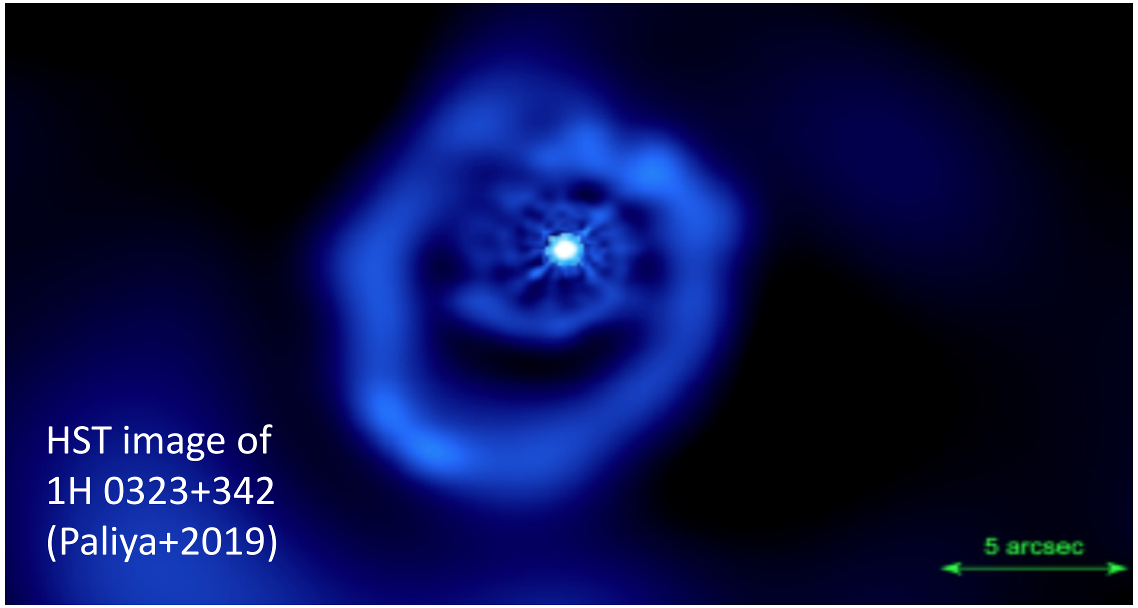
Characterisation of various γ-ray activity states of a sample of γ-NLS1 galaxies



HST image of
1H 0323+342
(Paliya+2019)

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High Energy Astrophysics in Southern Africa 2024
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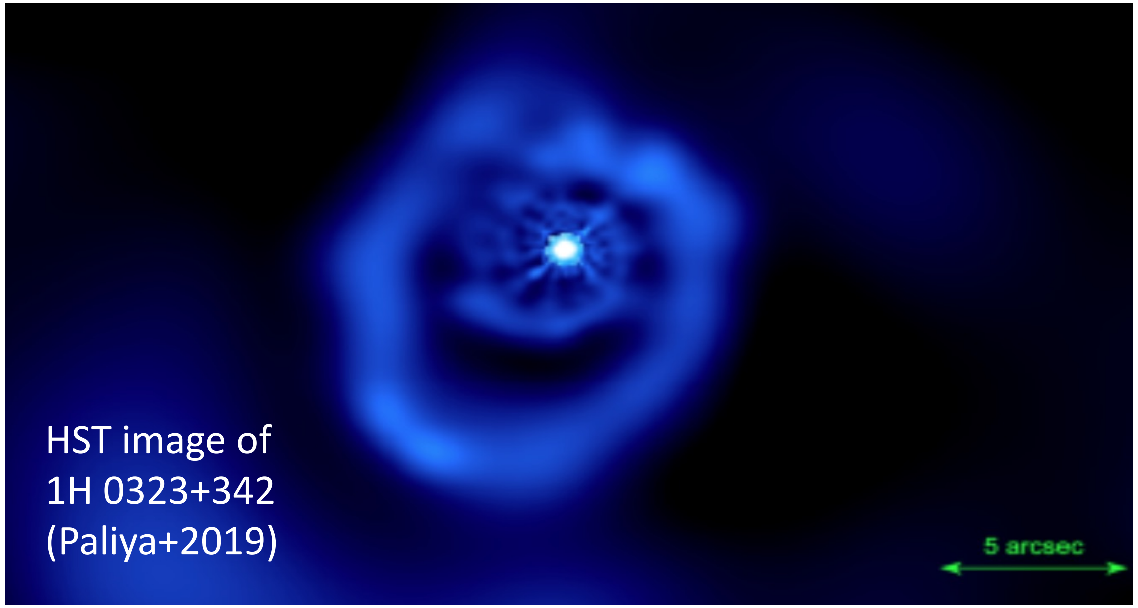

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PSL Research University Paris
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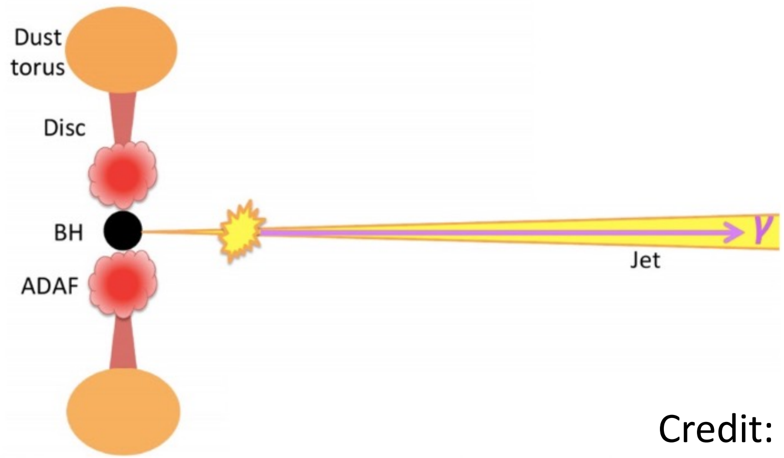
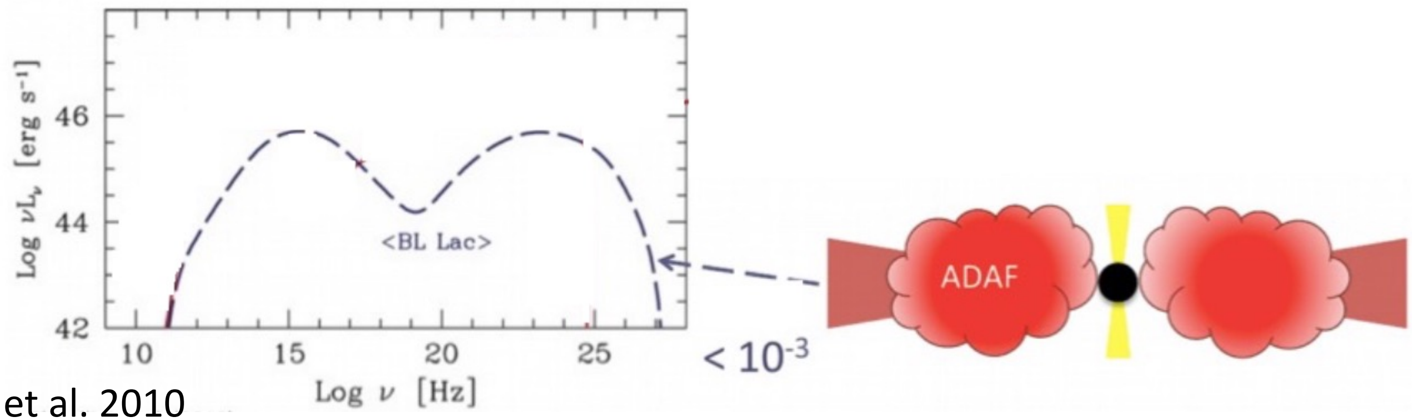
Blazar sub-classes

SSC (Synchrotron self Compton)

BL Lac



Credit: D. Kynoch



Ghisellini et al. 2010

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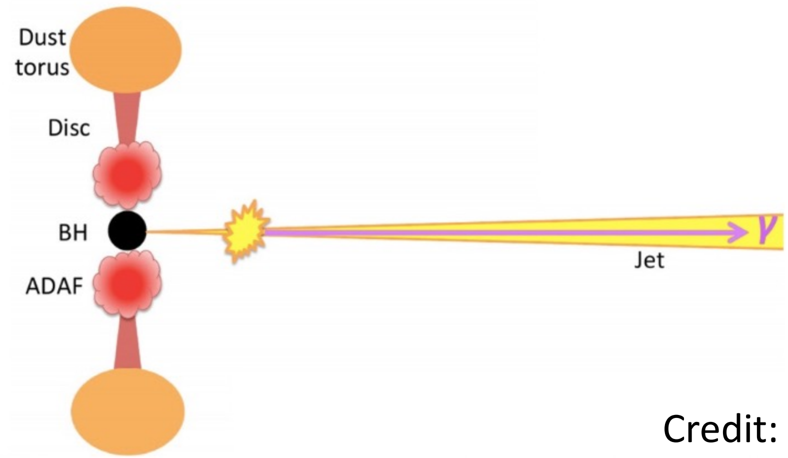
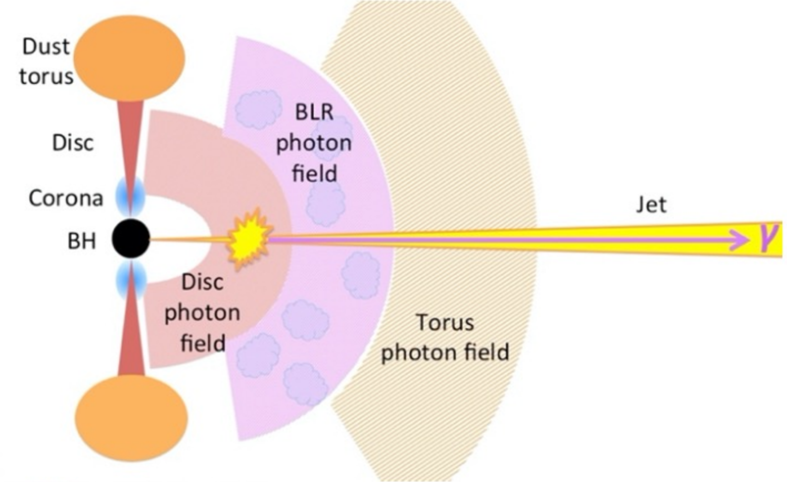


FSRQ

SSC + external photon field interactions



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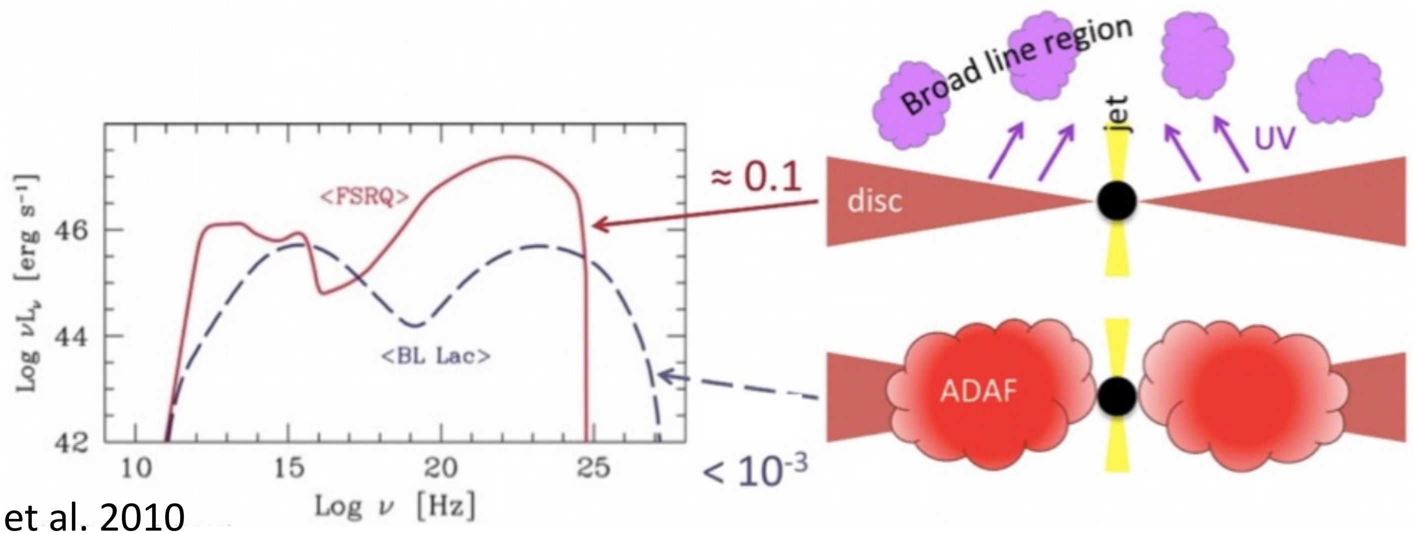

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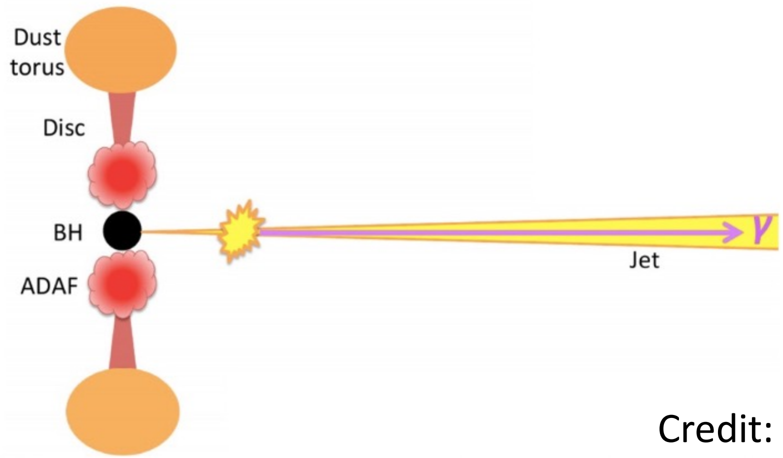
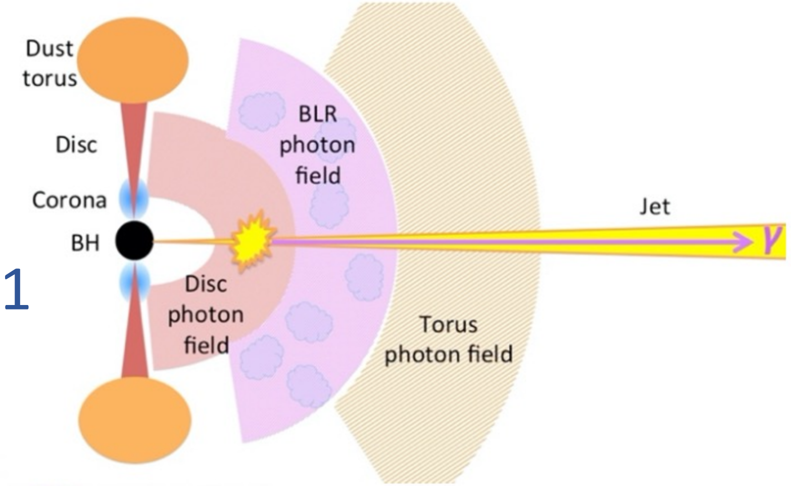


FSRQ
γ-NLS1



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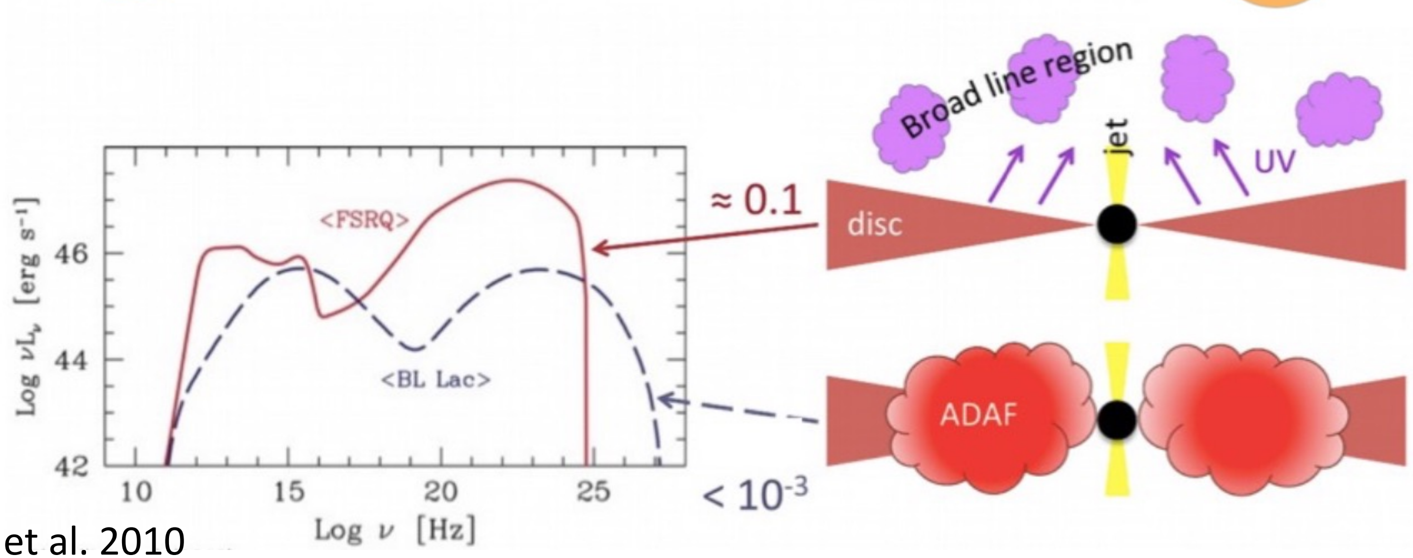

Ghisellini et al. 2010

Peculiar γ-ray emitting NLS1 galaxies

- NLS1 classification based on optical features (Osterbrock & Pogge 1985)
- Relatively low mass BH compared to FSRQs
  Thought to be hosted by spiral galaxies
- Only a small fraction of NLS1 found to be radio loud (7%, Komossa+2006)

→ 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, CTA projections not promising (Romano+2020)
- 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))

Multi-component model and considered scenarios

Sample:
- 1H 0323+342 (z=0.0625) (Paliya et al., 2014)
- PMN J0948+0022 (z=0.5846) (D’Ammando et al., 2015)
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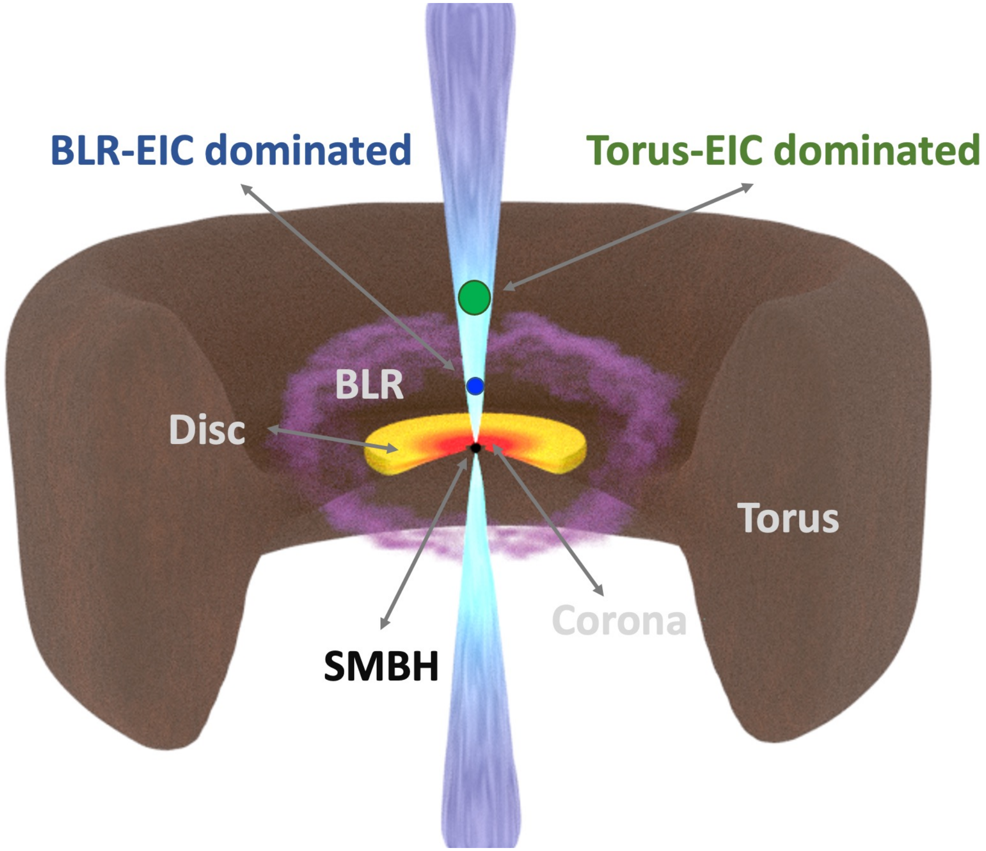

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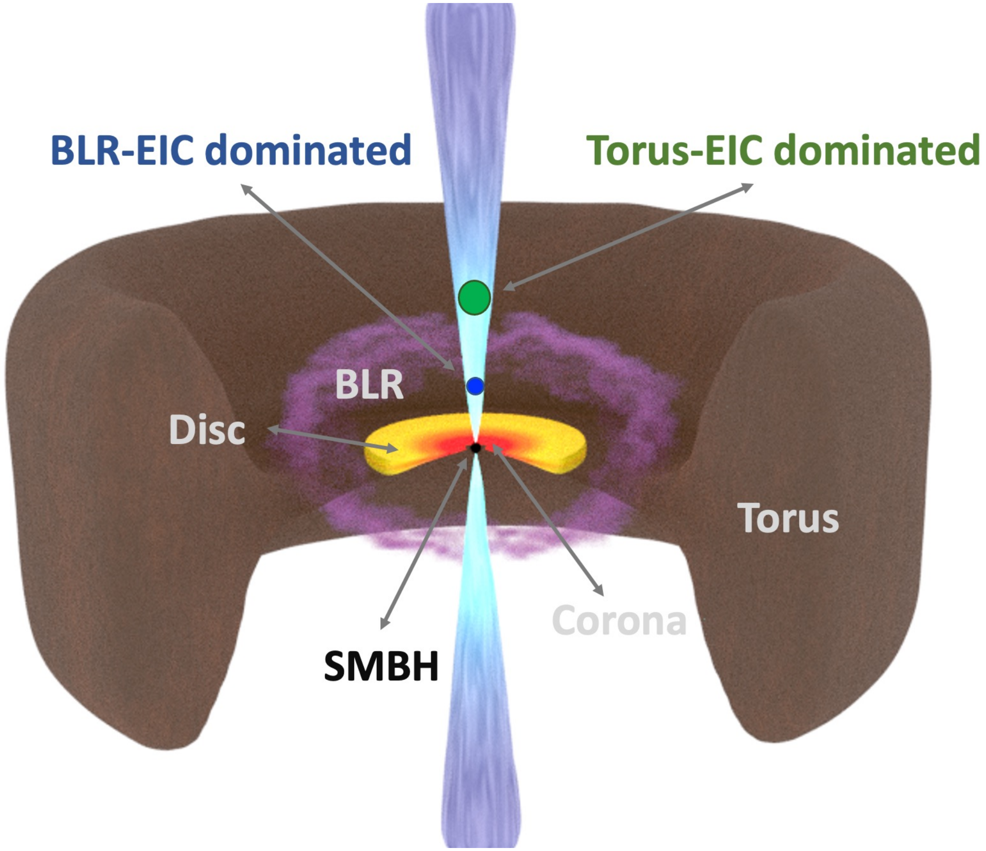

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$R_\gamma < R_{BLR,in}$: **BLR-EIC dominates**
$R_\gamma = R_{BLR,out}$: **Torus-EIC dominates**

→ Investigate the physical origin of their variability

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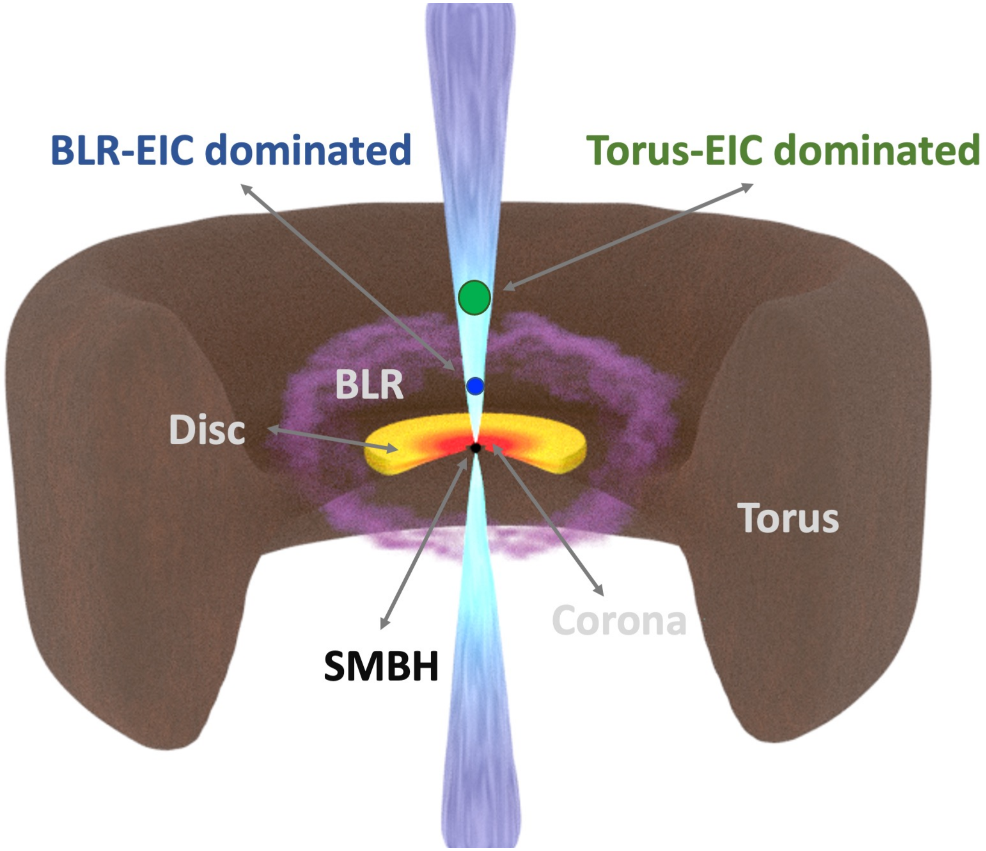

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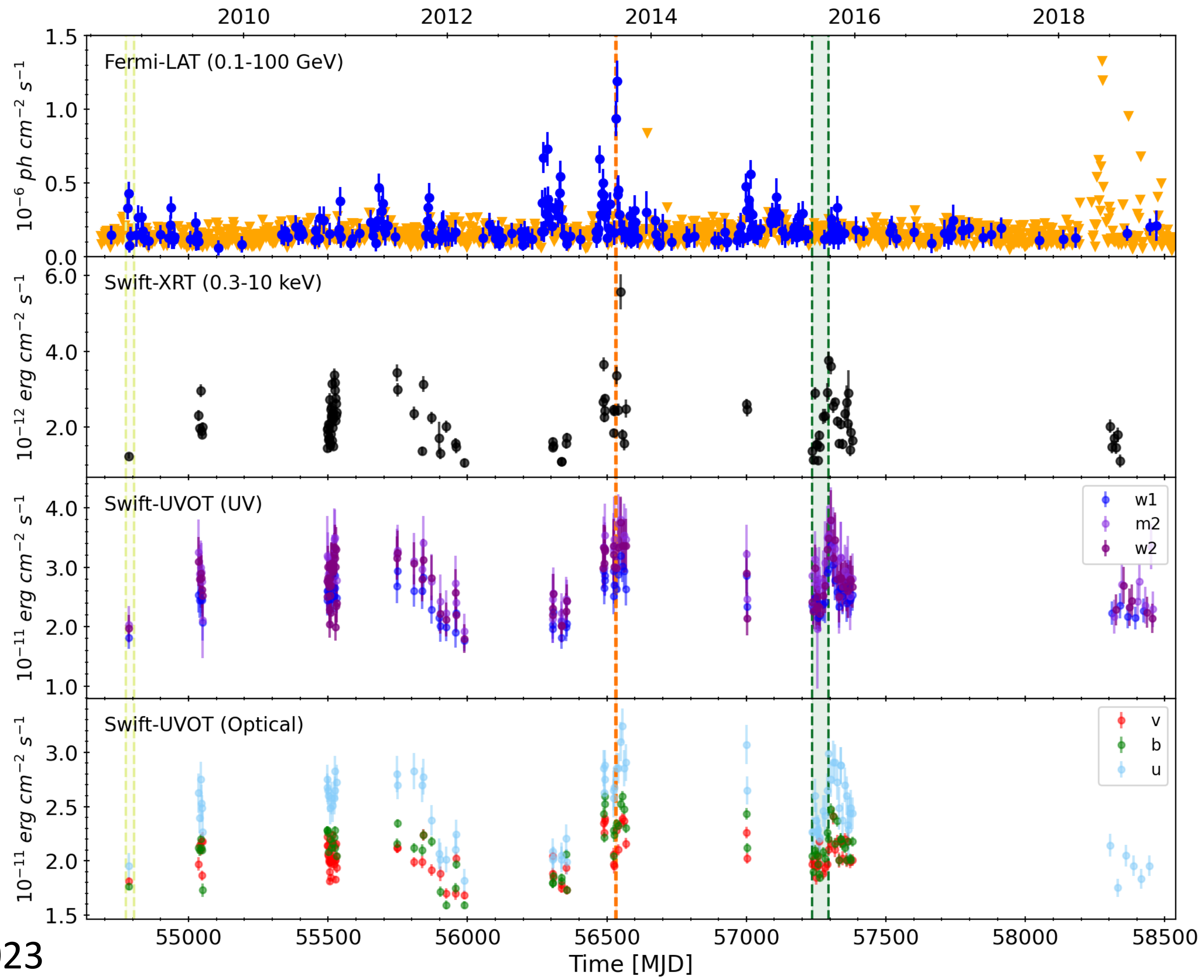
- Estimation of variable jet powers

1H 0323+342

1H 0323+342 (z=0.0625), closest known γ-NLS1

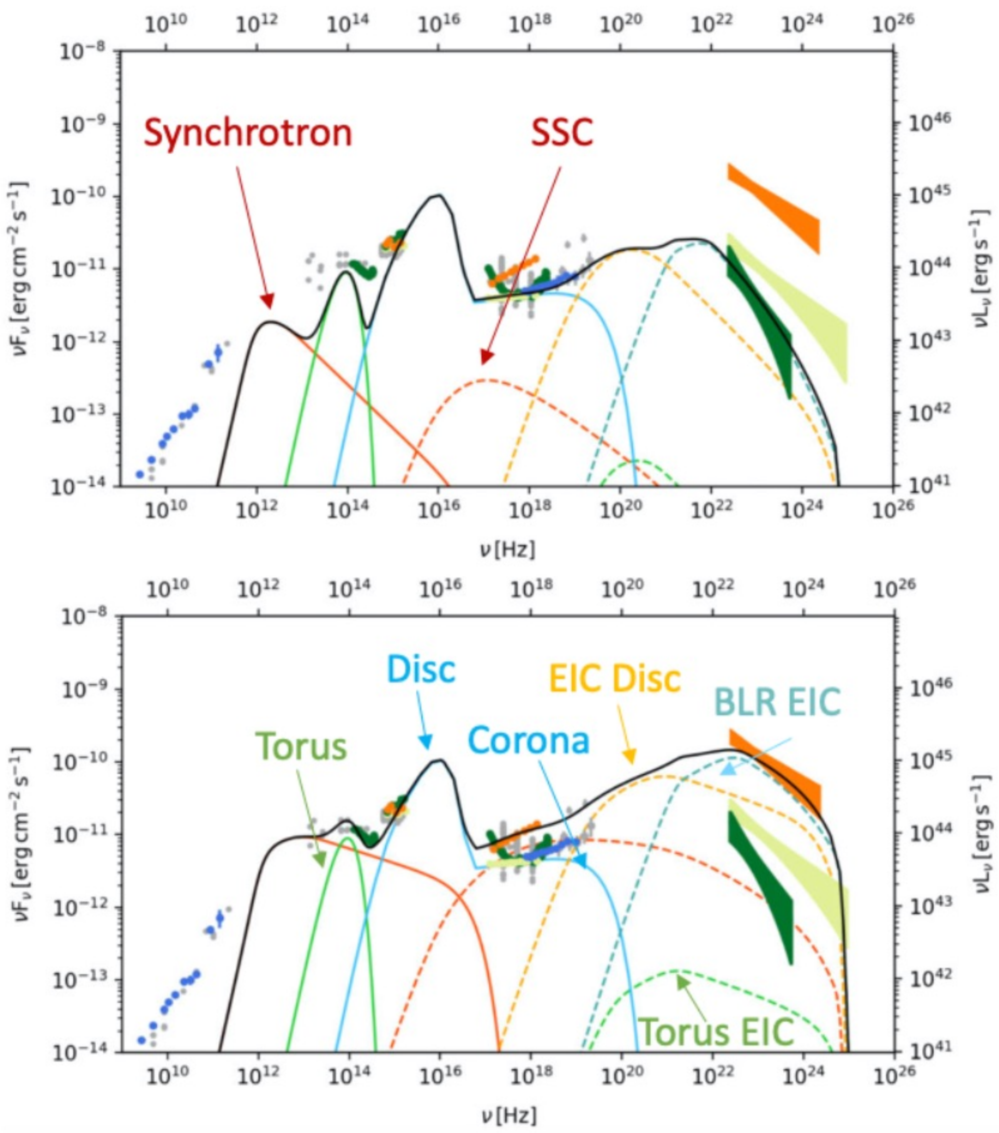
$M_{BH} = 2\ 10^7 M_\odot$ (Landt et al., 2017)

- Suspected to host an underpowered jet (Kynoch et al., 2018)
- Strong and fast variability (~hours – day), (Paliya et al., 2014, D’Ammando et al., 2020)
- Brightest flare in 2013 (Paliya et al., 2014)
- Intermediate/low state from 2008 and 2015 (Paliya et al., 2014, Kynoch et al., 2018)



Luashvili et al., 2023

1H 0323+342 – Disc & BLR dominated scenario



$R_\gamma < R_{BLR,in}$ **: dominant EIC BLR (& disc)**

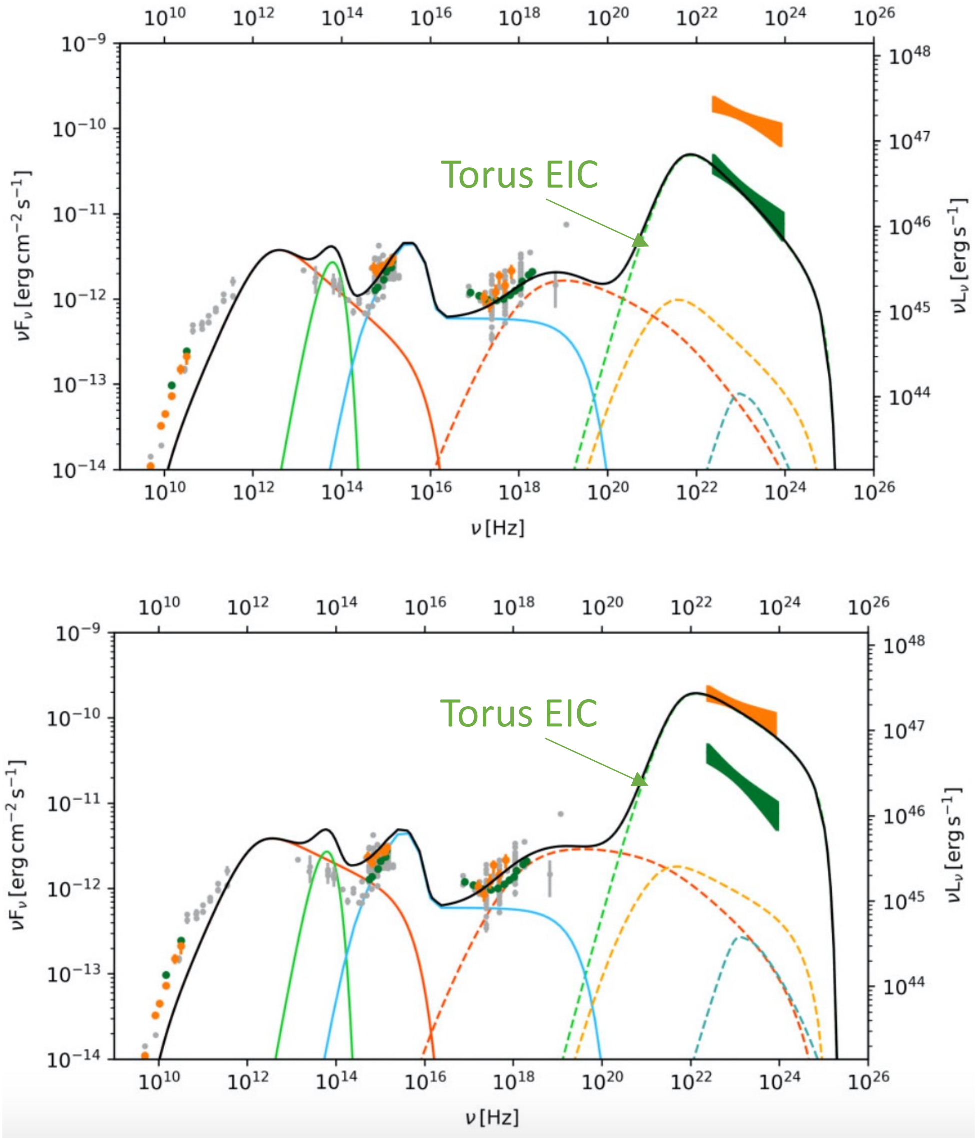
Constant external photon fields and varying jet parameters only

Fixed parameters	
θ	5°
$M_{BH}[M_\odot]$	2×10^7
$L_D[erg\ s^{-1}]$	2×10^{45}
l_{Edd}	0.80

State	**Low**	**High**
δ	9	10
$n_e\ [cm^{-3}]$	2.56×10^4	1.74×10^4
$R_{blob}\ [cm]$	1.15×10^{15}	1.03×10^{15}
n_2	4.2	3.4
γ_{min}	50	120
γ_b	150	280

- Denser blob and more relativistic blob in the high state
- Changes in the particle distribution

PMN J0948+0022 – torus dominated scenario



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

Constant external photon fields and varying jet parameters only

Fixed parameters	
θ	$3°$
$M_{BH}[M_\odot]$	1.5×10^8
$L_D[erg\ s^{-1}]$	9×10^{45}
l_{Edd}	0.48

State	**Low**	**High**
δ	10	12
$n_e\ [cm^{-3}]$	12.80	16.37
$R_{blob}\ [cm]$	9.37×10^{16}	9.35×10^{16}
$B\ [G]$	0.20	0.12
n_2	3.9	3.5
γ_b	900	1×10^3

- Denser blob and more relativistic blob in the high state
- Changes in the particle distribution (+ B)

Estimation of each contribution to the jet power

For each source of interest, considered scenario and activity state, various contributions to the total jet powers are estimated:

$$P_{jet,tot} = P_{rad} + P_B + P_e + P_{p,cold}$$

where

$$P_i = 2\pi R^2 c \Gamma^2 U_i'$$

two-sideness of the jet

associated energy density in the co-moving frame

Variable jet powers of γ-NLS1 galaxies

Source	Scenario	State	$\log P_e$	$\log P_B$	$\log P_{\rm rad}$	$\log P_{p,\,\rm cold}$	$\log P_{\rm tot,\,jet}$	$\eta_{\rm rad}$
1H 0323+342	Disc-BLR	Low	43.20	42.21	43.80	44.48	44.58	0.17
		Intermediate	43.32	42.21	43.97	44.58	44.70	0.19
		High	43.78	42.31	44.65	44.94	45.15	0.32
	Torus	Low	43.66	42.62	43.85	44.08	44.38	0.30
		Intermediate	43.62	42.63	43.91	44.00	44.36	0.36
		High	44.38	42.95	44.91	44.75	45.22	0.50
PMN J0948+0022	Disc-BLR	Intermediate	44.67	43.42	46.04	46.48	46.62	0.26
		High	45.08	43.43	46.62	46.85	47.05	0.37
	Torus	Intermediate	44.60	43.89	45.82	44.99	45.91	0.82
		High	44.93	43.64	46.46	45.28	46.50	0.91
B2 0954+25A	Disc-BLR	Low	44.39	43.78	45.14	46.28	46.31	0.07
		High	44.65	43.96	45.52	46.56	46.60	0.08
	Torus	Low	44.30	43.69	45.23	44.66	45.38	0.71
		High	44.56	43.64	45.53	44.93	45.67	0.73

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$$\eta_{rad} = \frac{P_{rad}}{P_{tot,jet}}$$

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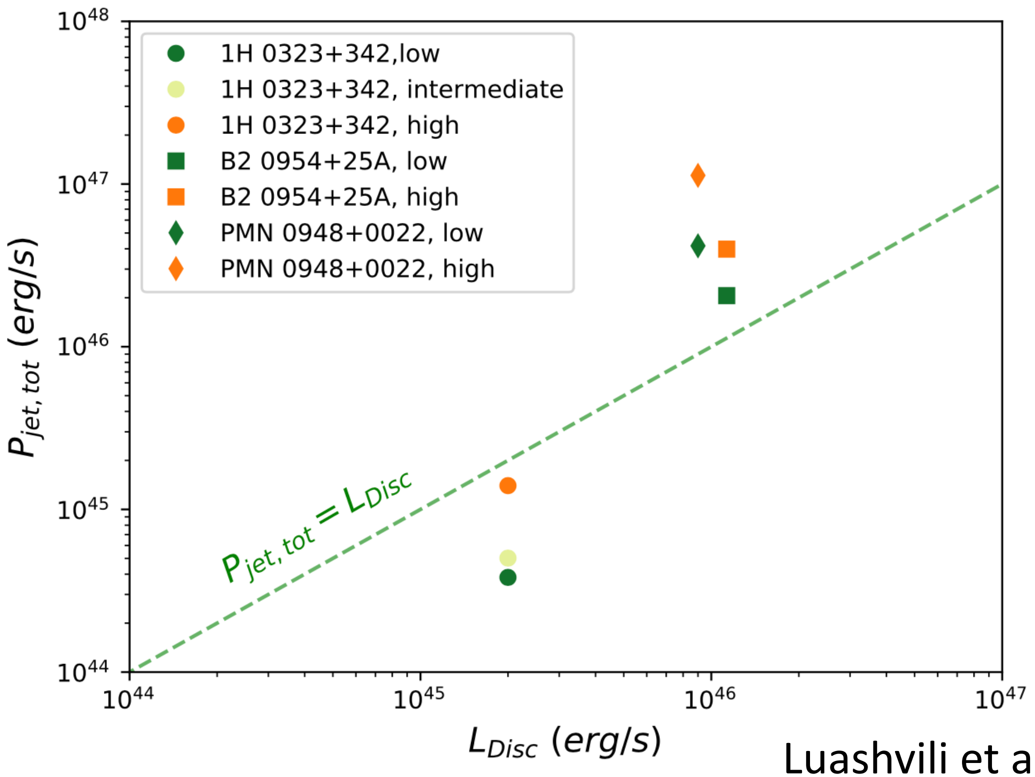
+ torus scenario violates observed variability time constraints

Total jet powers vs disc luminosity of γ-NLS1 galaxies – BLR dominated case



Luashvili et al., 2023

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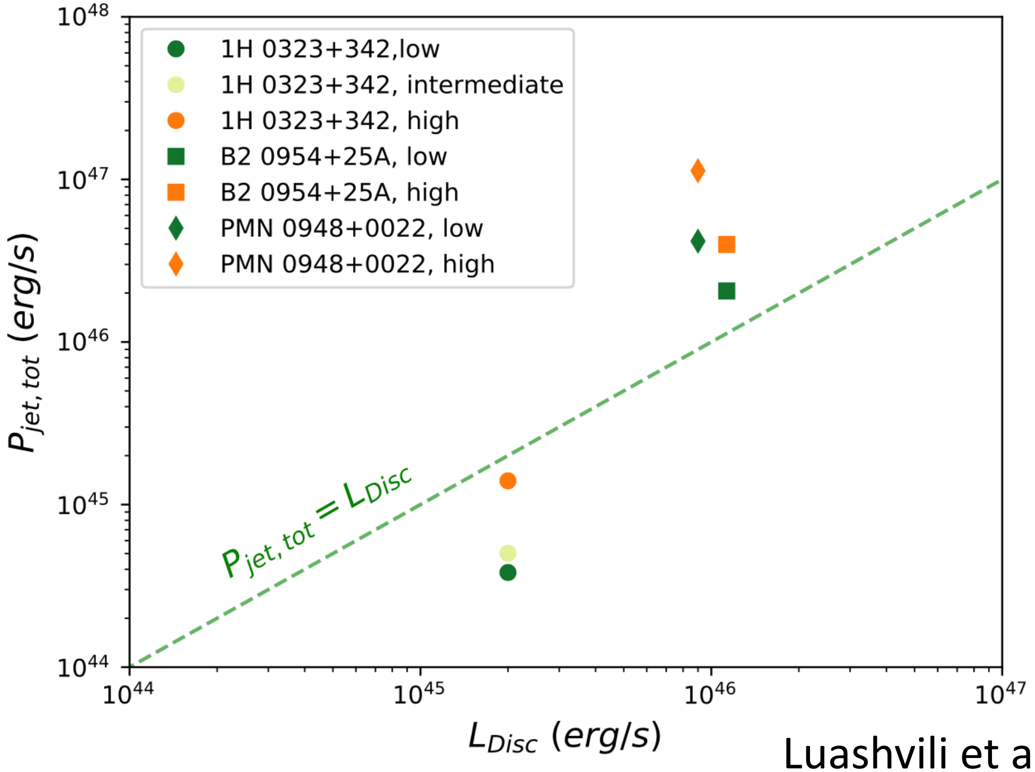

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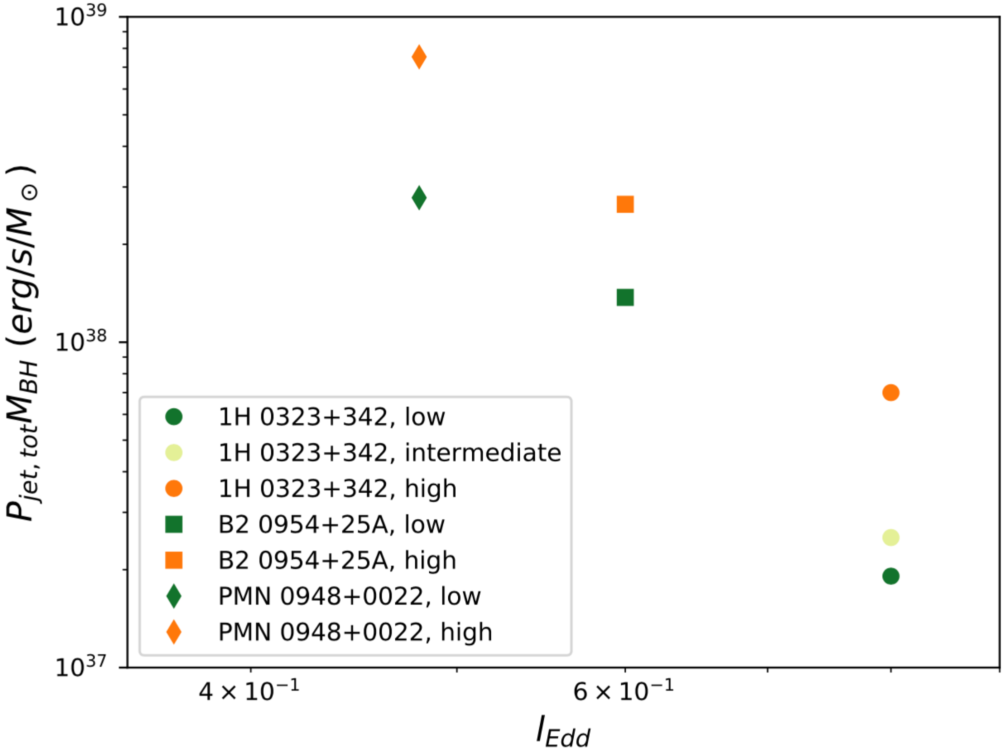

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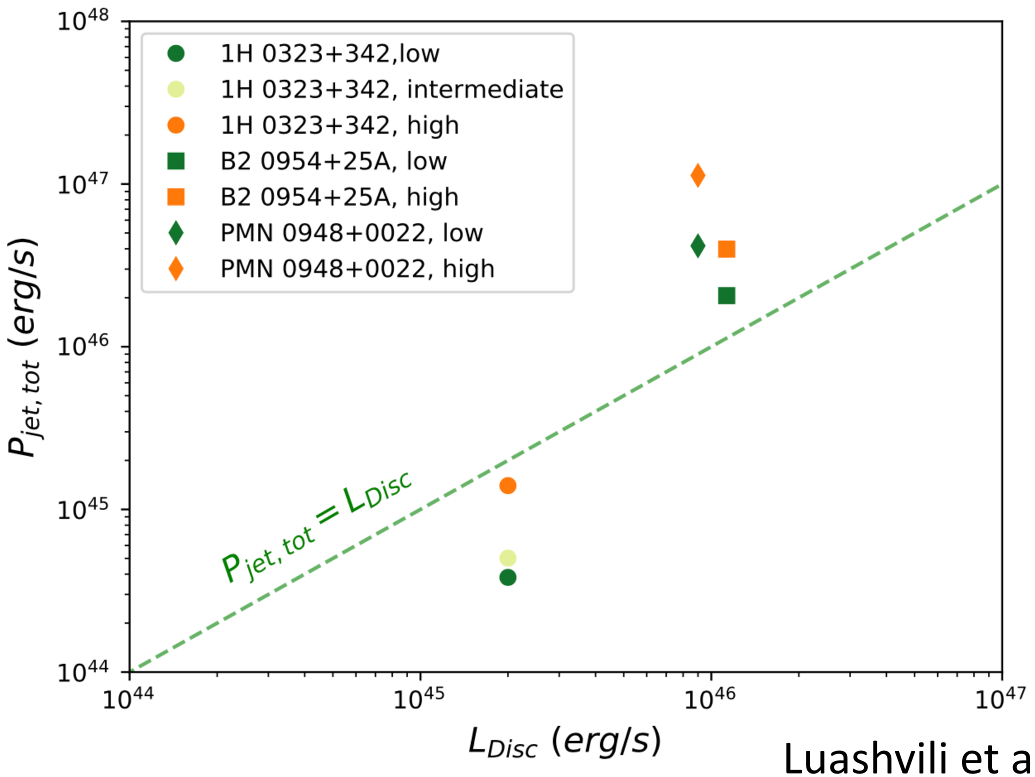

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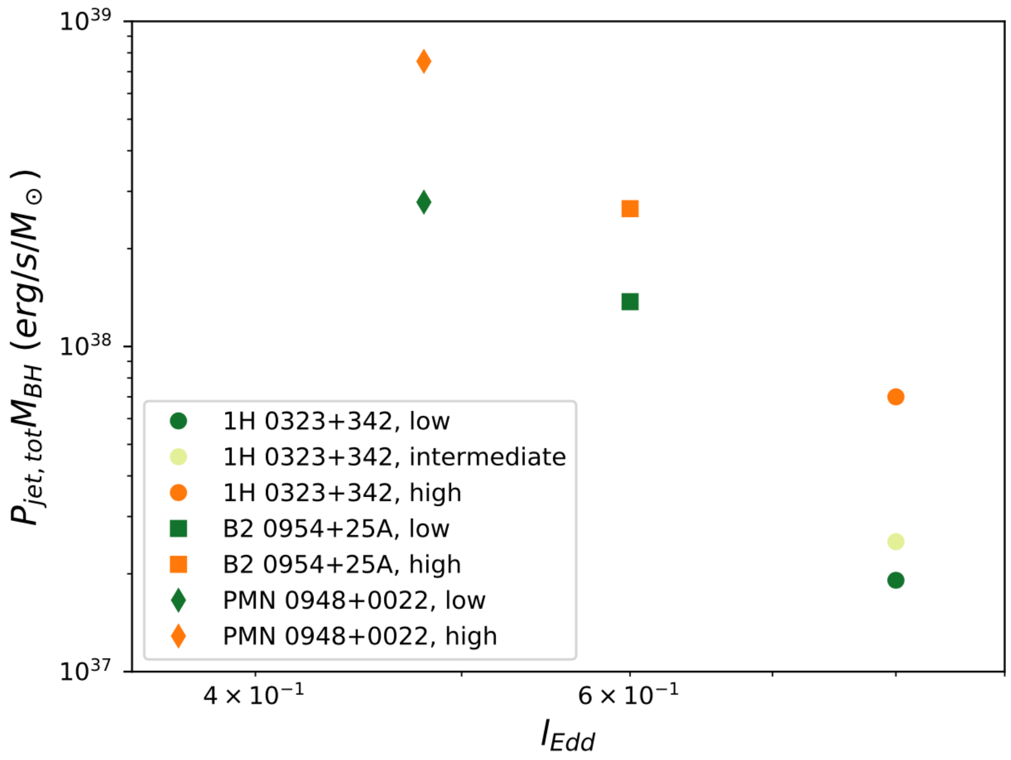

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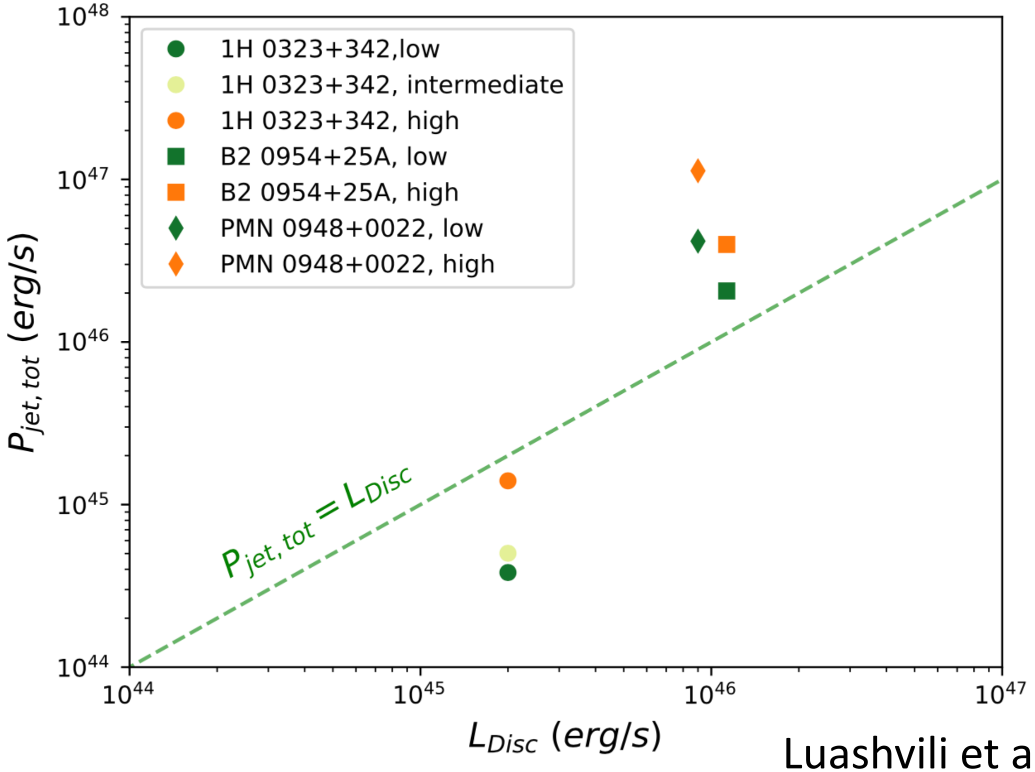

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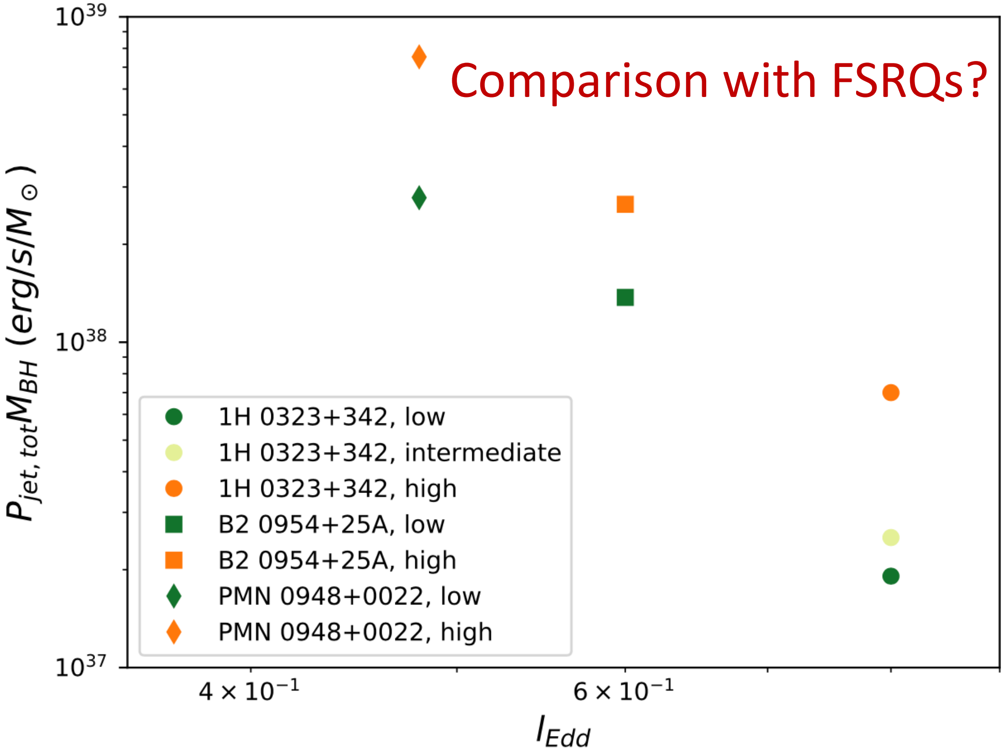

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