Spectral line shapes as a tool for invetigation kinematics and physics of plasma in quasars

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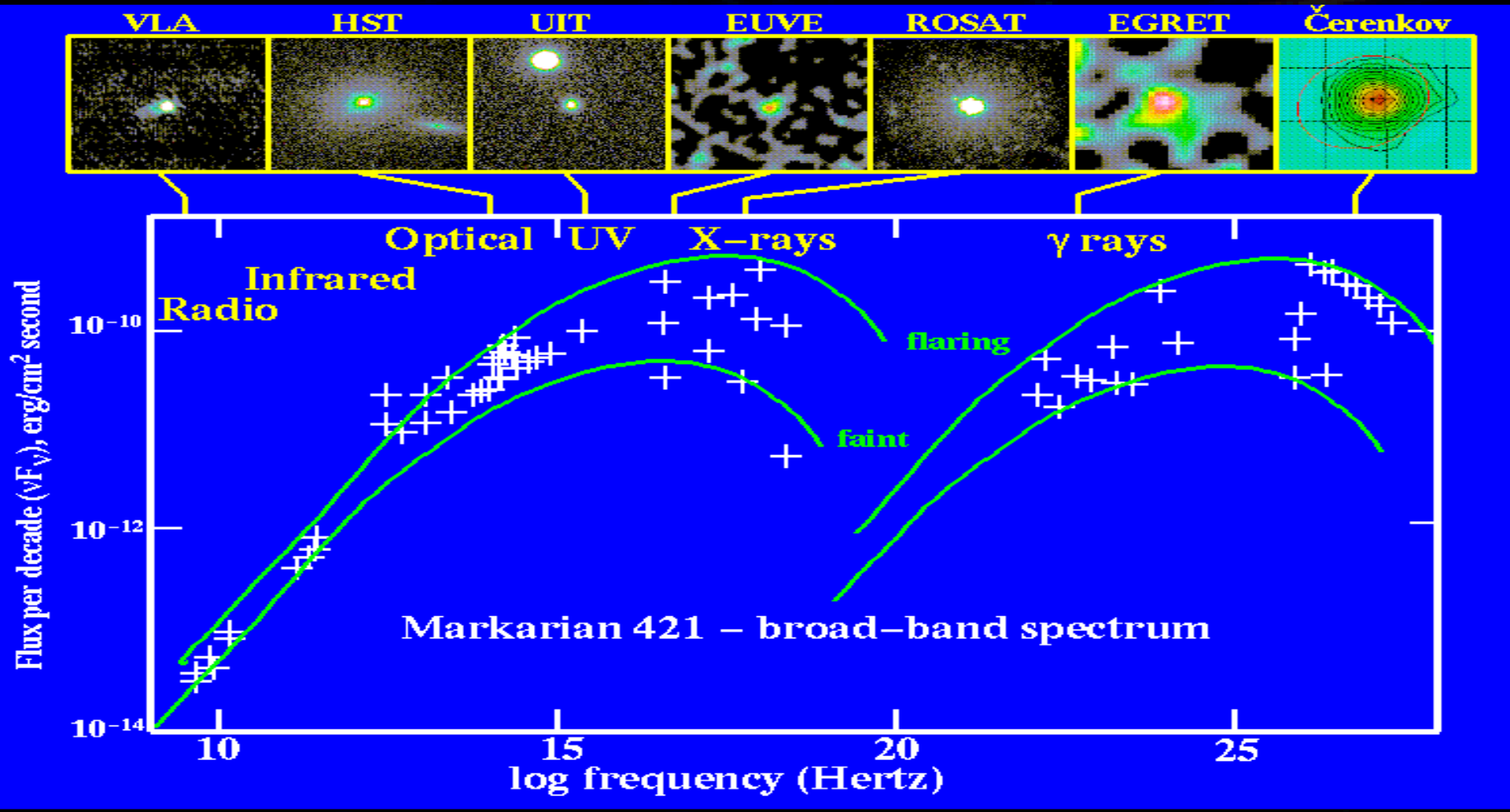
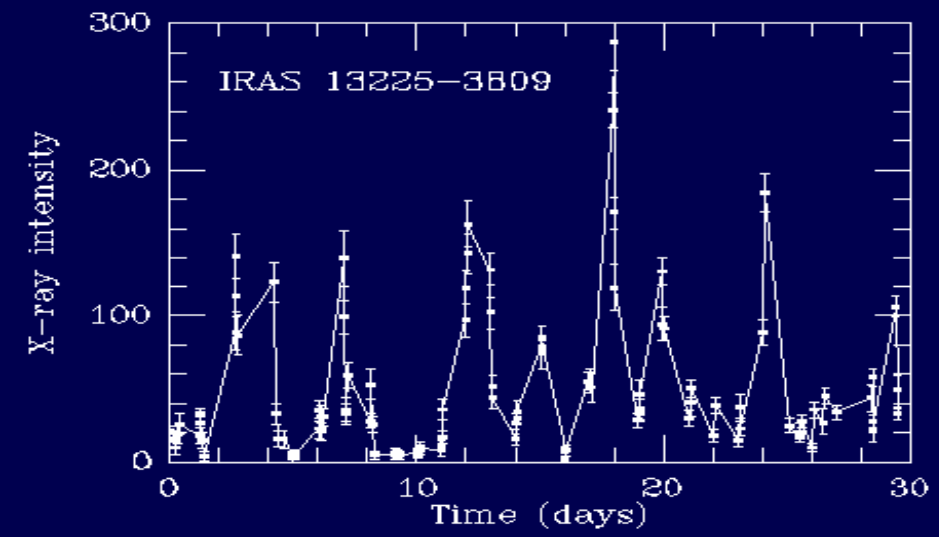
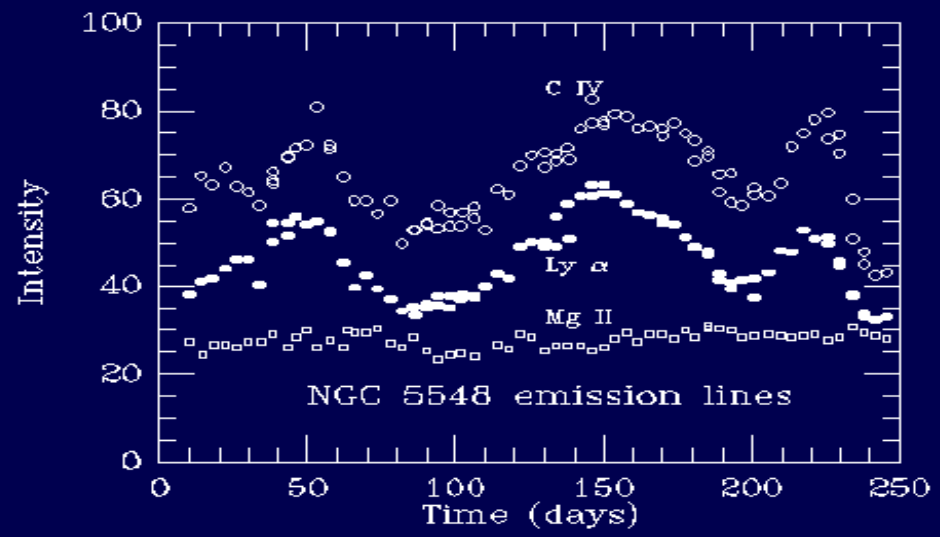
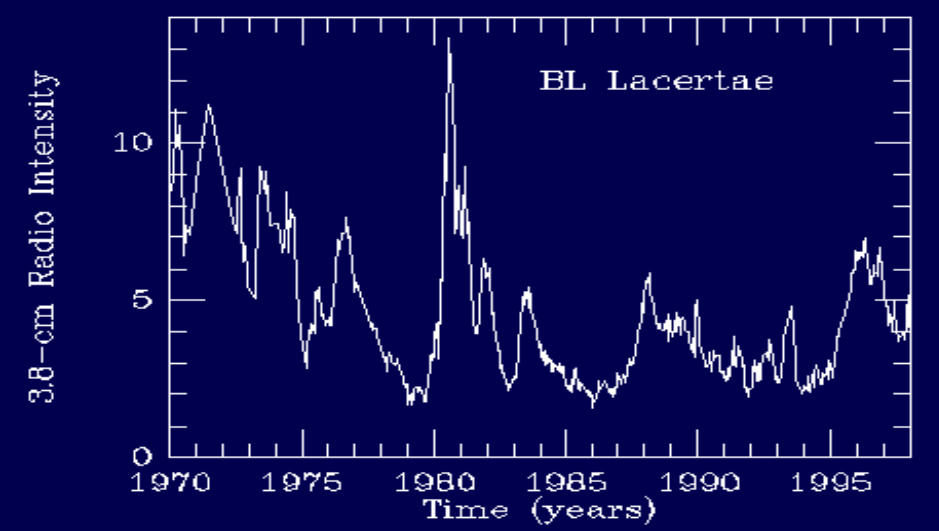
Bright nuclei, very compact angular size; high luminosity, broadband continuum

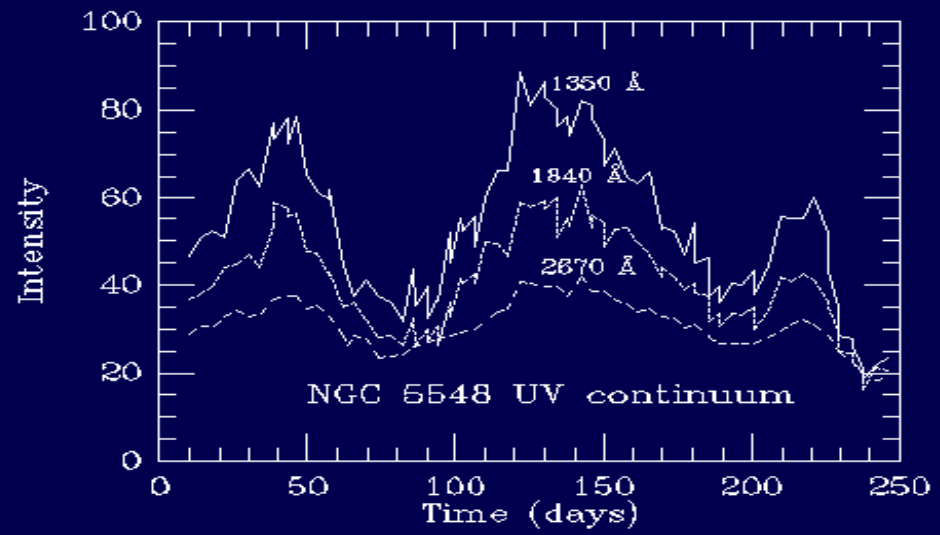


Often variability in the spectra, different dimension

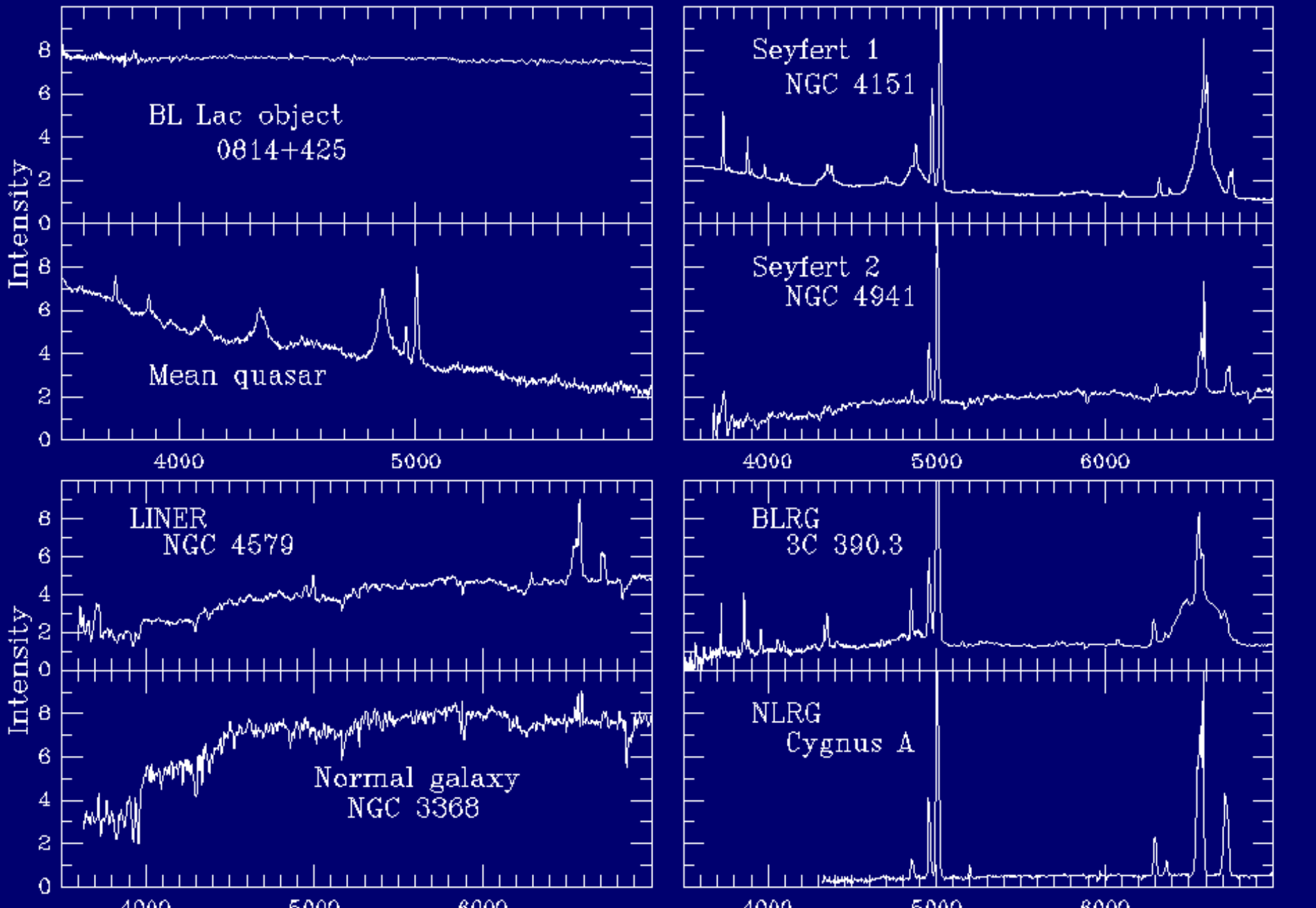








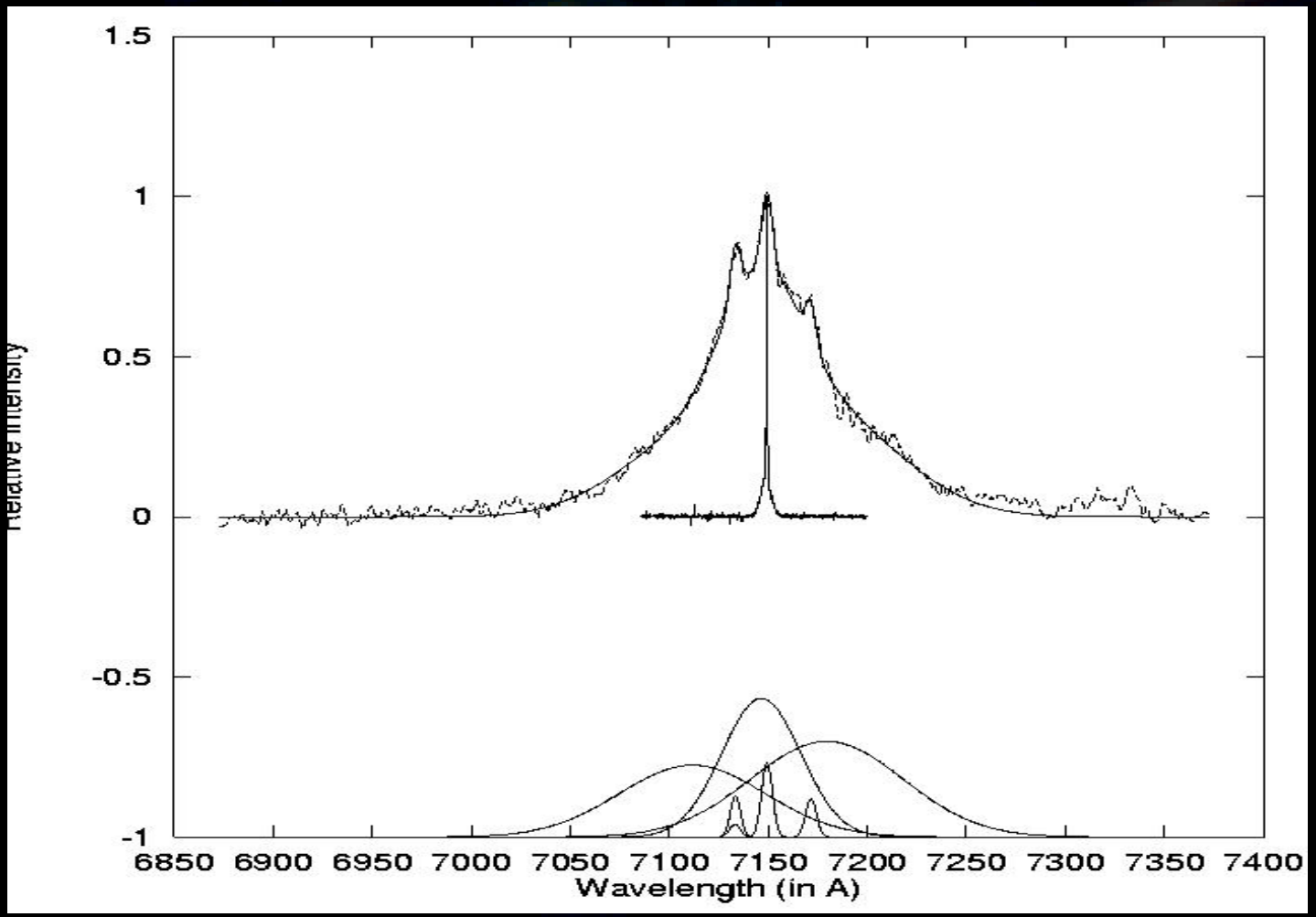
And spectral emission lines



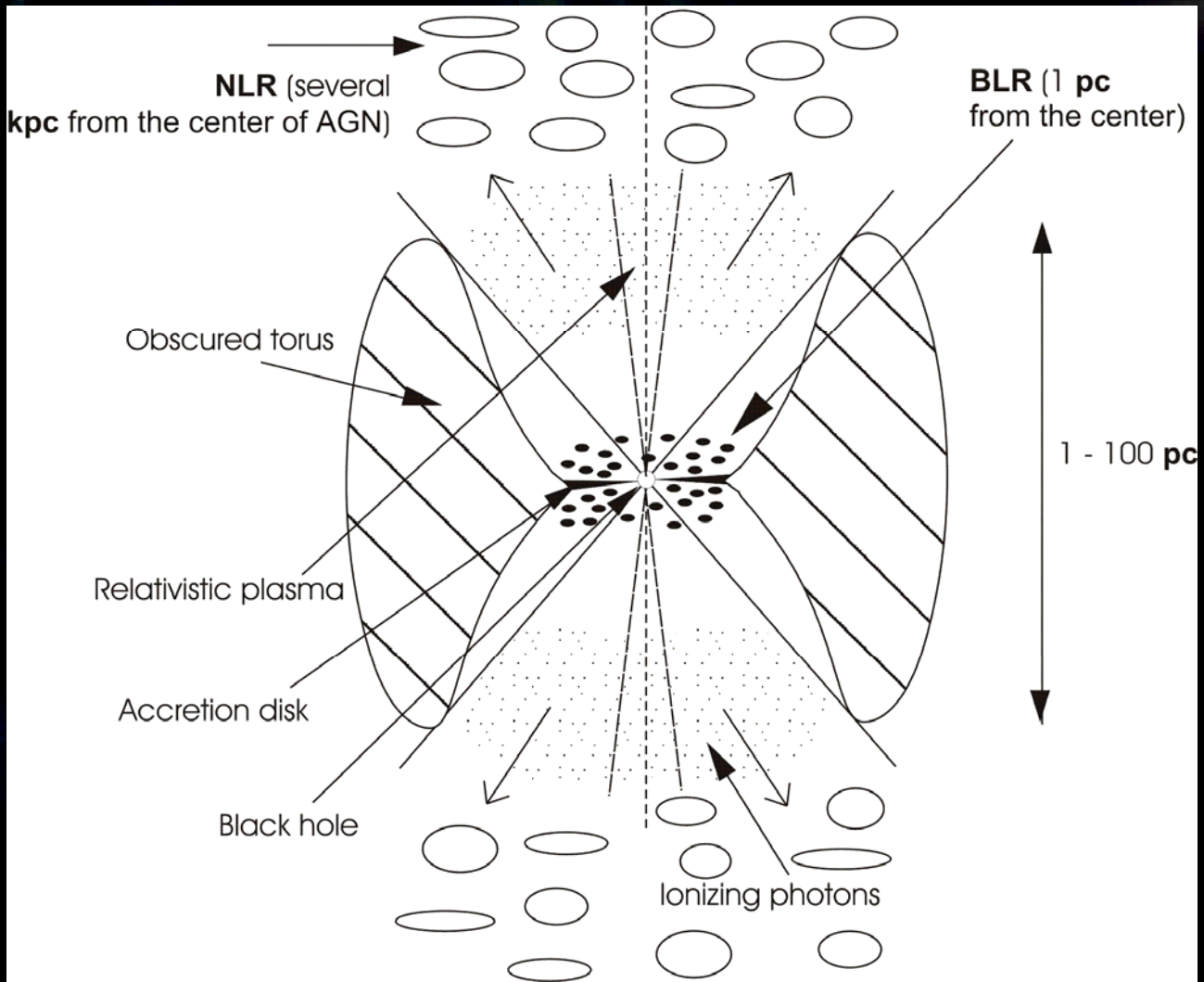
The spectral lines can help us to understand the physics in the center, but there is some problems:

- Obtained a spectra with a relatively good spectral resolution, subtract the continuum and satellite lines etc.

H-alpha of III Zw2: astrophysical vs. laboratory plasma



What is going on in the center: THE MODEL



AGN structure:

- Black hole (1E07 – 1E09 solar masses)
- Accretion disk (x-ray, uv-optical?) – iron K-alpha line
- Outflows – wind – UV absorption lines
- BLR (partly accretion disk?) – broad lines (kinematics & physics?)
- NLR –narrow lines
- Jets – radio emission (if there correlation with optical emission?)

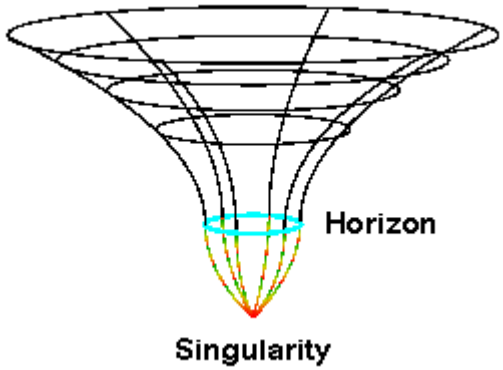
Black hole & SL

1. Detect BH using SL=> accretion disk

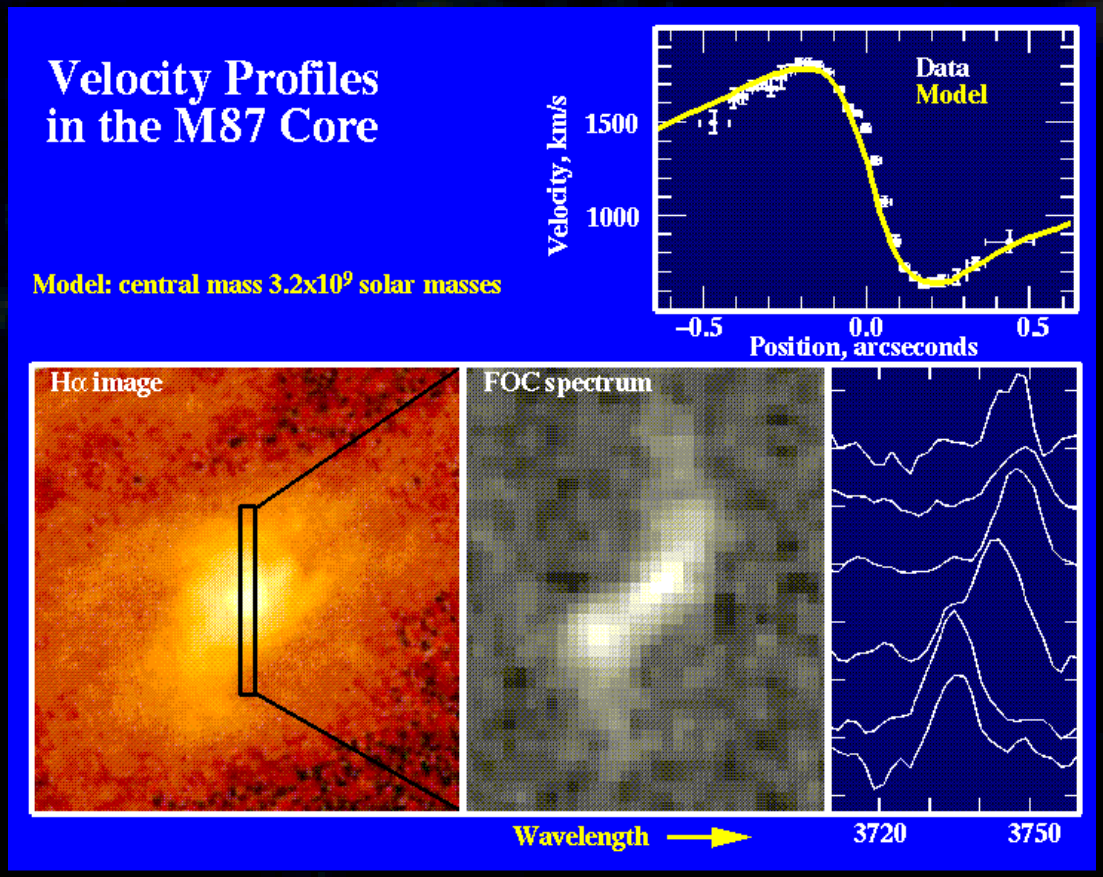
2. Estimate parameters of BH using SL:

Mass

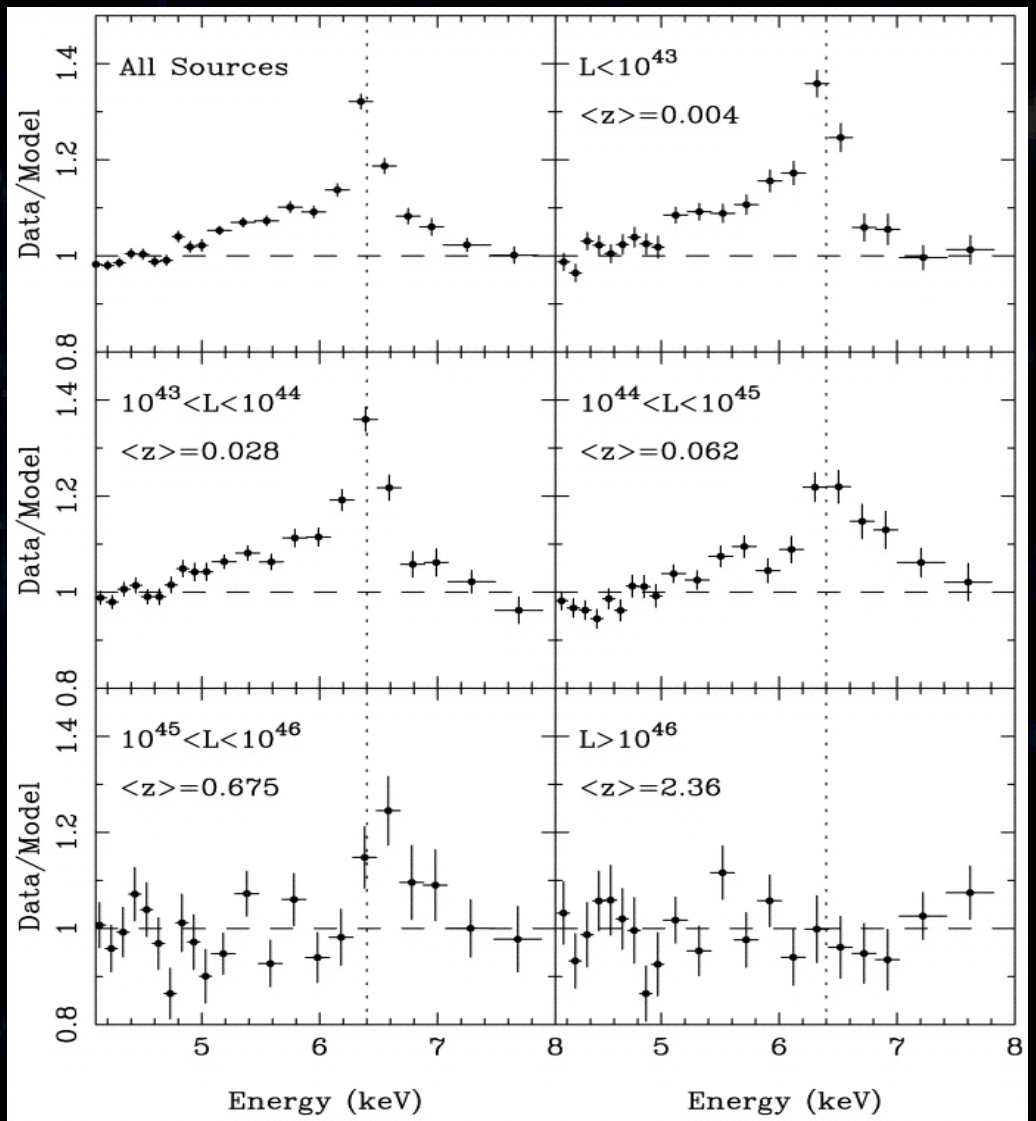
Spin



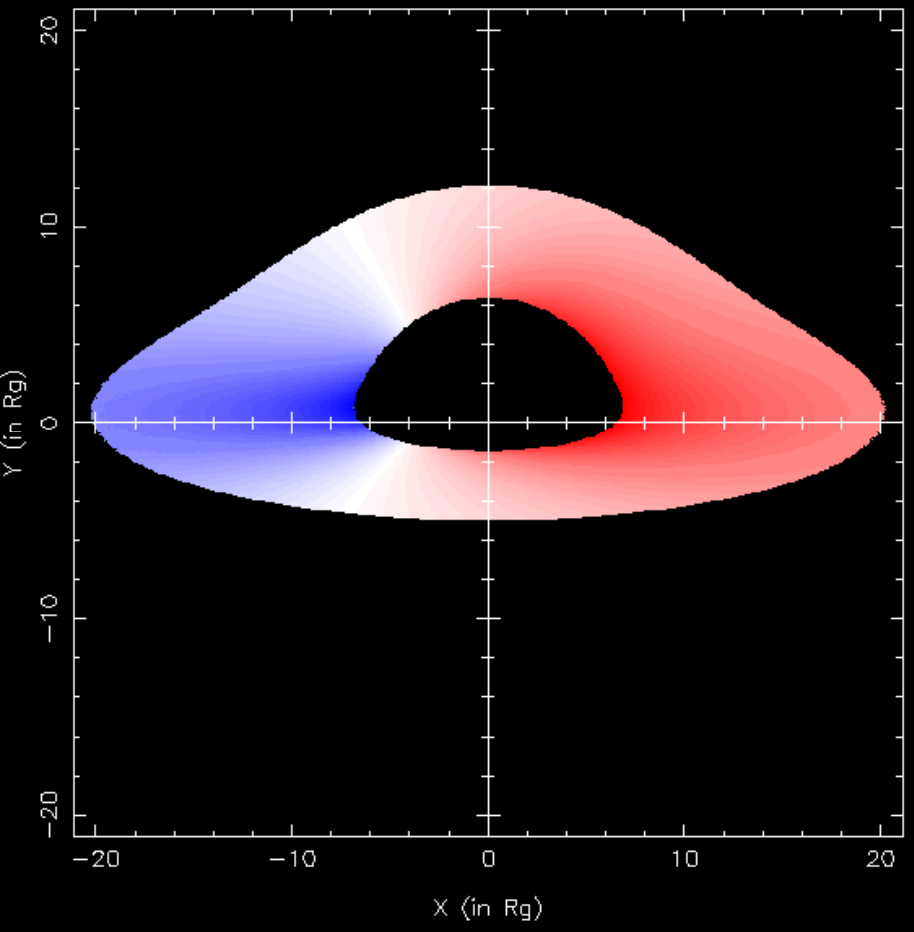
Mass of the black hole

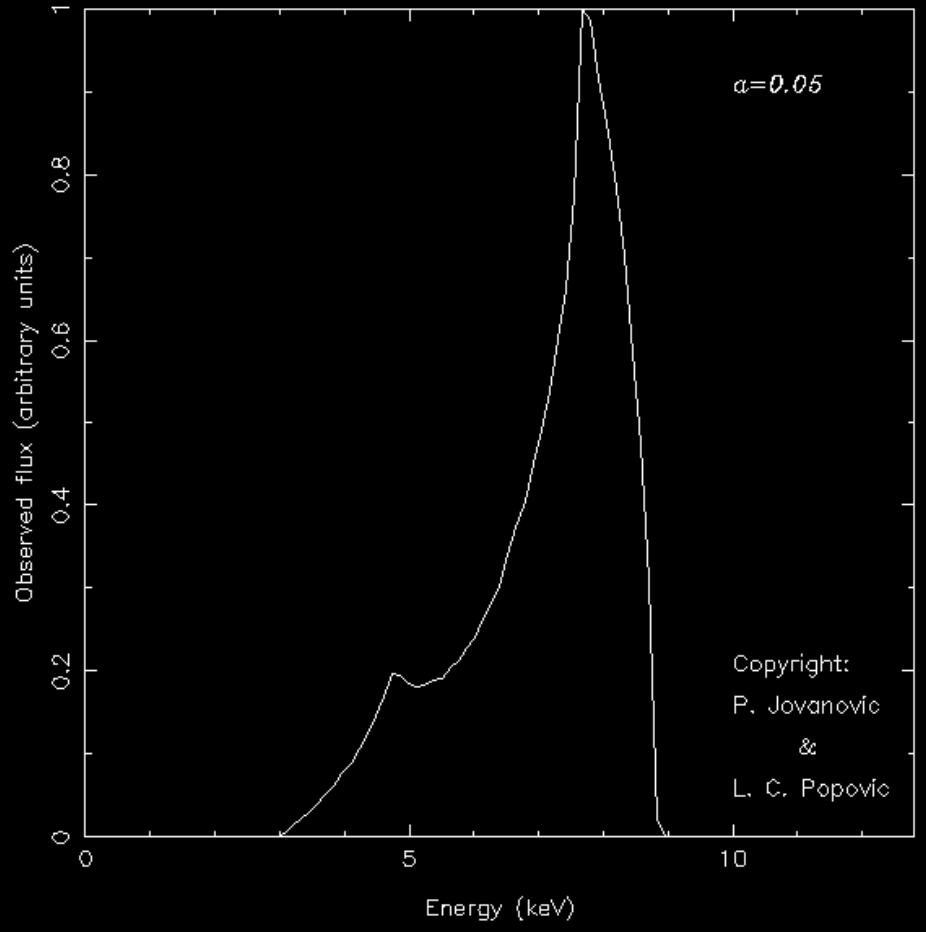


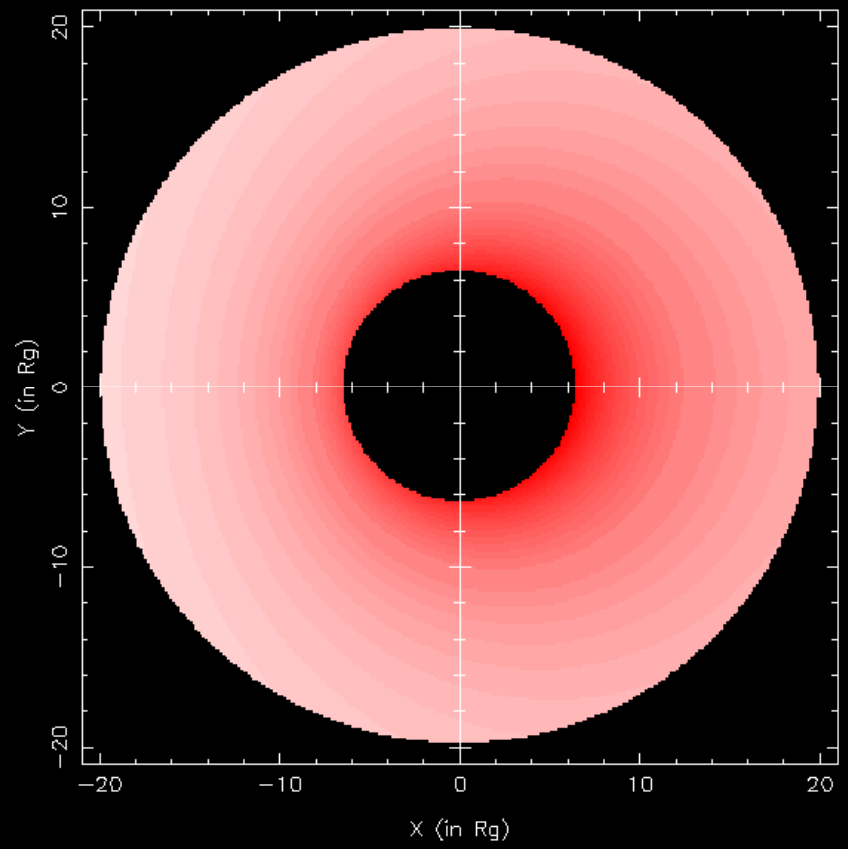
Nandra et al. 1997, 2007

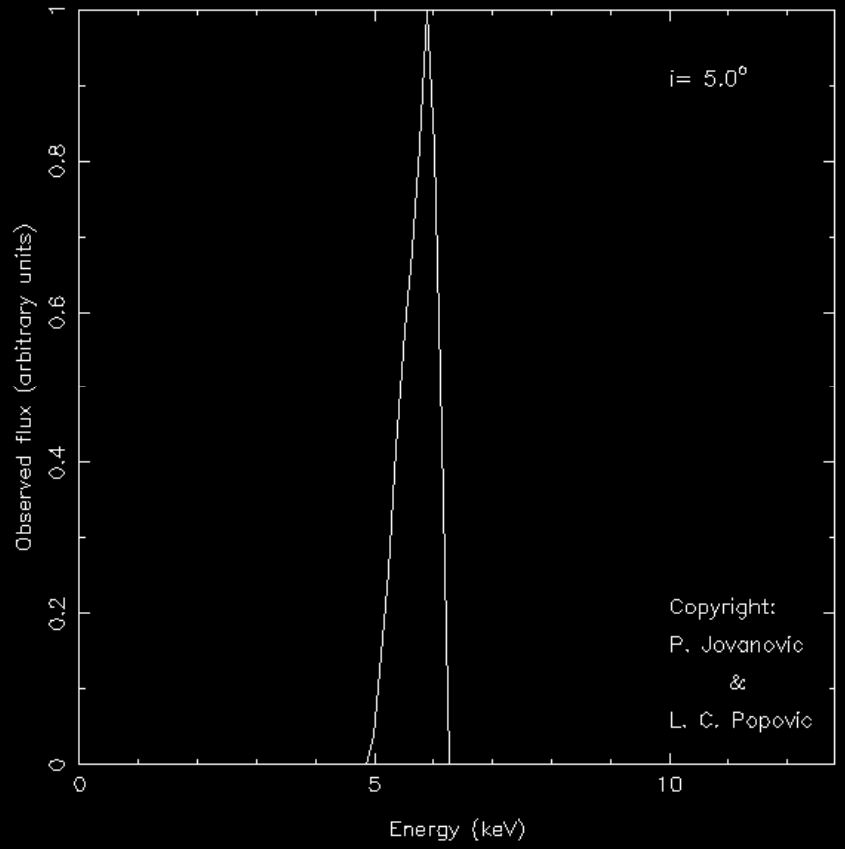


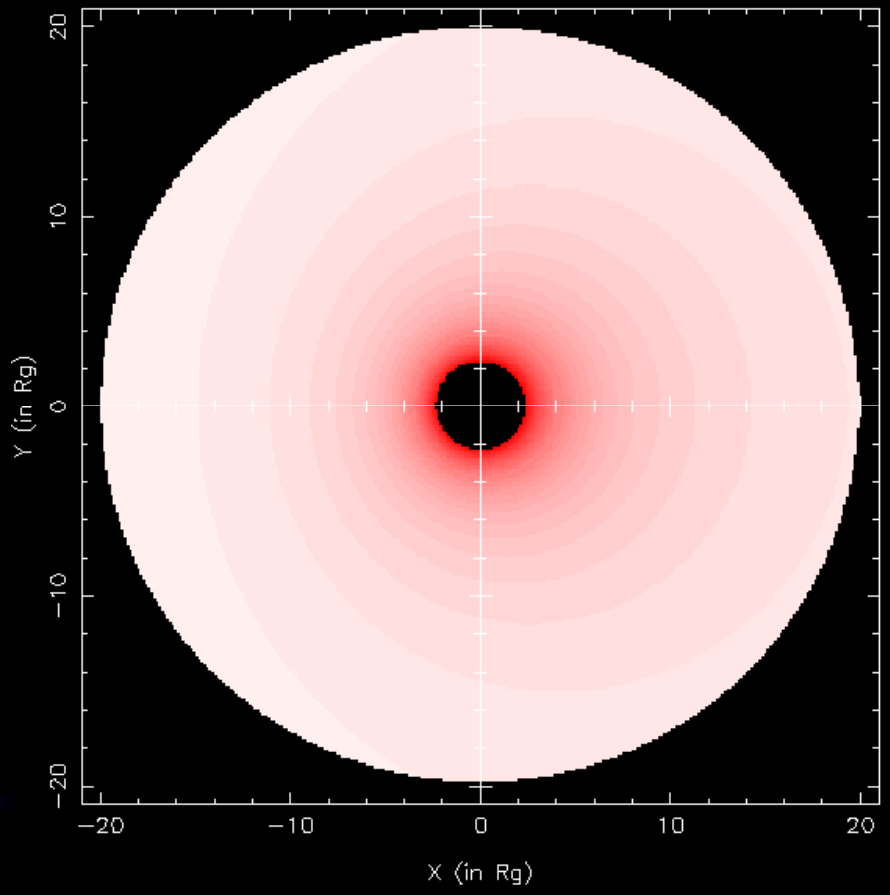
Jovanovic & Popovic 2008, 2009






Y (in Rg)
X (in Rg)
20
10
0
−10
−20
−20
−10
0
10
20


Observed flux (arbitrary units)
Energy (keV)
i= 5.0°
Copyright:
P. Jovanovic
&
L. C. Popovic
0
0.2
0.4
0.6
0.8
1
0
5
10


Y (in Rg)
X (in Rg)
20
10
0
−10
−20
−20
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10
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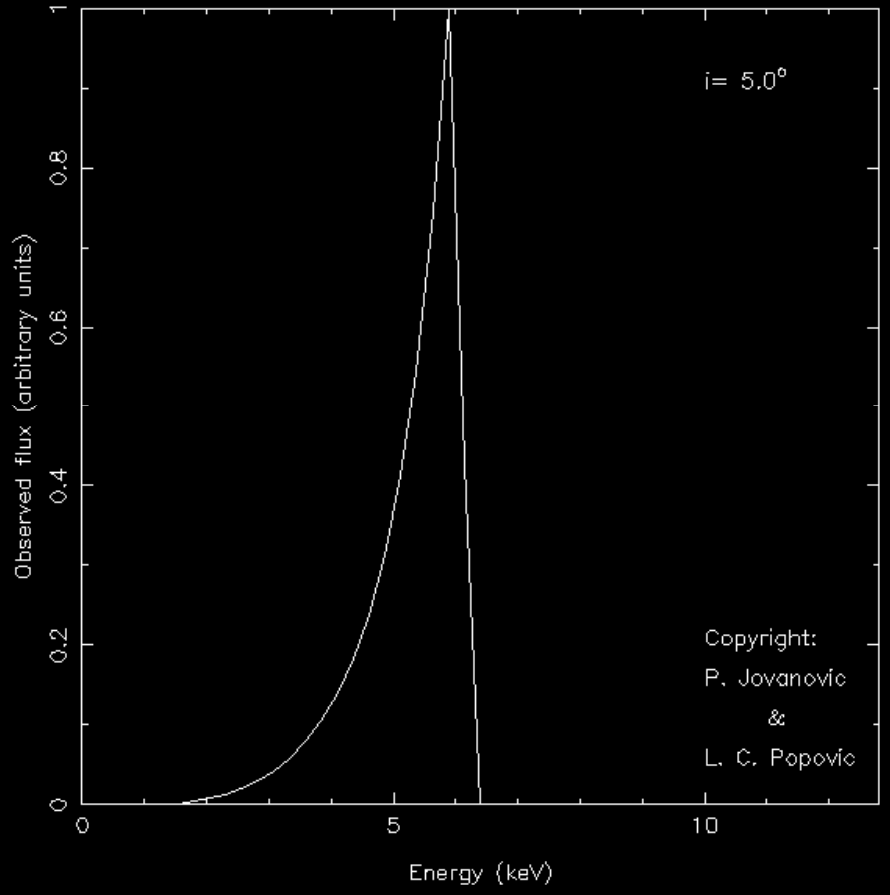
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Copyright:
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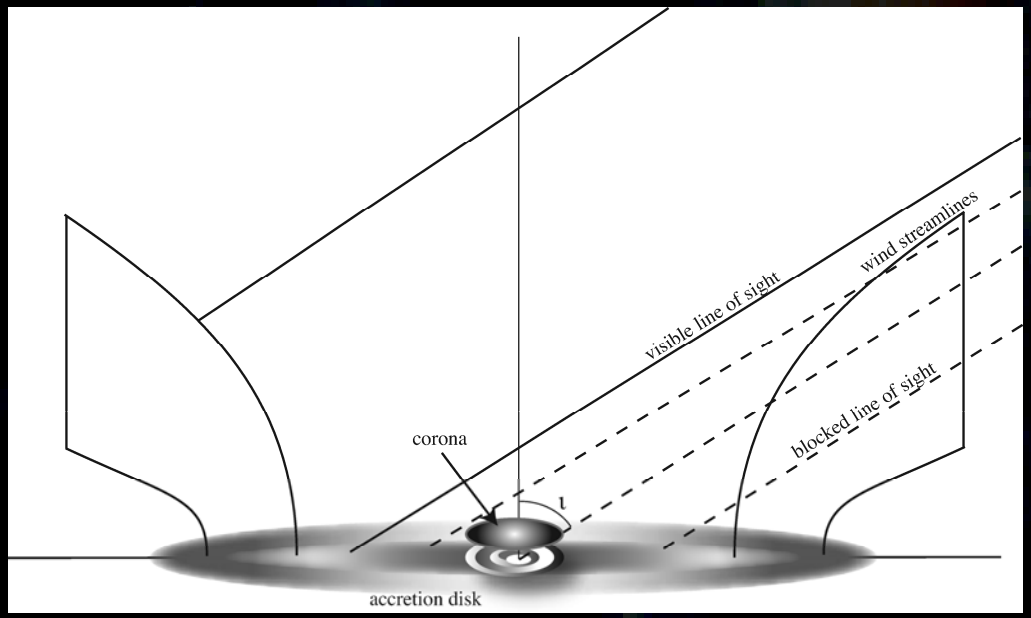
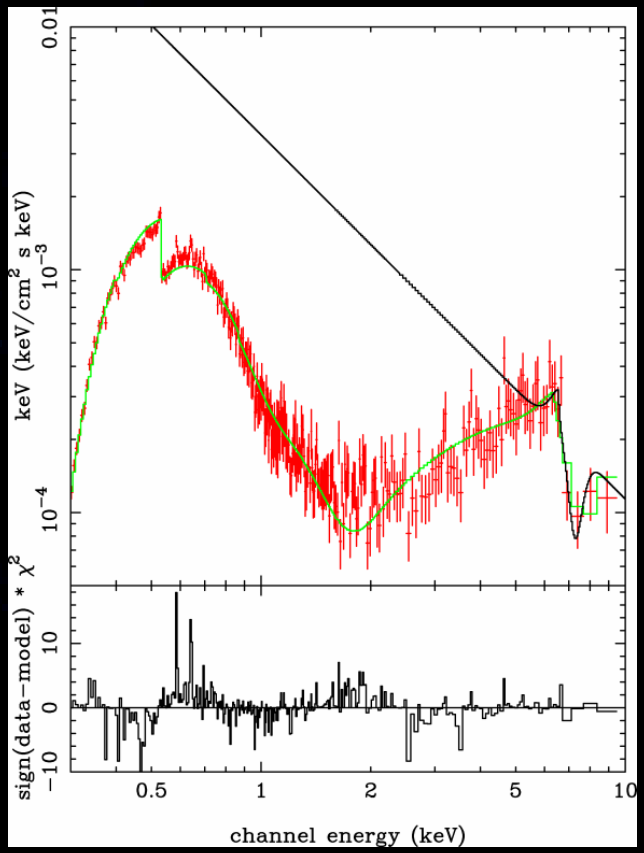
0
0.2
0.4
0.6
0.8
1
0
5
10

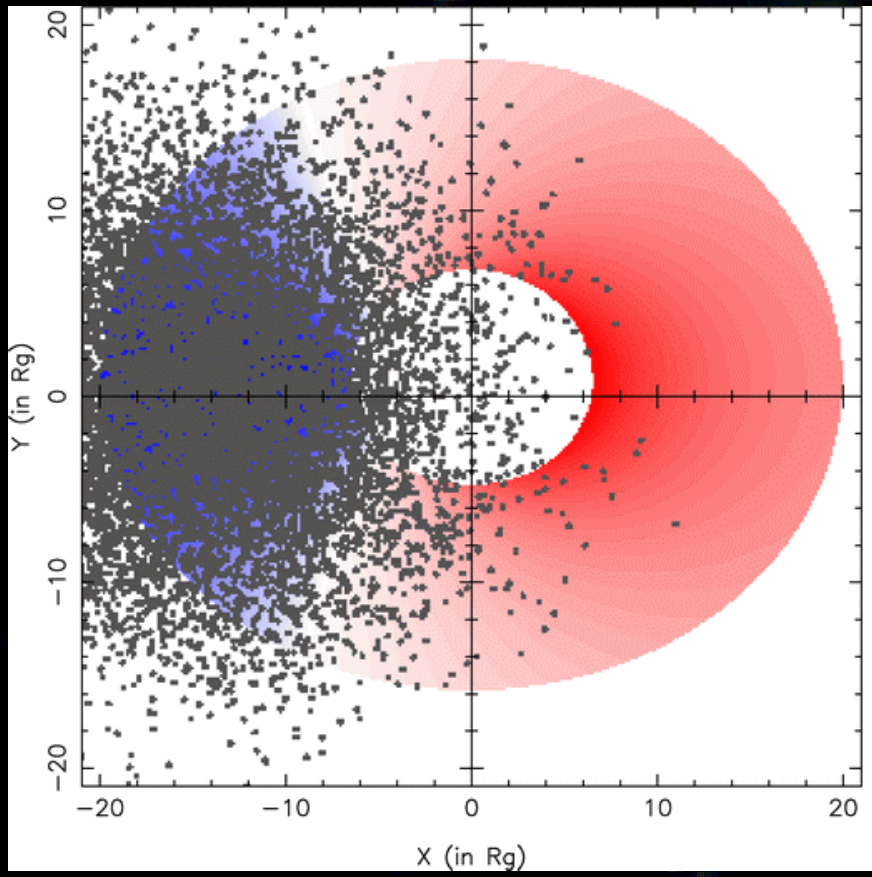
Wind in the accretion disk

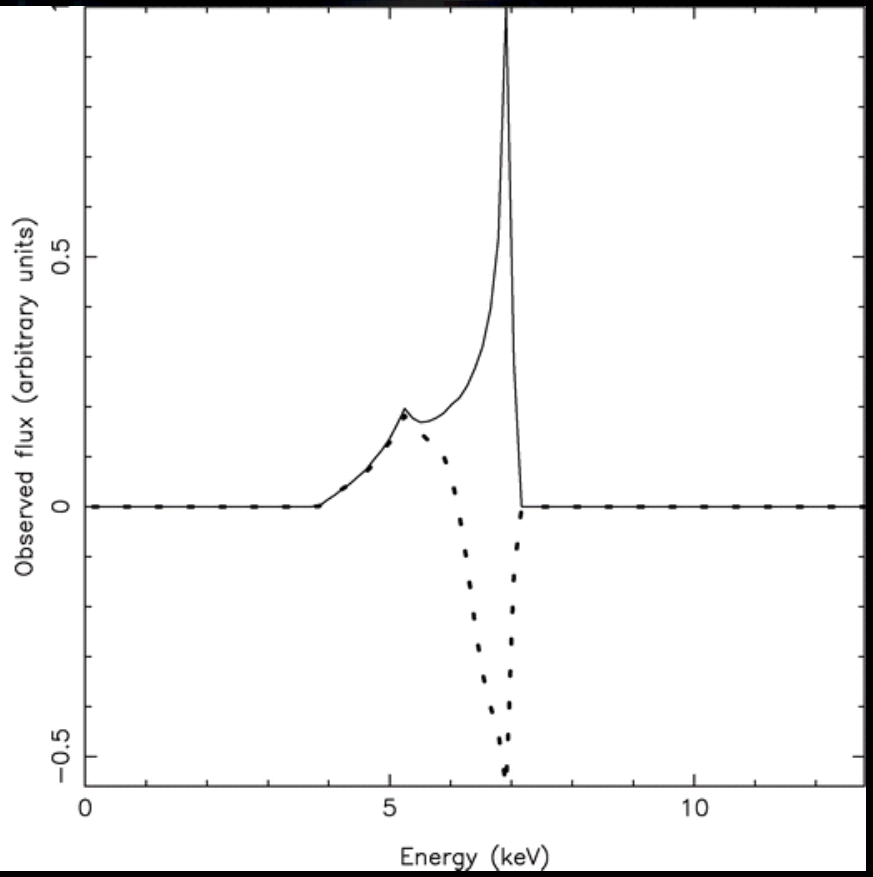
- We observed Fe K P-Cyg profile (Chartas et al. 2007)



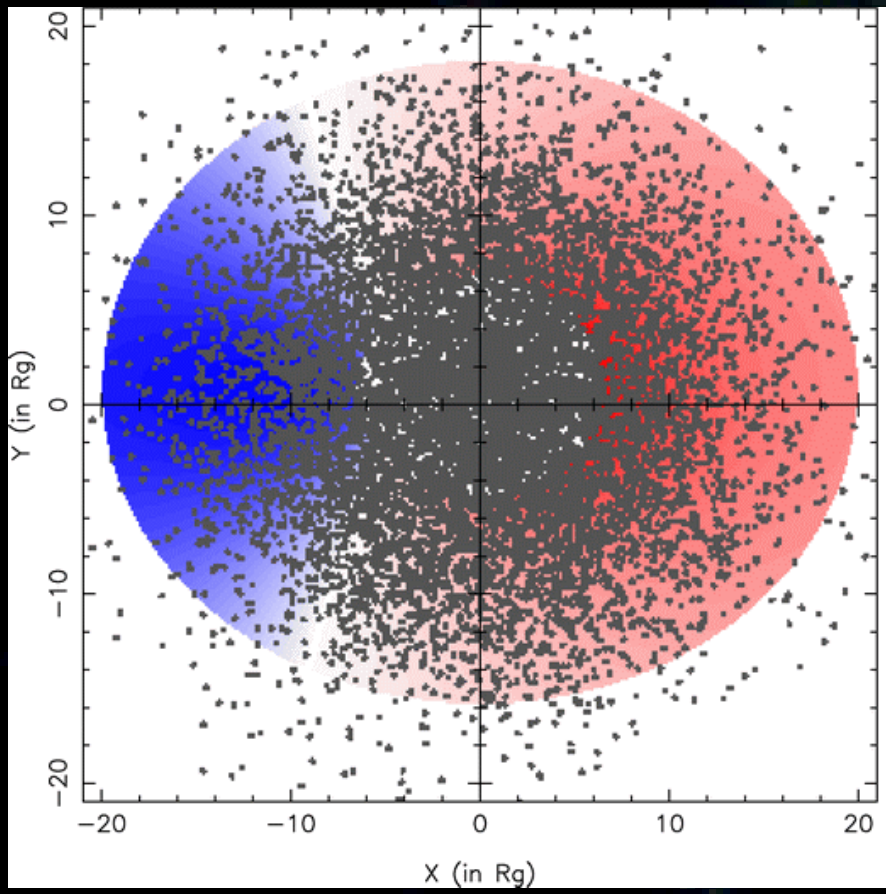


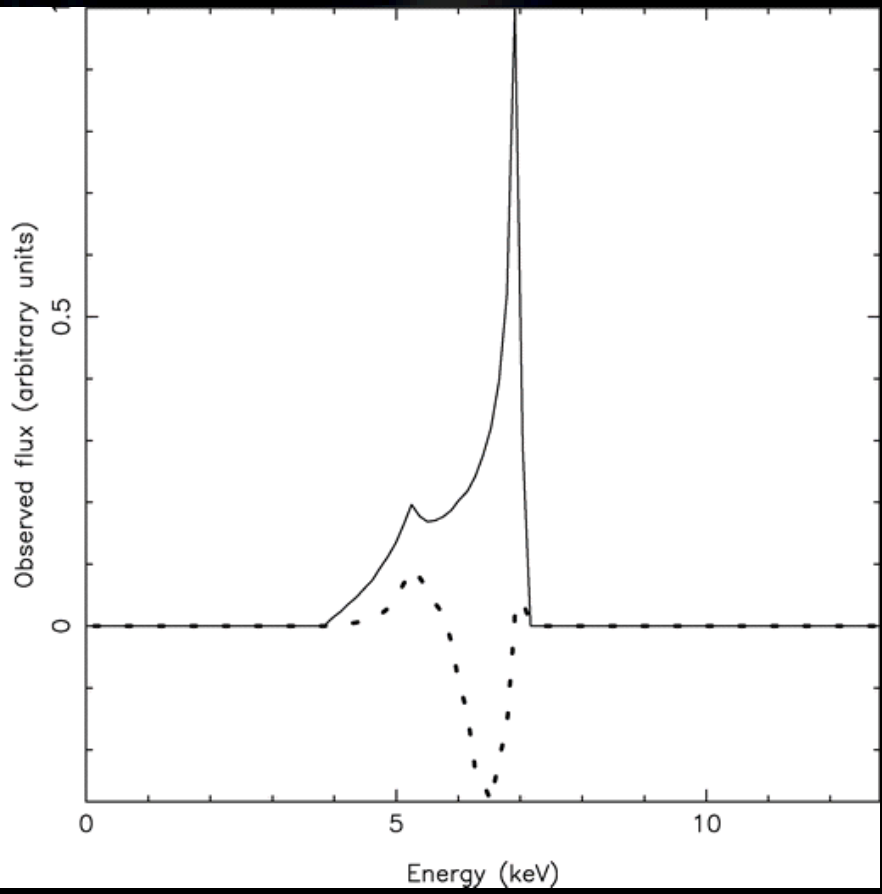
- **Case I:** $X_A = -15\ R_g$, $Y_A = 0\ R_g$



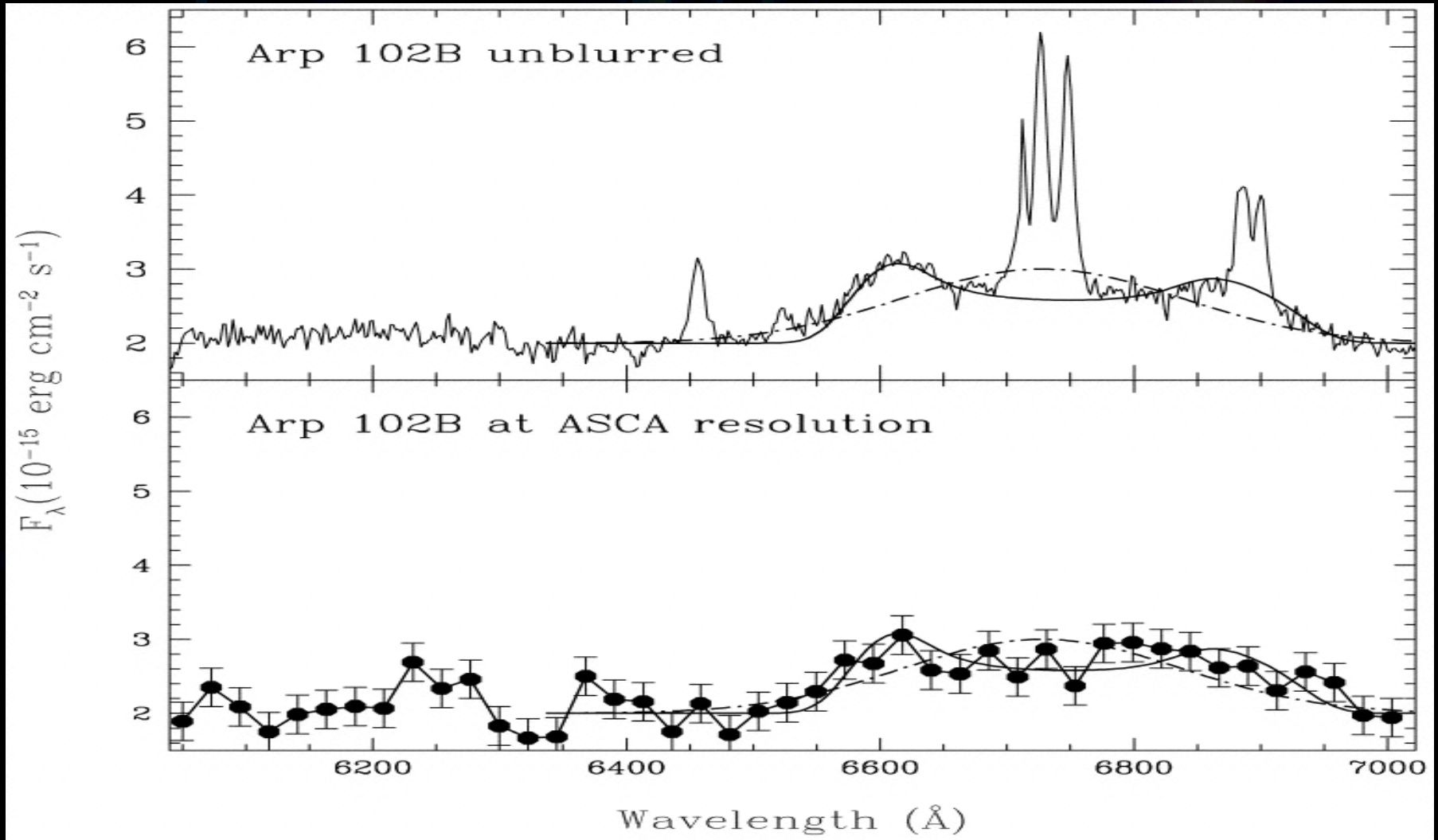


- **Case II**: $X_A = 0\ R_g$, $Y_A = 0\ R_g$

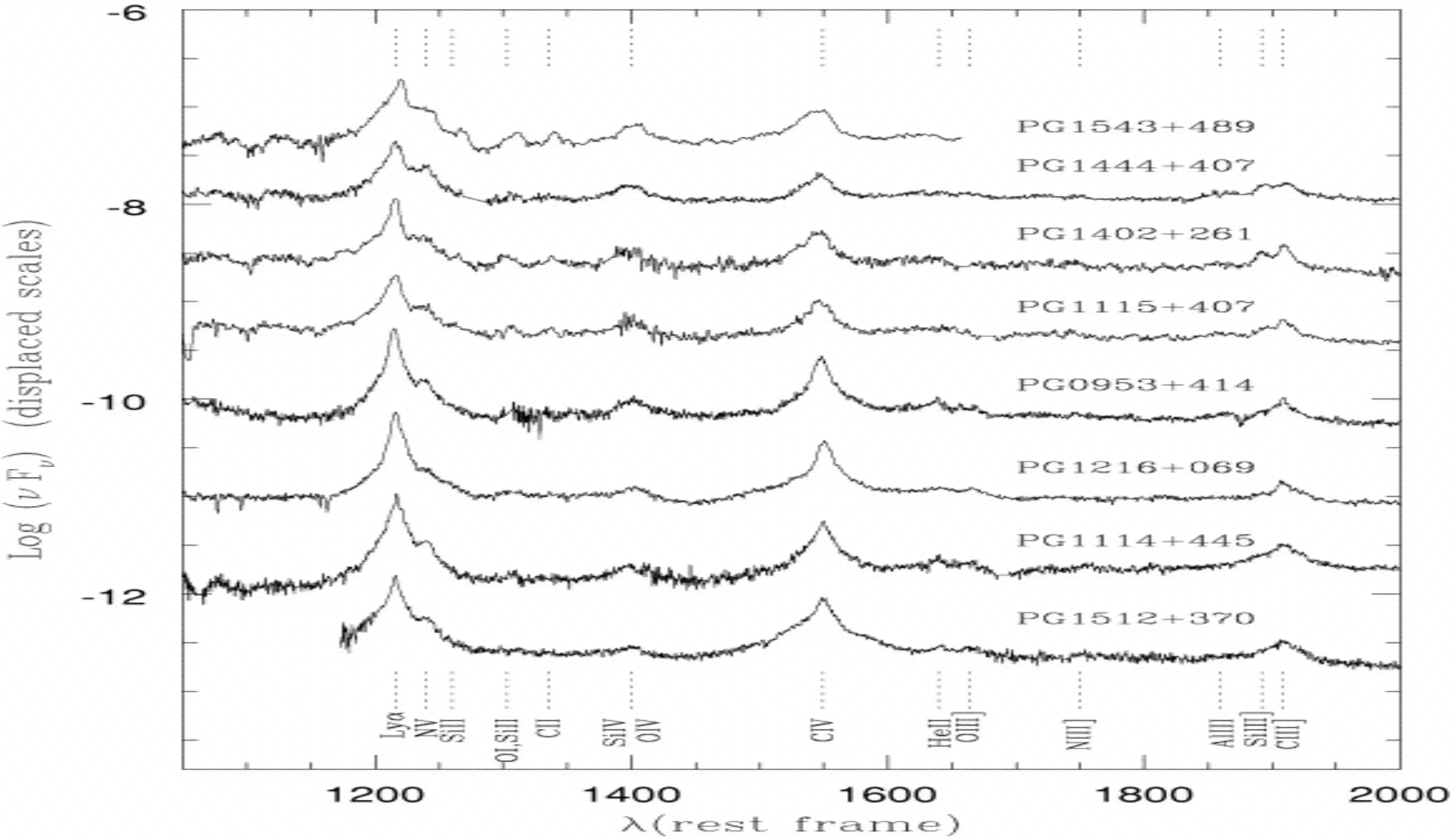


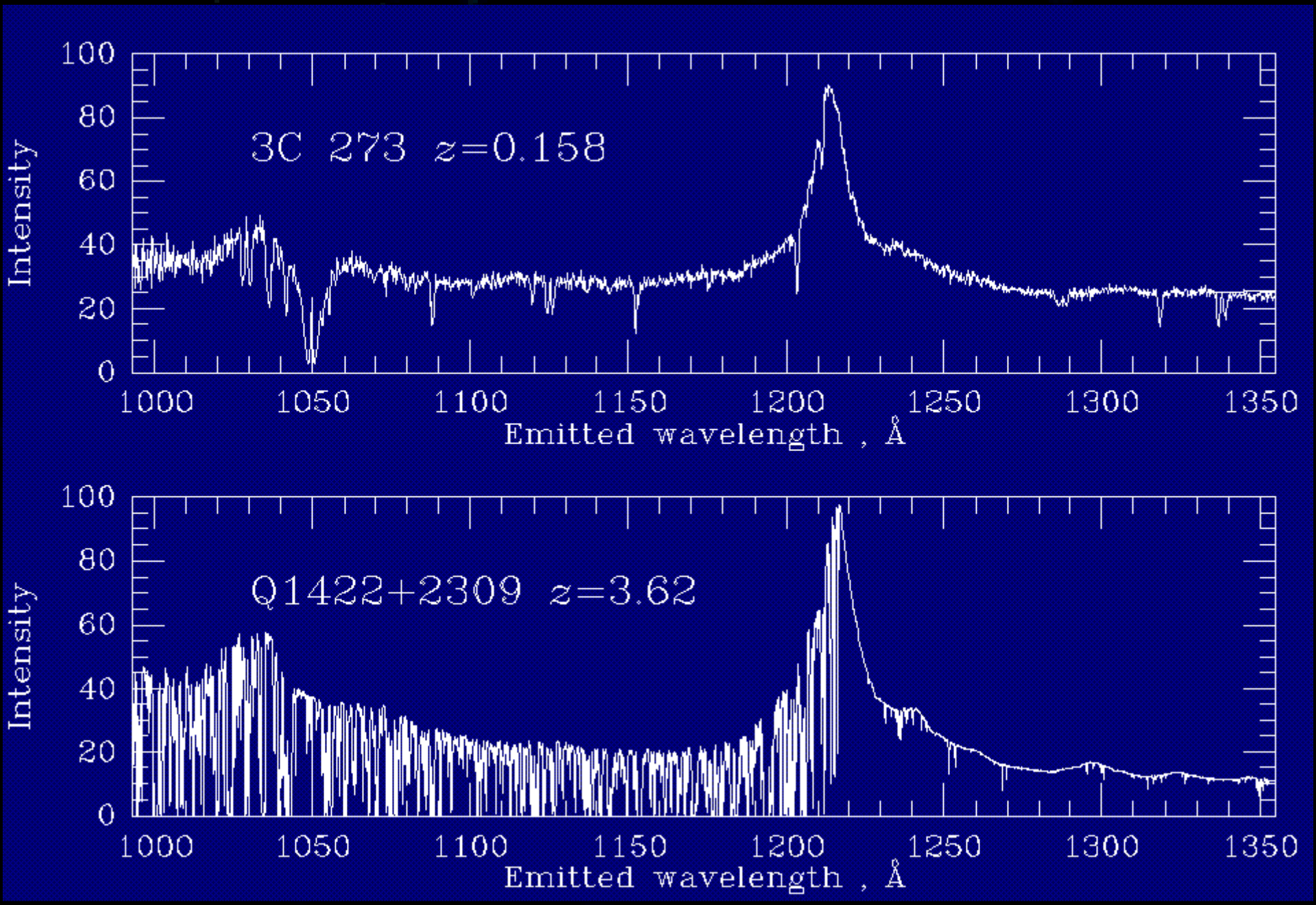


Problem: Low resolution in the X-ray (Sulentic et al. 1998)

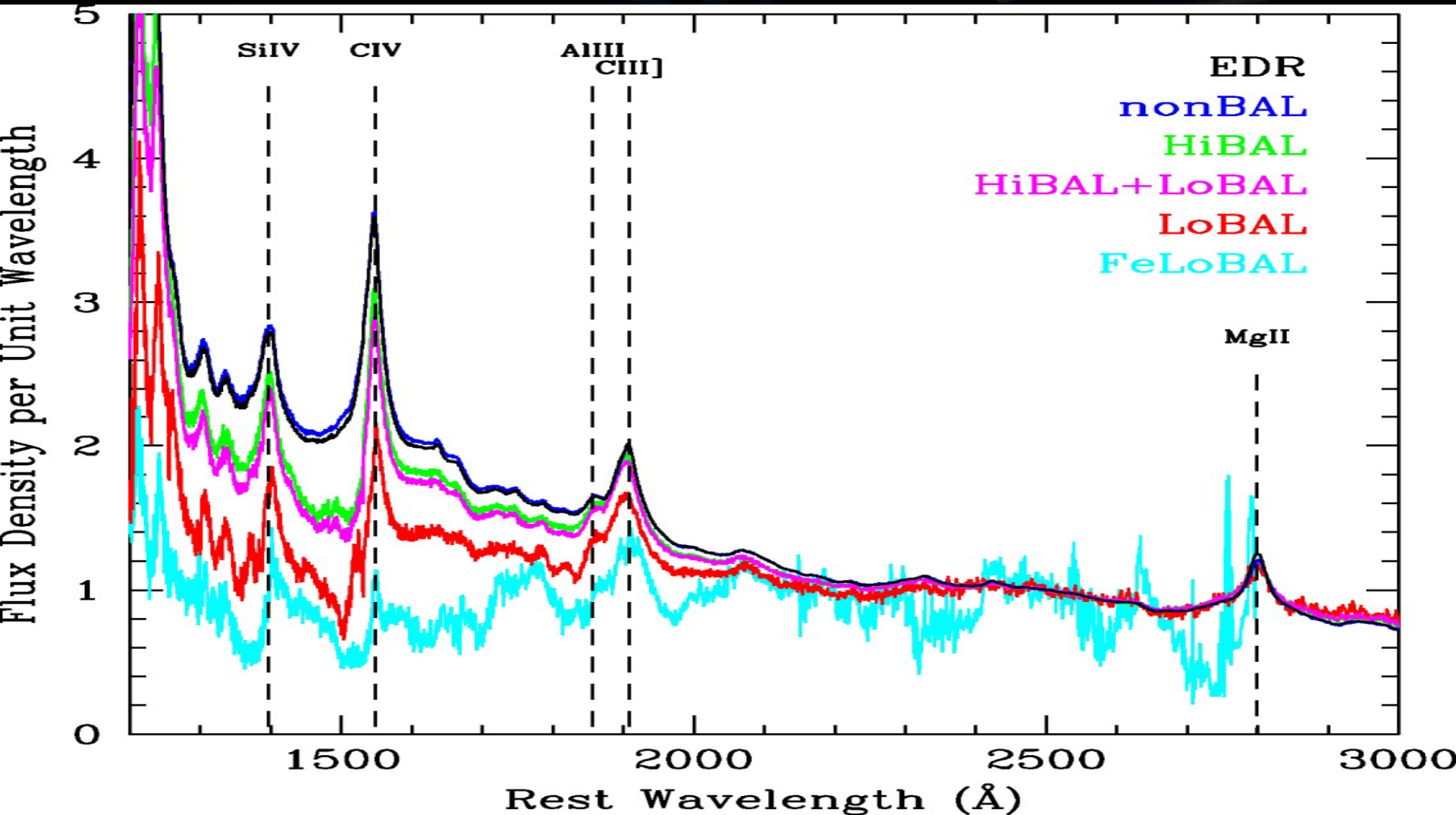


UV-lines (Wills et al. 1999)

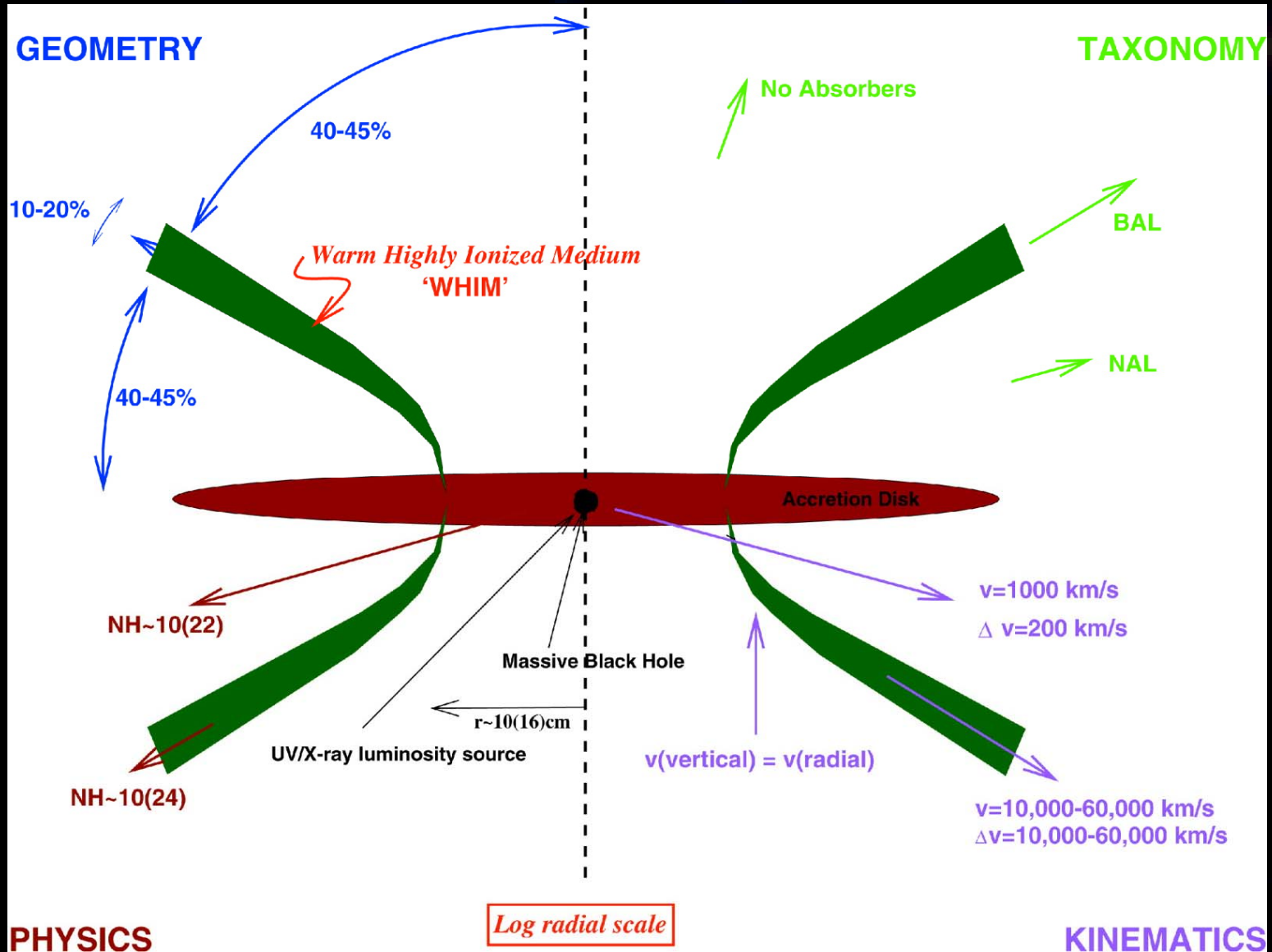



3C 273 z=0.158
Intensity
Emitted wavelength , Å
Q1422+2309 z=3.62
Intensity
Emitted wavelength , Å

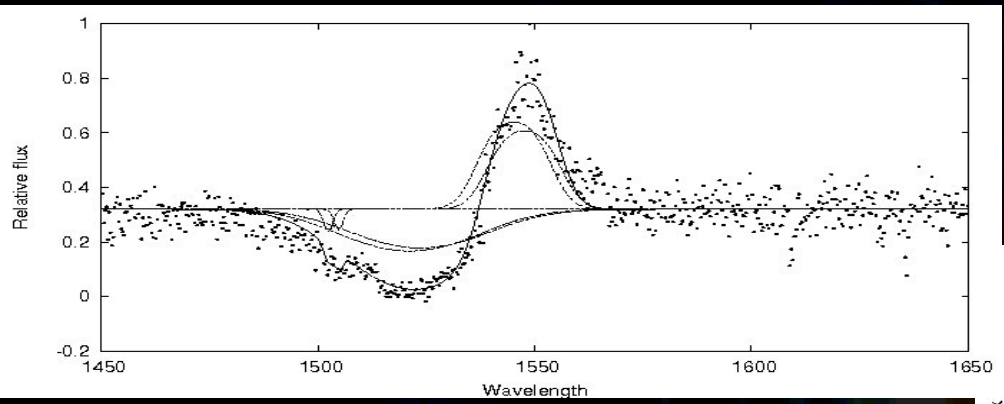
UV-lines (Richards et al. 2004)

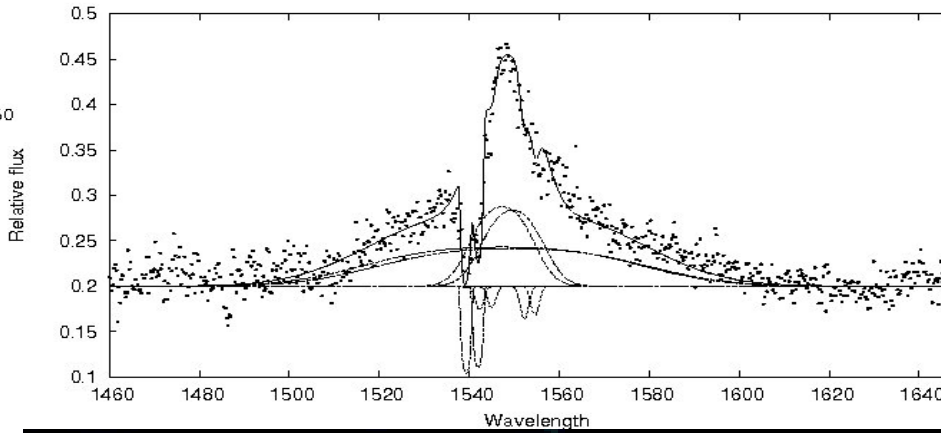


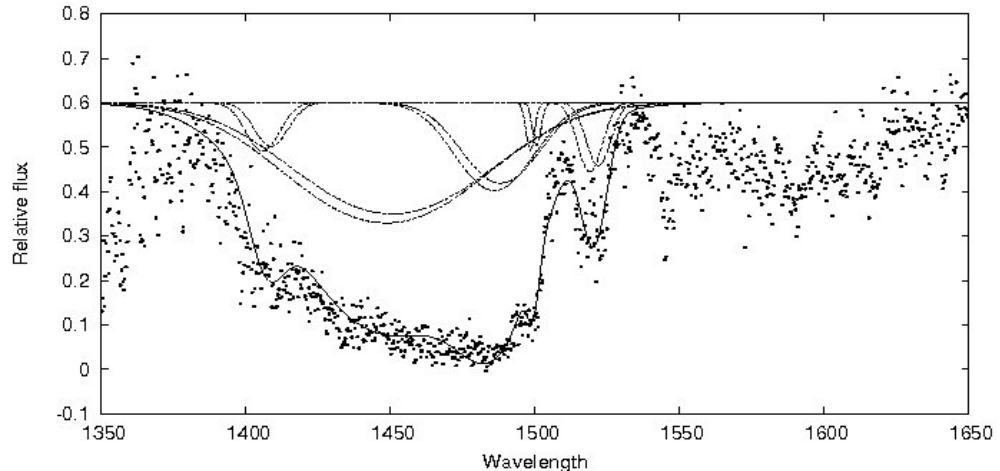
Structure of a QSO (Elvis 2000)

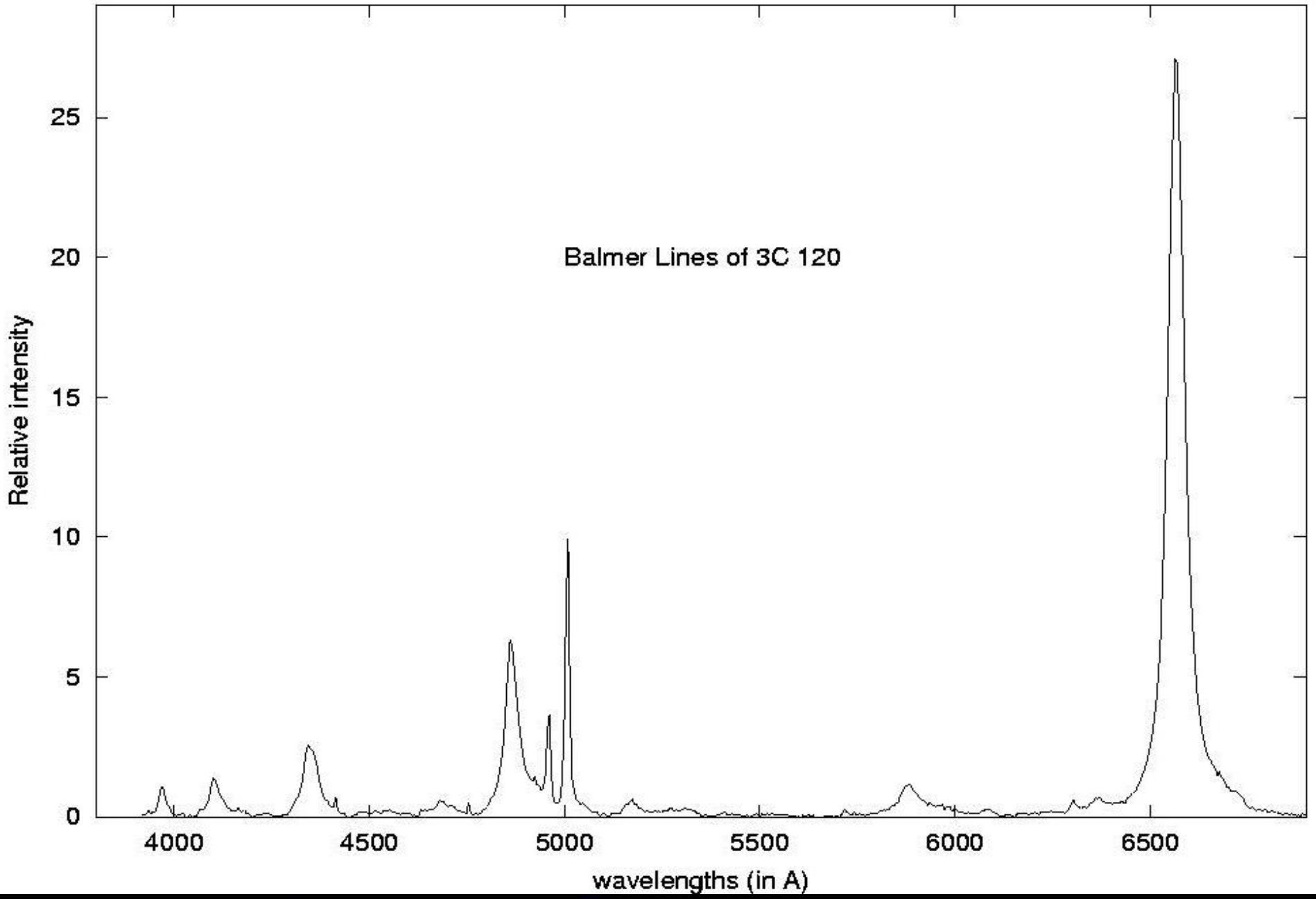


Modeling of the wind (Lyratzi et al. 2009)








Balmer Lines of 3C 120
Relative intensity
0
5
10
15
20
25
4000
4500
5000
5500
6000
6500
wavelengths (in A)

Broad Lines - BLR

- **Structure (Geometry):**

Disk, Spherical distributed clouds, outflows, inflows

Several ideas

Modeling the line shapes

- Physics:

Photoionization, the parameters of plasma in BLR

Two-component model

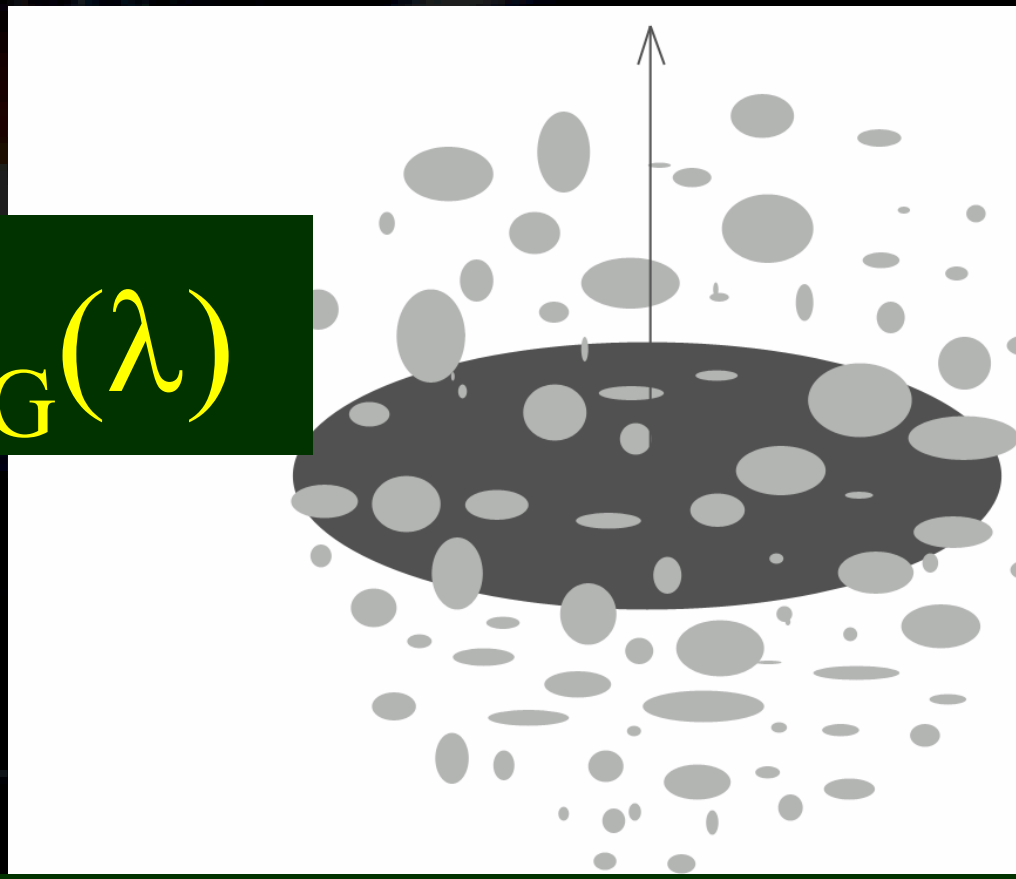
- The disk is contributing to the wings of the lines,
- a spherical region arround the disk => line core.

The whole line profile can be described by the relation:

$$I(\lambda)=I_{AD}(\lambda)+I_{G}(\lambda)$$

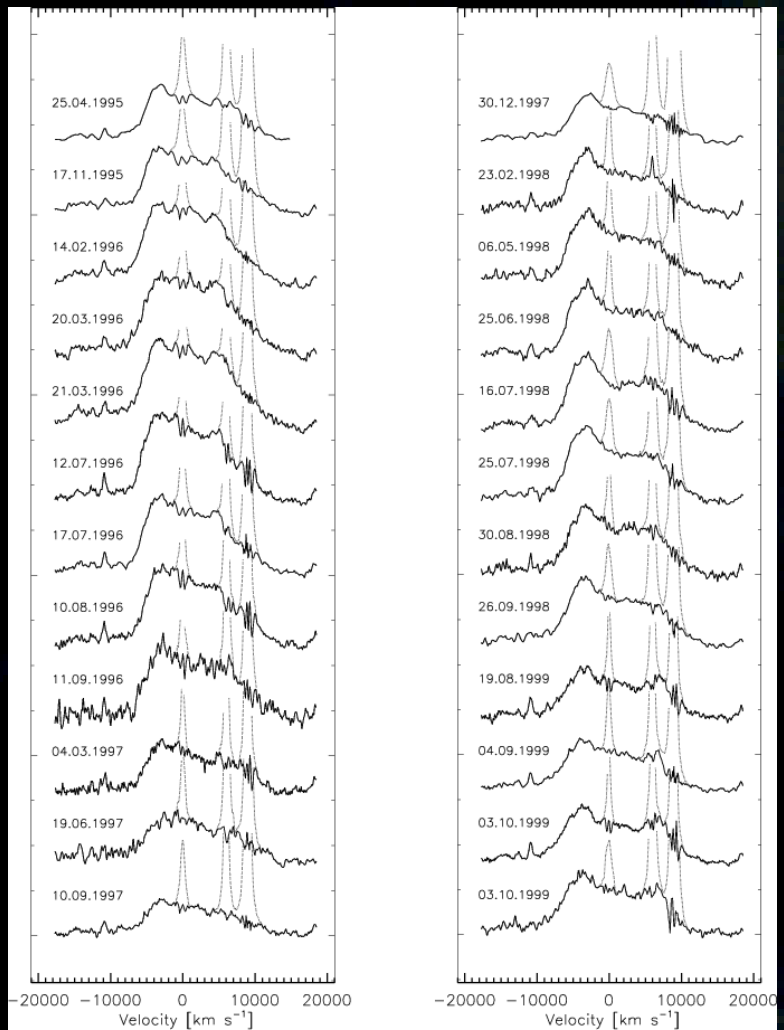
$I_{AD}(\lambda)$ the emissions of the relativistic accretion disk

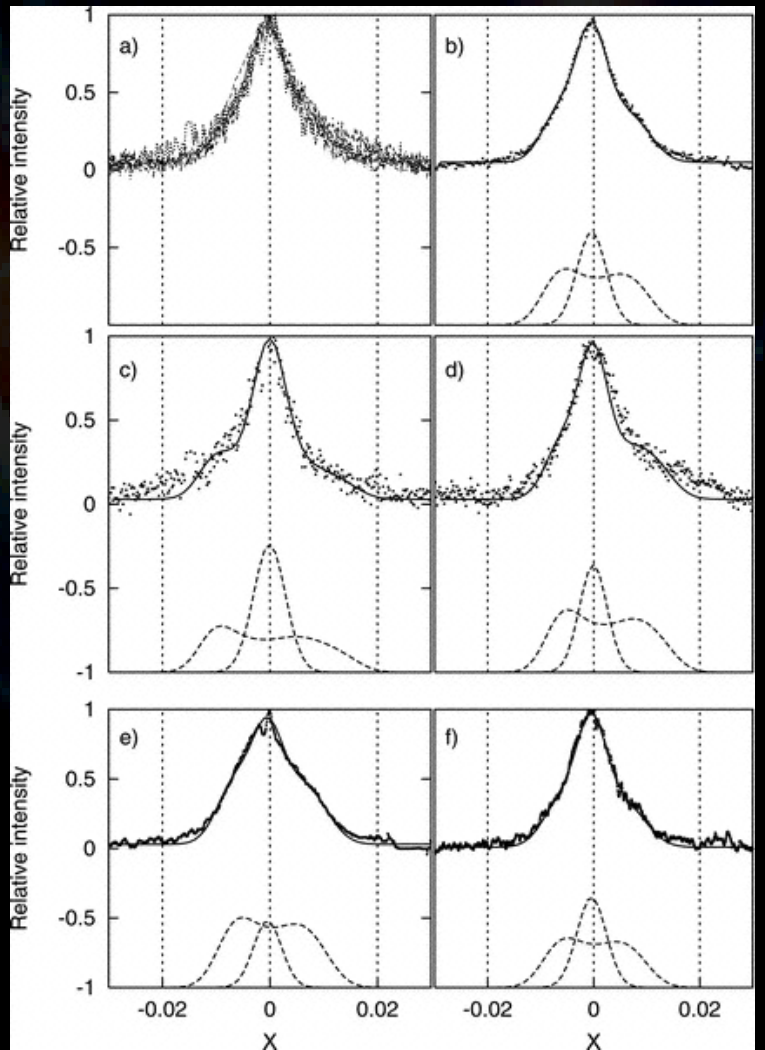
$I_{G}(\lambda)$ the emissions of the spherical region around the disk



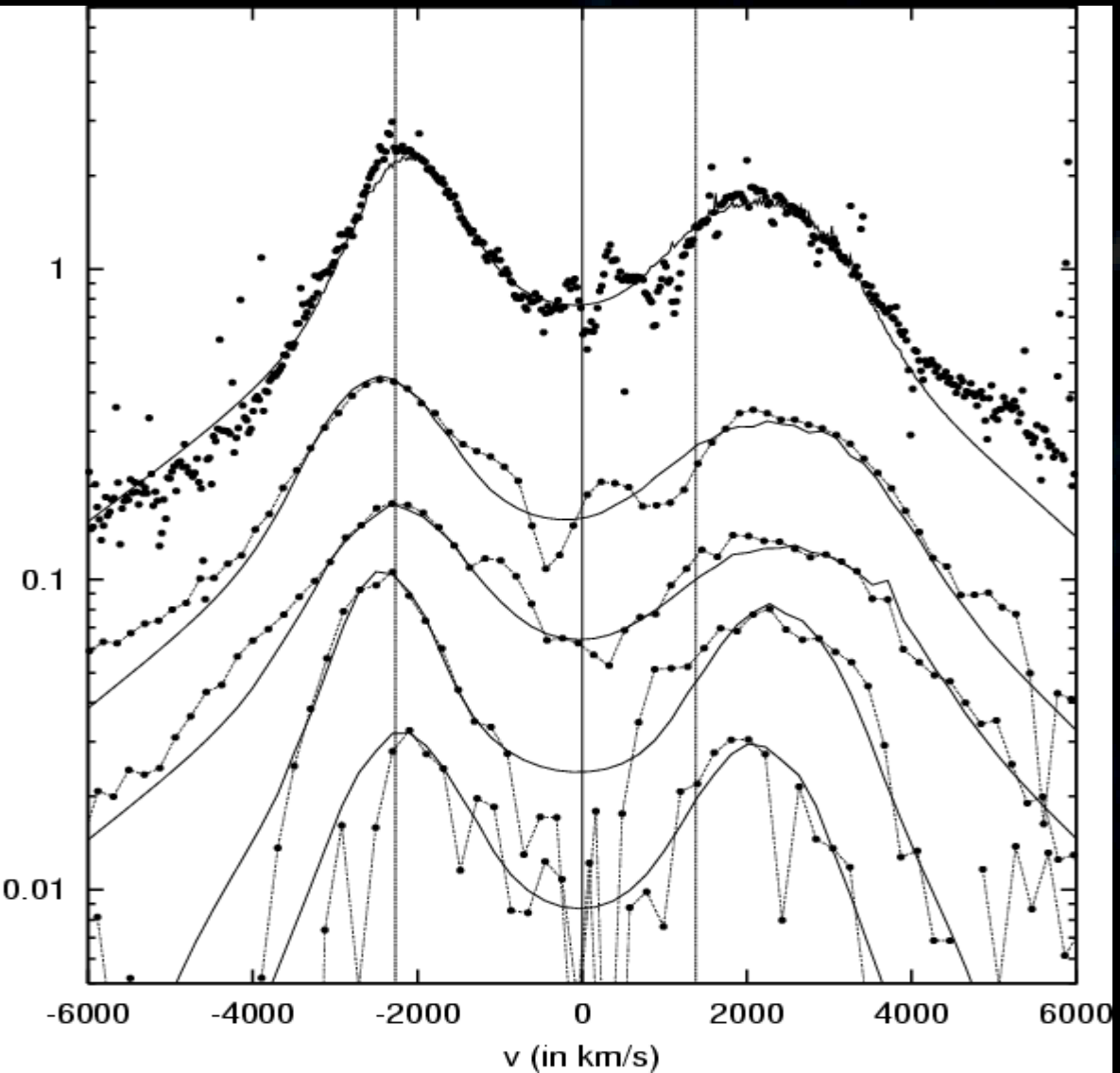
Popovic et al. 2003, 2004, Bon et al 2006, 2009 Ilic et al.

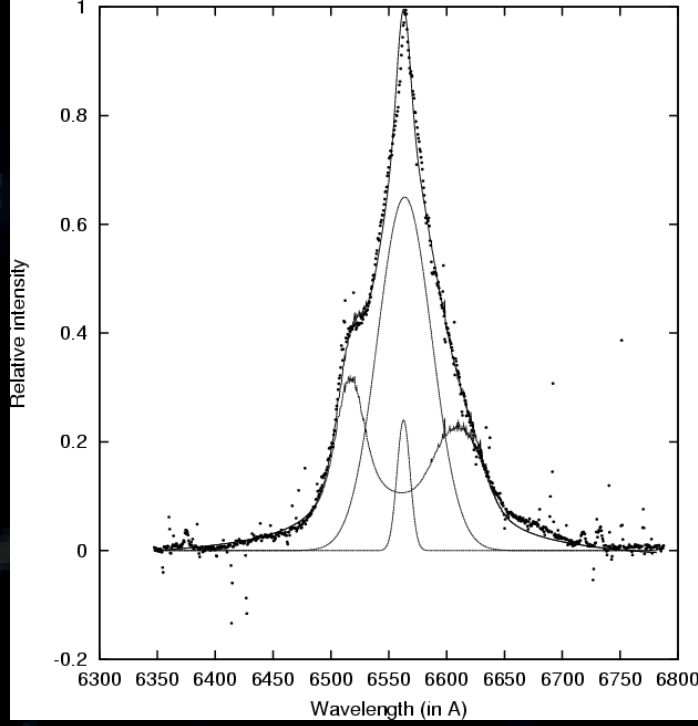
An example: 3C390.3 (Shapovalova et al. 2001)-left and III ZW2 –right (Popovic et al. 2003)

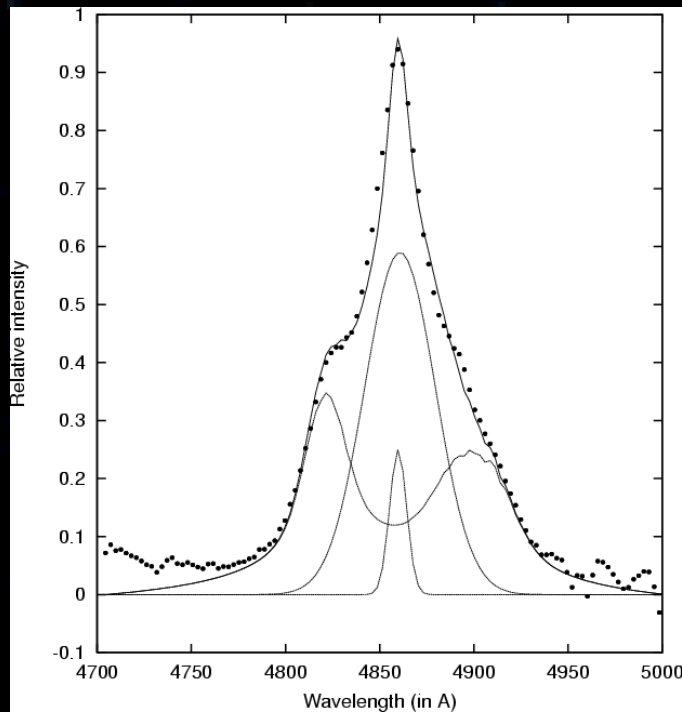




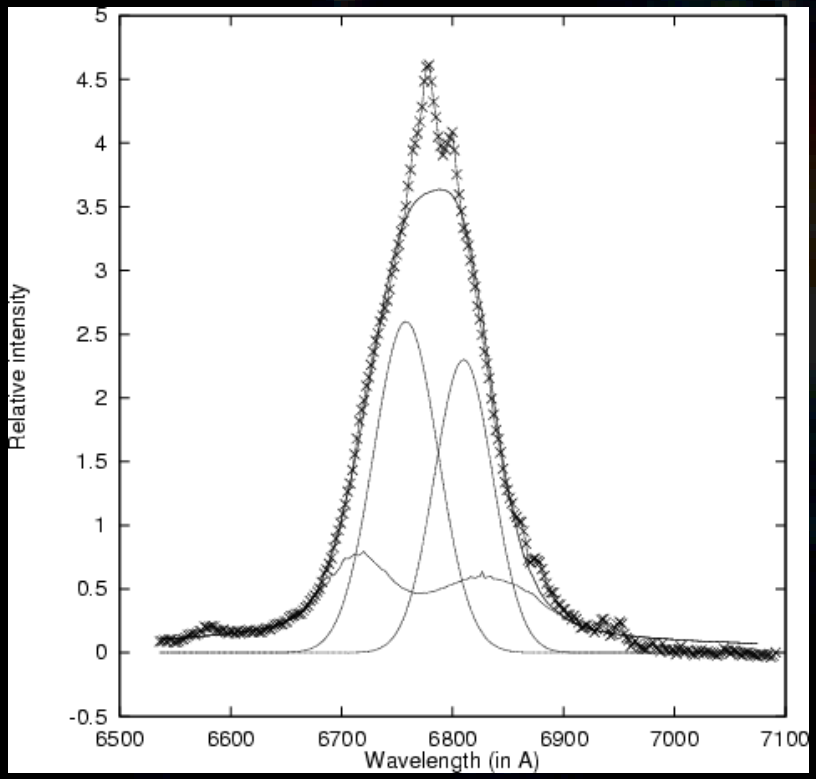
Balmer lines (Popovic et al. 2002)

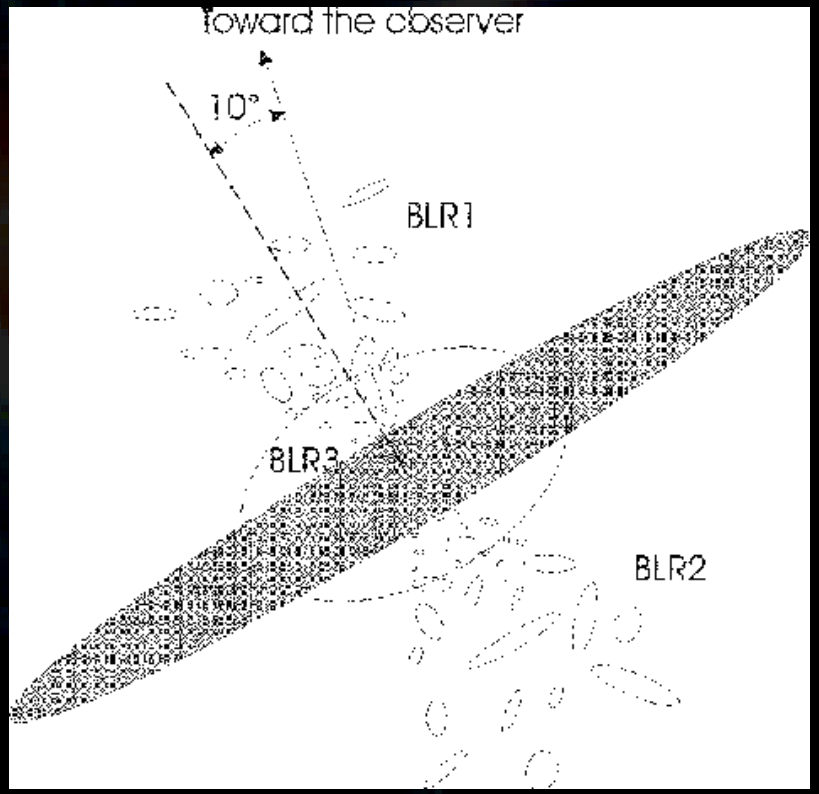






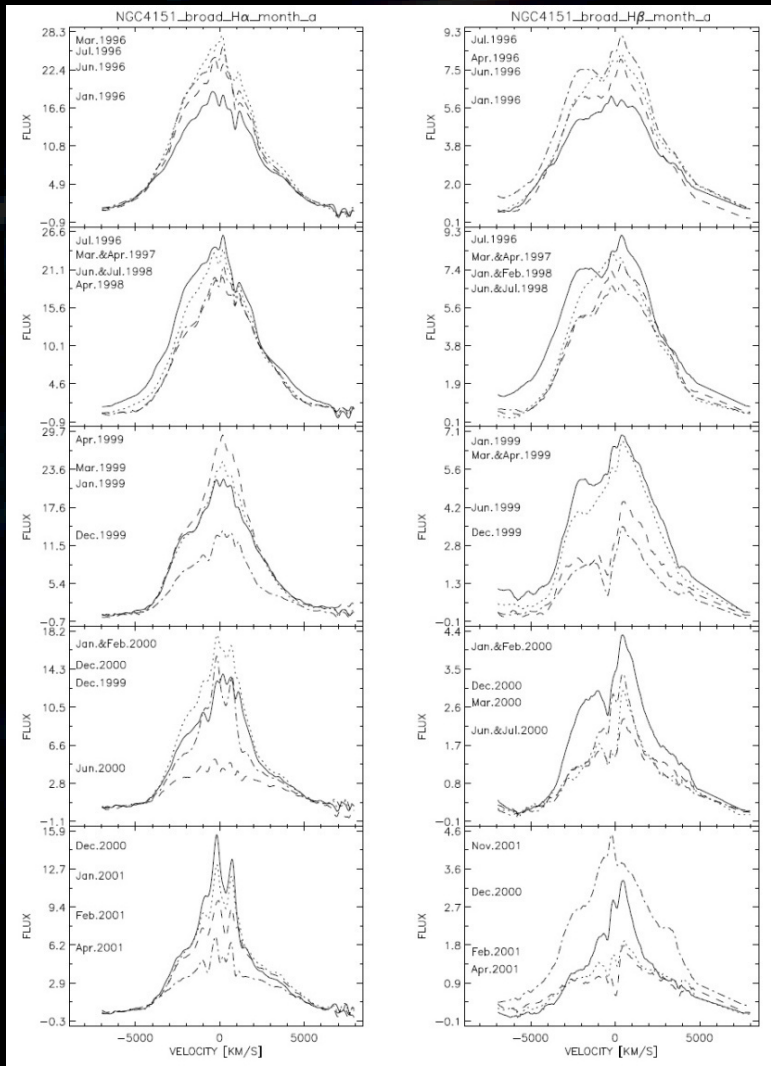
Ark 120 (Popovic et al. 2001) – BLR disk + outflows



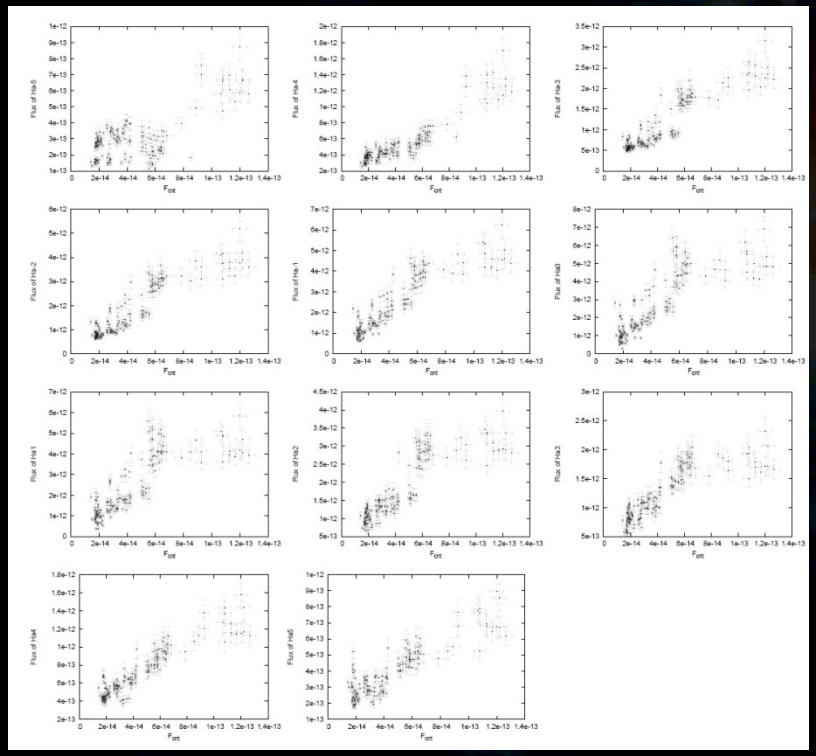


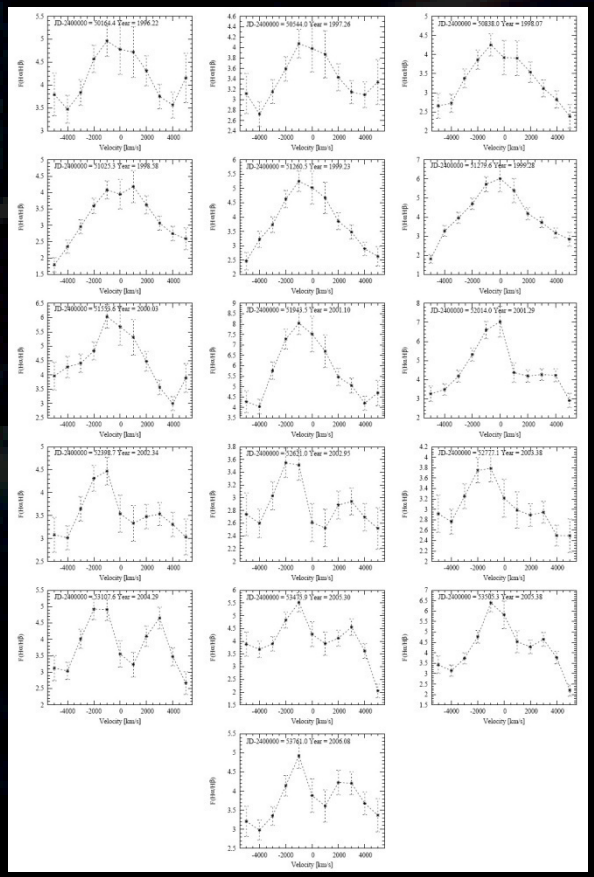
Physics

- Photoionization, but also other mechanisms
- As eg. NGC4151 (Shapovalova et al. 2008, 2009)

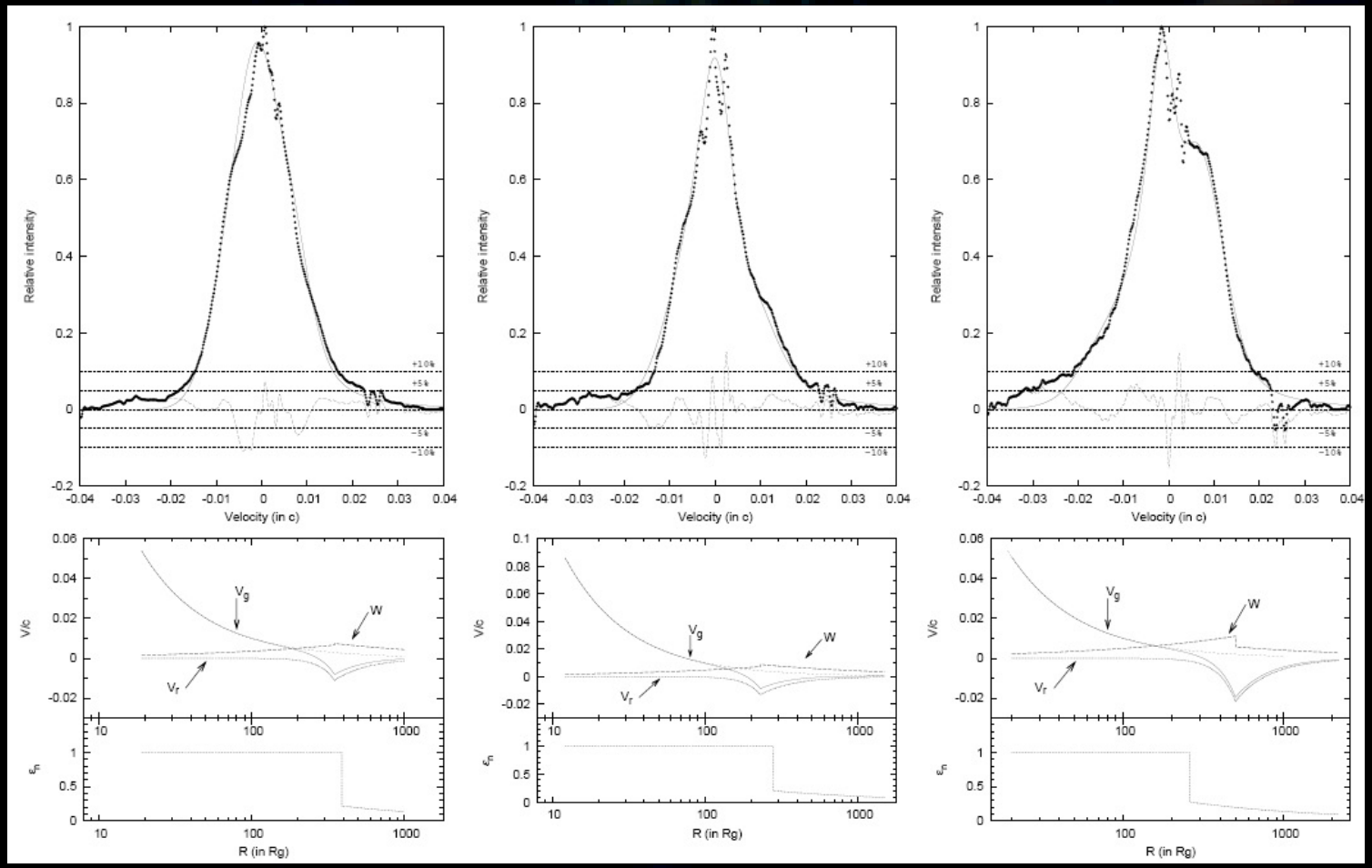


Flux line vs. flux of the continuum and BD of NGC 4151





Outflows in the BLR?



Investigations

- Characteristics of the Broad Absorption Lines
- Broad Lines and model of the BLR
- Physical properties of the BLR
- Gravlens & spectral lines
- Connection between the stellar population and AGN

Conclusions

- Spectral lines from X-ray to optical, shapes affected by the geometry of the emitting/absorbing regions => can be used to find the geometry of the ER
- Disk – wind, what is in the center of quasars, probably both of them
- The line ratios, physics; photoinozitation, but also other mechanism may be present