Multiwavelength analysis and the C IV emission line of the FSRQ B2 1633+382

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Image Credit: ESO/M. Kornmesser

Outline

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2. Why study FSRQs' emission in multiple wavelengths?
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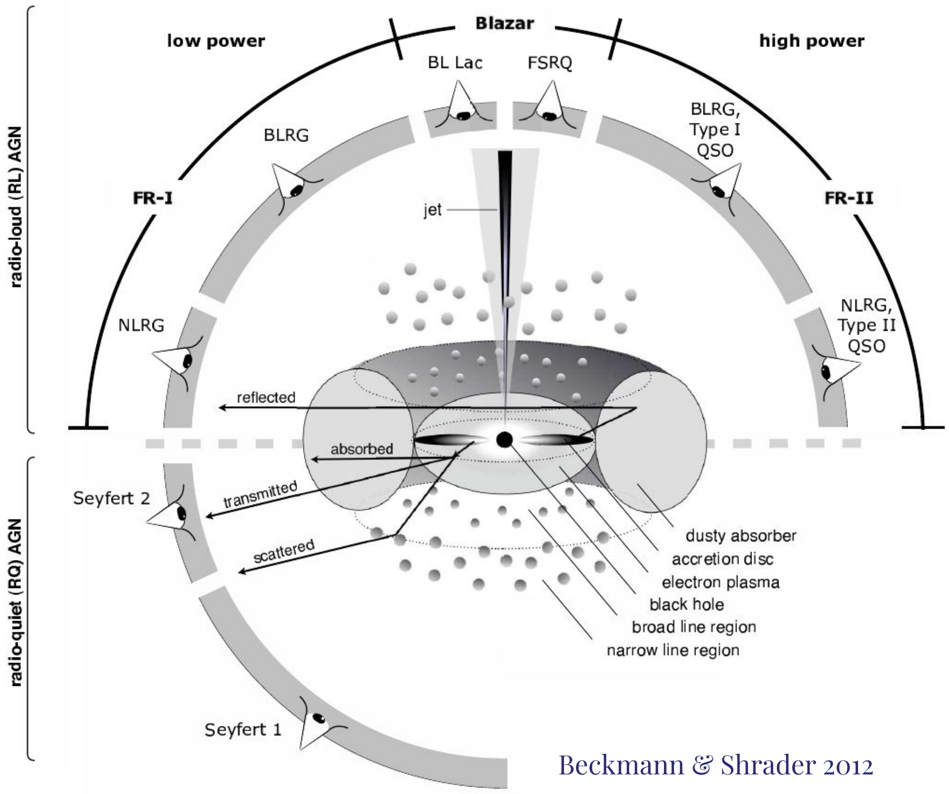
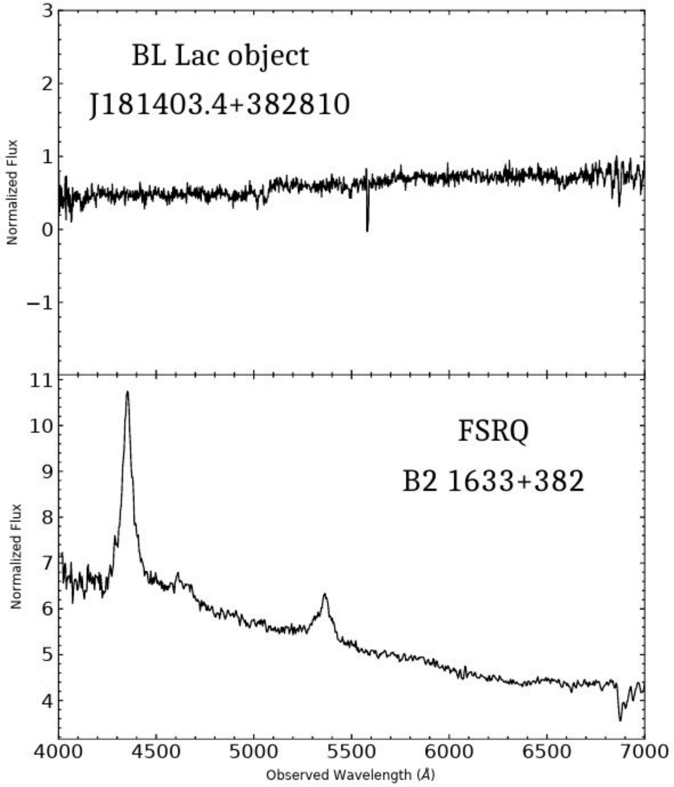
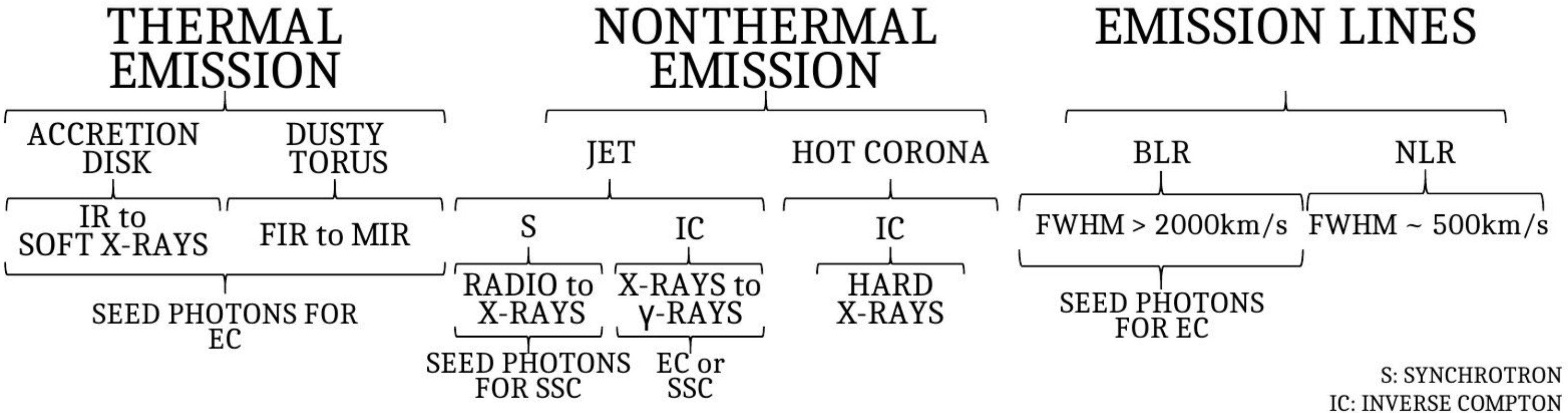
What is a FSRQ-type blazar?



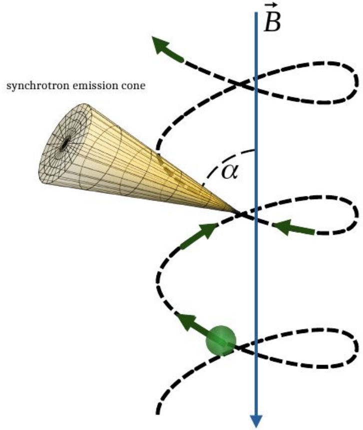
Beckmann & Shrader 2012

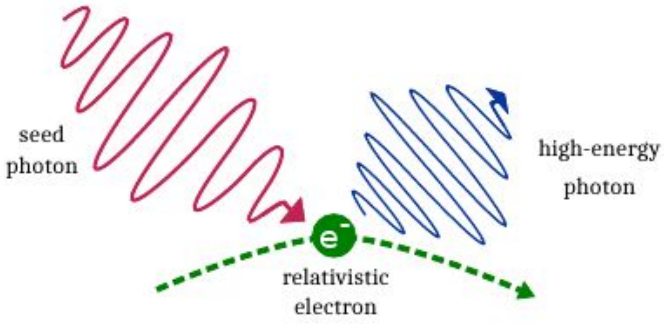


Why study FSRQs' emission in multiple wavelengths?



- **Radiate at all observable frequencies**
- **High variability**
- **Multiwavelength emission sometimes is correlated**



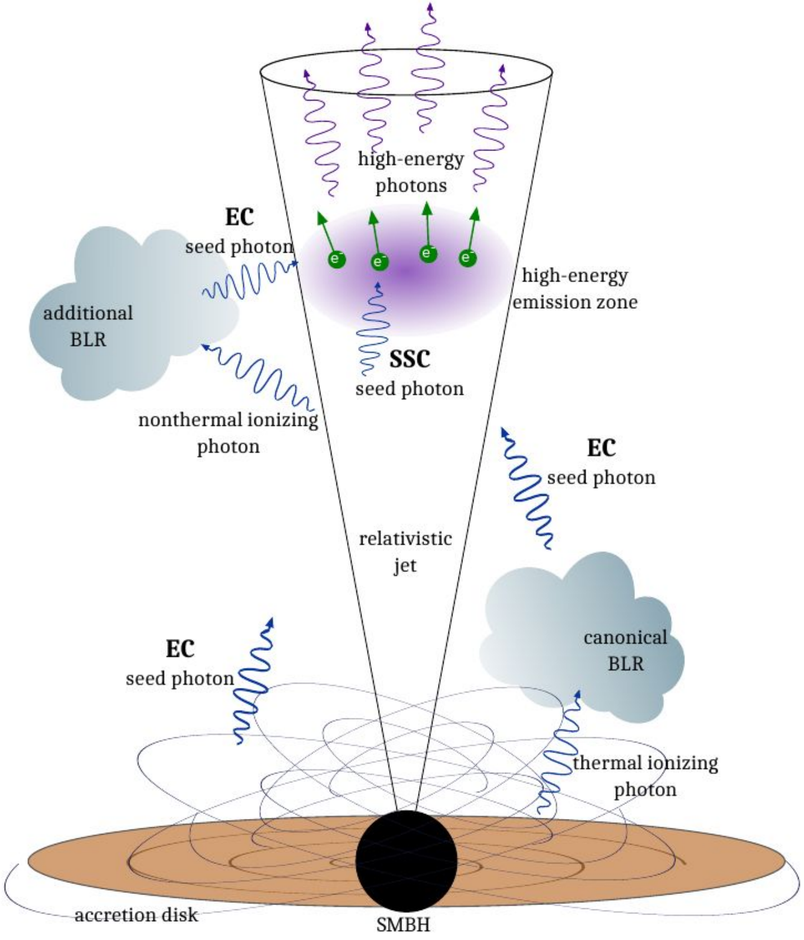


Scientific Objectives

- Locate the gamma-ray emission region
  - Within the central parsec?
  - Downstream the jet?
  - Multiple regions?

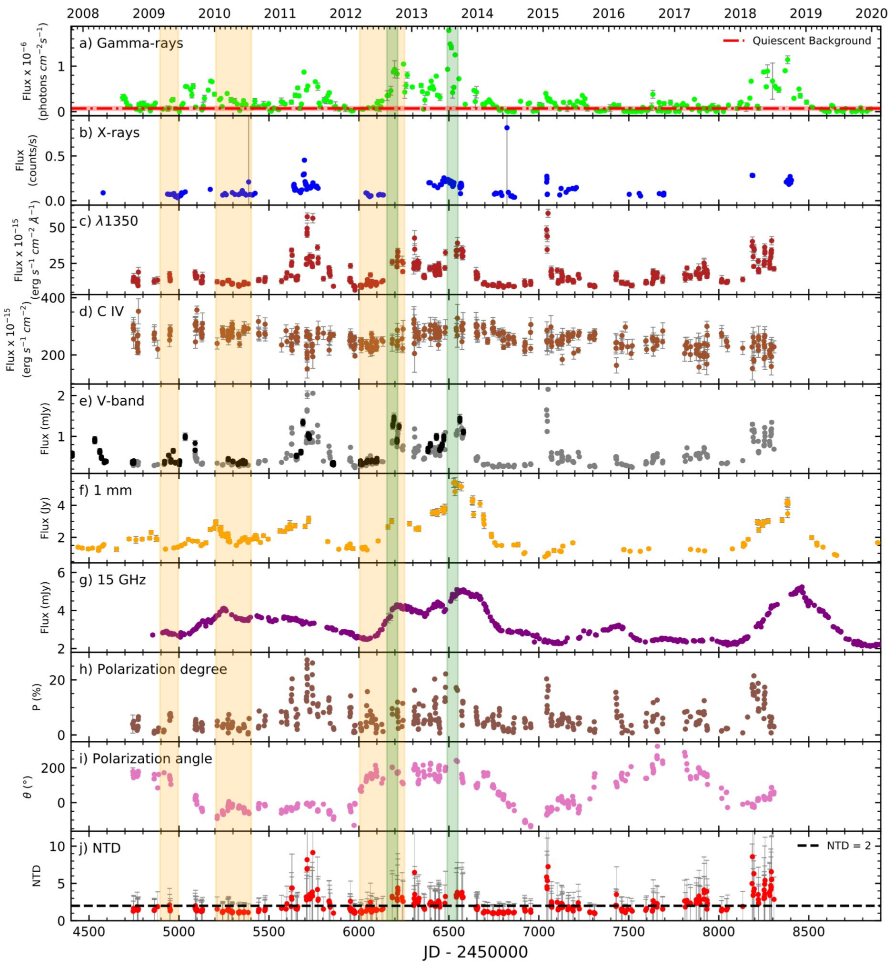
- Determine the mechanism driving the gamma-ray flares

- Is there an outflowing BLR component?

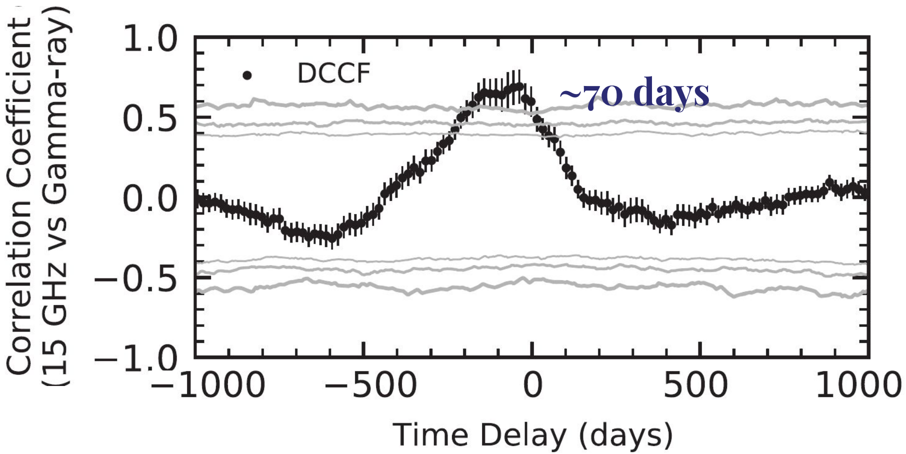


Multiwavelength observations of B2 1633+382

- Gamma-rays: Fermi Large Area Telescope (0.1 - 300 GeV)
- X-rays: Swift X-Ray Telescope (XRT)
- Optical spectra and V-band: Steward Observatory
- V-band: Catalina Surveys
- 1 mm: Submillimeter Array (SMA)
- 15 GHz: Owens Valley Radio Observatory (OVRO)
- Optical Polarization: Steward Observatory



The Gamma-ray Emission Region Location



$$d = \frac{\beta_{\rm app}\ c\ \tau_{\rm source}}{\sin\theta}$$

Fuhrmann et al. 2014

$\beta_{app} = 6.8 \pm 1.8$ Estimated from Jorstad et al. (2017) VLBI components

$\tau_{\rm source} = 69.5 \pm 8.7\ \mathrm{days}/(1+z)$ z = 1.814, Pâris et al. 2017

$\theta = 1^\circ - 3^\circ$ Hovatta et al. 2009

$$d_{15\rm GHz} \sim 41\ \mathrm{pc} - d = 4.4 \pm 1.9\ \mathrm{pc} = d_{\gamma\text{-rays}} \sim 37\ \mathrm{pc}$$

Pushkarev et al. 2012

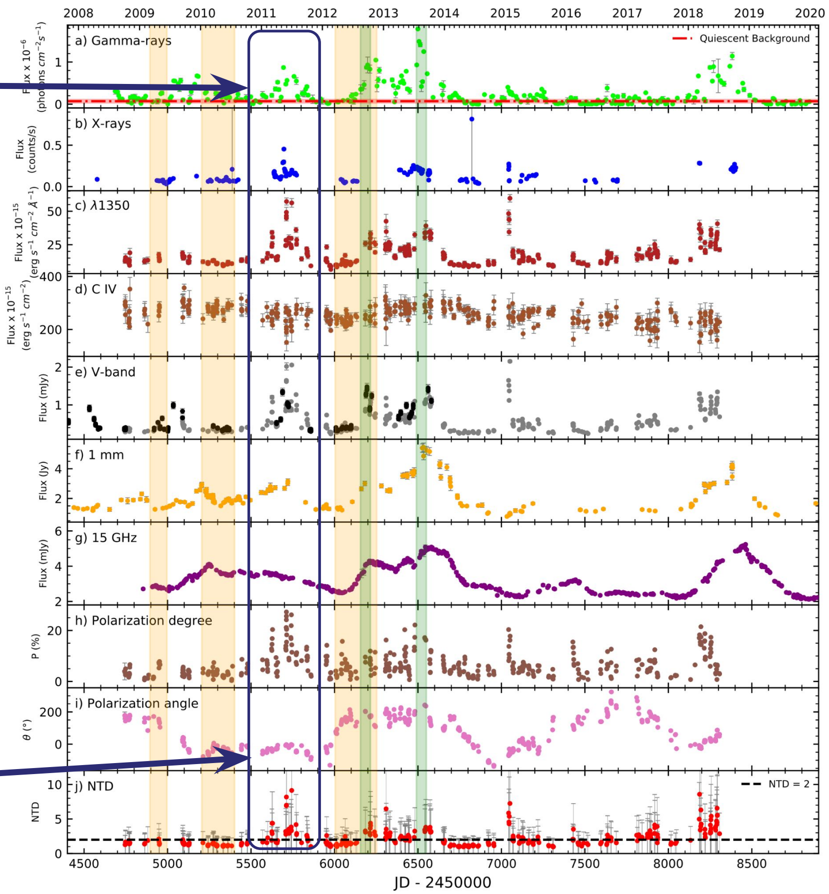
The Origin of the Gamma-ray Flares

No ejection from the radio core found. Jorstad et al. (2017)

Changes in the Doppler factor due to geometrical effects. Raiteri et al. (2012)

Algaba et al. (2018) and Hagen-Thorn et al. (2019) found variations in the Doppler factor are not enough to explain the flux variations.

Small changes in the polarization angle (<90°)



Flare of 2011 probably produced by magnetic reconnection.

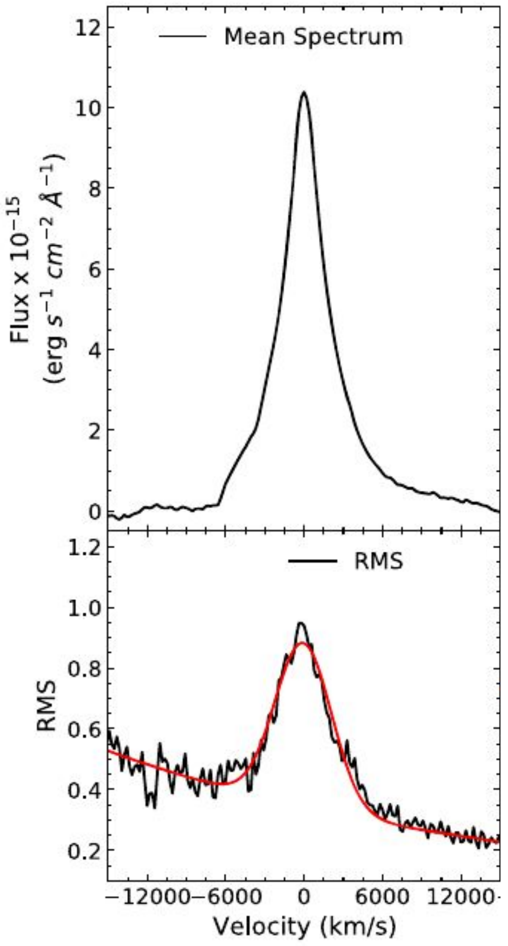
Outflowing BLR component

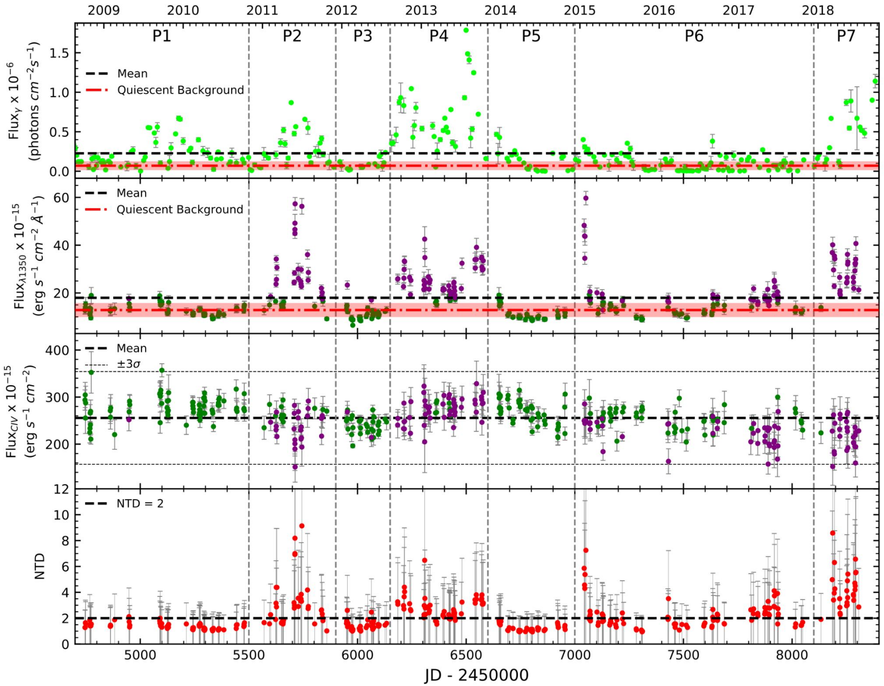
C IV λ1549Å emission line profile analysis

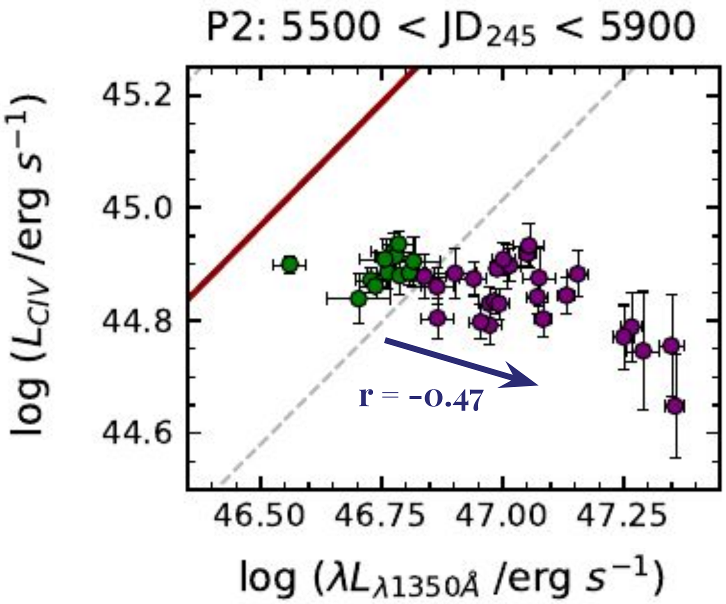
- Estimated Mean and RMS spectra
- RMS isolates the variable component

More variable in the blue side

BLR component moving in the direction of the observer.







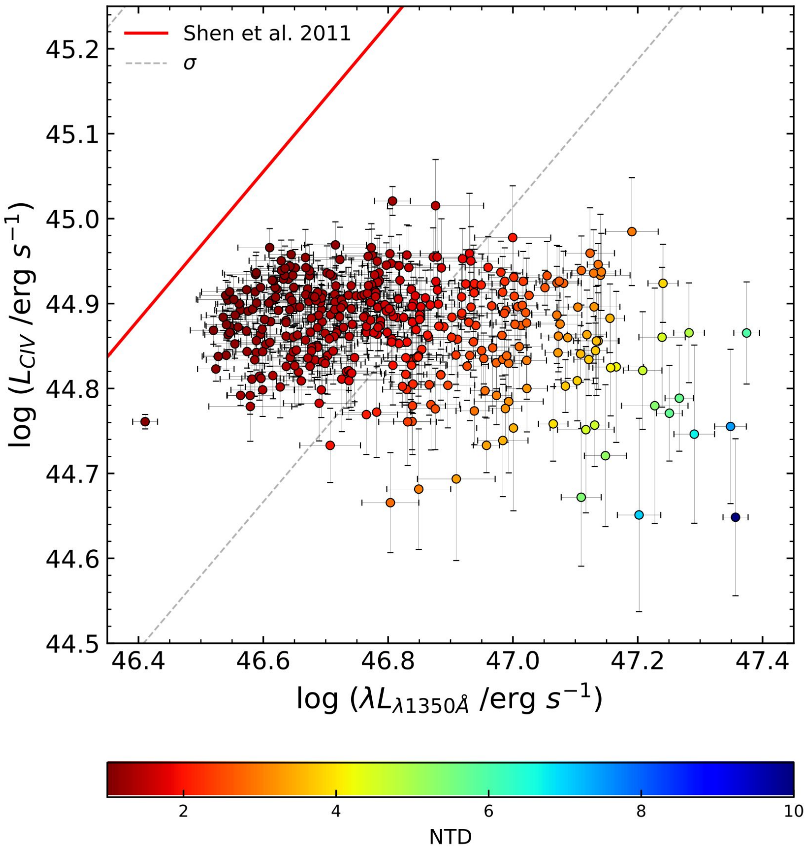
In P2, there is an anticorrelation. The emission line flux decreases as the continuum increases.

Interpretation: the jet steals BLR material decreasing the luminosity of the C IV line.

Consequence: the BLR outflow interacting with the jet could induce oscillations at its base driving the magnetic reconnection for the gamma-ray flare of 2011.

(GRMHD simulations Chatterjee et al. 2019)

Implication on the black hole mass estimation



The luminosity relation between the emission line and the continuum for radio-quiet sources is not followed by the observations of this source.

Other FSRQs e.g. CTA 102 (Chavushyan et al. 2020), 3C 454.3 (Amaya-Almazán et al. 2021) also do not follow this relation.

Reverberation mapping and single epoch techniques require these conditions:

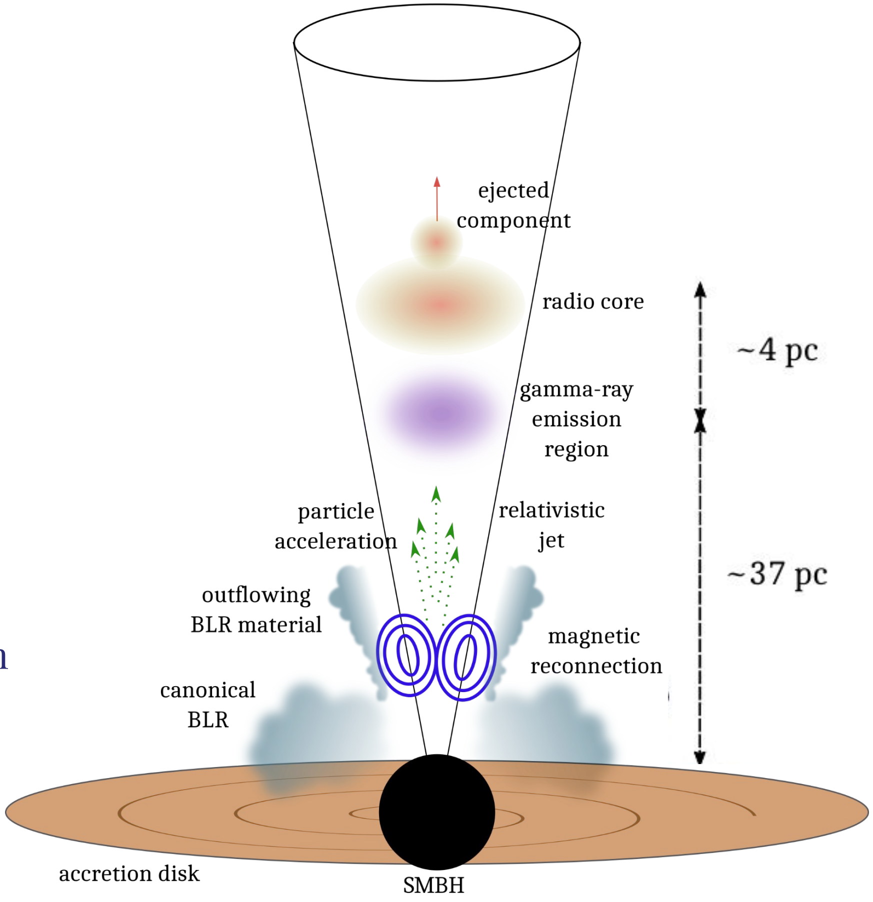
- Single ionizing source: the accretion disk
- Virialized BLR

<u>Neither of these conditions is met.</u>

The use of these techniques with FSRQs might need the use **of observations when the continuum is dominated by the accretion disk** and a possible spectral decomposition to **use only the line component corresponding to the virialized central BLR**.

Summary

1. Gamma-ray emission region at ~37 pc from the base of the jet.
2. Larger variable component in the blue wing of the CIV emission line ⟶ outflow of BLR material.
3. Gamma-ray flare of 2011 was probably produced by a magnetic reconnection.
4. Lag of 0±7 days between the C IV and the continuum ⟶ C IV BLR component is very small.
5. The luminosity relation between the line and the continuum does not follow the estimated relation for radio-quiet AGNs (Shen et al. 2011). The black hole mass estimations can be affected by this.



THANK YOU!

If you want to collaborate or have any suggestions, please contact me at:
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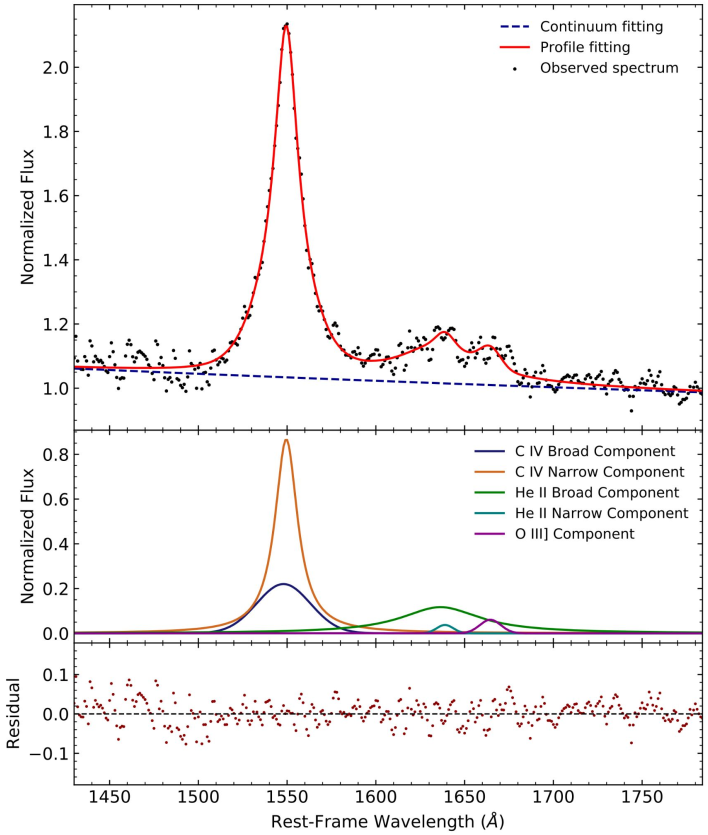
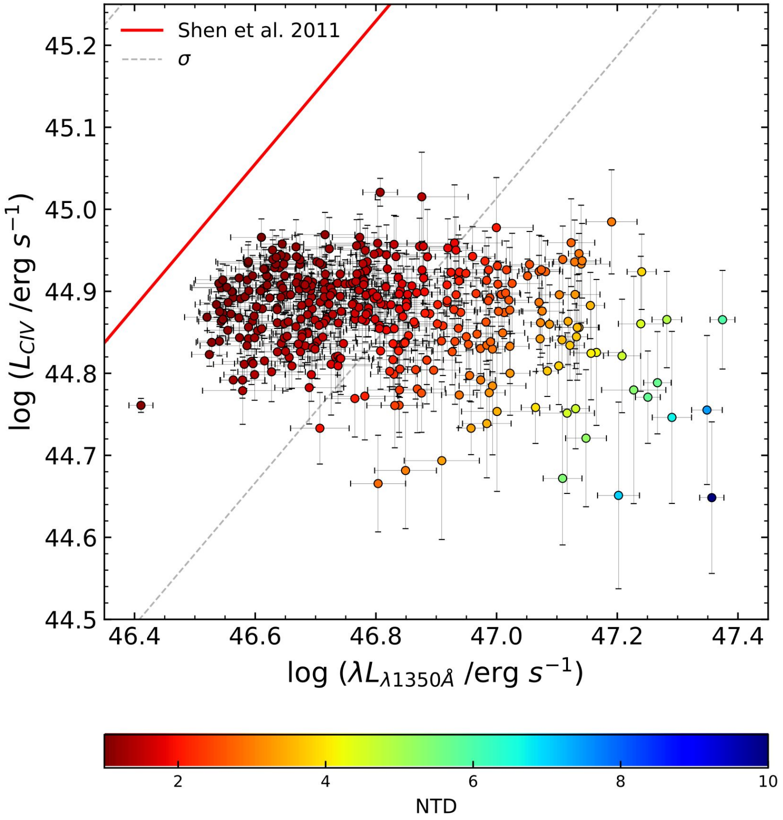
Other figures from this work





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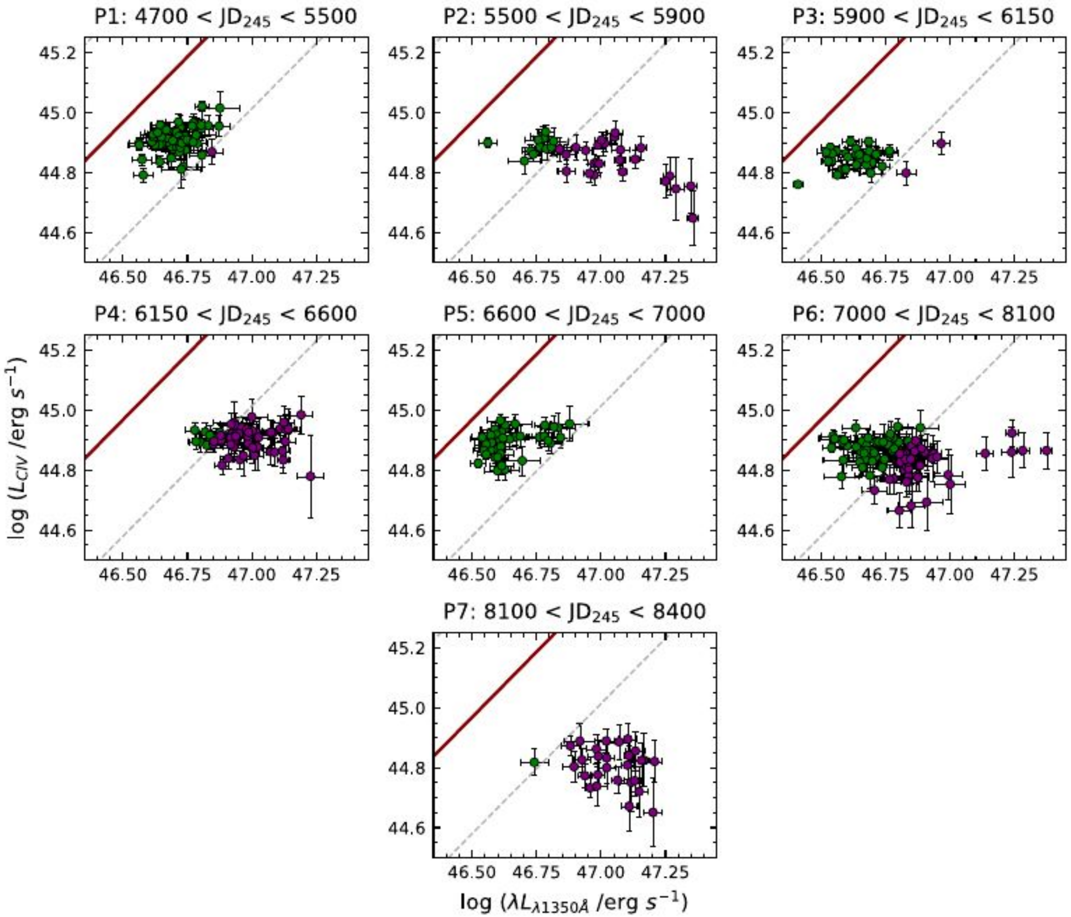

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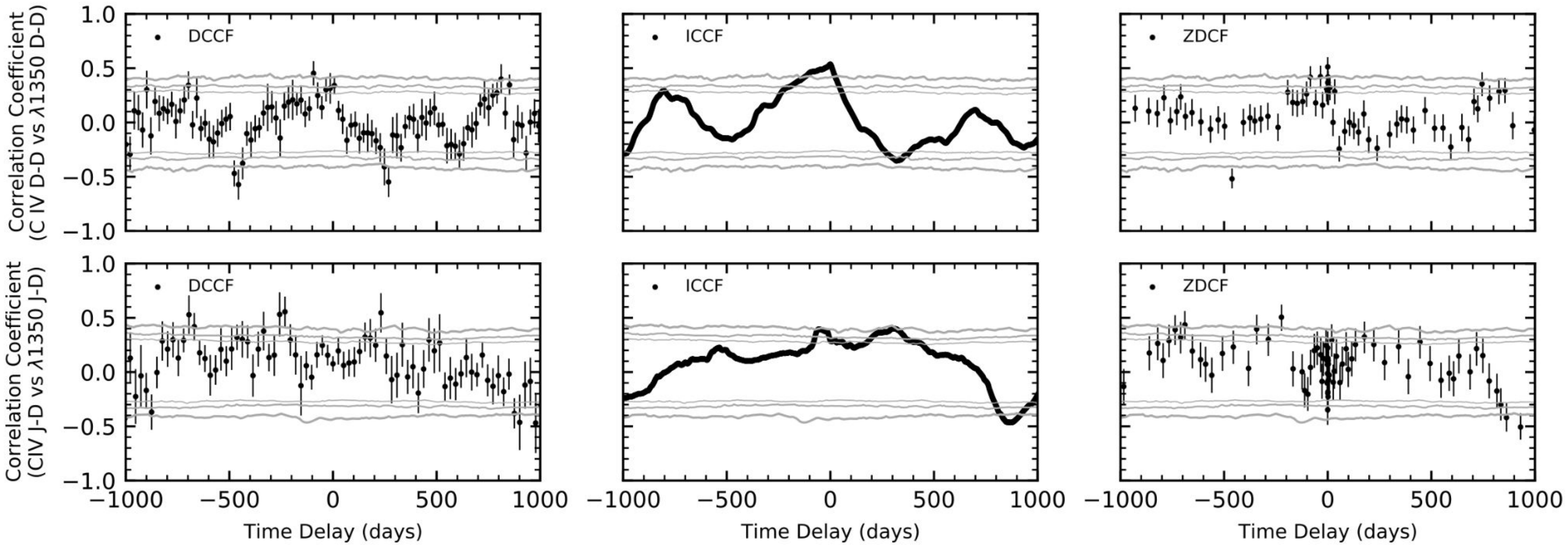

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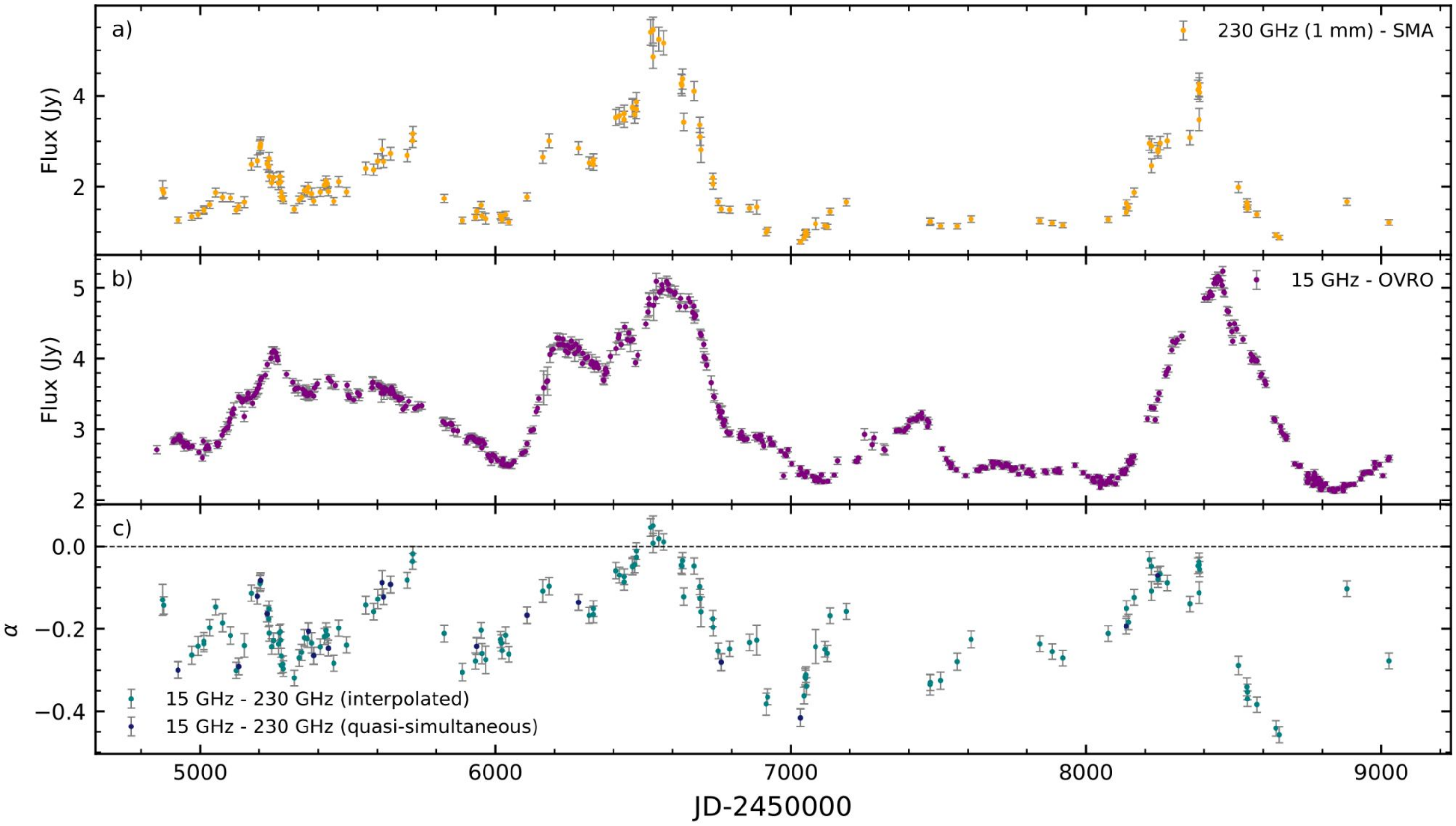
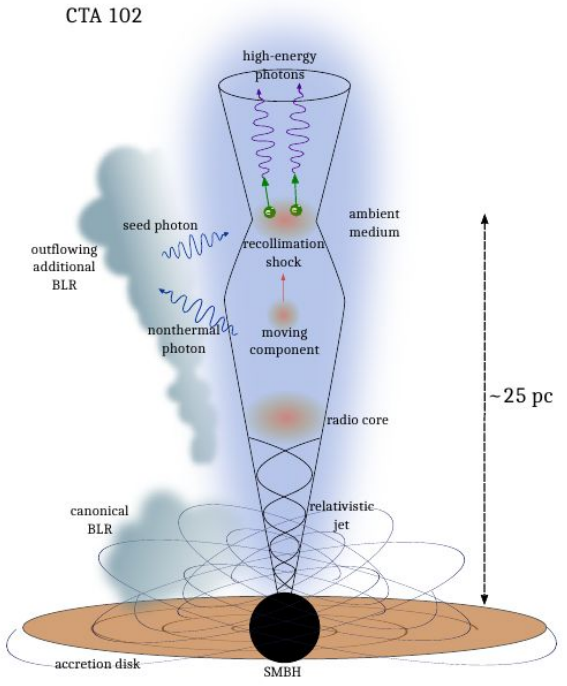
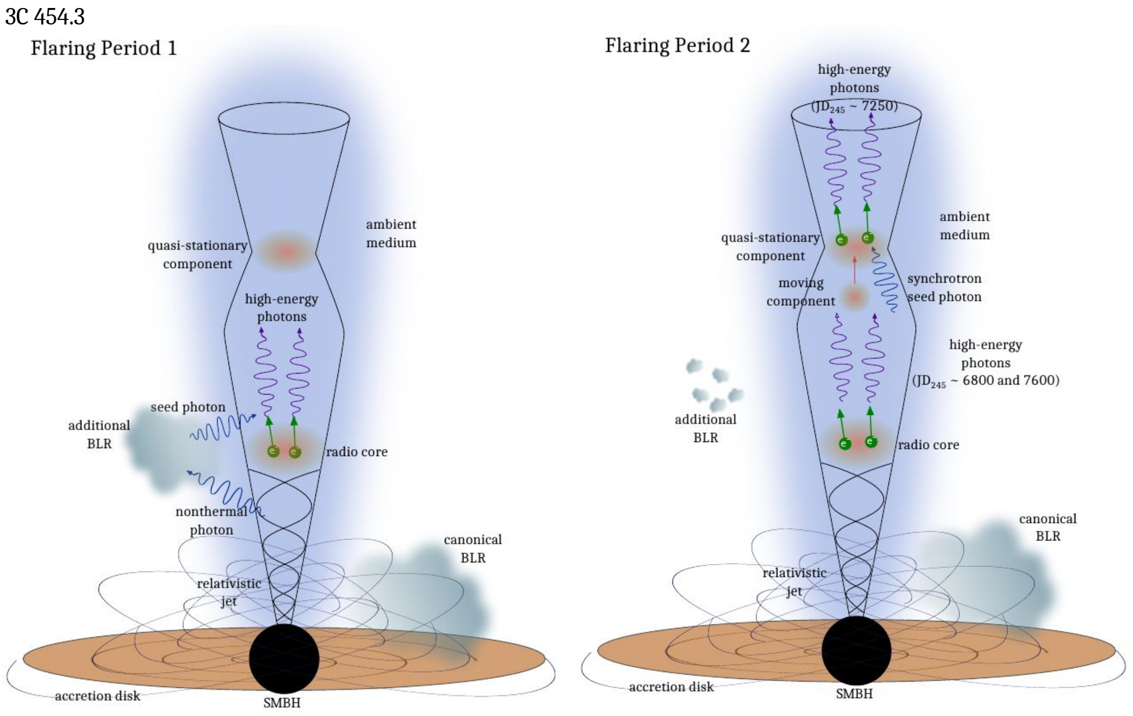


Previous Works about FSRQs



Chavushyan, et al. 2020



Amaya-Almazán, et al. 2021