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Transition from low to high activity states in γ-ray emitting NLS1 galaxies

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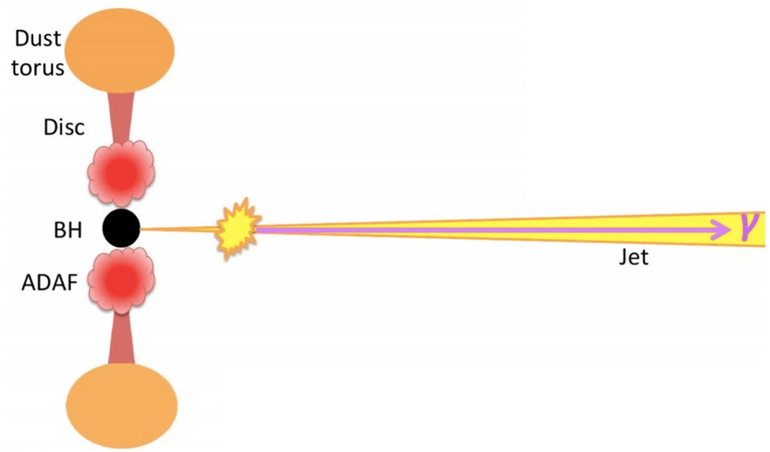
XXVIII Cracow EPIPHANY Conference
on Recent Advances in Astroparticle Physics

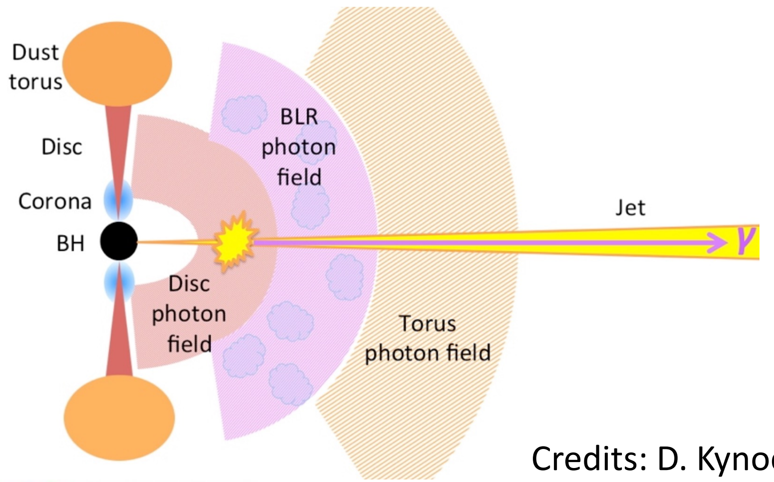
Cracow,
13 Jan, 2021

Blazars in general

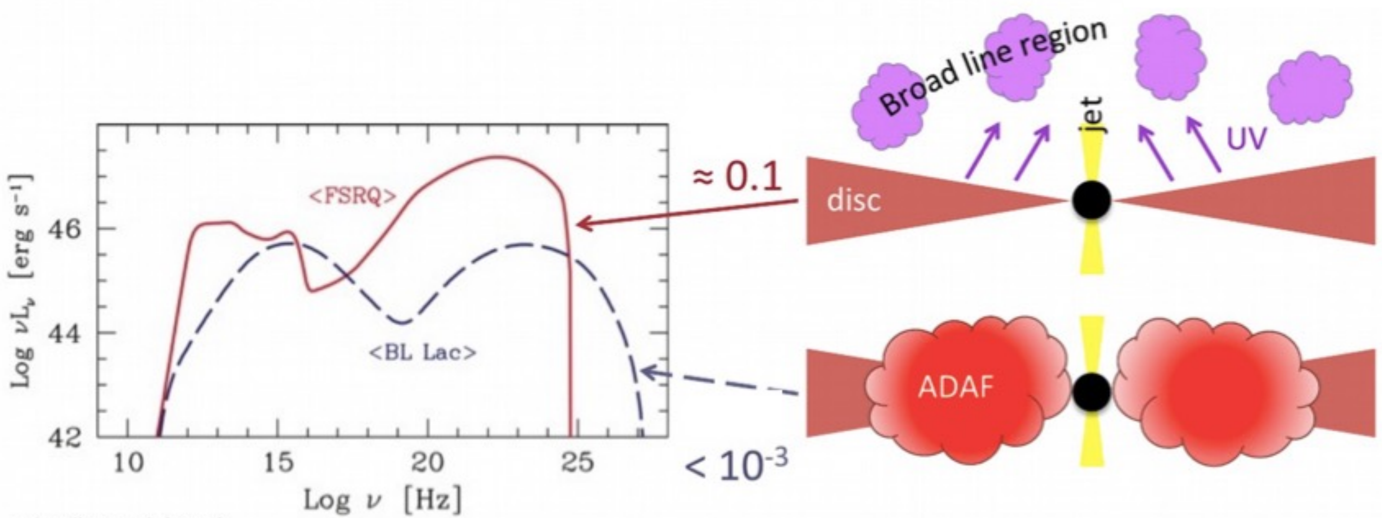
SSC (Synchrotron self Compton)



SSC + external photon field interactions



Credits: D. Kynoch



Ghisellini et al. (2010)

What about γ-NLS1?

Where do they fit on the *blazar sequence*? Or do they?

Peculiar γ-ray emitting NLS1 galaxies

- Relatively low mass BH compared to FSRQs
- γ-NLS1 thought to be hosted by spiral galaxies

→ Unexpected Gamma-ray detection (PMN J0948+0022, Abdo+2009)

Confirmed the presence of a powerful relativistic jet

- Rare objects: ~ 20 discovered up to date (*e.g.* Paliya+2019)
- Never detected in the VHE band
- Short variability timescales ~ hours (*e.g.* Paliya+2015)
- Extremely high (close-Eddington) accretion rates, changing SED properties (disc or completely jet dominated states… (Calderone+2012, D'Ammando+2015))

Approach

Sample:
- 1H 0323+342 (z=0.0625) (Paliya+2014)
- B2 0954+25A (z=0.712) (Calderone+2012)
- PMN J0948+0022 (z =0.5846) (D'Ammando+2015)

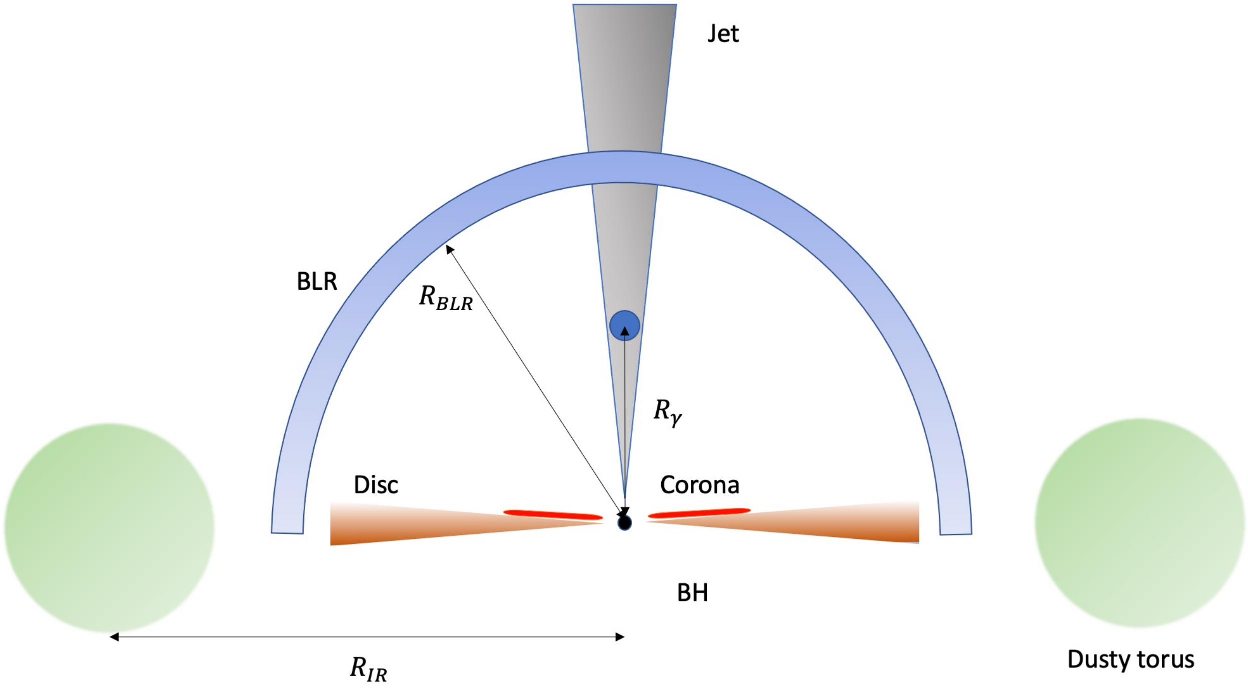
➢ MWL data analysis of low and high states

➢ SED modelling using:
One-zone SSC model (Katarzynski+2001)
EIC processes - Dermer & Menon (2009)

➢ BLR and Torus dominated scenario tests

$R_\gamma = R_{BLR,out}$ **: Torus-EIC dominates**
$R_\gamma < R_{BLR,in}$ **: BLR-EIC dominates**

- Origin of variability in HE
- Physical properties of the sources



Central engine of AGN - Simplified representation

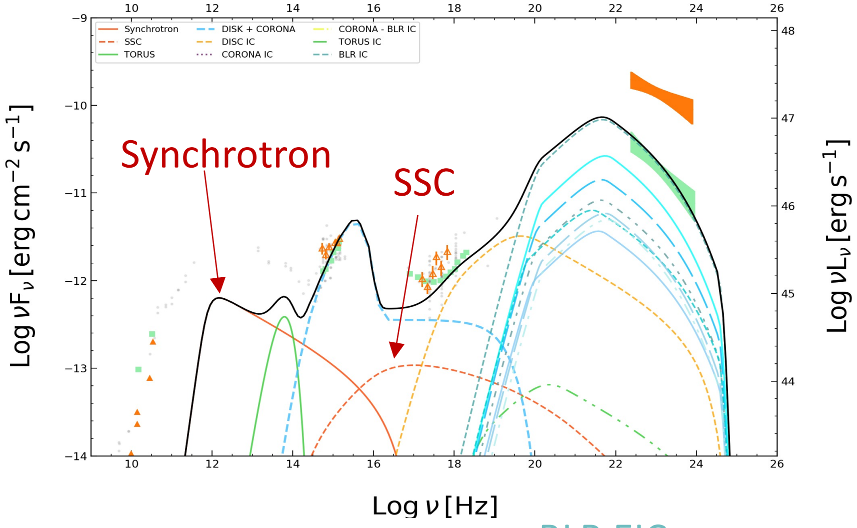
BLR EIC scenario for PMN J0948+0022

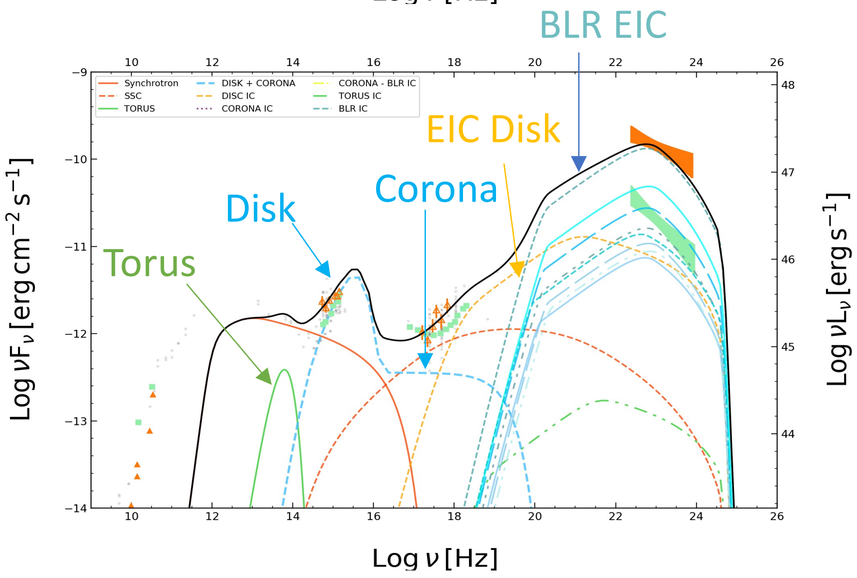
PMN J0948+0022 (z= 0.5846)

$M_{BH} = 1.5\ 10^{8} M_{Sun}$
(Zhou+2003, Abdo+2009)

$R_{\gamma} < R_{BLR,in}$ **: dominant BLR EIC**

- Constant external photon fields
- Varying jet parameters only





SED and parameter table

Scenario	Disc & BLR	
State	Average	Flare
δ	16	19
$K\ [1/cm^3]$	1×10^6	4×10^6
$R_{src}\ [cm]$	3.8×10^{15}	2.25×10^{15}
$B\ [G]$	1.5	1.5
n_1	2.1	2.3
n_2	3.5	3.2
γ_{min}	10	10
γ_b	80	300
γ_{max}	2×10^4	2×10^4
$T_{IR}\ [K]$	1200	1200
τ_{IR}	0.05	0.05
α_X	1.0	1.0
τ_X	0.3	0.3
$R_{\gamma}\ [R_G]$	1.8×10^3	1.8×10^3
τ_{BLR}	0.40	0.40
$R_{in}^{BLR}\ [R_G]$	1.5×10^4	1.5×10^4
$R_{out}^{BLR}\ [R_G]$	4.5×10^4	4.5×10^4
u_e/u_b	17.68	44.57
$n_e\ [1/cm^3]$	6.90×10^4	1.56×10^5
$L_{jet}\ [erg\ s^{-1}]$	4.15×10^{46}	1.12×10^{47}
l_{Edd}	0.48	
$L_{Disc}\ [erg\ s^{-1}]$	9×10^{45}	

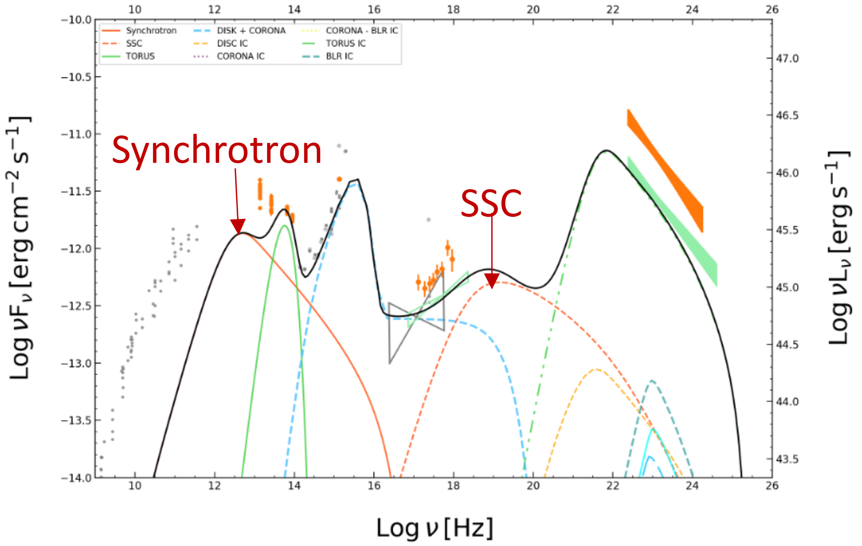
Torus EIC scenario for B2 0954+25A

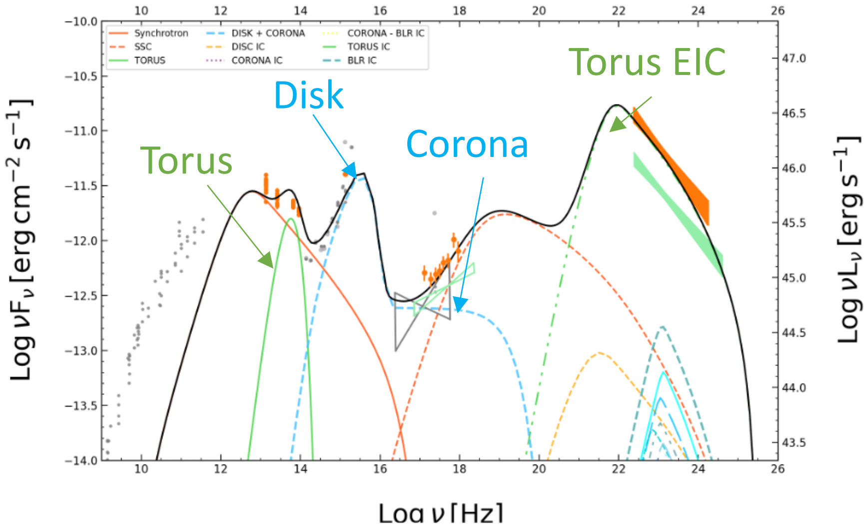
B2 0954+25A (z=0.712)

$M_{BH} = (1-3)10^8 M_{Sun}$
(Calderone+2012)

$R_\gamma = R_{BLR,out}$ **: dominant Torus-EIC**

- Constant external photon fields
- Varying jet parameters only





SED and parameter table

Scenario	Torus	
State	Average	Flare
δ	10	12
$K\ [1/cm^3]$	8×10^5	2.5×10^6
$R_{src}\ [cm]$	5.49×10^{16}	3.77×10^{16}
$B\ [G]$	0.27	0.30
n_1	2.6	2.6
n_2	3.75	3.8
γ_{min}	500	500
γ_b	680	550
γ_{max}	5×10^4	5×10^4
$T_{IR}\ [K]$	1200	1200
τ_{IR}	0.25	0.25
α_X	1.0	1.0
τ_X	0.25	0.25
$R_\gamma\ [R_G]$	7.5×10^4	7.5×10^4
τ_{BLR}	1×10^{-3}	1×10^{-3}
$R_{in}^{BLR}\ [R_G]$	2.5×10^4	2.5×10^4
$R_{out}^{BLR}\ [R_G]$	7.5×10^4	7.5×10^4
u_e/u_b	4.04	8.39
$n_e\ [1/cm^3]$	17.81	47.43
$L_{jet}\ [erg\ s^{-1}]$	2.05×10^{45}	4.09×10^{45}
l_{Edd}	0.60	
$L_{Disc}\ [erg\ s^{-1}]$	1.13×10^{46}	

Transition low – high state

- HE emission explained by IC scattering of external photons

- External IC processes dominate the radiative output in all sources

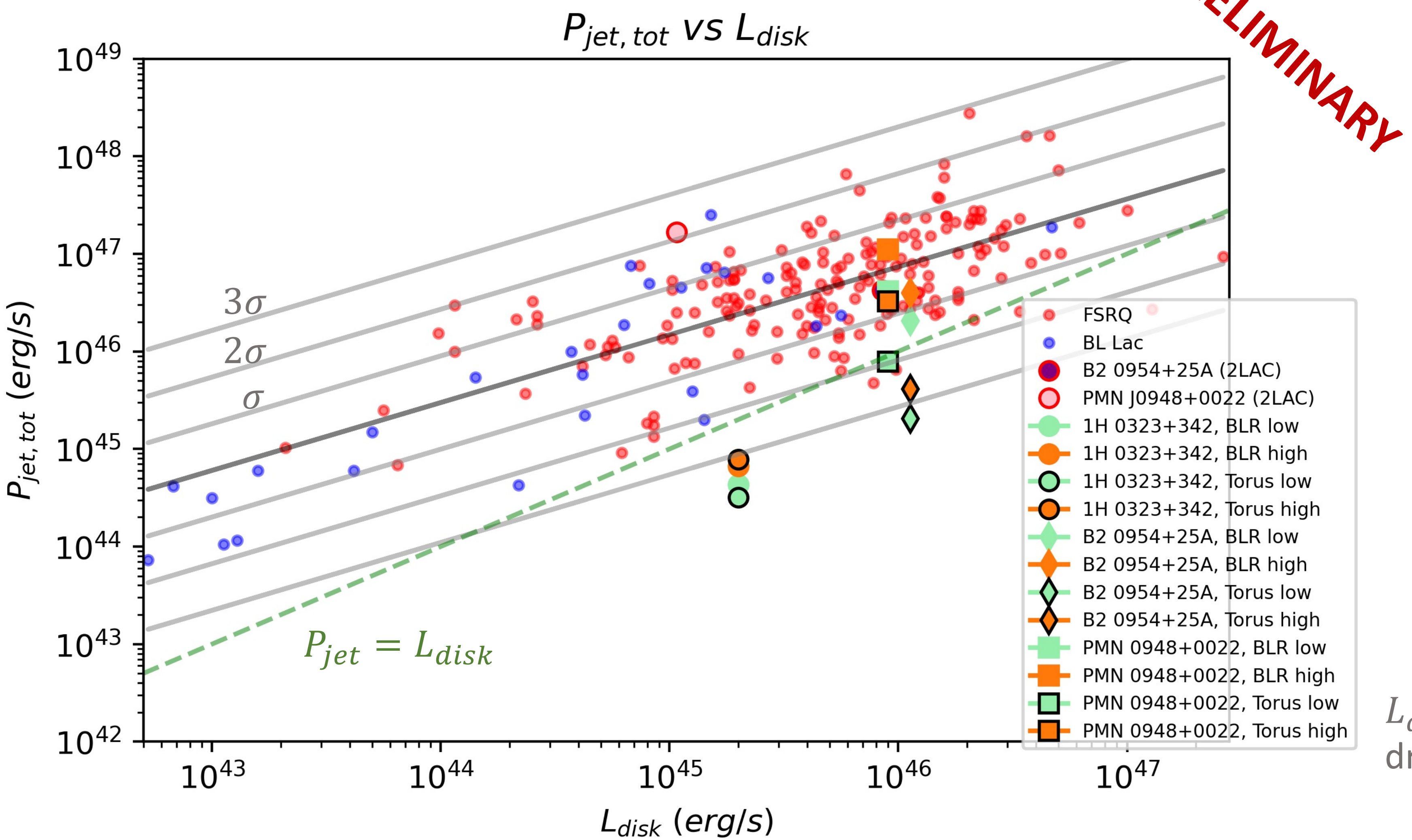
- Transition from low to high states: changes in the jet parameters only

Flaring states explained by denser and more relativistic blob

- Unchanged BH – blob distance between low and high states
  → stationary shock scenario

Multi-epoch modelling – advantages

Fermi Blazar distribution from Ghisellini+2014



- BLR dominated solutions require larger $P_{tot,jet}$ than torus dominated case. (similar for 1H 0323+342)
- 1H 0323+342 lies below the blazar distribution
- PMN J0948+0022 and B2 0954+25A closer to FSRQ distribution - not genuine γ-NLS1?

L_{disk} often uncertain -> difficult to draw strong conclusions

Conclusion / Outlook

- Physical parameters (varying from one state/scenario to another) derived from **multi-epoch modelling**

  → **Intrinsic nature of γ-NLS1**

- Expand the study to other γ-NLS1 with different activity states for better statistics and physical characterization

- Questions: Different trends between low/high masses? Are γ-NLS1 low mass analogues of FSRQs or intrinsically less powerful?

- Regular monitoring needed