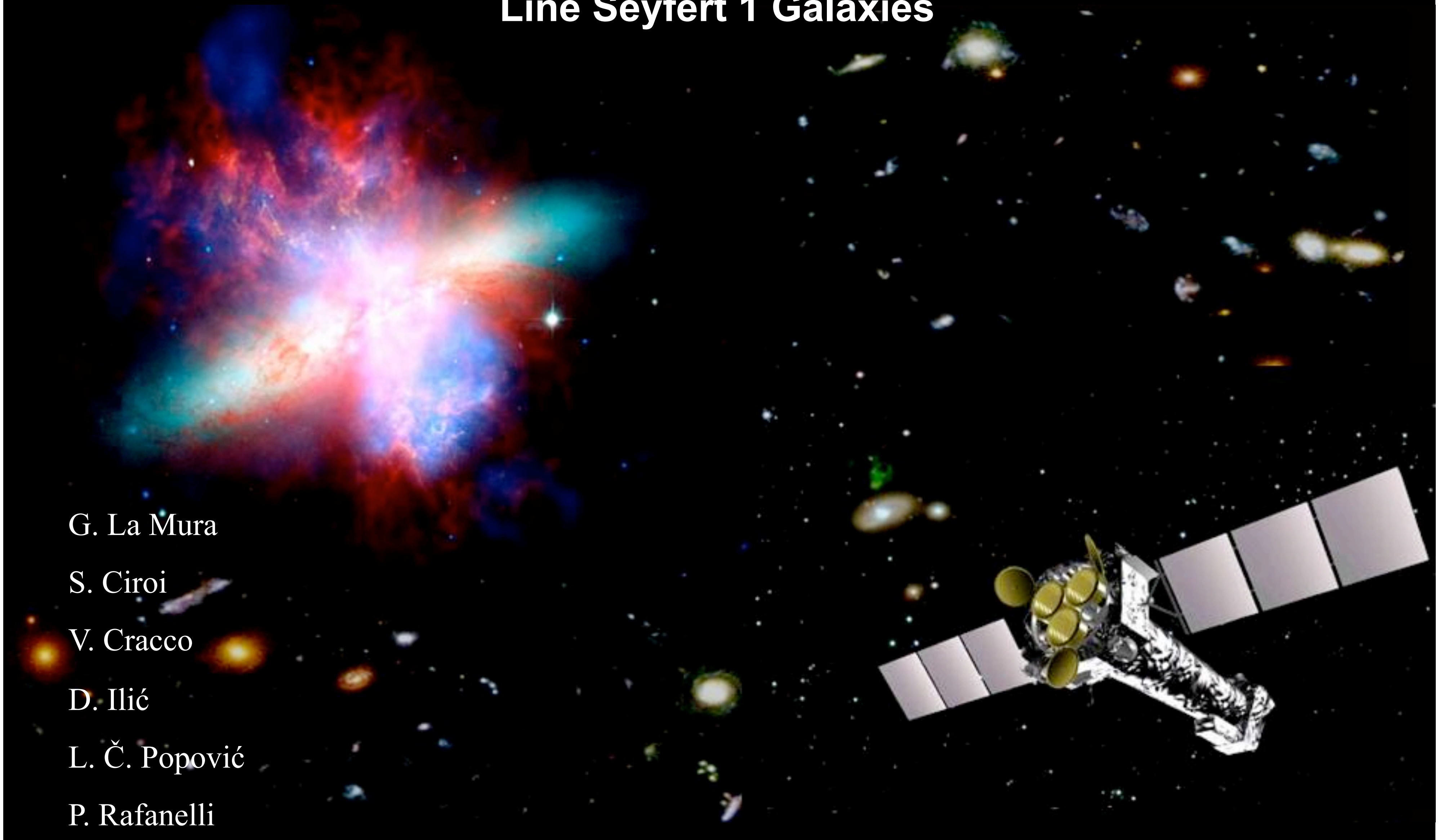
Emission line profiles and X-ray observations of Broad and Narrow Line Seyfert 1 Galaxies



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International Scientific Workshop: "Narrow Line Seyfert 1 Galaxies and their Place in the Universe"

4 – 6 April 2011, Milano – Italy

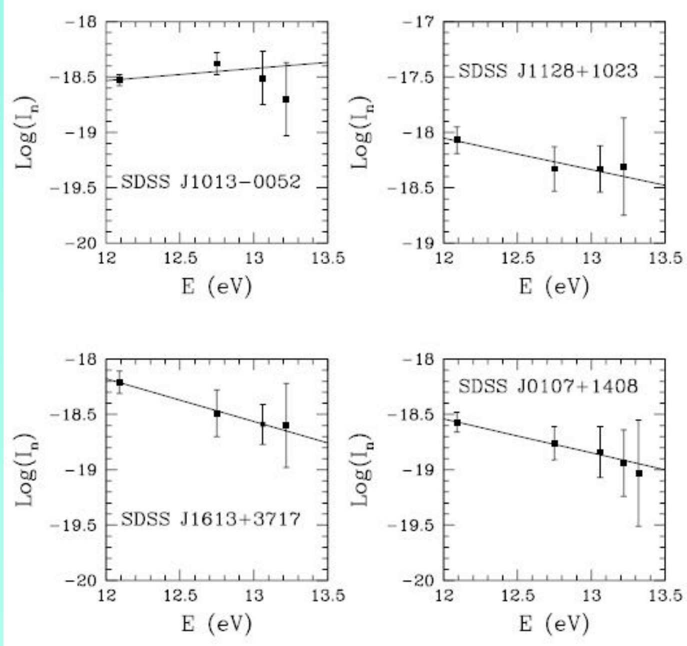
A little bit of History

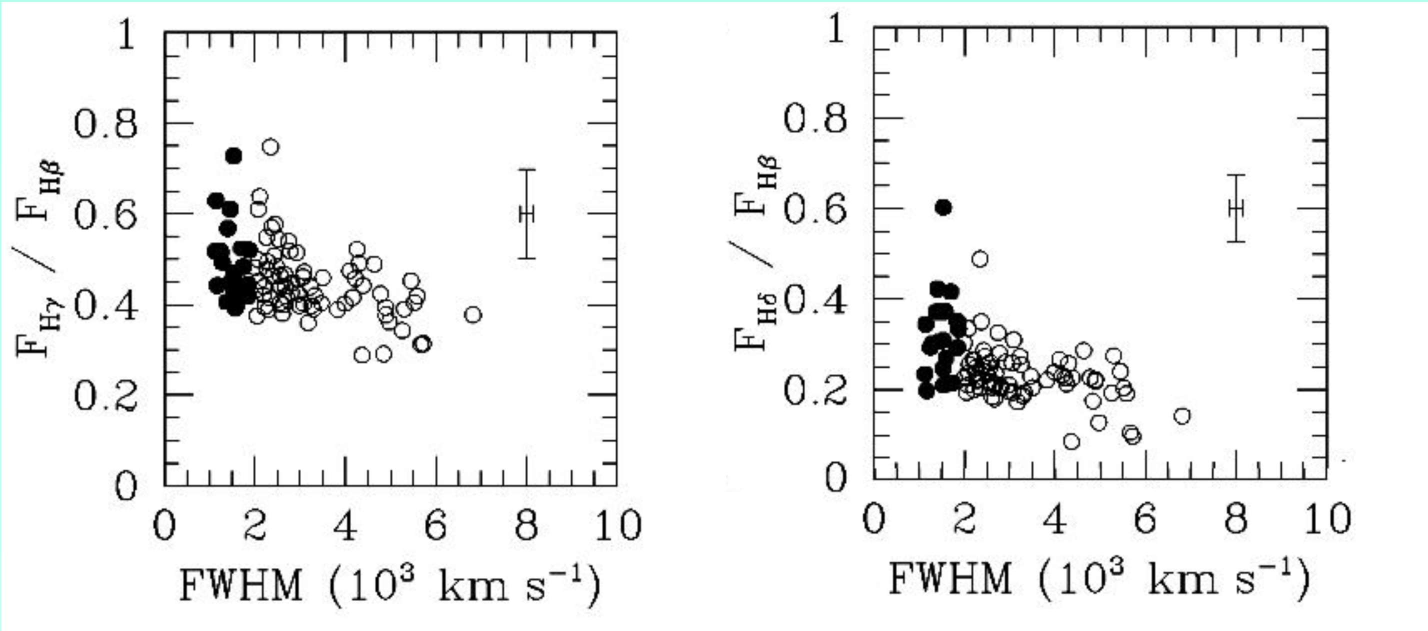
The Boltzmann Plot: given the normalized line intensity

$$I_n = \frac{\lambda_{ul} F_{ul}}{A_{ul} g_u}.$$

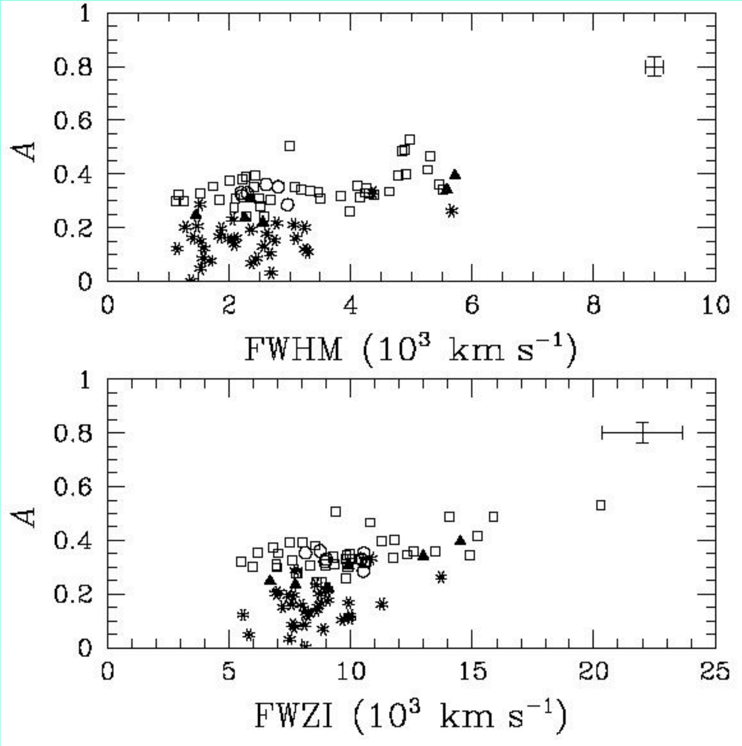
The logarithm of I_n for a particular transition series, in an optically thin plasma, is a linear function of the upper level's excitation energy, with a slope that depends on the plasma electron temperature

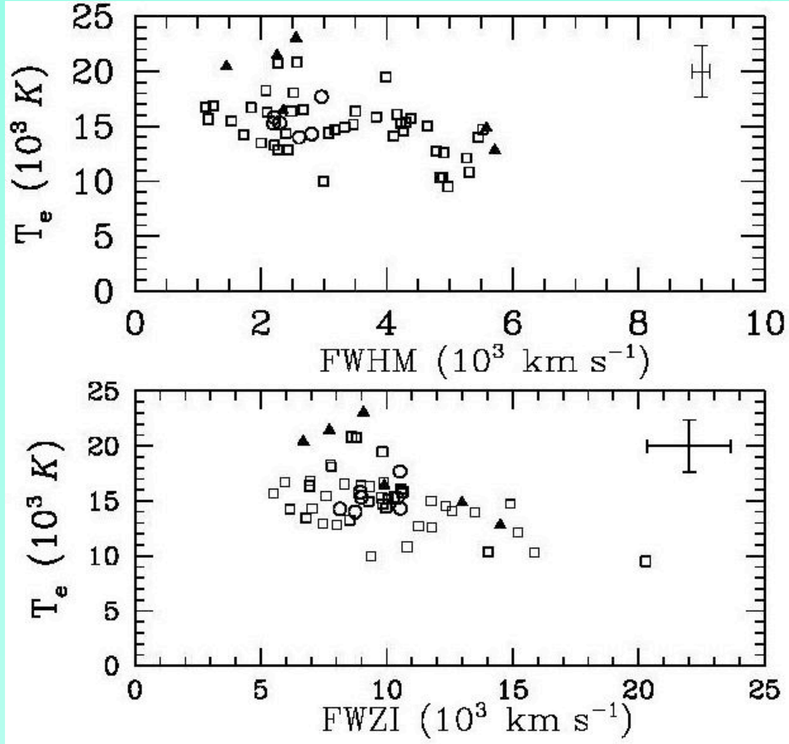
$$\log I_n = -\frac{\log e}{k_B T_e} E_u + \text{const.}$$





A little bit of history

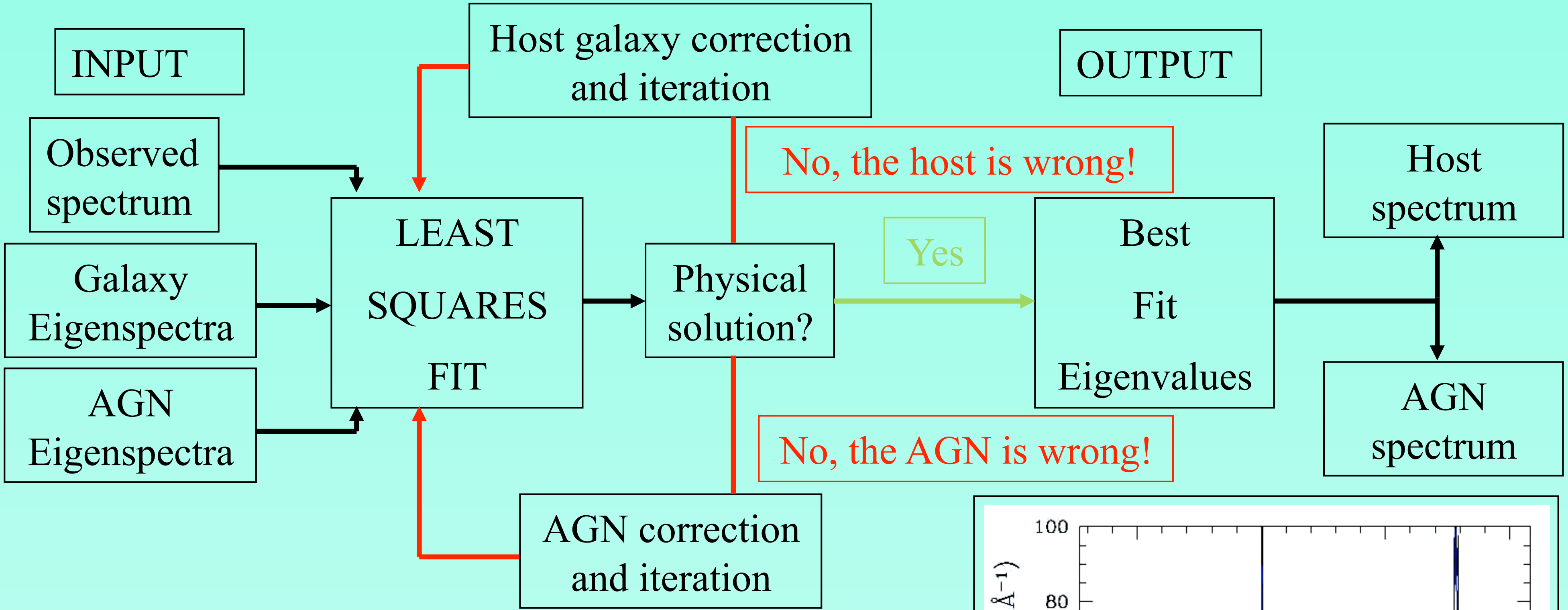


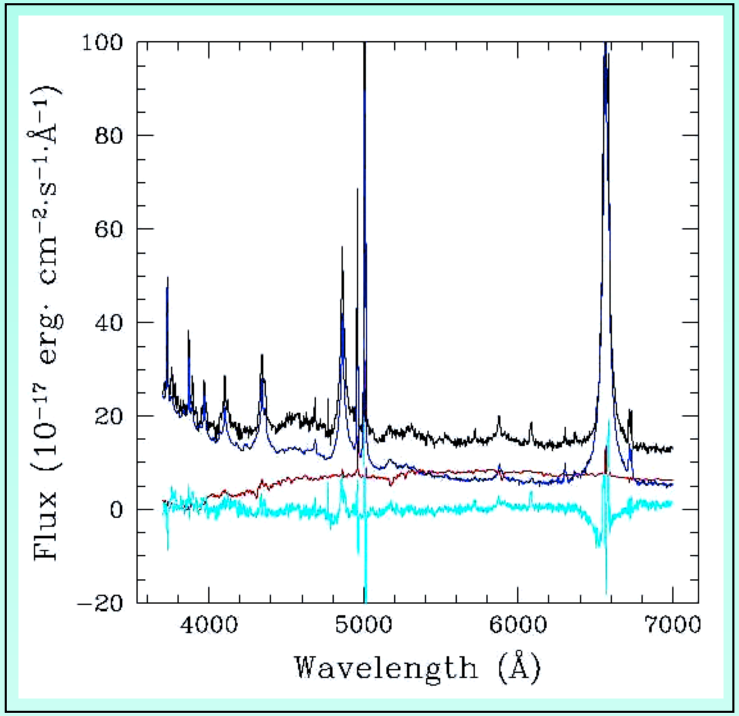


Boltzmann Plot slopes as a function of line profile widths (left panel), with the corresponding plasma temperature estimates (central panel).

The Boltzmann Plot assumptions only hold in a fraction of the selected AGN sample (~ 30%), preferably in the range of broad line emitting sources. In narrow lined objects the analysis points towards stronger ionization and higher plasma temperatures.

Optical observations

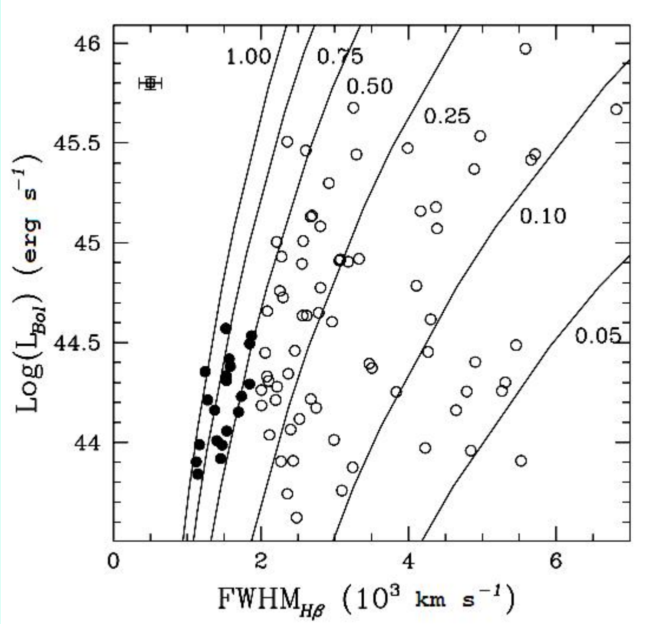


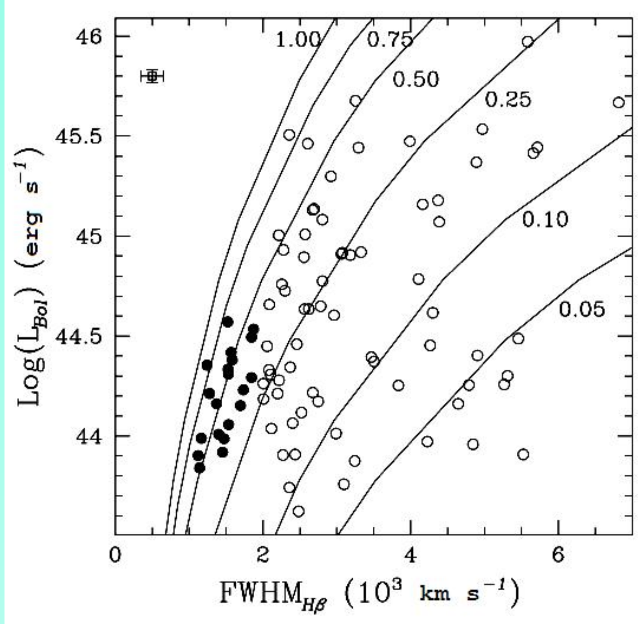


A principal component analysis technique, based on iterative fits to observational data, was developed to isolate the AGN contribution from host galaxy contamination in the SDSS spectra

Connolly et al. 1995, AJ, 110, 1071
Yip et al. 2004, AJ, 128, 585
Yip et al. 2004, AJ, 128, 2603

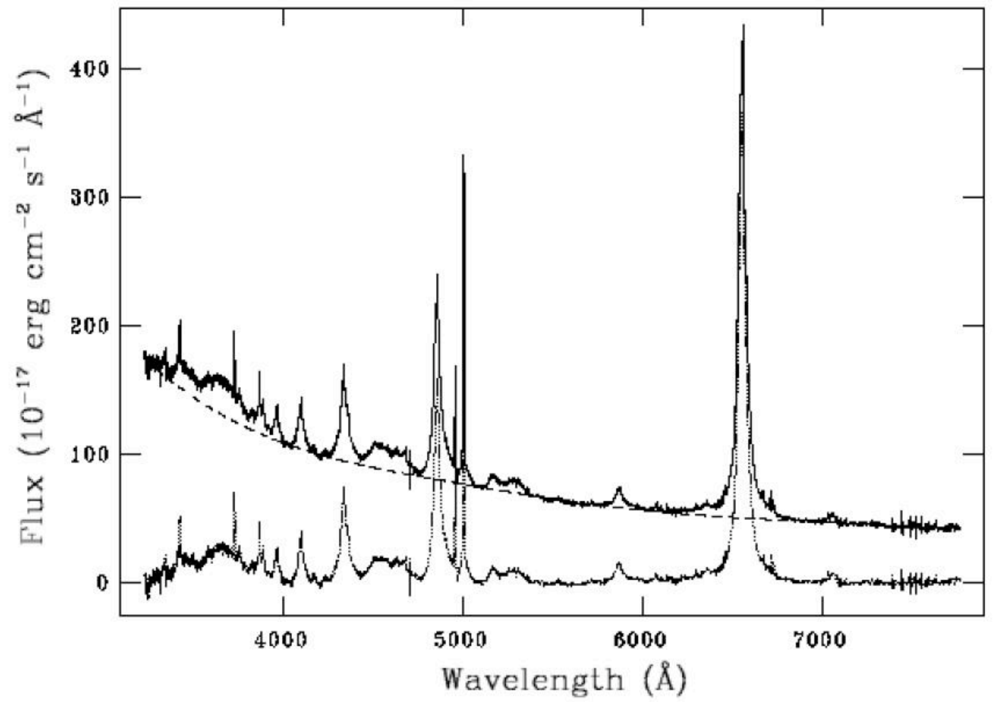
Optical observations



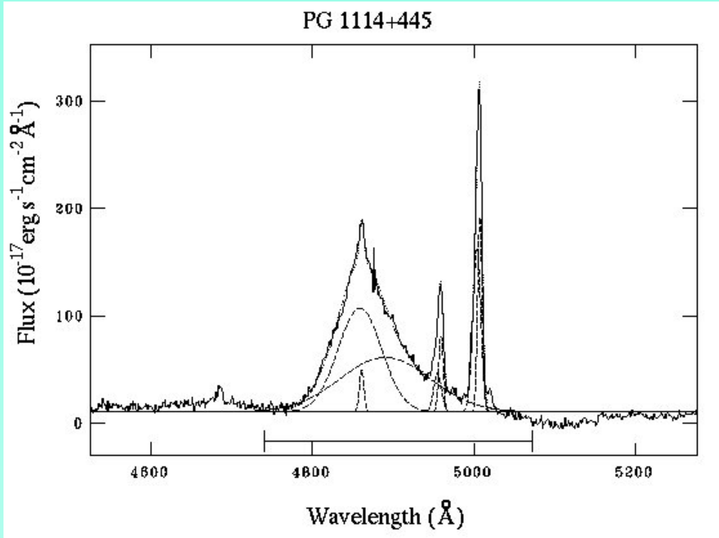


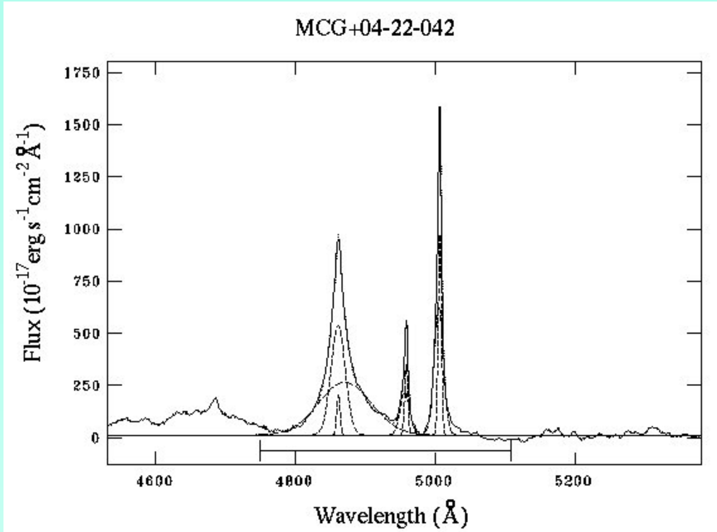
Bolometric luminosities vs. FWHM(Hβ) according to the structural models of Kaspi et al. (left panel) and Bentz et al. (right panel). Filled circles are NLS1 galaxies, while the continuous lines represent SMBH, having masses in the range from $10^6 M_{\odot}$ to $10^9 M_{\odot}$ and accreting at the labeled Eddington ratios. These observations suggest that objects with narrow emission lines are more commonly powered by low mass black holes working at very high accretion rates.

Optical observations



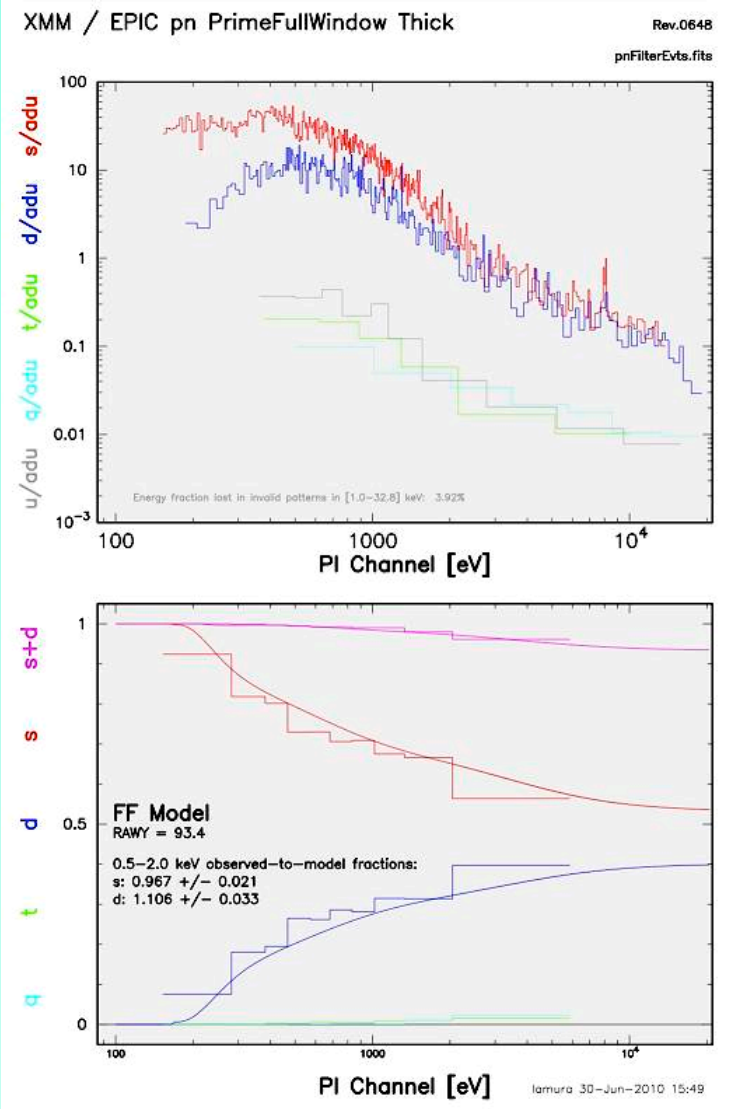
An SDSS observation carries several contributions in the spectrum, which are blended together with the BLR signal and must be accounted for, in order to study the broad emission lines. This example illustrates the subtraction of the underlying continuum in the spectrum of 2MASS J03221390+0055134.



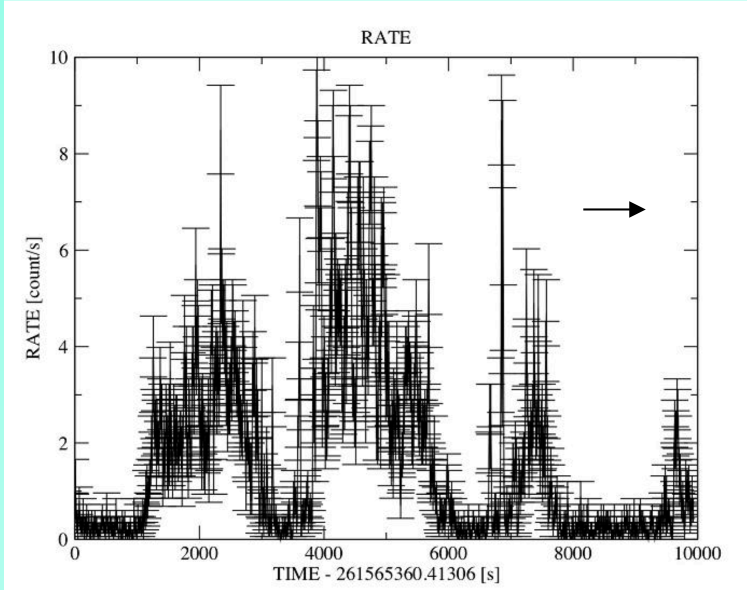


Examples of multiple component emission line fits for broad and narrow line S1 galaxies

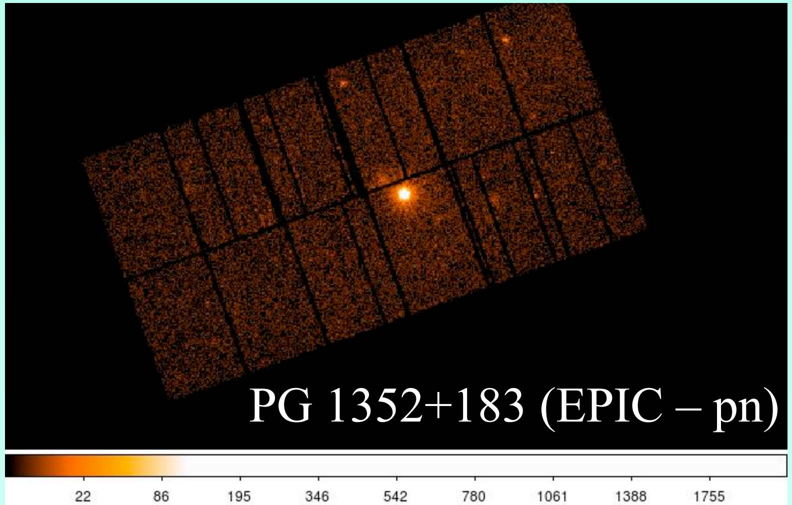
X-ray observations



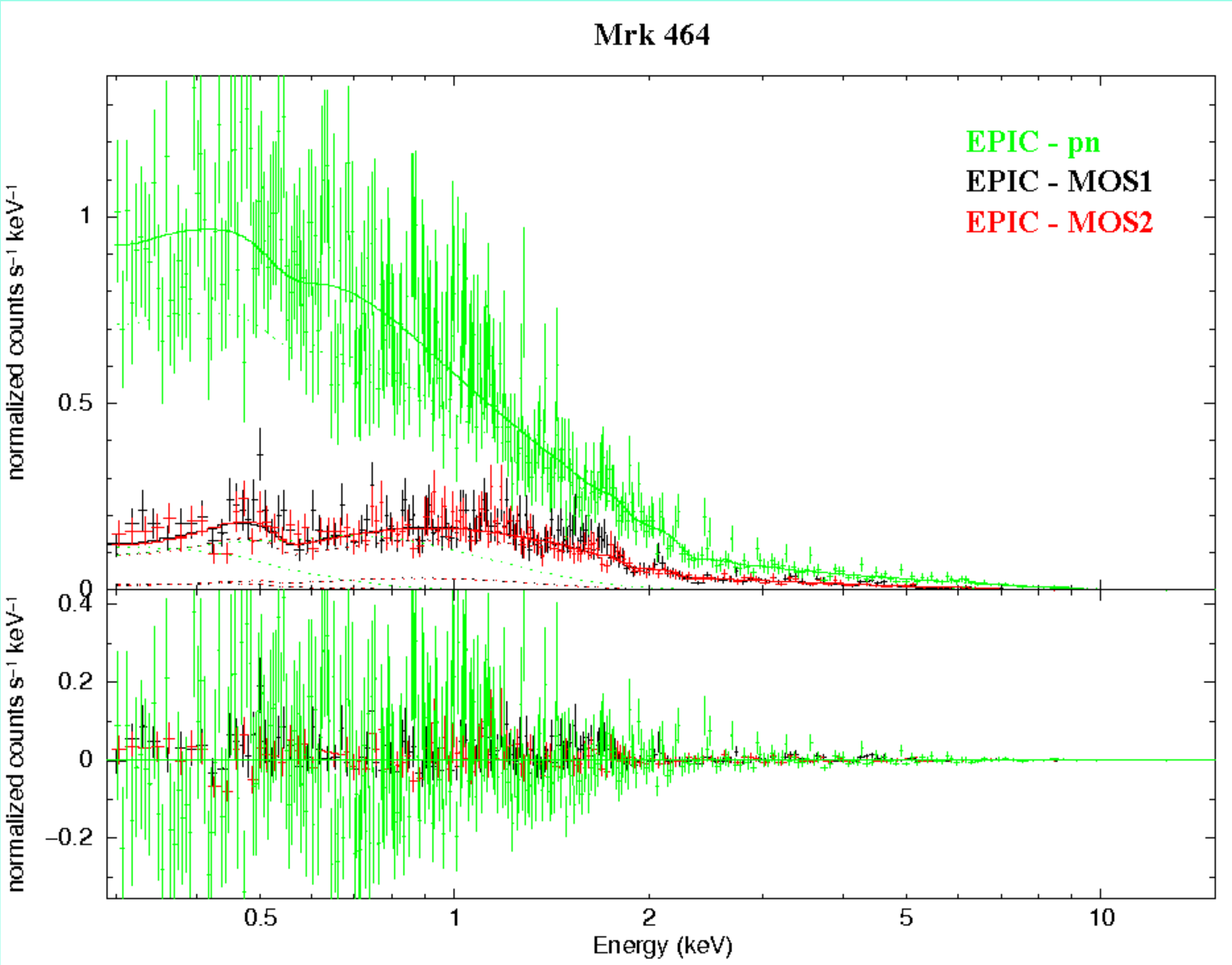
Photon counting pile-up occurs when multiple soft photons are recorded by the detector as a single harder photon.



Flaring particle background can affect the spacecraft, reducing the effective exposure time required for detection of faint objects.

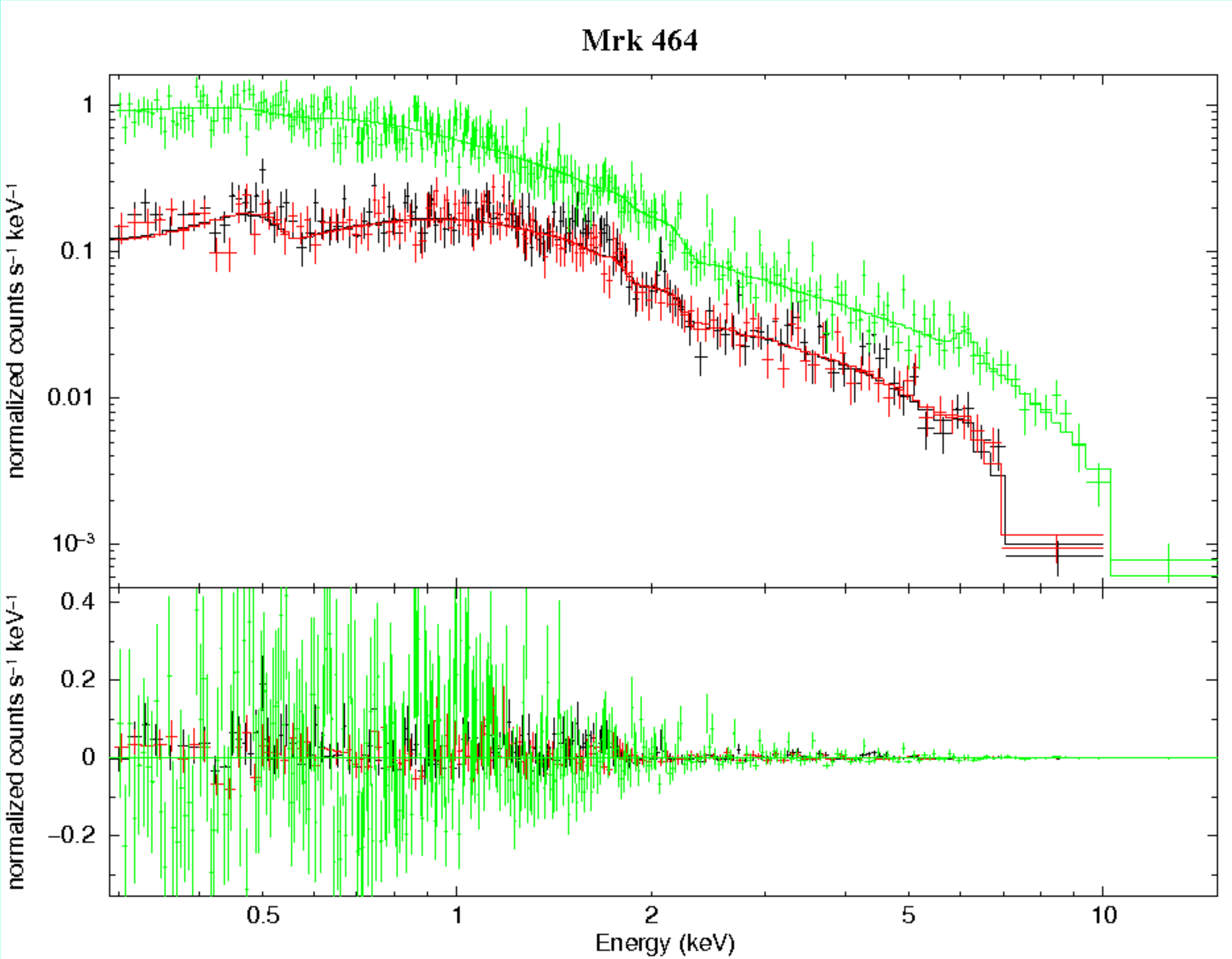


X-ray spectral modeling: Broad Line Seyfert 1



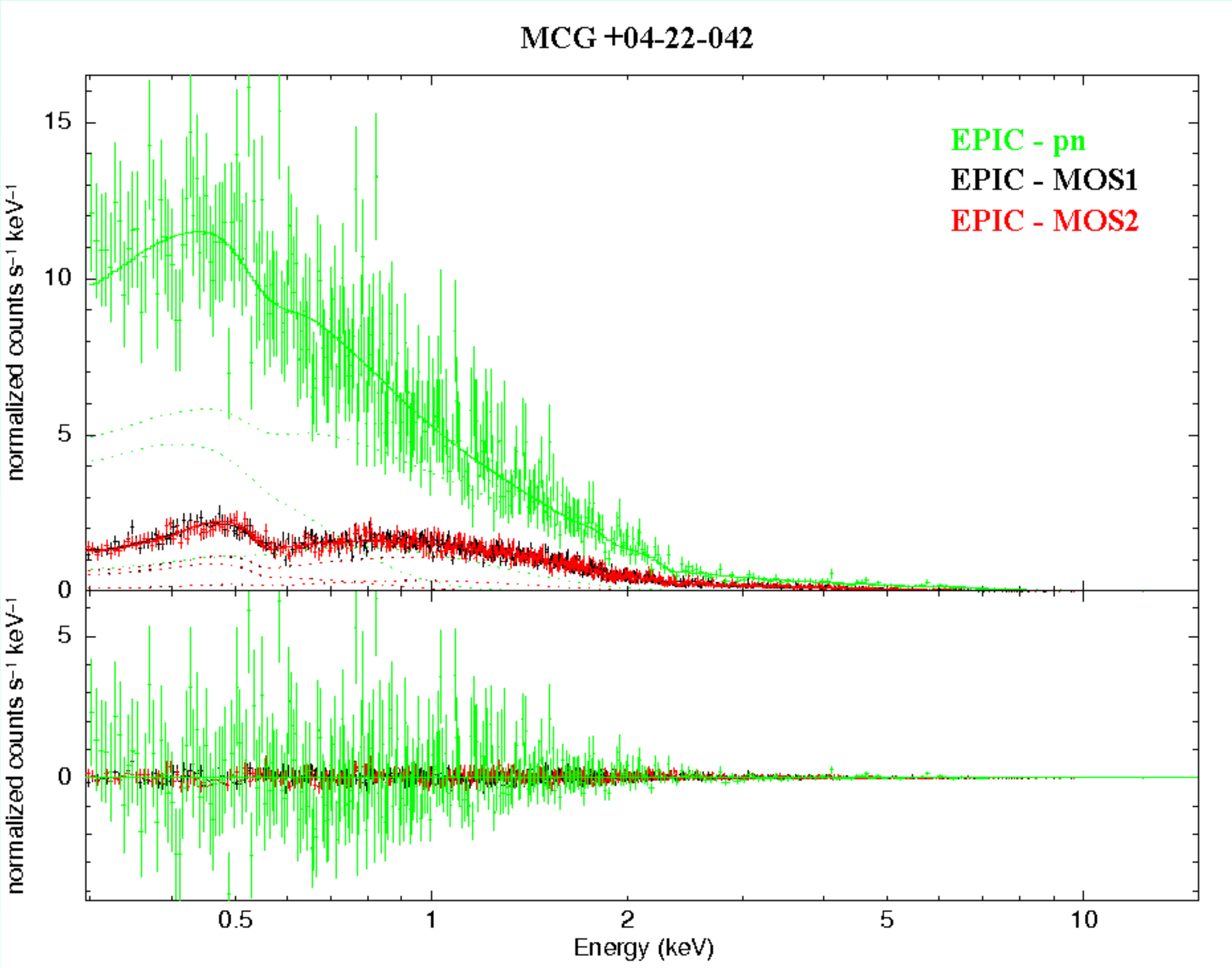
Multiple component fit to the soft and hard X-ray broad band spectrum of the BLS1 galaxy Mrk 464. Due to the large noise fluctuations, the model components were required to describe simultaneously the observation of different instruments.

X-ray spectral modeling: Broad Line Seyfert 1



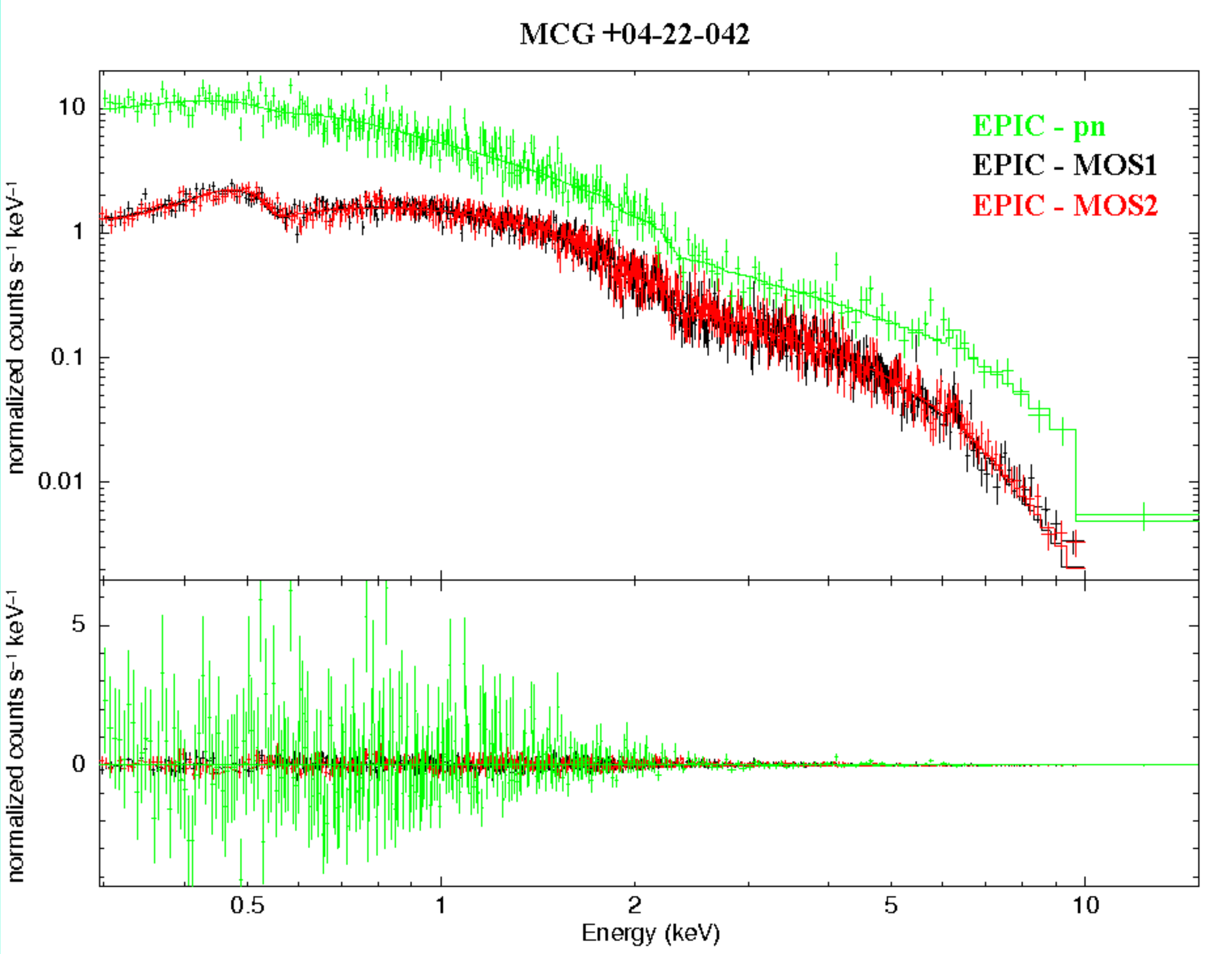
The soft X-ray spectra of BLS1 show a complex thermal component in the soft band, little or no evidence of absorption and a hard X-ray power-law component. A low ionization Fe Kα can usually be detected.

X-ray spectral modeling: Narrow Line Seyfert 1



Multiple component fit to the soft and hard X-ray broad band spectrum of the NLS1 galaxy MCG +04-22-042. The model components are chosen to fit simultaneously the observation of different instruments.

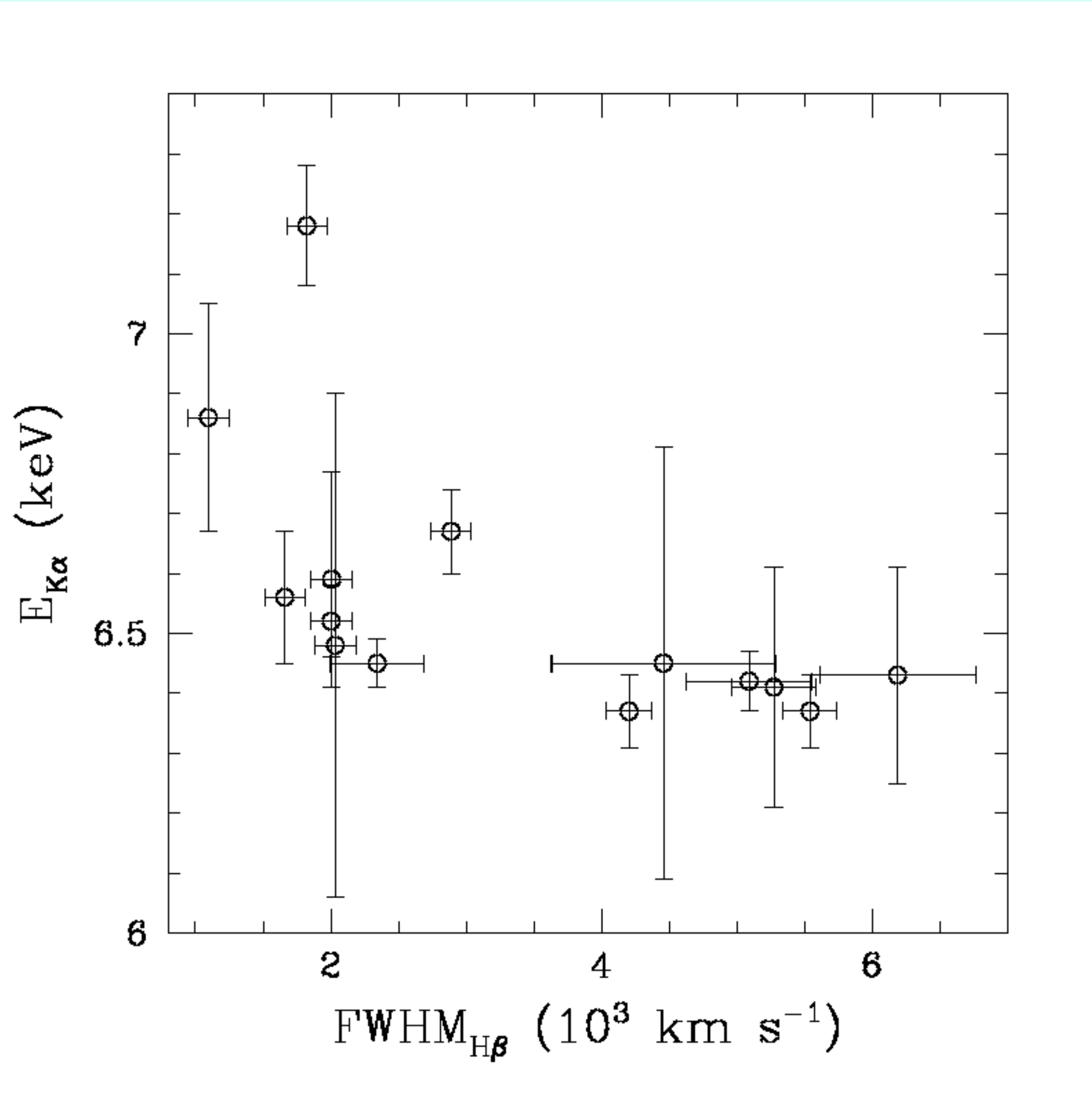
X-ray spectral modeling: Narrow Line Seyfert 1



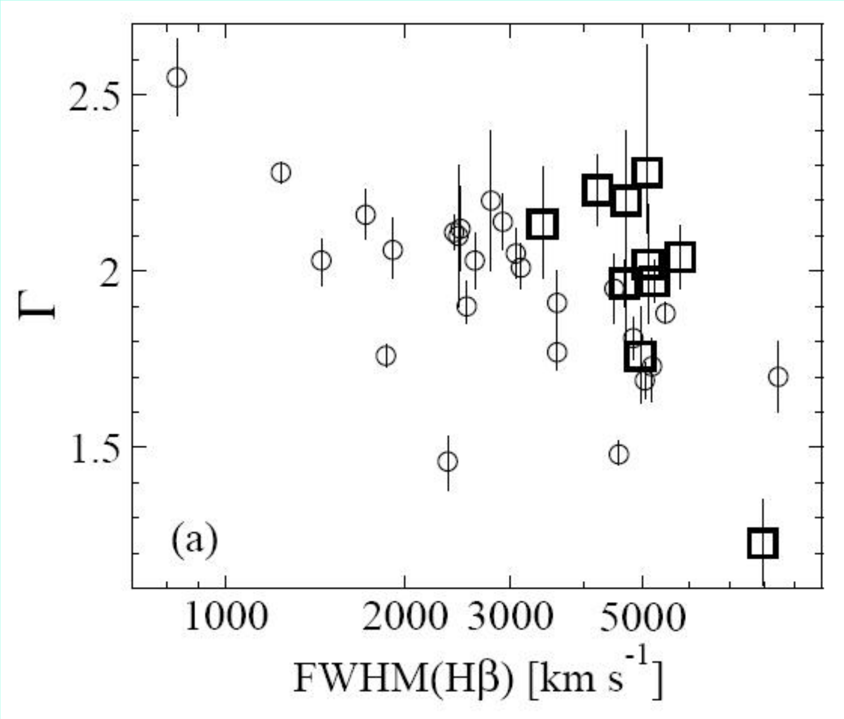
The soft X-ray spectra of NLS1 show a complex thermal component in the soft band, no evidence of absorption and the hard X-ray power-law component. The Fe Kα emission line is detected as the product of reflection by a high ionization medium.

Preliminary Results

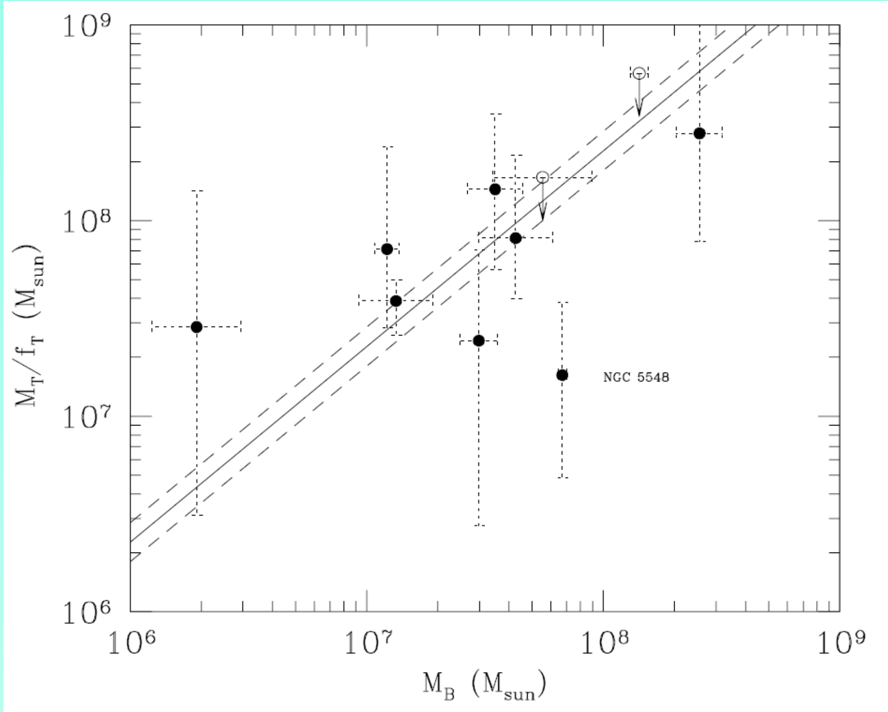
Using the FWHM of the Hβ emission line as a flag to investigate the degree of ionization, corresponding to the Fe Kα energy, it is found that the degree of matter ionization increases while moving from the domain of BLS1 galaxies to that of NLS1 objects. A larger sample would be required to investigate the actual dependence of the X-ray observation on the profile of the optical emission lines and, in particular, to assess whether the difference represents a true break among the AGN classes or it is the consequence of a smooth transition.



What's around?

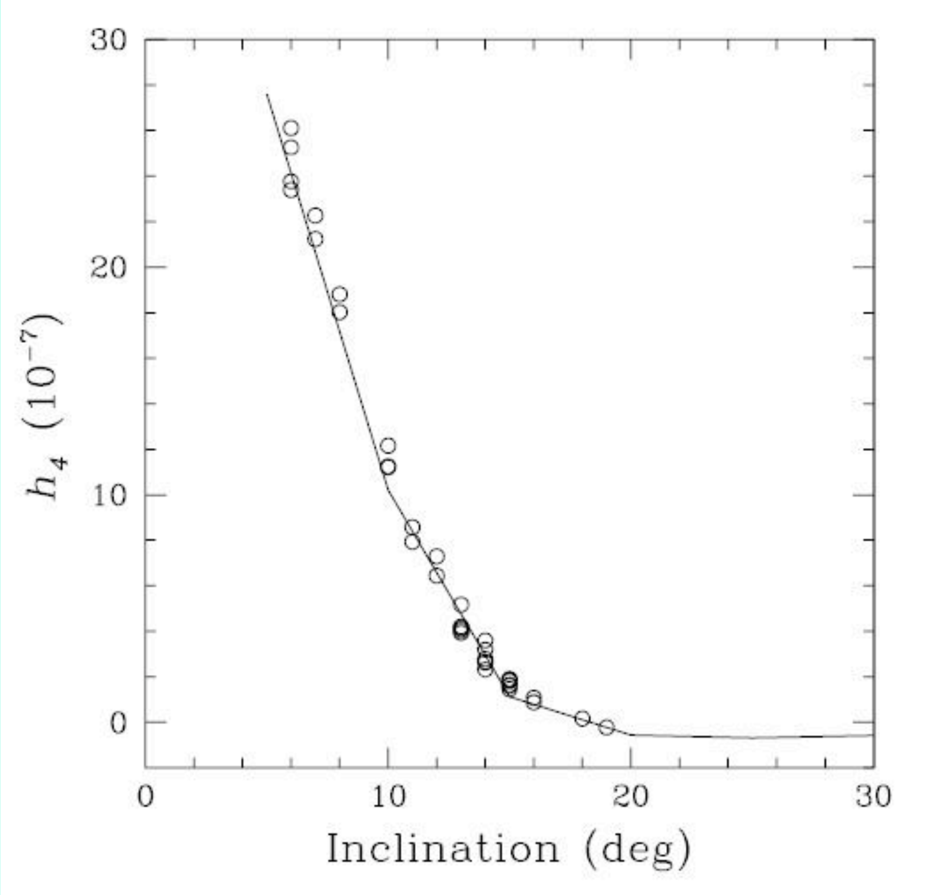


The relationship among the hard X-ray power law slope of low redshift Seyfert1 galaxies (open circles) and high redshift QSO (open squares) and the FWHM of the Hβ emission line. (Shemmer et al. 2008, ApJ, 682, 81)

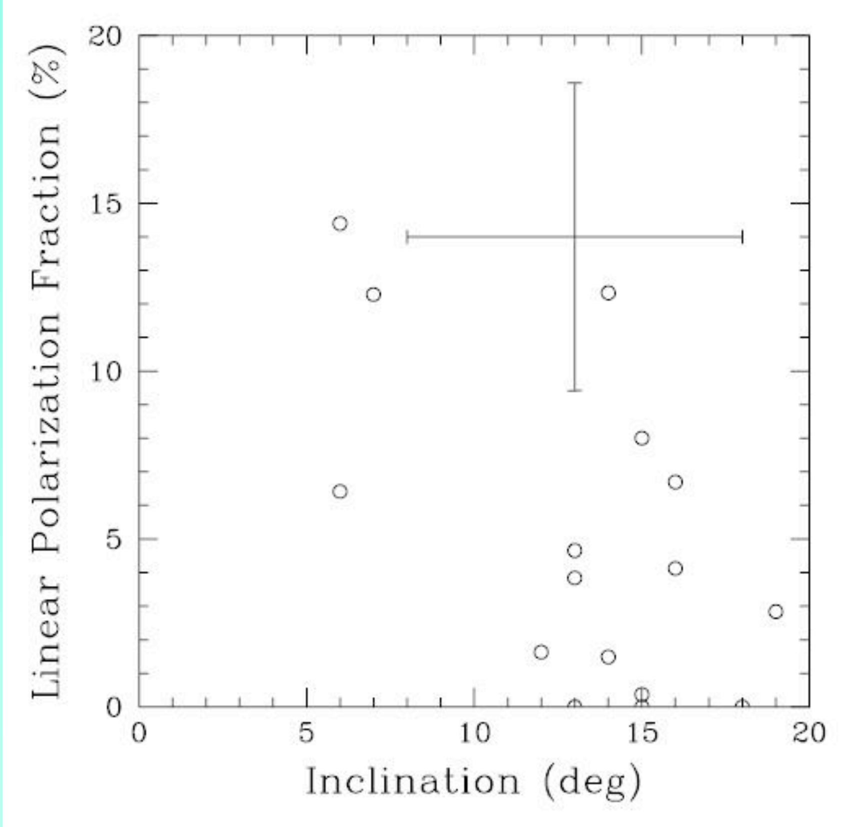


Estimate of the SMBH masses extracted from the properties of the X-ray Fe Kα emission line compared with the $M_{BH} - M_{Bulge}$ relationship. (Jiang et al. 2011, in press)

What's around?



Inclination of BLR, with respect to the line of sight, estimated from the line profile kurtosis predicted by complex BLR structural models, allowing for the existence of a flattened component.



Degree of linear polarization in the radio observations of Type 1 AGN as a function of the inferred BLR inclination with respect to the observational line of sight.

Conclusions

$$M_{BH} = f \frac{R_{BLR} v^2}{G} \qquad f \cdot v^2 = v_{eq}^2 = \frac{1}{4}\left[\frac{\sqrt{3}}{2}\mathrm{FWHM}_{Turb} + \frac{\mathrm{FWHM}_{Disk}}{4\sin i}\right]^2$$

Geometrical factors to estimate the SMBH mass from the profile of the Hβ emission line. Adopting the complex BLR structural model which is required to take into account the effects of BLR geometrical properties, it is confirmed that inclination is not the critical factor to explain the properties of NLS1 galaxies, though still playing an important role.