The spectral state transition of Mkn 590

(A potential link between AGNs and X-ray binaries?)

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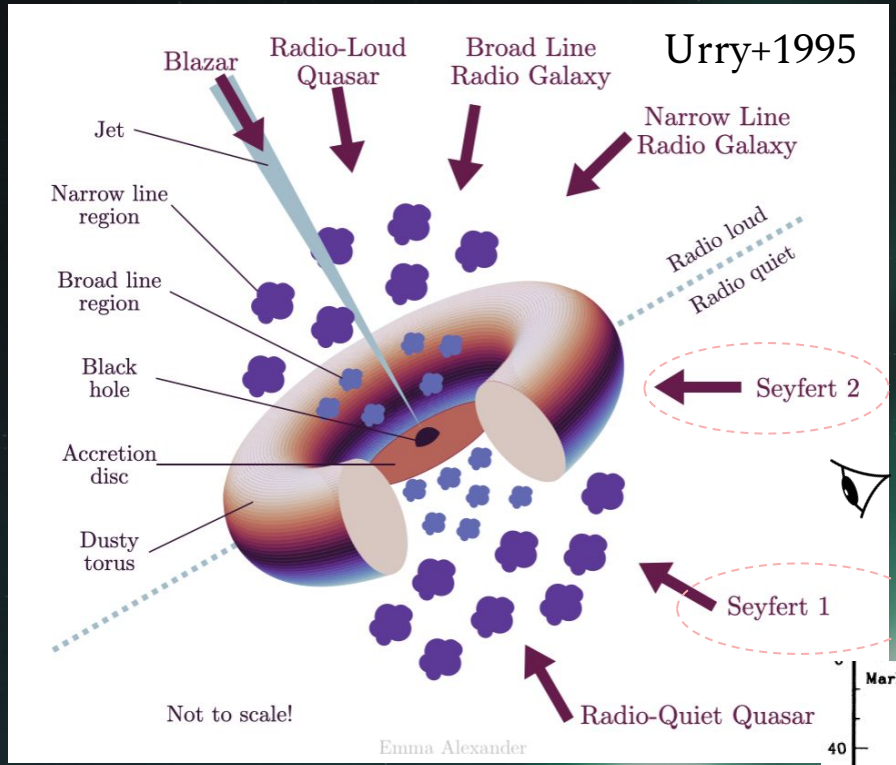
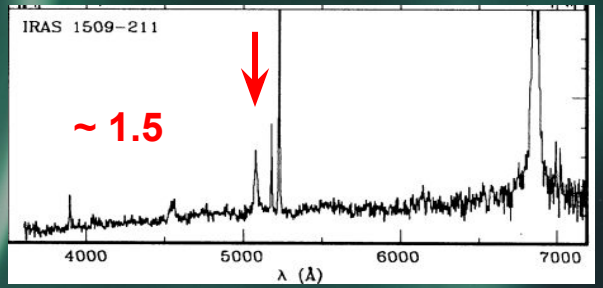
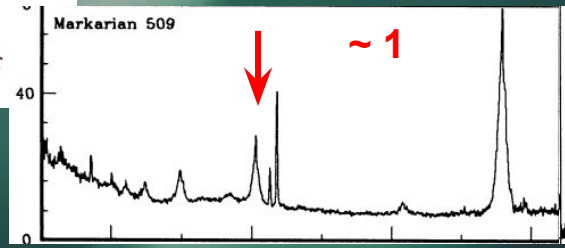
DARK[2], ASU CAS[3], IPA de Grenoble[4], Yunnan Observatories[5]

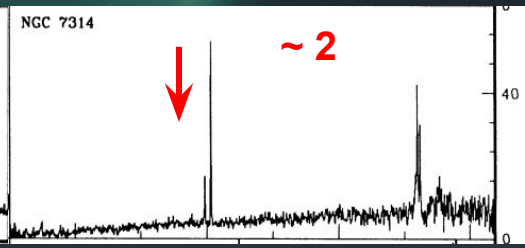
Classical unification scheme



Seyfert galaxies classified based on viewing angle (Antonucci+1993, Urry+1995)

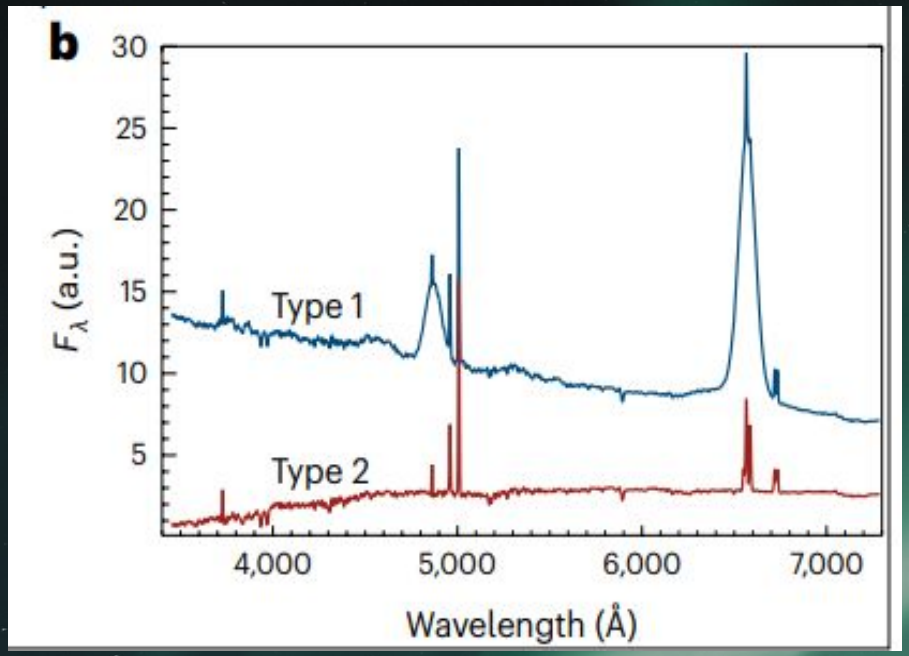






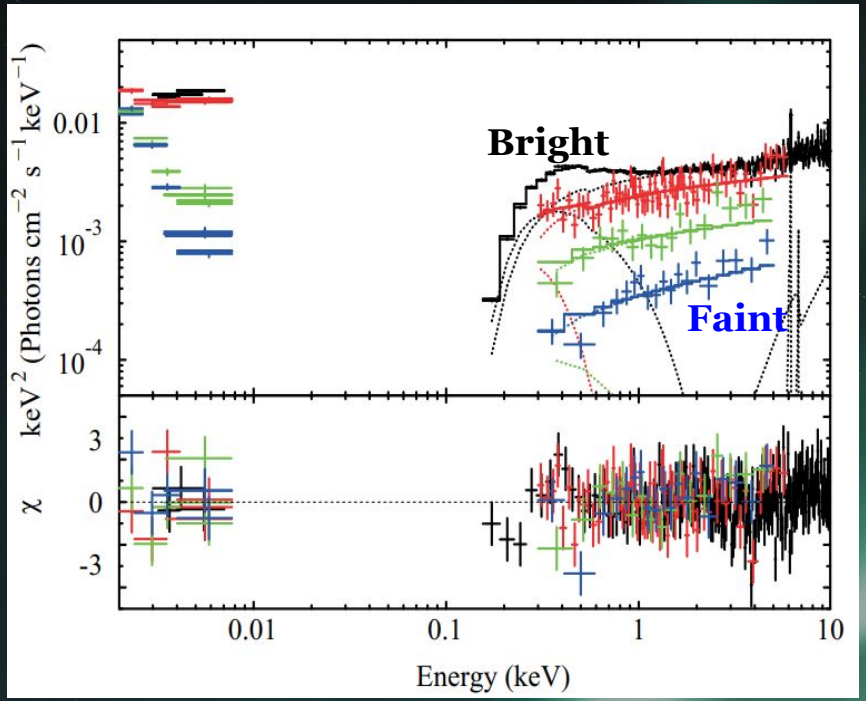
Changing state AGNs

Ricci+2023



Rapid changes in mass accretion rate ~ order of mag. in few months to few years; No evidence of line of sight absorption or reddening

Changing state AGNs



Mrk 1018; Noda+2018

Rapid changes in mass accretion rate ~ order of mag. in few months to few years; No evidence of line of sight absorption or reddening

Appearance of broad lines corresponds to increase in optical continuum; X-ray/IR proportional to optical/UV

FAINT phase ⟷ BRIGHT phase (vice versa)

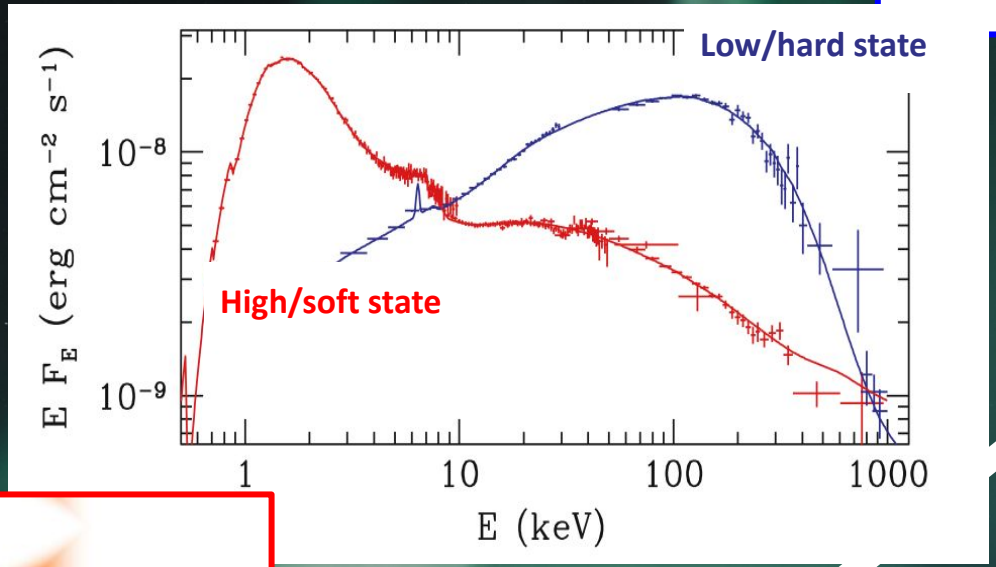
Repeating phenomena, BUT few documented cases

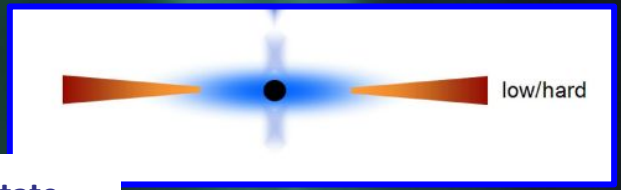
Strongly variable soft X-ray excess component !

Puzzling timescales: $T_{dy} << T_{CL} \sim T_{th} <<< T_{vis}$

Spectral state-transition in XRBs

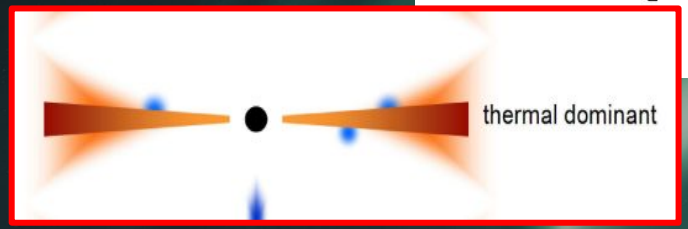
Gierlinski+1999, Done+2007





λ_{Edd} << 0.01 → Radiatively inefficient flow / ADAF

λ_{Edd} >> 0.01 → Radiatively efficient flow / slim disks

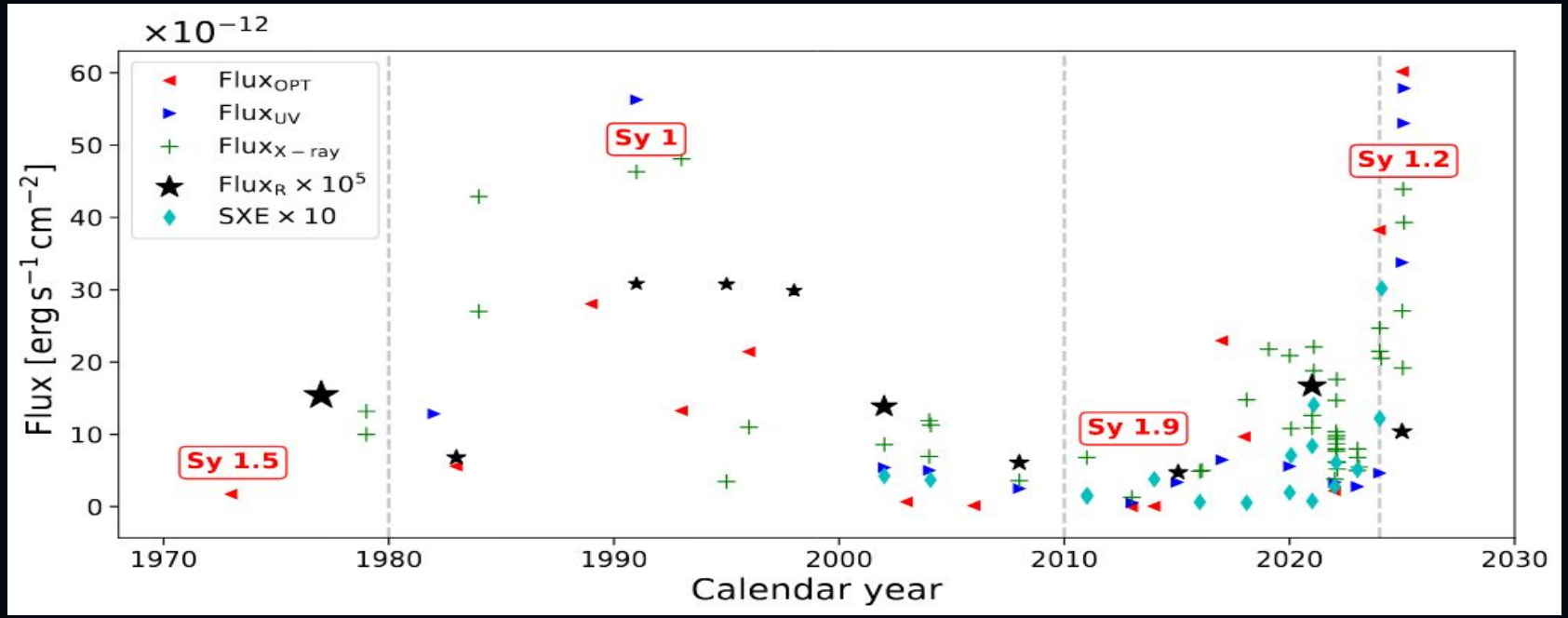


Eddington ratio ~ 0.01


50 years of Changing-Look events
Markarian 590

50 years ~ 3 changing look events

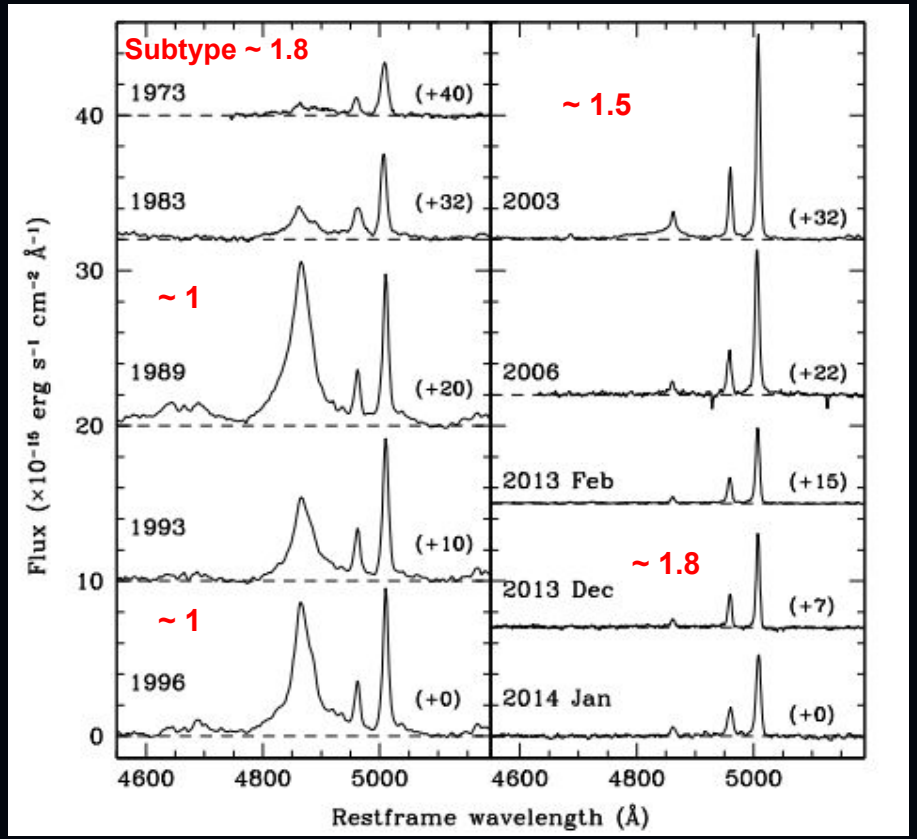
Palit+2026b



Denney+2014 and references within
Koay+2016b and references within
Raimundo+2017, Mondal+2022

Ghosh+2023
Lawther+2023, 2025
Palit+2025,2026a

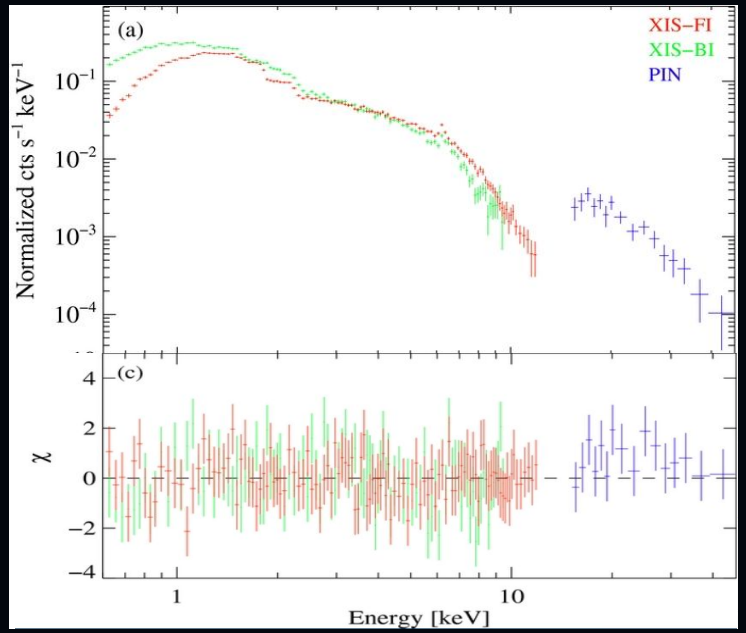
1970s - 2014



Denney+2014

1970s - 2014

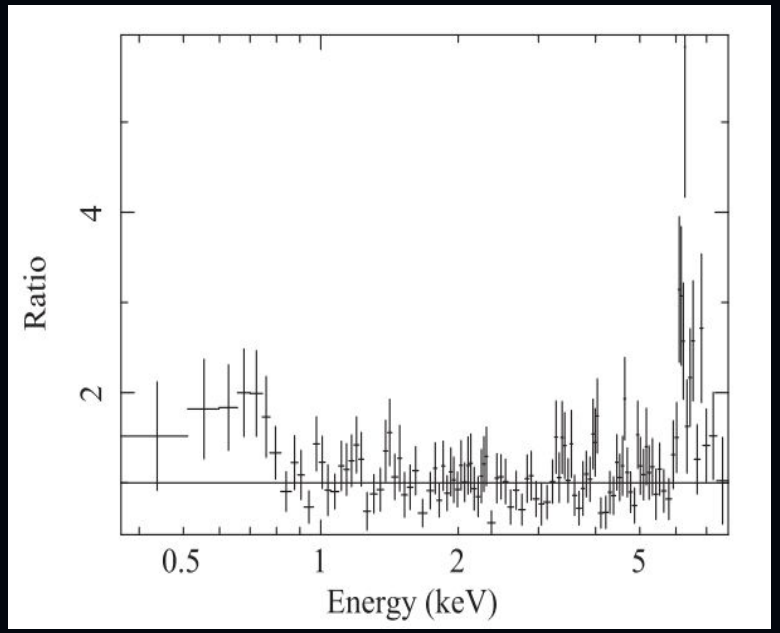
2011: No soft X-ray excess



Rivers+2012; Suzaku observations

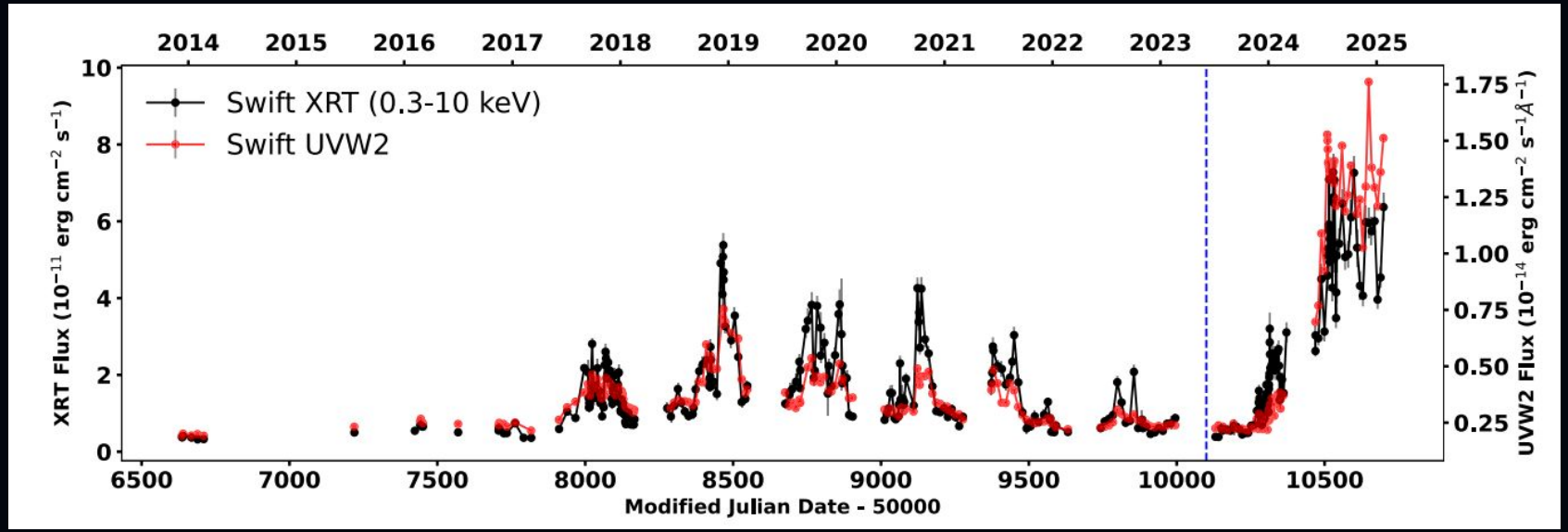
Denney+2014

2014: Weak re-appearance



Mathur+2018; Chandra/ACIS

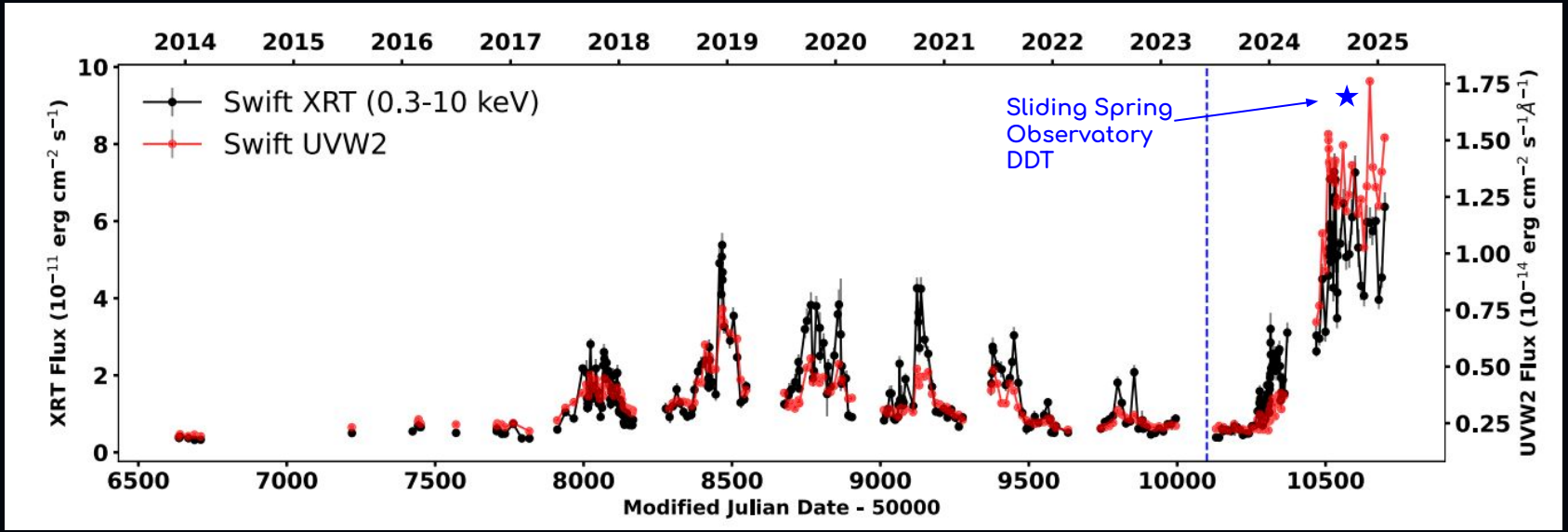
2014 - 2025



Palit+2025

Denney+2014

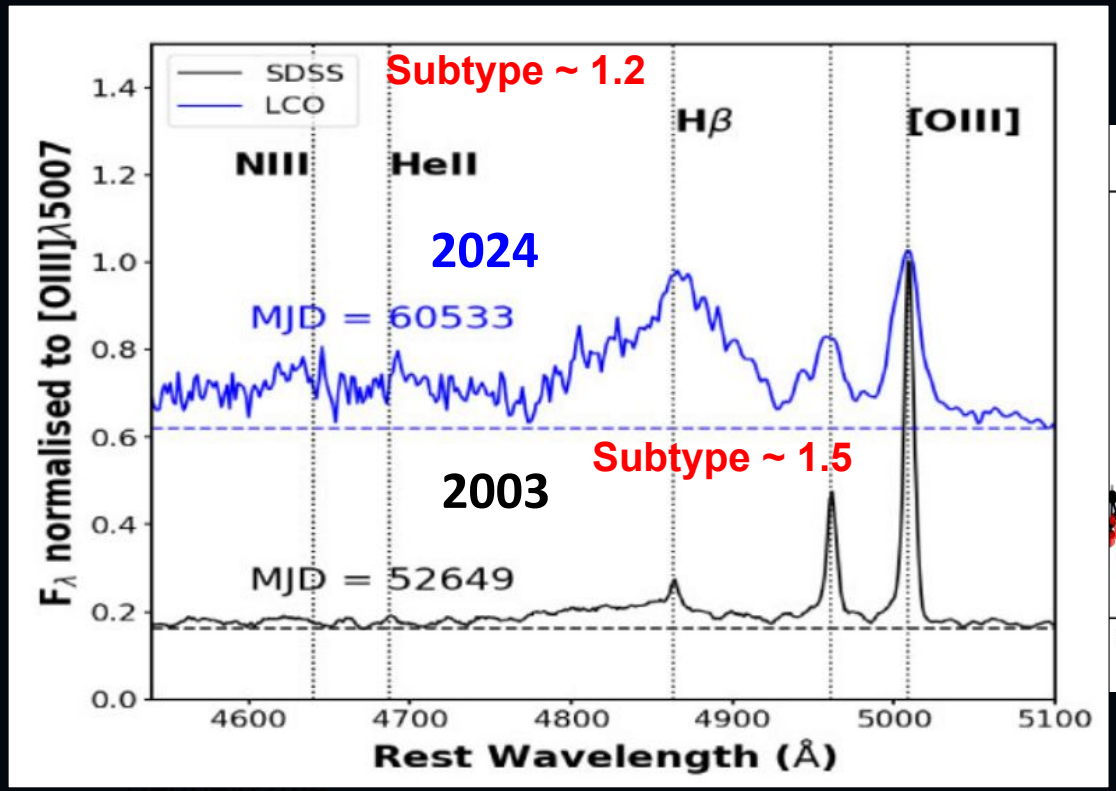
2014 - 2025



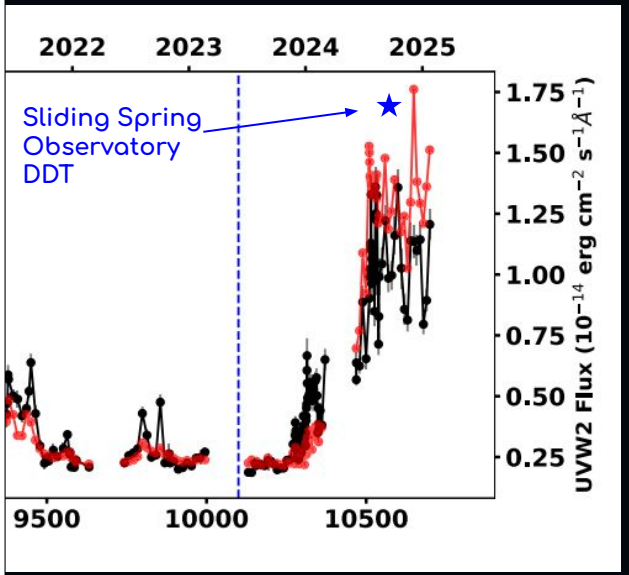
Palit+2025

Denney+2014

2014 - 2025

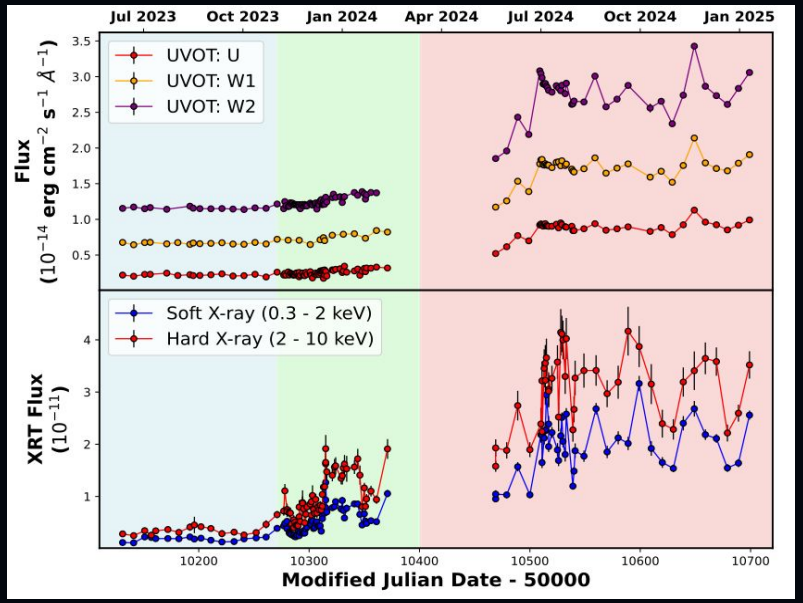


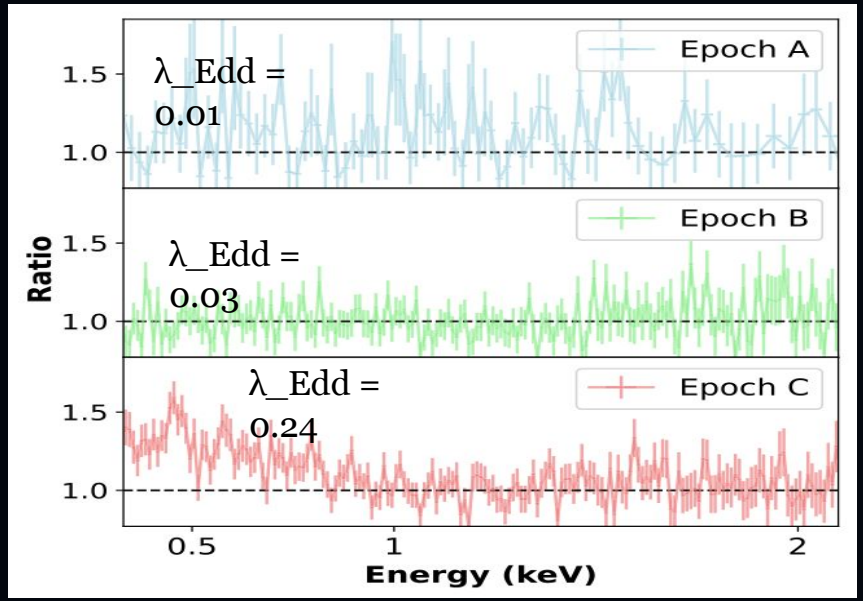
Palit+2025



Flux of Hβ (broad comp.) increased by factor ~ 7

2023 - 2025





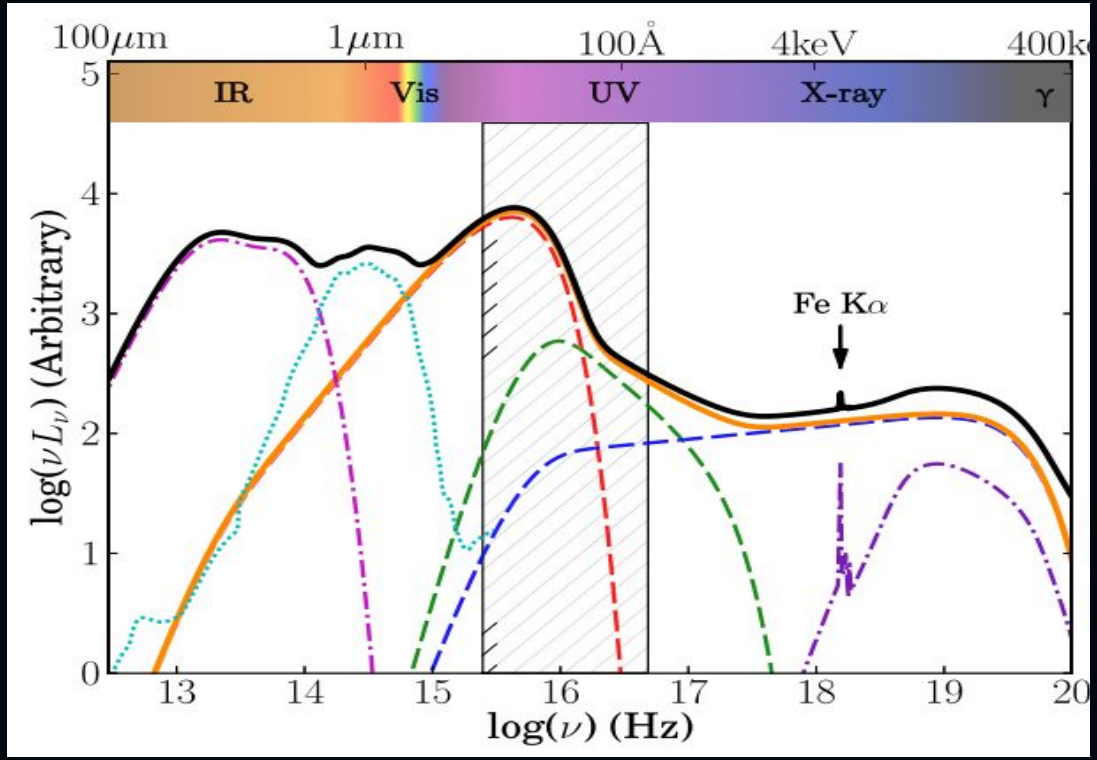
Palit+2025

Extreme Non-Linear Scaling: A 10x increase in Far-UV triggered a ~80x surge in soft X-ray excess flux.

Denney+2014

α_{ox} parameter →Diagnostic for state transition

Collinson+2016



Denney+2014

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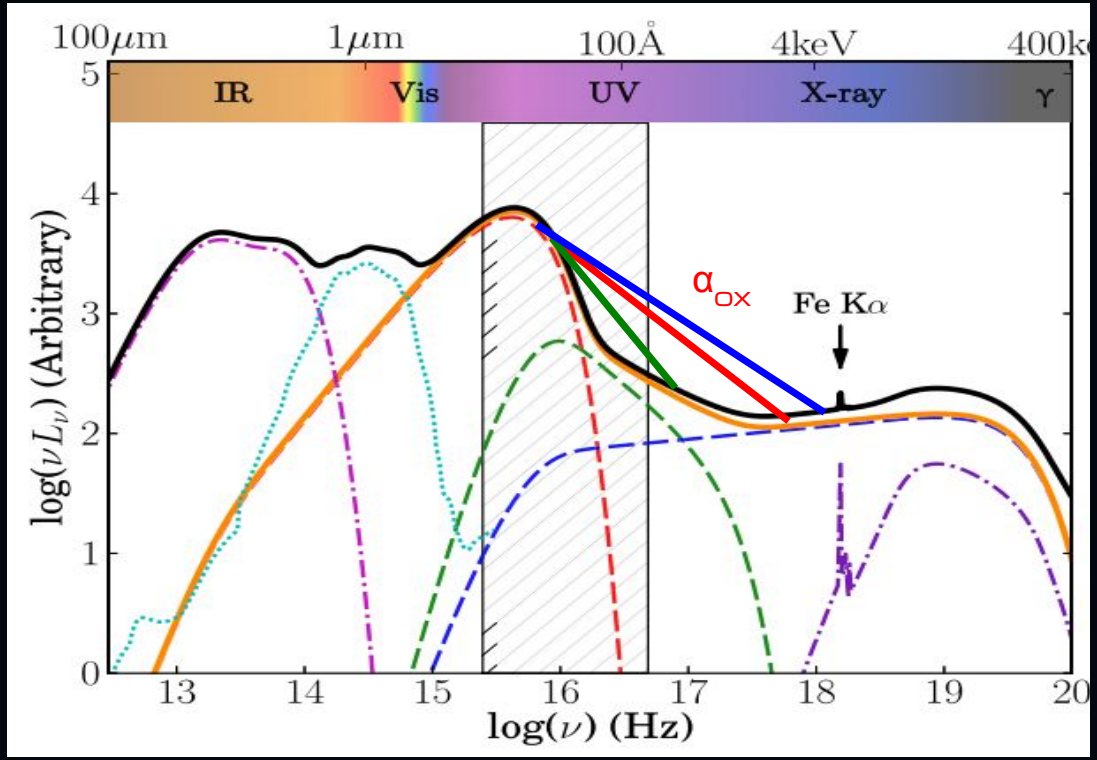
Collinson+2016

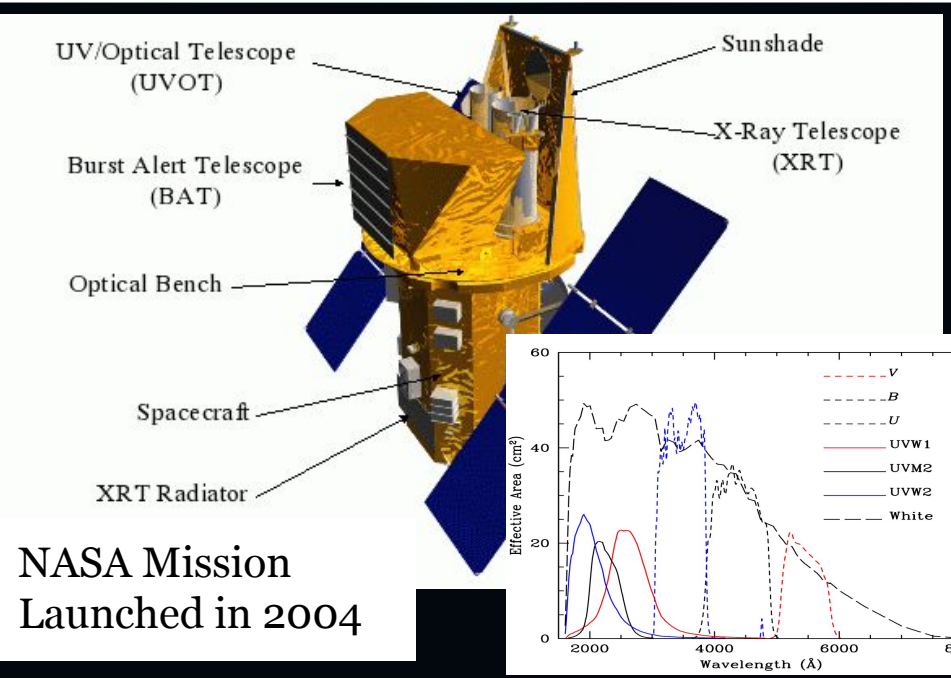


Denney+2014

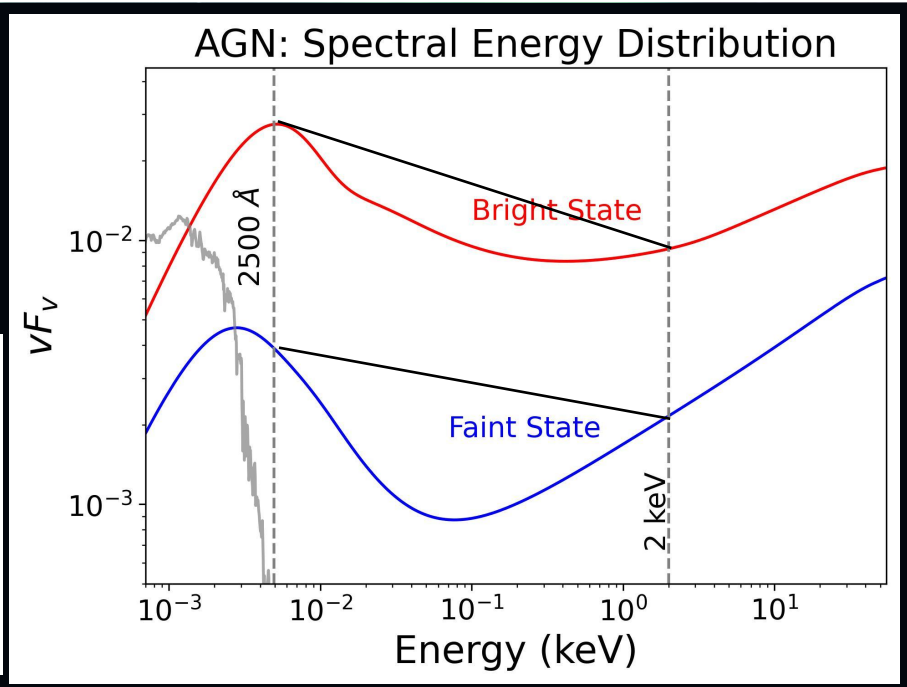
2500 A ≈ accretion disk
0.5 keV ≈ warm corona
2 keV ≈ X-ray corona
4 keV ≈ X-ray corona

α_{OX} vs Eddington ratio

Swift XRT/UVOT



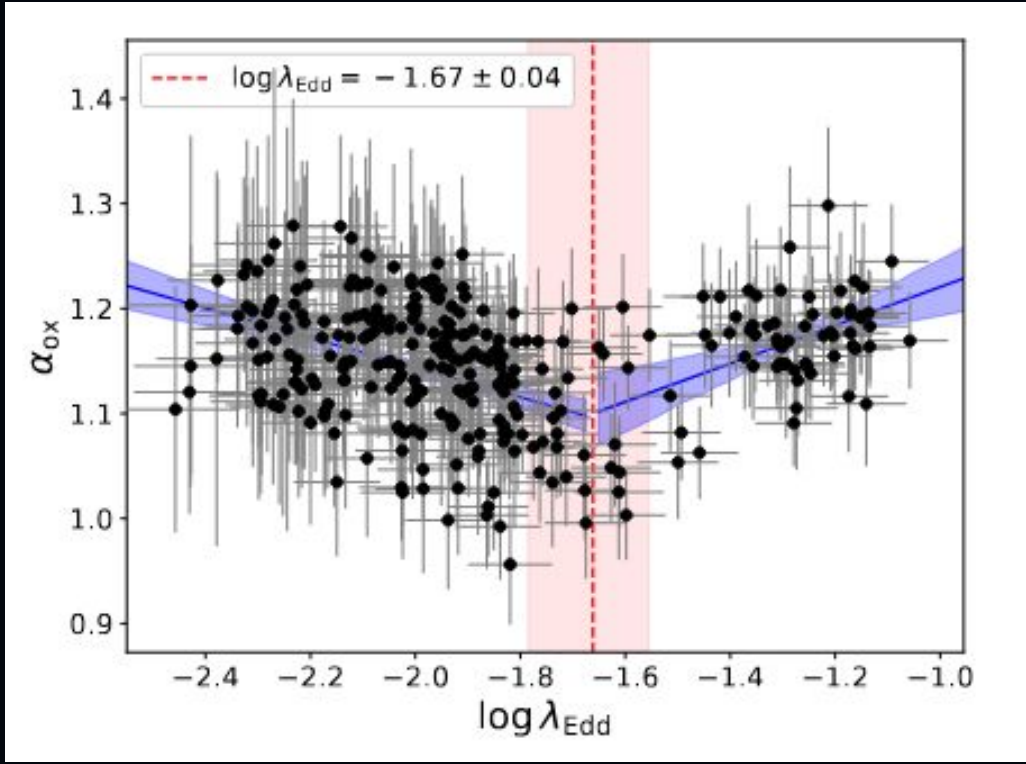
NASA Mission
Launched in 2004



6 - UV filters: v, b, u, w1, m2, w2
0.5 - 10 keV X-ray coverage

400 *Swift* Telescope pointings from the last 12 years

'V'-shaped break in α_{ox}



Palit+2026b

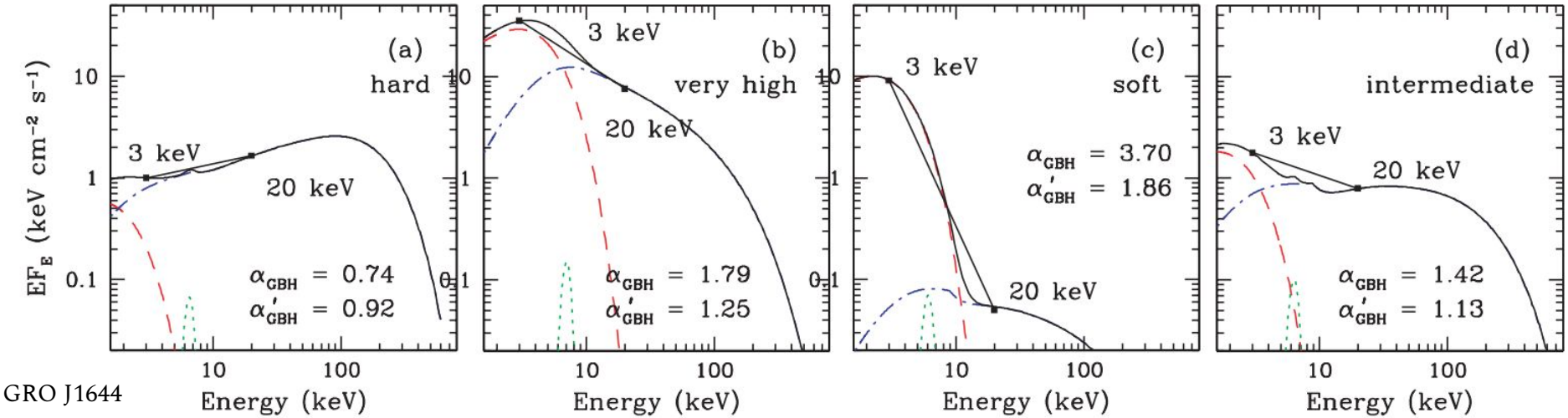
λ_{Edd} break at 0.021 +/- 0.008

Break dependent on k_{bol} *!*

Are CS-AGNs fundamentally different from stable Seyferts ?

Diagnostics of state transition (in XRBs)

Sobolewska+2009, 2011a, 2011b

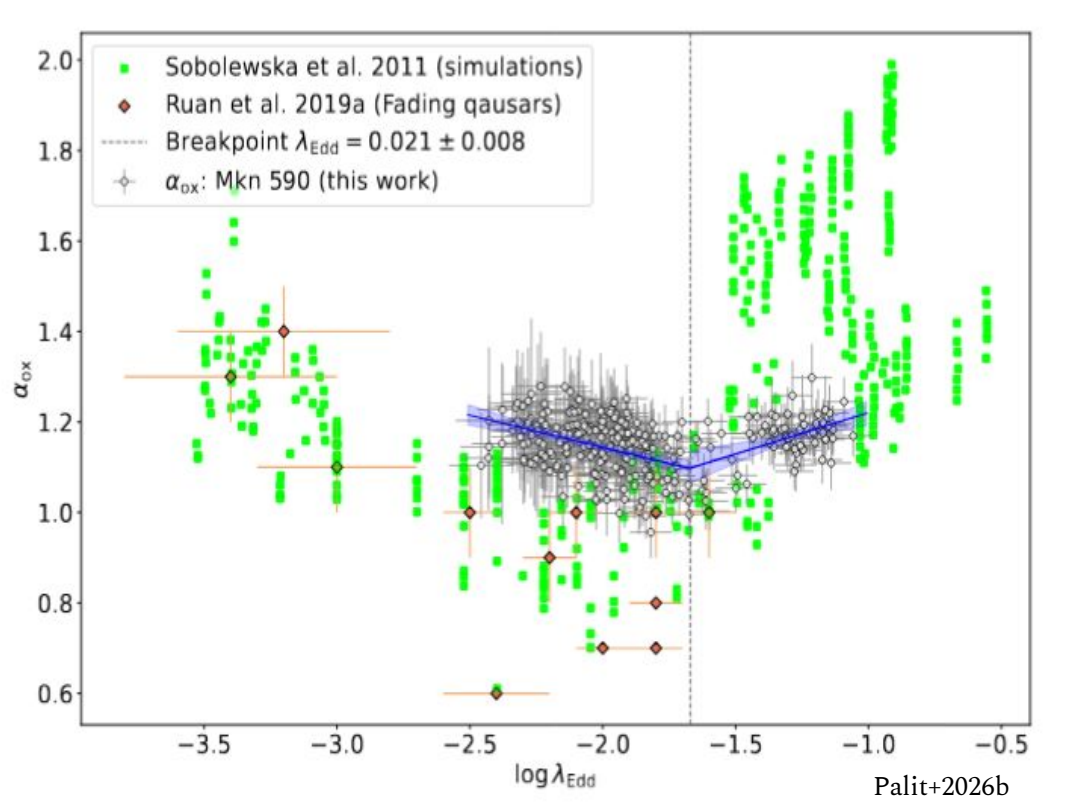


$$\alpha_{GBH} = -\frac{\log(ef_e)_3 - \log(ef_e)_{20}}{\log 3 - \log 20} + 1,$$

3 keV ~ thermalized disk emission
20 keV ~ Comptonized emission from corona

Mrk 590 vs XRBs

Turned-off quasars



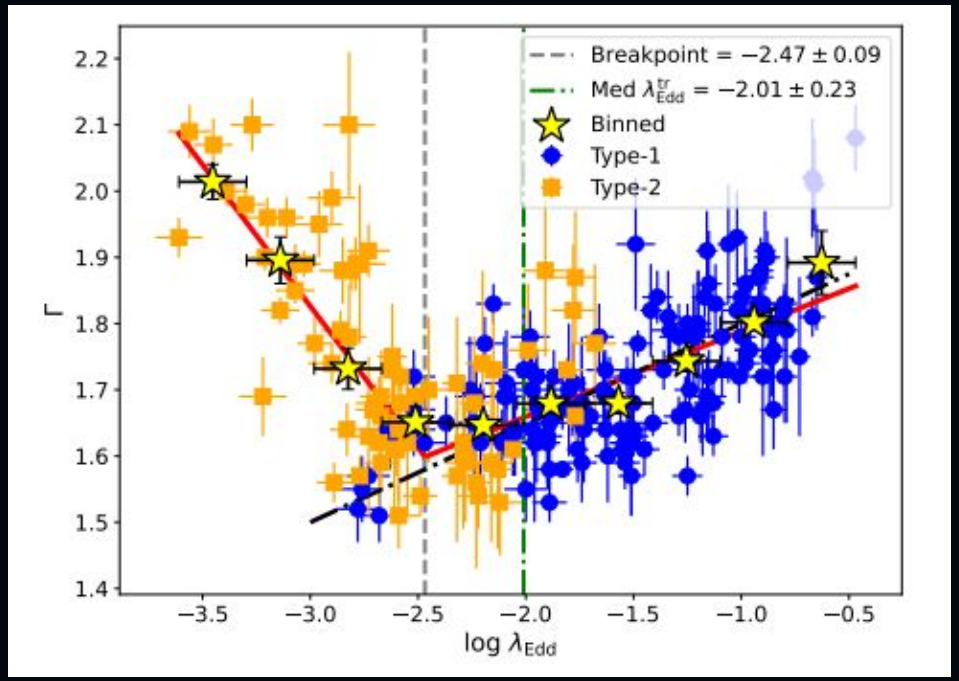
Palit+2026b

Expectations from canonical XRB spectral states

XRB: GRO J1655−40 scaled to BH masses of $10^{6\text{-}10}$ M_{solar}

numerically consistent with the XRB picture

Recurring 'V-shaped' breaks



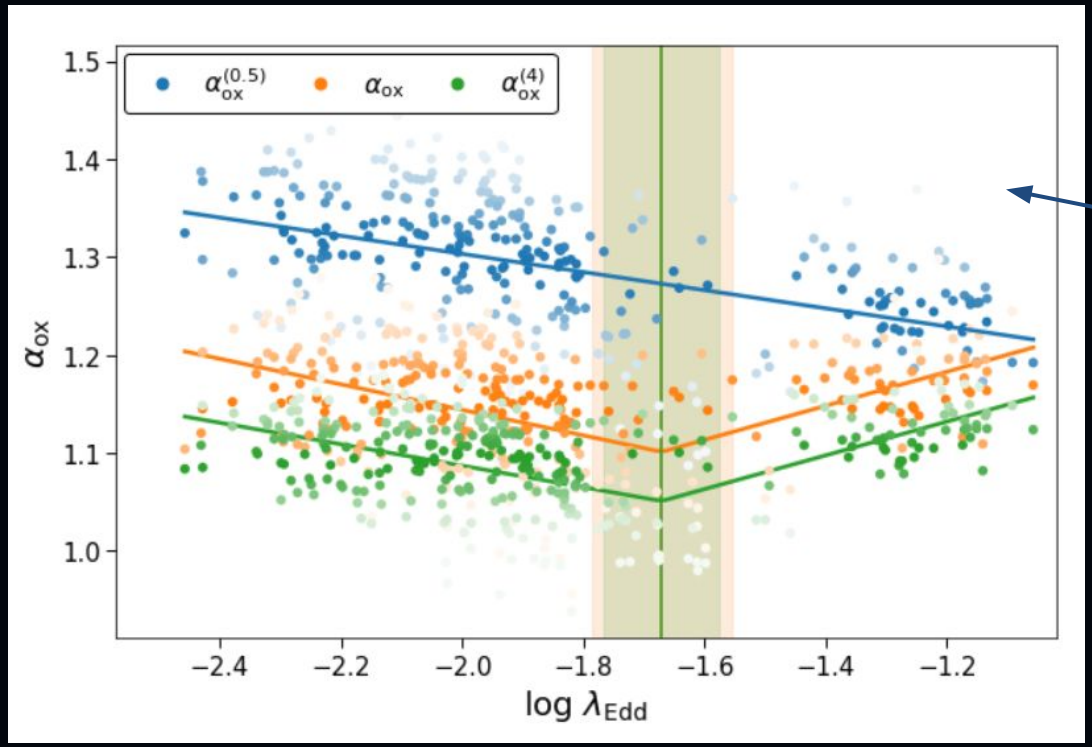
Jana, Ricci+2026

Five typical CL-AGNs: Break at ≈ -2.47 +/- 0.09

Soft X-ray excess flux is MORE variable than power law continuum in CS-AGNs

Change in geometry below the break, soft X-ray excess vanishes below ~ -2.5

No 'V'-shaped break in soft X-rays



Palit+2026b

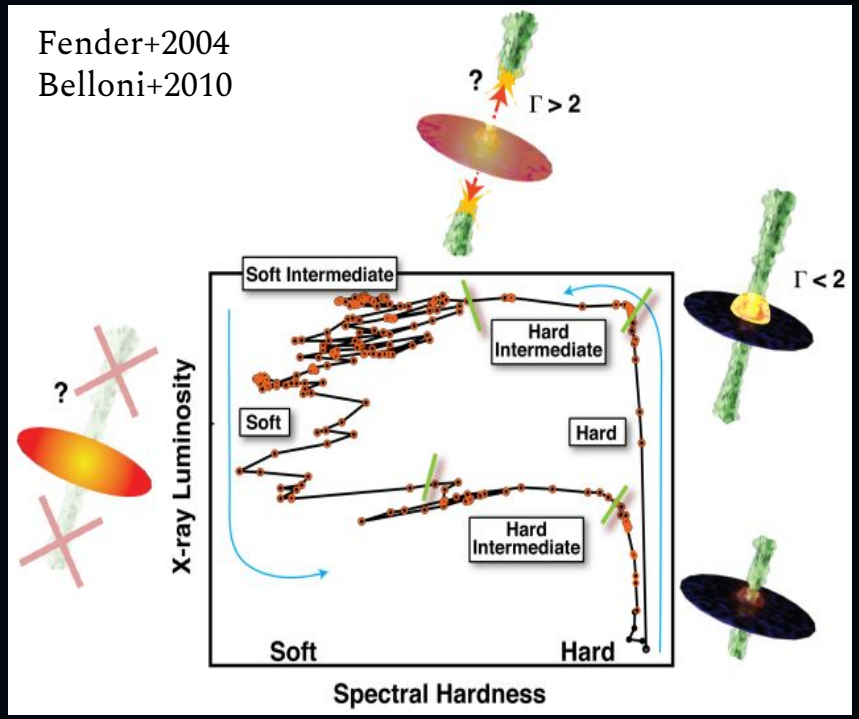
No such break appears for disk -- warm corona slope !

Likely the UV (2500 A) and warm corona (0.5 keV) are radiatively linked

Consistent with a slab like warm corona covering the disk

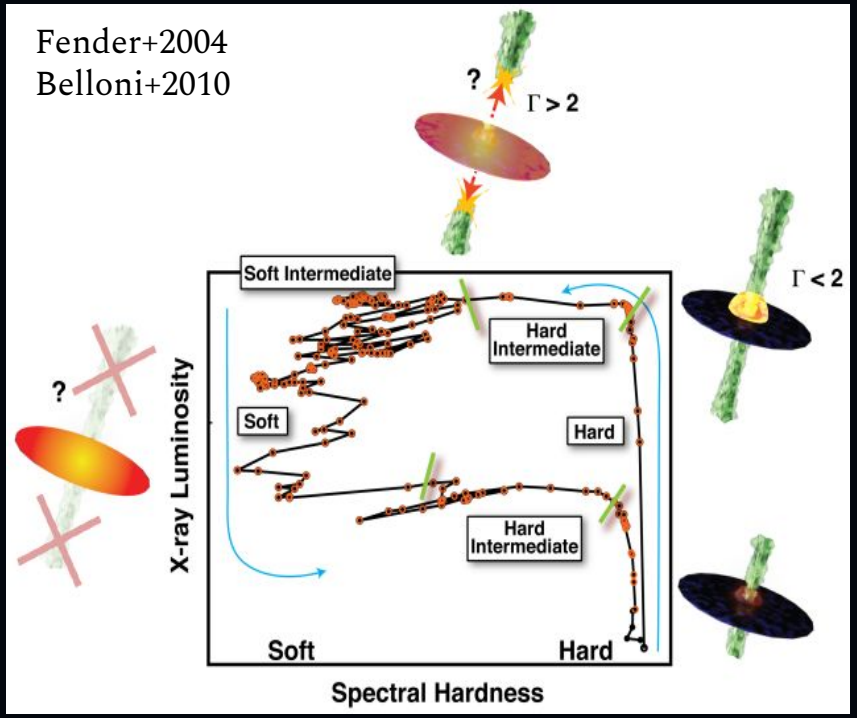
Can we expect a break below -2.5 ?

Jet variability vs state transition



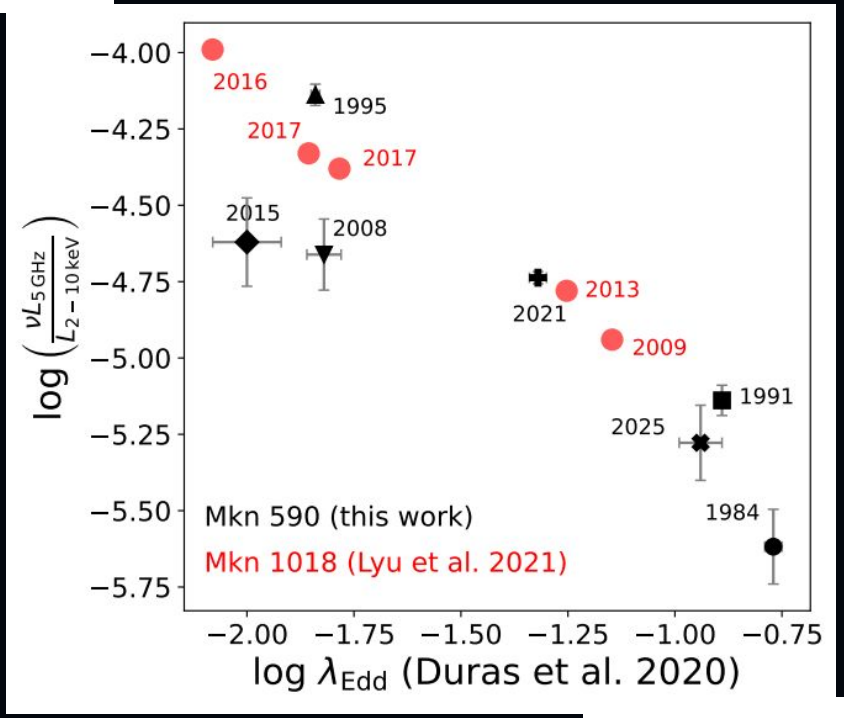
Jet variability vs state transition

Fender+2004
Belloni+2010



Jet ?

Palit+2026b



Suppressed Jet ?

Takeaways (Accepted for publication in *ApJ*; arXiv:2602.17572)

CLAGNs *likely* undergo XRB-like spectral state transitions

Change in disk-corona structure at 1-2 % of Eddington luminosity
→ analogous to XRBs

The UV emitting disk and soft X-ray emitting warm corona are *likely* tightly radiatively coupled → as expected in a slab geometry

Strong soft X-ray emission linked to CL-event (Type 2/1.5/1.5 → 1/1.2) in changing state AGNs → key to understanding how Eddington ratio regulates accretion flow evolution

State dependent jet activity *likely* analogous to XRBs → Needs further sustained radio/X-ray homogeneous monitoring across large dynamic luminosity range

Thank you

Reach me at:
bpalit@camk.edu.pl

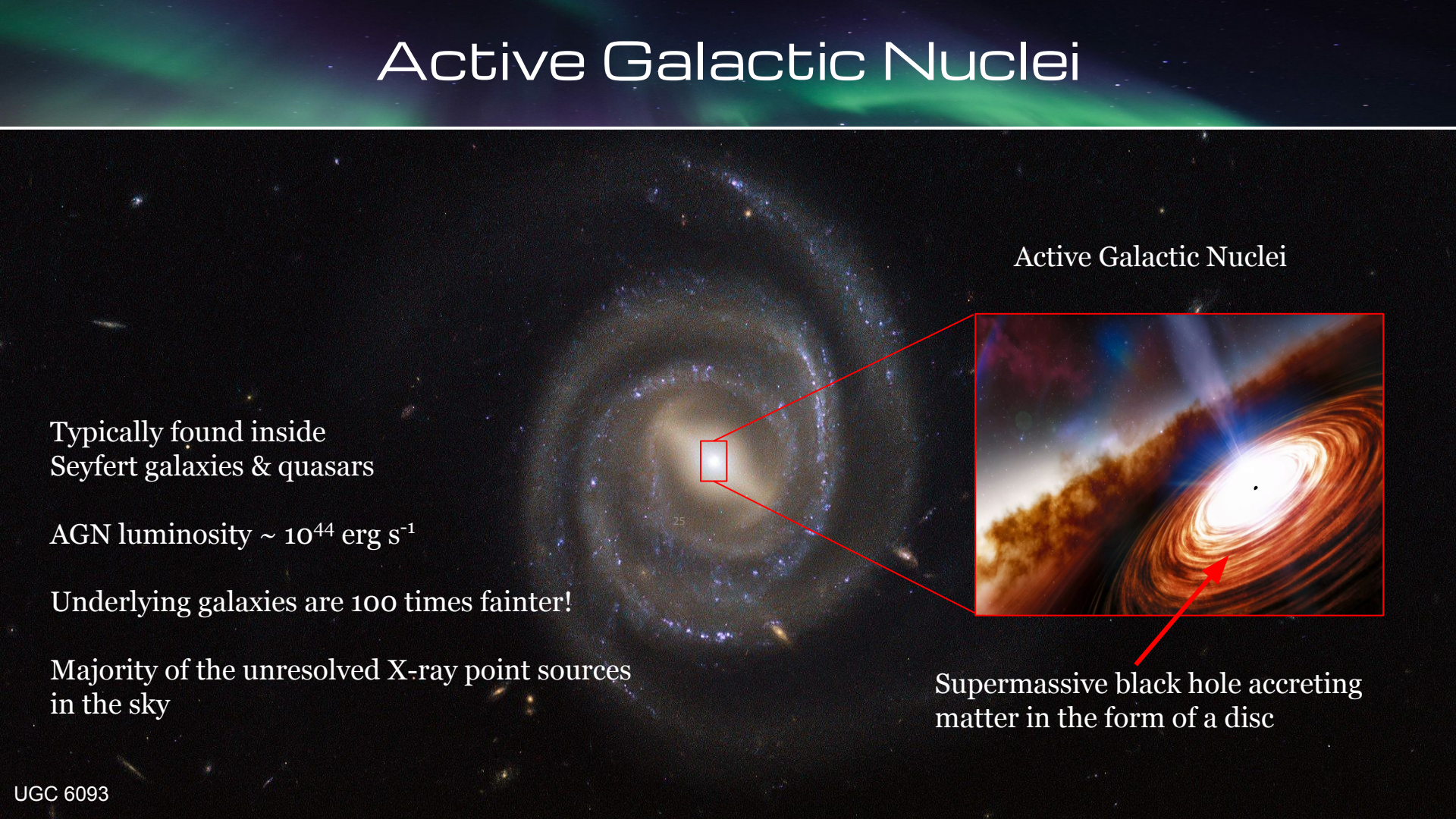
Active Galactic Nuclei

Typically found inside
Seyfert galaxies & quasars

AGN luminosity ~ 10^{44} erg s^{-1}

Underlying galaxies are 100 times fainter!

Majority of the unresolved X-ray point sources in the sky



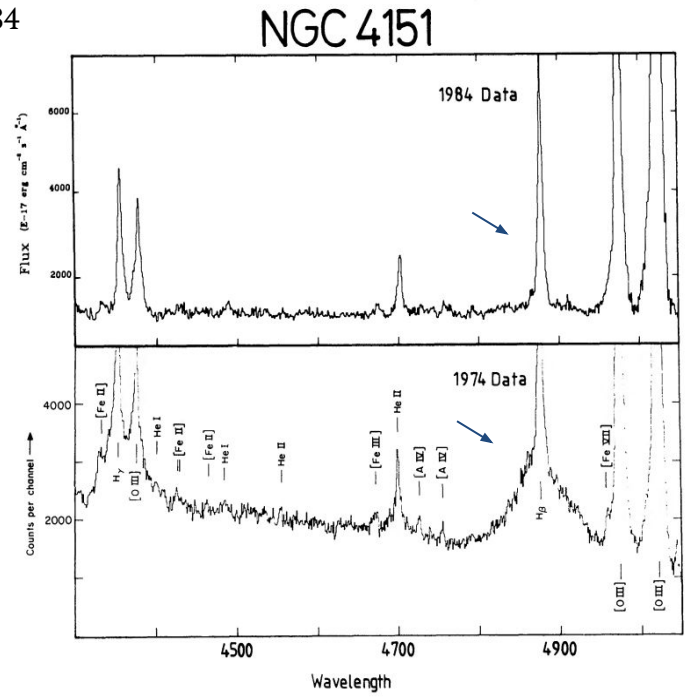
Active Galactic Nuclei

Supermassive black hole accreting matter in the form of a disc

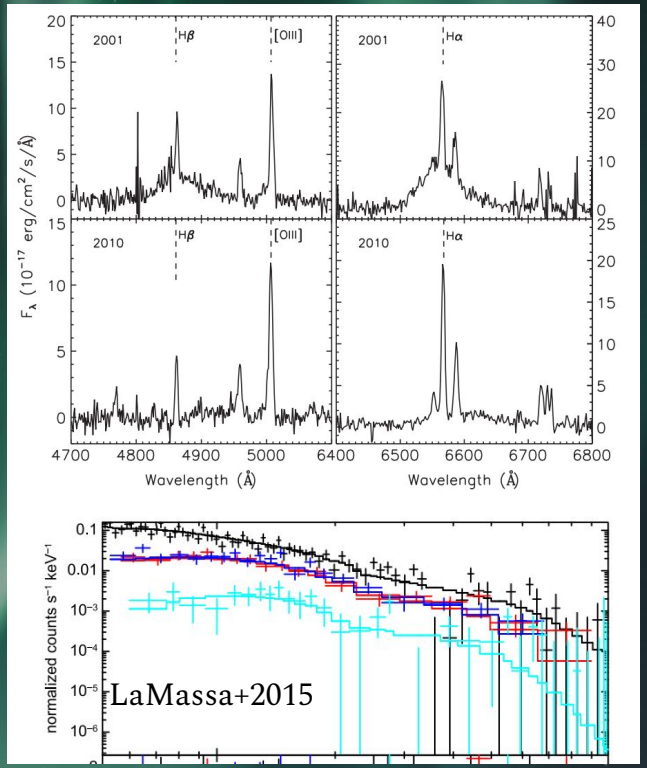
UGC 6093

Not all AGNs follow the unification scheme !

Penston & Pérez, *An Evolutionary link between Seyfert Is and IIs?*
1984



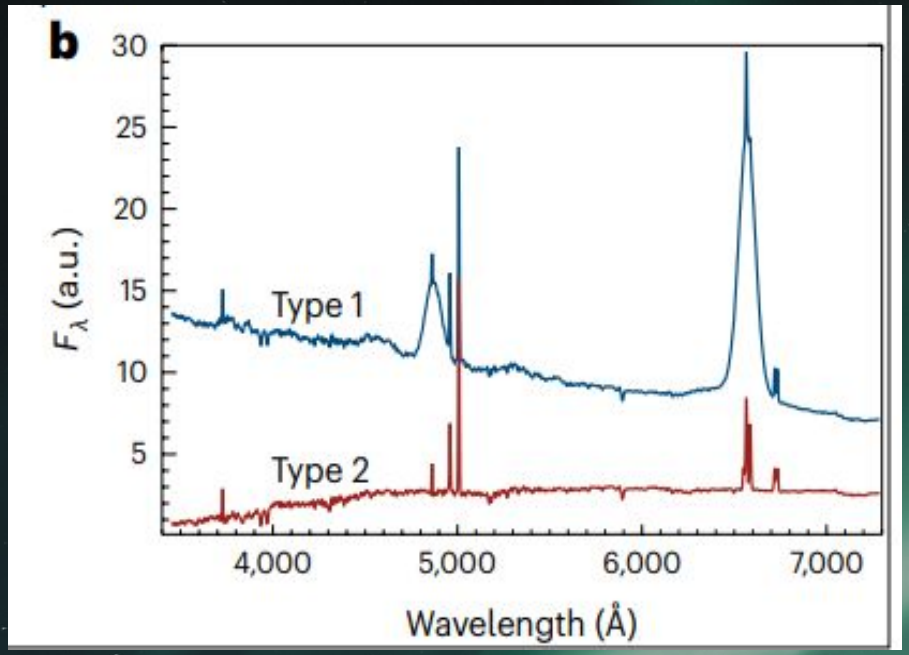
Alloin+1985 detected similar phenomena in Seyfert gal. NGC 1566



SDSS J0159+0033 ; $z = 0.31$; $|\triangle g| > 1$
X-ray flux change factor ~ 10 in 10 years

Not all AGNs follow the unification scheme !

Ricci+2023



Type 1 $\Longleftrightarrow$ Type 2 occuring in ~ few months ~ few years ~ a decade

Appearance / disappearance of broad emission lines -- Hydrogen Balmer lines

Large continuum changes in Optical, UV and X-rays ; factor of 15-20 in X-rays / $|\triangle g| > 1$ mag

Takeaways (arXiv:2602.17572)

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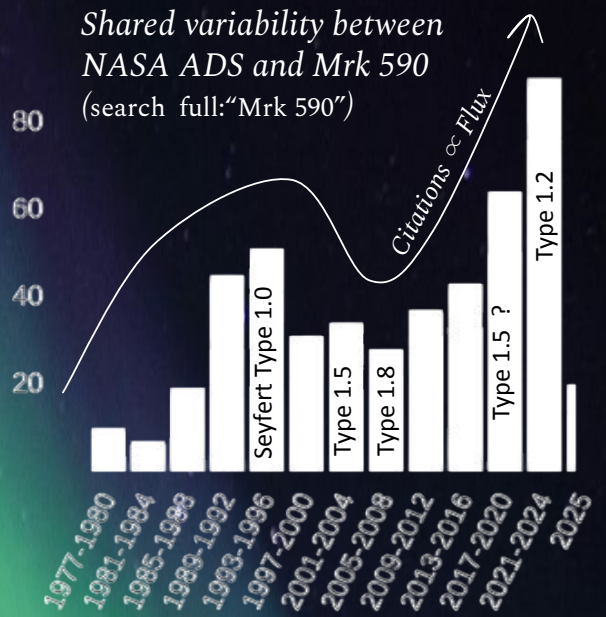

Thank you
Reach me at:
bpalit@camk.edu.pl

Diagnostics of state-transition (in XRBs)

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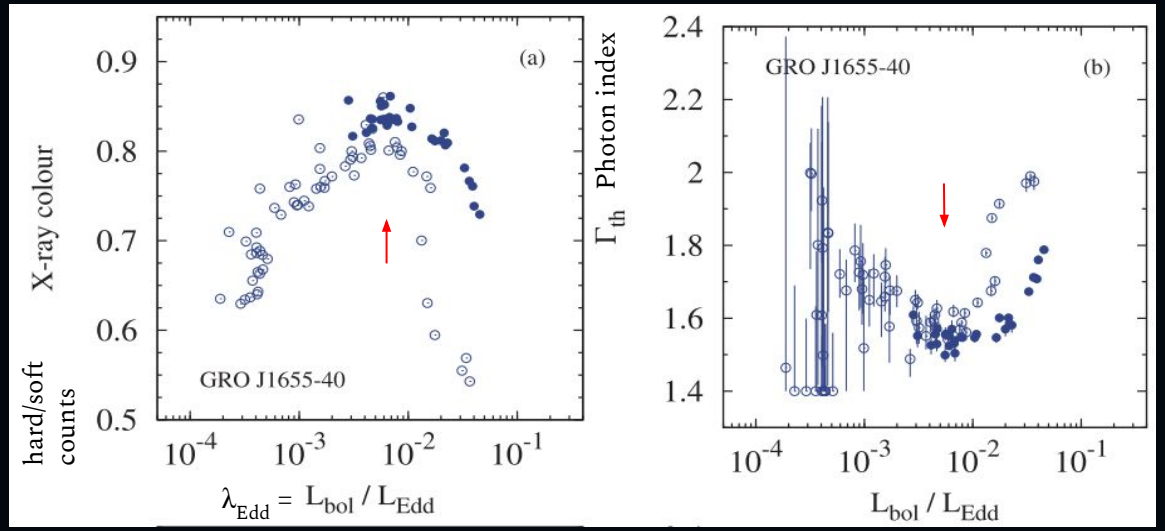
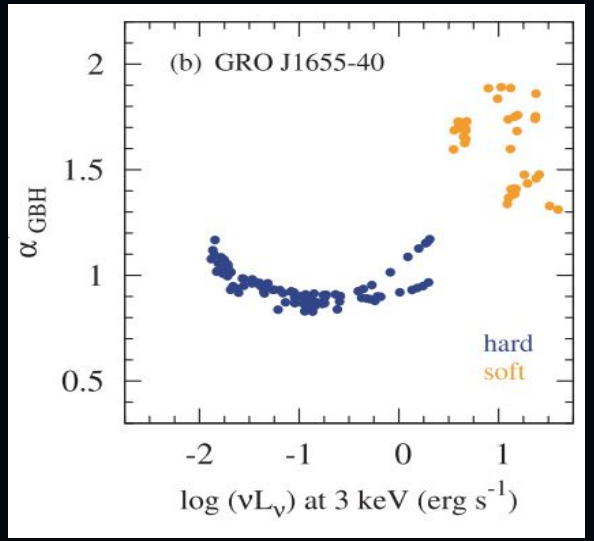




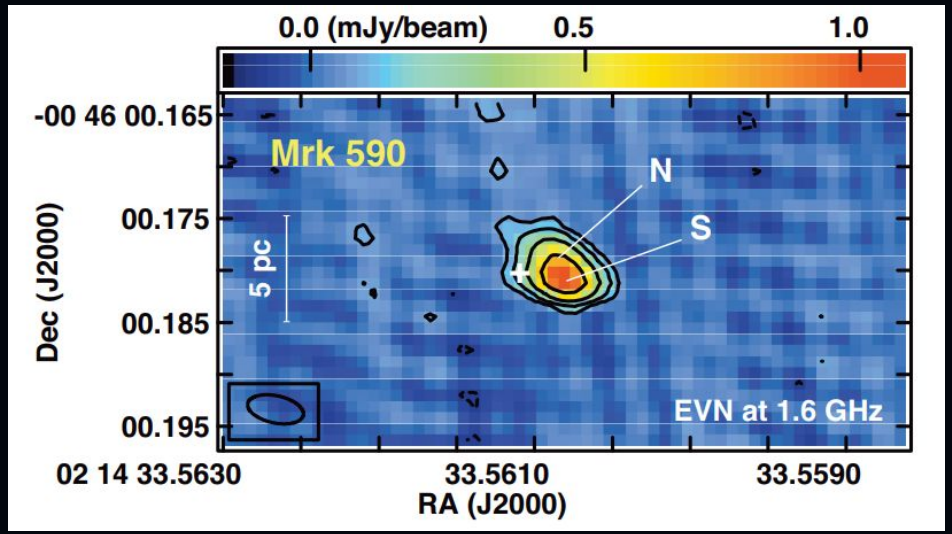
Change in the X-ray emission mechanism beyond $\lambda_{Edd} \sim 0.01$

Connected to geometry of disk-corona system

Recurring (inverted) v-shaped trends

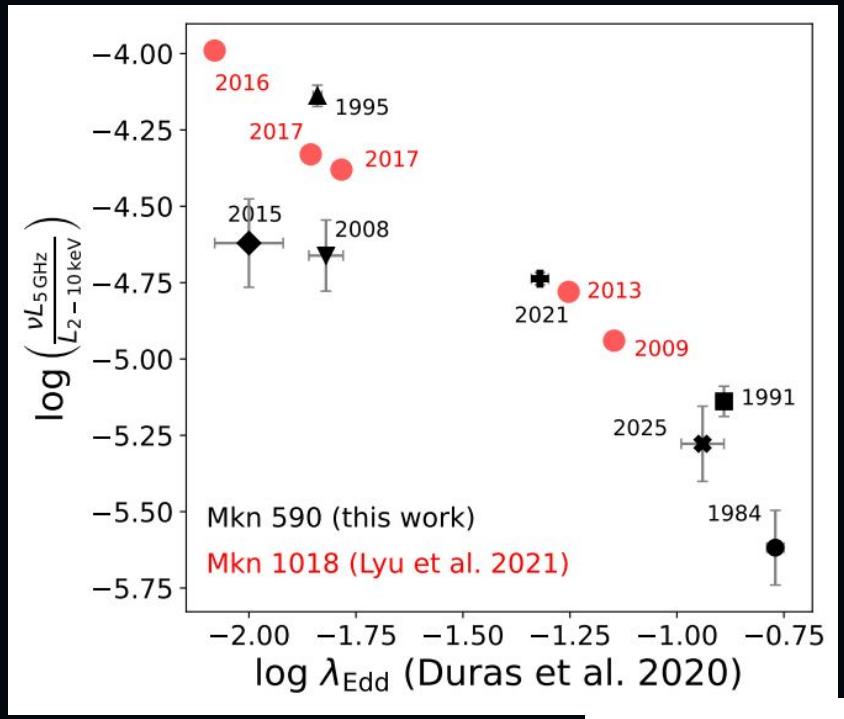
Jet variability vs state transition

Jet ?



Yang+2021; Parsec scale jet detected in 2015 using European VLBI Network

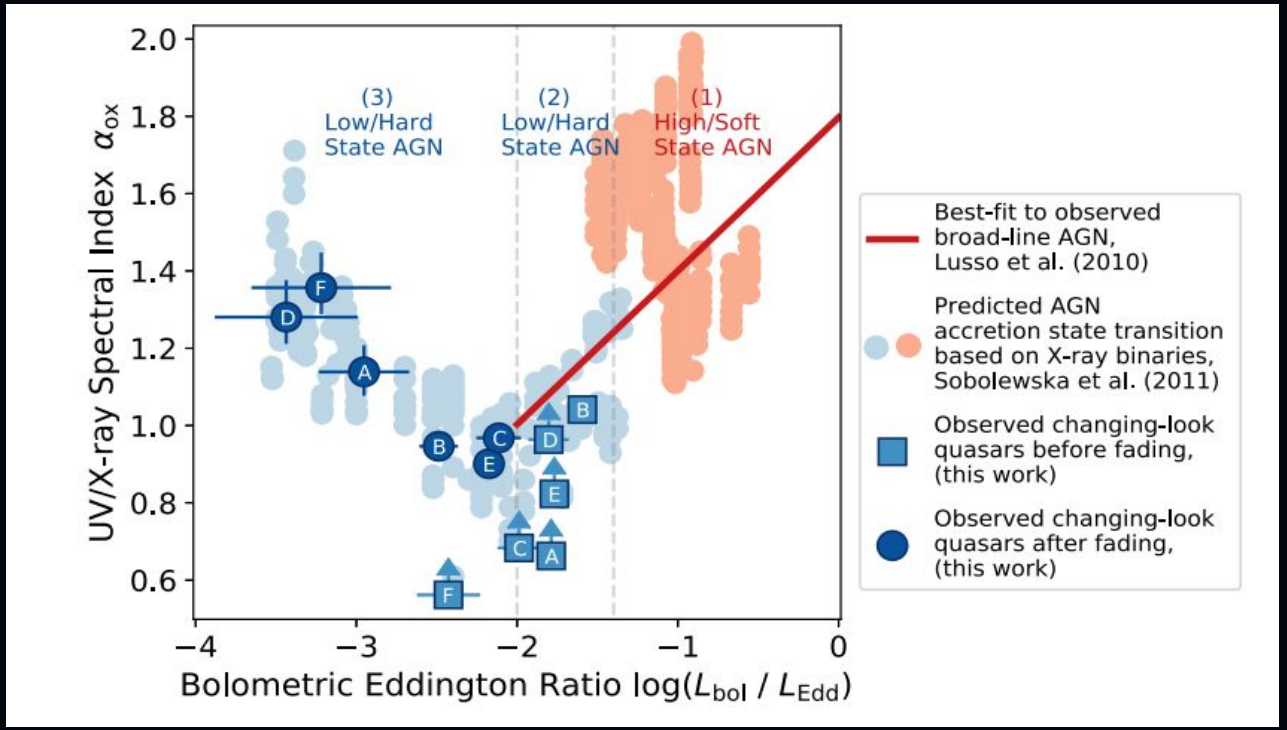
Palit+2026b



Suppressed Jet ?

Spectral state transition in CLAGNs

Motivation: Ruan+2019



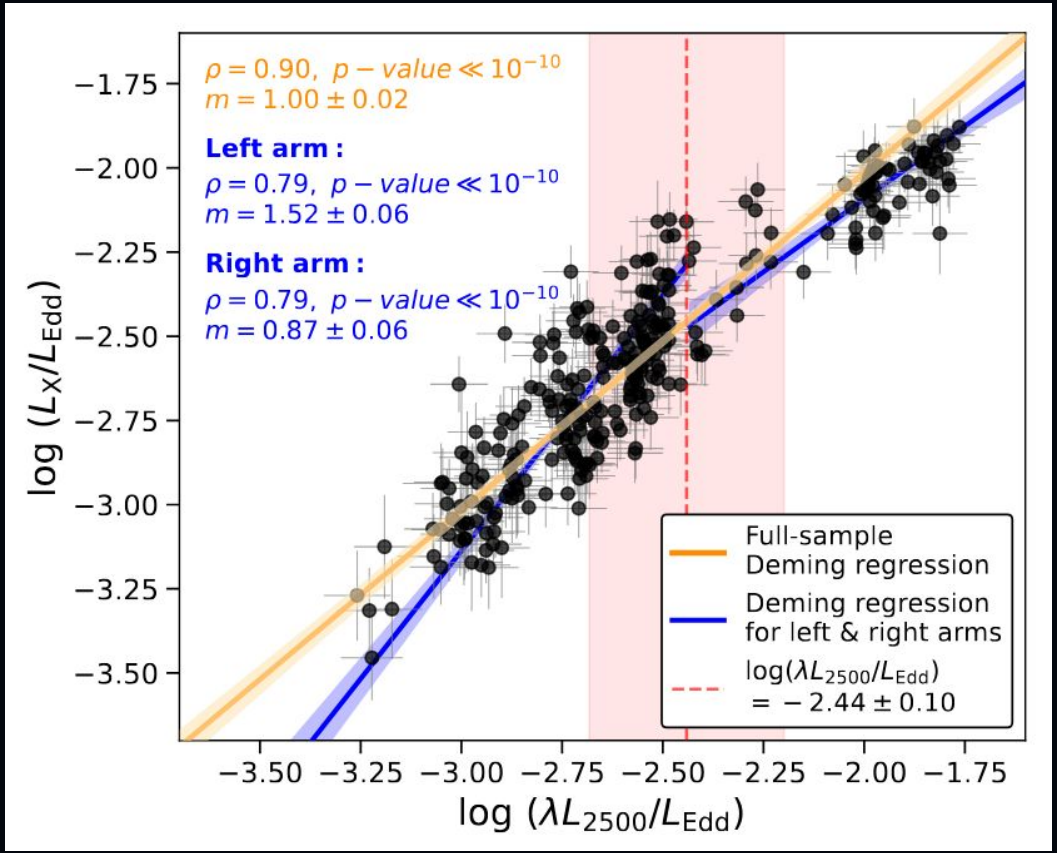
Results from changing-look quasars (fading)

vs

Simulated α_{ox} from hard and soft states of XRB: GRO J1655−40 scaled to BH masses $10^{6\text{-}10}$ M_{solar}

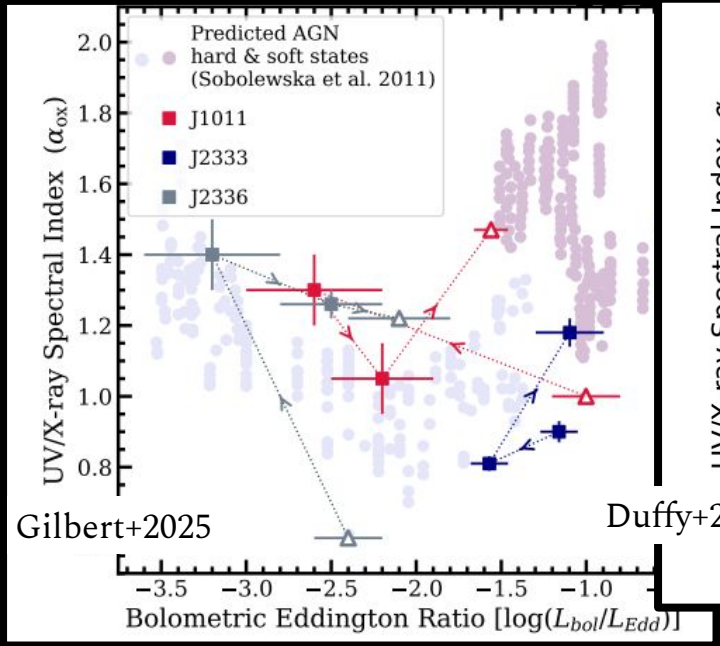
A break at ~ 0.01 λ_{Edd} !

UV - Xray correlation

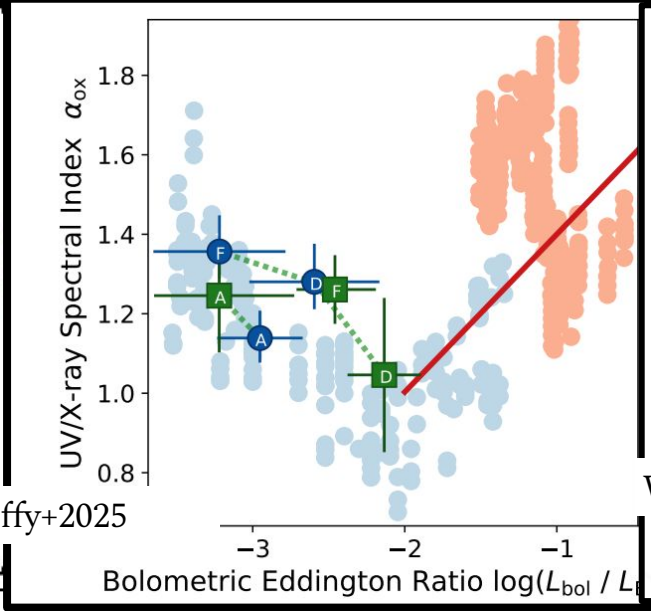


Further evidences

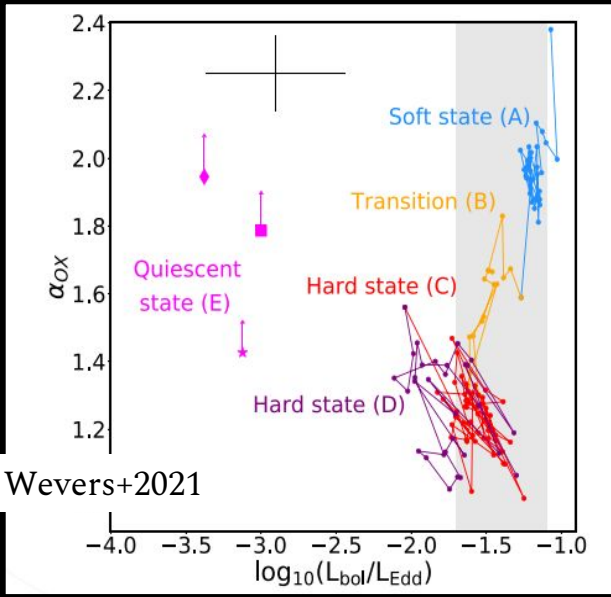
Results from CL Quasars and TDEs



Gilbert+2025



Duffy+2025



Wevers+2021

Transition around Eddington fraction ~ 0.01

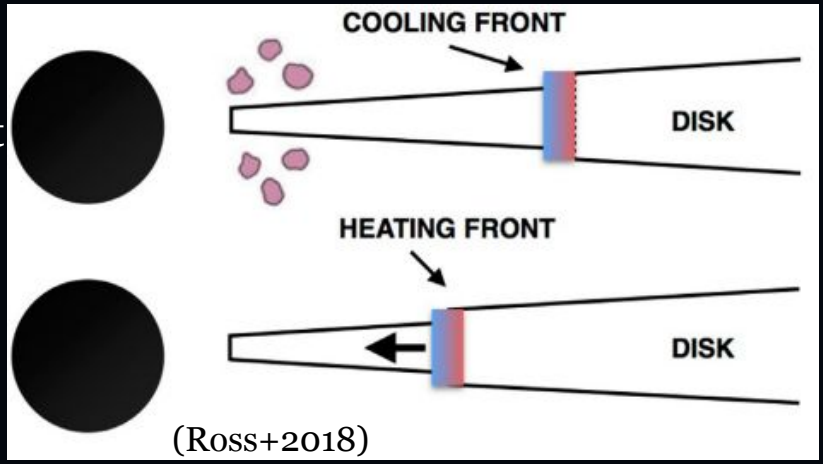
Puzzling Timescales

$T_{dy} << T_{CL} \sim T_{th} <<< T_{vis}$

Observed CLQ transitions (months-years) align most naturally with thermal timescales.

A trigger at ISCO (often as a magnetic configuration change)
launches a cooling front suppressing UV/optical emissivity at increasing radii
later a heating front can propagate inward to restore the inner disk.
(Ross+, Stern+, 2018);

The effective thermal front timescale is extremely sensitive to αC_s and (h/R)



(Ross+2018)