The Case for Two Quasar **Populations**

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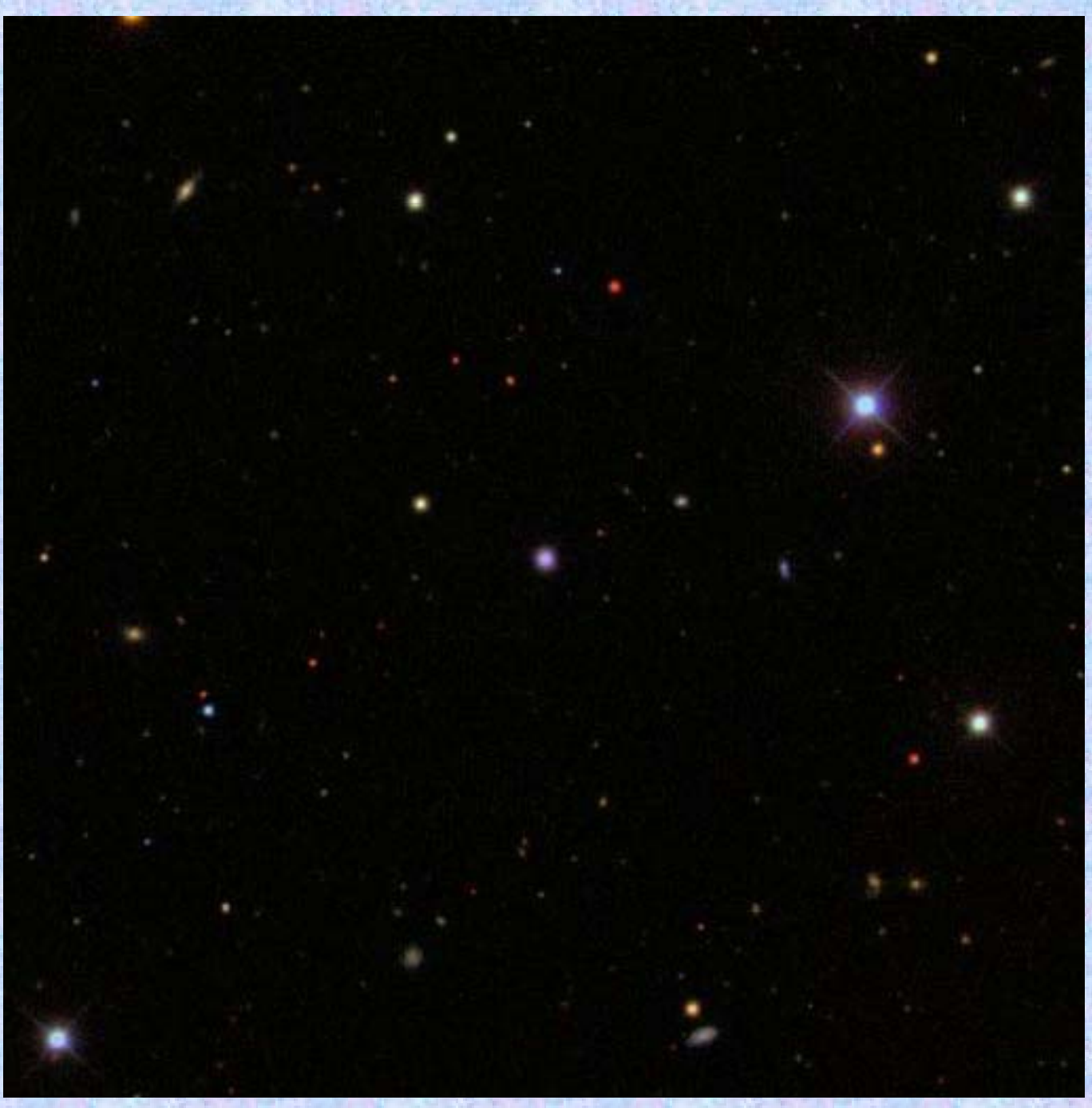
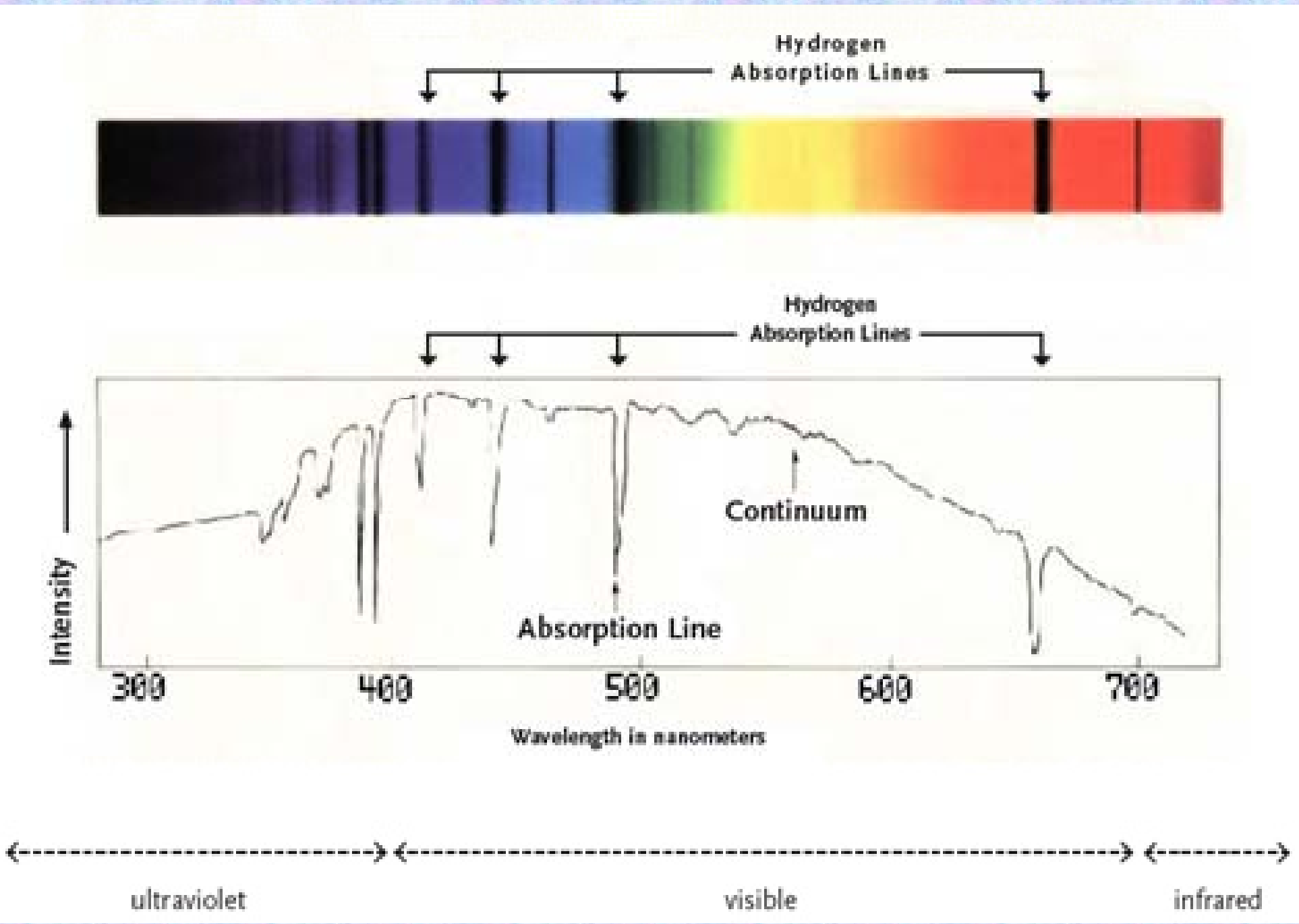
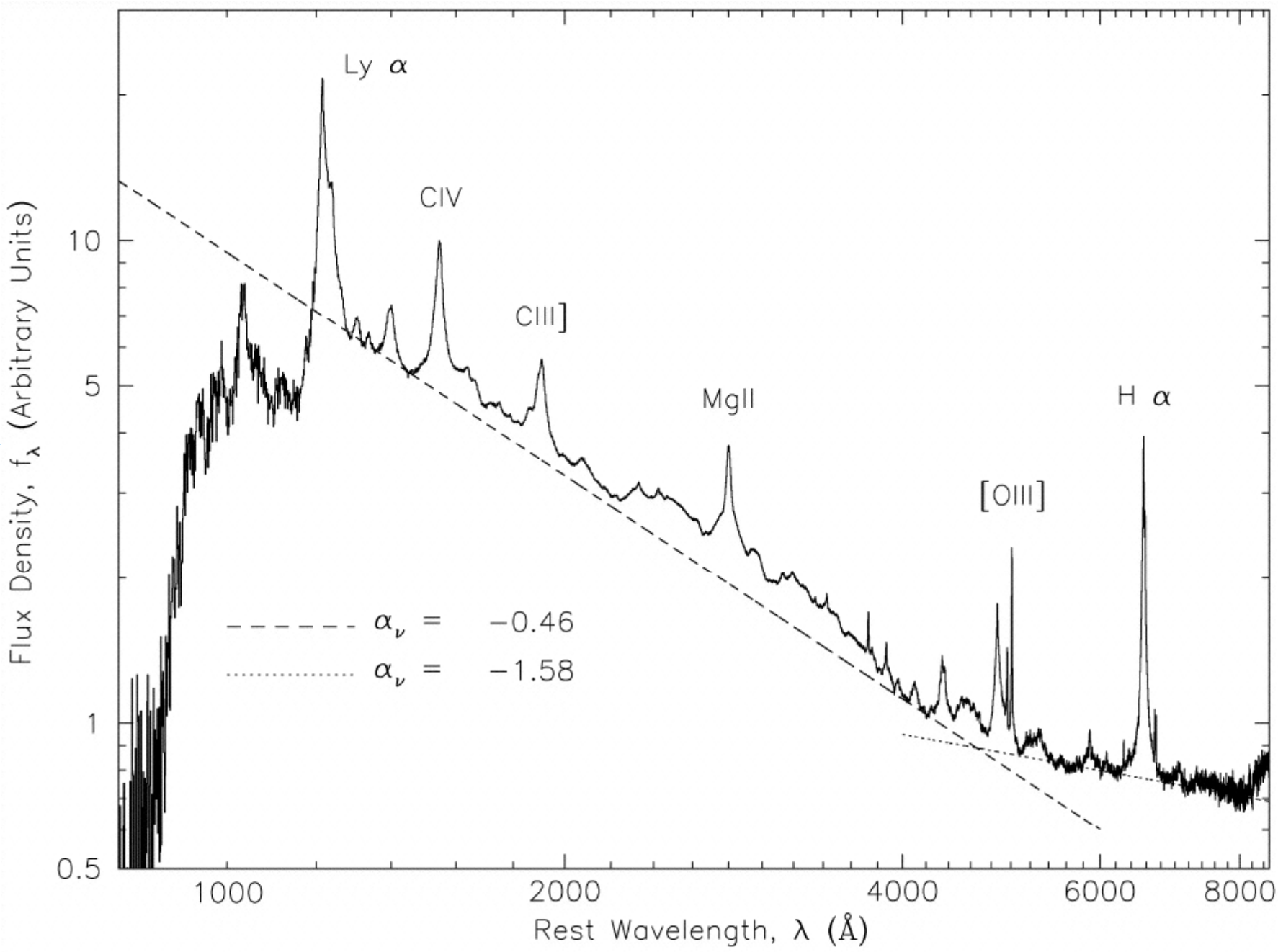



Hydrogen
Absorption Lines
Hydrogen
Absorption Lines
Intensity
Continuum
Absorption Line
300
400
500
600
700
Wavelength in nanometers
ultraviolet
visible
infrared

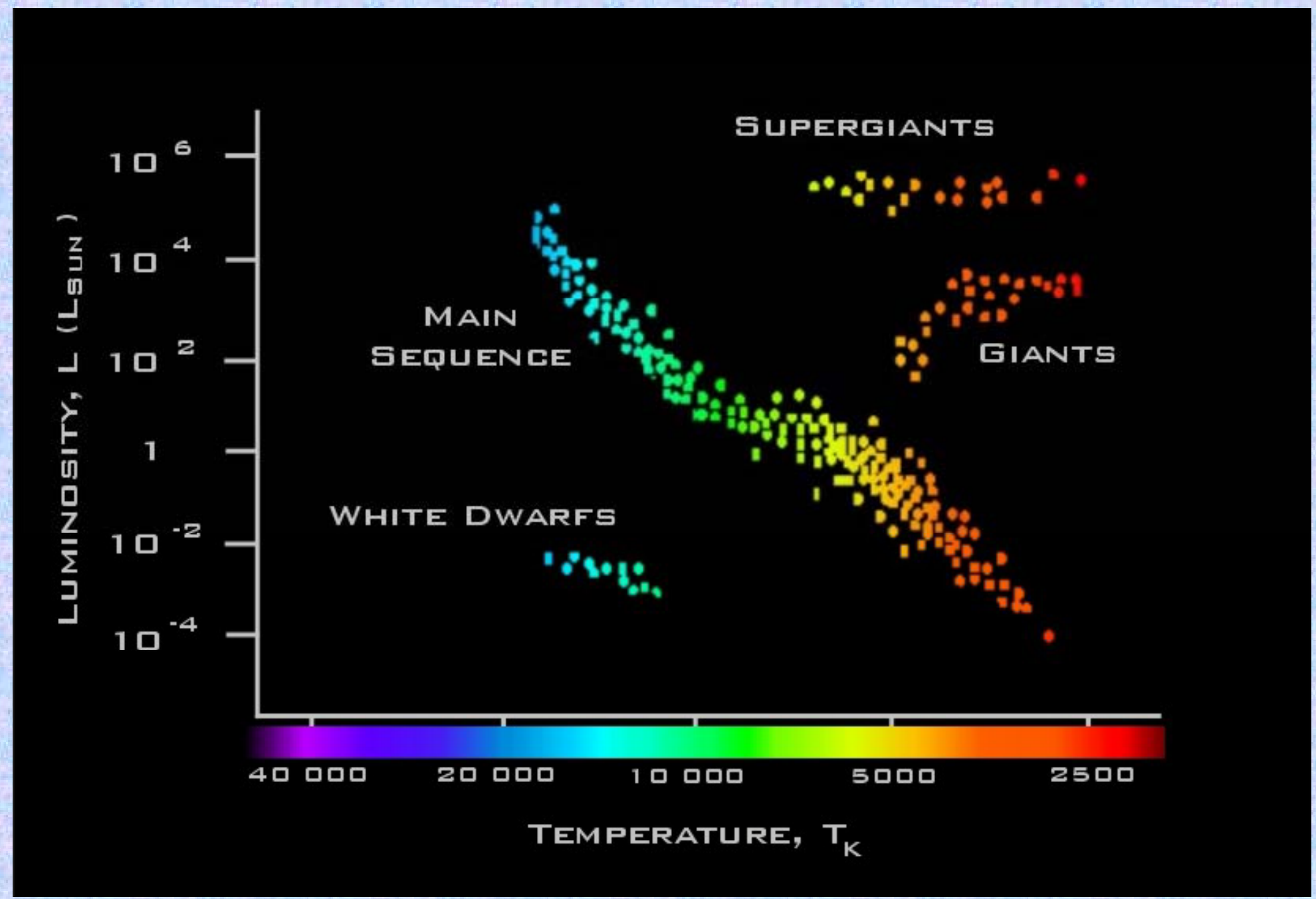


median

Vanden Berk, D. E. et al. – 2001, AJ, 122, 549

A SURROGATE H-R DIAGRAM FOR QUASARS

- A CONTEXT THAT UNIFIES SPECTROSCOPIC DIVERSITY
- MULTI-WAVELENGTH
- MULTI-DIMENSIONAL
- TO REMOVE DEGENERACY BETWEEN PHYSICS AND ORIENTATION


SUPERGIANTS
MAIN SEQUENCE
GIANTS
WHITE DWARFS
LUMINOSITY, L (LSUN)
10 6
10 4
10 2
1
10 -2
10 -4
40 000
20 000
10 000
5000
2500
TEMPERATURE, TK

4D EIGENVECTOR 1 PARAMETER SPACE

FWHM H_β

velocity dispersion of LIL

EW (FeII Optical) / EW (Broad H_β) (R_{FeII})

ratio of LIL with opposite density dependences

Soft X-ray Photon Index (Γ_{soft})

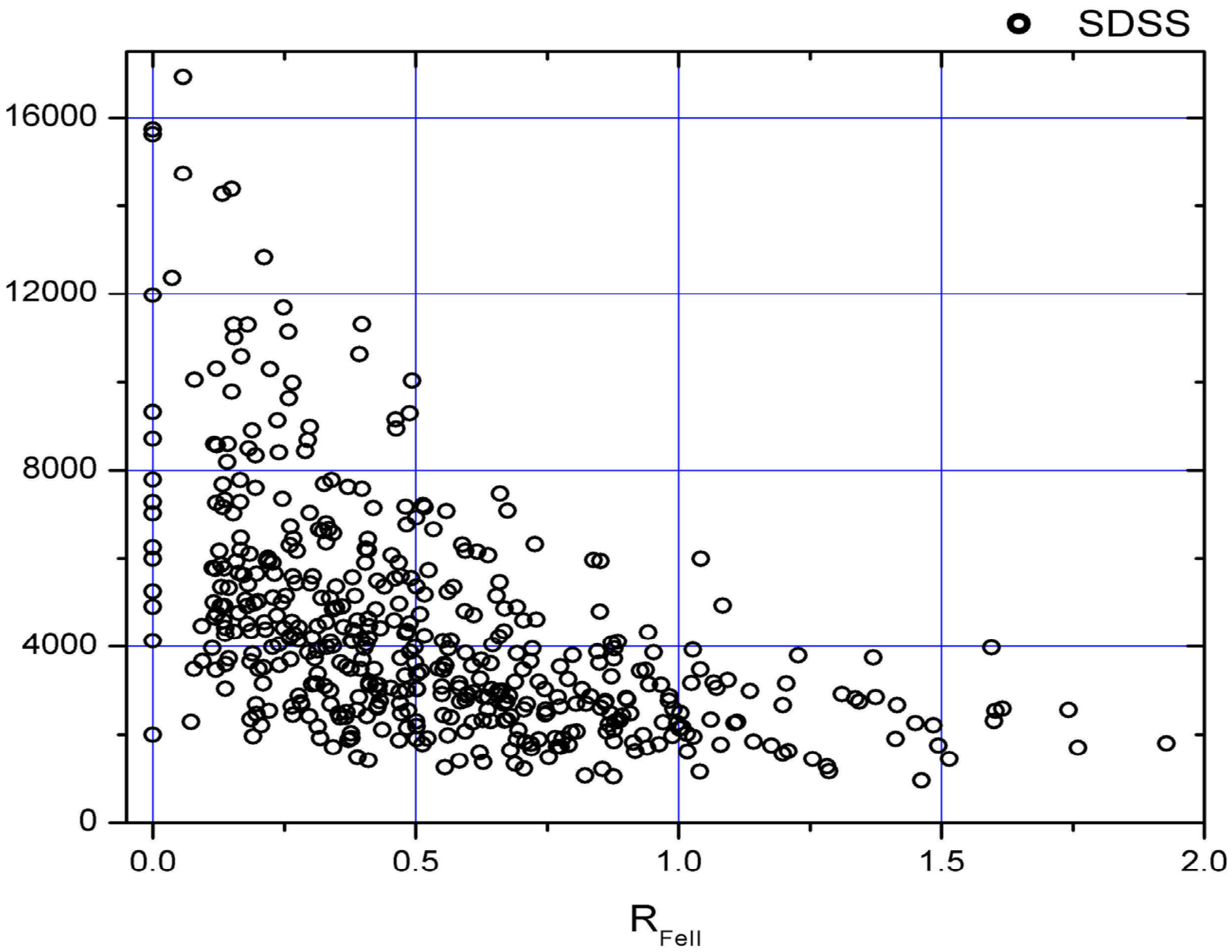
thermal emission signature

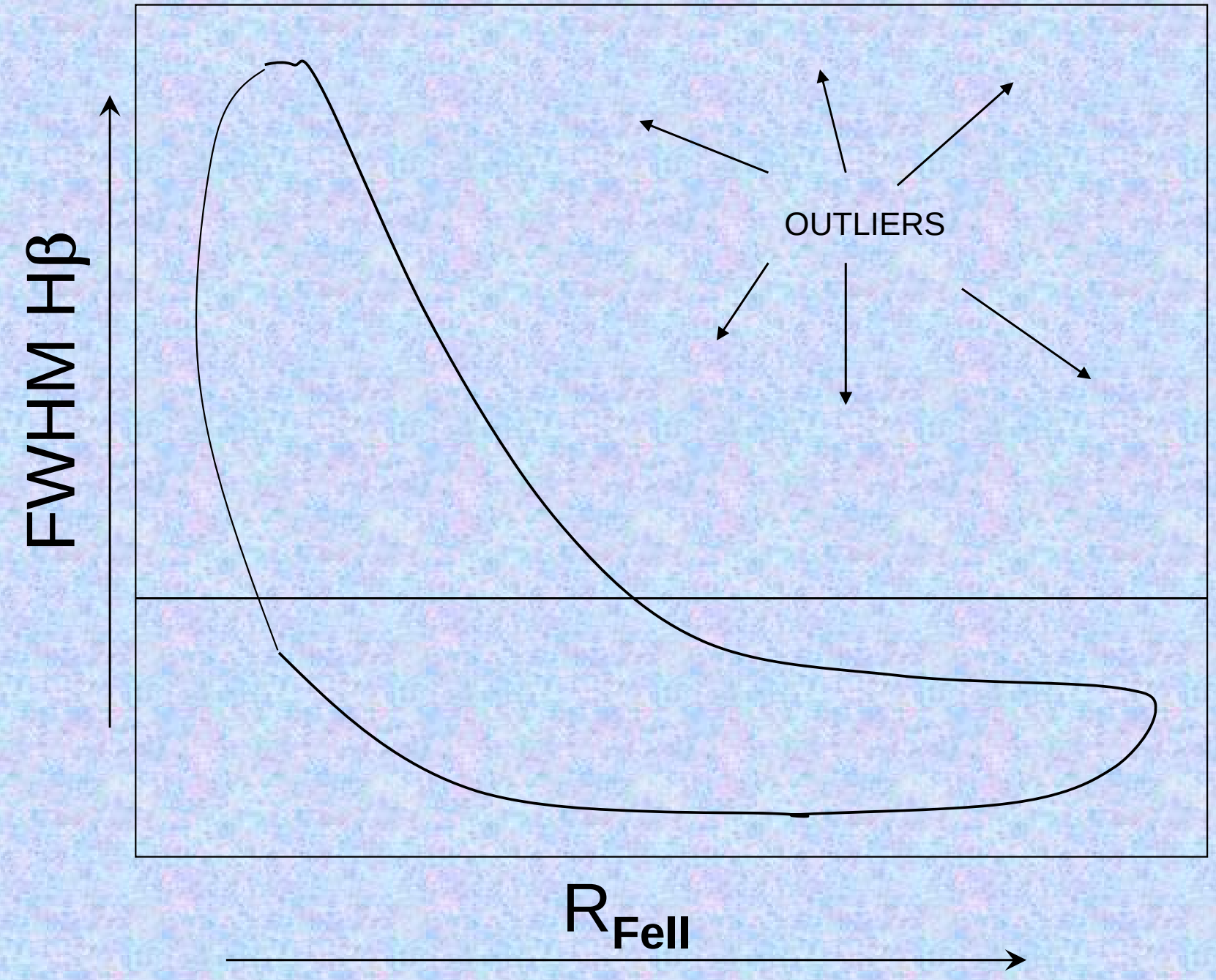
CIV λ1549 Broad Line Shift

systematic motions of HIL

Precursors:

Boroson & Green (1992); Boller et al. (1996);
Marziani et al. (1996); Wang et al. (1996);Laor et al. (1997)

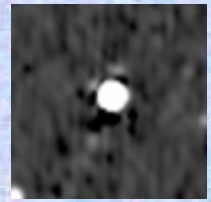

SDSS
16000
12000
8000
4000
0
0.0
0.5
1.0
1.5
2.0
R_FeII

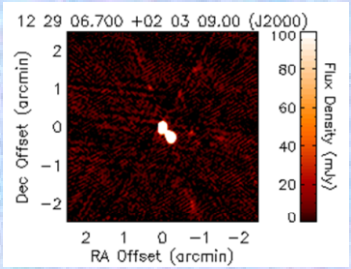

FWHM Hβ
OUTLIERS
R FeII

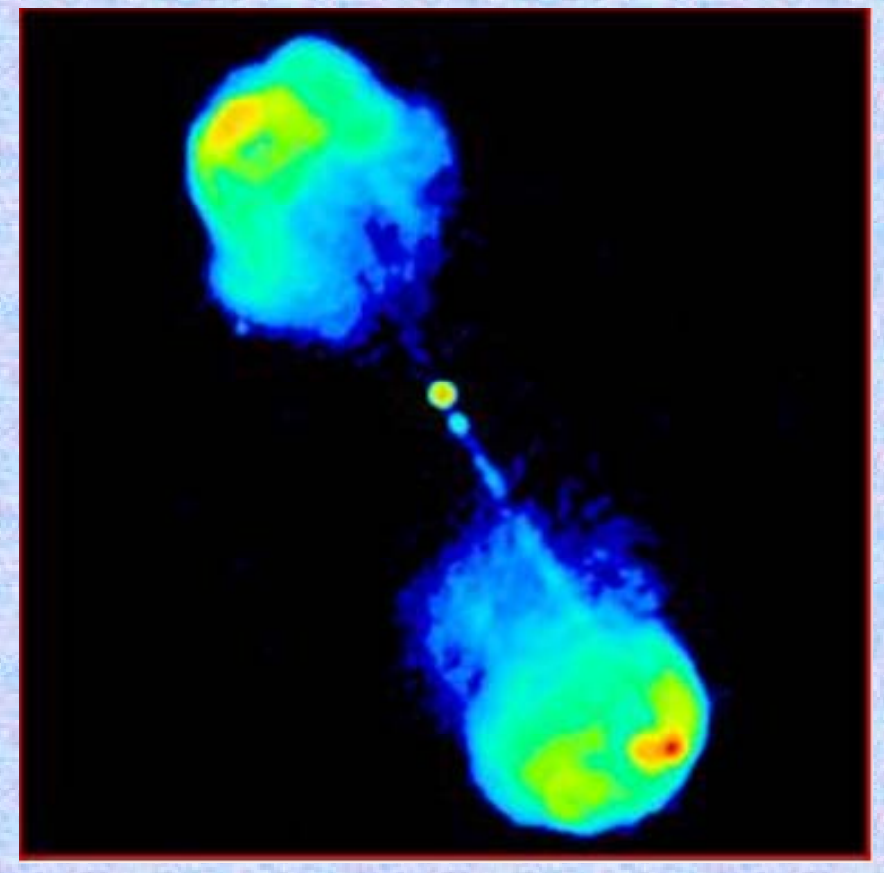
RL --RQ DICHOTOMY?

RL QUASARS OCCUPY A RESTRICTED PARAMETER SPACE RELATIVE TO THE RQ MAJORITY

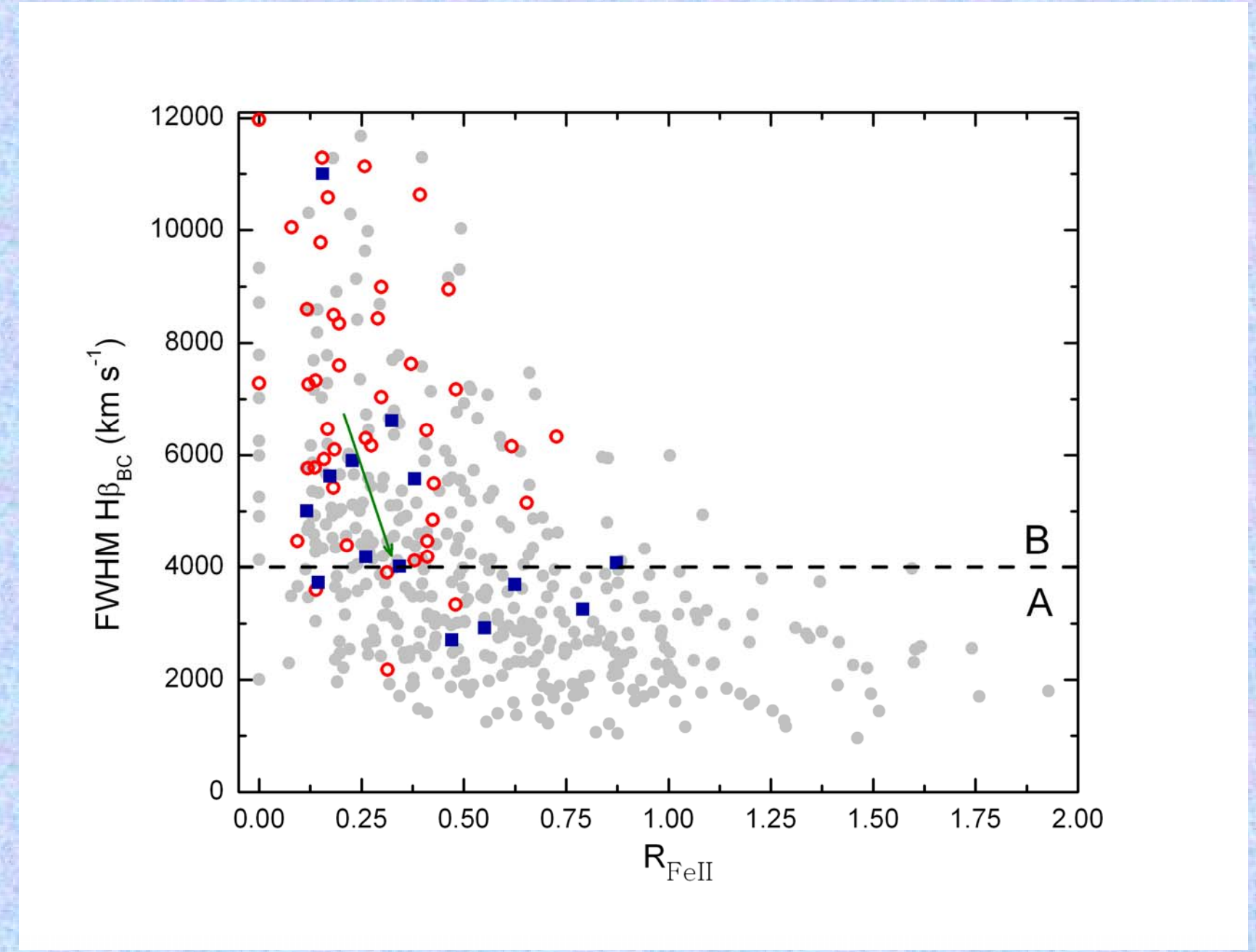
CORE AND LOBE DOMINATED RL's ALSO SHOW PARAMETER SPACE DIFFERENCES

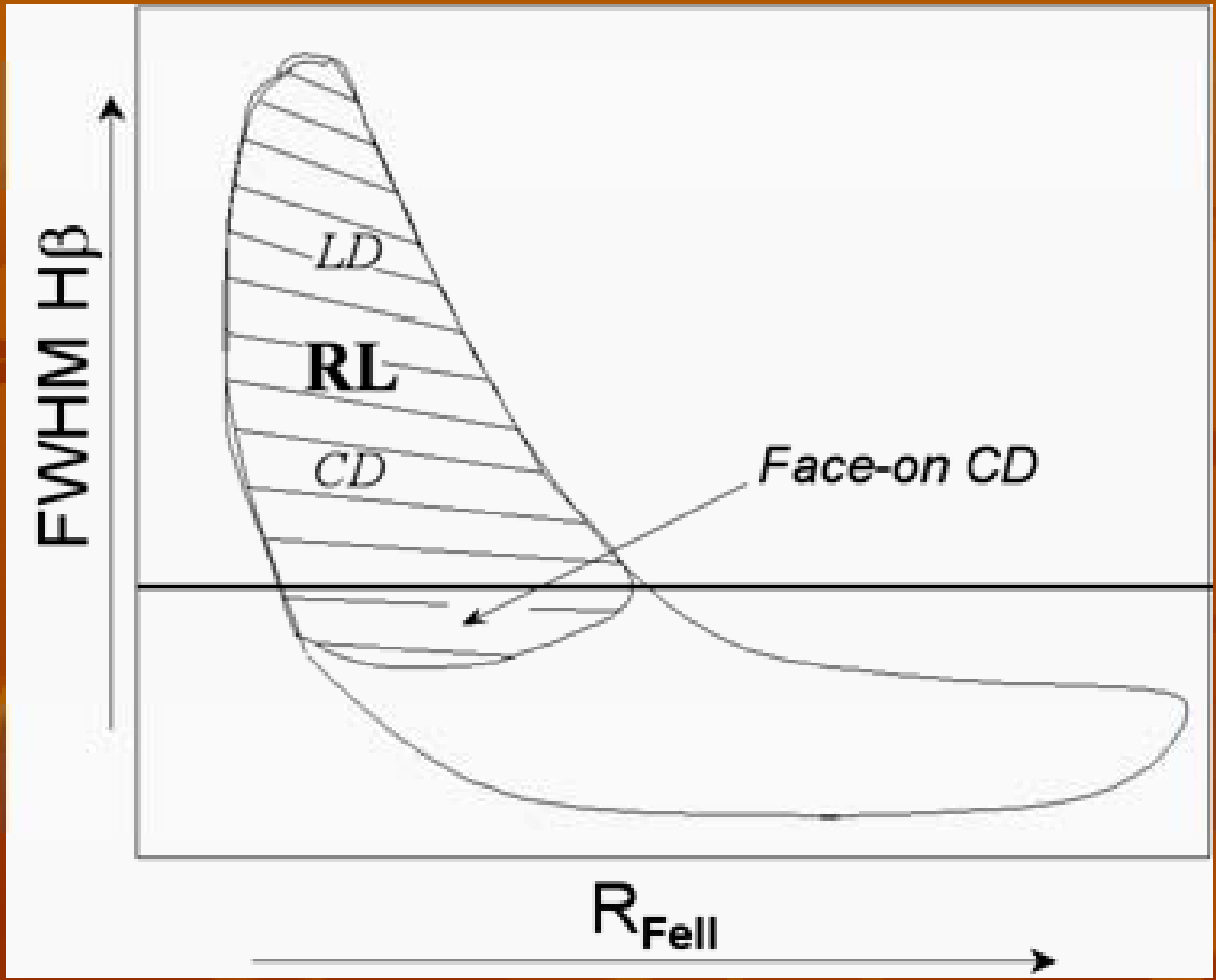



12 29 06.700 +02 03 09.00 (J2000)
Dec Offset (arcmin)
2
1
0
−1
−2
RA Offset (arcmin)
2 1 0 −1 −2
Flux Density (mJy)
100
80
60
40
20
0



Samples n1-parent and n2-test	Coordinates of quadrants FWHM Hβ (km s^{-1}) ; R$_{FeII}$	Probability of null hypothesis
392-non-RL and 85-RL	3875 ; 0.49	P$\sim 6.2\times10^{-8}$
46-RL FRII and 39-RL CD	6100 ; 0.18	P$\sim 9.8\times10^{-4}$

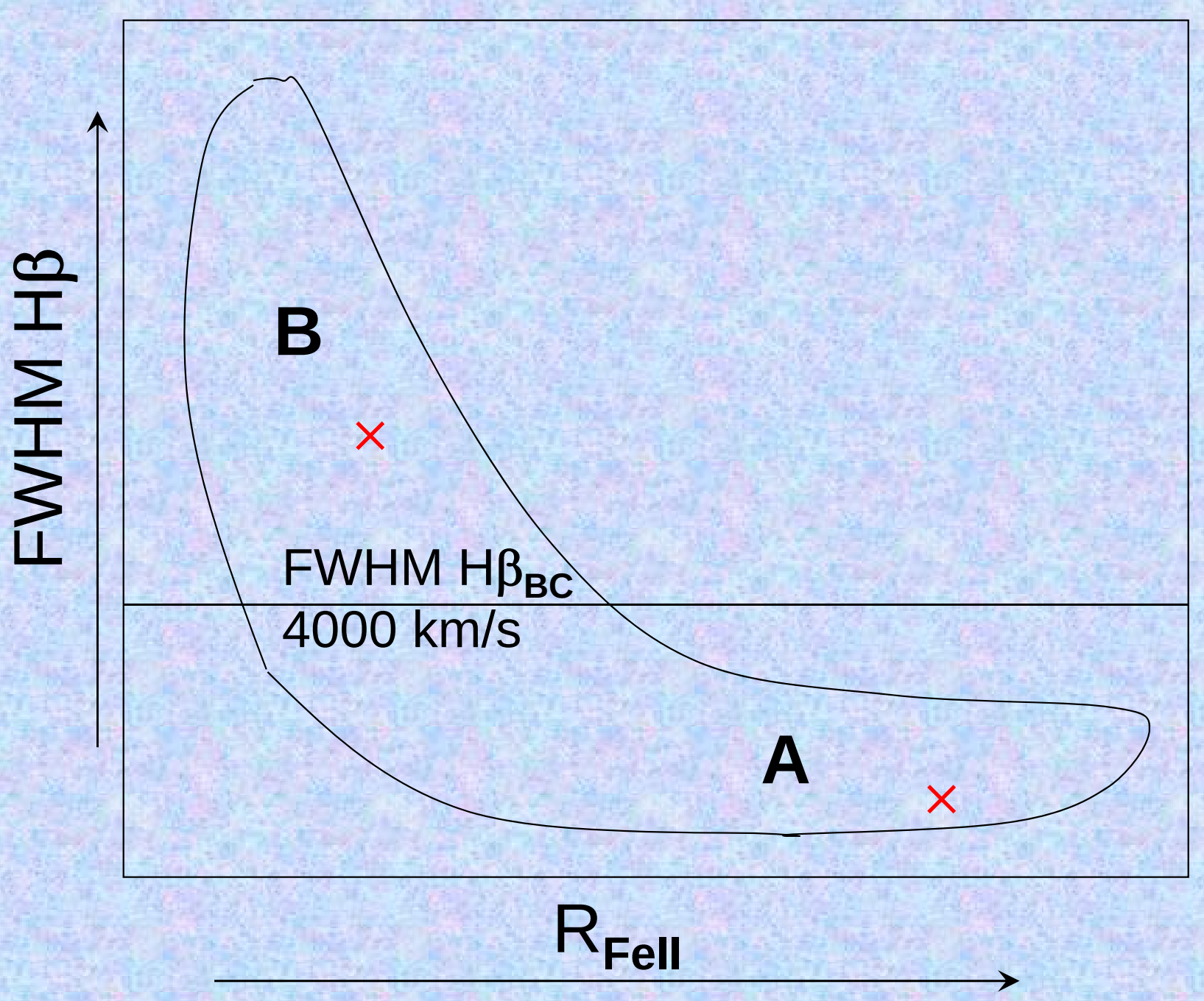

12000
10000
8000
6000
4000
2000
0
FWHM Hβ$_{BC}$ (km s^{-1})
0.00
0.25
0.50
0.75
1.00
1.25
1.50
1.75
2.00
R$_{FeII}$
B
A


FWHM Hβ
LD
RL
CD
Face-on CD
R_{FeII}

IS

FWHM HBETA = 4000 km/s

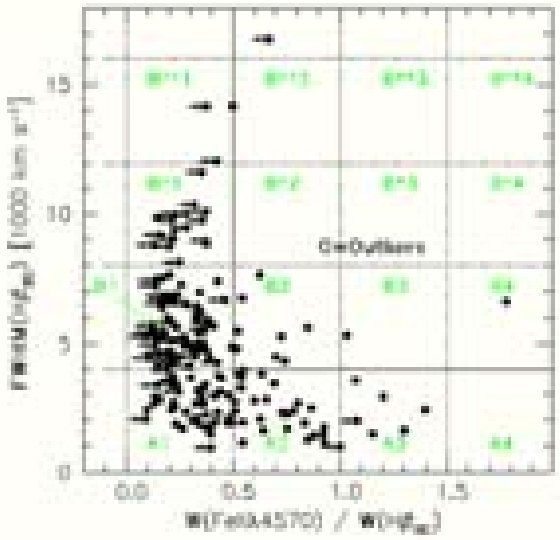
A MAGIC NUMBER?


FWHM Hβ
B
FWHM Hβ$_{BC}$
4000 km/s
A
R$_{FeII}$

DICHOTOMY?

- Population A: FWHM HBETA<4000km/s, RFE>0.5, HIL (e.g. CIV1549) blueshift/asymmetry, soft X-ray excess, RQ

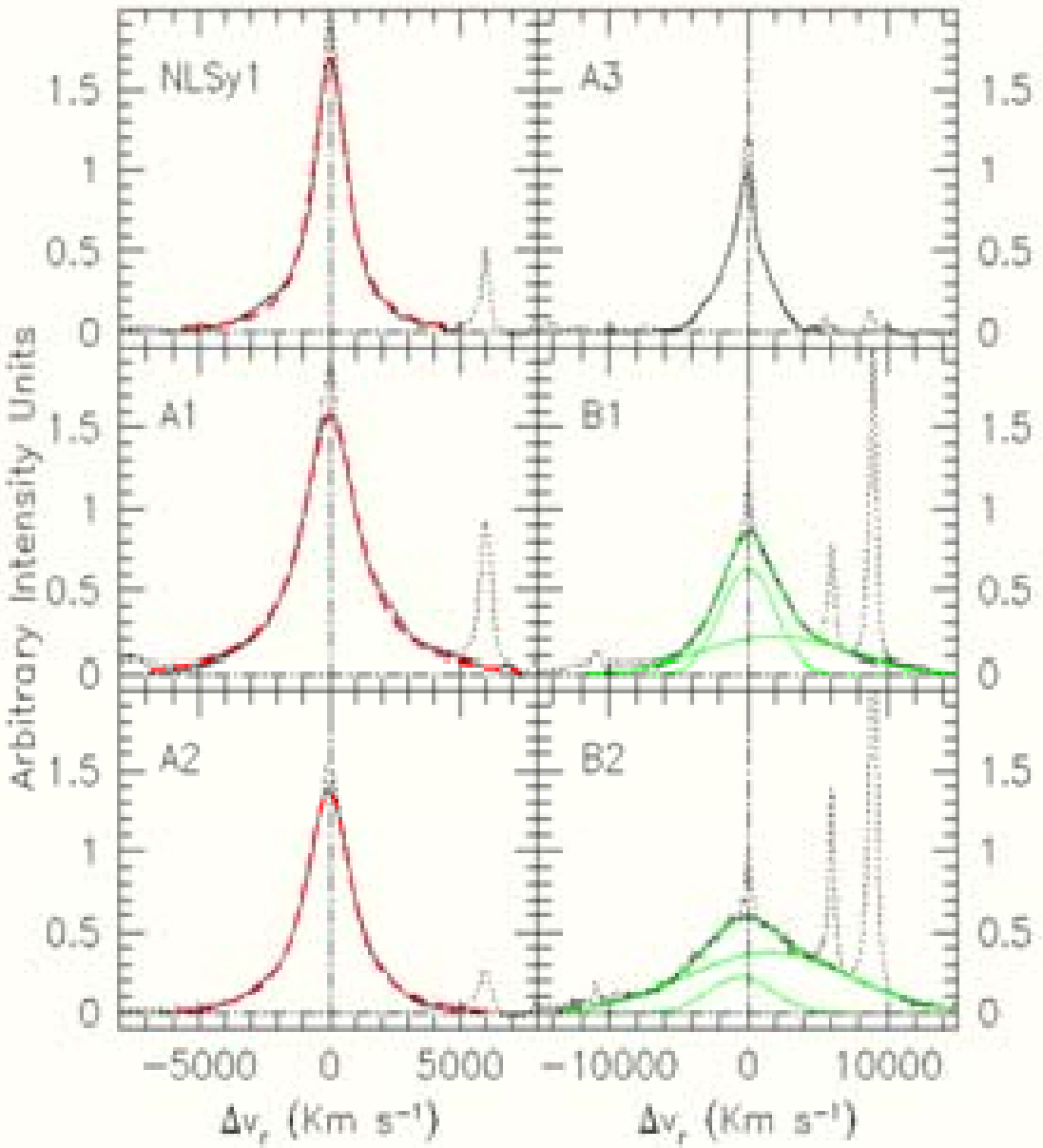
- Population B: FWHM HBETA>4000km/s, RFE<0.5, no HIL blueshift or soft X-ray excess, mixed RL-RQ



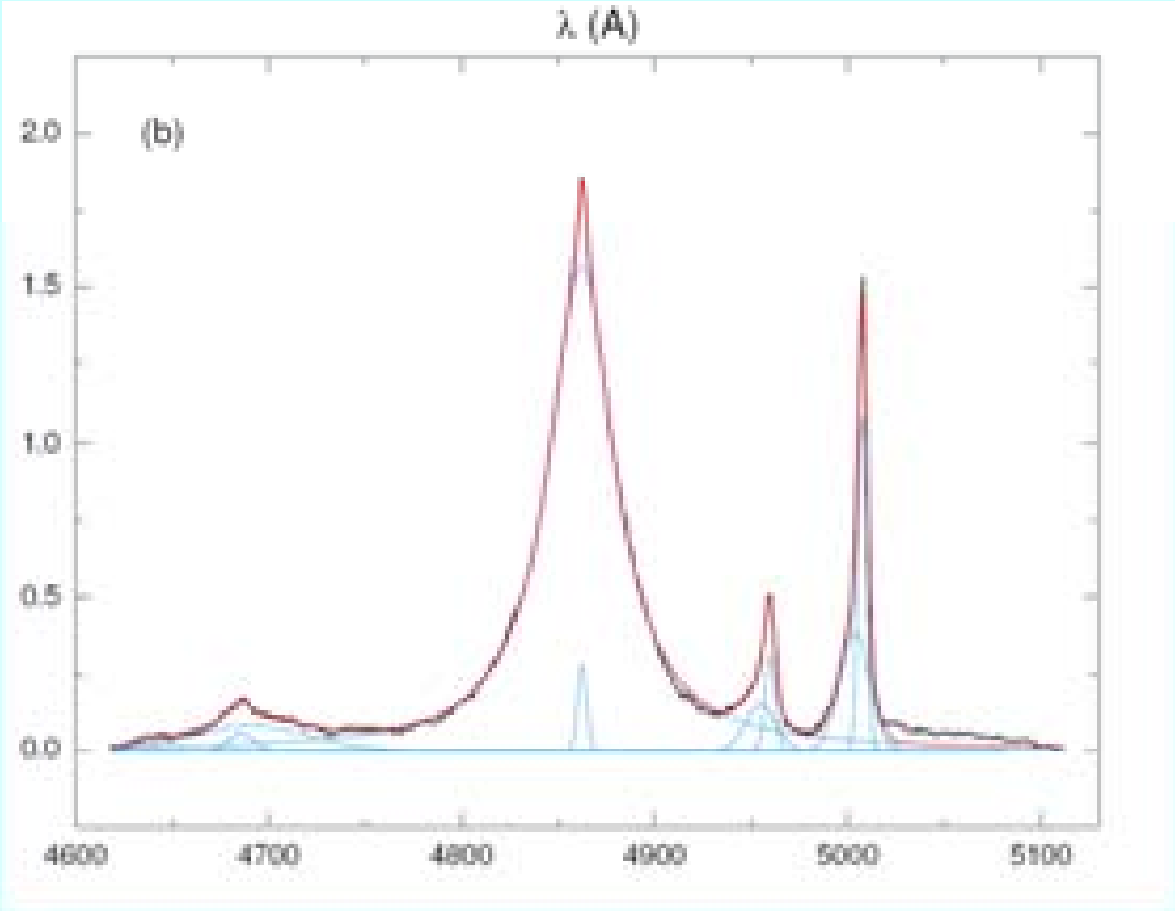
Sulentic et al. 2002:

LIL/BLR Structural Difference between Population A and B

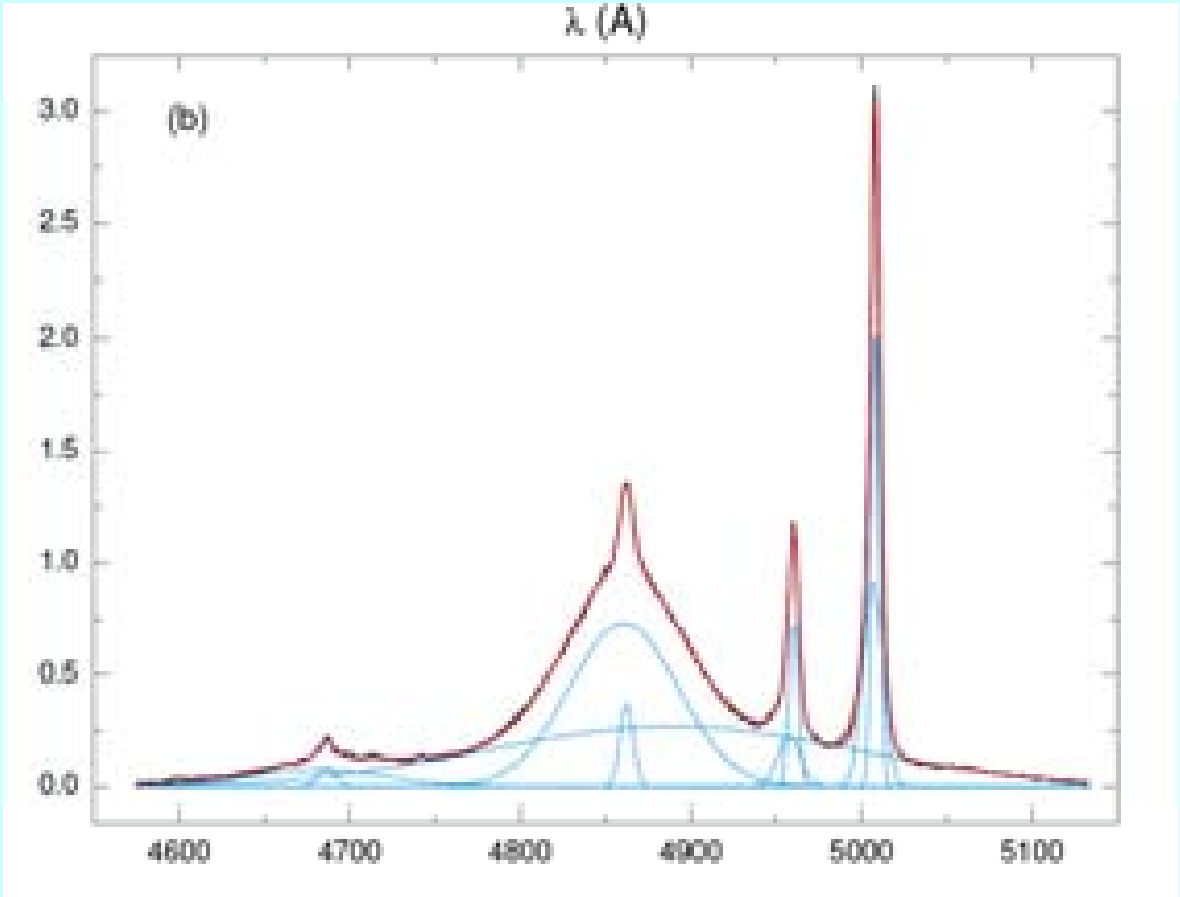
(Sample of about 200 Seyfert 1 and low-redshift quasars High S/N and resolution 4 Å FWHM)

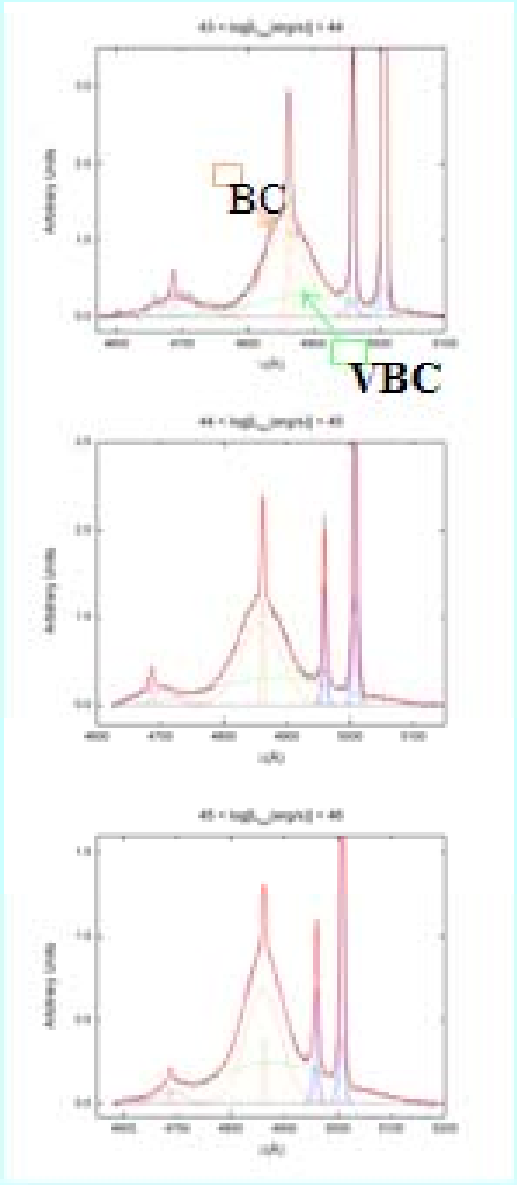


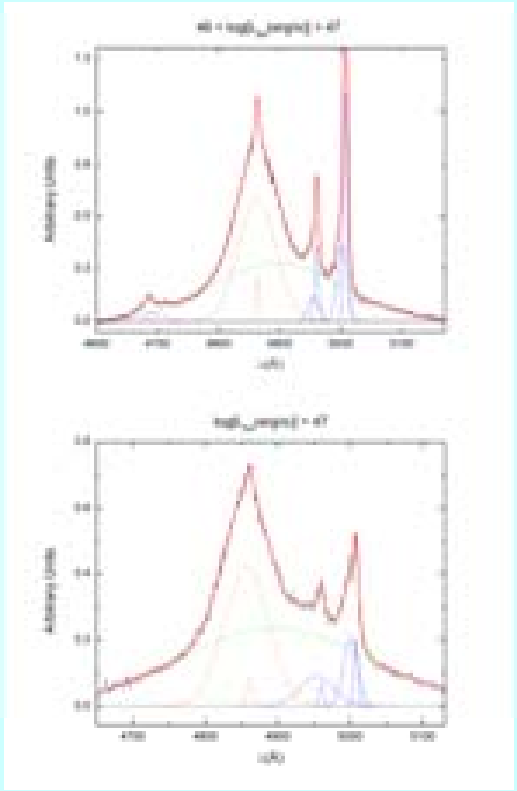
BIN A1 MEDIAN



BIN B1 MEDIAN




BC
VBC



AN EXTRA LINE
COMPONENT IN POPULATION B
HBETA

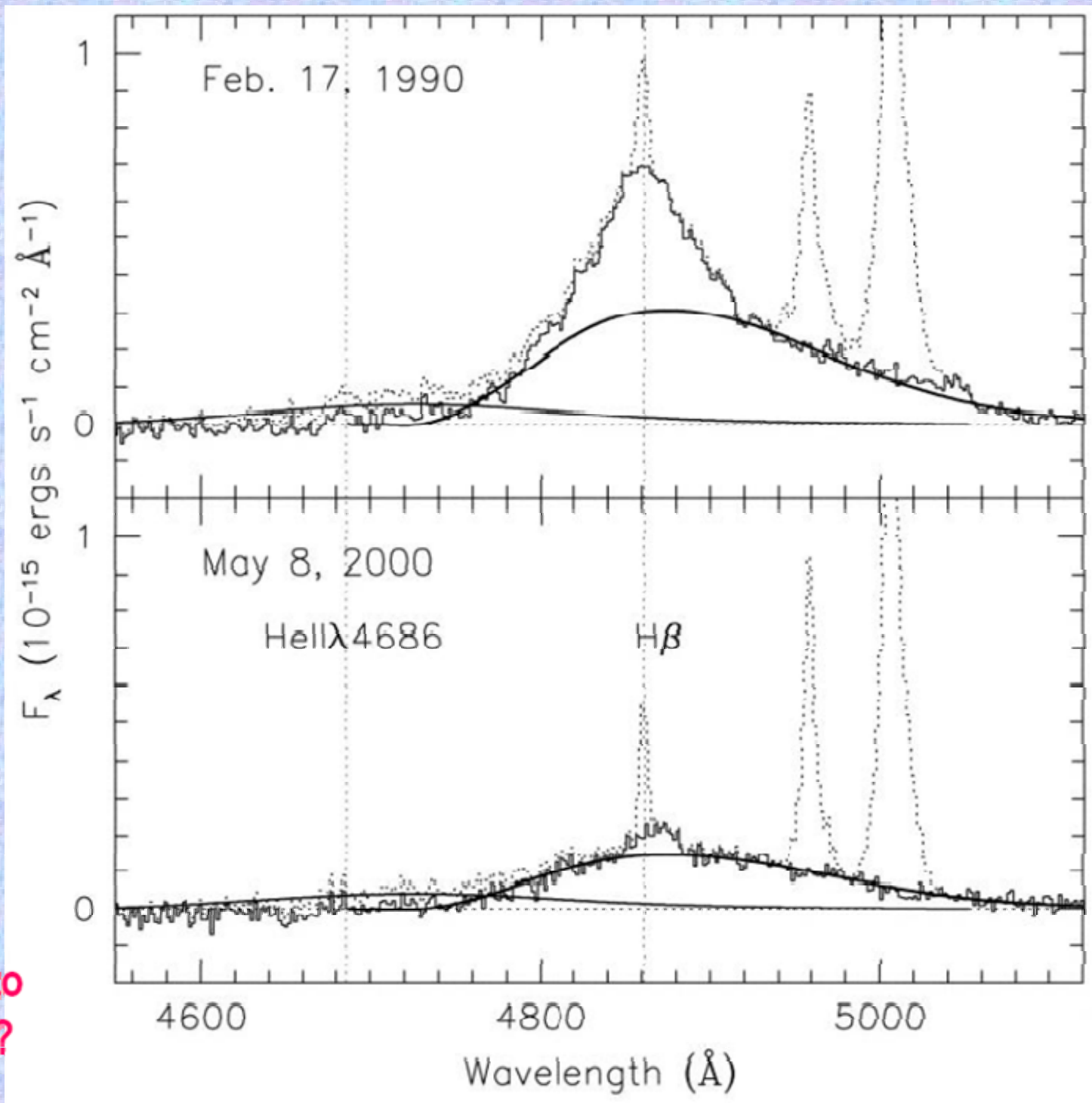
VERY BROAD LINE COMPONENT

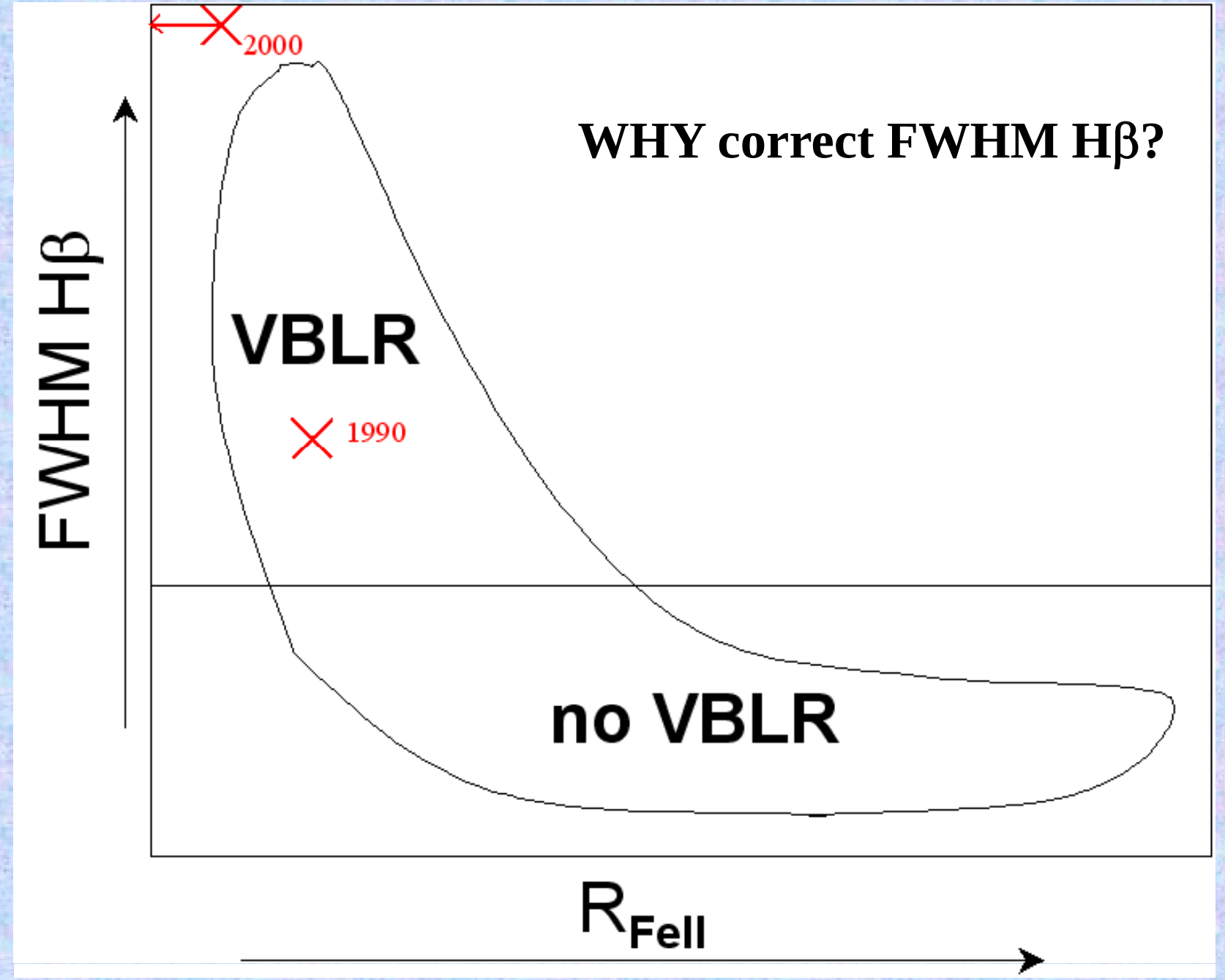
FWHM HBETA~~10000km/s

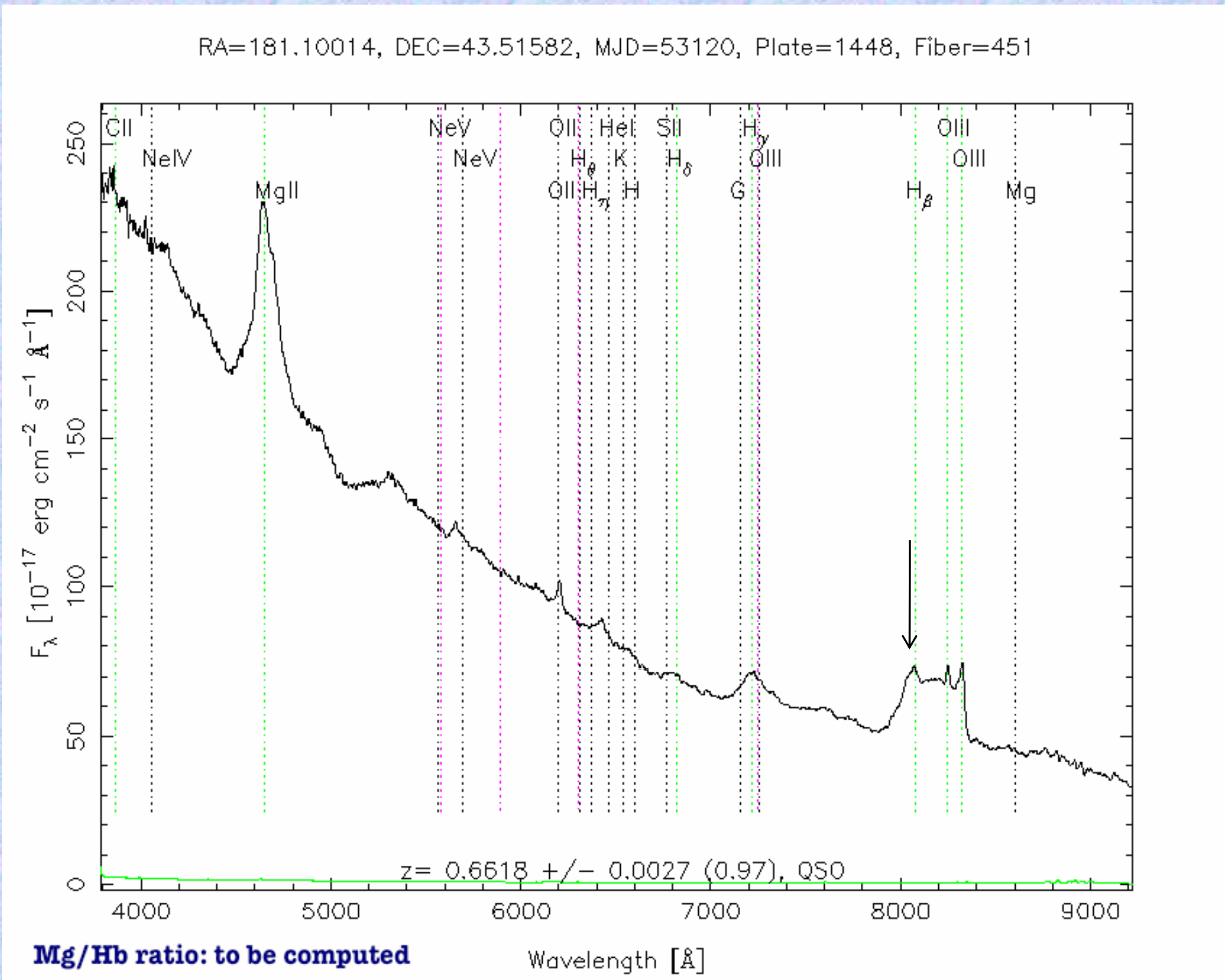
REDSHIFT ~~ 1-2000km/s

PG 1416-129:
Inner Hβ Very Broad Component:
A large covering factor region (i.e., almost a thin shell) located closest to continuum source and marginally thick or optically thin to the HI ionizing continuum

Redward Asymmetry of Population B sources due to optically thin infalling gas?




WHY correct FWHM Hβ?
2000
1990
VBLR
no VBLR
FWHM Hβ
R_FeII

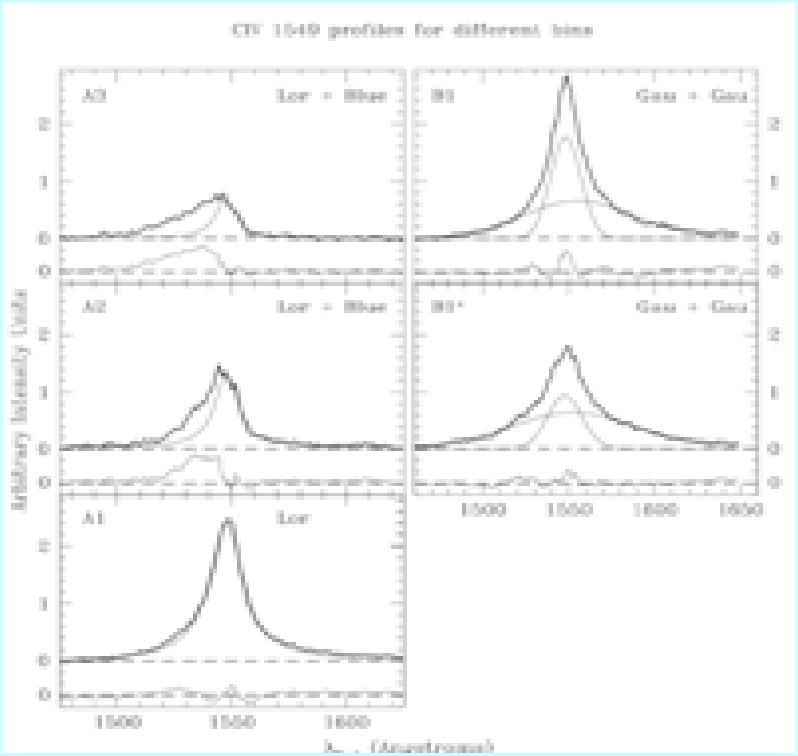


Mg/Hb ratio: to be computed

AN EXTRA LINE
COMPONENT IN POPULATION A
CIV

BLUE ASYMMETRIC COMPONENT

AVG. CIV PROFILES



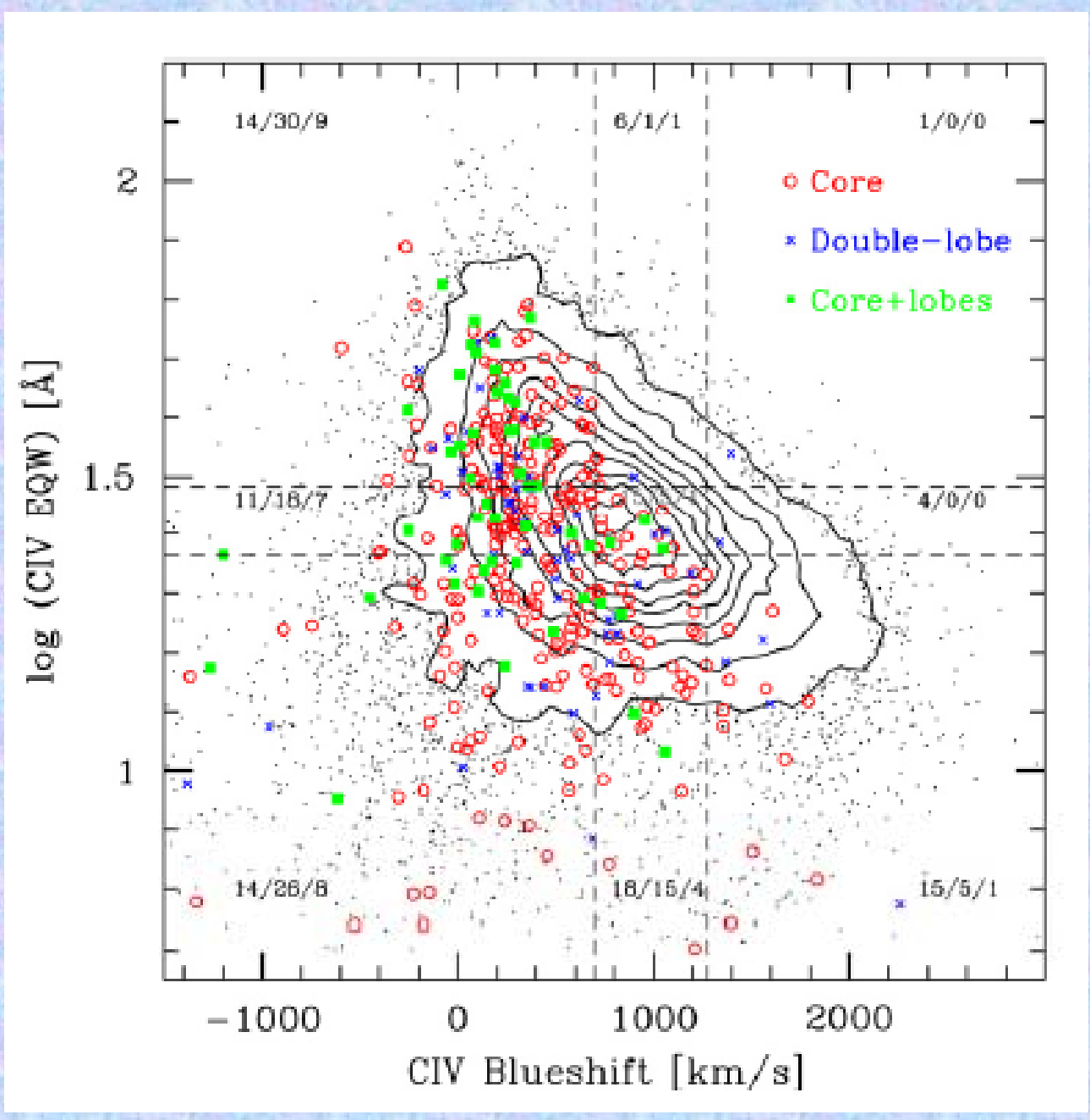
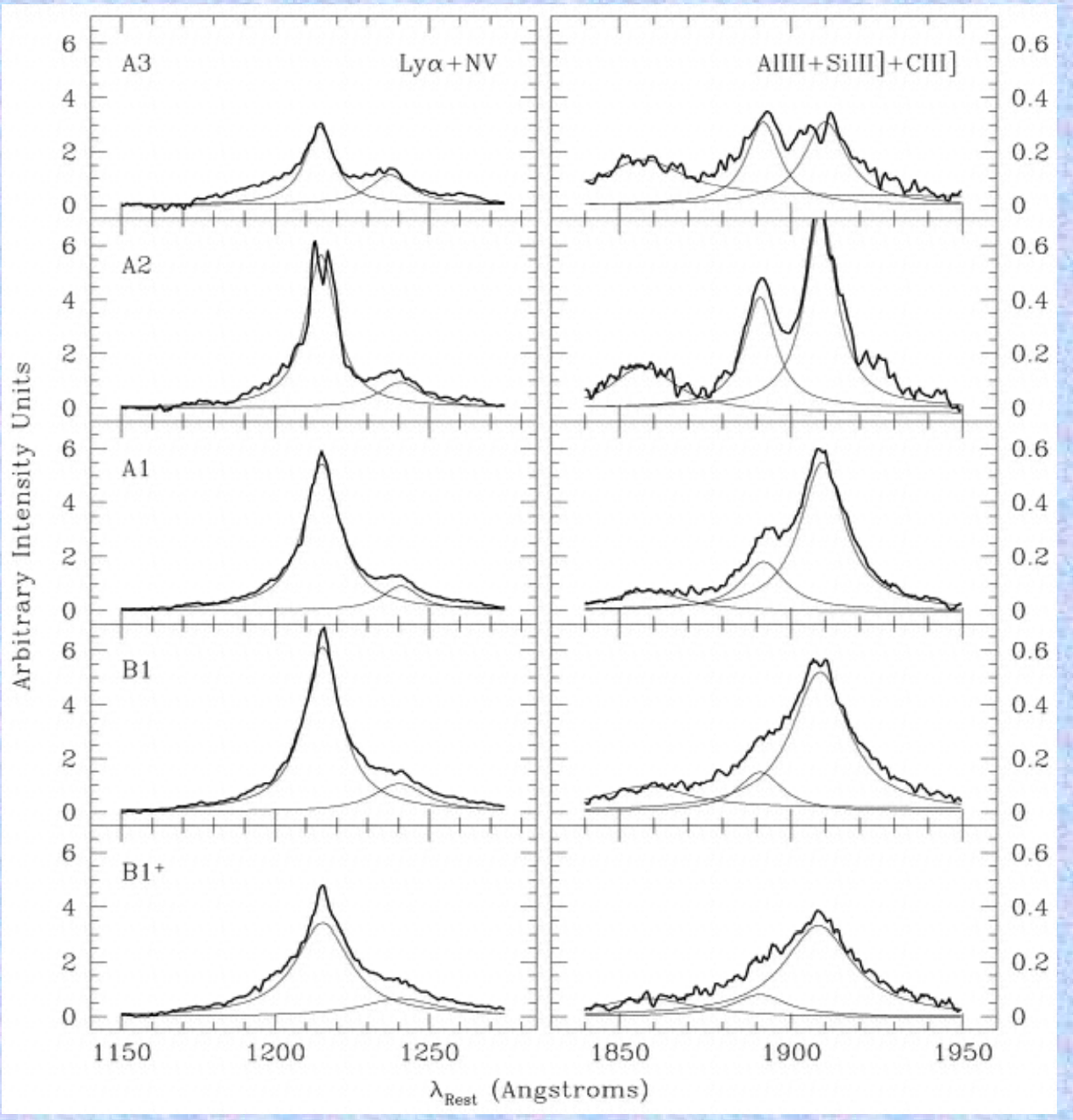
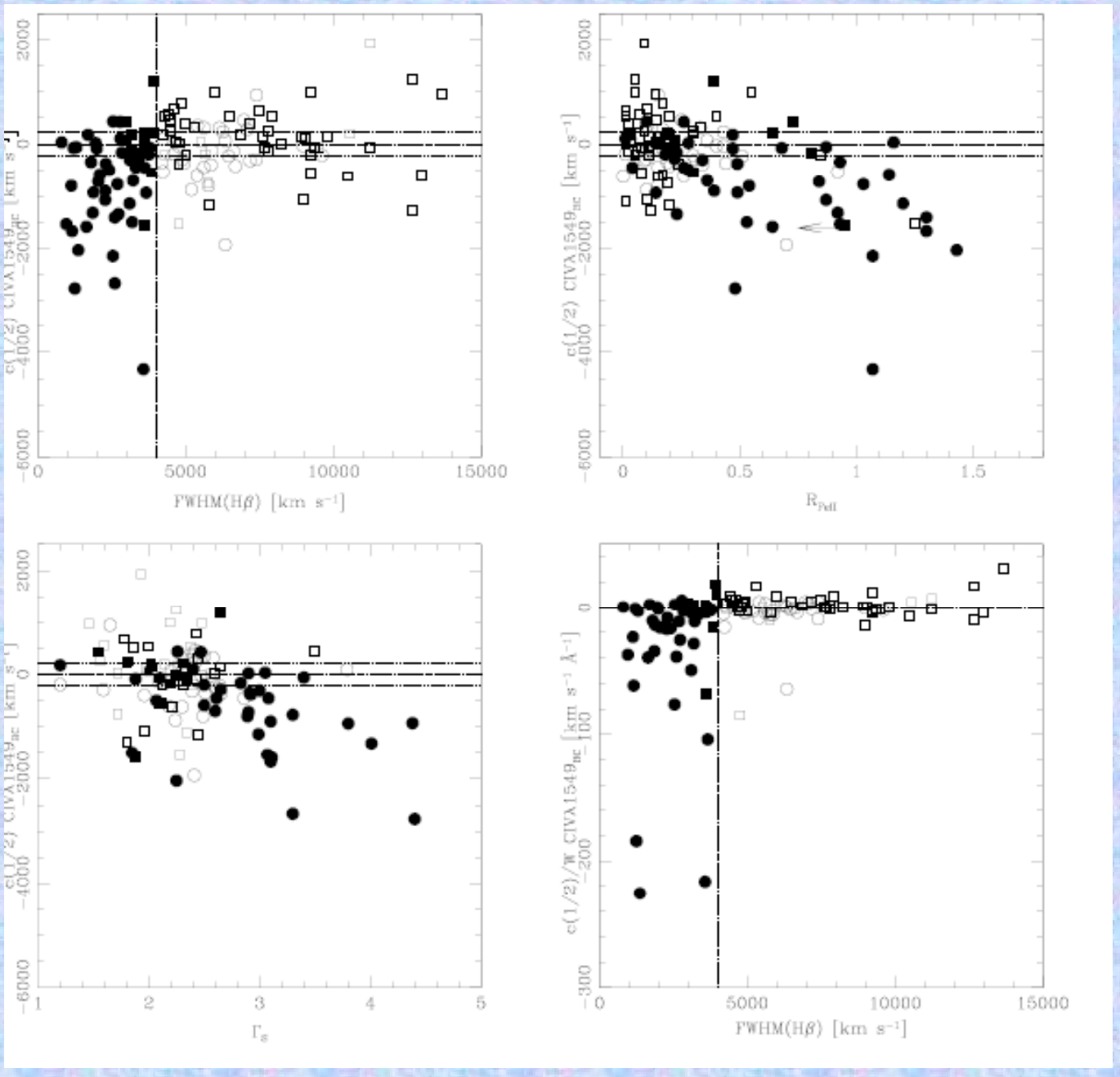

14/30/9
6/1/1
1/0/0
Core
Double−lobe
Core+lobes
11/18/7
4/0/0
14/26/8
18/15/4
15/5/1
log (CIV EQW) [Å]
2
1.5
1
−1000
0
1000
2000
CIV Blueshift [km/s]

Table 1. MAIN TRENDS ALONG THE 4DE1 SEQUENCE

Parameter	Population A	Population B	References
FWHM($H\beta_{BC}$)	800 – 4000 km s^{-1}	4000 – 10000 km s^{-1}	1,2
R_{Fe}	0.7	0.3	1
$c(\frac{1}{2})$ CIVλ1549$_{BC}$	–800 km s^{-1}	zero	3,10
Γ_S	often large	rarely large	1,11
W($H\beta_{BC}$)	$\sim$ 80 Å	$\sim$ 100 Å	1
$H\beta_{BC}$ profile shape	Lorentzian	double Gaussian	4,7
$c(\frac{1}{2})$ $H\beta_{BC}$	$\sim$ zero	+500 km s^{-1}	5
SiIII] / CIII]	0.4	0.2	8,9
FWHMCIVλ1549$_{BC}$	(2–6) $\cdot 10^3$ km s^{-1}	(2–10) $\cdot 10^3$ km s^{-1}	0
W(CIVλ1549$_{BC}$)	58 Å	105 Å	0
AI(CIVλ1549$_{BC}$)	–0.1	0.05	0
X-ray variability	extreme/rapid common	less common	12,13
optical variability	possible	more frequent/higher amplitude	14
probability radio loud	$\approx$ 3–4%	$\approx$ 0.25 %	15
BALs	extreme BALs	less extreme BALs	16,17
log density[1]	>11	9.5 – 10	8
log U[1]	–2.0/–1.5	–1.0/–0.5	8
log M_{BH}	6.5 – 8.5	8.0 – 10.0	5,6
L/L_{Edd}	0.1 – 1.0	0.01 – 0.5	5,6

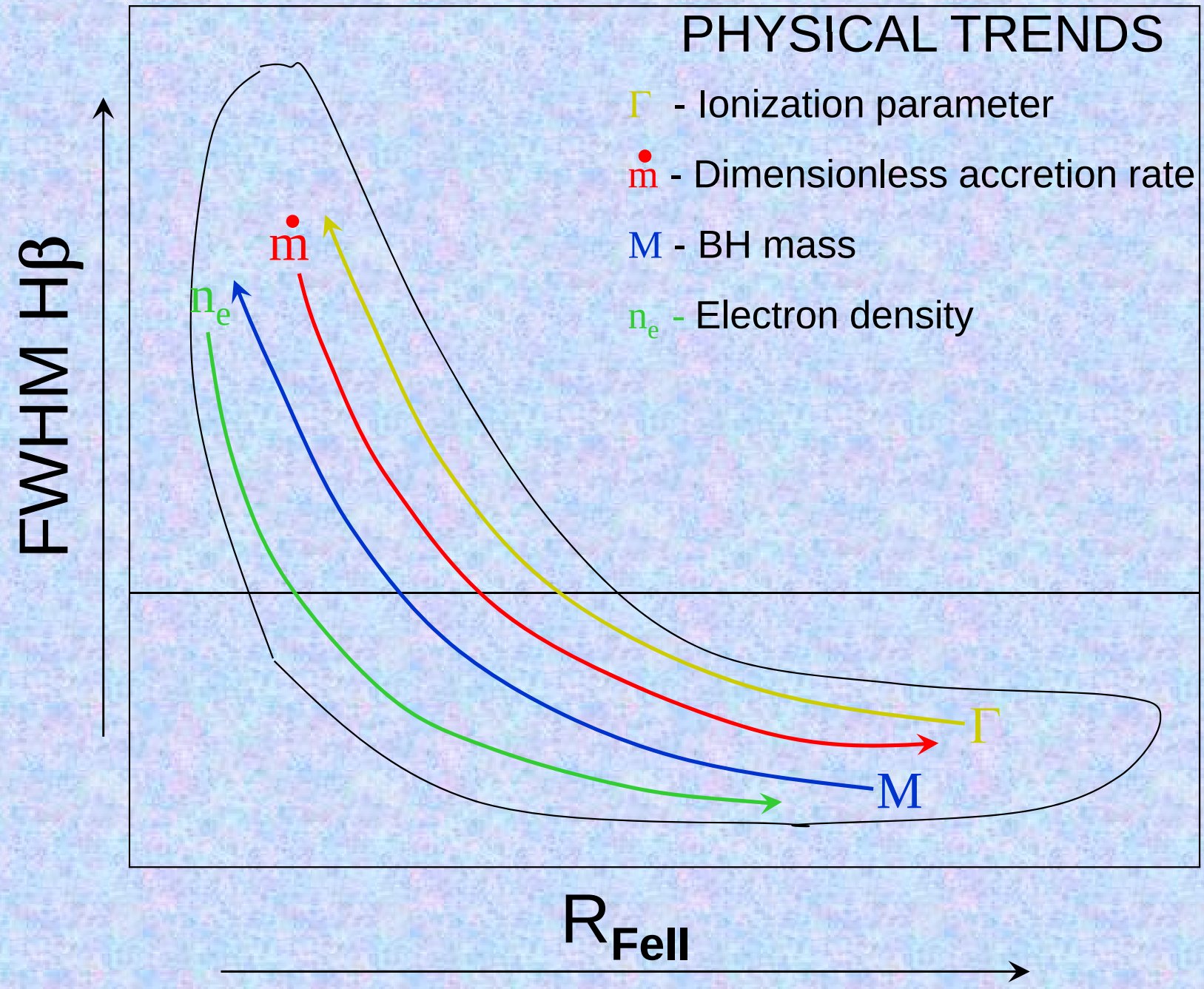
1: Sulentic et al. 2000a; 2: Collin et al. 2006; 3: Sulentic et al. 2007; 4: Veron-Cetty et al. 2001; 5: Marziani et al. 2003b; 6: Peterson et al. 2004; 7: Sulentic et al. 2002; 8: Marziani et al. 2001; 9: Wills et al. 1999; 10: Baskin & Laor 2005; 11: Wang et al. 1996 12: Turner et al. 1999 13: Grupe et al. 2001; 14: Giveon et al. 1999; 15: Zamfir et al.


A3
Lyα+NV
AlIII+SiIII]+CIII]
A2
A1
B1
B1+
Arbitrary Intensity Units
λRest (Angstroms)
1150
1200
1250
1850
1900
1950


c(1/2) CIVλ1549$_{bc}$ [km s^{-1}]
FWHM(Hβ) [km s^{-1}]
c(1/2) CIVλ1549$_{bc}$ [km s^{-1}]
R$_{FeII}$
c(1/2) CIVλ1549$_{bc}$ [km s^{-1}]
Γ$_s$
c(1/2)/W CIVλ1549$_{bc}$ [km s^{-1} Å^{-1}]
FWHM(Hβ) [km s^{-1}]

PHYSICAL DRIVERS FOR QUASARS?

- Orientation
- Black Hole Mass
- Eddington Ratio
- BH Spin?
- Host Galaxy Morphology?


PHYSICAL TRENDS
Γ - Ionization parameter
ṁ - Dimensionless accretion rate
M - BH mass
n_e - Electron density
FWHM Hβ
R_FeII
ṁ
n_e
Γ
M