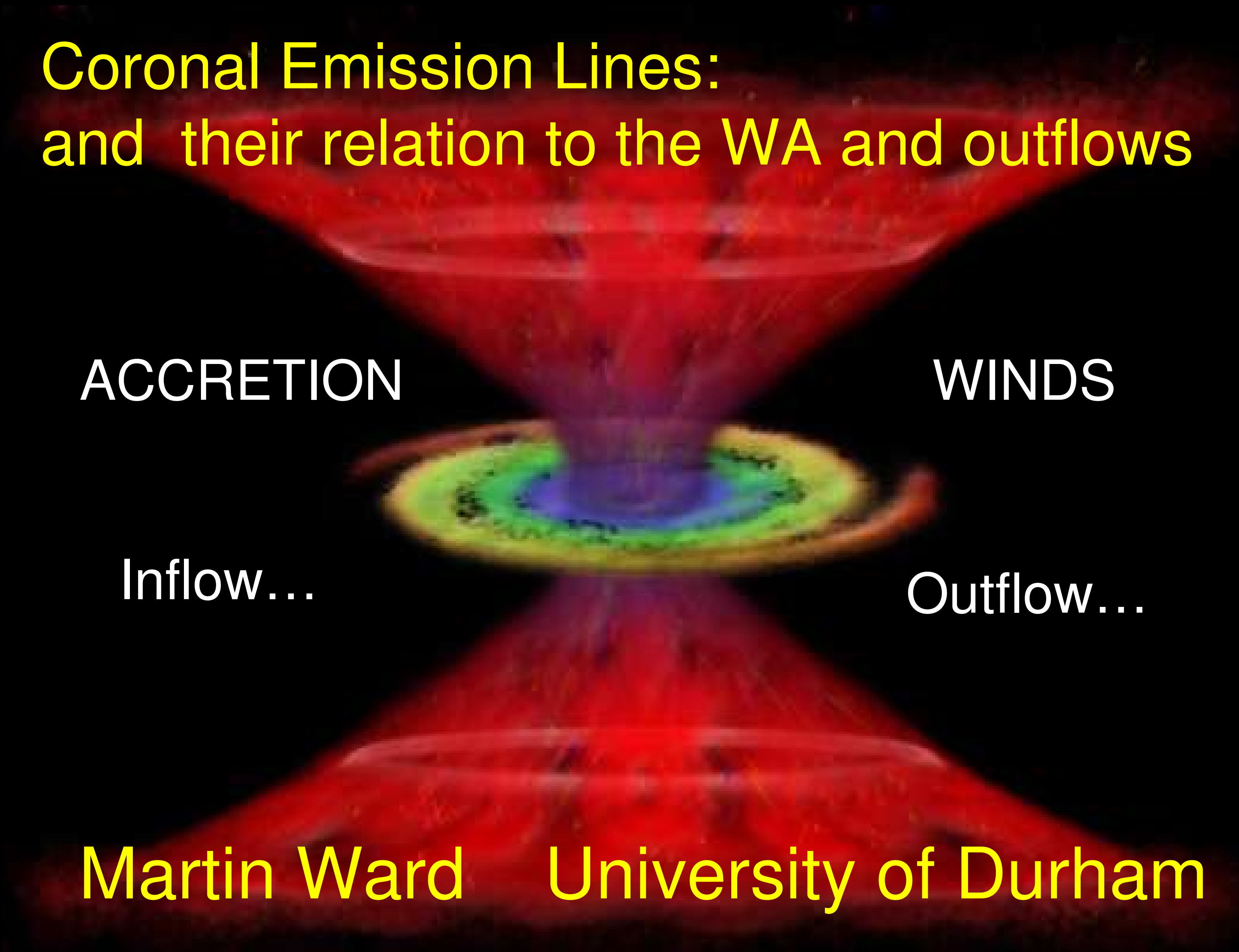
Coronal Emission Lines: and their relation to the WA and outflows



Martin Ward University of Durham

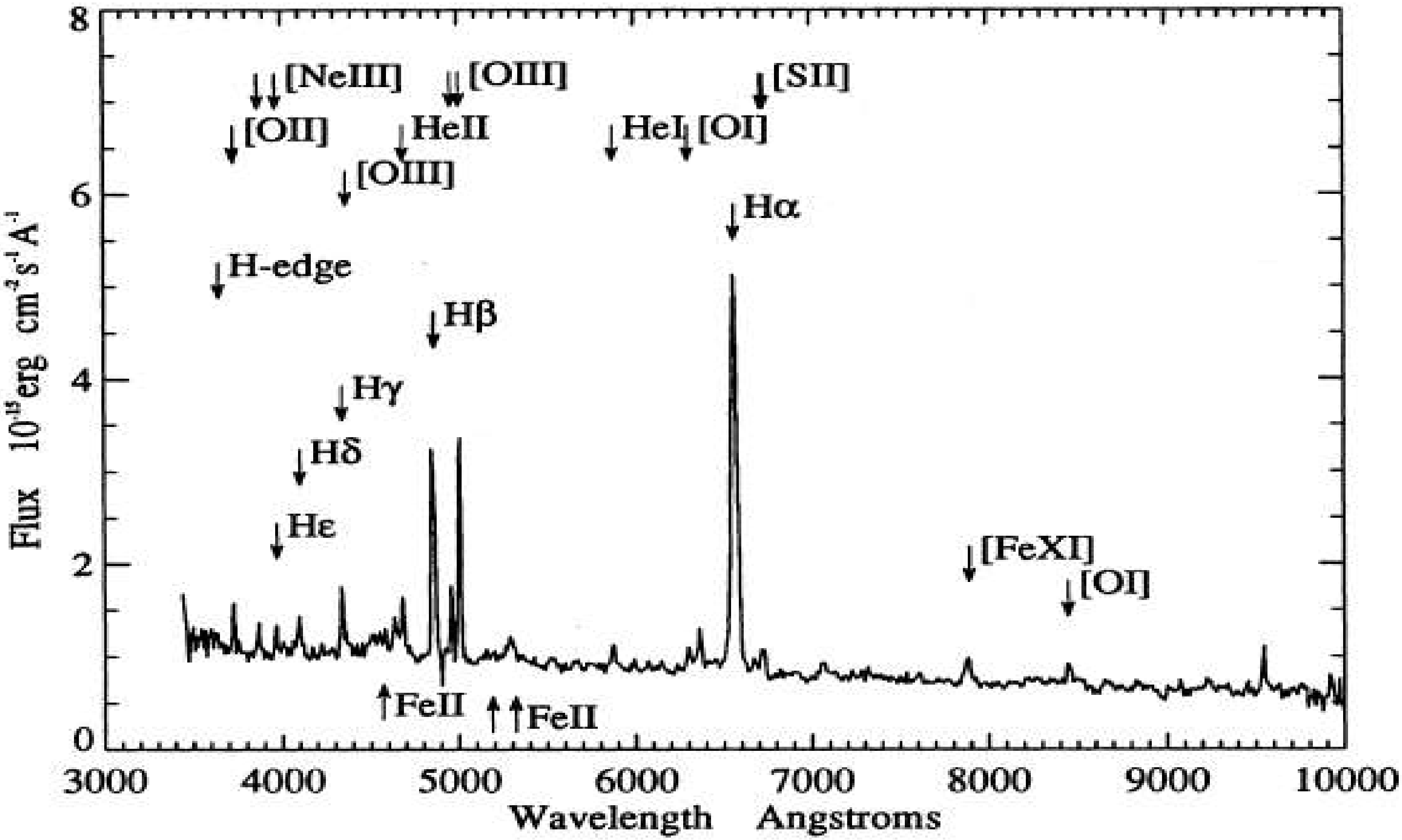
Previous work on opt./near IR CLs in AGN
(incomplete list, only illustrative)

- Physical conditions and size of CLR: Oliva et al. (1994), Nazarova et al (1999), Fergusen et al (1997)
- WA and coronal lines: Porquet et al. (1999), Komossa et al. (1999), Pfeiffer et al. (2000)
- CLs and winds: Erkens et al. (1997)

What we know about Coronal Lines

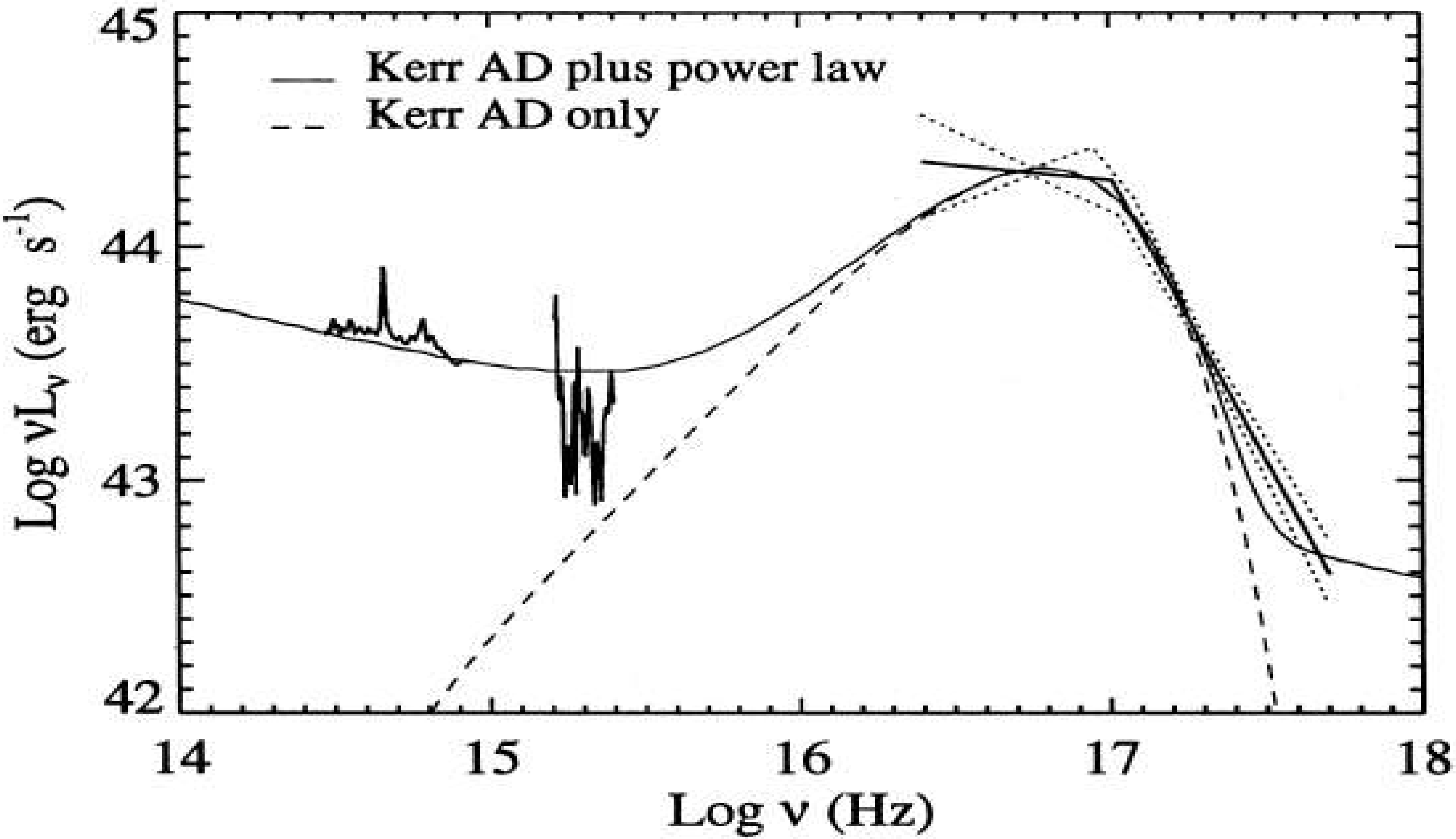
- Very high I.P. (by definition), up to ~0.4 keV (thermal = 3 million K)
- Sometimes (not always) very broad cf. the NLR profiles
- Sometimes (not always) blue shifted peak w.r.t the NLR profiles
- Sometimes they have obvious blue winged profile
- Variability? Not very clear – future work

RE J1034+389 – NLS1



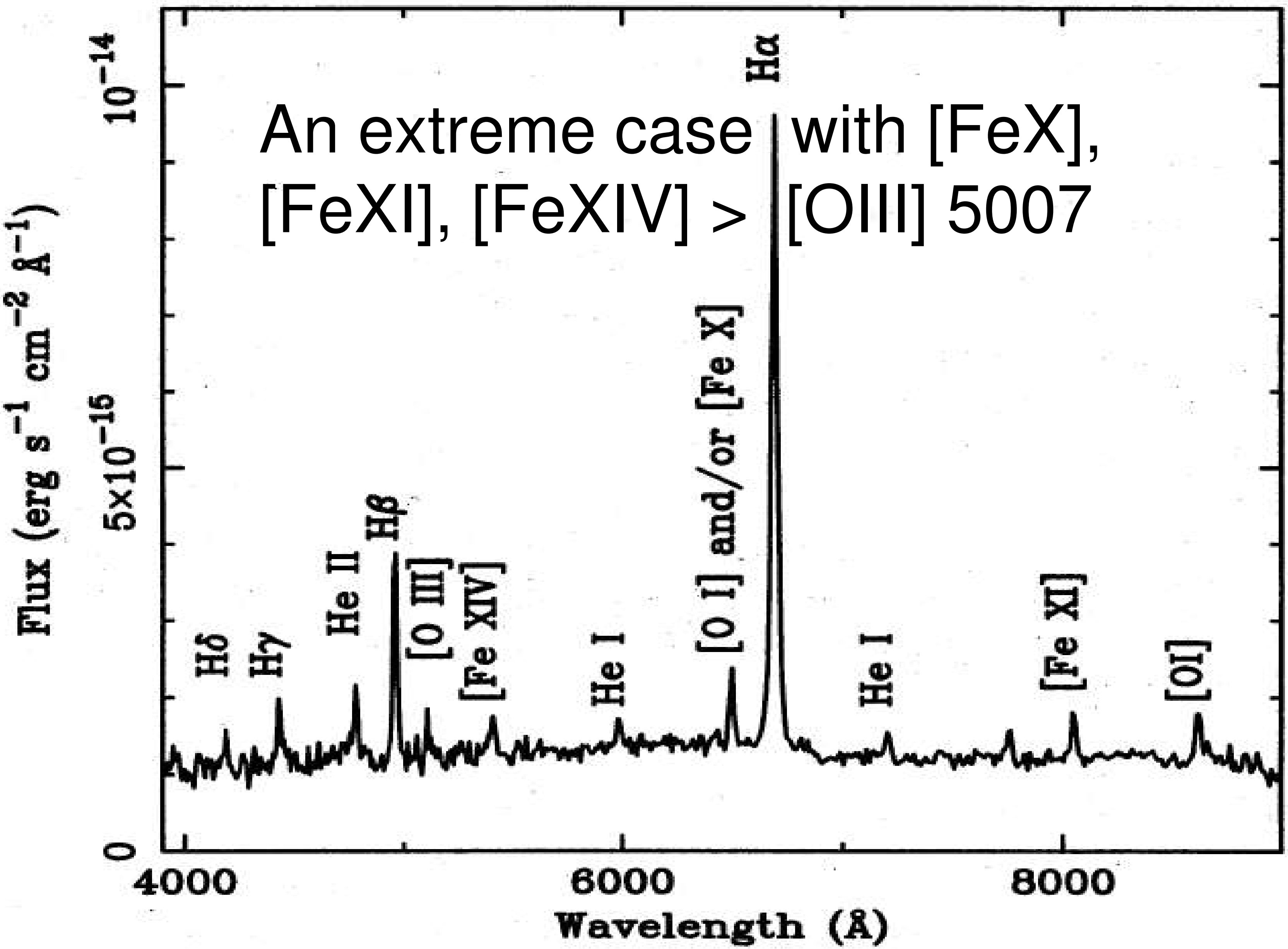
Pucharewicz et al. (1995)

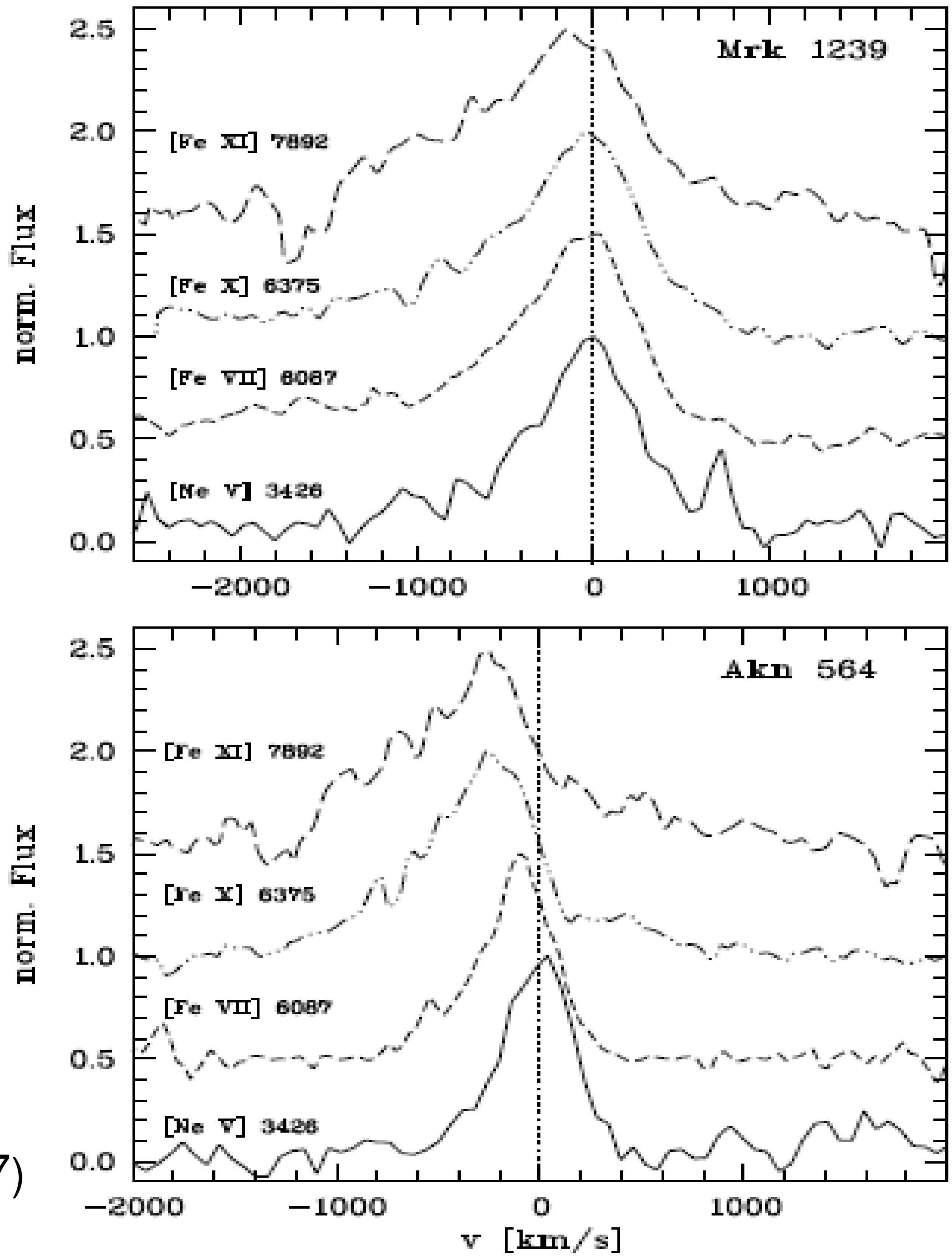
RE J1034+389



Kerr AD plus power law
Kerr AD only
Log νL$_ν$ (erg s^{-1})
Log ν (Hz)
45
44
43
42
14
15
16
17
18

RE J1237+264 (Brandt et al. 1995)





Erkens et al. (1997)

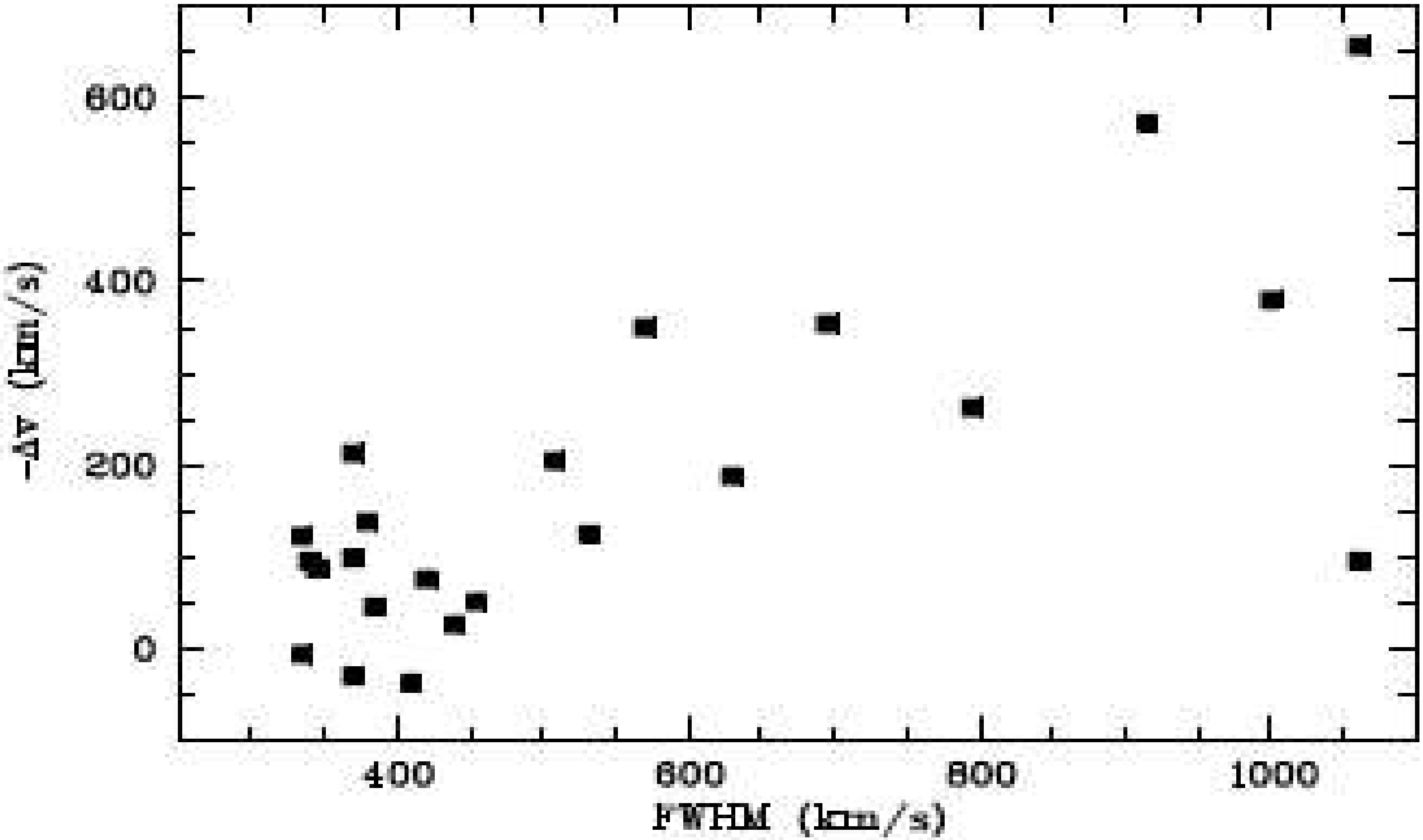


Fig. 5. Relation between the observed blueshift (-Δv) and the observed (FWHM) line width of the [Fe X] and [Fe XI] lines

Where are the CL's emitted?
Circinus Galaxy – Sey.2 (Oliva et al. 1994)

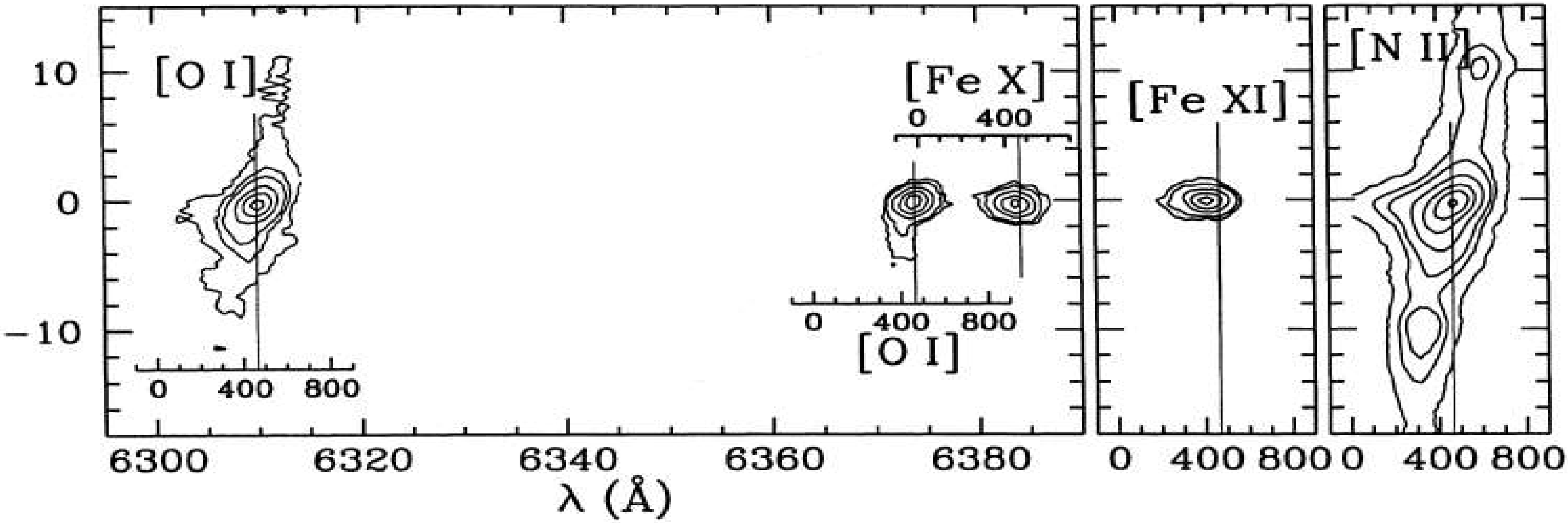
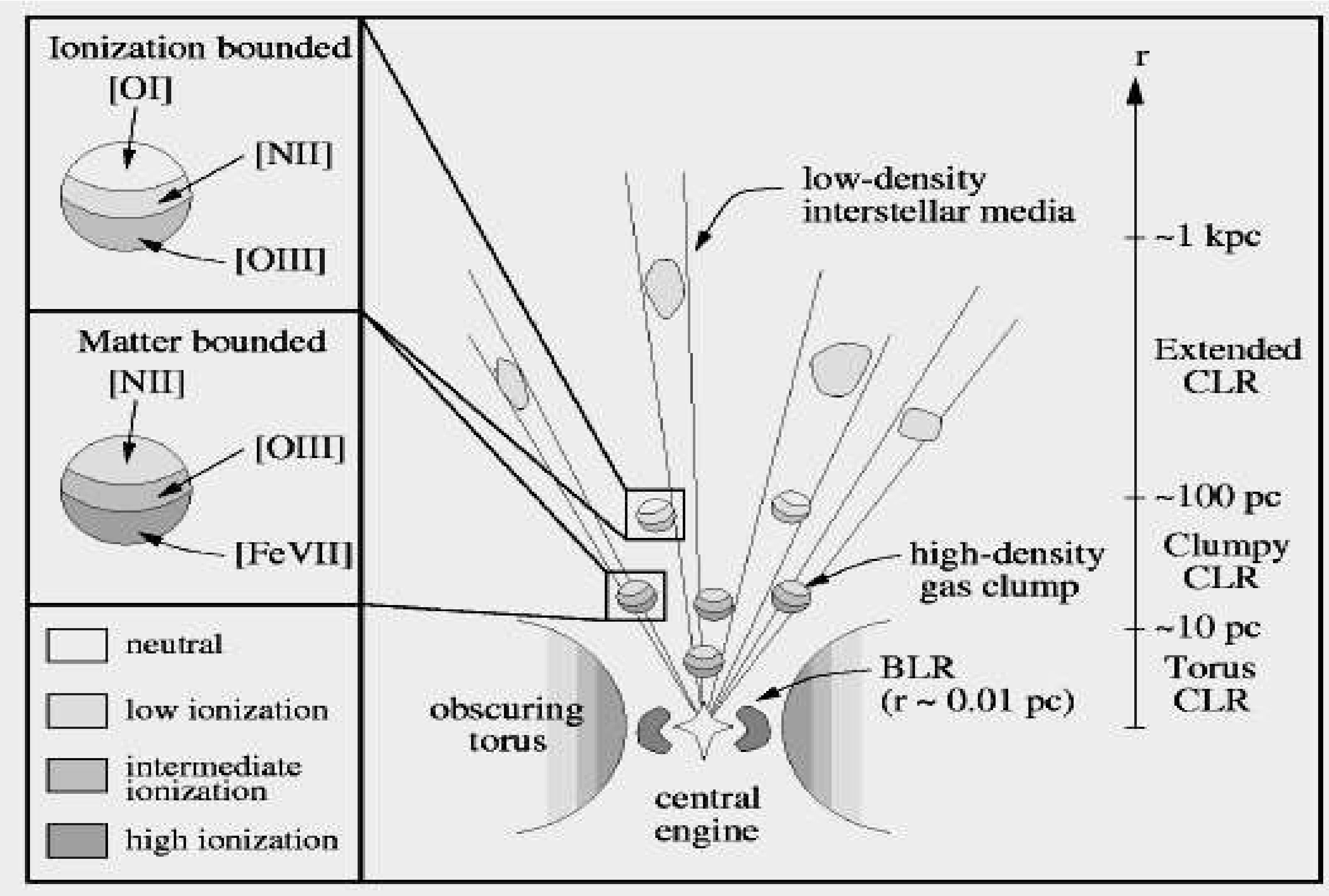


Fig. 4. Intensity contour plots in the position–velocity plane for selected optical lines. The ordinate gives the relative position (in arc–sec) along the slit which is at P.A.=160°, i.e. N is down. The velocity scales are in km/s and the vertical bars are at +465 km/s. Levels are normalized to 100, 75, 50, 25, 15, 5, and 1 percent of the highest contour, lowest levels are shown only when above the noise. Note that [O I] λ6364 and [Fe X] λ6374 have the same peak intensity and their different shapes cannot be attributed to s/n effects



Murayama and Taniguchi (1998)

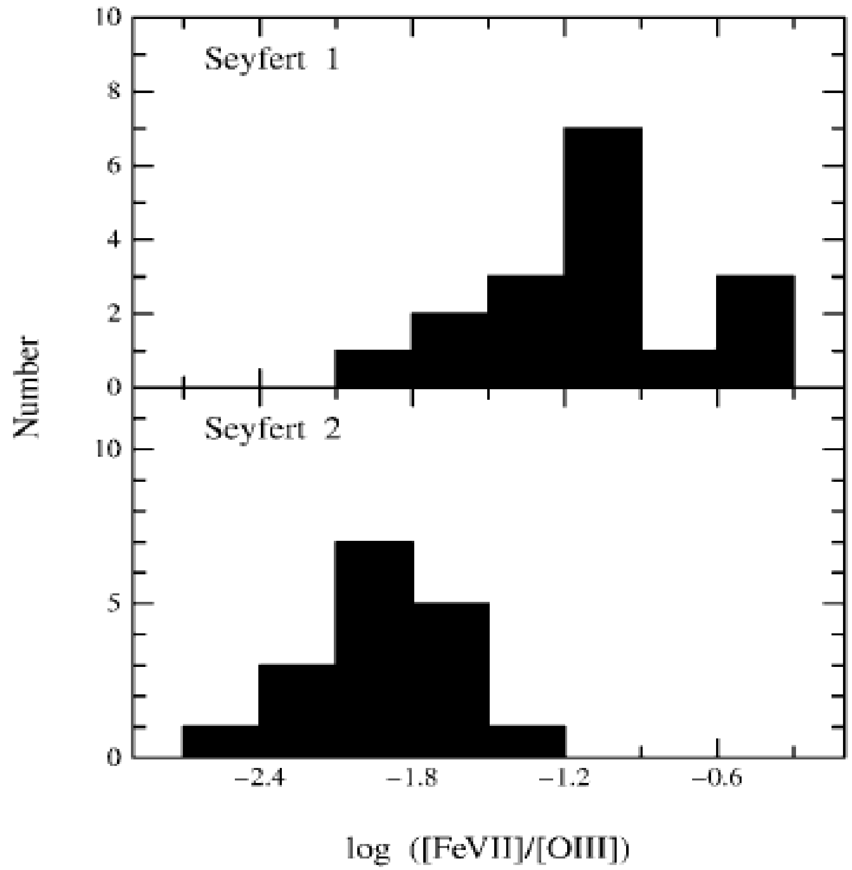


FIG. 1.—Frequency distributions of the [Fe VII] λ6087/[O III] λ5007 intensity ratio between the S1s and the S2s.

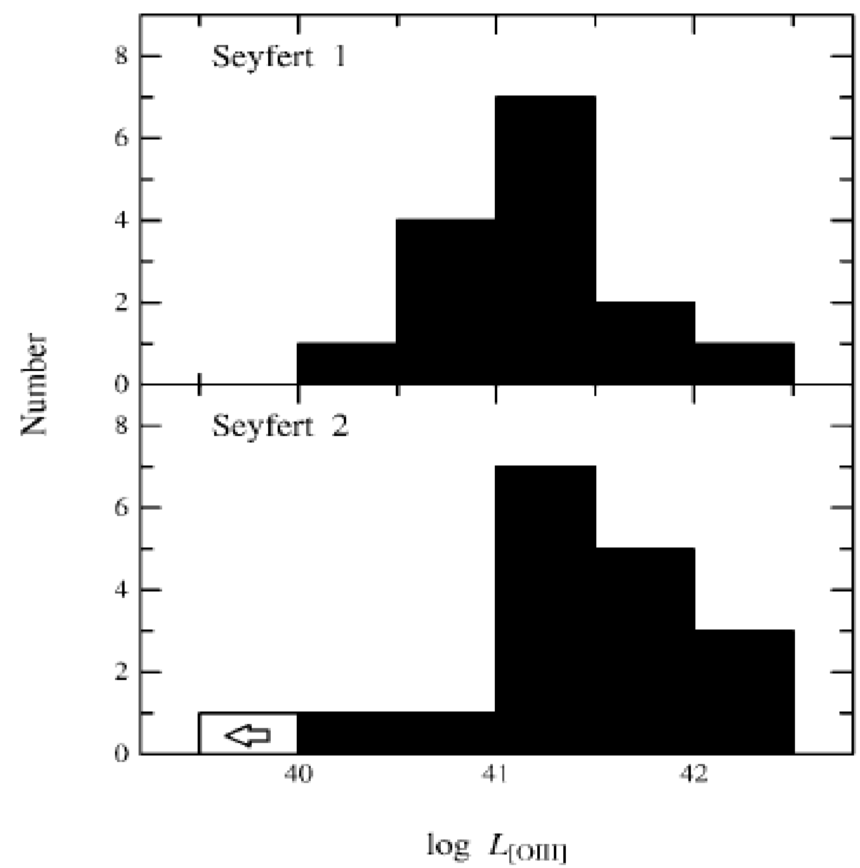


FIG. 2.—Frequency distributions of the [O III] λ5007 luminosity between the S1s and the S2s.

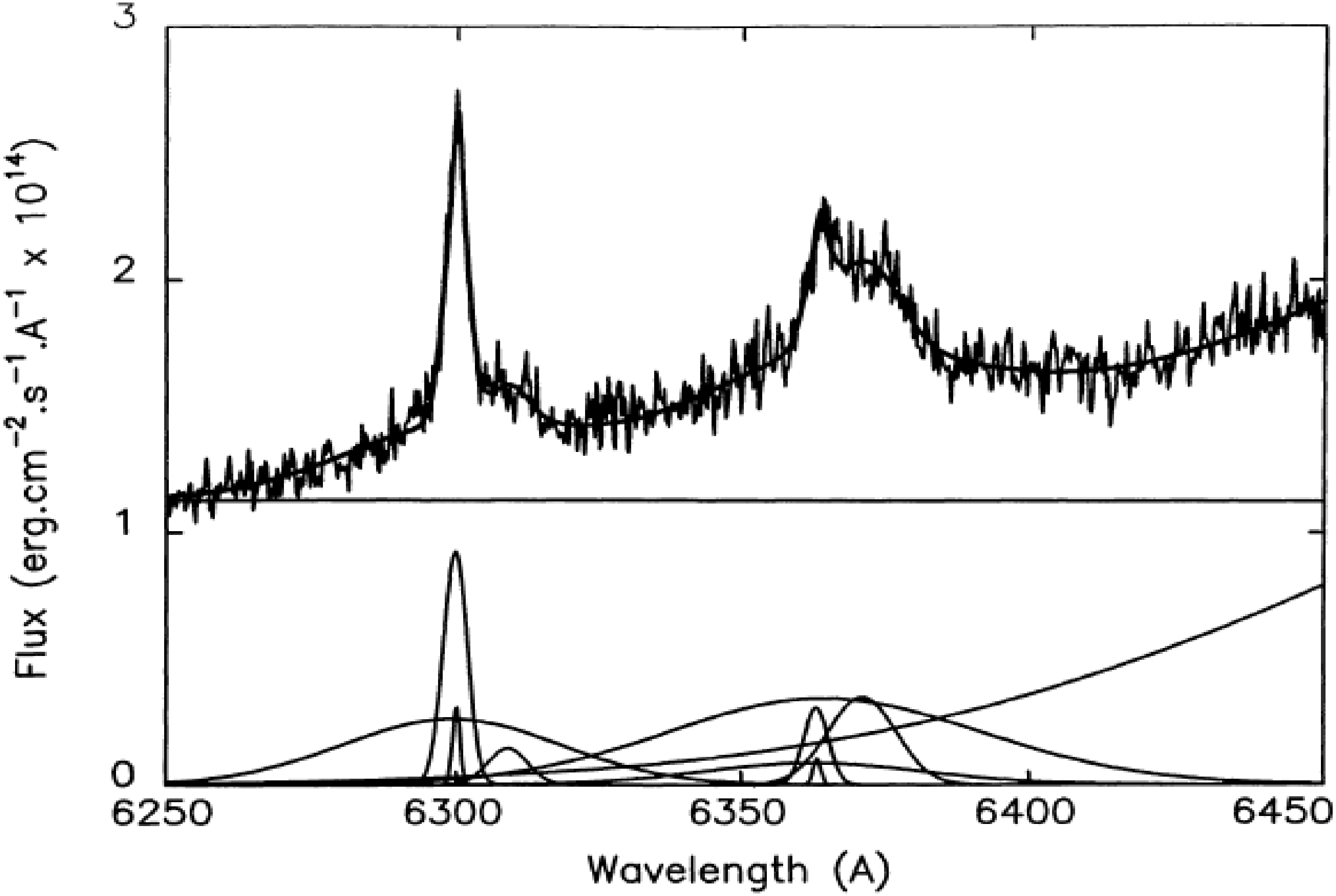


FIG. 3.—Same as Fig. 2, but for the wavelength range 6250–6450 Å, covering the [O I] λ6300–[Fe X] λ6374 spectral region

NGC 3783 (Sey.1) Evans et al. (1988)

NGC 3783 Evans et al. (1988)

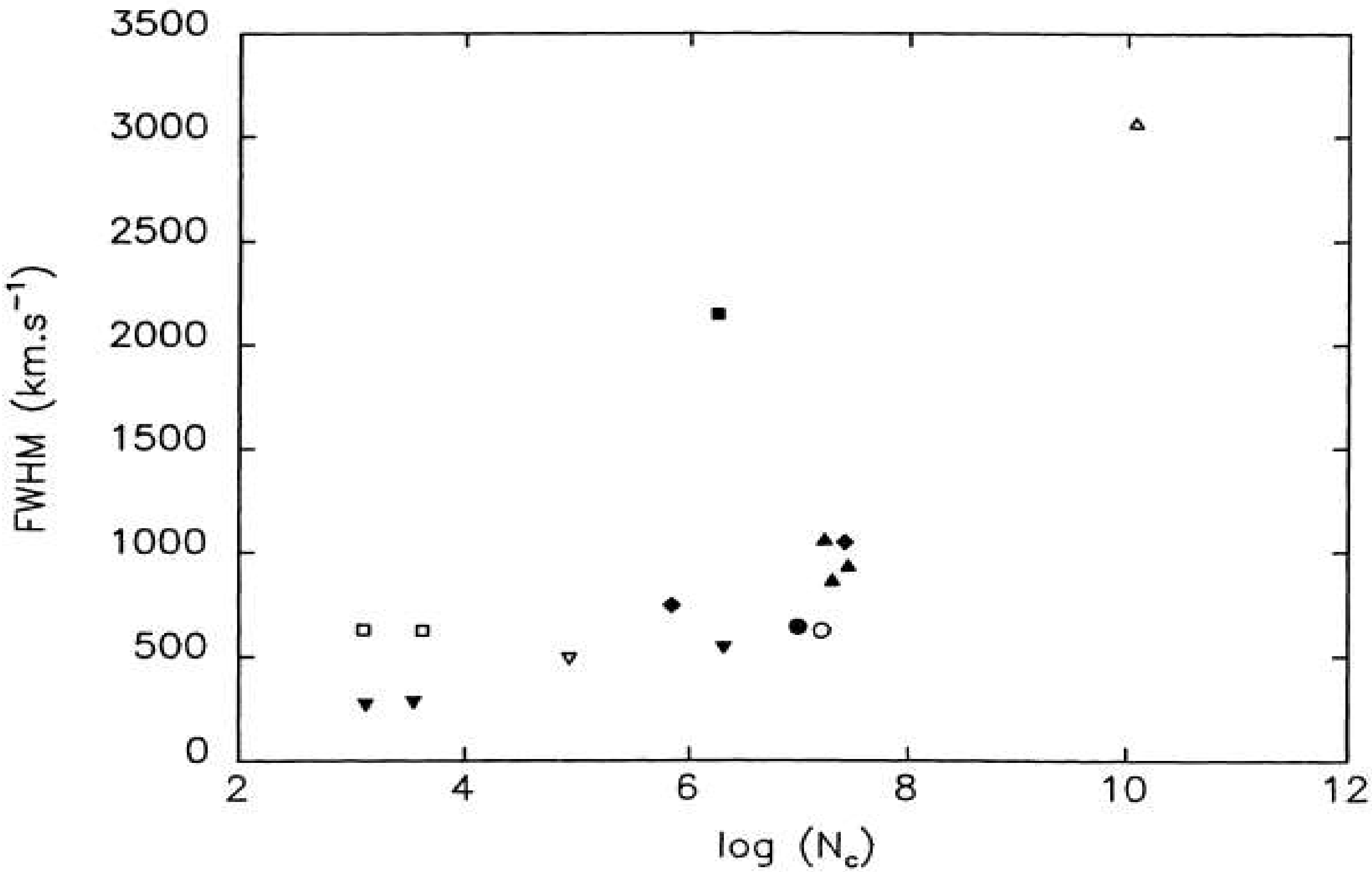
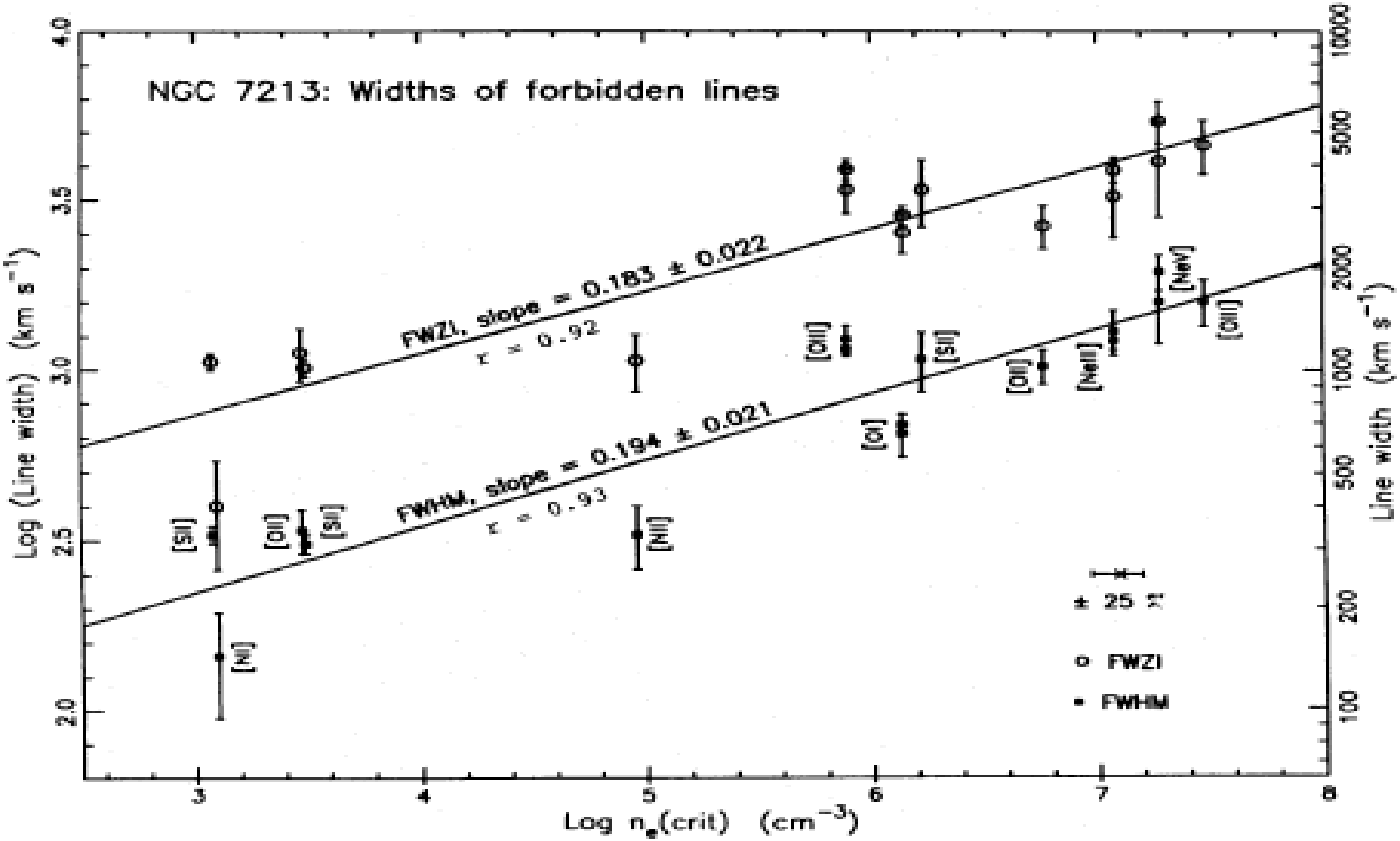
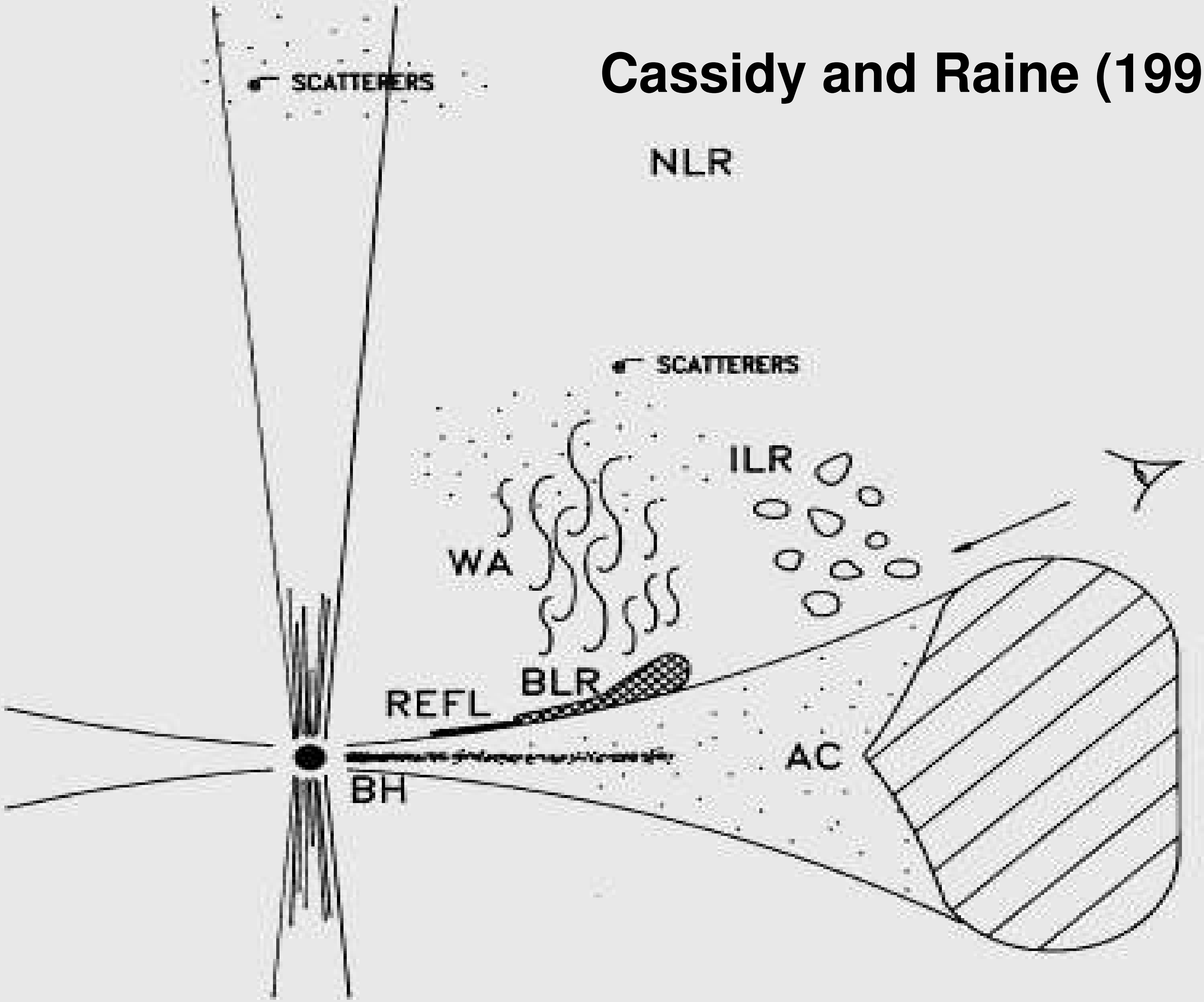


FIG. 7.—Relationship between the FWHM of the broadest line components and the critical density for collisional de-excitation of the upper state of the line transition. Symbols representing different ionization stages are as follows: Ne^{++} *filled circle*; Ne^{+4} *open circle*; O^0, *filled square*; O^+, *open squares*; O^{++}, *filled diamonds*; S^+, *filled inverted triangles*; N^+, *open inverted triangle*; Fe^{+6}, *filled triangles*; Fe^{+9}, *open triangle*.

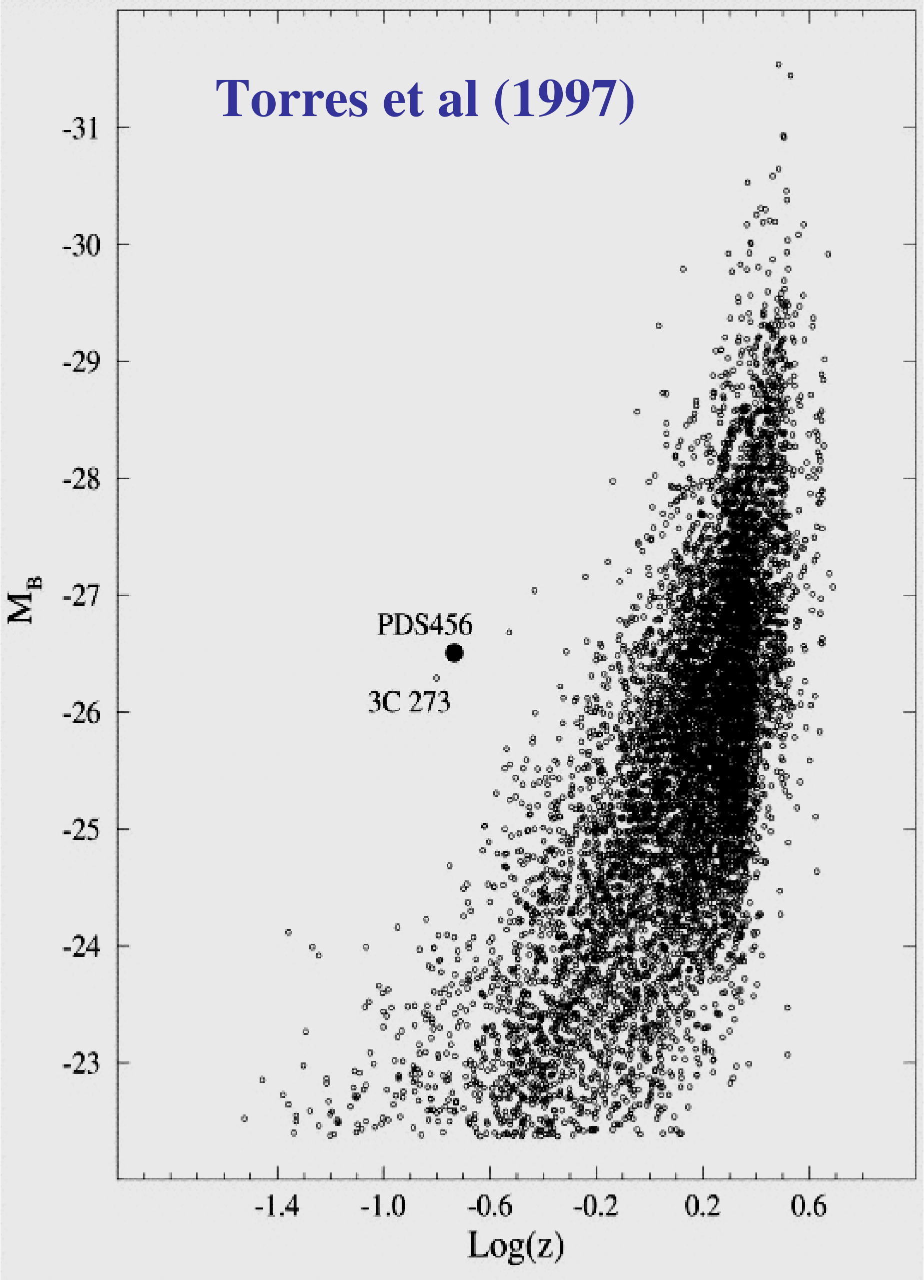


NGC 7213: Widths of forbidden lines
FWZI, slope = 0.183 ± 0.022
r = 0.92
FWHM, slope = 0.194 ± 0.021
r = 0.93
Log (Line width) (km s^{-1})
Line width (km s^{-1})
Log n_e(crit) (cm^{-3})
[SII]
[NI]
[OII]
[SII]
[NII]
[OIII]
[OI]
[SII]
[OII]
[NeII]
[NeV]
[OIII]
± 25 %
FWZI
FWHM

Cassidy and Raine (1997)

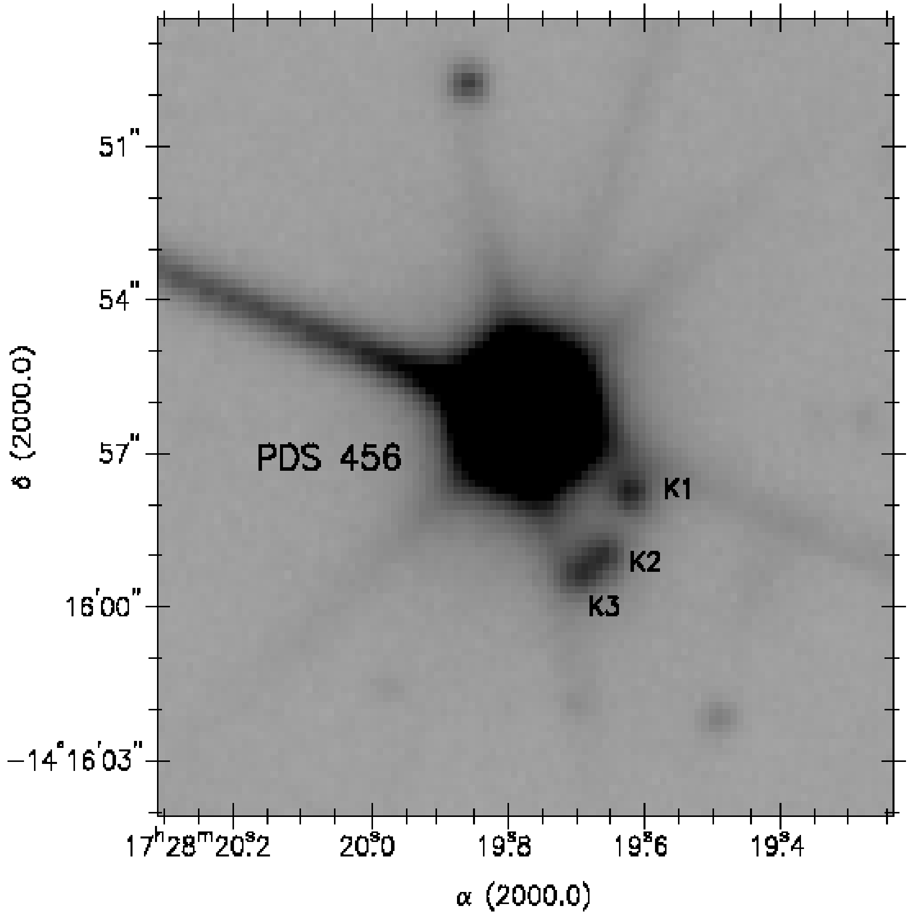


PDS456: the radio quiet analogue of 3C273



K-band image of PDS 456

(Yun et al. 2004)



At z=0.184, 1'' = 3.1 kpc

PDS456: The Most Luminous Nearby Quasar

- $L_{BOL} = 10^{47}$ erg s^{-1} , z= 0.184
- PDS 456 is radio-quiet, so no jet contamination (cf. 3C 273)

SUMMARY OF X-RAY DATA

- RXTE/ASCA/XMM-Newton observations reveal ionised absorber (see papers by Reeves et al…)

➢ Derive $\xi \sim 10^3$ and $N_H \sim 10^{24}$ cm^{-2} outflowing at ~ 0.15c

➢ If hard X-rays driving outflow, mass-loss rate ~ 10 M yr^{-1}

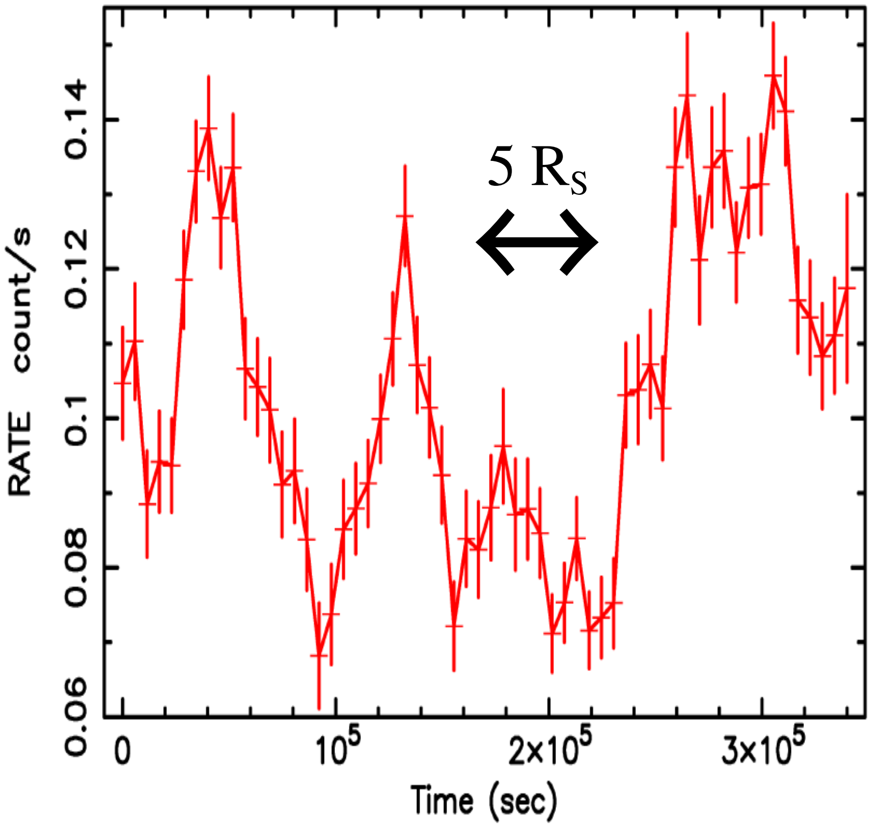
➢ If 10% covering factor, outflow K.E. ~ 10^{46} erg s^{-1} (10% L_{bol})

➢ Highly variable in X-rays

➢ Properties consistent with high accretion-rate object

Highly variable X-rays from PDS 456

Beppo-SAX MECS: 2-10 keV



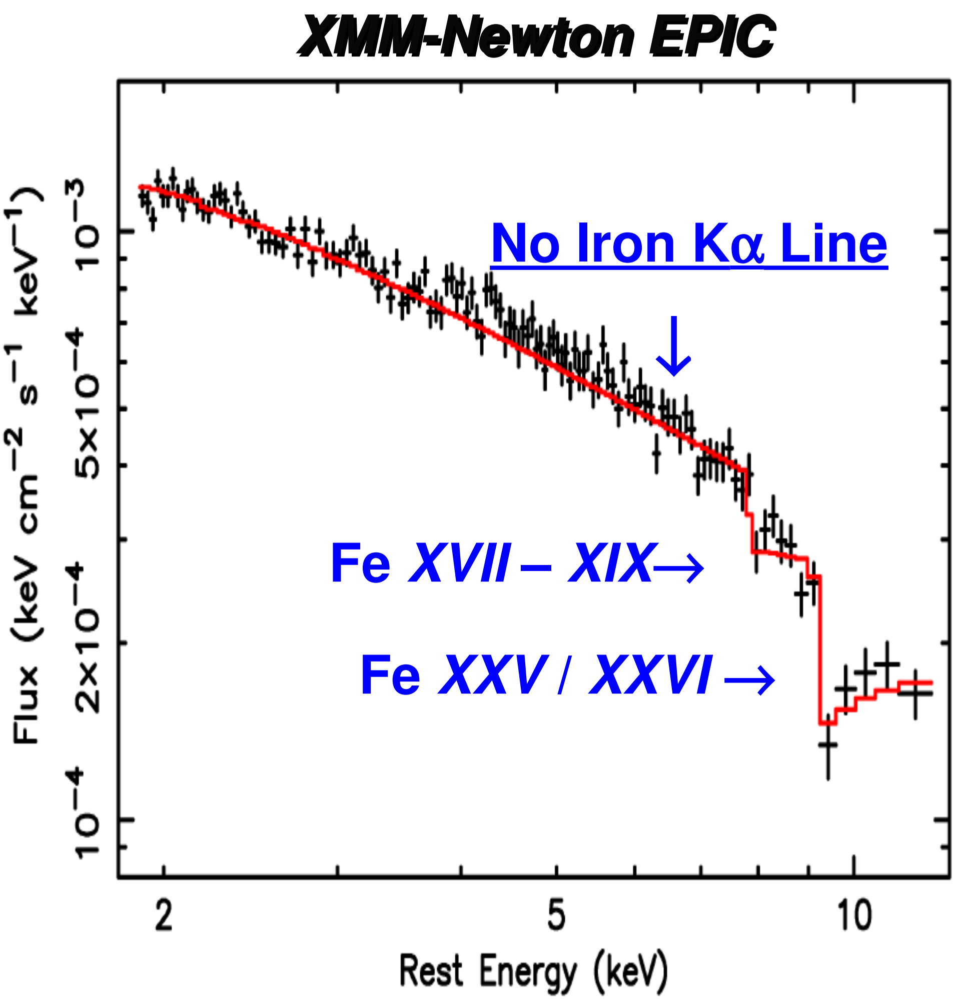
Observed properties

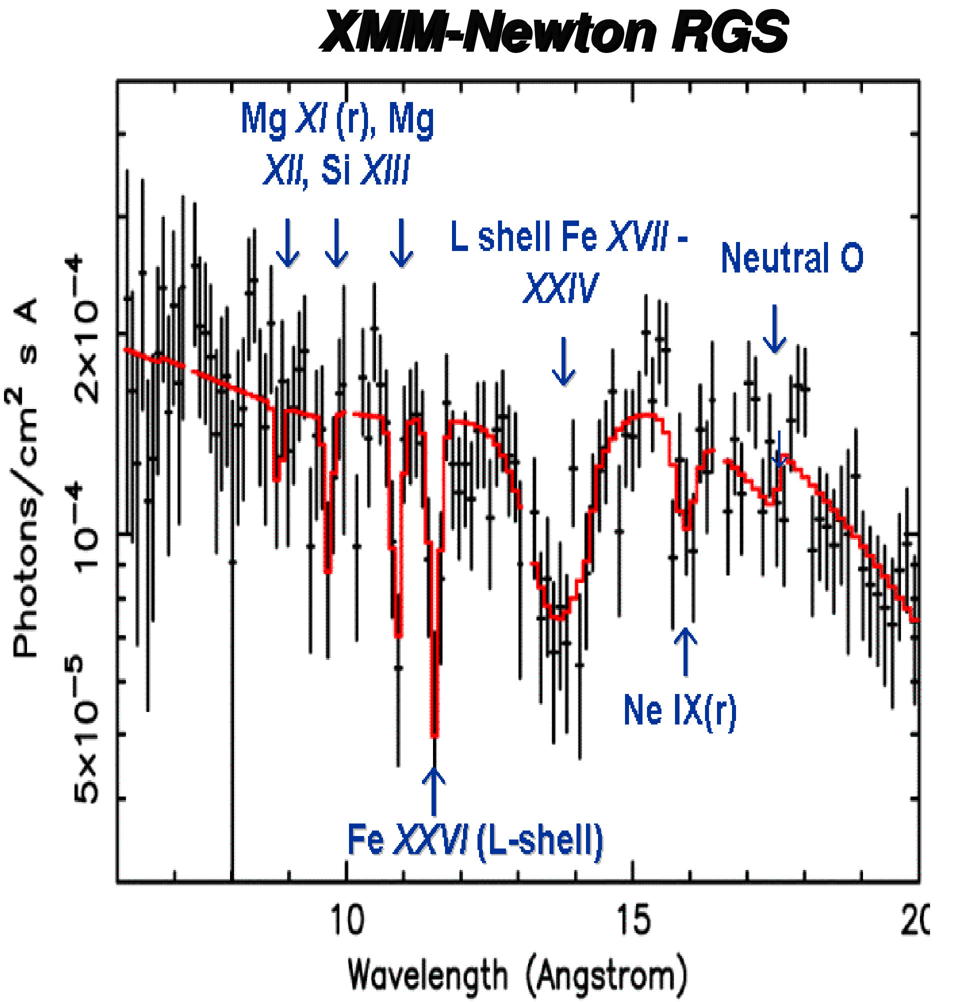
- Large flares ~ $10^{50} - 10^{51}$ erg d^{-1}
- MECS flux **×2** increase **in 30 ksec**
- Implies **size < 3R$_S$** (for ~ 10^9 M)

Magnetic reconnection in corona

- Driven by K.E. of inner disc
- Enhanced by high accretion-rate and mass
- Radial flux tubes shear in the inner disc which then reconnect releasing energy

X-ray Absorption in PDS 456





The Highly Ionised Absorber in PDS 456

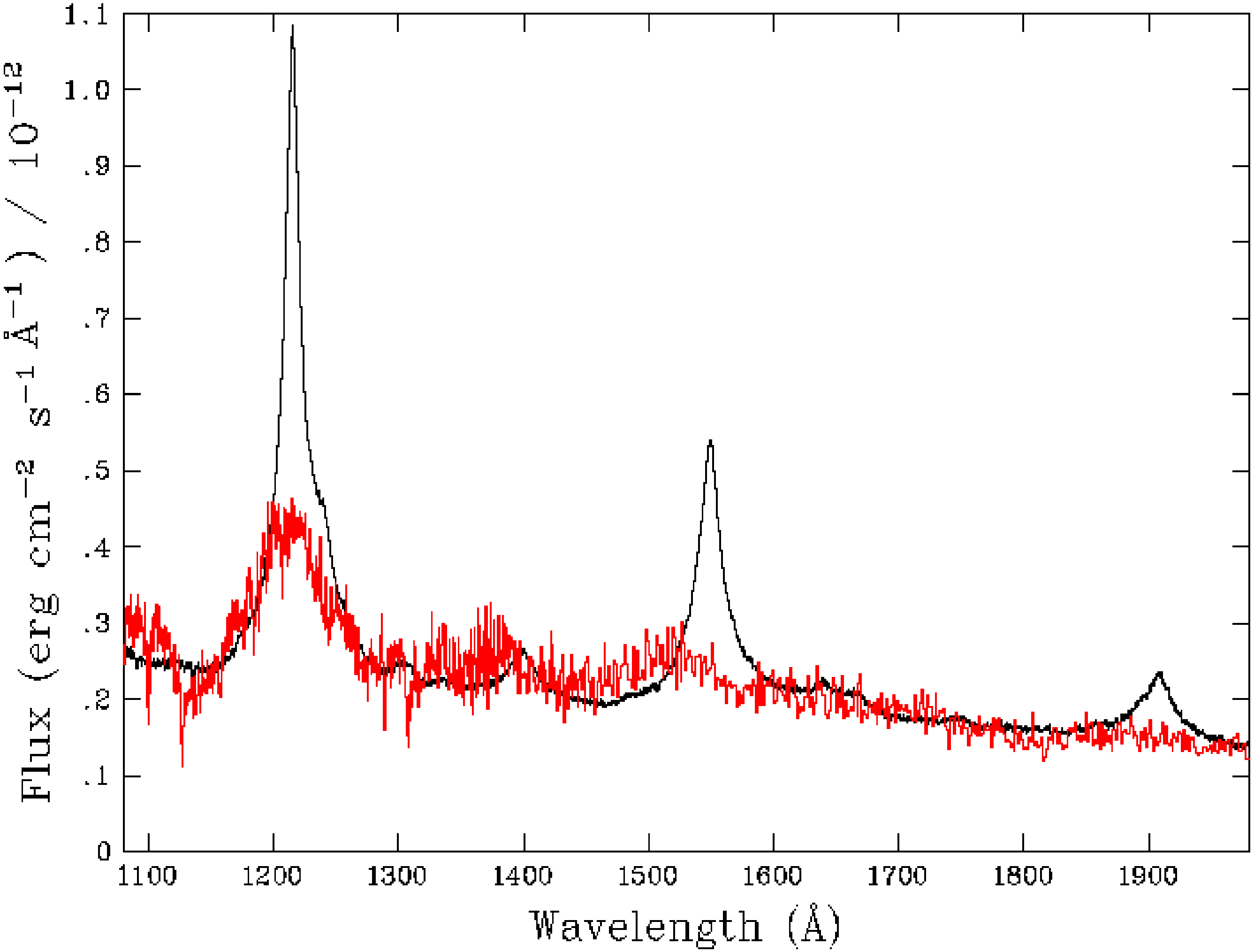
- The XMM RGS detects ***broad absorption lines*** from high ionisation species; K-shell: **Ne *IX*, Mg*XI*, Mg*XII***, L-shell **Fe *XVII-XXIV*** (velocity width Δv ~ 5000 km s^{-1})

- Deep K shell absorption edges from both **K *<u>and</u>* L-shell like Fe** ions in XMM EPIC spectrum - 2 zone warm absorber

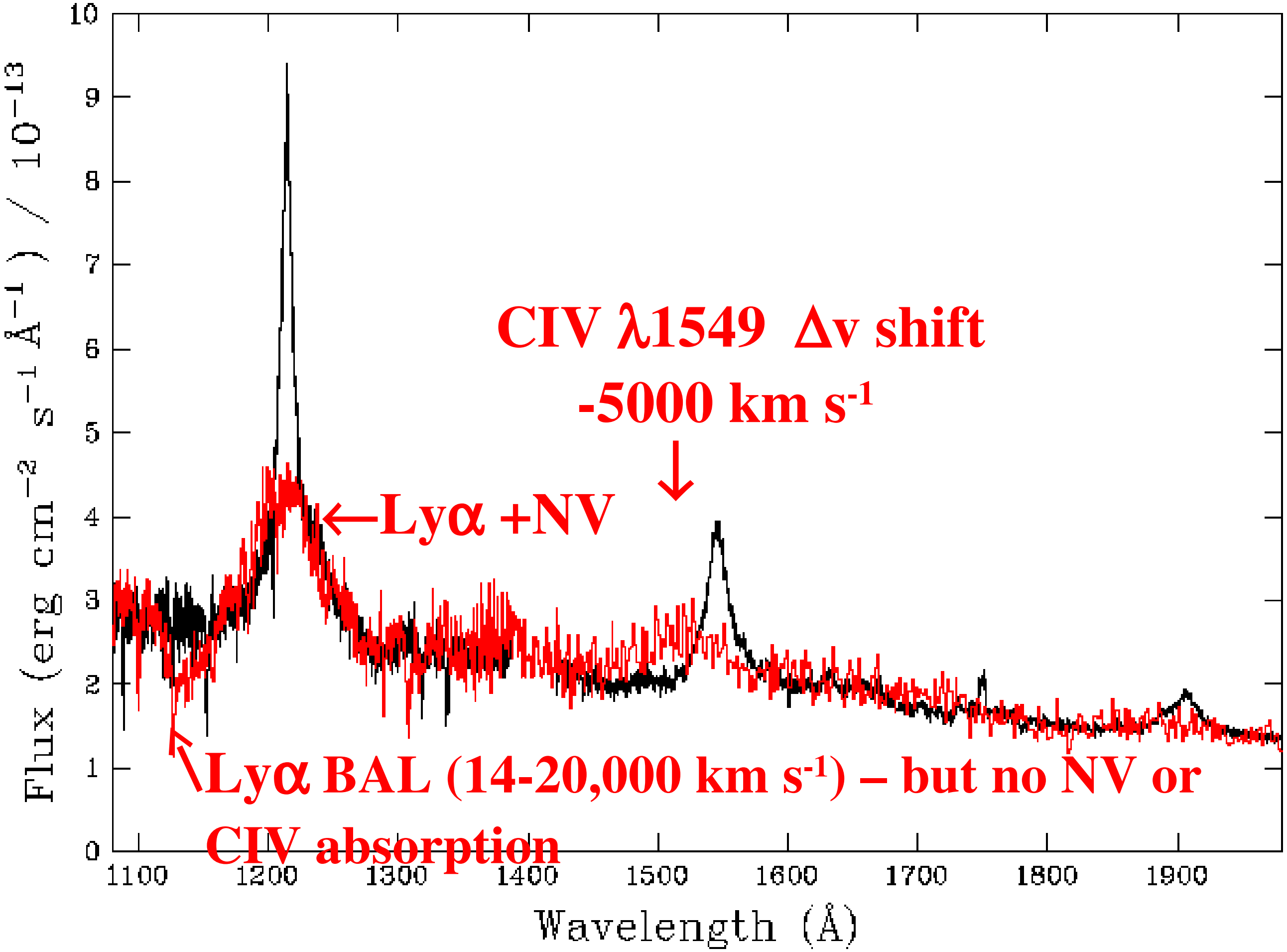
- Extreme high ionisation component has N_H ~ $\mathbf{10^{24}\ cm^{-2}}$ and ionisation **logU=3.5**

- No K shell Fe *emission* - **low covering fraction** (<5%)

HST Ultraviolet Spectra of PDS 456 & Mean FOS QSO (from Zeng et al. 1997)

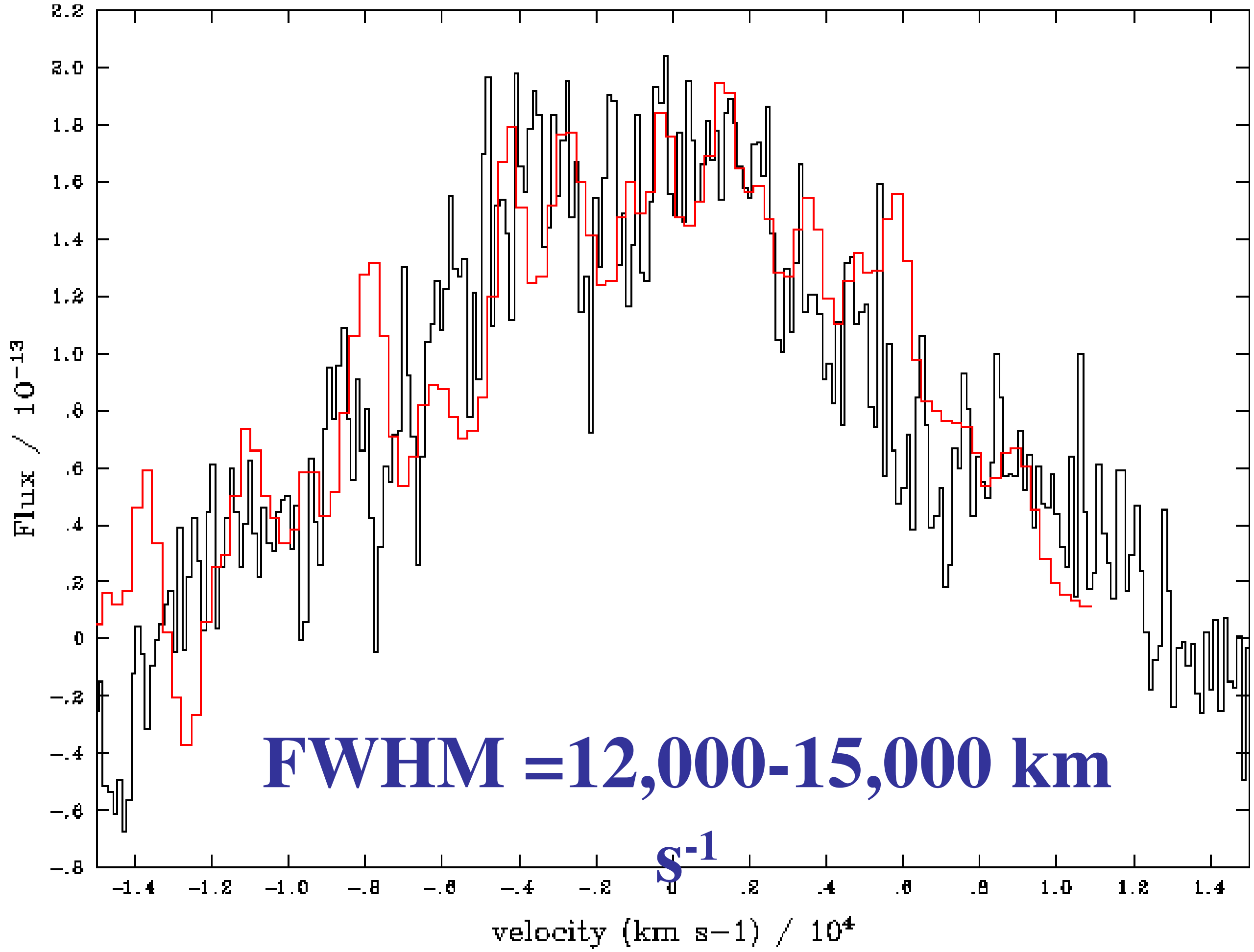


Ultraviolet Properties of PDS 456

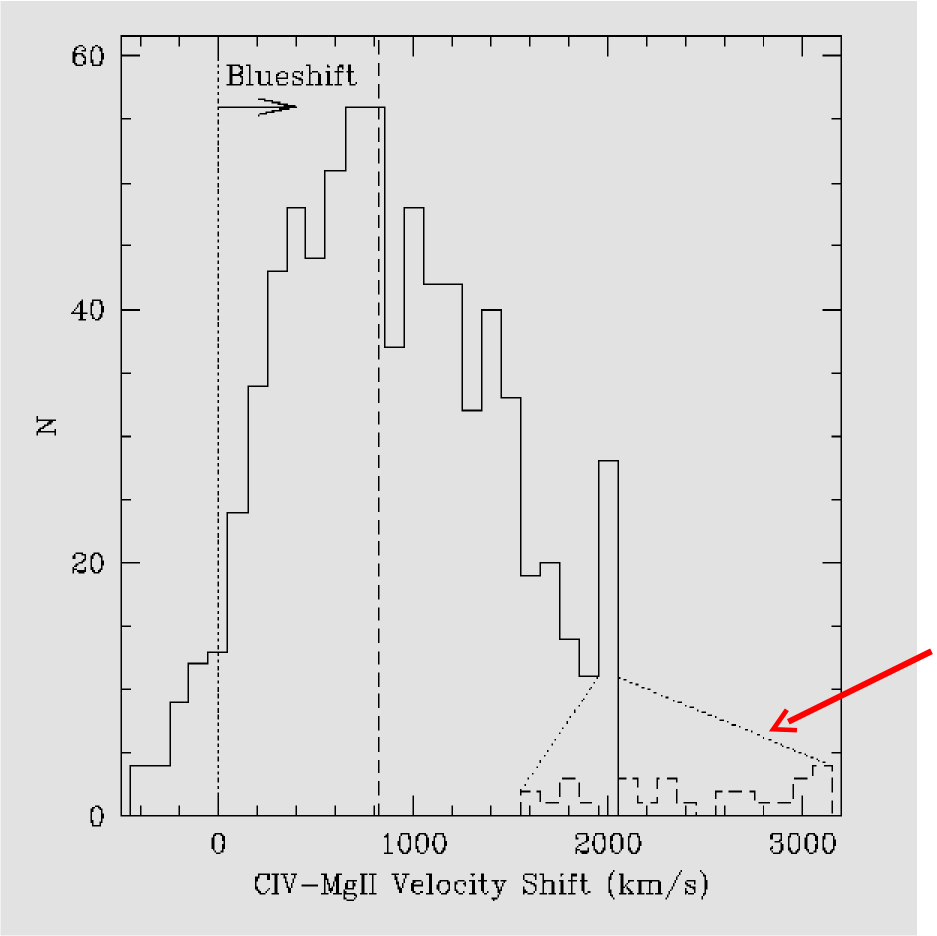


HST Spectra of PDS 456 & 3C273, O'Brien et al. (2004)

Comparison of Lyα & CIV profiles in PDS 456



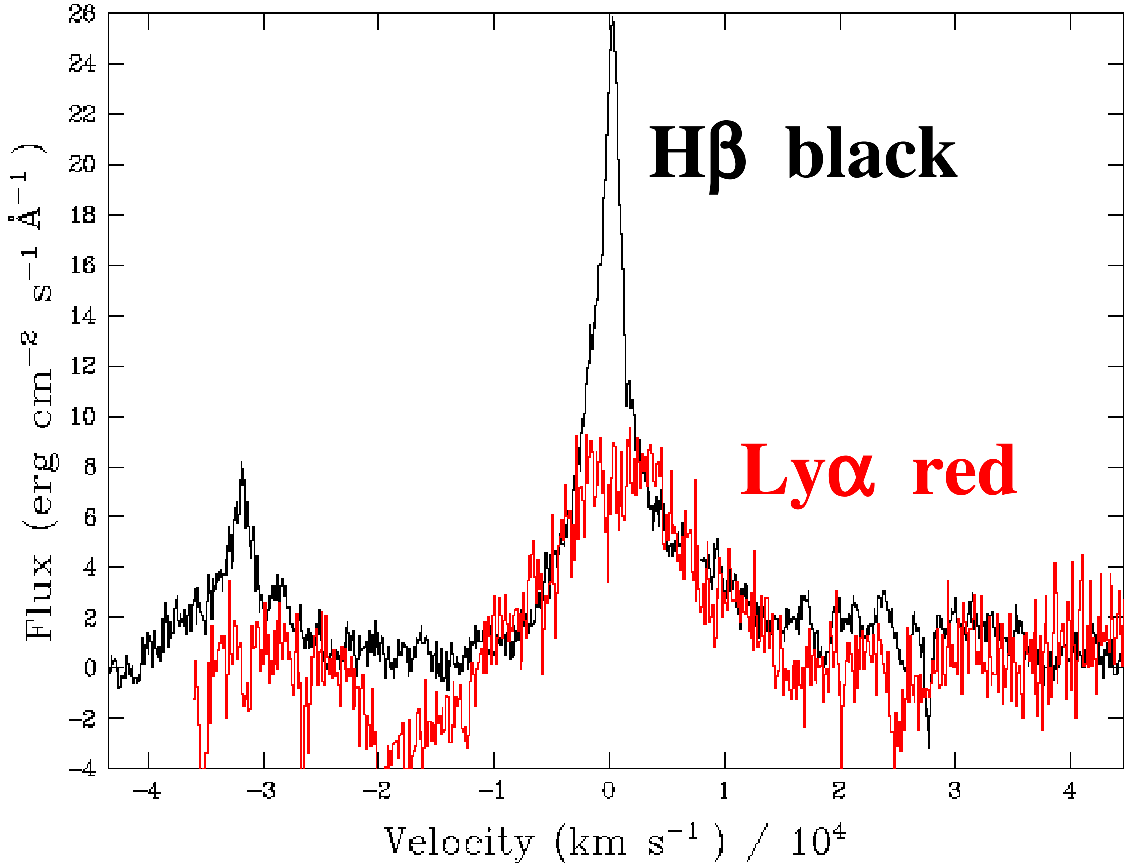
CIV velocity shifts in Sloan quasars (Richards et al. 2002)



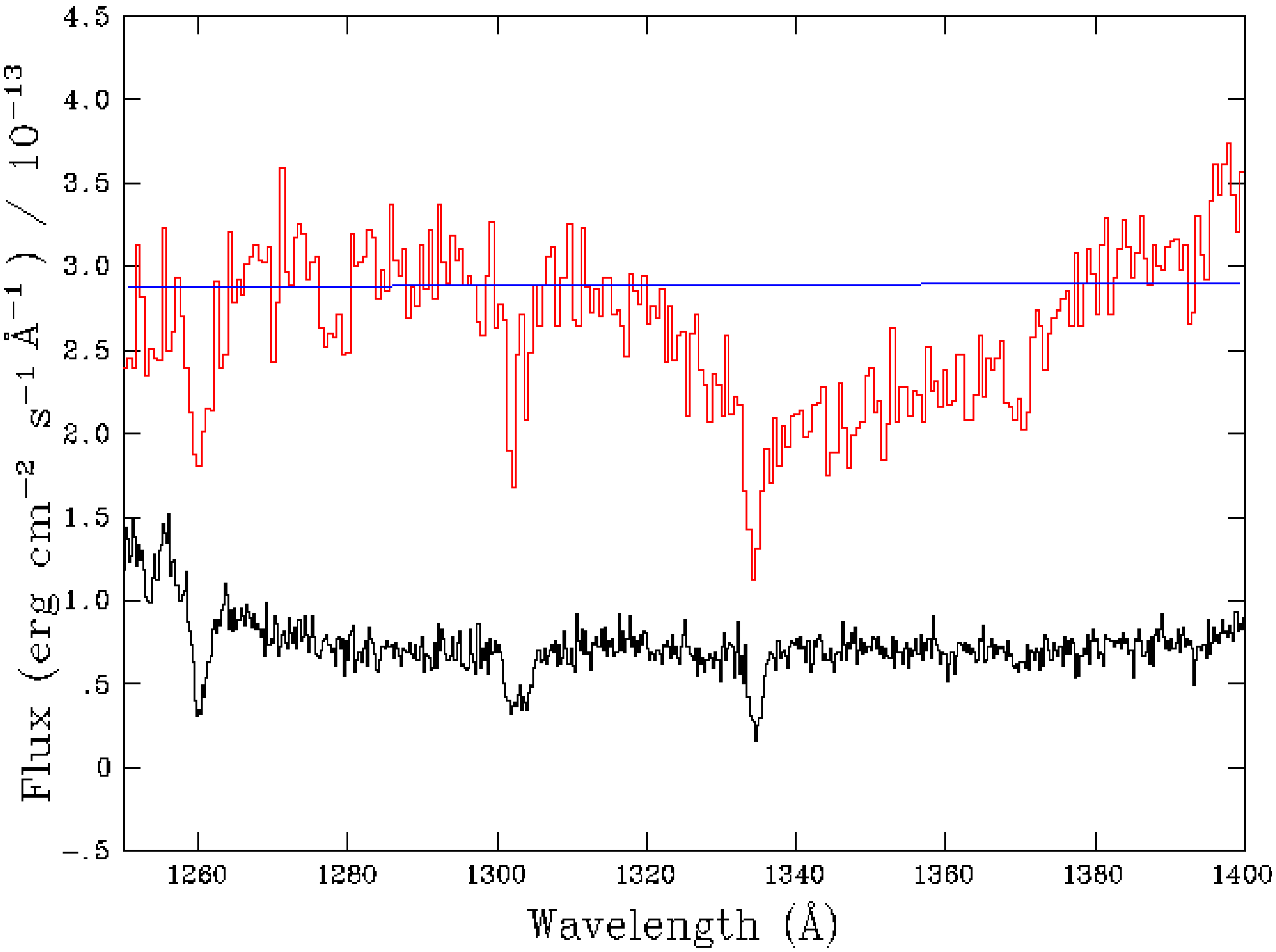
Dashed ones are recomputed by hand

Blue shift for CIV in PDS456 is 4,000-5,000 km/s

Comparison of Hβ and Lyα profiles in PDS 456

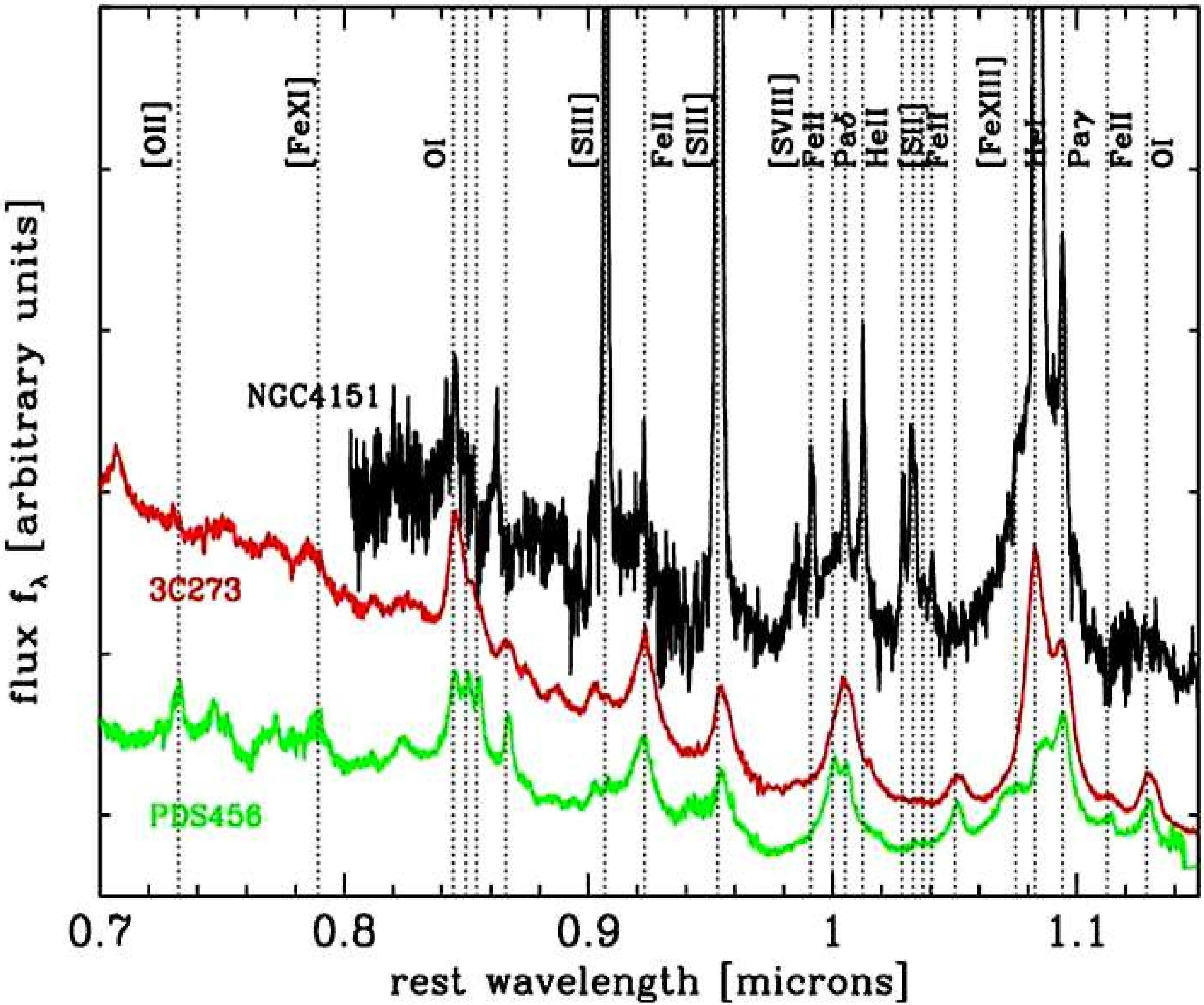


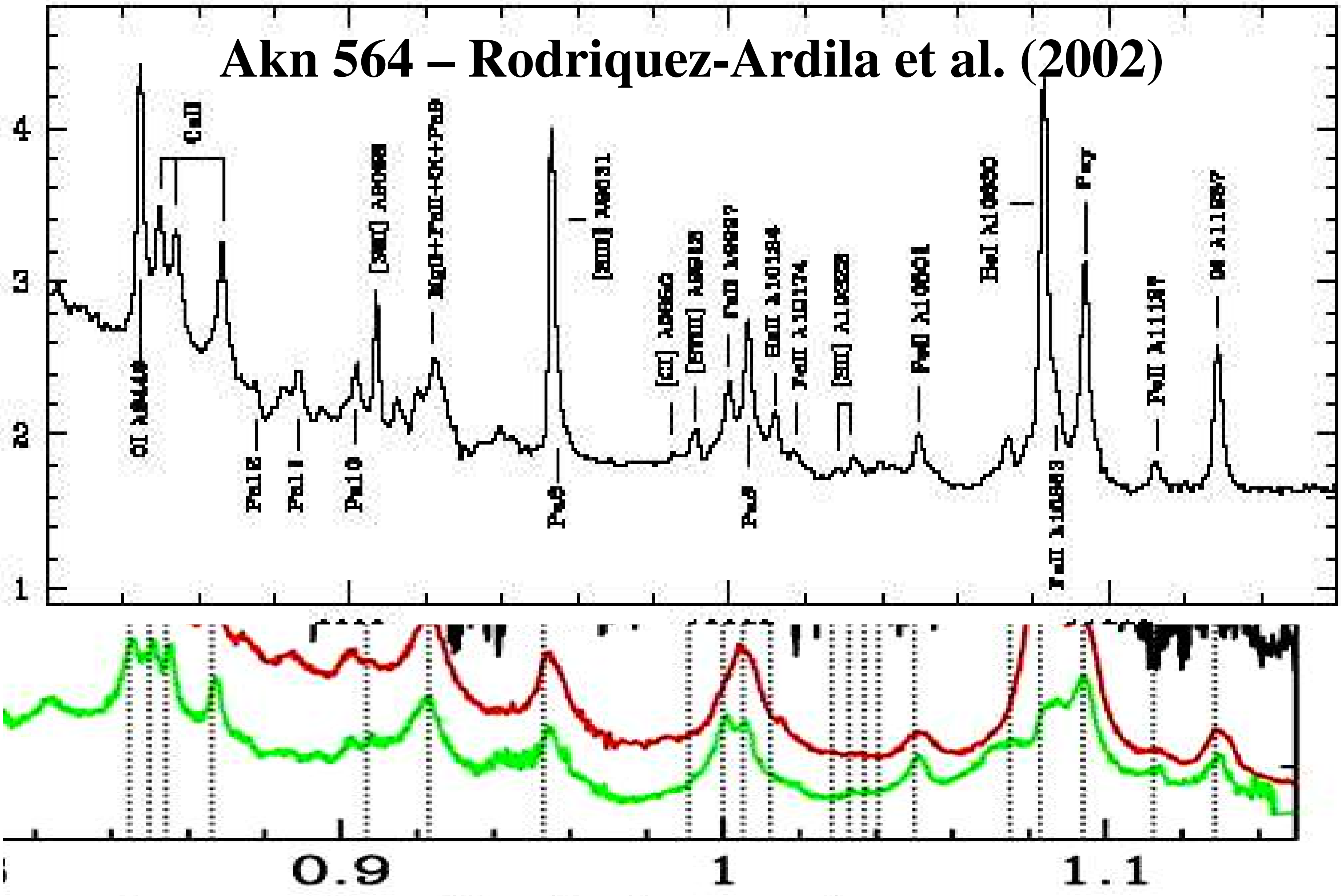
HST Ultraviolet Spectra of PDS 456 & NGC 3783



Showing narrow gal. absorption & broad intrinsic absorption which, if associated with Lyα, has vel. shift 14,000 – 20,000 km/s

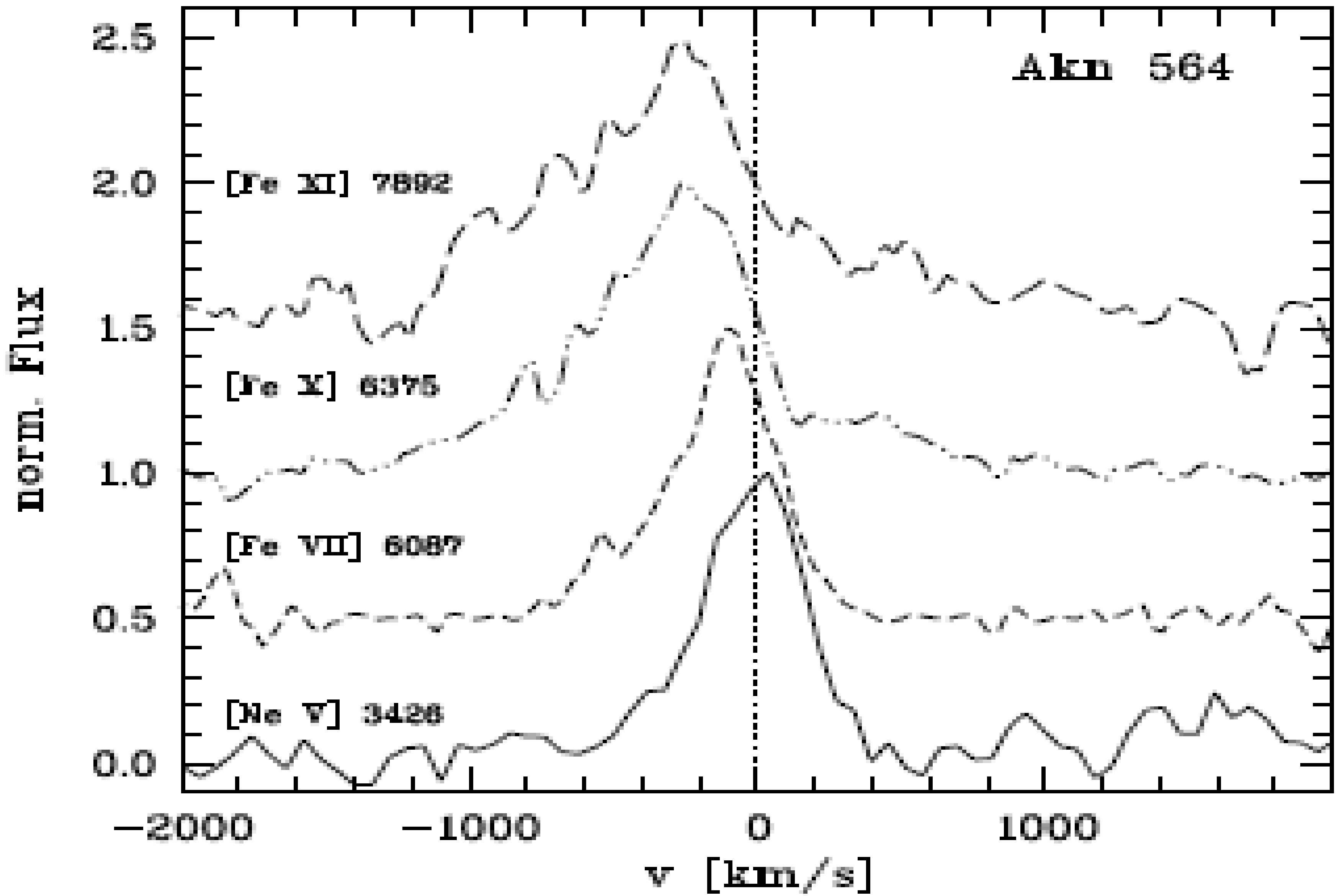
Near IR Spec. of PDS456 + comp. with 3C273 & NGC4151



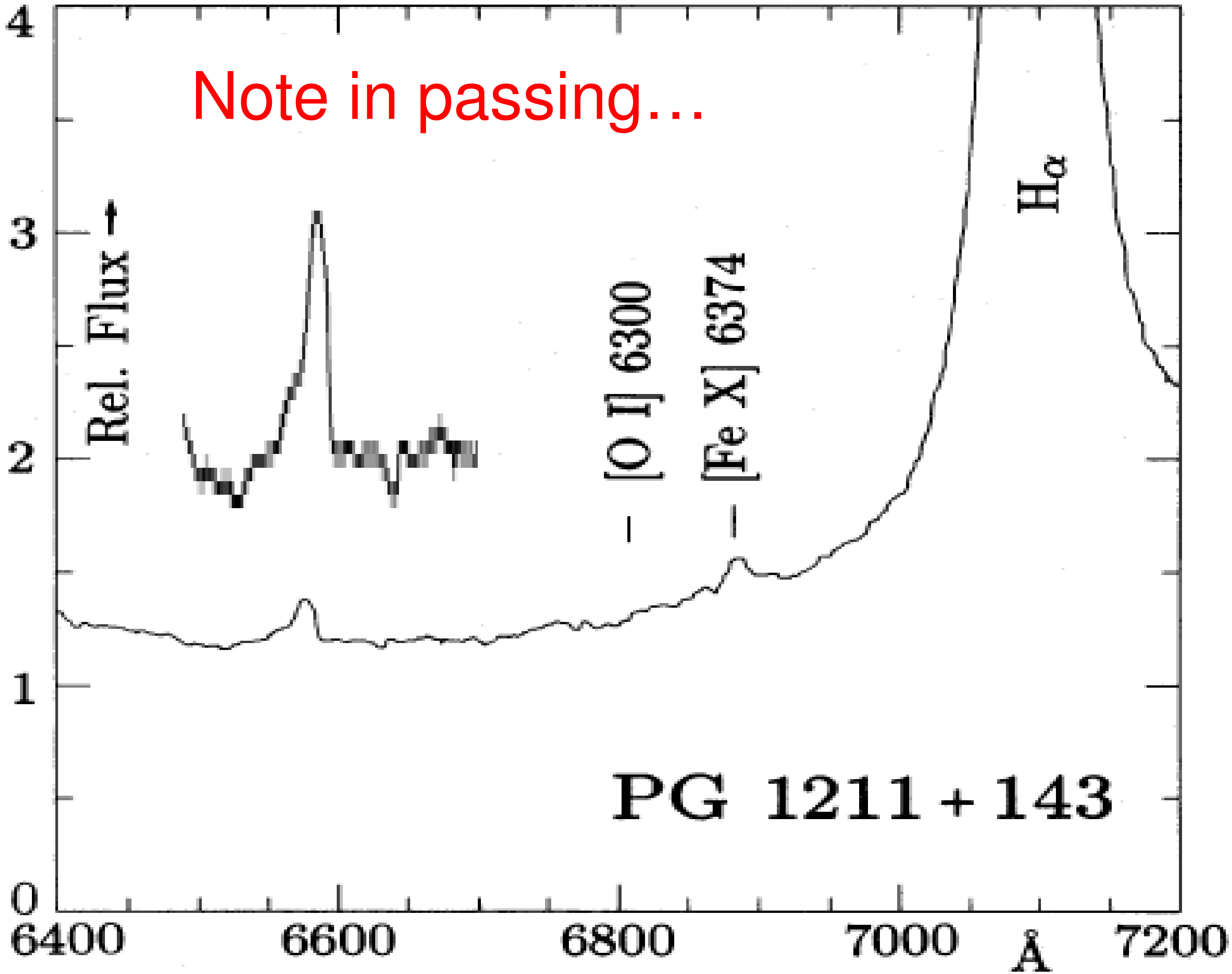


Akn 564 – Rodriquez-Ardila et al. (2002)
0.9
1
1.1

Akn 564: No evidence for WA or X-ray wind ? gg



Note in passing…



Appenzeller and Wagner (1991)

The Infrared Spectrum of PDS 456

- Strong calcium triplet in emission
- Weak OI 8446A w.r.t calcium triplet emission
- He I 10830A weak w.r.t Hydrogen Paschen lines
- Very strong [FeXIII] and [FeXI]

Conclusions

- CL's may be related spatially to the WA
- If so they can be used as a "proxy" (easier) measurement of its properties
- Even if the CL's are not closely related to the WA, they certainly contain information about outflows and the SED of AGN in the UV/soft X-ray region
- Now is a good time to revitalise the study of CLs – (near IR studies, hi-res. spectra, and monitoring with robotic telescopes)