THE TRANSIENT SLIM DISK OF THE CHANGING-LOOK ACTIVE GALACTIC NUCLEUS 1ES 1927+654

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See details：
Li, Ho, Ricci et al. (2022 ApJ, 933 70)
Li, Ricci, Ho et al. (2024a, arxiv.2409.09264)
Li, Ho, Ricci et al. (2024b, arxiv.2409.09265)

CONTENT

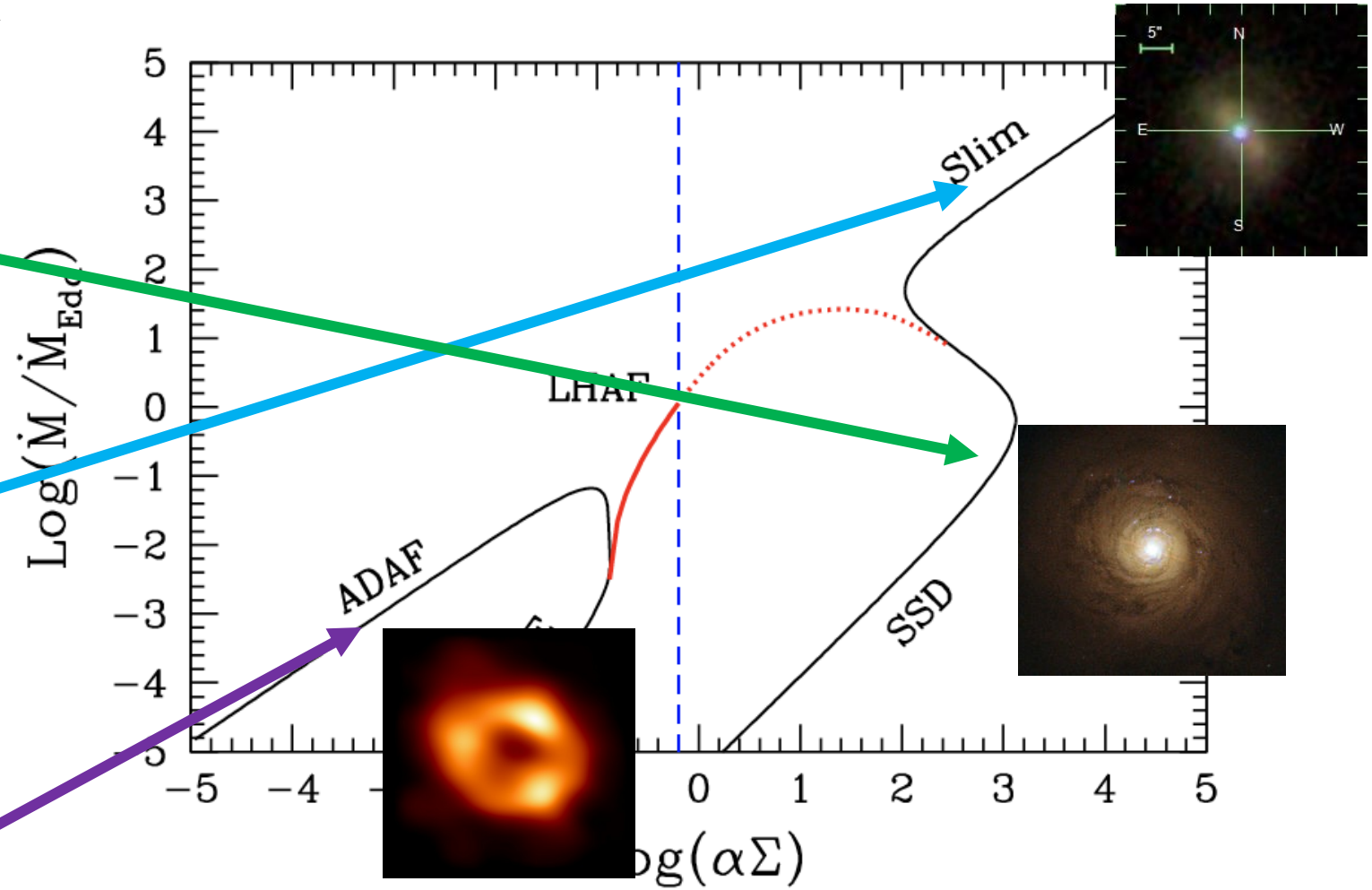
- Introduction to slim disk
- Changing-look AGN 1ES 1927+654
- The transient slim disk
- Properties of the slim disk
- Inplications
- Summary

SLIM DISK

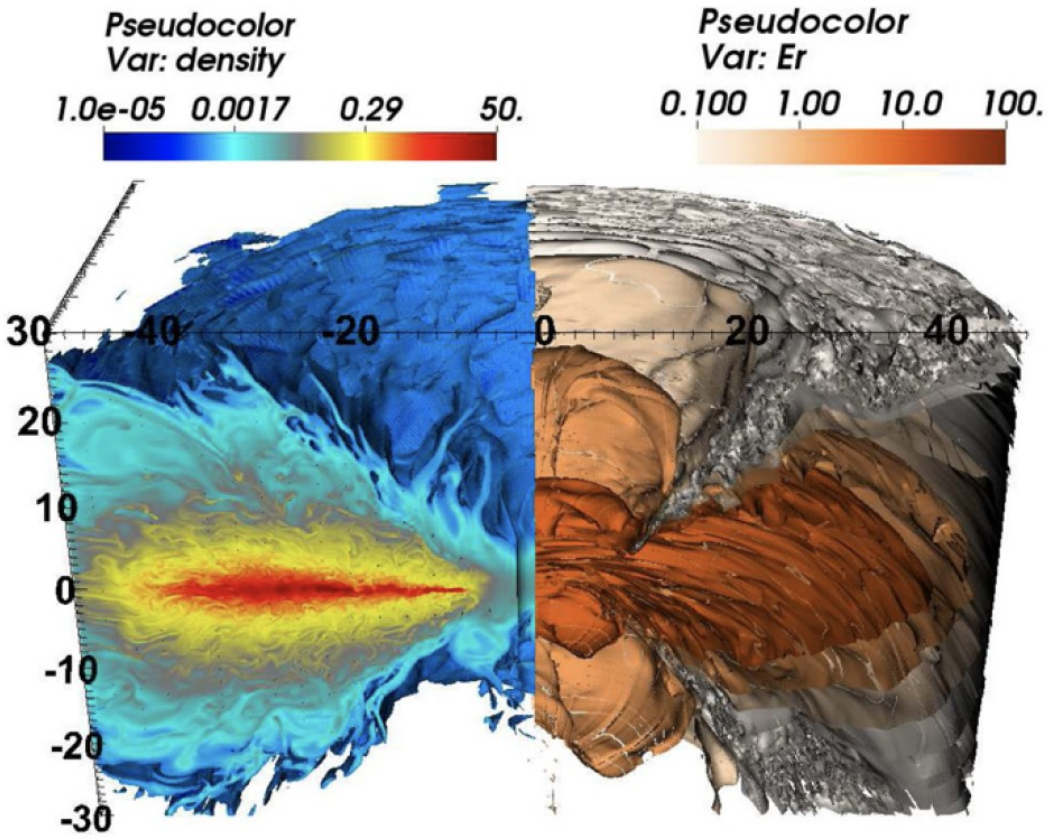
Lynden Bell + 1972
Shakura & Sunyeav 1973
Novikov & Thorne 1973

Abramowicz + 1988

Narayan & Yi 1994

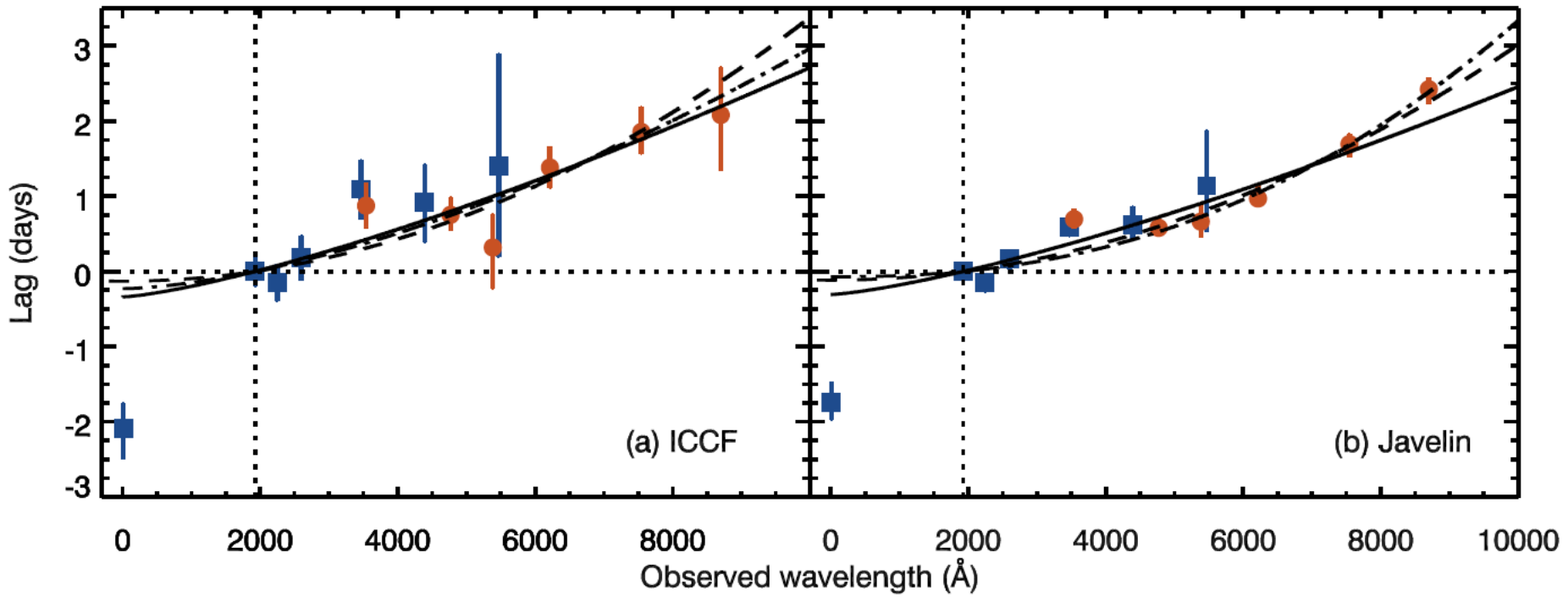


RADIATION EFFICIENCY



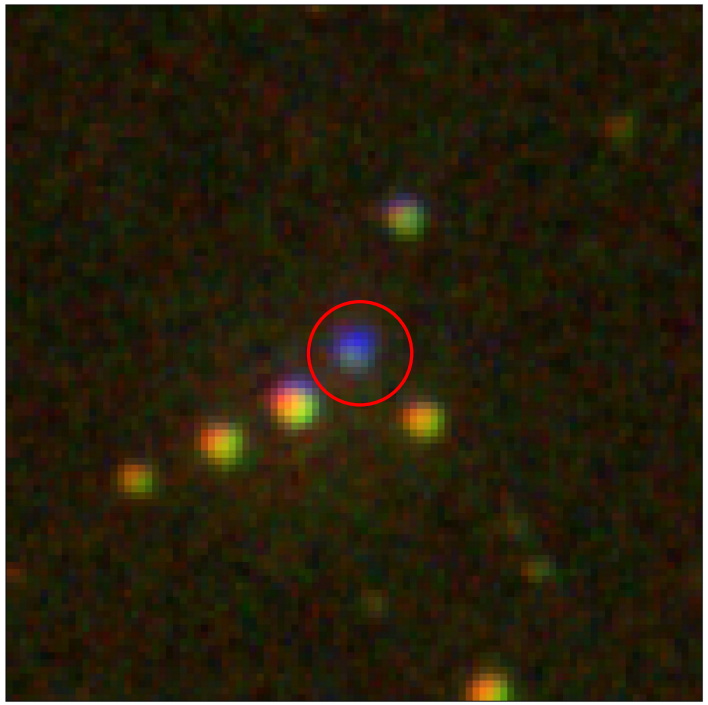
- Logarithmic relation from 1D analytical theory Abramowicz + 1988
- A even lower value from 2D-RHD simulation (~1%) Ohsuga + 2005
- Normal radiation efficiency in 3D-RMHD simulation Jiang + 2014
- 2 times lower radiation efficiency in 3D-GRRMHD (M1) Sadowski + 2016

TEMPERATURE PROFILE



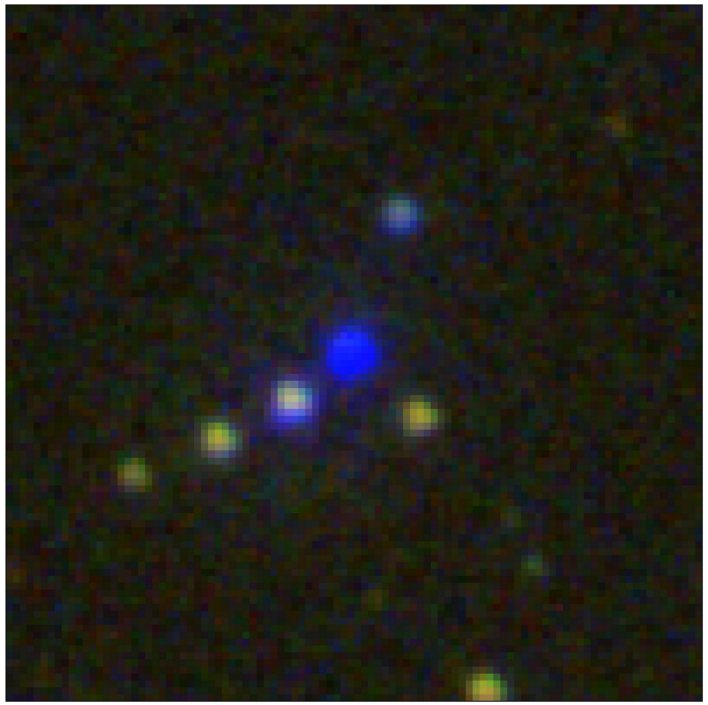
- Observational evidence is not clear from disk RM
- e,g, Mrk 142 (Cackett + 2020), Mrk 335 (Kara + 2023)

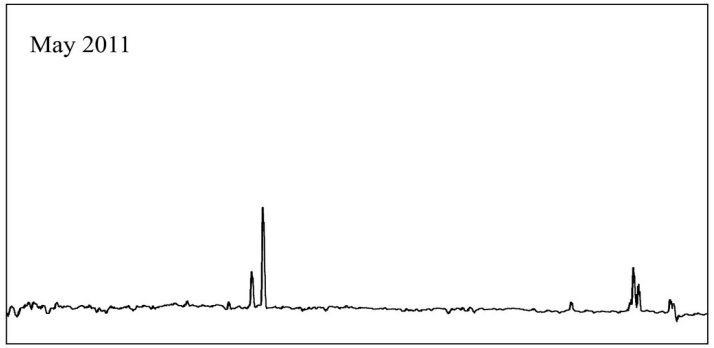
1ES 1927+654

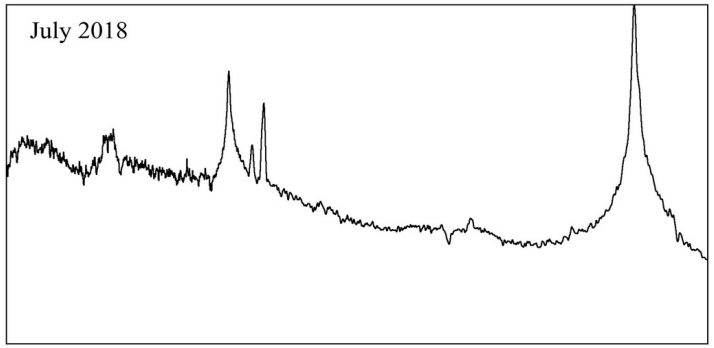


Outburst 12/2017

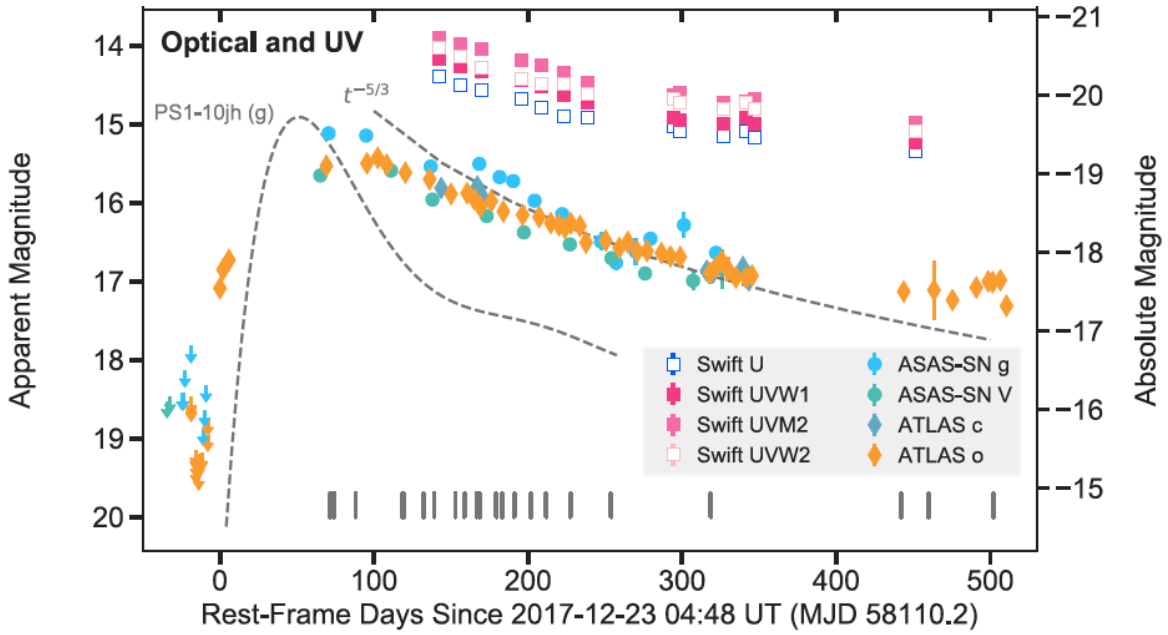
Type 2 -> Type 1

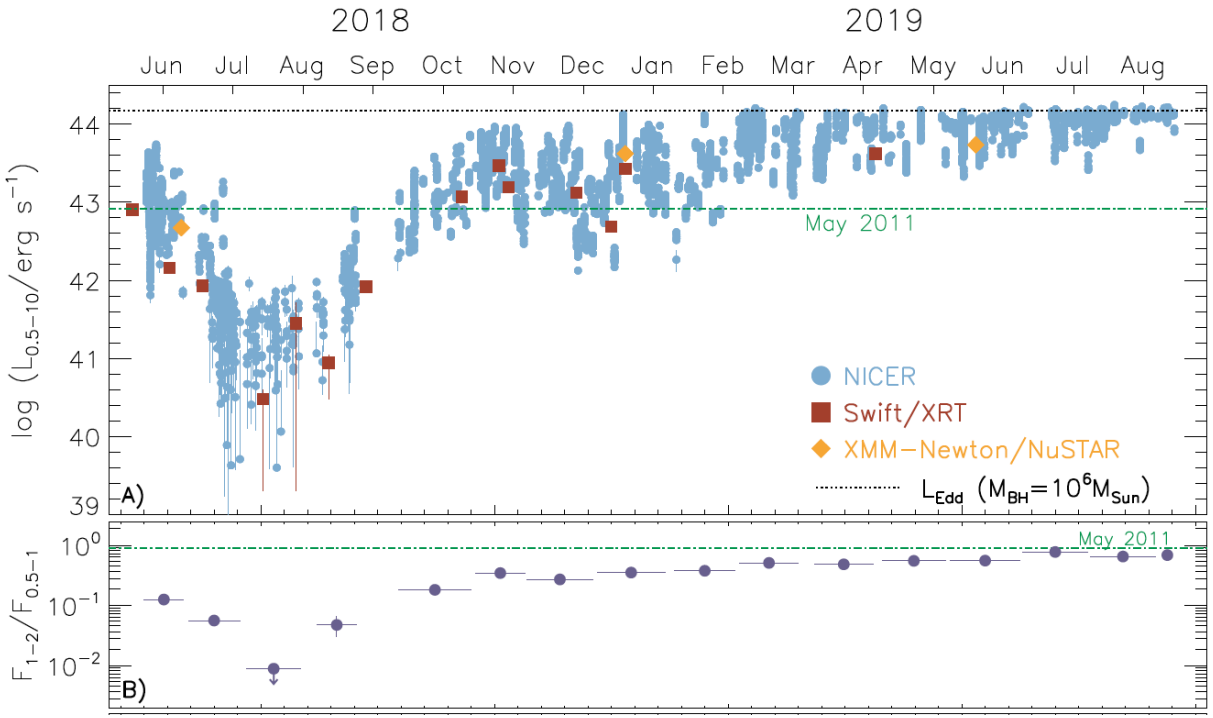






POST-OUTBURST

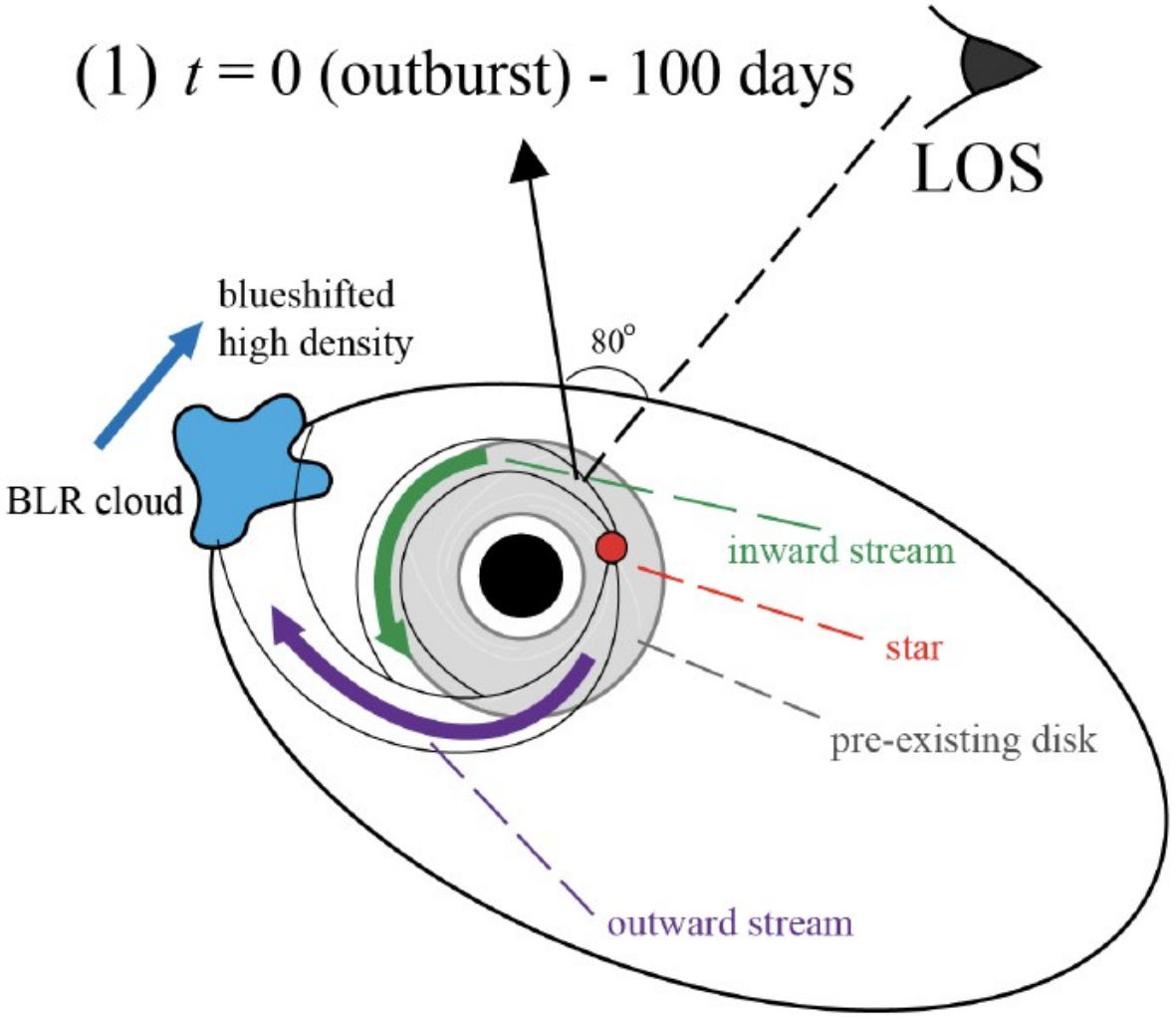




Trakhtenbrot + 2019. Ricci + 2020

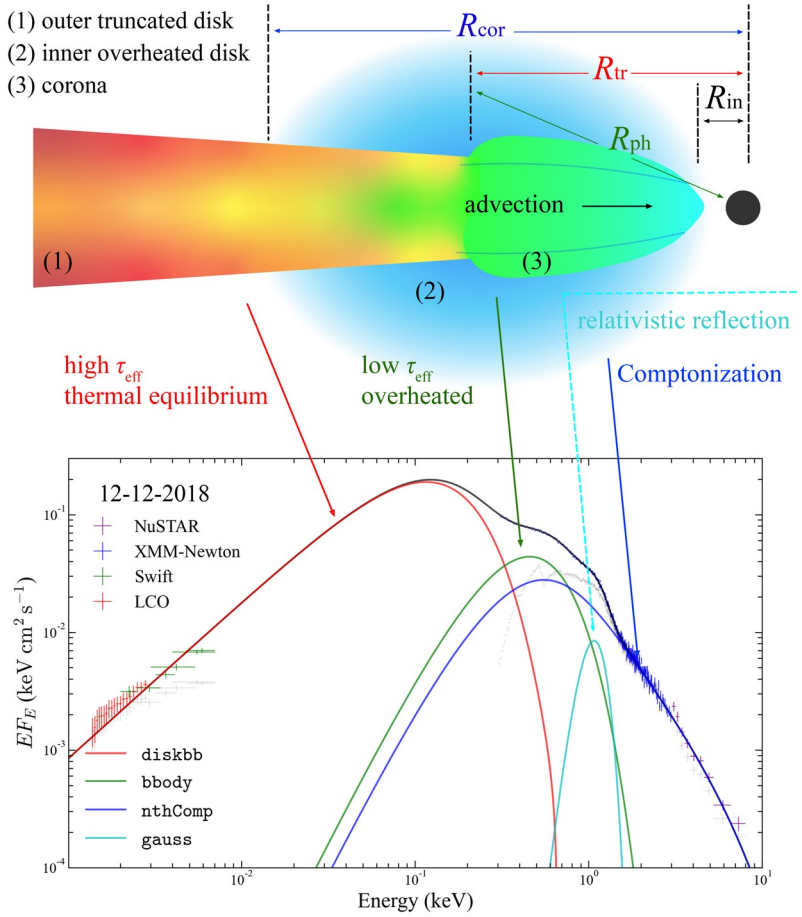
ORIGIN

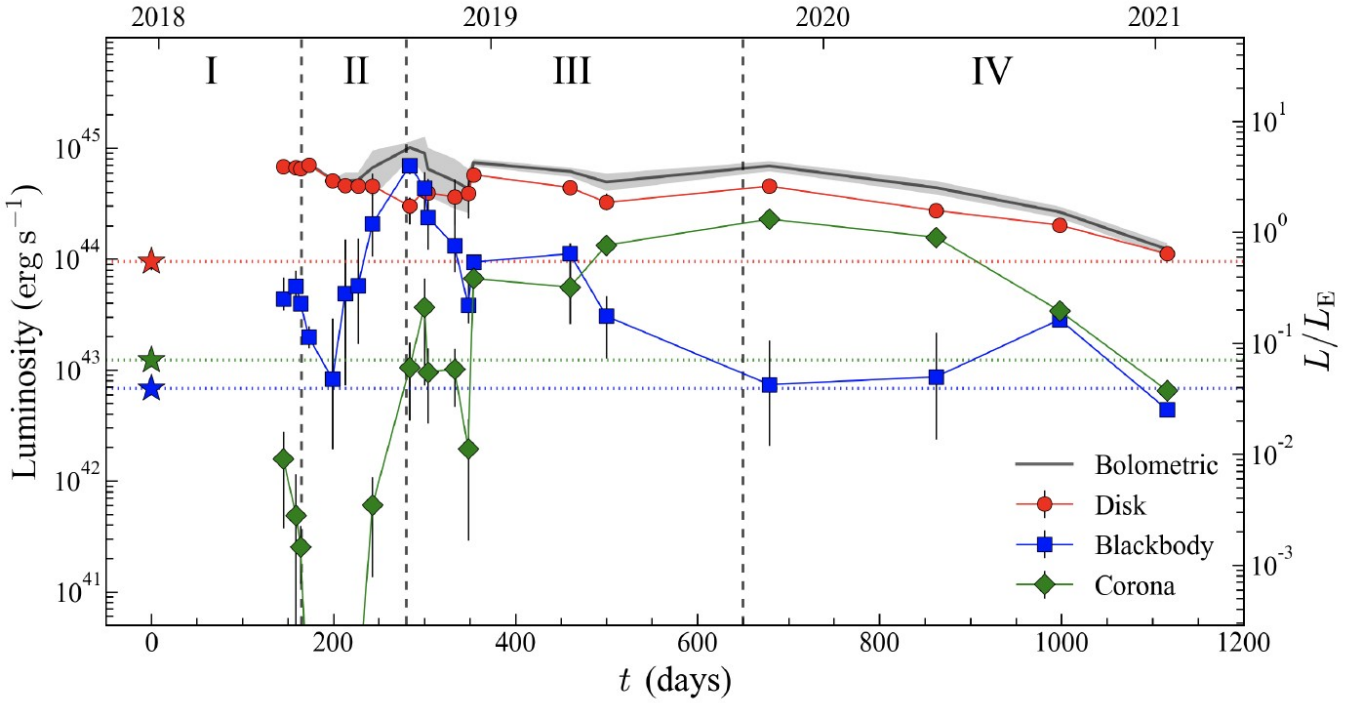
- Broad emission lines are produced by a newly formed BLR
- BLR is not virialized, the black hole mass is about solar mass
- Orbit of the cloud is eccentric
- Triggered by TDE, very likely



Guillochon + 2014, Li + 2022

THE BROAD-BAND SED





- 3-component SED, different light curve
  Li + 2024a

ACCRETION RATE

$$Q_{\rm vis}^{+}=\frac{3GM_{\rm BH}\dot{M}}{4\pi R^3}\left(1-\sqrt{\frac{R_{\rm in}}{R}}\right)$$

$$Q_{\rm adv}^{-}=\frac{\xi}{2\pi}\frac{\Pi\dot{M}}{\Sigma R^2},$$

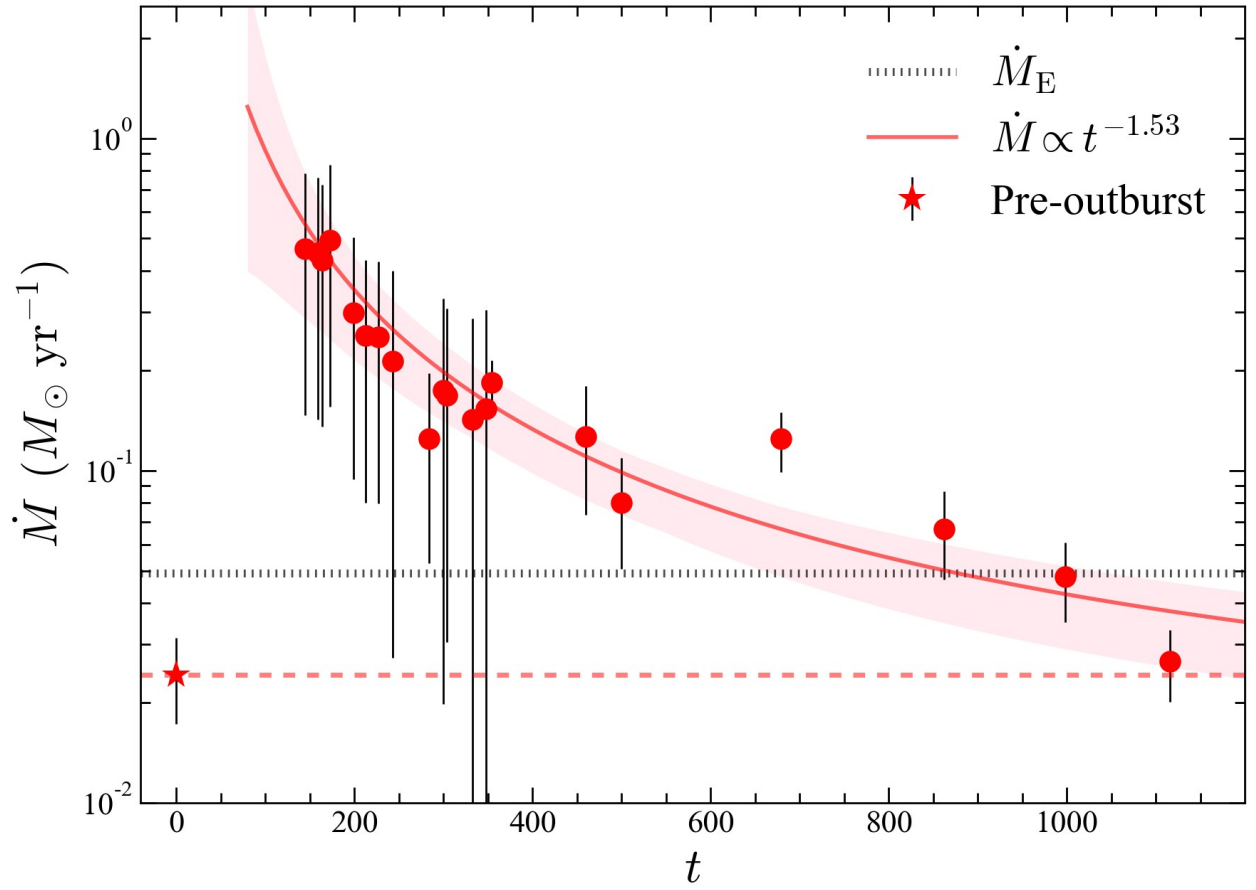
$$-2\pi R\Sigma v_R=\dot{M},$$

$$\Pi=\frac{k_{\rm B}I_4}{\bar{\mu}m_{\rm H}I_3}\Sigma T_c+\frac{2a}{3}I_4T_c^4H,$$

$$\dot{M}(\sqrt{GMR}-\sqrt{GMR_{\rm in}})=2\pi\alpha\Pi R^2.$$

$$\Omega_{\rm K}^2H^2=9\frac{\Pi}{\Sigma},$$

$$Q_{\rm rad}^{-}=\frac{8acT_c^4}{3\kappa_{\rm R}\Sigma},$$



Super-Eddington Accretion

$$\dot{M}=\dot{M}_{\rm p}\left(\frac{t-t_0}{t_p-t_0}\right)^{-\gamma}+\dot{M}_0$$

$$\gamma=1.53\pm0.10$$

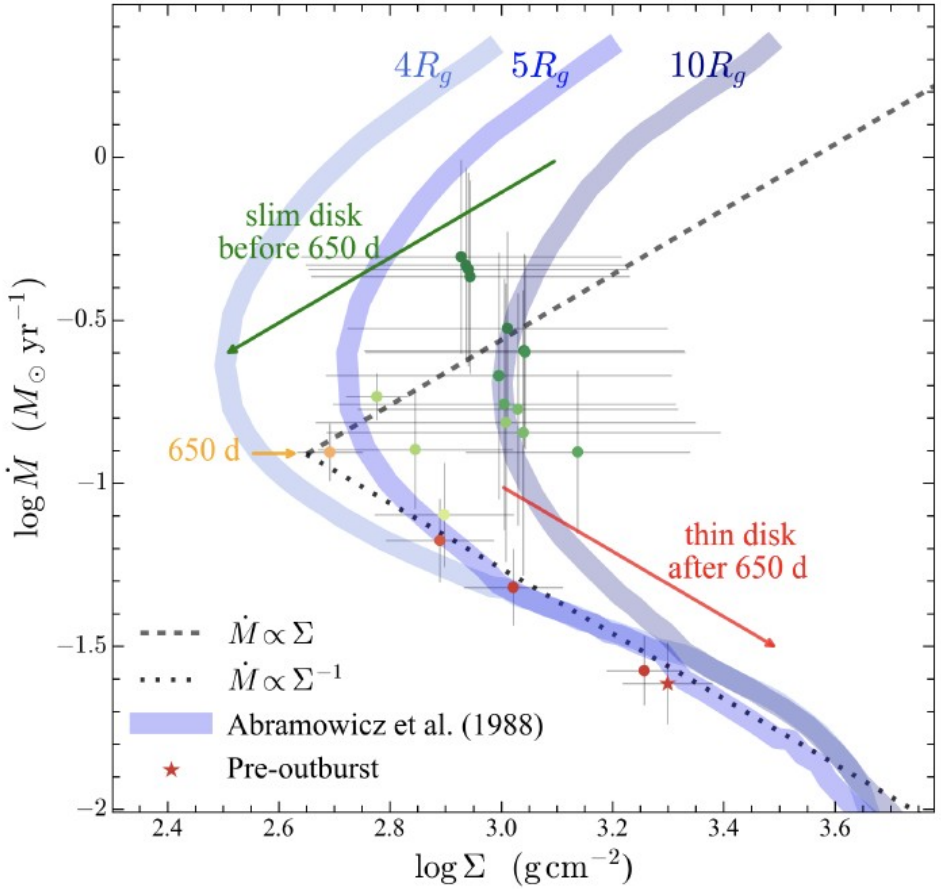
0.55 accreted mass

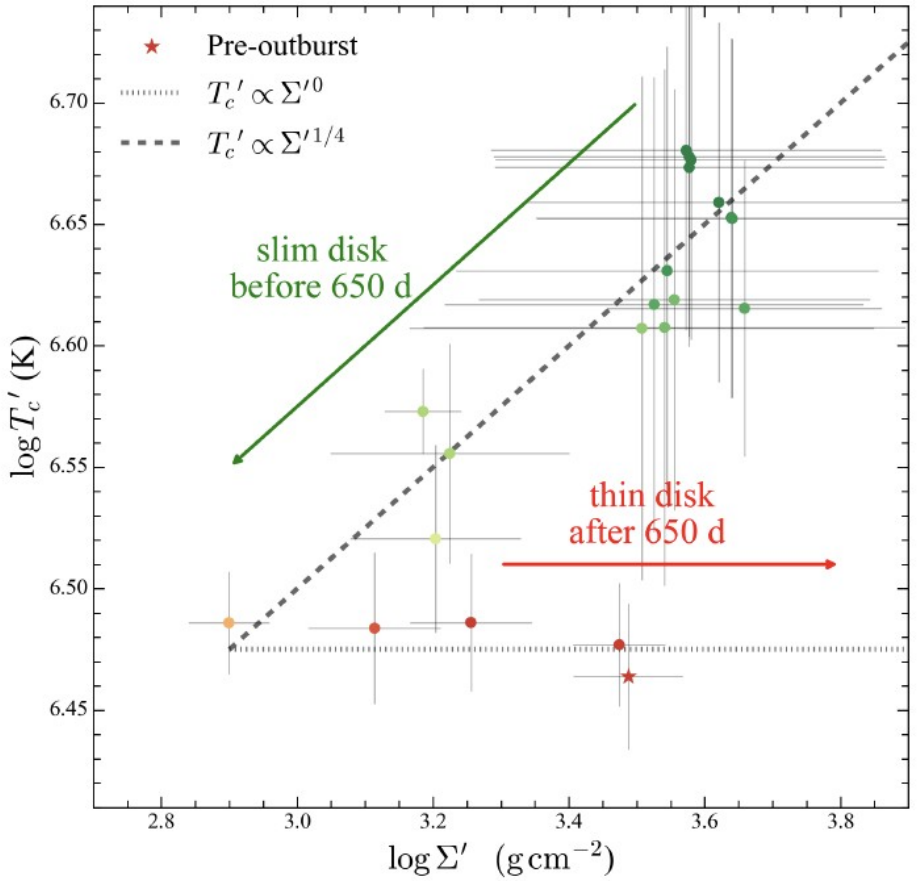
Support TDE picture

$$a_{\rm mb}\simeq\left(\frac{M_{\rm BH}}{M_*}\right)^{2/3}R_*\simeq\left(\frac{R_*}{R_\odot}\right)\times1984\,R_g$$

Li + 2024b

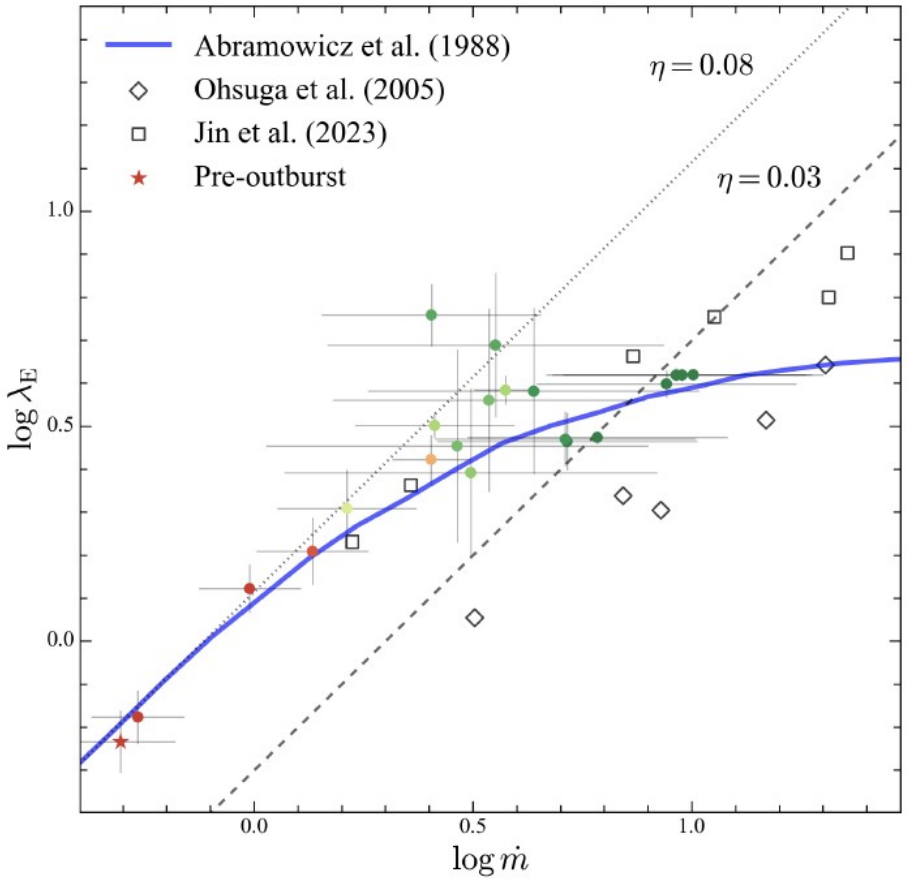
THE TRANSIENT SLIM DISK





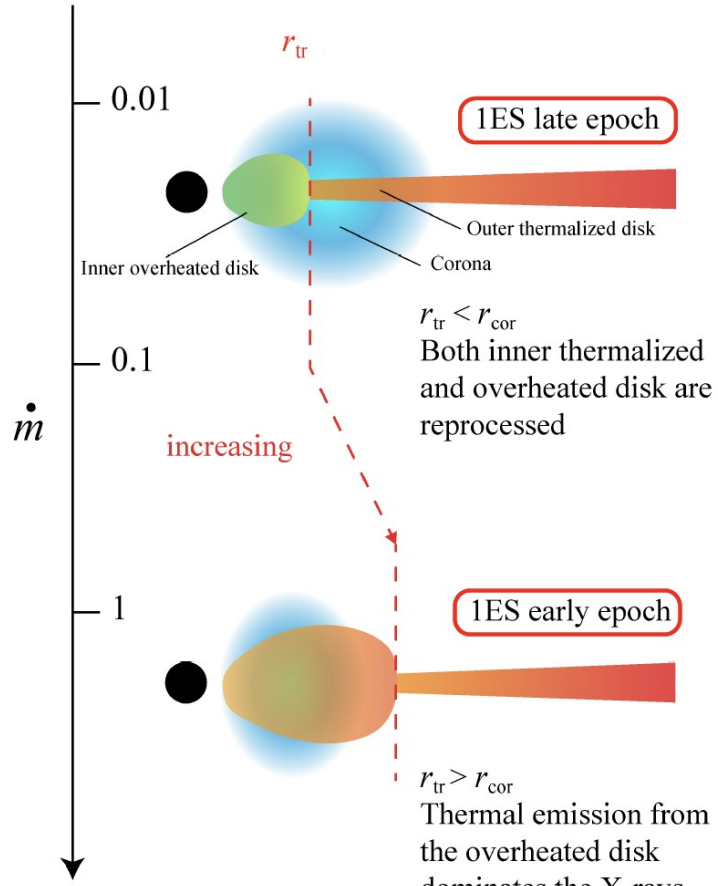
WHAT’S THE PROPERTIES?

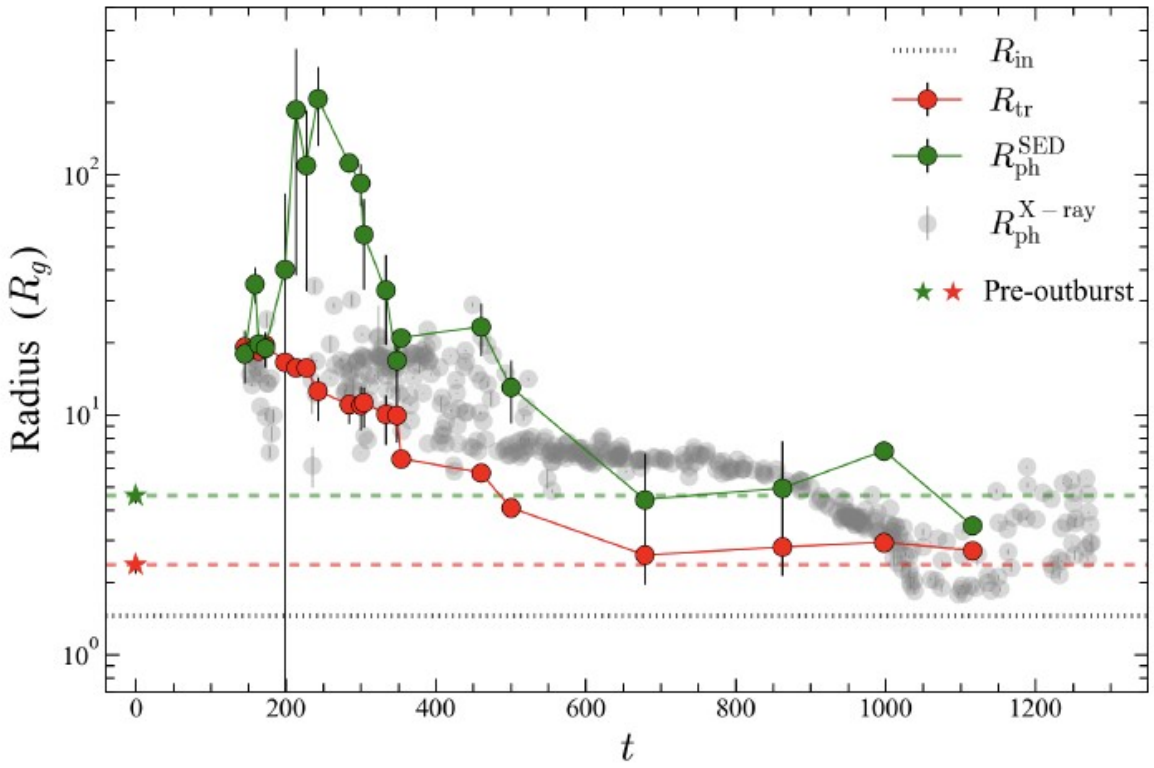
1. LOWER RADIATION EFFICICENCY



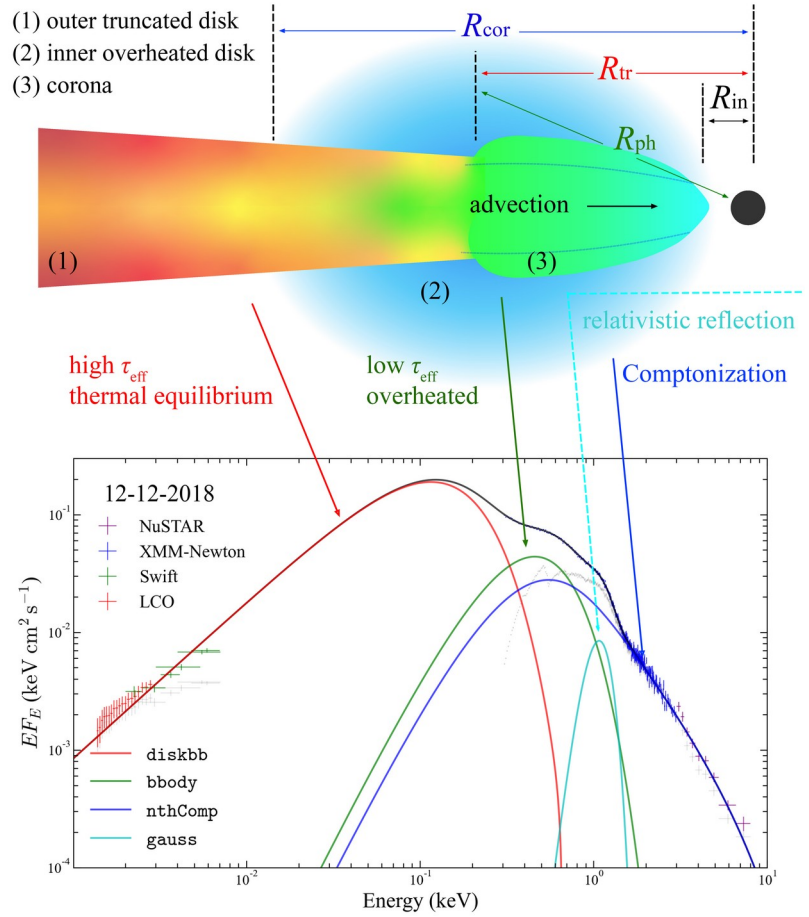
- A lower efficiency
- Close to theoretical predication, as well as RHD simulation and NLS1s

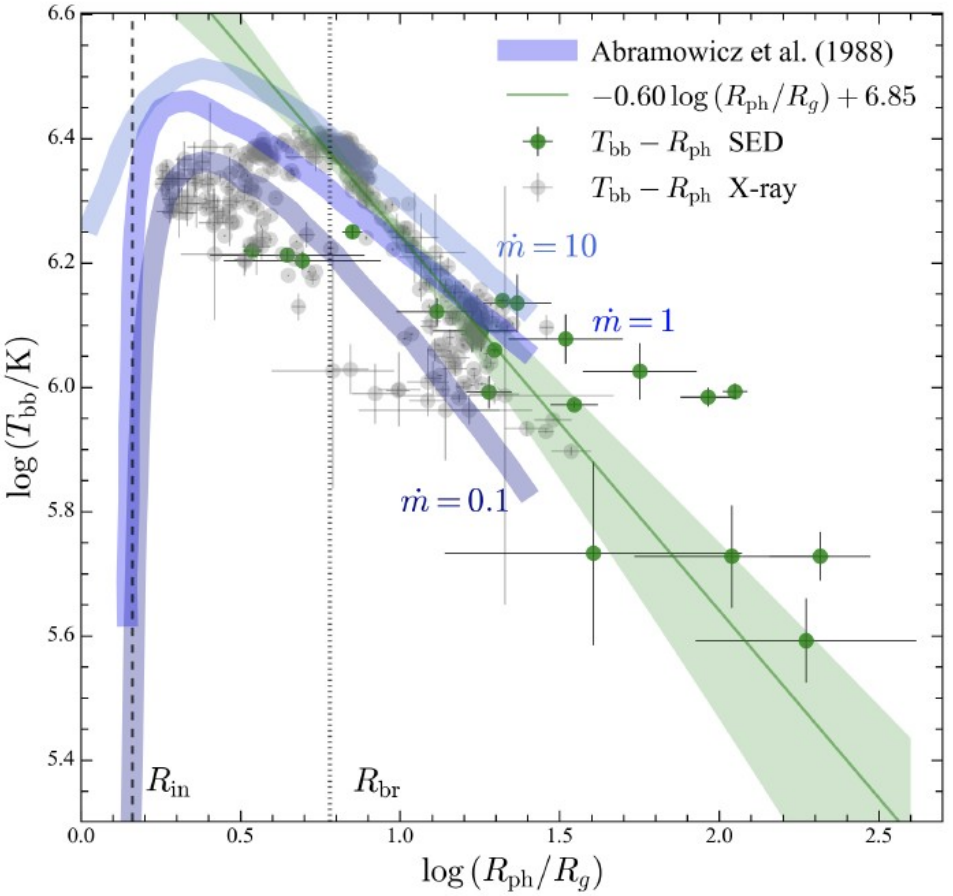
2. SIZE DEPENDS ON ACCRETION RATE



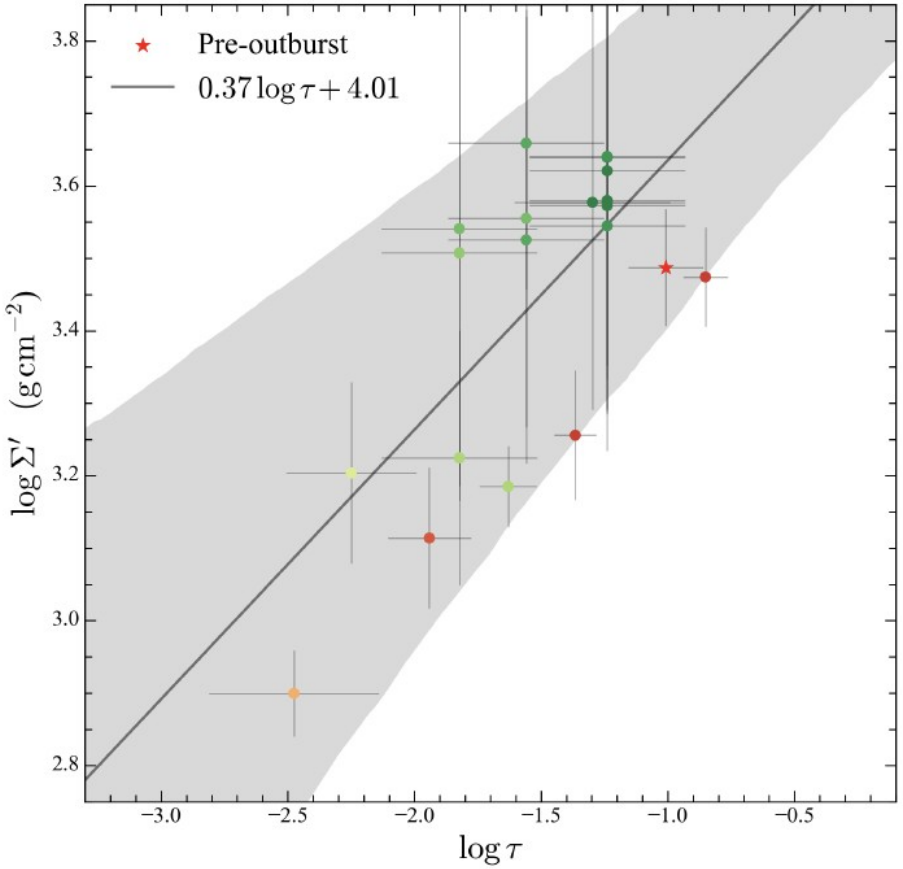


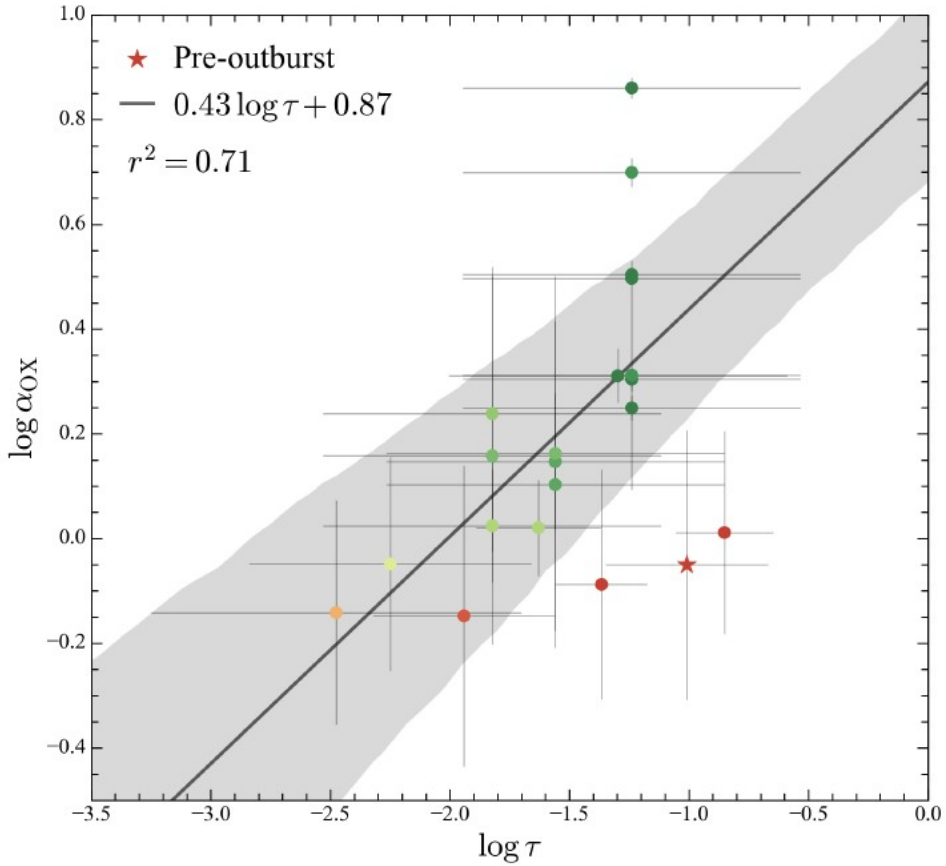
3. SOFT X-RAY EMISSION





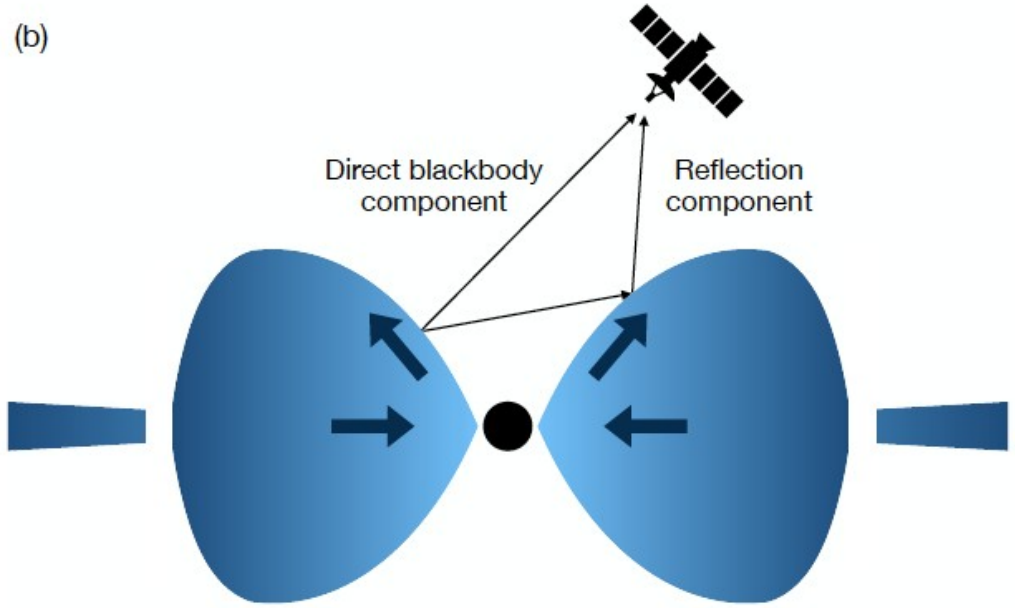
4. CONNECTED WITH CORONA

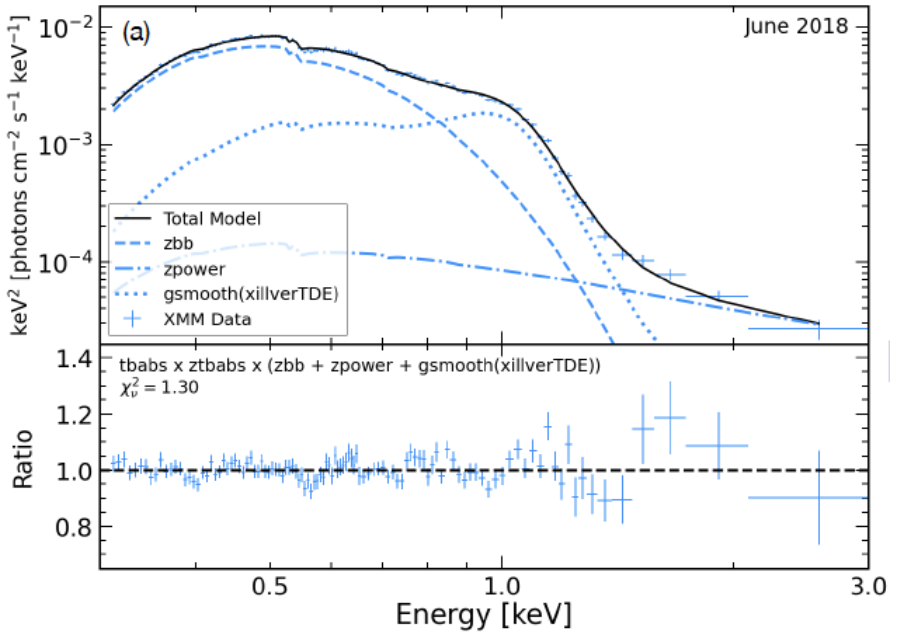




- Slim disk and thin disk phases share a same disk-corona connection Li + 2024a

5. WITH OUTFLOW





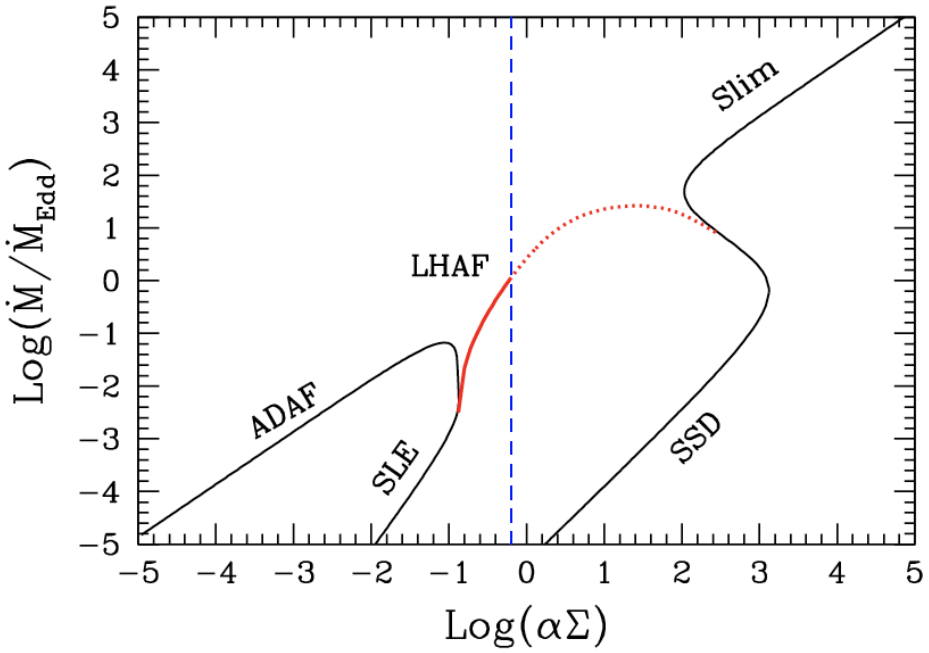
- Reflection between the hot slim disk
- Primary emission is black body

- 1ES 1927+654
- Produce a 1 keV feature

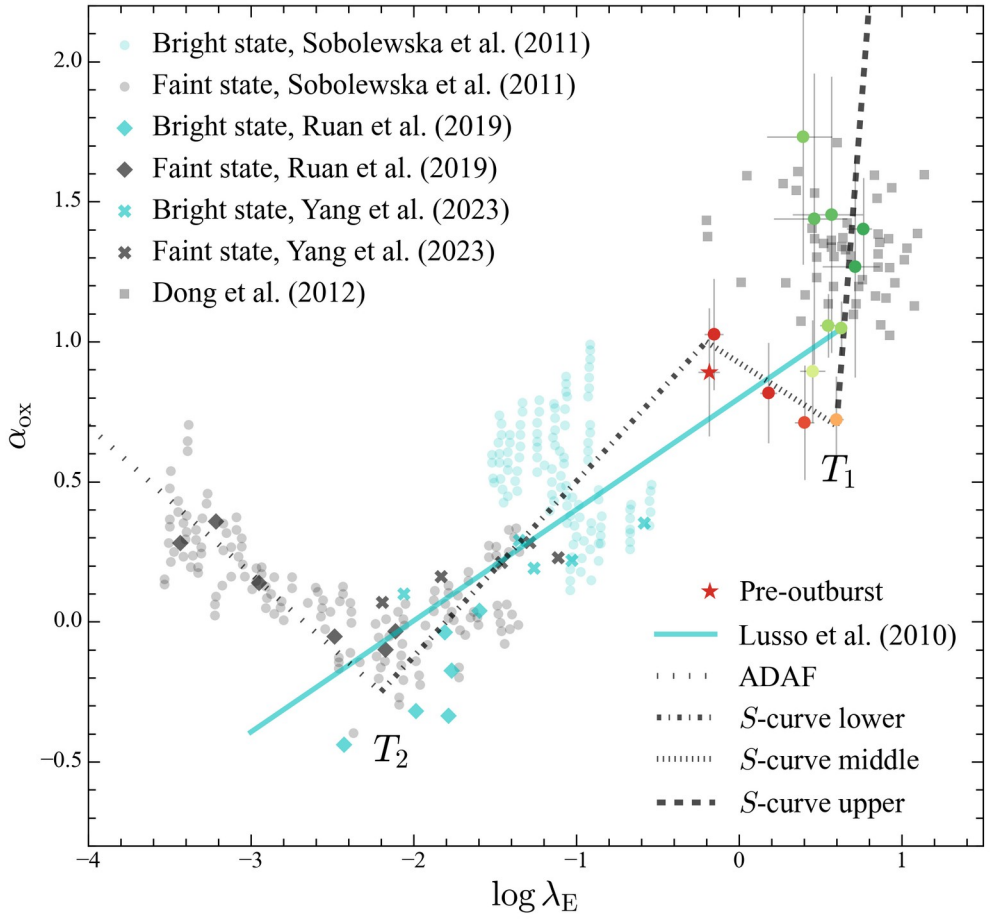
Masterson + 2022

INPLICATIONS

ACCRETION DISK STATE

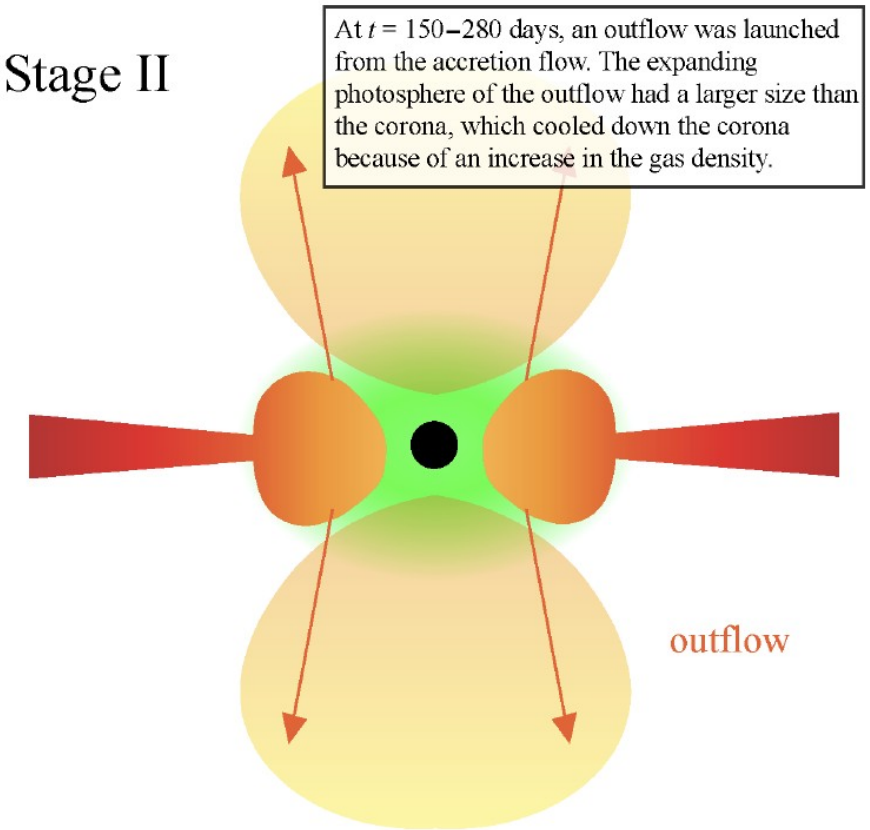


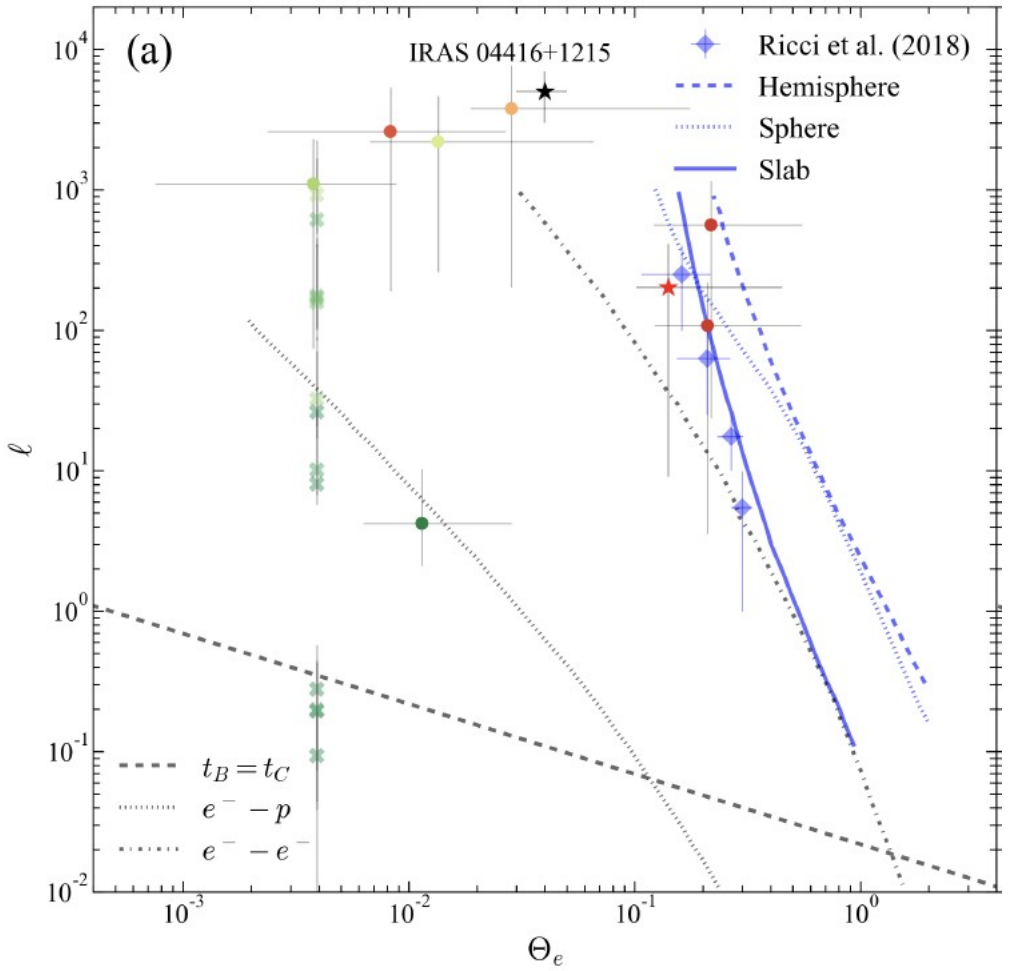
Yuan & Narayan 2014



Li + 2024a

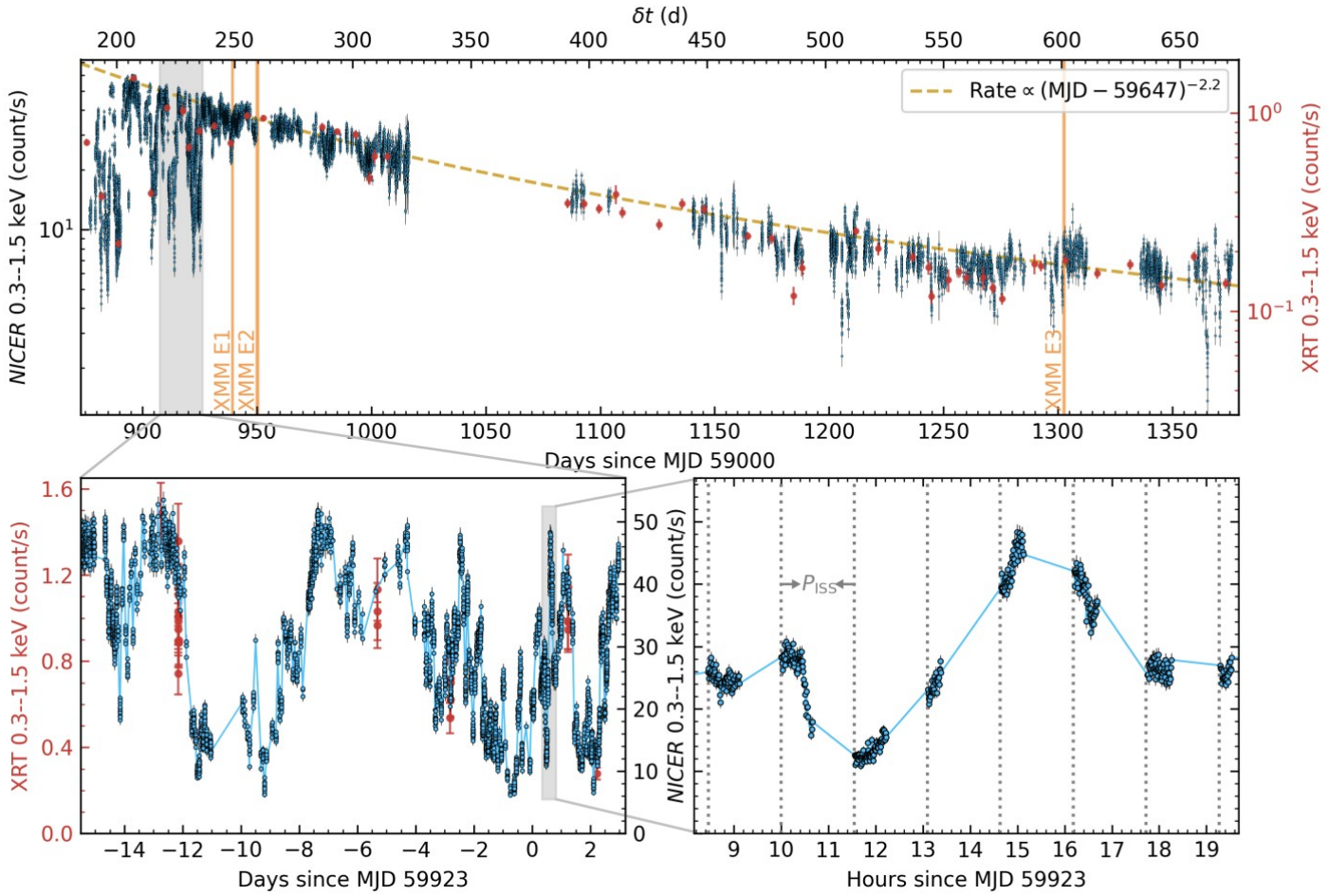
COOL THE CORONA



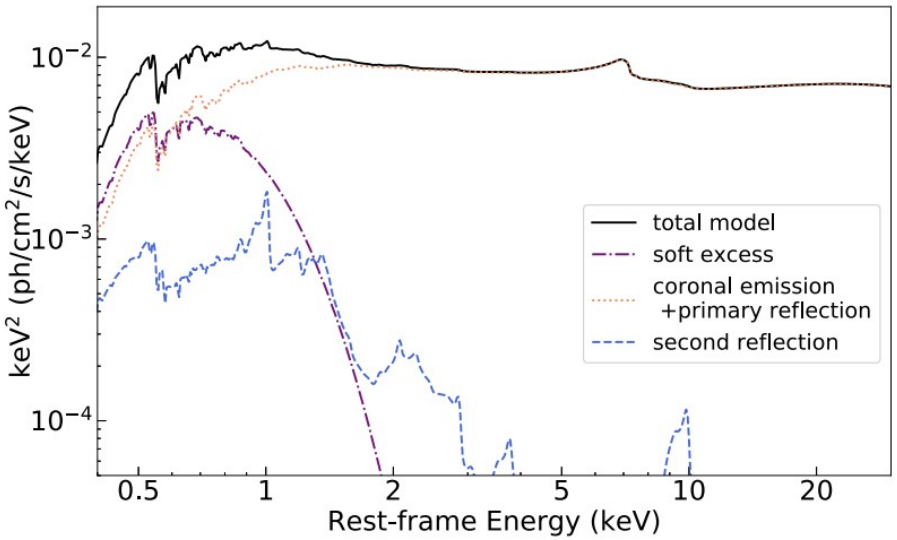


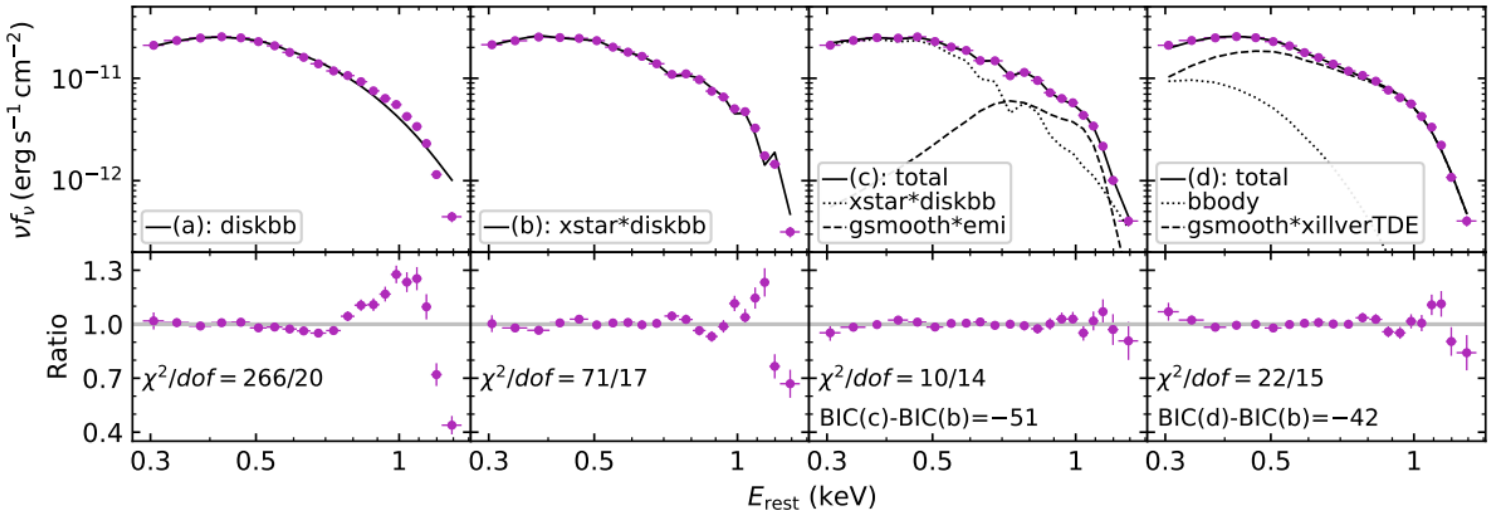
AT2022LRI

- AT2022lri is a TDE with black hole mass is about solar mass
- Variability in 0.5 hr–1 d with amplitude of ≈ 2–8
- X-ray dips are correlated with drops in the inner disk temperature
- Yao + 2024



REFLECTION





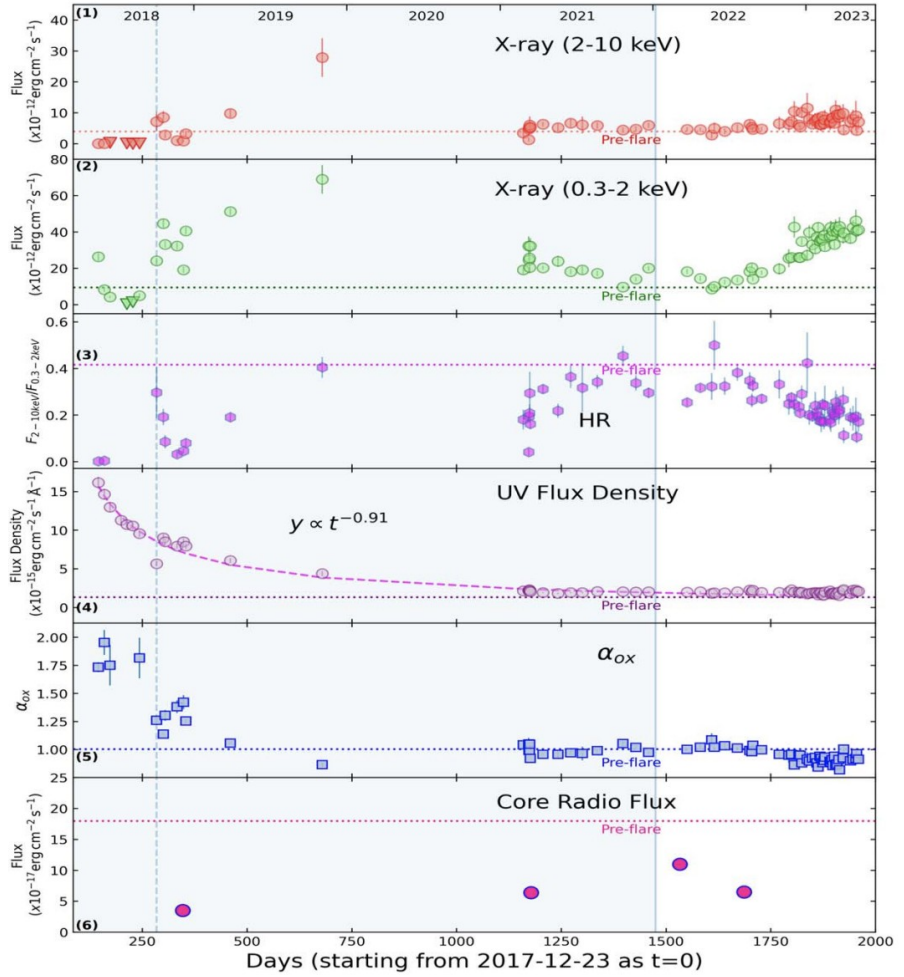
NLS1 1H 1934-063 Xu + 2022

TDE AT2022lri Yao + 2024

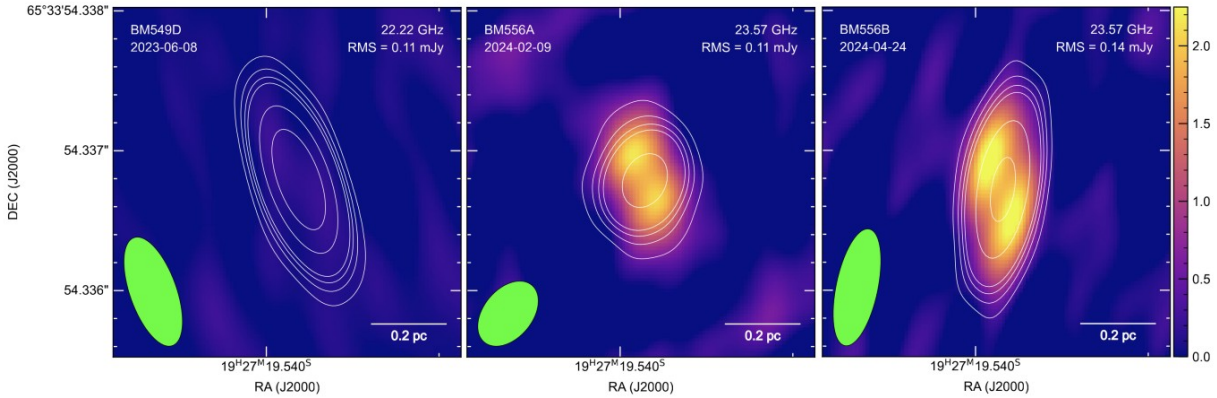
WHAT'S MORE?

SOFT X-RAY REEMERGING

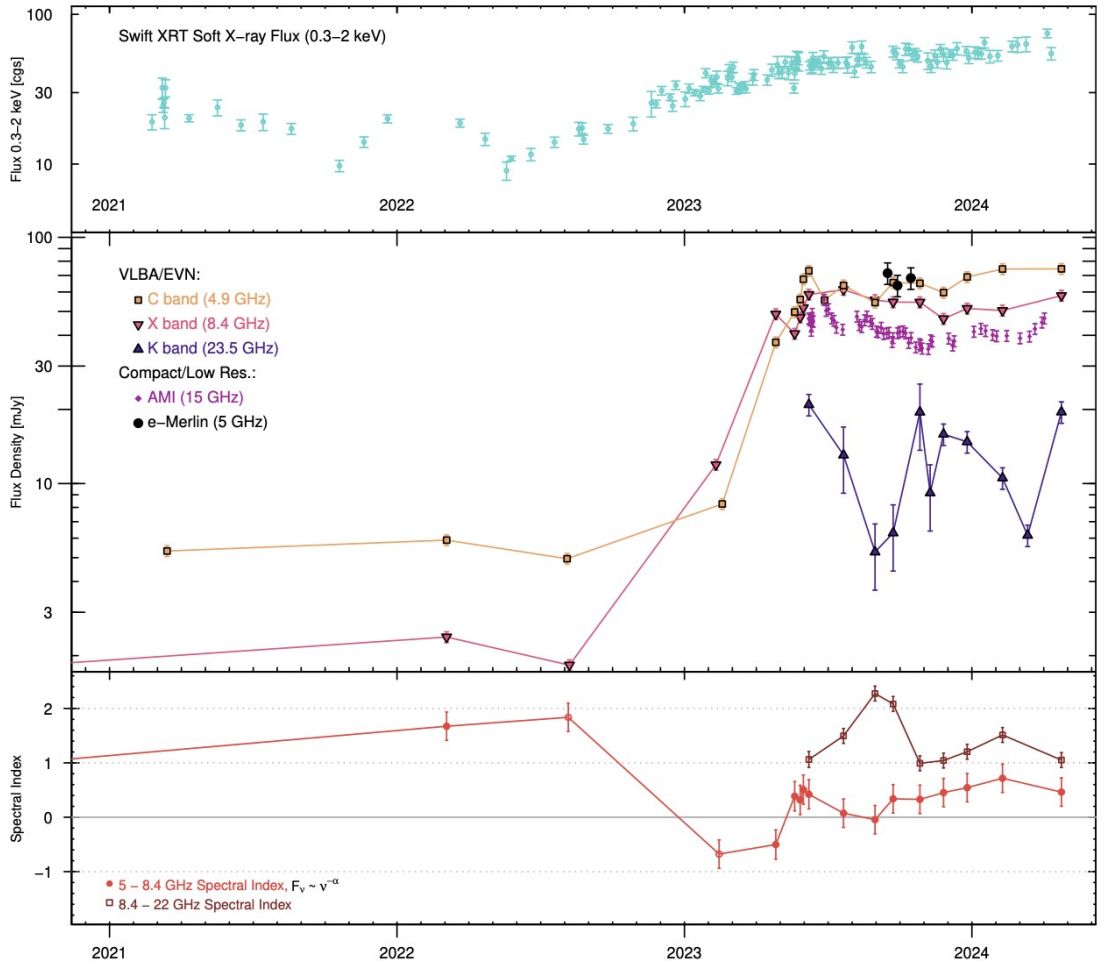
- Soft X-ray flux of 1ES is reemerging in 2023
- For UV/hard X-ray, the flux increase is not significant
- Rebrightening like other TDE? (AT2019ehz)
- Ghosh + 2023



EMERGENCE OF A RADIO JET



- In radio, reaching a peak 60 times previous flux levels
- VLBA observations show resolved extensions on either side of the core, consistent with a new and mildly relativistic bipolar outflow
- Meyer + 2023



SUMMARY

- 1. Multi-band observations caught the post-outburst evolution of CLAGN 1ES 1927+654. SED evolution prefer the TDE explanation.
- 2. The BLR clouds was undergoing dynamical evolution, following a eccentric orbit and varying density. The newly formed BLR was not virialized, overestimating M_{BH}
- 3. The black hole was accreting super-critically, with $t^{-5/3}$ declining mass accretion rate, where about 0.55 been accreted
- 4. The energy distribution shows a clear 2-branch evolution, indicating the existence of a transient slim accretion disk
- 5. The X-ray disappearance at ~ 200 days can be explanied by a optically thick outflow launched above the slim disk, overcooling the corona & producing reflection feature. The similarity is shared for other super-Eddington sources, and further observations.