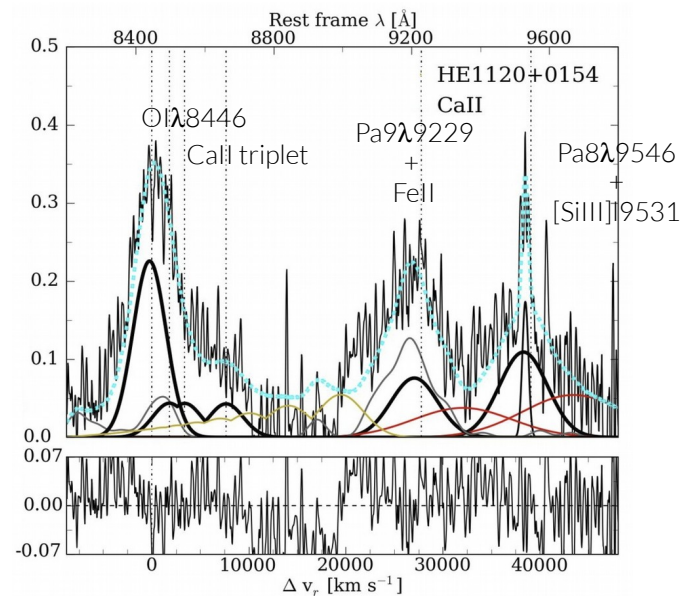
Pop. B1



NIR



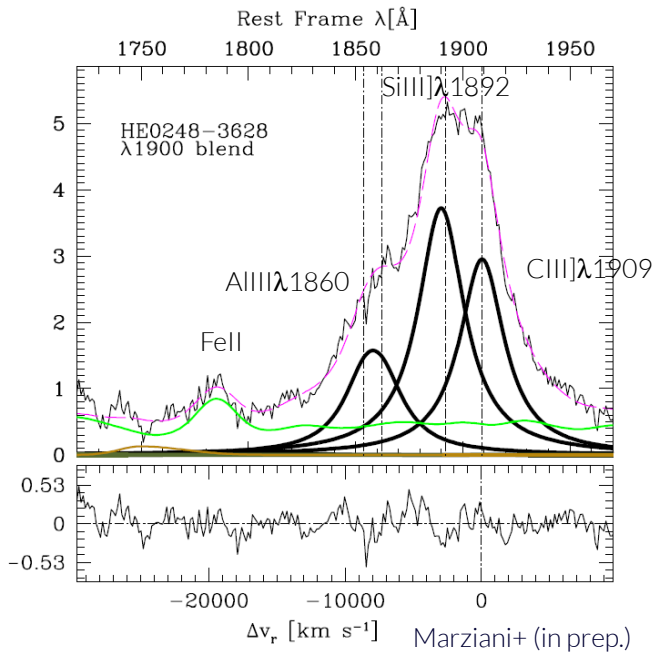
Martínez-Aldama+ 2015



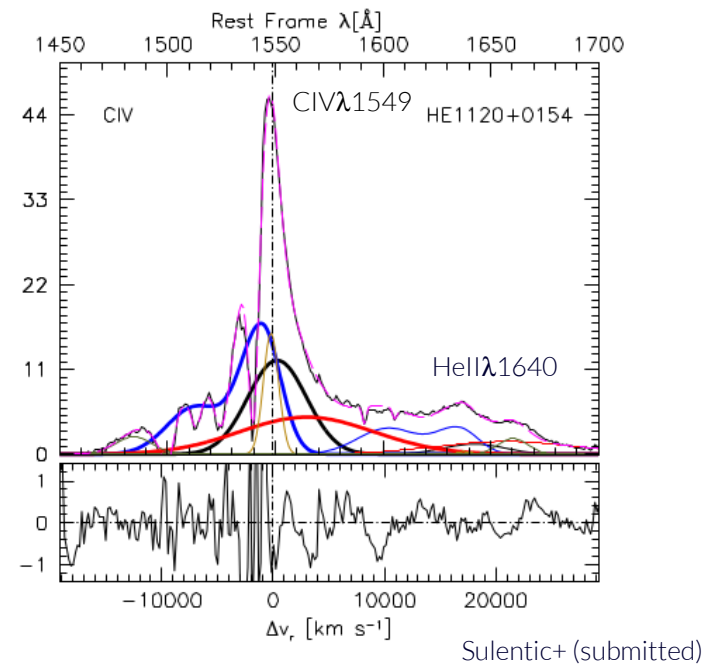
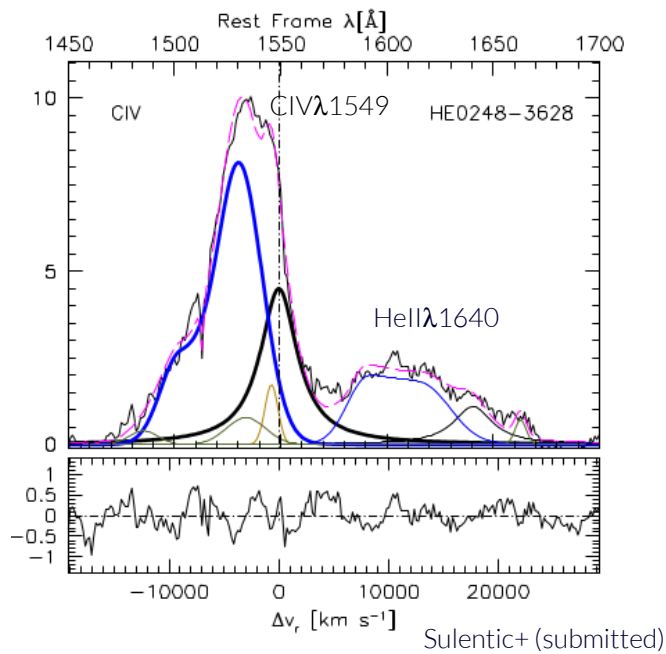
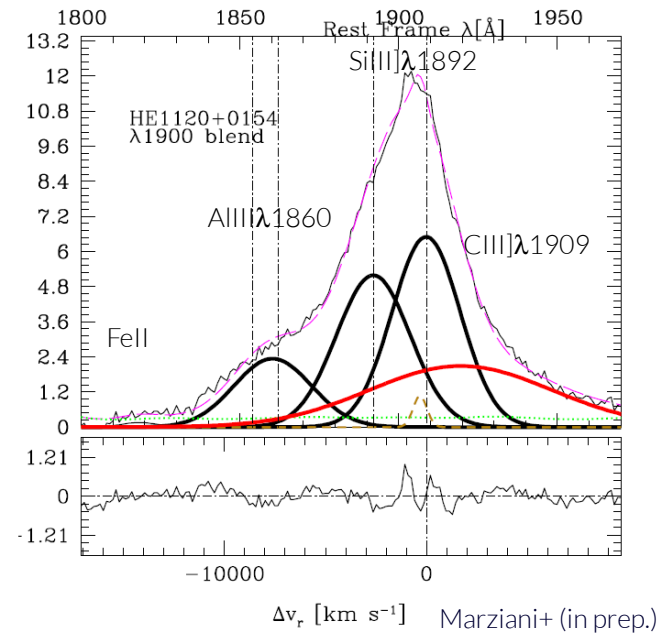
Martínez-Aldama+ (in prep.)

4DE1 along the spectral range

Pop. A1



Pop. B1



xA sources: highly accreting AGN

Considering several UV and optical samples (Bachev+ 2004; Marziani+ 2003, 2009; Negrete+ 2012, 2013; Sulentic+ 2004, 2007), we have identified properties associated to the the highly accreting AGNs based on the 4DE1: **xA sources**.

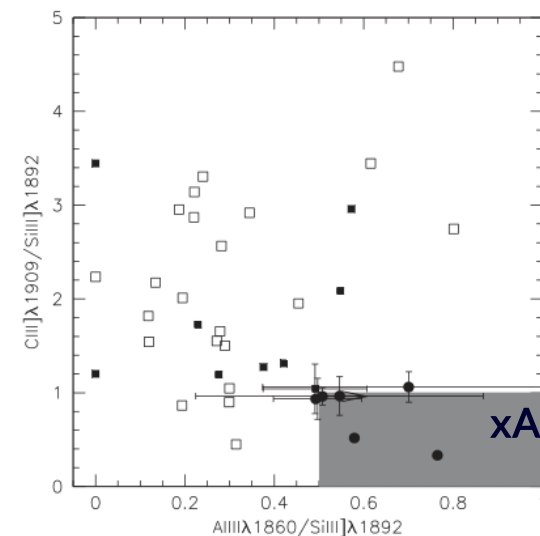
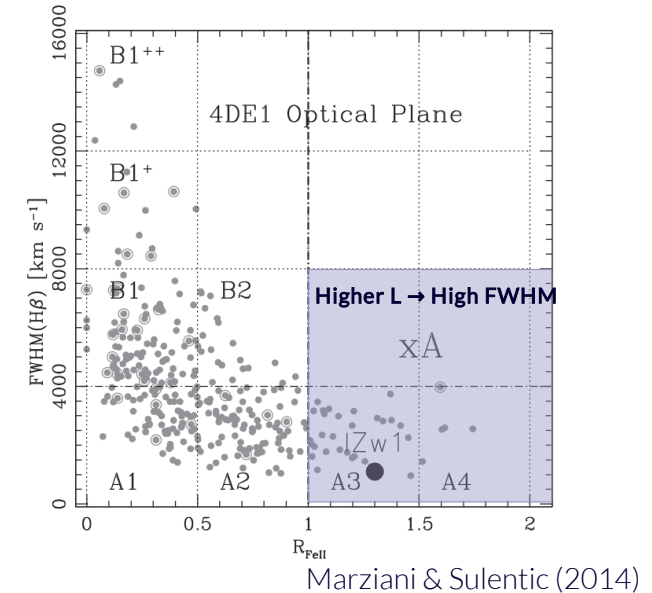
xA sources show the next properties:

- A3 and A4 along the 4DE1
- Strong FeII contribution: $R_{\text{FeII}} \geq 1.0$
- High intensity of $\text{Al III } \lambda 1860$ and $\text{Si III } \lambda 1397$:

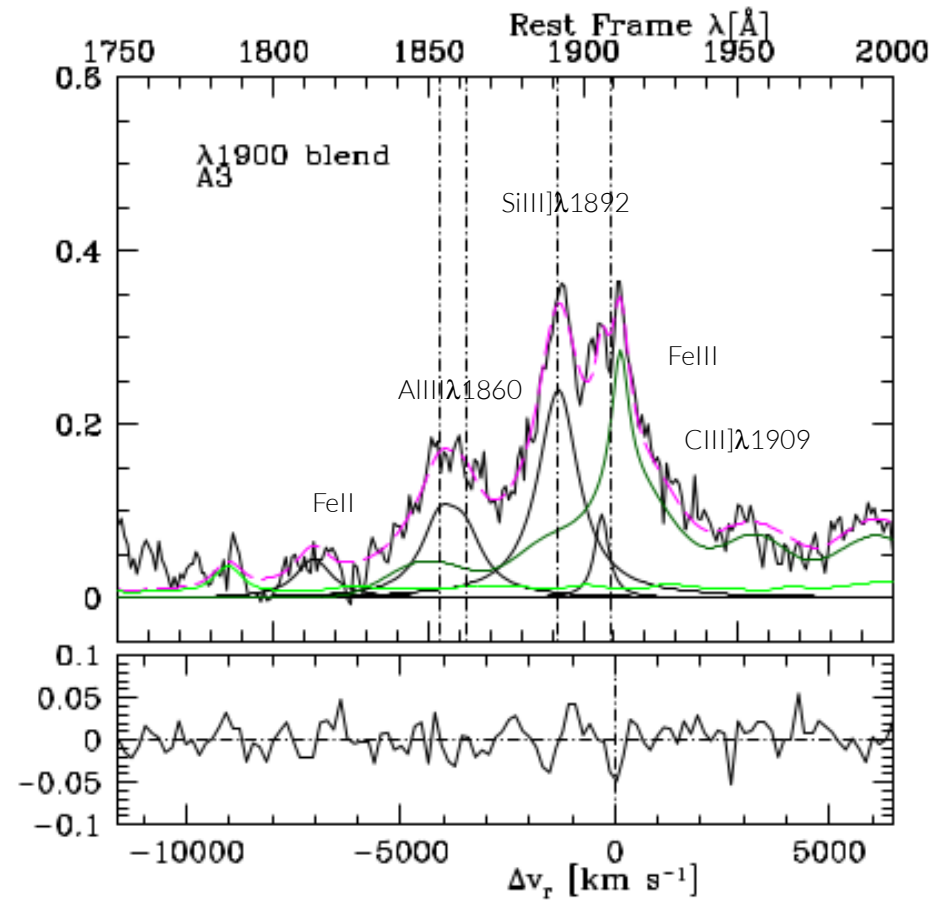
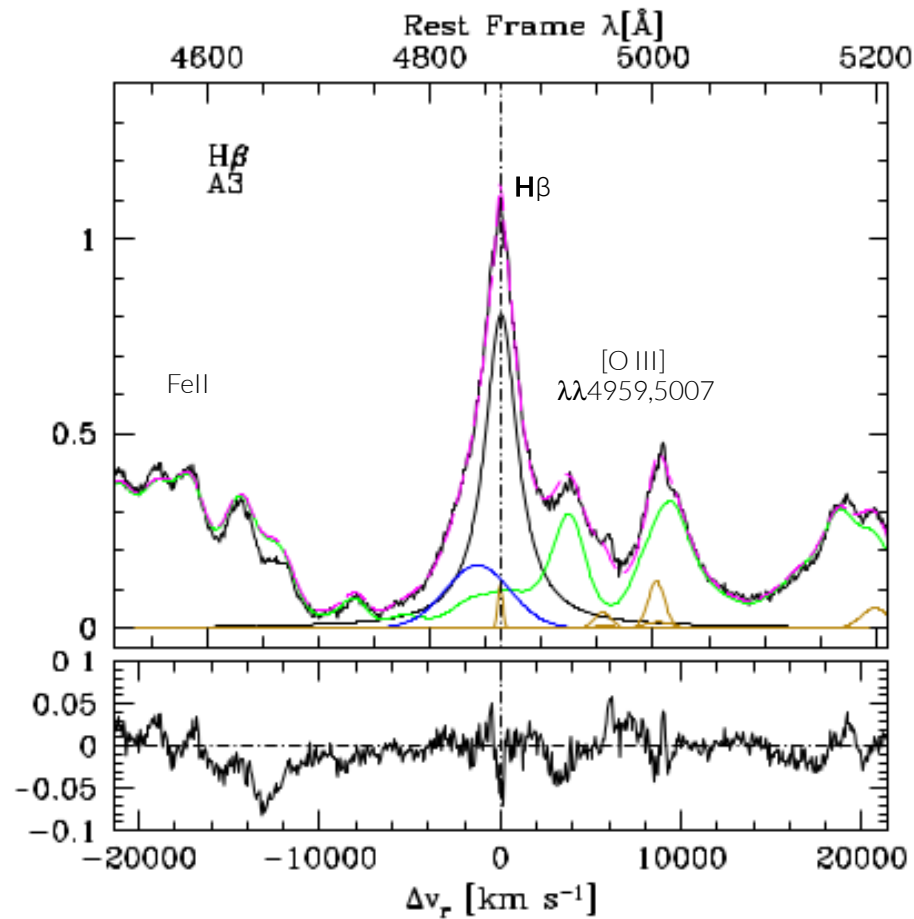
$$\frac{\text{Al III } \lambda 1860}{\text{Si III } \lambda 1892} \geq 0.5$$

$$\frac{\text{C III } \lambda 1909}{\text{Si III } \lambda 1892} \leq 1.0$$

- High ionization outflows
- High Eddington ratios: $L/L_{\text{Edd}} \geq 0.2$



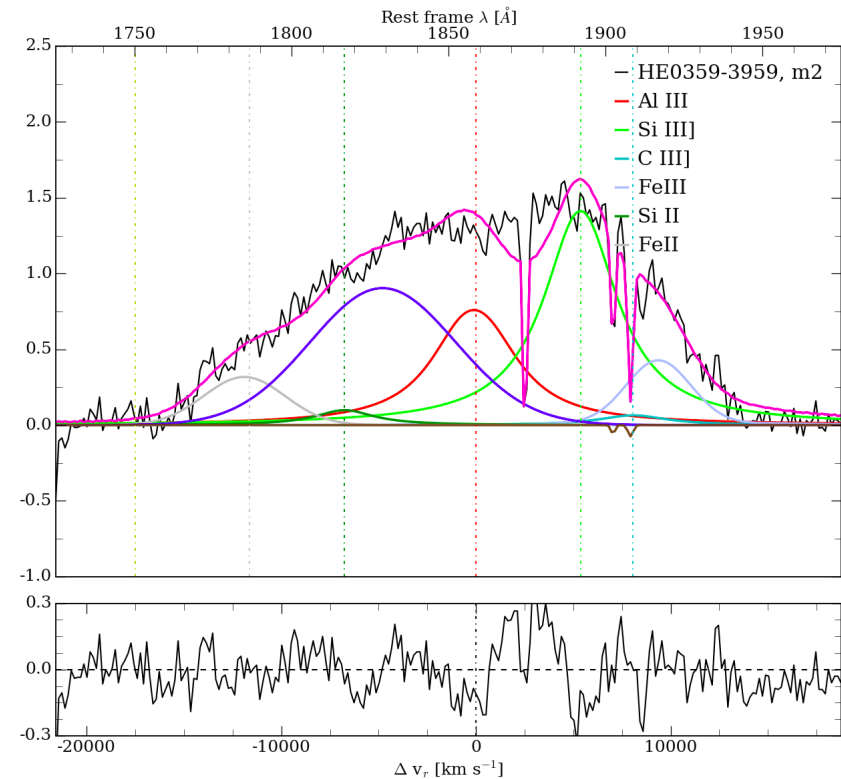
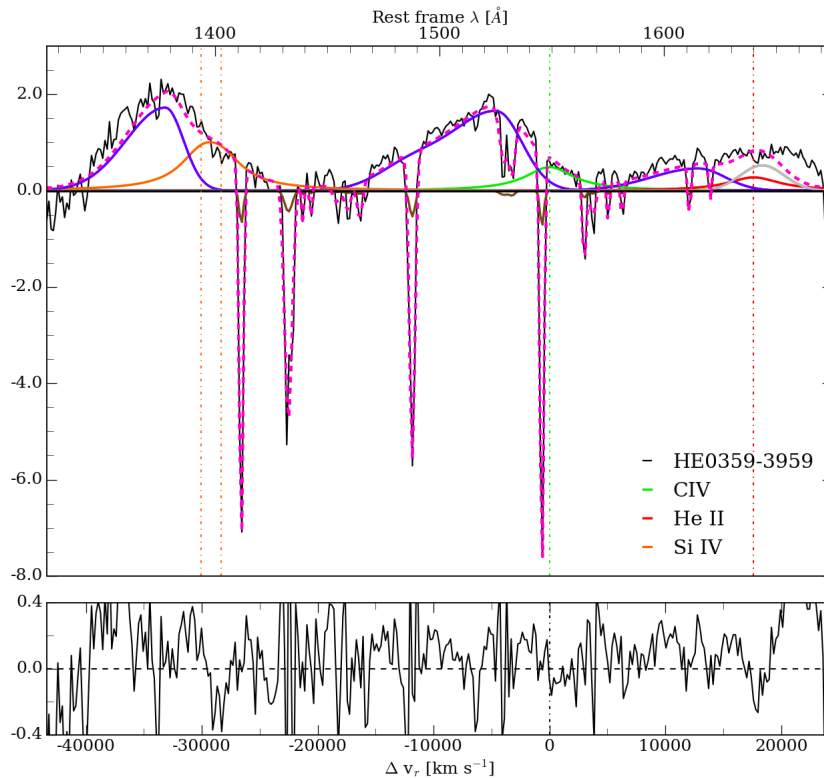
xA average spectrum



Credit P. Marziani

xA typical spectrum: extreme cases

We find some examples of extreme cases xA, like the **HE0359-3959**. This QSO shows a strong blue component associated to the $\lambda 1900$ Blend, which is also observed in the CIV $\lambda 1549$ line profile. **See poster A22.**

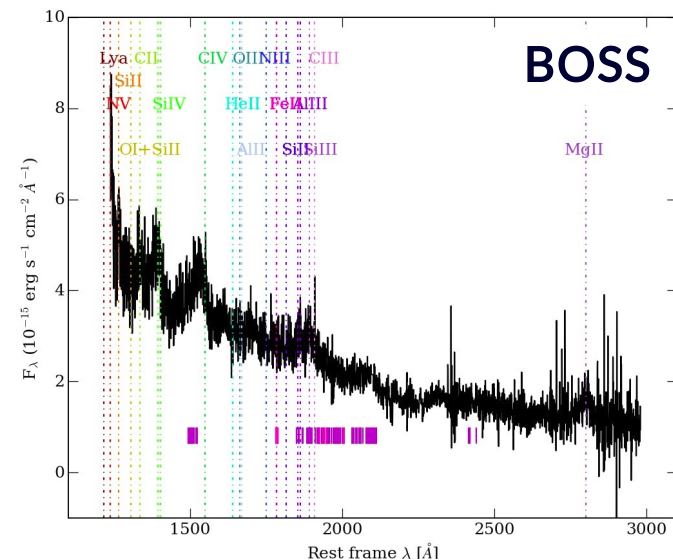
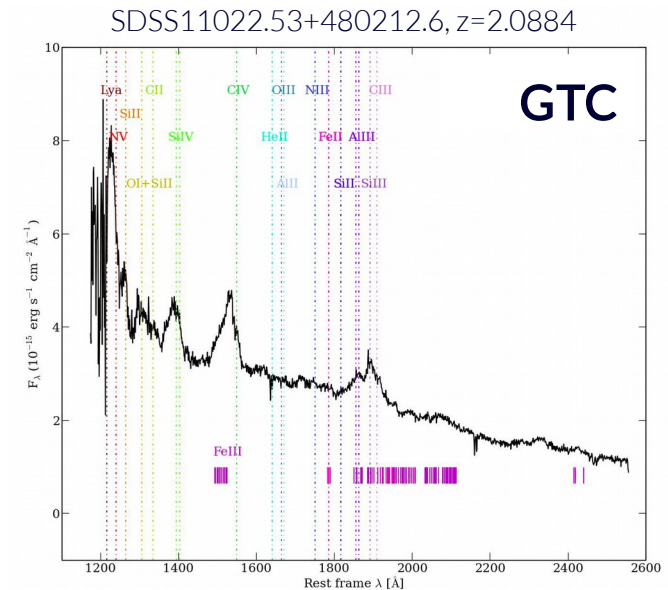


Martínez-Aldama in prep.

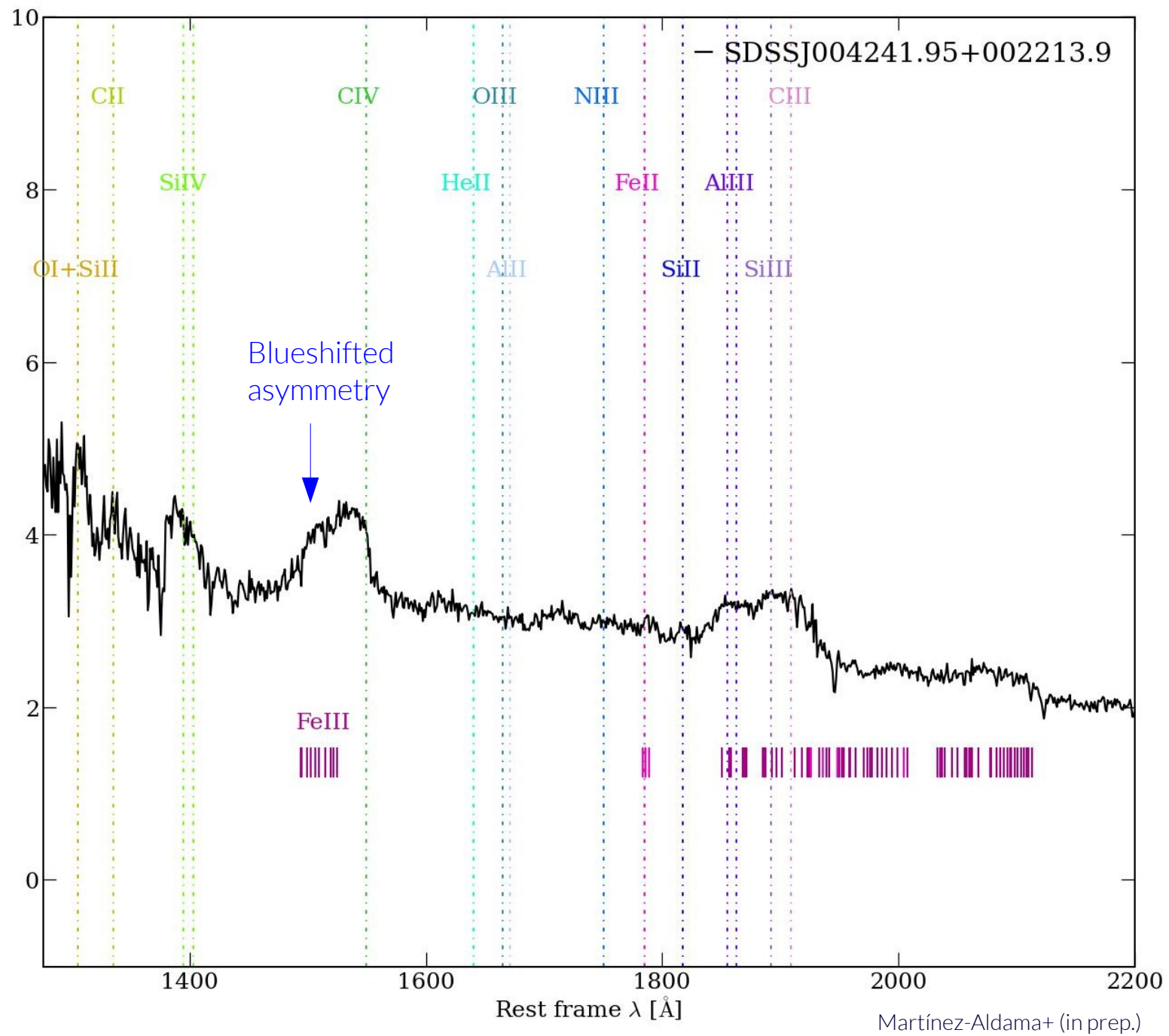
GTC highly accreting sample

We observed a sample of highly accreting quasars (~ 50 sources) with $z=2-3$ using the **OSIRIS** spectrograph mounted in the **Gran Telescopio Canarias (GTC)**. They were selected from SDSS objects considering the UV criteria proposed by 4DE1 (Marziani & Sulentic 2014).

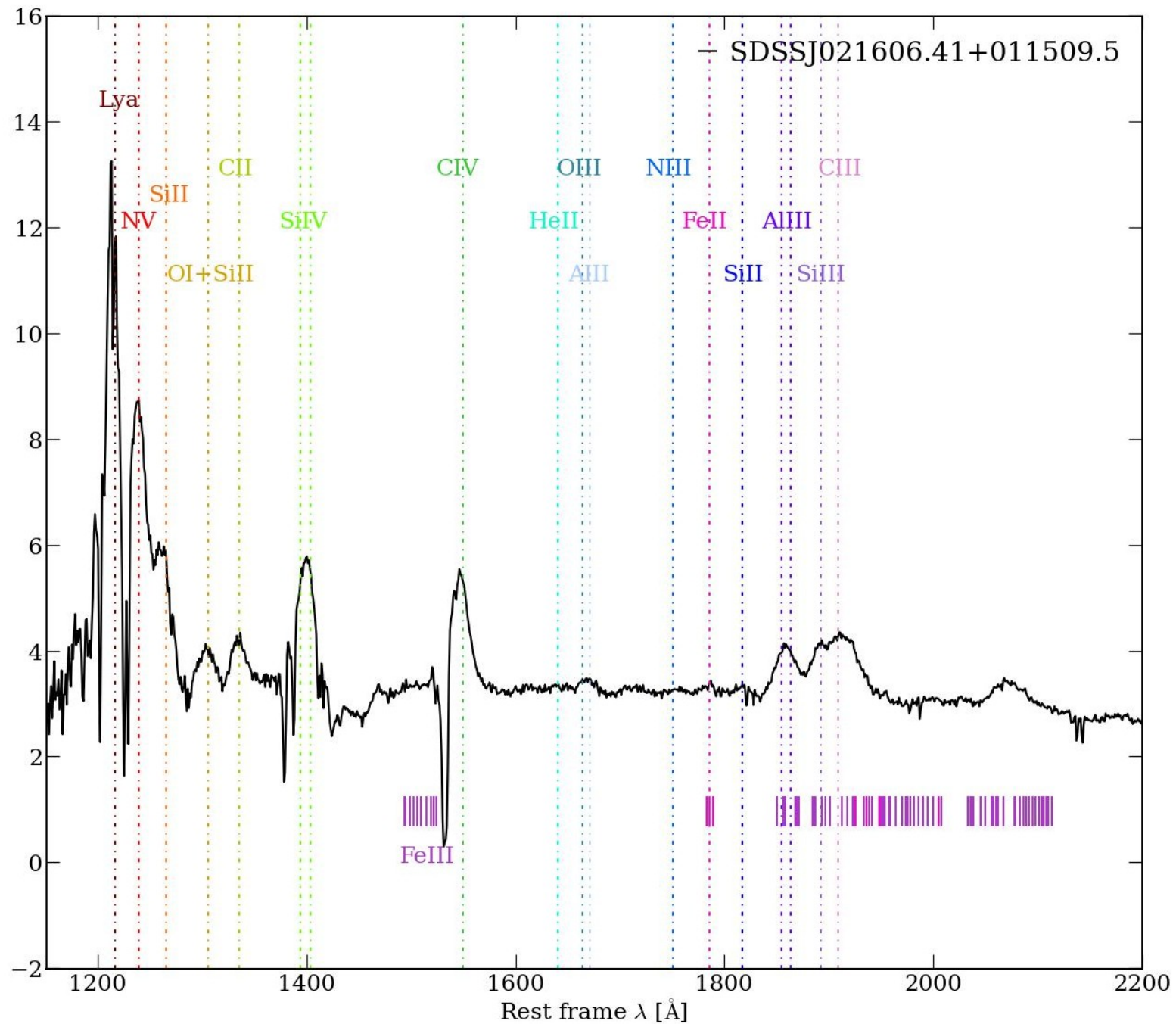
SDSS IDENTIFICATION	z	m_v	M_B	S/N
SDSSJ000807.27-103942.7	2.4660	19.15	-26.2	33
SDSSJ004241.95+002213.9	2.0560	19.05	-25.6	49
SDSSJ021606.41+011509.5	2.2236	19.36	-25.2	81
SDSSJ024154.42-004757.5	2.3919	19.24	-26.0	41
SDSSJ084036.16+235524.7	2.1840	19.46	-25.3	40
SDSSJ101822.96+203558.6	2.2502	19.27	-25.5	36
SDSSJ103527.40+445435.6	2.2639	19.34	-25.6	43
SDSSJ105806.16+600826.9	2.9406	19.29	-26.7	30
SDSSJ110022.53+484012.6	2.0884	18.90	-25.9	44
SDSSJ125659.79-033813.8	2.9801	19.27	-26.7	14
SDSSJ131132.92+052751.2	2.1234	19.06	-25.4	39
SDSSJ143525.31+400112.2	2.2615	18.30	-26.6	91
SDSSJ144412.37+582636.9	2.3455	19.21	-25.8	22
SDSSJ151258.36+352533.2	2.2382	19.21	-25.8	46
SDSSJ214009.01-064403.9	2.0808	19.26	-25.3	60
SDSSJ220119.62-083911.6	2.1840	18.68	-26.1	90
SDSSJ222753.07-092951.7	2.1639	19.11	-25.6	48
SDSSJ233132.83+010620.9	2.6271	19.19	-26.1	31
SDSSJ234657.25+145736.0	2.1682	19.11	-25.7	57



Some examples



Some examples: BAL QSO

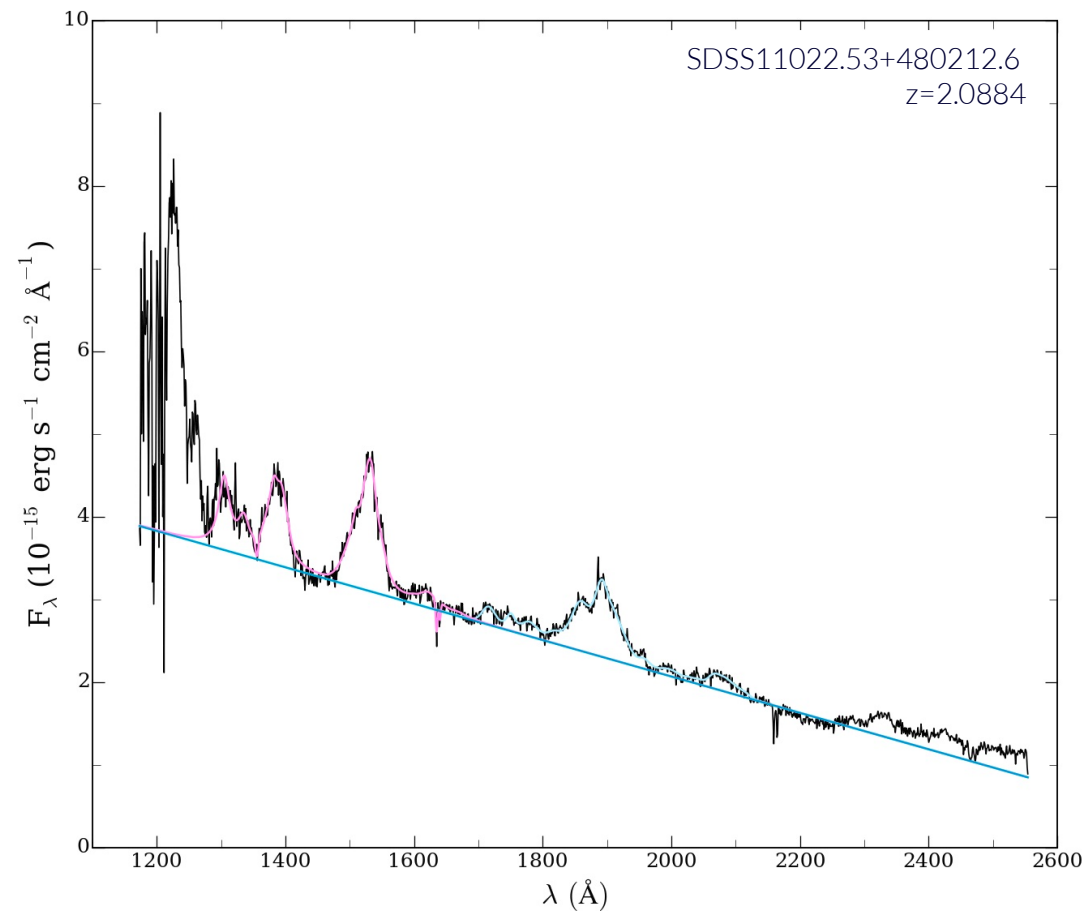


Multicomponent fits

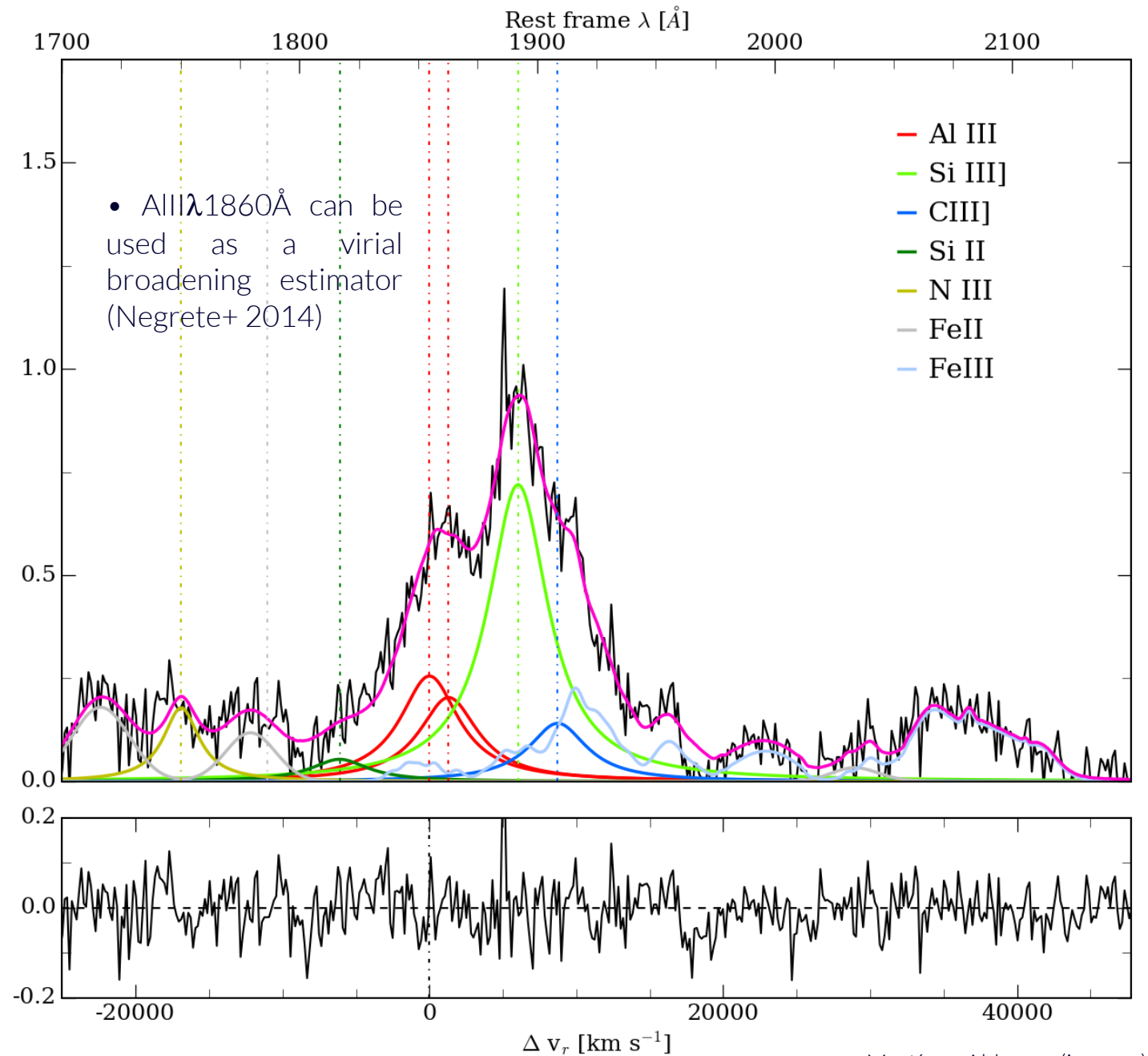
Following the 4DE1 context, we performed multicomponent fits using the routine SPECFIT (IRAF).

Fitting criteria {

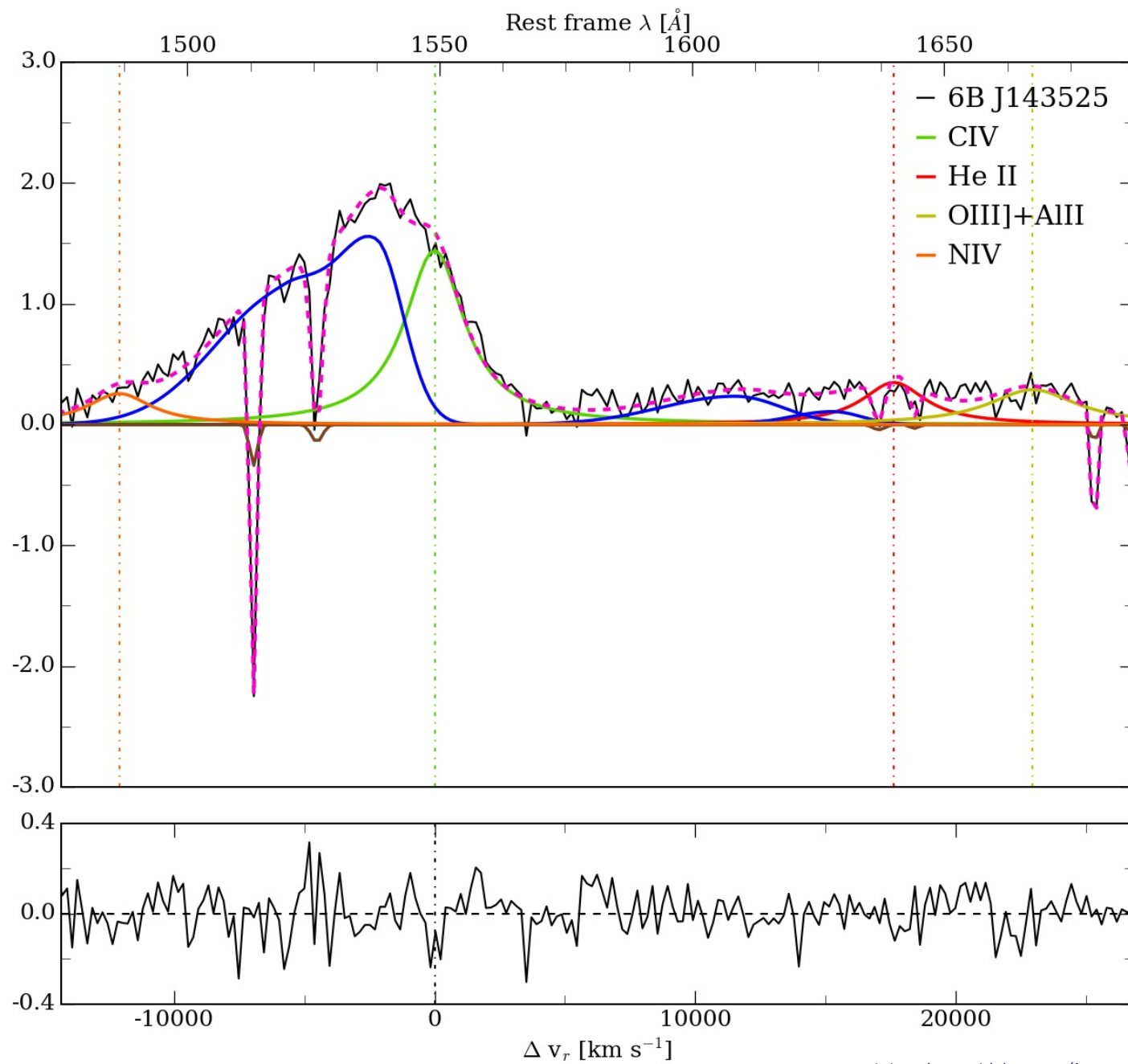
- Continuum: local or global
- Pop. A: lorentzian profiles
- Low Ionization Lines: BC (lorentzian)
- High Ionization Lines: BC (lorentzian)+Blueshift (gaussian)



Multicomponent fits



Multicomponent fits



Photoionization method

Considering the flux ratios of the UV lines, we can determine U and n_H using a photoionization model. And then, we can get the size of the Broad Line Region, r_{BLR} (Negrete+ 12).

Ionization parameter

$$U = \frac{\int_{\nu_0}^{+\infty} \frac{L_\nu}{h\nu} d\nu}{4\pi n_H c r^2}$$

Broad Line Region size

$$r_{BLR} = \left[\frac{\int_{\nu_0}^{+\infty} \frac{L_\nu}{h\nu} d\nu}{4\pi U n_H c} \right]^{1/2}$$

SDSSJ084036.16+235524.7, $1Z_\odot$

CLOUDY (Ferland+ 2013) input conditions:

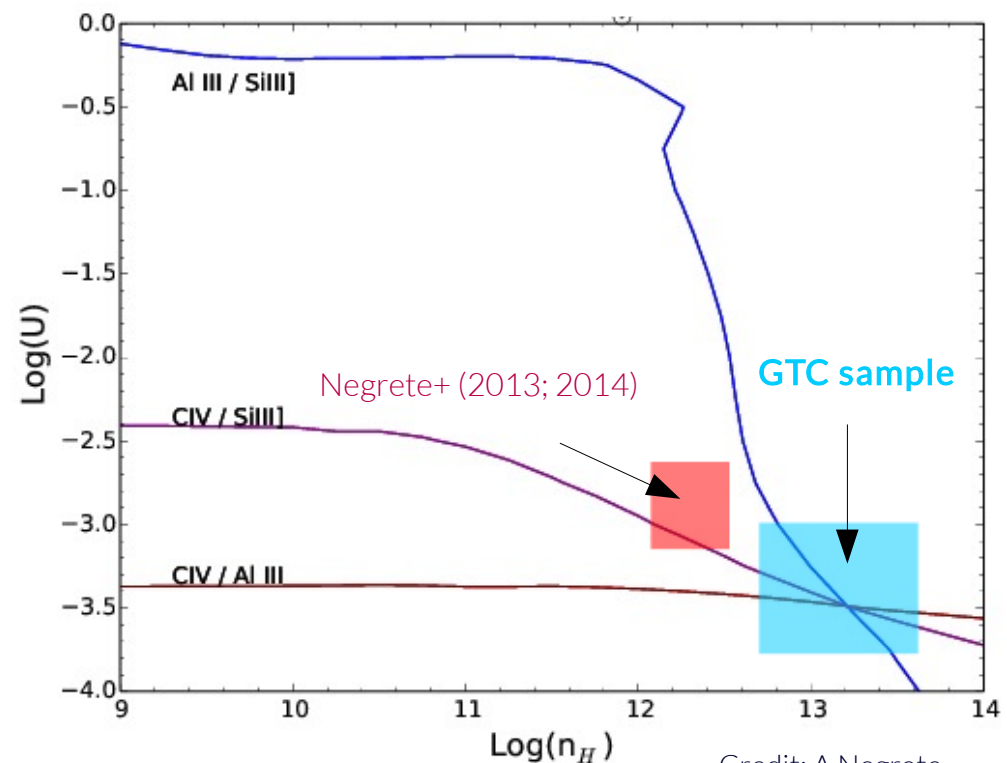
- Mathews & Ferland continuum (1987)

- $N_c = 10^{23-25} \text{ cm}^{-2}$

- $1Z_\odot, 5Z_\odot$

- $-4 \leq \log(U) \leq 0$

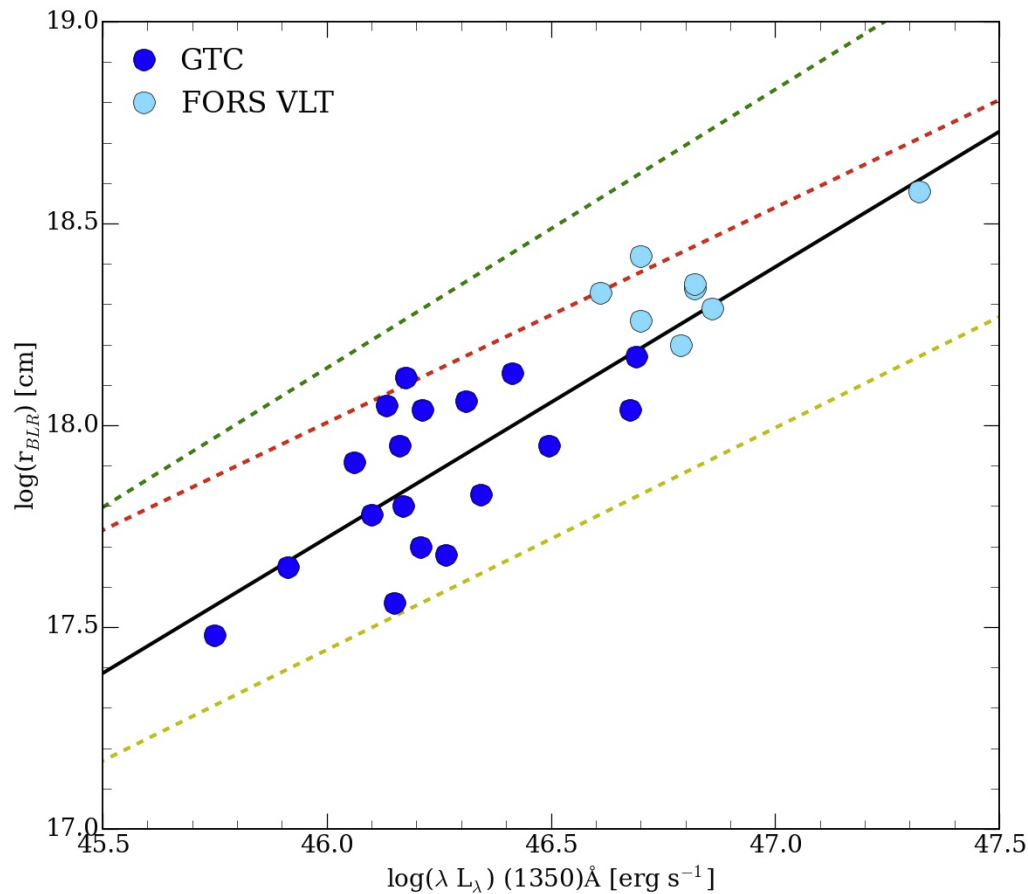
- $-9 \leq \log(n_H) \leq 14$



Credit: A Negrete

Broad Line Region Size

Including a small high- z QSO sample but not-highly accreting (Negrete+ 2012, 2013), we find that they follow the same trend. The comparison with the reverberation mapping relations is in agreement with a small trend to get small radius.



Martínez-Aldama+ (in prep.)

Photonization
model

■ Negrete+ (2012)

$$r_{BLR} = \frac{1}{h^{(1/2)}c} (UN_e)^{(1/2)} \left(\int_0^{\lambda_{Ly}} f_{\lambda} \lambda d\lambda \right)^{(1/2)} d_p$$

Reverberation
mapping
 $5100 \cdot L_{5100}$

■ Vestergaard+ (2005): H β

$$\frac{R_{BLR}}{10 \text{ lt-days}} = (2.23 \pm 0.21) \left[\frac{\lambda L_{\lambda}(5100 \text{ \AA})}{10^{44} \text{ ergs s}^{-1}} \right]^{0.69 \pm 0.05}$$

■ Kaspi+ (2007): CIV $\lambda 1549$

$$\log(R_{BLR}/10 \text{ lt-day}) = 1.527^{+0.031}_{-0.031} + 0.533^{+0.035}_{-0.033} \log(\lambda L_{\lambda}/10^{44} L_{\odot})$$

■ Bentz+ (2013): H β

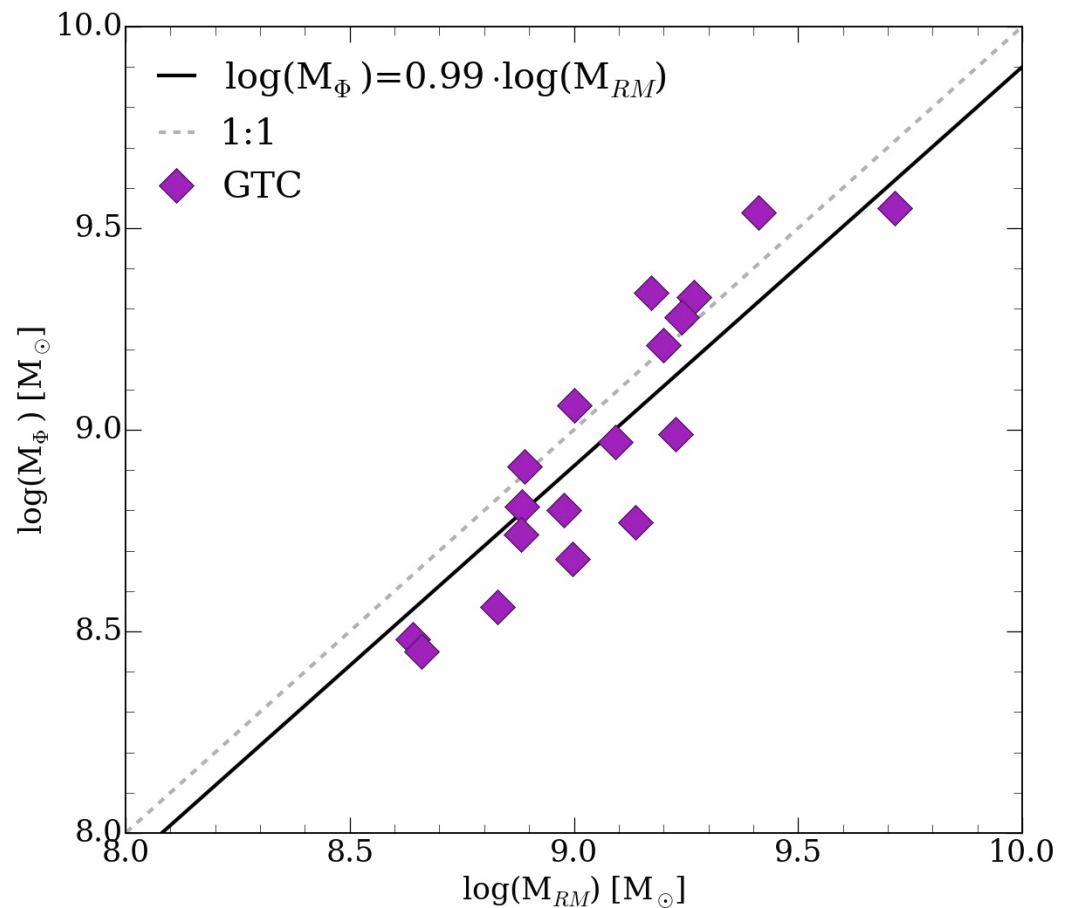
$$\frac{R_{BLR}}{10 \text{ lt-days}} = (0.24 \pm 0.06) \left[\frac{\lambda L_{\lambda}(1350 \text{ \AA})}{10^{43} \text{ ergs s}^{-1}} \right]^{0.55 \pm 0.04}$$

Black Hole Mass determination

Computing the black hole mas, we get that the mass obtained is closely related to the computed by the reverberation mapping results (Vestergaard & Peterson, 2006).

$$M_{\text{BH},\Phi} \left\{ \begin{array}{l} \text{Negrete (2012)} \\ M = \frac{3}{4G} f_{0.75} r_{\text{BLR}} (\text{FWHM})^2 \end{array} \right.$$

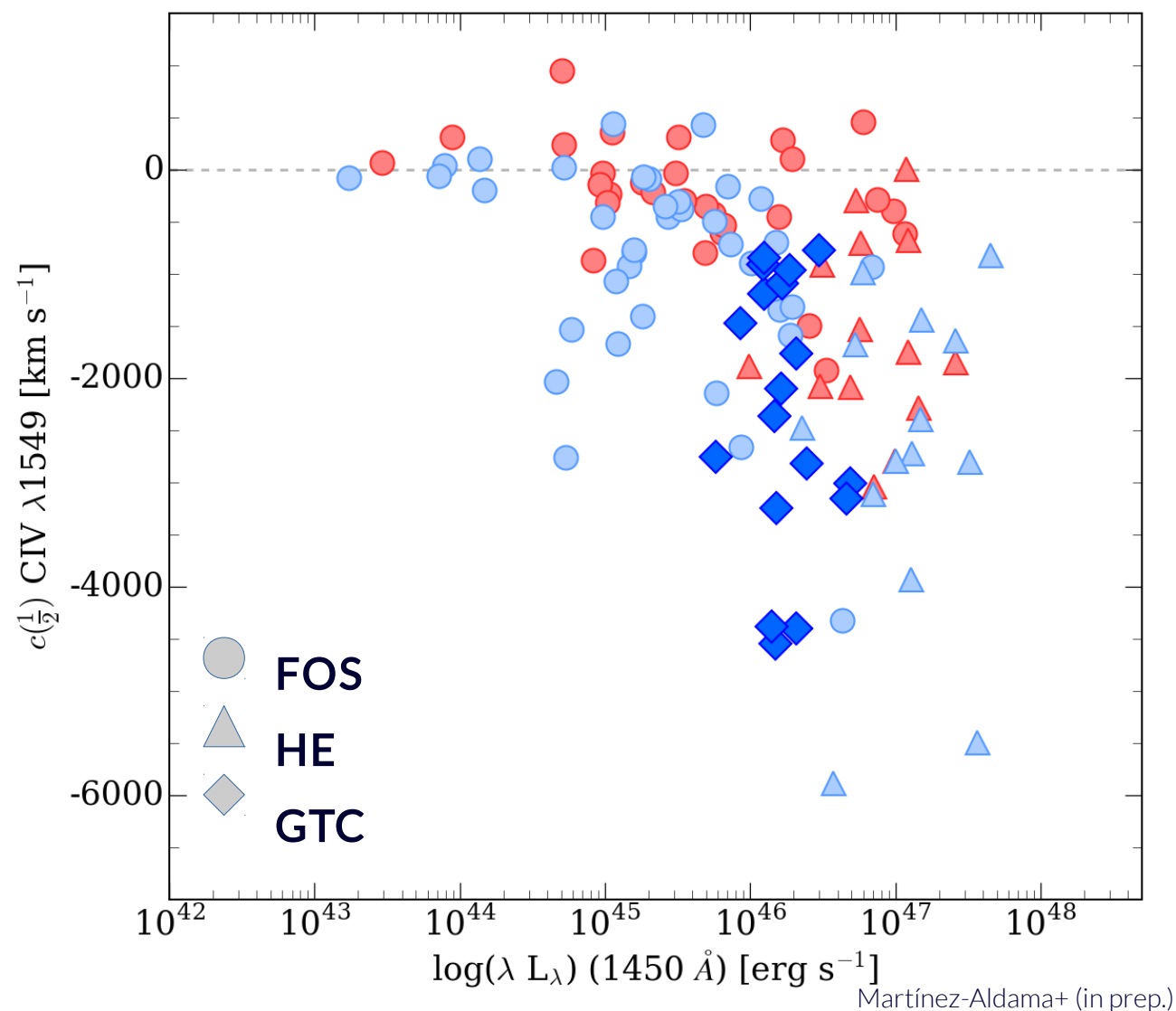
$$M_{\text{BH},\text{RM}} \left\{ \begin{array}{l} \text{Vestergaard \quad \& \quad Peterson (2006)} \\ \log M_{\text{BH}}(\text{C iv}) = \log \left\{ \left[\frac{\text{FWHM}(\text{C iv})}{1000 \text{ km s}^{-1}} \right]^2 \left[\frac{\lambda L_{\lambda}(1350 \text{ \AA})}{10^{44} \text{ ergs s}^{-1}} \right]^{0.53} \right\} \\ \quad + (6.66 \pm 0.01) \end{array} \right.$$



Martínez-Aldama+ (in prep.)

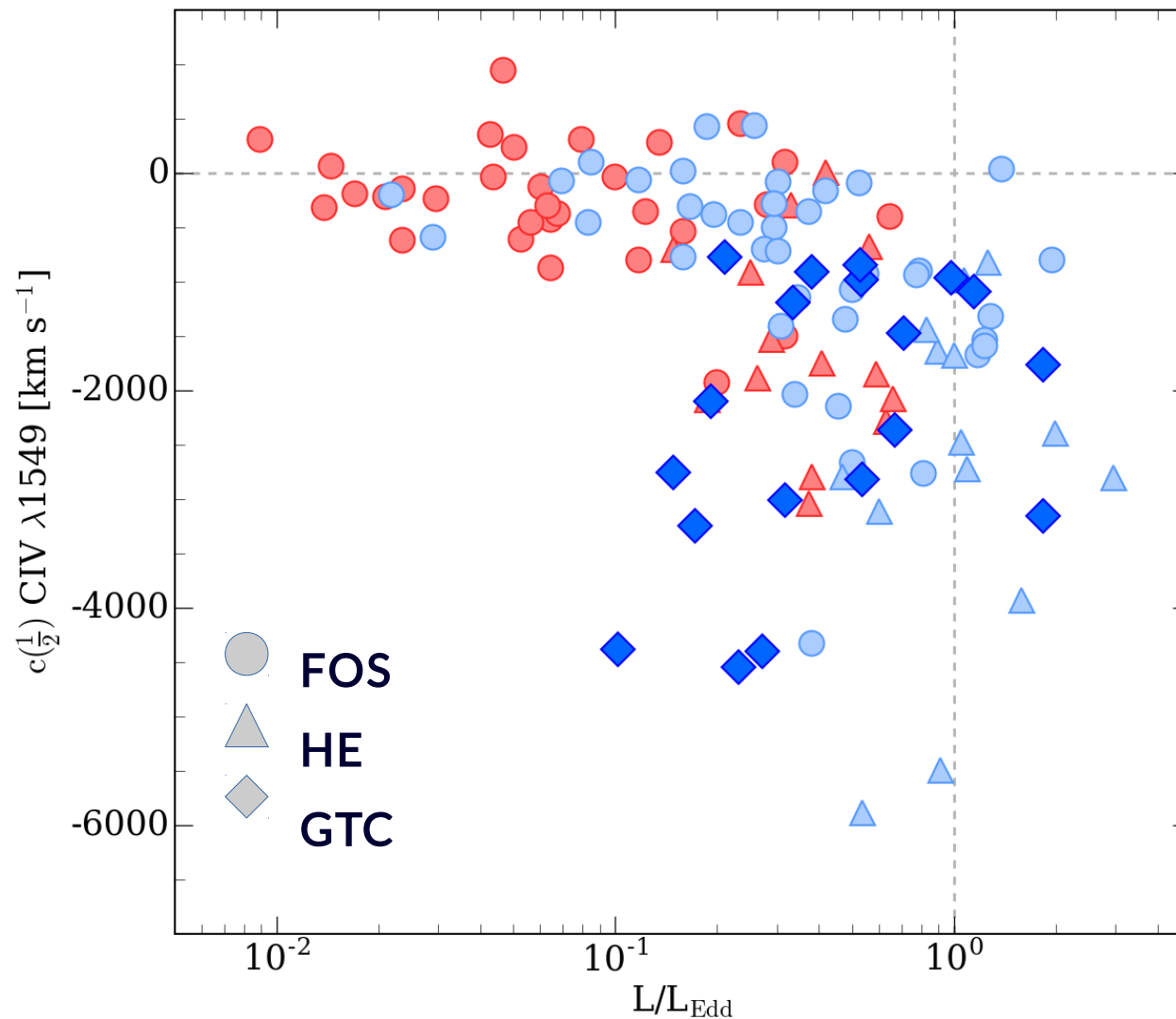
CIV $\lambda 1549$ outflows and the Eddington ratios

Including two samples (FOS VLT+HE) with Pop. A and B sources (Marziani & Sulentic 2014; Sulentic+ 2004, 2006, 2007; Marziani+ 2009), we find a strong trend to the Pop. A sources to show strong asymmetries.



CIV $\lambda 1549$ outflows and the Eddington ratios

Moreover, the Pop. A sources, specially high accretors, tend to show high luminosities and Eddington ratios.



Conclusions

- 4DE1 criteria gives a correct selection of the highly accreting type 1 AGNs: A3 and A4
- Highly accreting quasars show special features:
 - $R_{\text{FeII}} \geq 1.0$
 - High ionization outflows
 - $L/L_{\text{Edd}} \geq 0.2$
- The BLR has high density ($\log(n_{\text{H}}) > 12$) and low ionization parameter, which is different to the not-highly accreting sources
- The photoionization models give other method to compute the r_{BLR} and M_{BH} , which are in agreement with the reverberation scaling laws.



Highly accreting quasars can be used as standard candles

See Negrete's talk