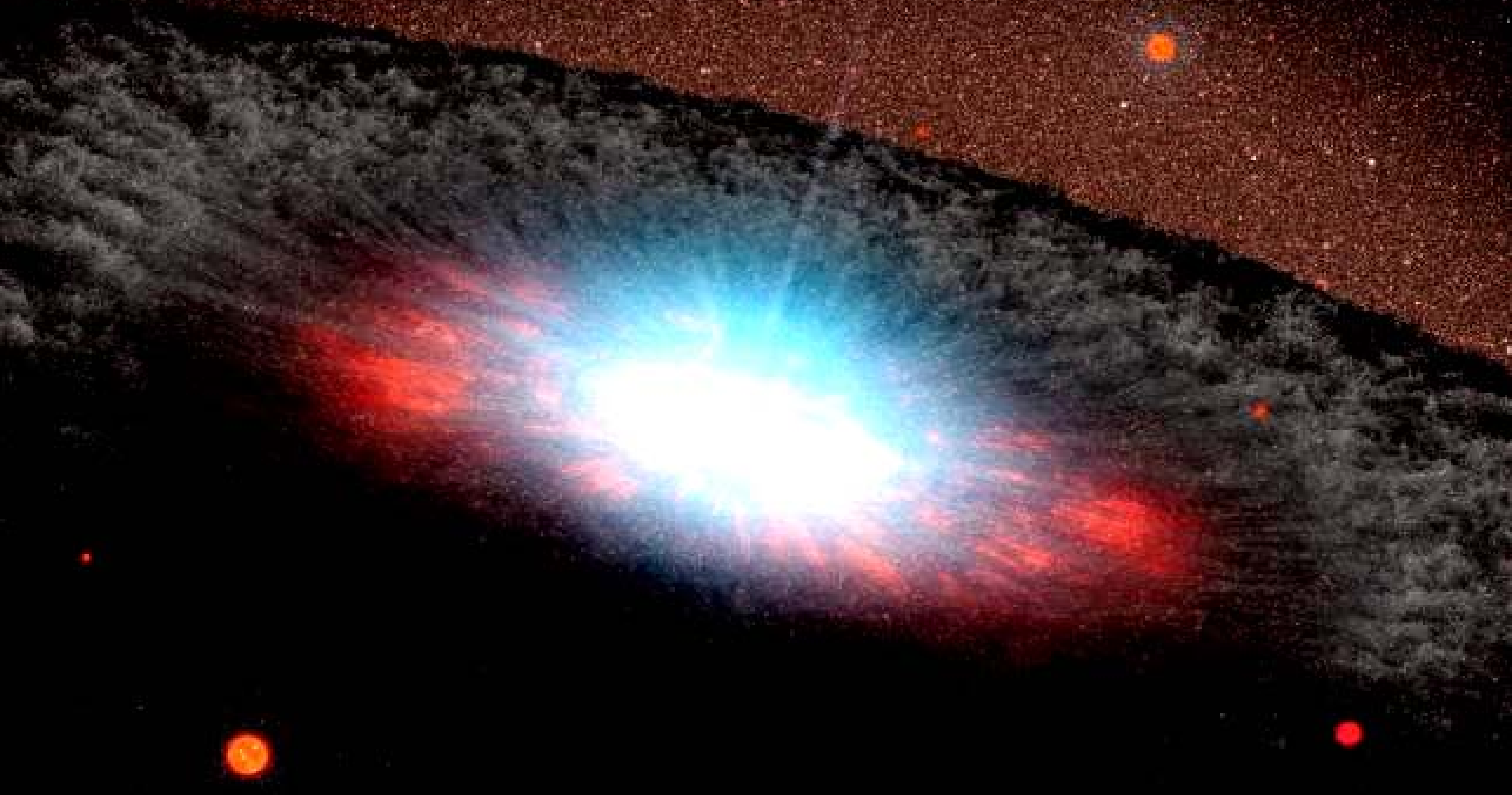
Detailed Analysis of the Balmer Lines in a Selected Sample of 90 Broad Line AGN



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VI Serbian Conference on Spectral Line Shapes in Astrophysics – Sremski Karlovci 11-15/06/2007

Introduction to Active Galactic Nuclei (AGN)

3C 273, QUASAR

NGC 1316, Radio Galaxy

When large amounts of energy are released by the nuclear region of a galaxy, we refer to the source as an Active Galactic Nucleus or AGN. The peculiar and sometimes very different properties of AGN led us to define several classes of objects

NGC 1566, Seyfert 1

NGC 1566, Seyfert 2

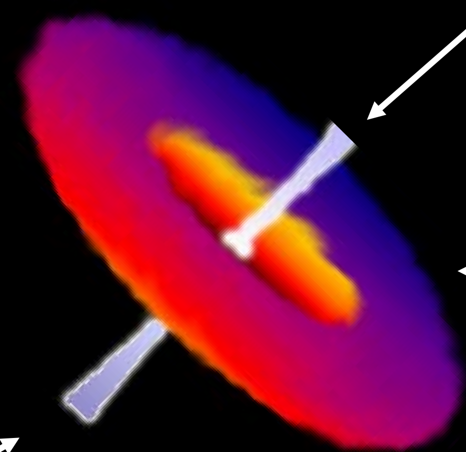
At present, however, we believe that the ultimate source of power is always the same: a Super Massive Black Hole, located in the centre of these galaxies, which is accreting large amounts of fuel from the surrounding regions

Introduction to Active Galactic Nuclei (AGN)

The Unified Model for AGN tries to explain most of the observational differences in terms of our various lines of sight onto the source. This model enables a natural explanation for the presence or absence of broad emission lines, but more complex physics is required to account for radio loudness, absorption, etc.

The dust torus may obscure direct radiation coming from the source, though the surrounding medium can still be ionized and emit narrow lines

Line of sight along the approaching jet. Boosted continuum with usually no emission lines and an extreme variability



The obscuring torus and the jets are believed to be a common feature of these accretion powered sources

Depending on the power of the jet and the properties of the host galaxy, the ejected plasma can interact with the IGM and result in radio lobes. A full explanation of the radio loudness of the source itself cannot be given by this picture

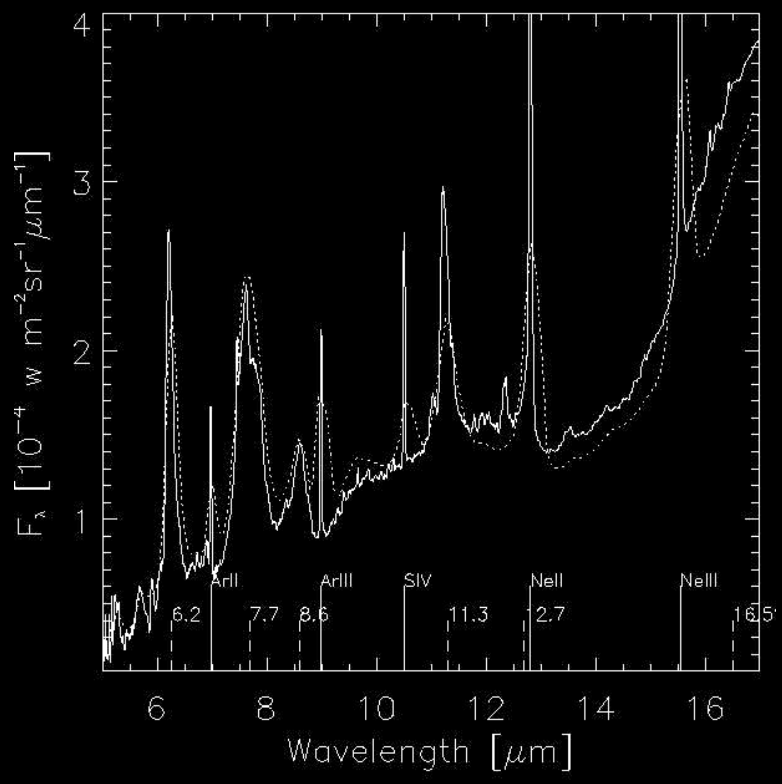
Direct view to the gaseous flows accreting onto the central black hole. Broad emission lines, sometimes together with absorption troughs, especially in the UV

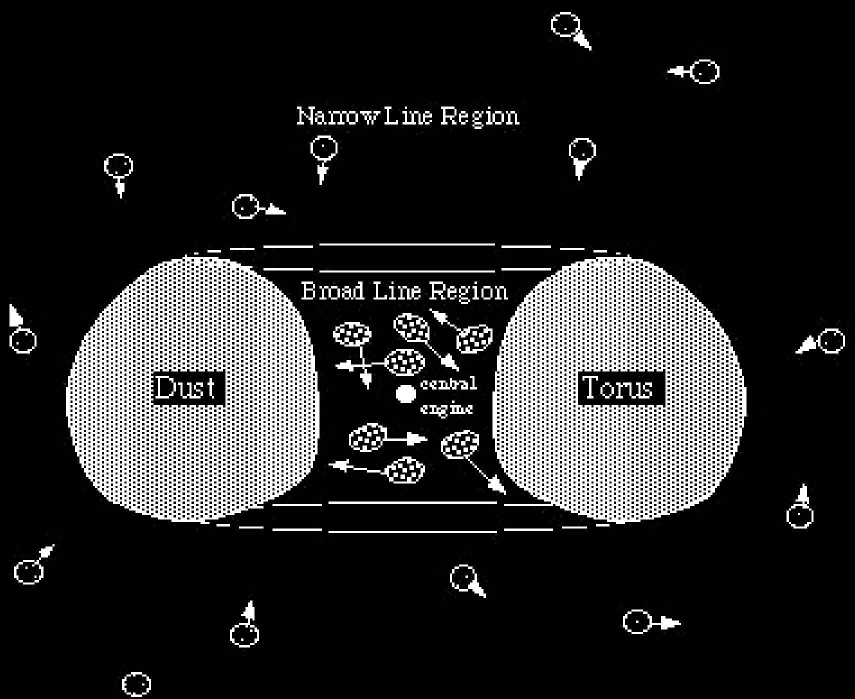
The Nature of the Broad Line Region (BLR)

Two distinct emission line regions:

Narrow Line Region (NLR)

Extended Structure, Low Density Plasma ($n \sim 10^4$ cm^{-3}), Radiative Decays, Small Velocity Fields ($V \sim 10^2$ km·s^{-1})

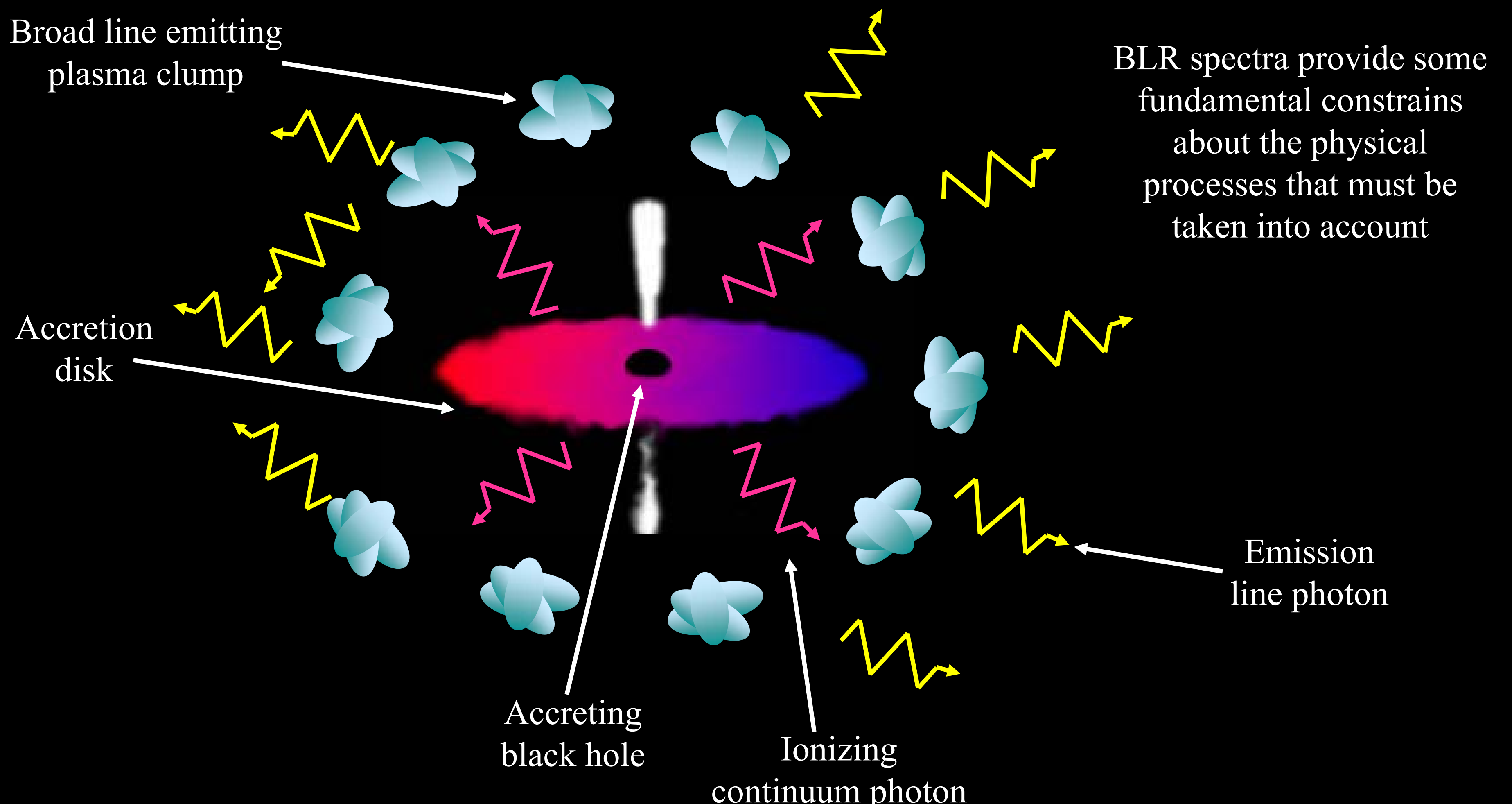




Broad Line Region (BLR)

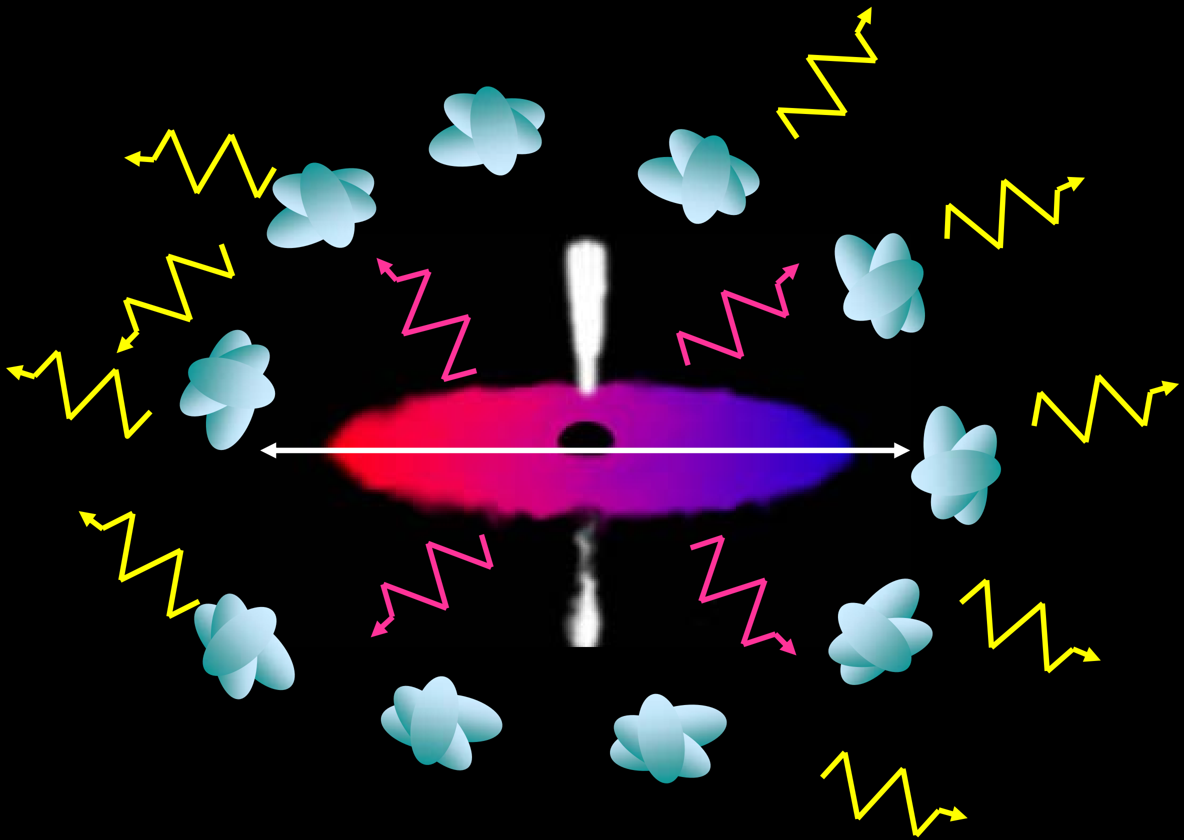
Unresolved Point-Like Structure, High Density Plasma ($n > 10^9$ cm^{-3}) with Collisional Suppression of Forbidden Transitions, Large Velocity Fields ($v \sim 10^4$ km·s^{-1})

The Nature of the Broad Line Region (BLR)



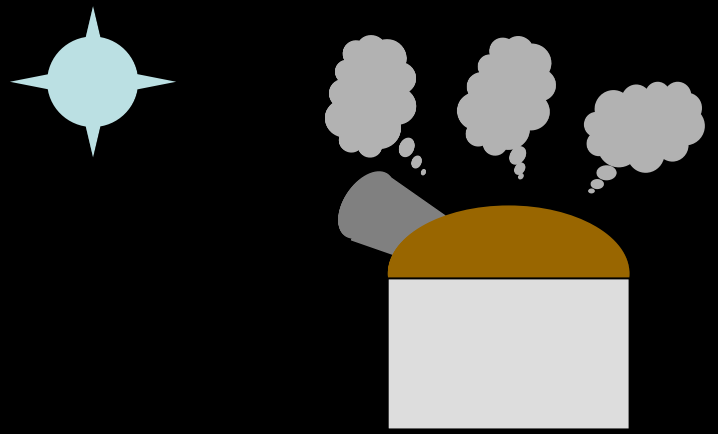
Line emission is essentially activated by photoionization of the BLR gas in the continuous radiation field generated by the central source. This is the most natural way to account for the existence of several ionization stages in a small spatial region, provided that the plasma is optically thick. The absence of a strong dependence of line profiles on their excitation potential suggests that the line emitting medium cannot be uniformly distributed in space around the source, but it must exist in the form of small clumps

The Nature of the Broad Line Region (BLR)



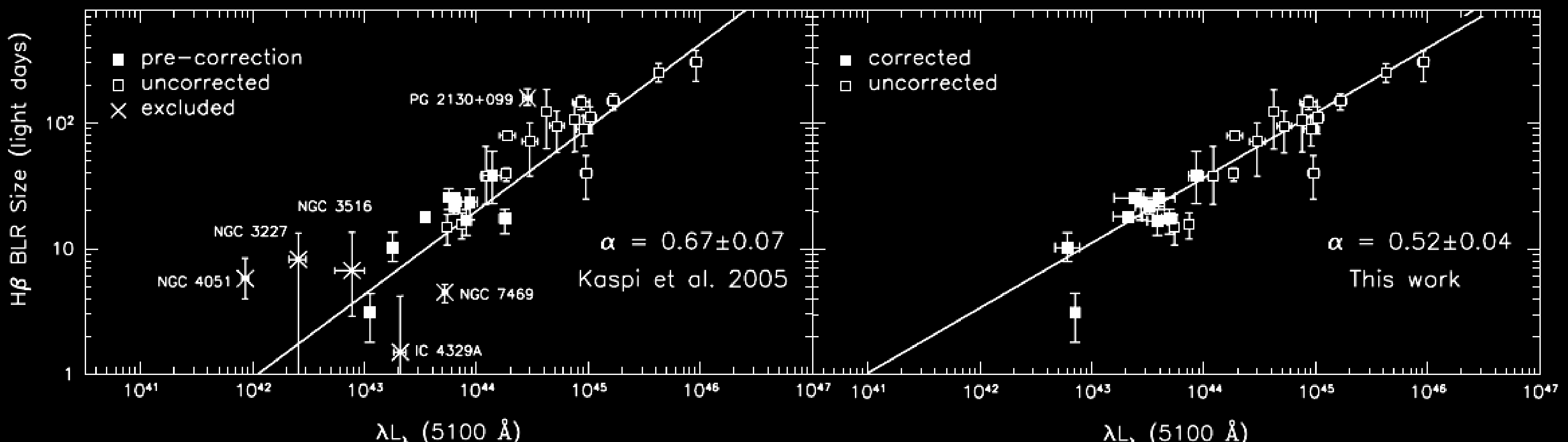
Applying the light travel time to the interactions between the ionizing radiation source and the line emitting medium, the *Reverberation Mapping* technique estimates the size and, to some extent, the structure of the broad line region. The inferred results depend on the assumptions of predominantly orbital motion pattern, symmetric distribution of matter and photoionization induced by the central source

The Nature of the Broad Line Region (BLR)



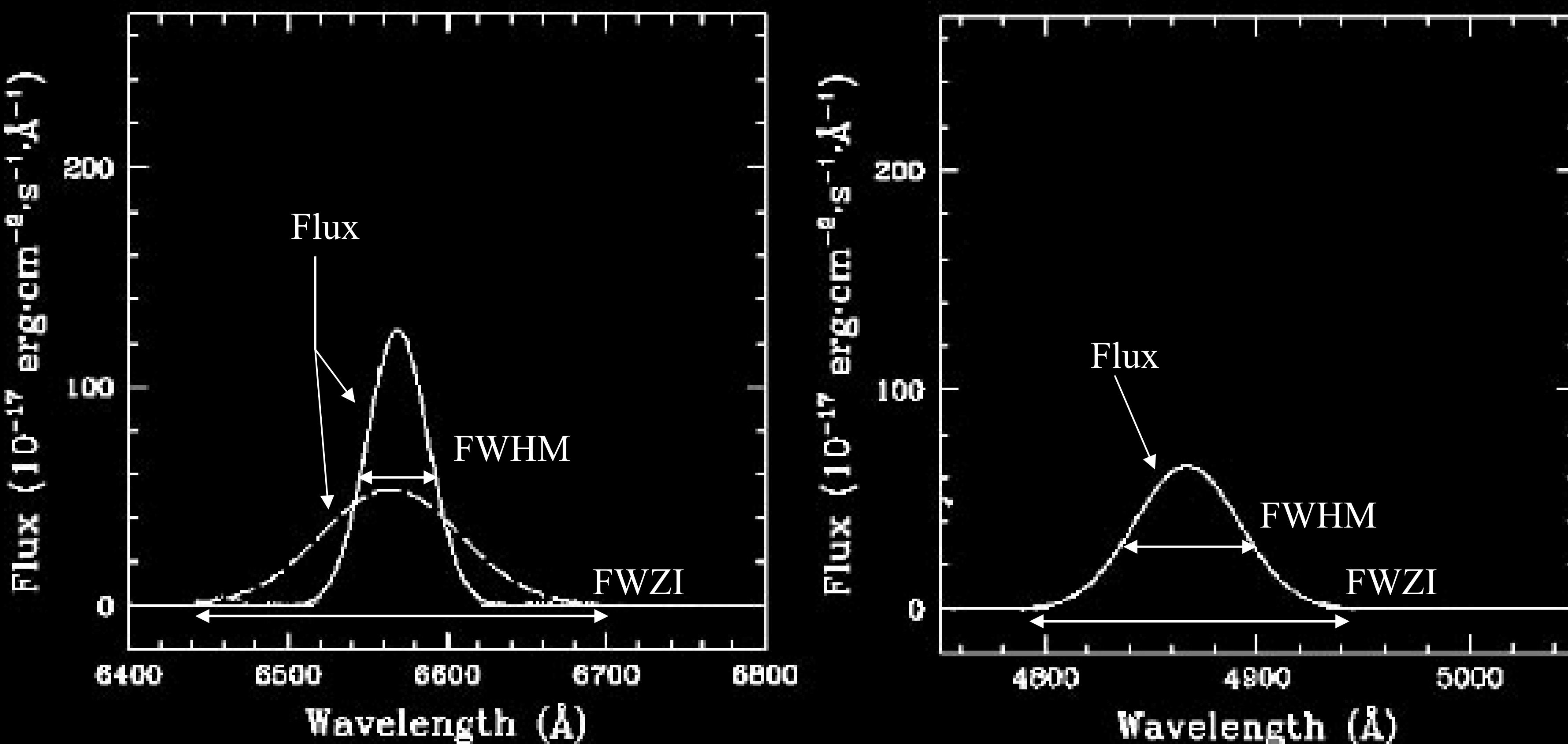
Reverberation Mapping (RM) is expensive: many observations are required for 1 object!

The available results are therefore useful to calibrate empirical relations with other properties, whose observation is much easier.



Two empirical size – luminosity relationships for the broad line regions of various RM observed AGN. The left panel gives the relation found in Kaspi et al. 2005, ApJ, 629, 61 between the optical luminosity and the BLR size as estimated from Hβ time delay. The right panel gives the same relationship as described in Bentz et al. 2006, ApJ, 644, 133 to account for the host galaxy contributions in the faintest objects

Spectroscopic Investigation in the BLR

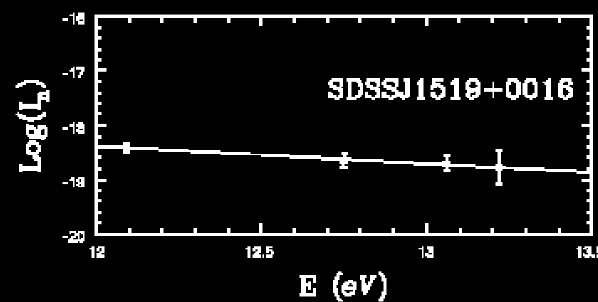


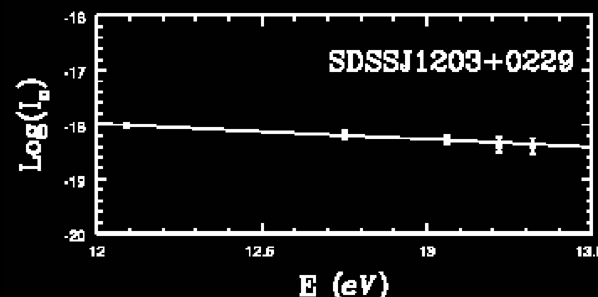
Example of the BLR contribution extraction from Hα and Hβ in the spectrum of a broad line emitting AGN

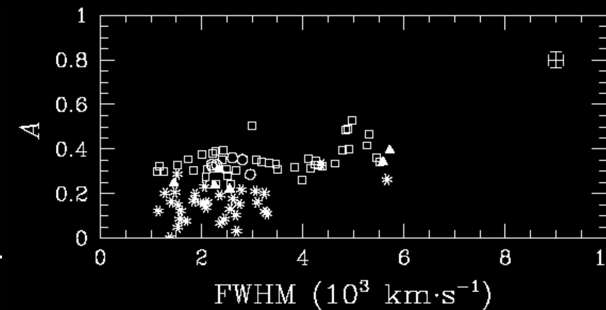
In our project we look mainly at the properties of the broad Balmer emission line components, in order to investigate their relations with the continuum source luminosity and, possibly, with its mass. Because our estimates exploit similar assumptions to those required by RM, our results may be useful for a comparison of the predictions implied by different empirical relationships and to test their agreement in different types of objects

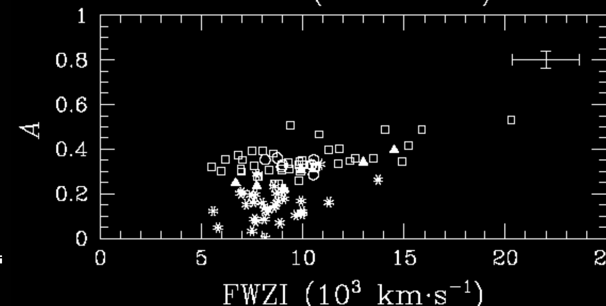
Spectroscopic Investigation in the BLR

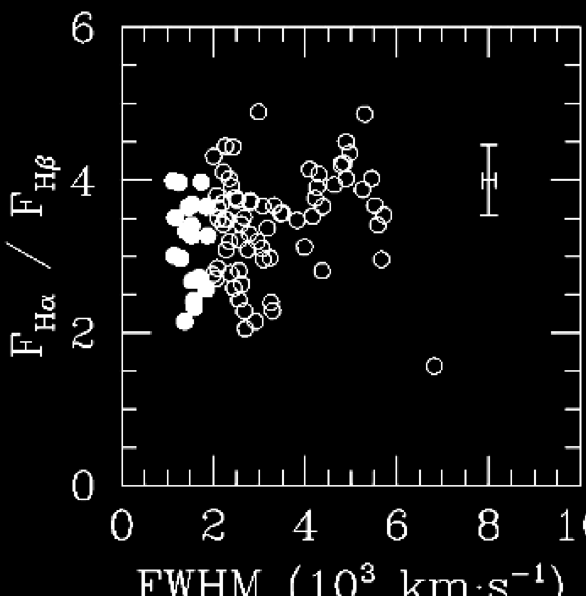
Applying the Boltzmann Plot to the Balmer lines detected in the BLR spectra we find an increasing plot slope in those objects which are emitting the broadest lines. Moreover, this is generally associated with a better fit of the emission lines onto the linear function predicted in the case of LTE. The increasing slope of the Boltzmann Plots implies a larger Balmer decrement in broad line emitting sources

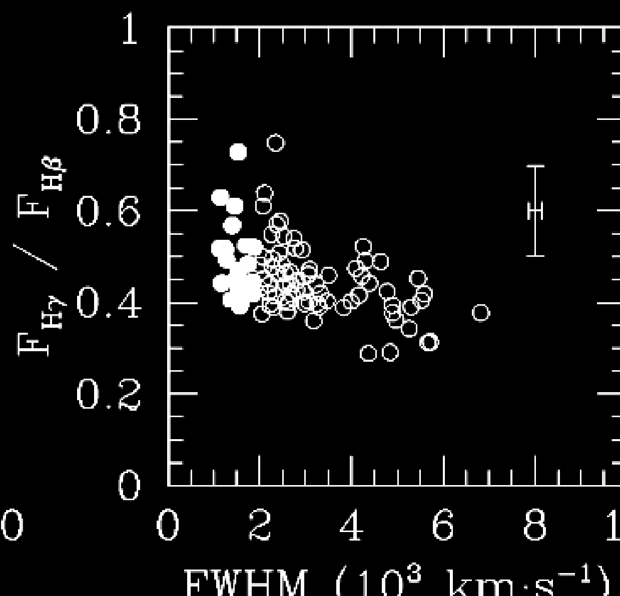


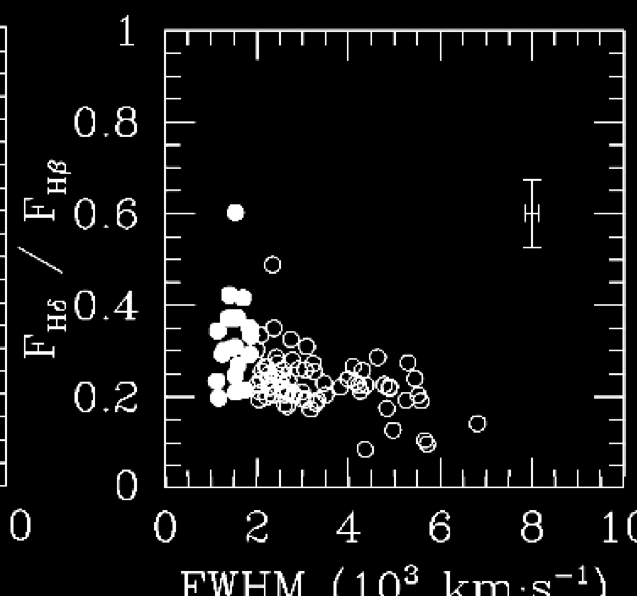






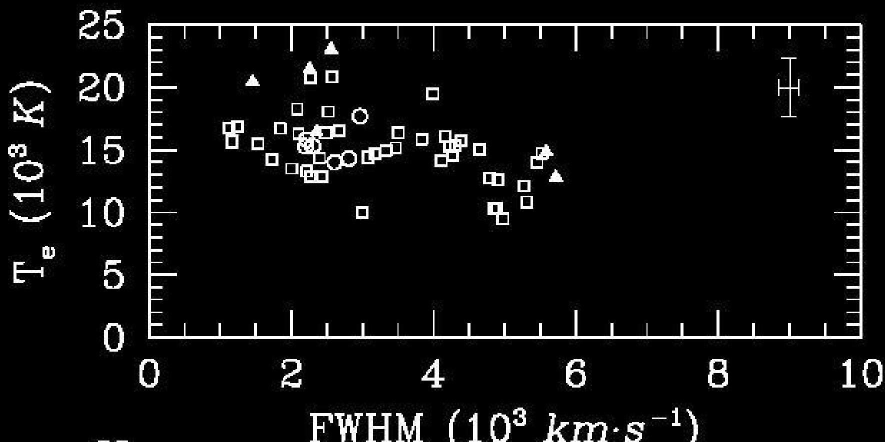


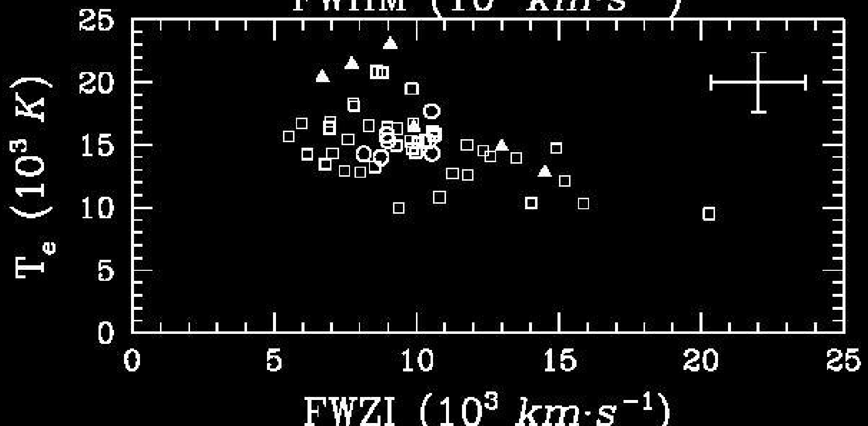


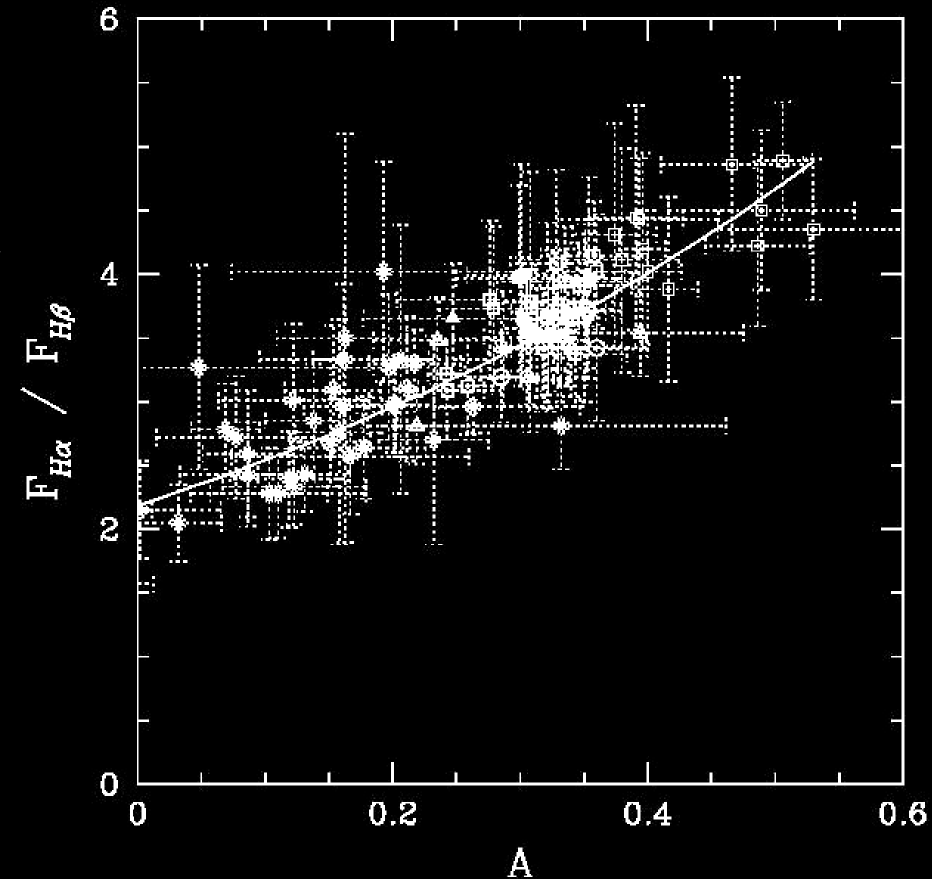


Spectroscopic Investigation in the BLR

How much can we trust BP? The required assumptions may not be generally valid, but the distribution of the sample suggests that they are indeed at least partially satisfactory, especially in broad line emitting objects

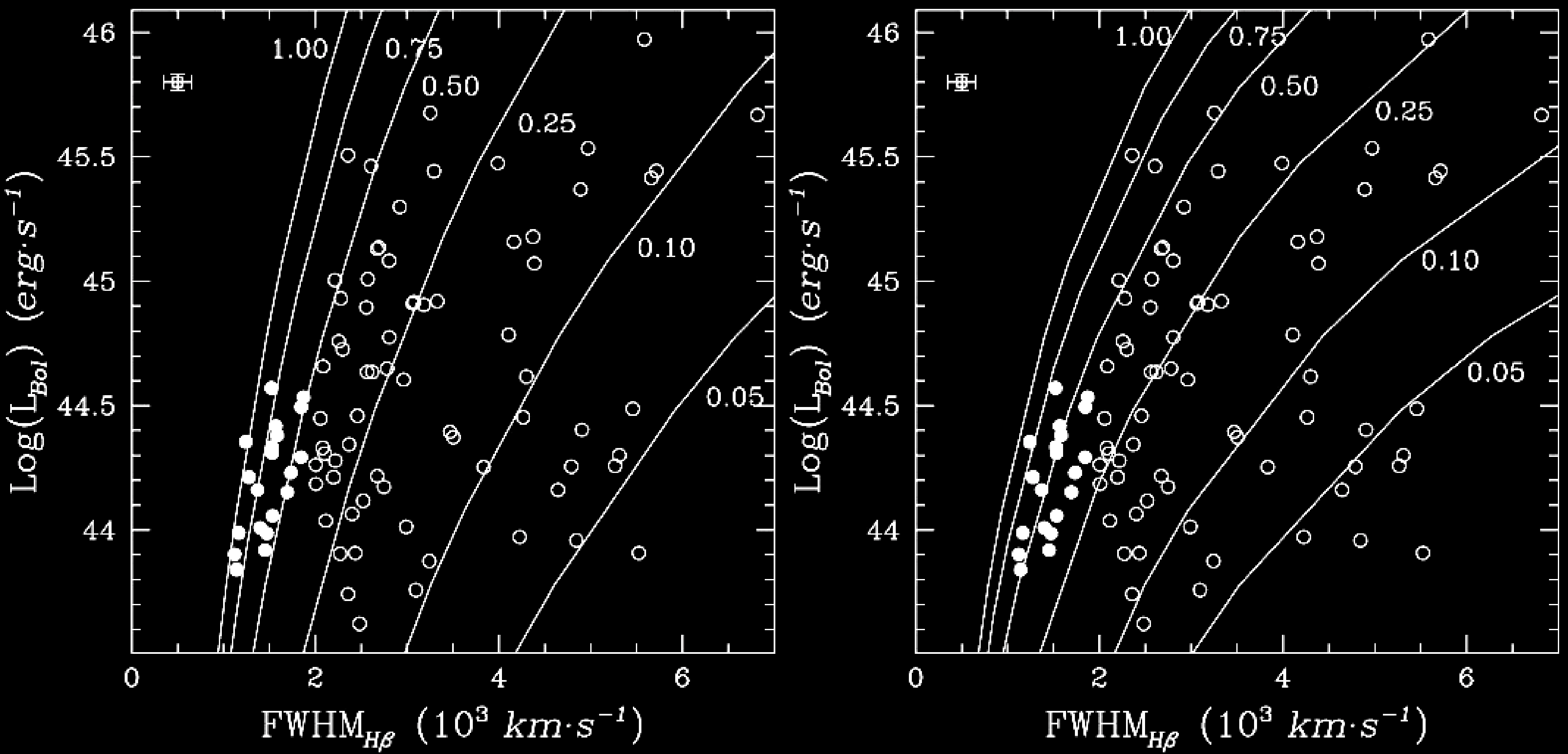






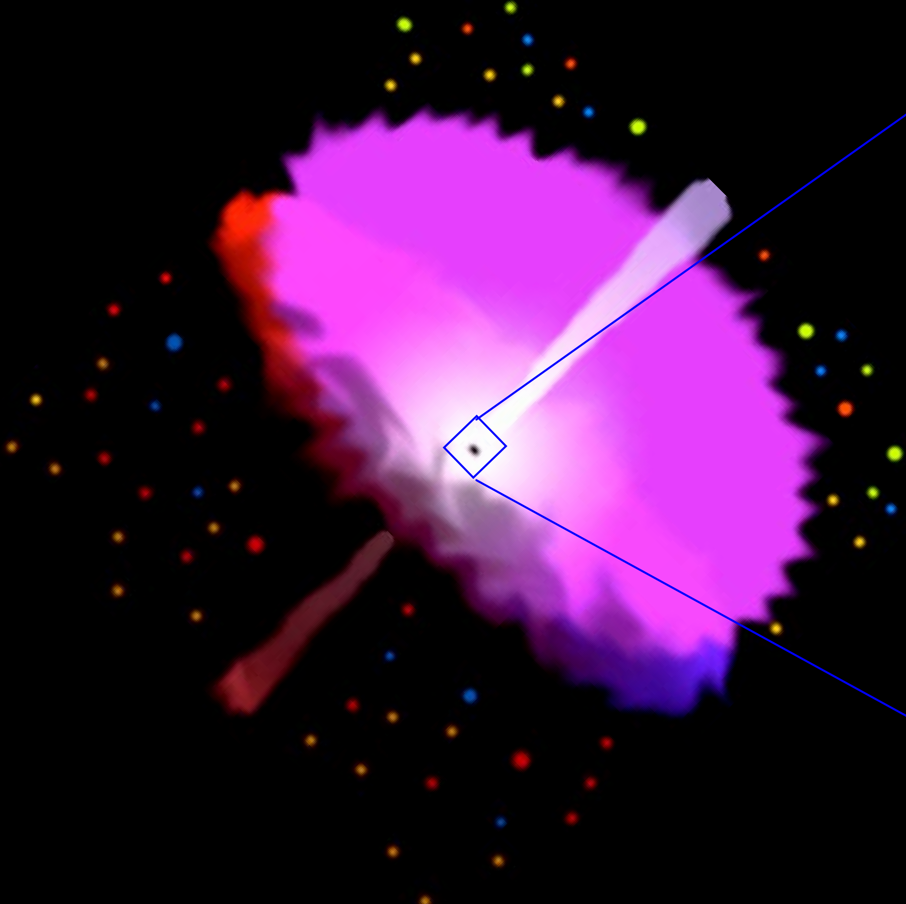
The inferred BLR temperatures are a decreasing function of the line profile widths. According to RM models, stronger interactions between the BLR plasma and the ionizing radiation field are found in AGN powered by BH with smaller mass

Spectroscopic Investigation of the BLR



Distribution of 90 broad line emitting AGN spectra on the luminosity – FWHM plane. The continuous curves track the locations of sources which host black holes of increasing masses, each one accreting at the labeled fraction of its Eddington limit, according to the two empirical relations given by Kaspi et al. 2005 (left panel) and by Bentz et al. 2006 (right panel). Filled circles represent the observed fraction of *Narrow Line Seyfert* 1 galaxies, while the open circles are broad line emitting sources. Tracks are computed using the assumptions of RM, which suggest that narrow line emitting sources have quite high accretion rates

Conclusions



Our results currently support the interpretation of narrow line emitting sources with small mass SBH working at very high accretion rates

This is very important for constraining the BLR structure and dynamics, but more advanced observations and modeling are needed for an independent confirmation

Studying the properties of the spectral lines and continuum it is possible to model the physical processes within the BLR

This time we conclude here