3C 120 :Cosmovision led by Dr. Wolfgang Steffen

Broad-Line Region and Black-hole Mass of Quasar PKS 0736+017

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"Galaxies with Active Nuclei on Scales from Black Hole to Host Galaxy"

आर्यभट्ट प्रेक्षण विज्ञान शोध संस्थान
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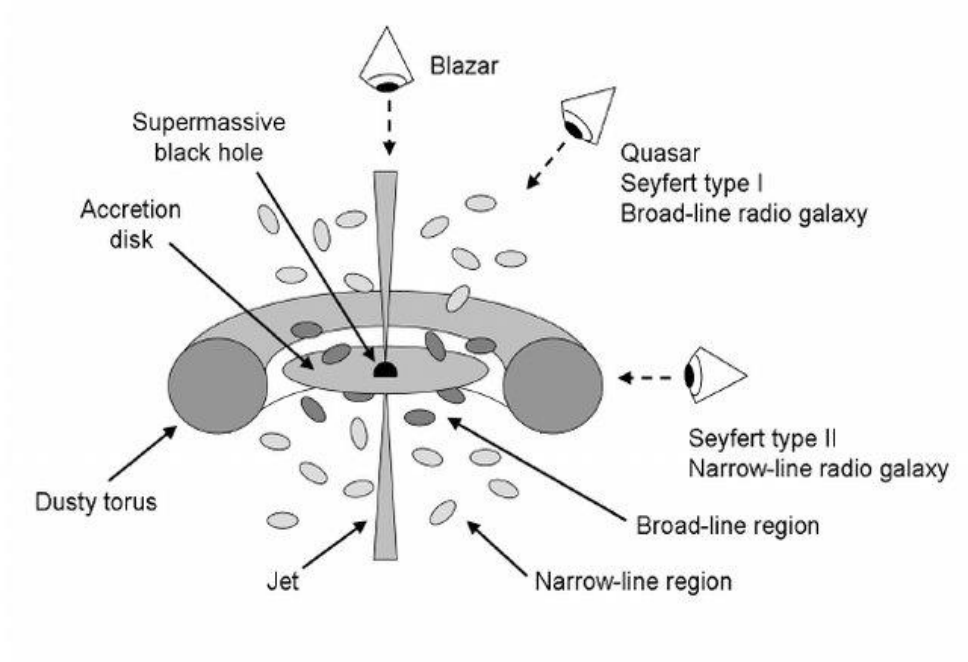
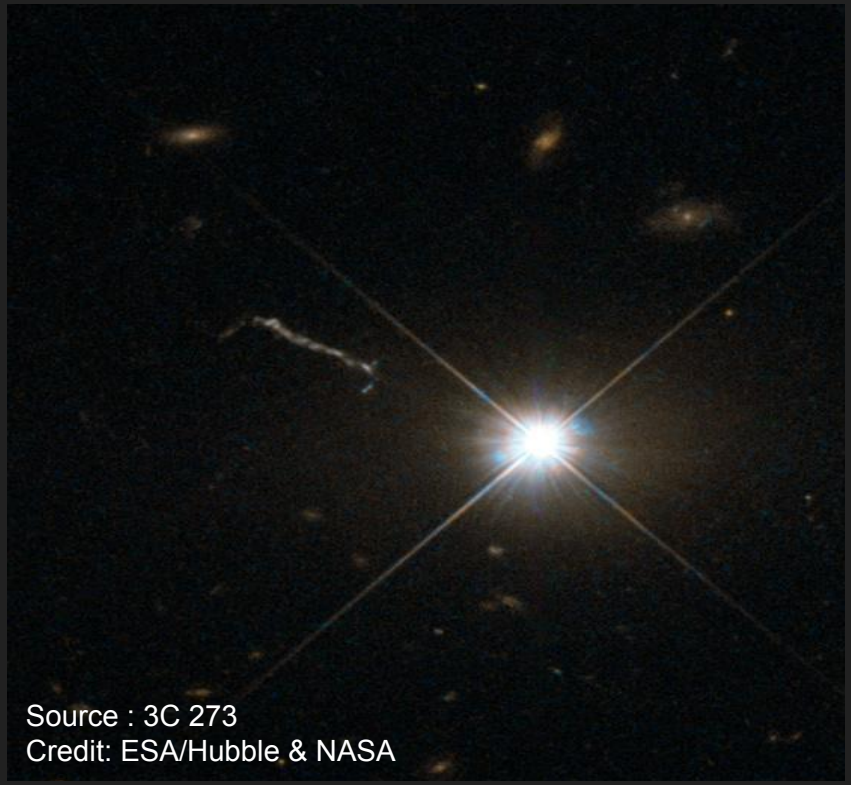
Central Engine and BLR: AGN



Credits: Erik Zackrisson based on Urry & Padovani+1995

- AGNs powered by SMBH at the center.
- Luminosity lies 10^{42} -10^{47}erg s^{-1}.
- Accretion disk.
- Broad line region (BLR).
- Dusty Torus.
- Narrow line region (NLR).
- Variable in the entire electromagnetic spectrum.

MASS OF BLACK HOLE



Source : 3C 273
Credit: ESA/Hubble & NASA

- The central engine is highly compact and unresolved even for low-z AGN and the majority of AGNs are at high redshift.
- The core outshines the host making the host galaxy difficult to observe.

MASS OF BLACK HOLE

- Reverberation Mapping is one such technique.

Reverberation Mapping(RM):

"Size and structure of BLR can be obtained by observing the response of emission lines to continuum variations from the central source"

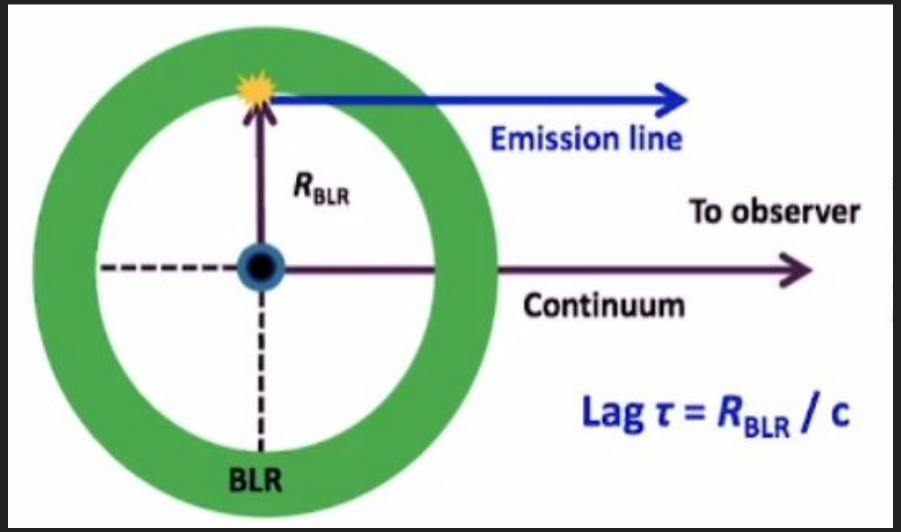
Assumptions of RM:

I. The continuum emitting region is a point source.

II. BLR clouds themselves occupy a small fraction of the total BLR volume.

III. Emission line clouds respond instantaneously to the changes in the continuum.

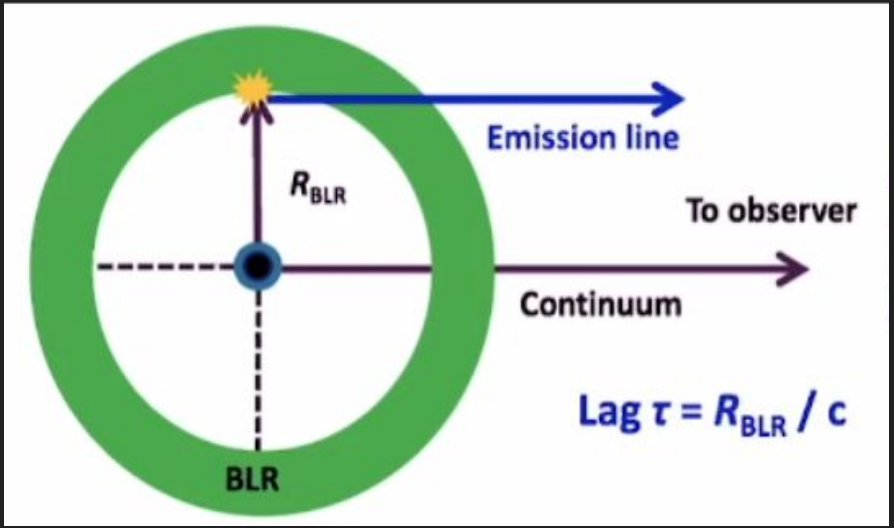
IV. The relationship between the observed line flux and continuum flux is simple, though not necessarily linear.



Pic:Peterson 1993

Reverberation Mapping(RM):

"Size and structure of BLR can be obtained by observing the response of emission lines to continuum variations from the central source"

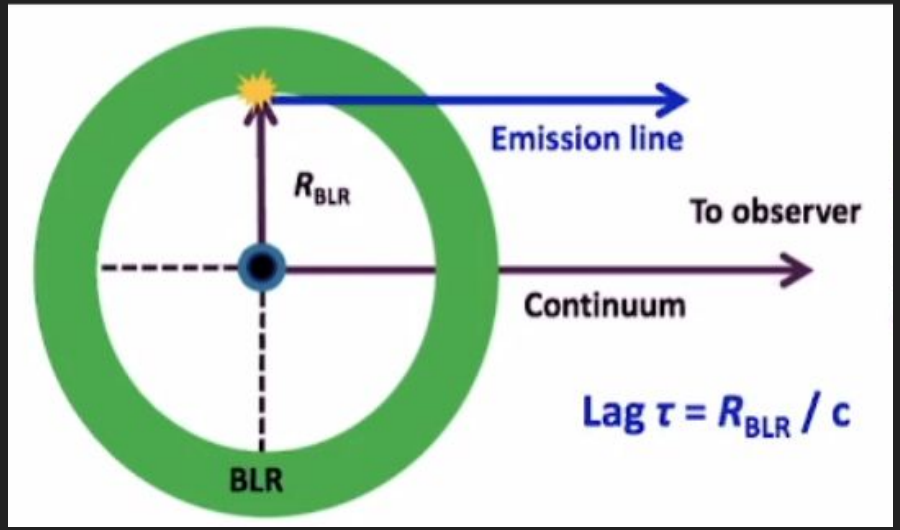


Peterson 1993

$$M_{BH} = \frac{f \times R_{BLR} (\Delta V)^2}{G}$$

Size-Luminosity Relation:

"Size and structure of BLR can be obtained by observing the response of emission lines to continuum variations from the central source"



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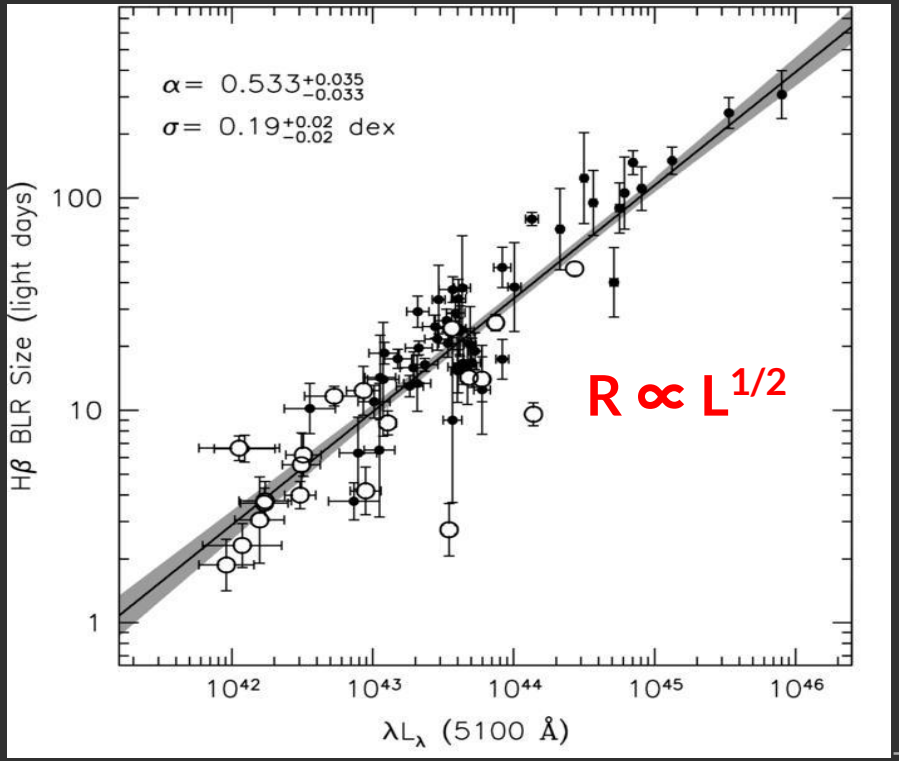
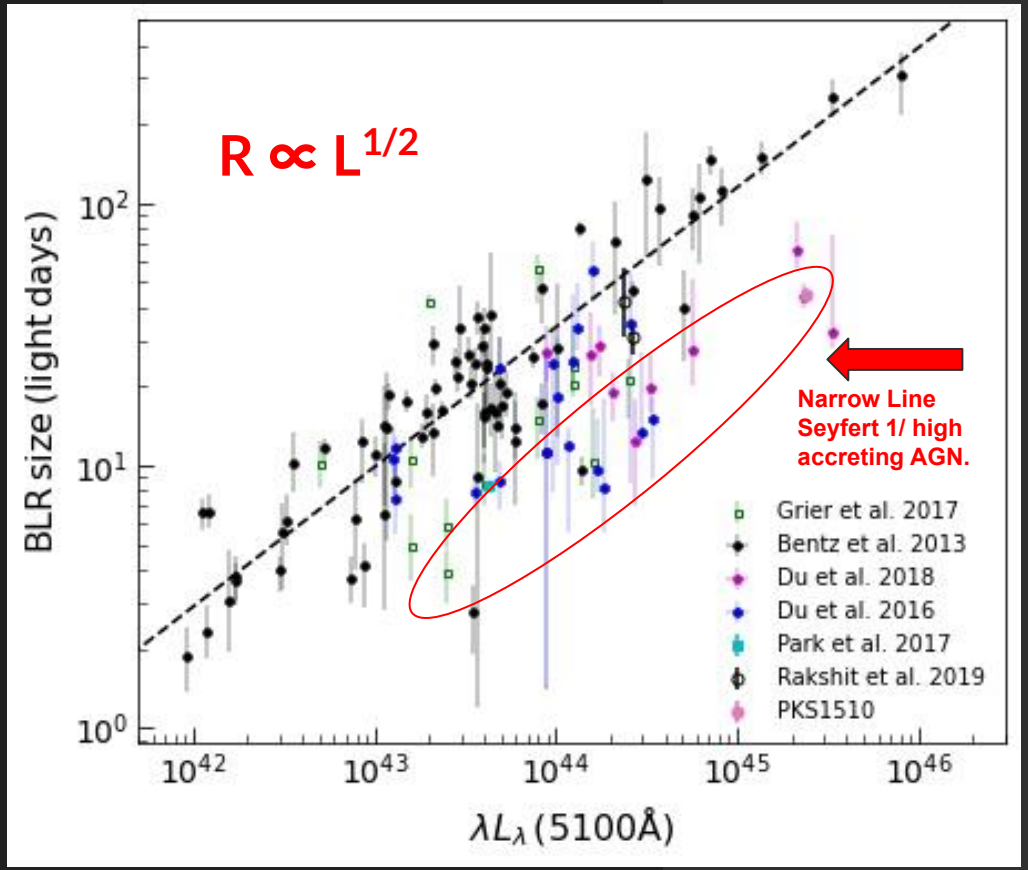


Bentz+2013

Size-Luminosity Relation:



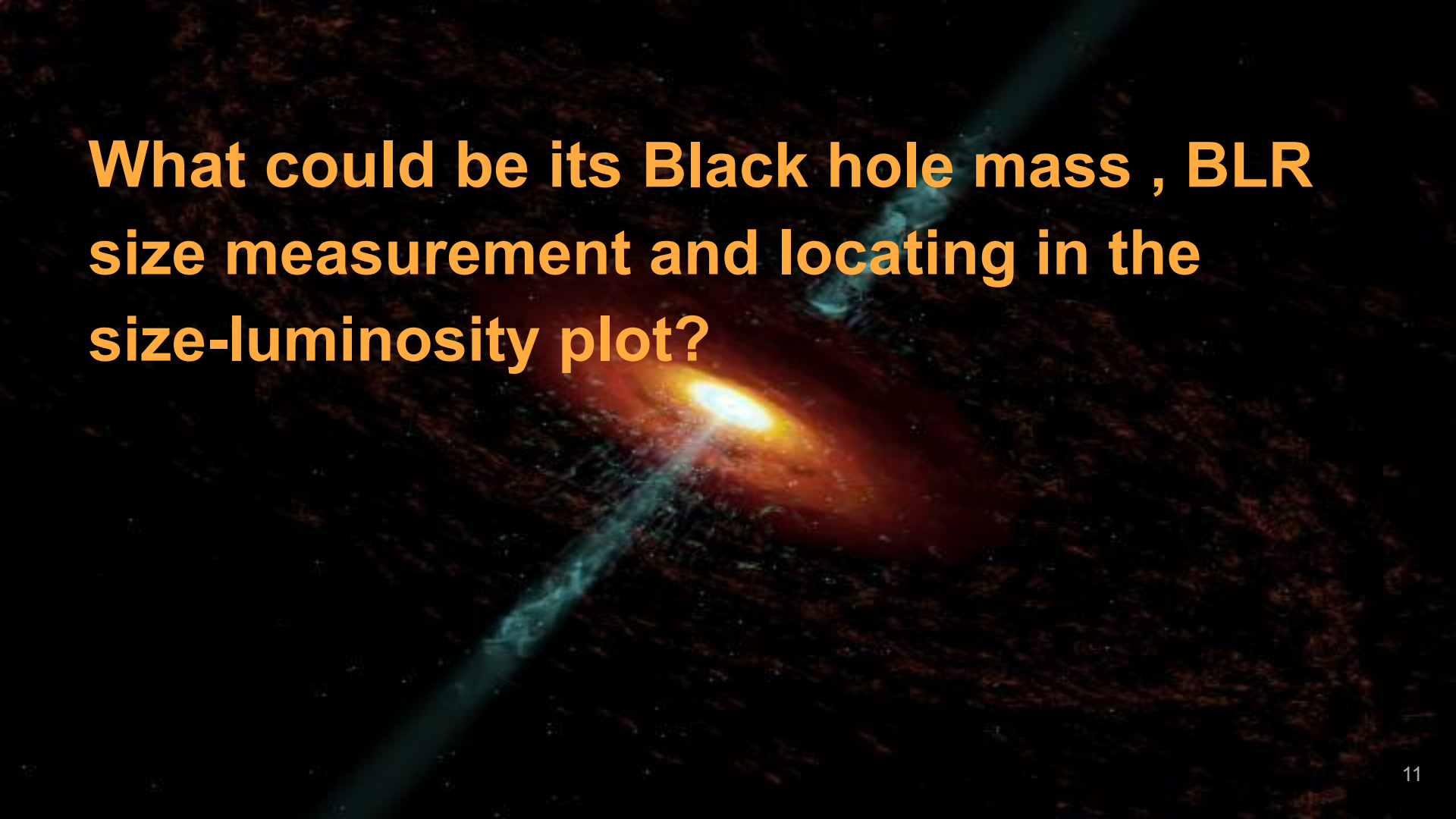
Source PKS 0736+017 and data:

Flat spectrum radio quasar of type blazar (100 MeV<E<100 GeV) (H.E.S.S.+2019), at z=0.189 (Ho & Kim 2009) , hosted by giant elliptical galaxy (Kotilainen et al. 1998).

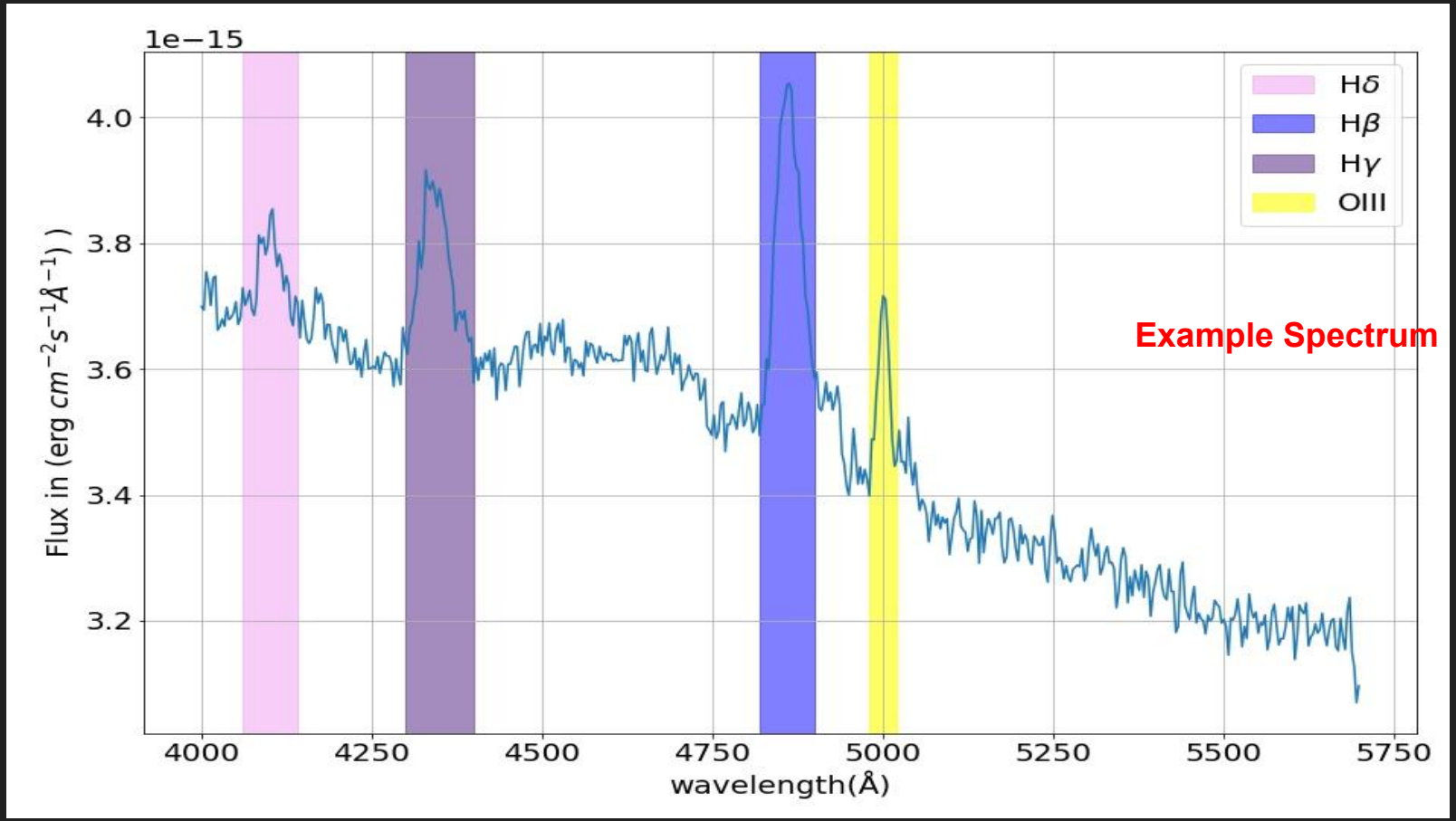
“Black hole mass , BLR size and it’s geometry is unknown till now, having strong emission lines and availability of long term monitoring data”

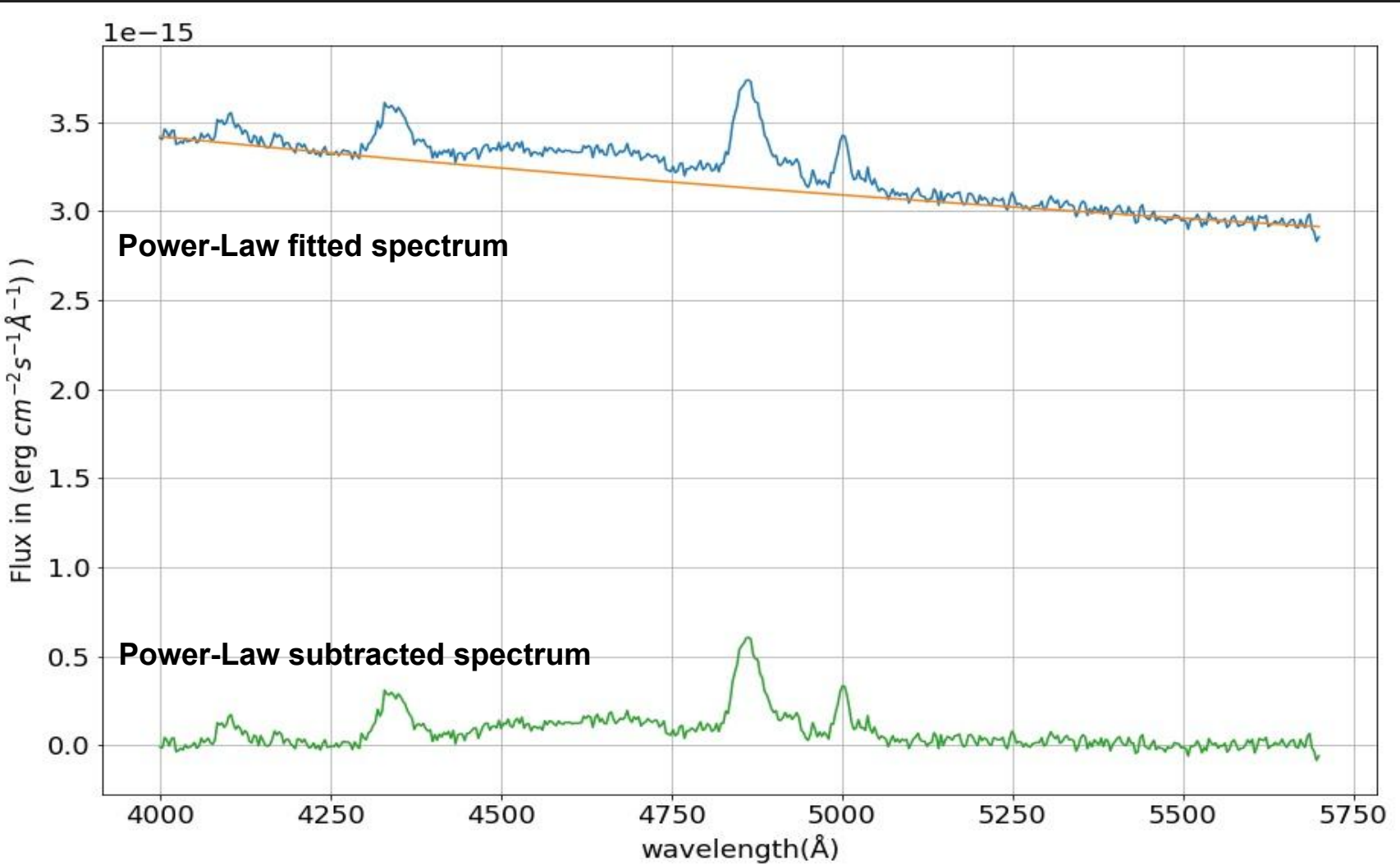
Source PKS 0736+017 and data:

- ➔ Optical V-band photometry and spectroscopic data from the Steward Observatory spectropolarimetric monitoring project, a support program for the Fermi Gamma-Ray Space Telescope, was used. Observations were carried out using the spectrophotometric instrument SPOL during Nov 2014 to May 2018.
- ➔ Contributing around 130 spectra (4-5 spectra per month).
- ➔ The γ-ray light curve were collected from the publicly available database of the Large Area Telescope (LAT) on board the Fermi Gamma-Ray Space Telescope (Bhoomika+2021).

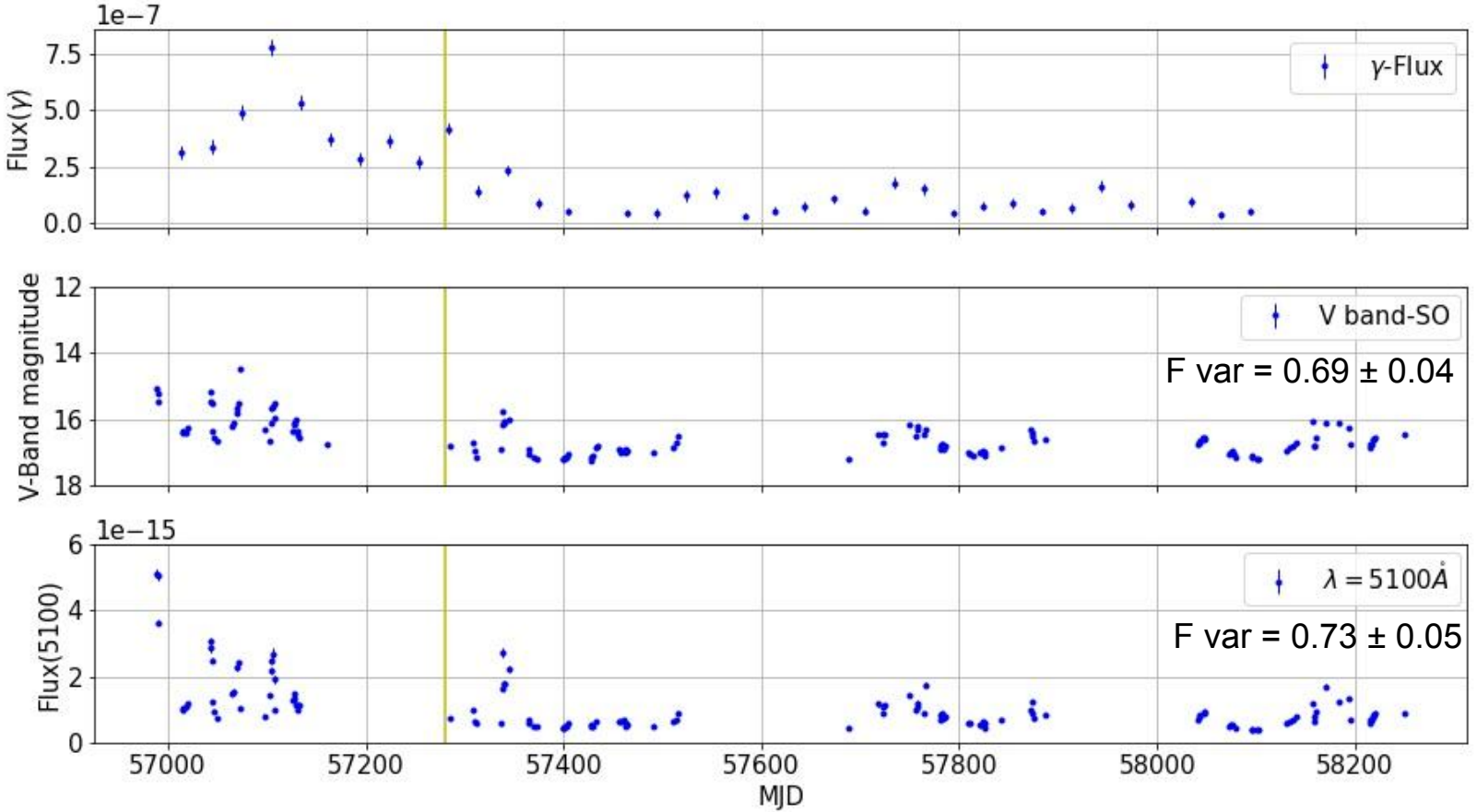

What could be its Black hole mass , BLR size measurement and locating in the size-luminosity plot?

Spectrum and light curves:

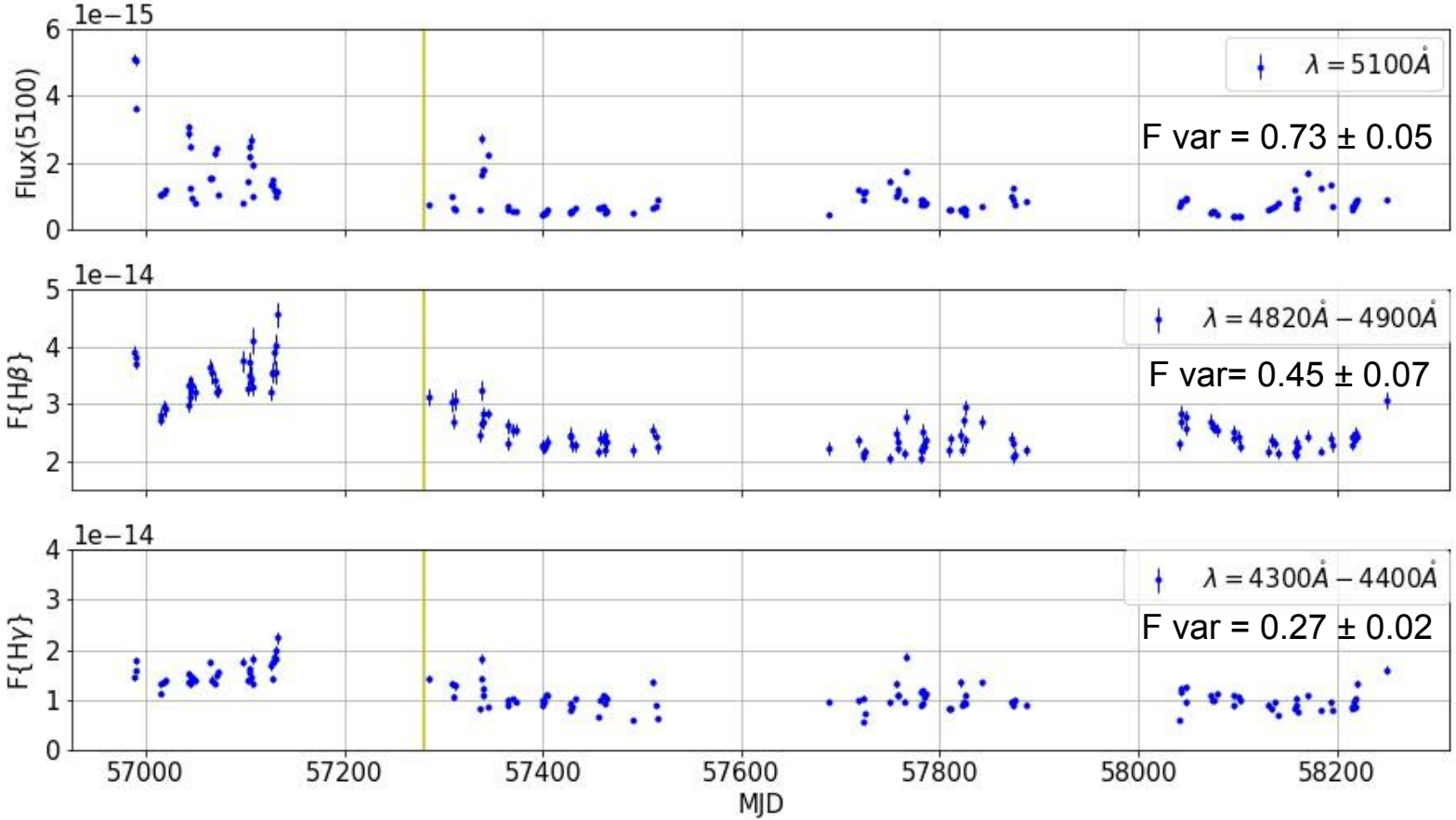



1e−15
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
Flux in (erg $cm^{-2}s^{-1}\AA^{-1}$))
Power-Law fitted spectrum
Power-Law subtracted spectrum
4000
4250
4500
4750
5000
5250
5500
5750
wavelength(Å)

Light curve: Top to bottom(F(γ) in photons s $^{-1}$ cm $^{-2}$, V-Band, F(5100 Å) in erg cm^{-2} s^{-1} Å^{-1})

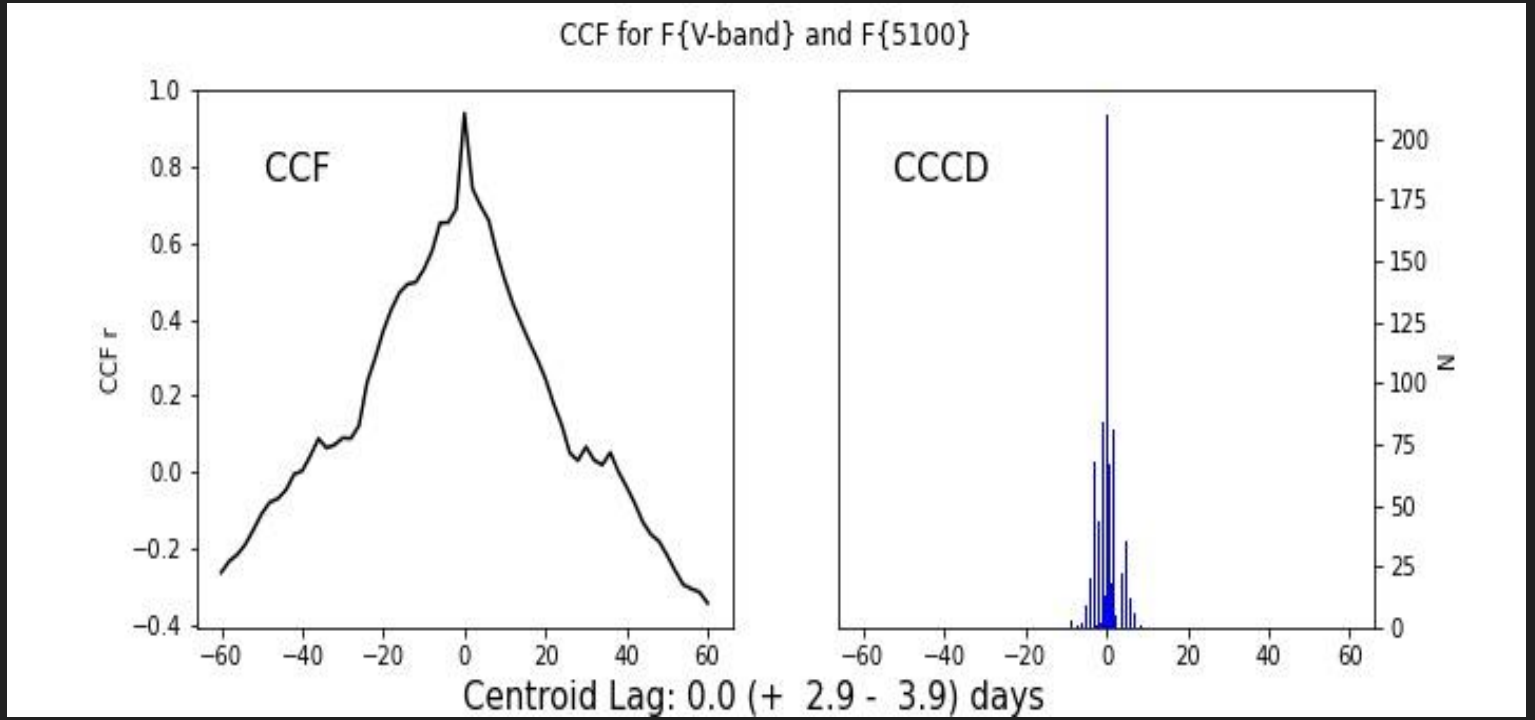


Light curve: Top to bottom(F(5100 Å) in erg cm^{-2} s^{-1} Å^{-1}, F(Hβ), F(Hɣ) in erg cm^{-2} s^{-1})



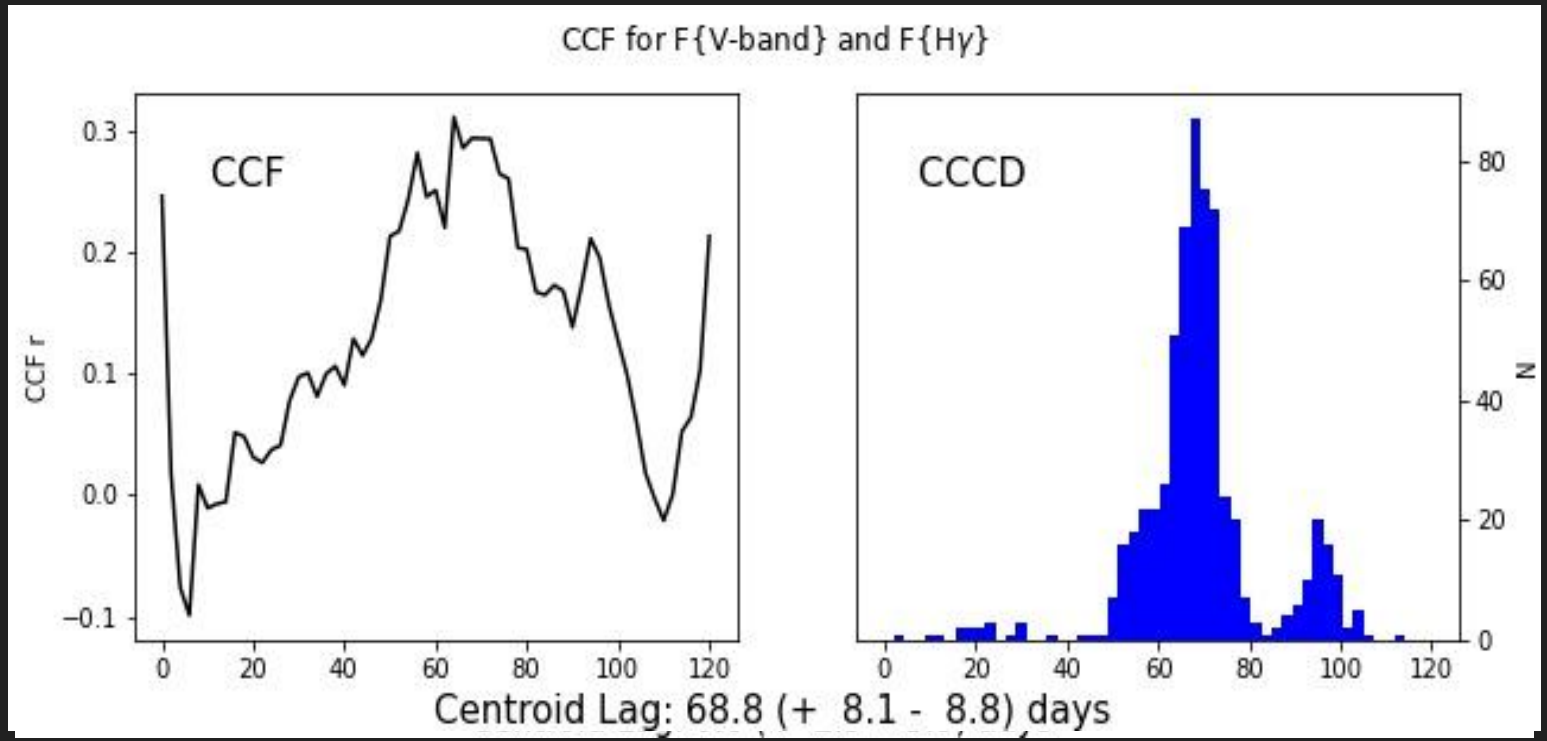
Results: Cross-Correlation results

Autocorrelation btw Continuum V-Band and Continuum Flux at 5100Å



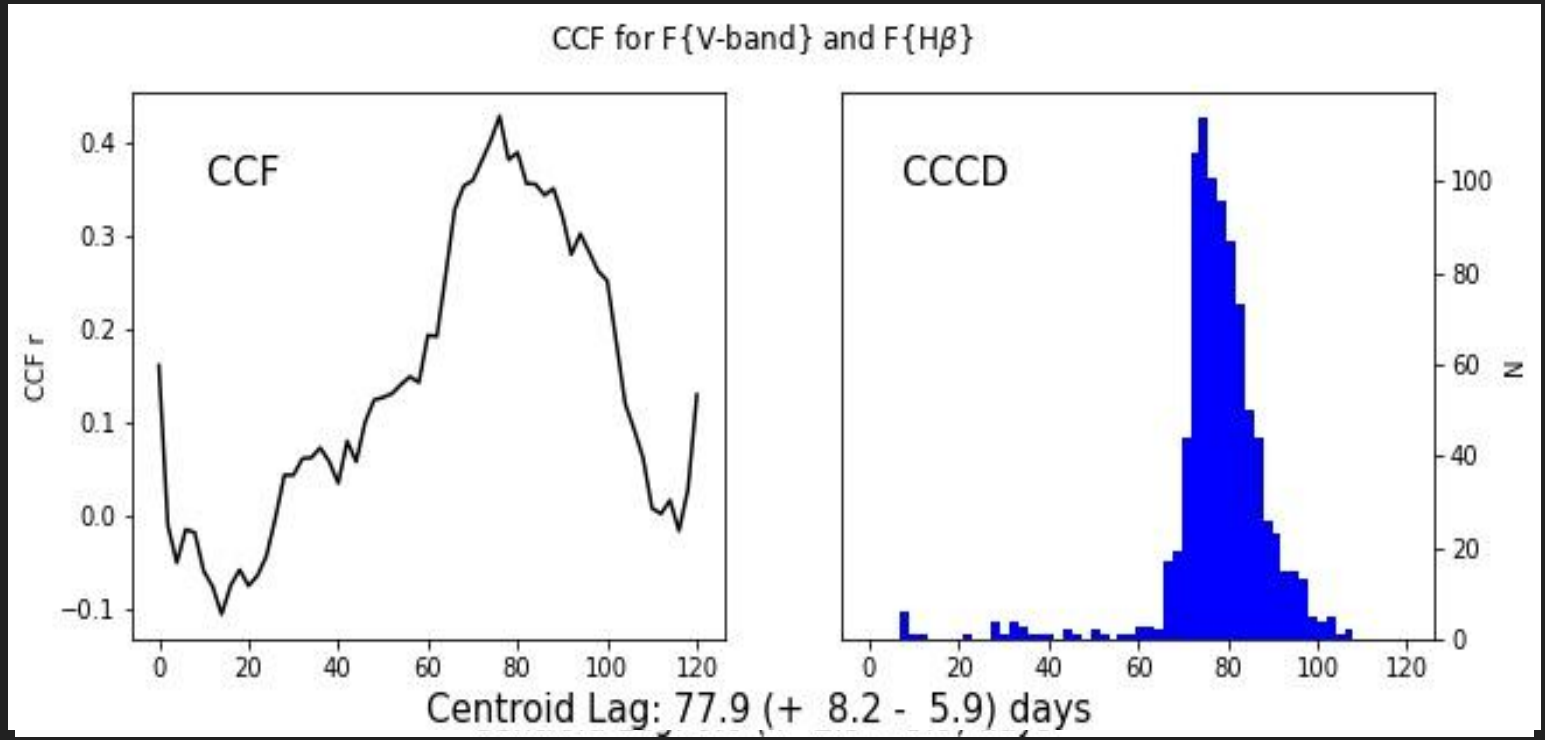
Results: Cross-Correlation results

CCF btw Continuum V-Band and Hγ



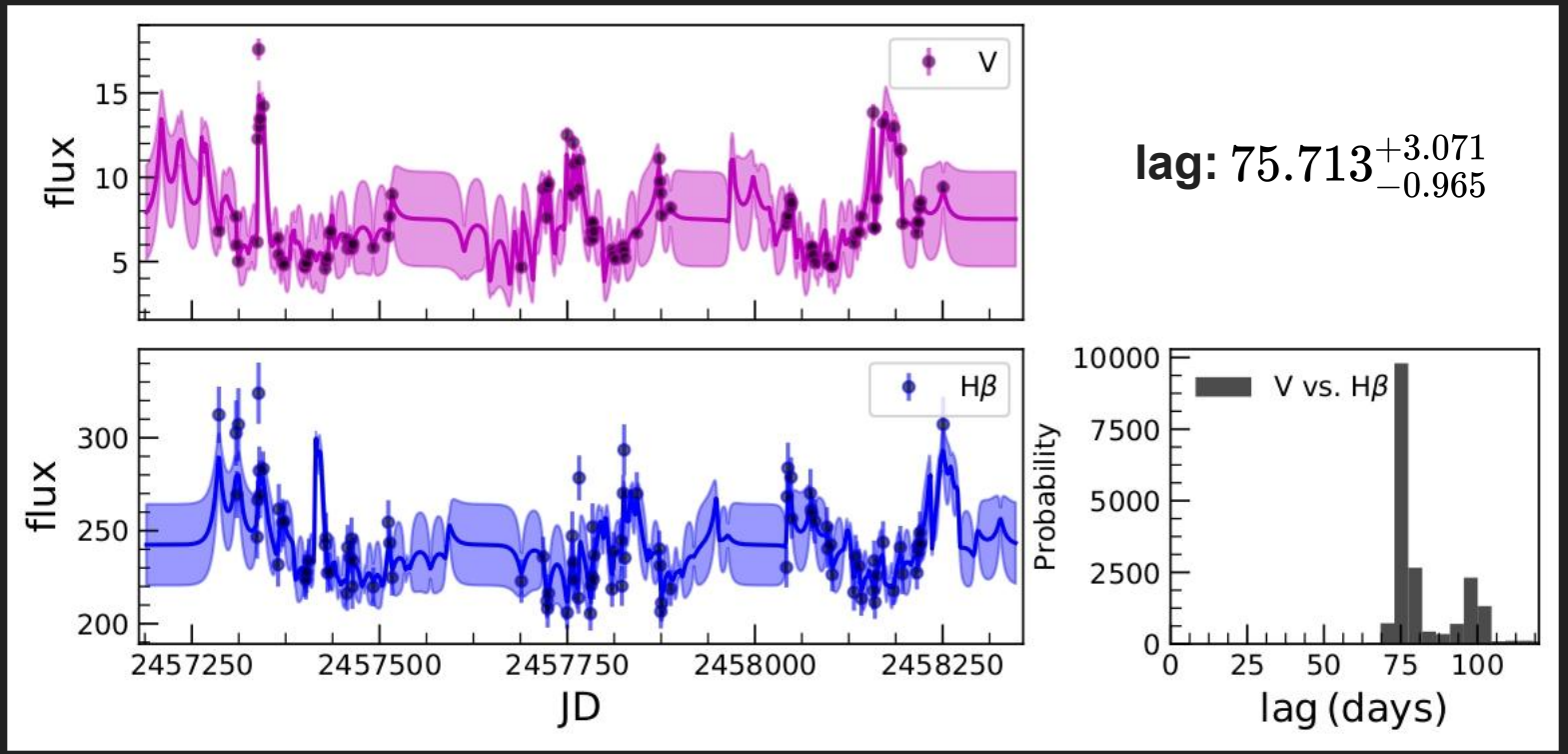
Results: Cross-Correlation results

CCF btw Continuum V-Band and Hβ



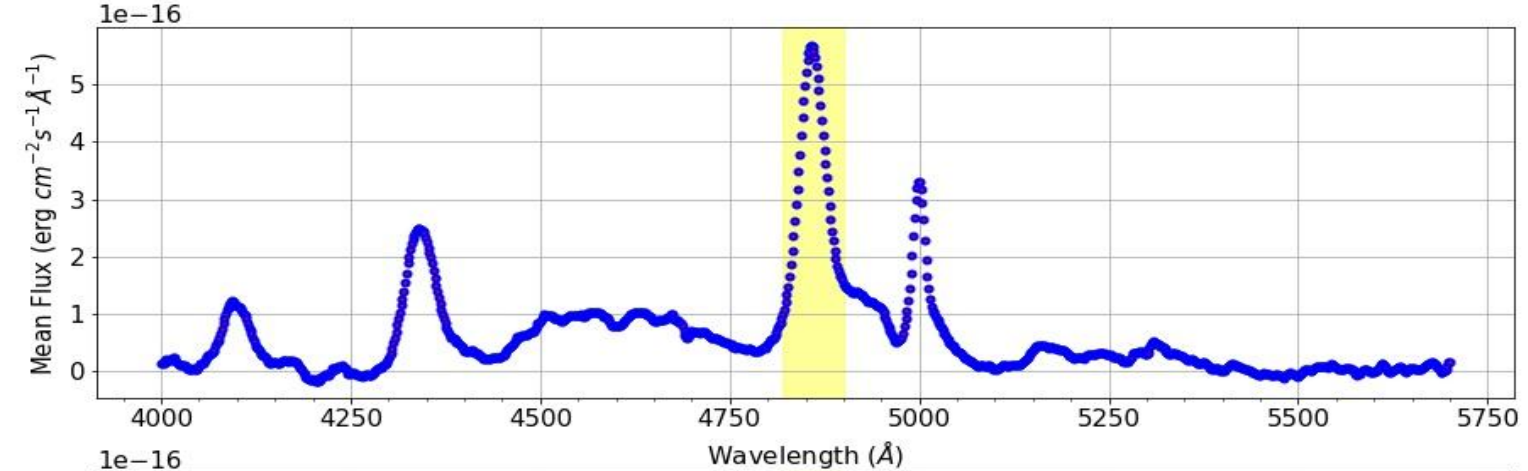
Results: Javelin result

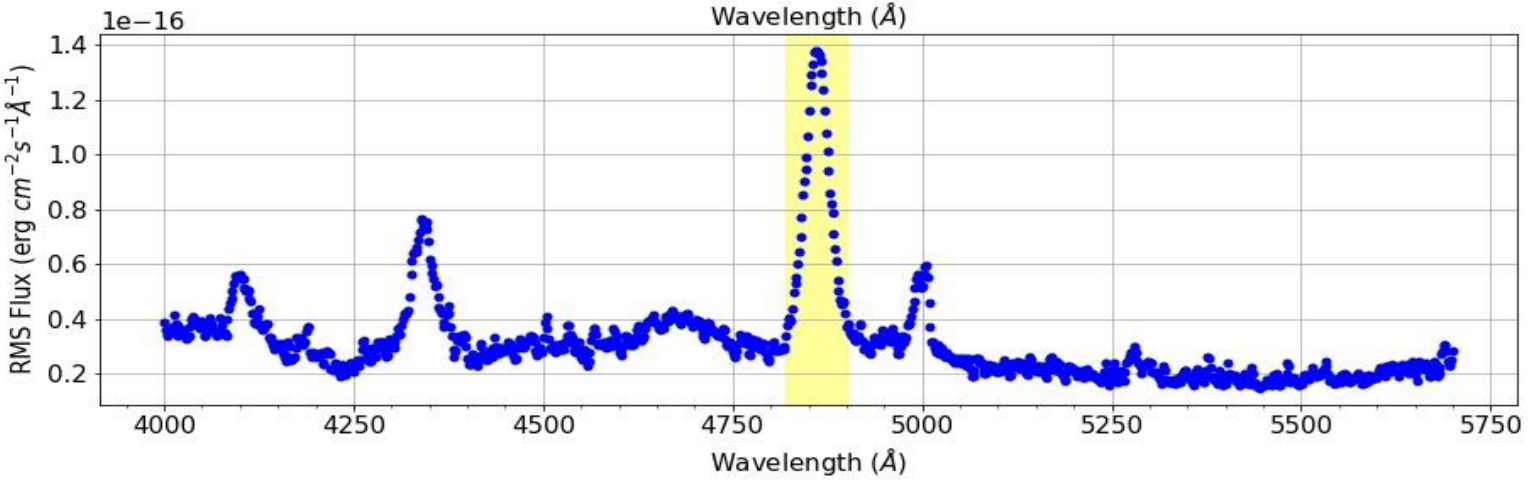
Javelin Result btw Continuum V-Band and Hβ



Javelin: Zu et al.(2011, 2013)

Results: Mean and RMS spectrum





Results: Mean and RMS spectrum

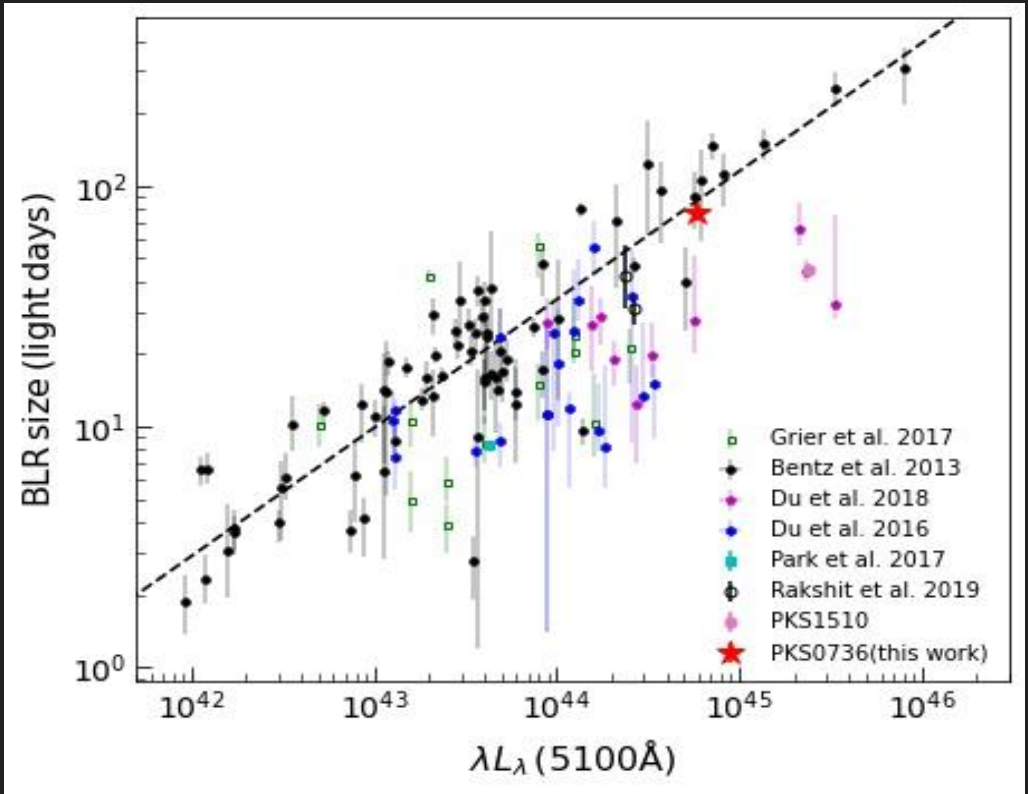
Spectrum	Type	ΔV(km s^{-1})
RMS	FWHM	$1807.96^{+181.10}_{-184.40}$
RMS	σ line	$1076.33^{+66.19}_{-72.19}$
Mean	FWHM	$2094.61^{+208.66}_{-235.08}$
Mean	σ line	$1334.32^{+127.22}_{-123.92}$

RESULTS:

f= 4.47(σ) , 1.12(FWHM) (Woo+2015)

Spectrum	Type	ΔV(km s^{-1})	M_{BH} ($\times 10^7 M_\odot$)
RMS	FWHM	$1807.96^{+181.10}_{-184.40}$	$4.67^{+0.98}_{-0.90}$
RMS	σ line	$1076.33^{+66.19}_{-72.19}$	$6.7^{+0.84}_{-0.86}$
Mean	FWHM	$2094.61^{+208.66}_{-235.08}$	$6.28^{+1.34}_{-1.36}$
Mean	σ line	$1334.32^{+127.22}_{-123.92}$	$10.17^{+2.03}_{-1.80}$

Discussion and Conclusions:



Size Luminosity plot

- The source follows the relation of luminosity vs BLR size.

Discussion and Conclusions:

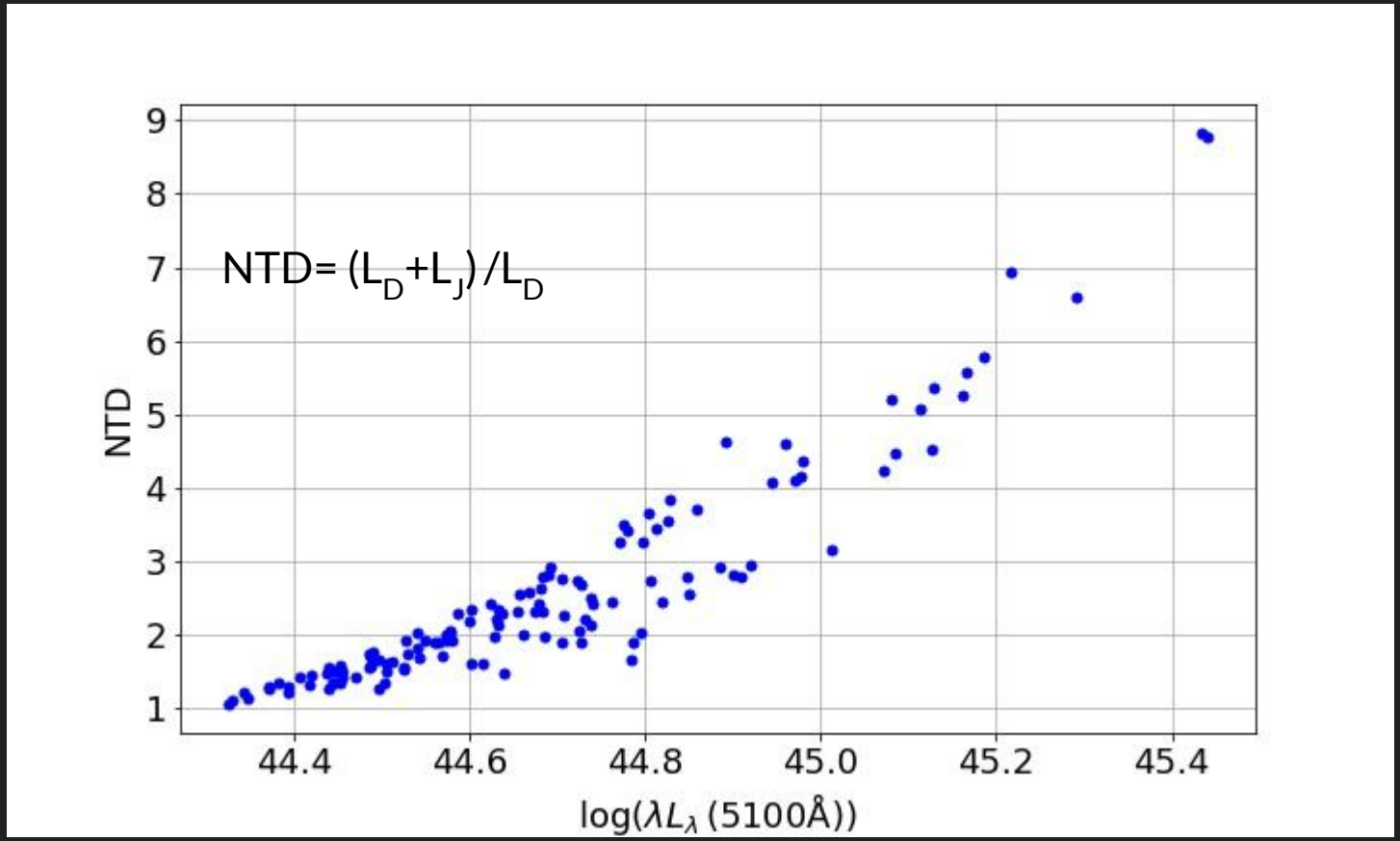
NTD= L_O/L_P , $L_O=L_D+L_J$

L_D = disk luminosity

L_J = jet luminosity

L_P = predicted disk luminosity =L_D

Discussion and Conclusions:



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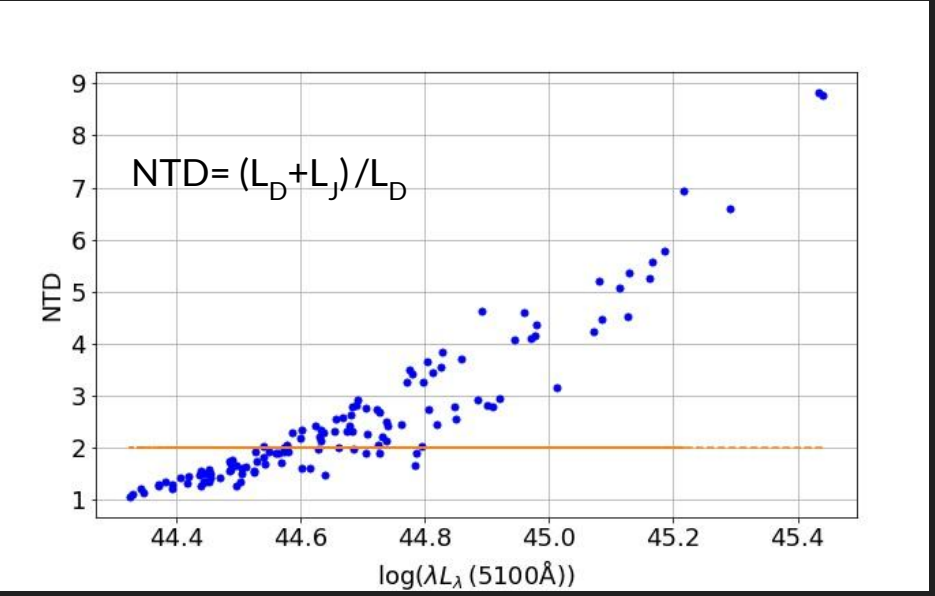

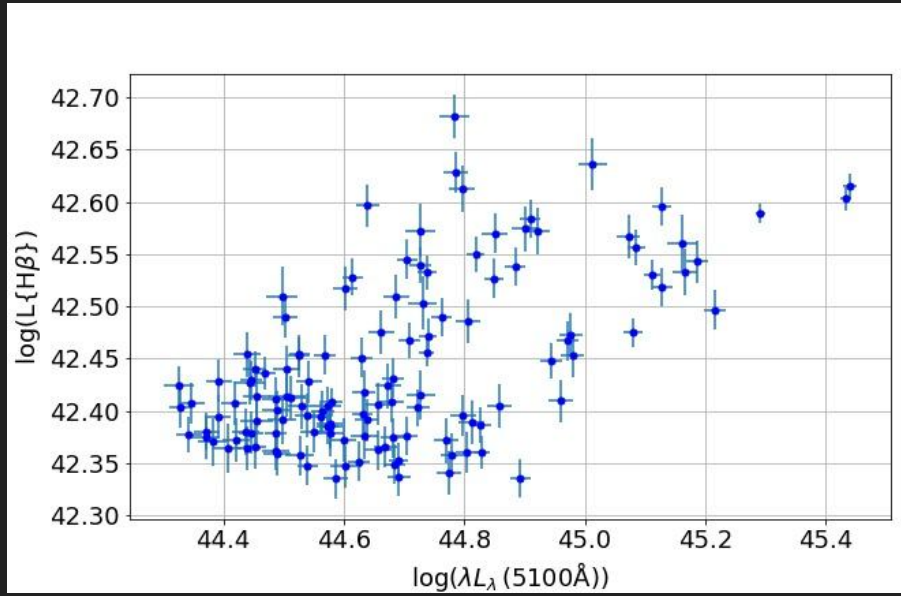

The measured L_{5100} is a combination of non-thermal emission from the jet and thermal emission from the accretion disk.

Discussion and Conclusions:

- The BLR size in light days is ~ $77.9^{+9.1}_{-5.9}$.
- The mean L_{5100} of 5.8X10^{44} ergs s^{-1}.
- The Blackhole mass is estimated as $6.7 \times 10^7 M_\odot$.
- The measured L_{5100} is affected by the non-thermal emission.

THANK YOU!

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