Insights into X-ray-Selected AGN Transient accretion events from eROSITA's All-Sky Surveys: Followups on selected individual events

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(image credit: MPE/DLR)

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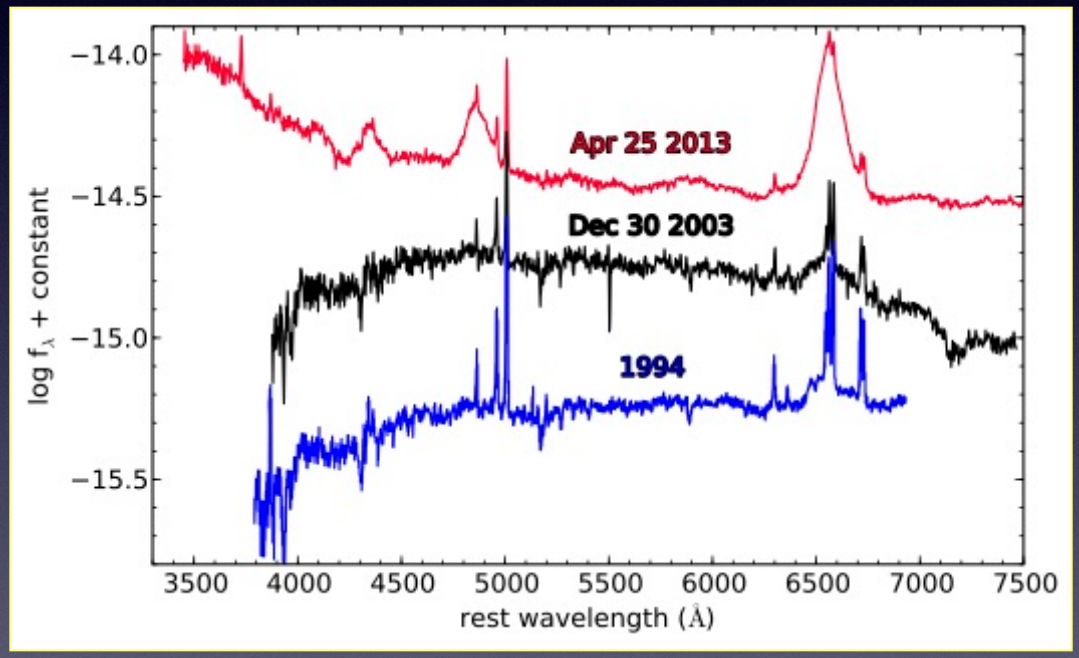
AND OTHERS

“Extreme-variability” accretion events

-Changing-State/Changing-(optical) look Seyferts (Shappee+14, LaMassa+15, MANY MORE!!!)

Driven by major changes in L_{Bol}/L_{Edd}

Probes accretion structure as a function of L_{Bol}/L_{Edd} (thin, ADAF, puffy disks)



Shappee+ (2014)

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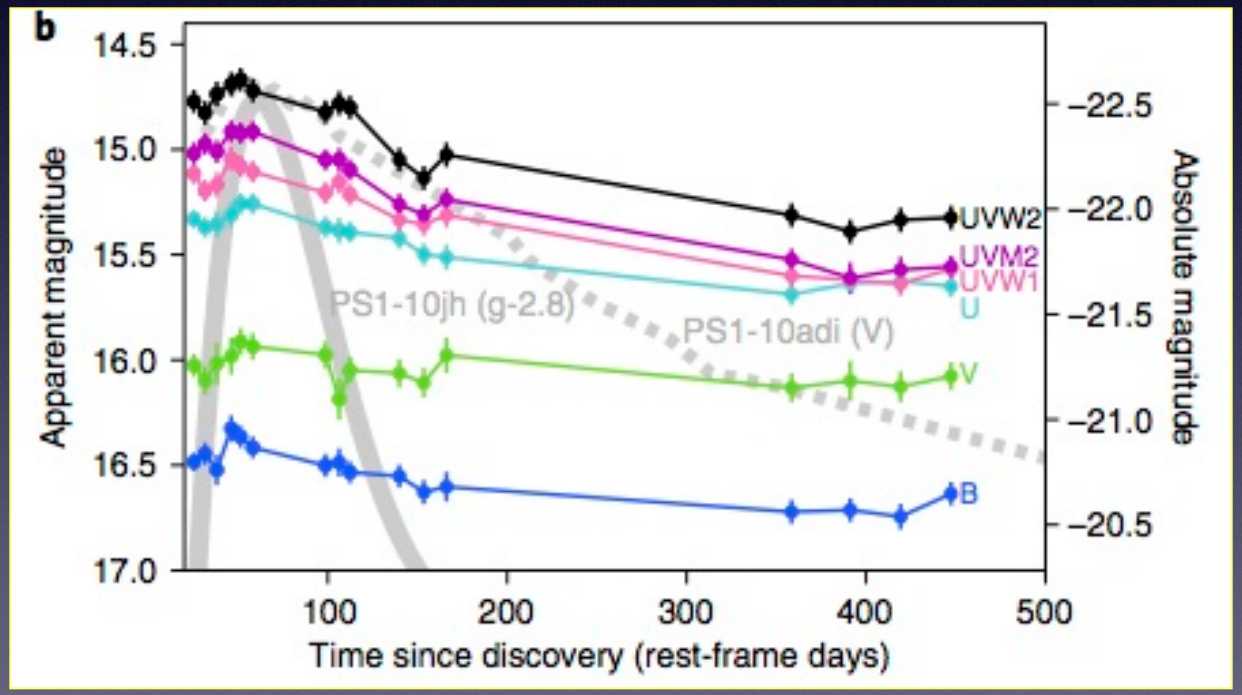

(Trakhtenbrot+ 2019a)

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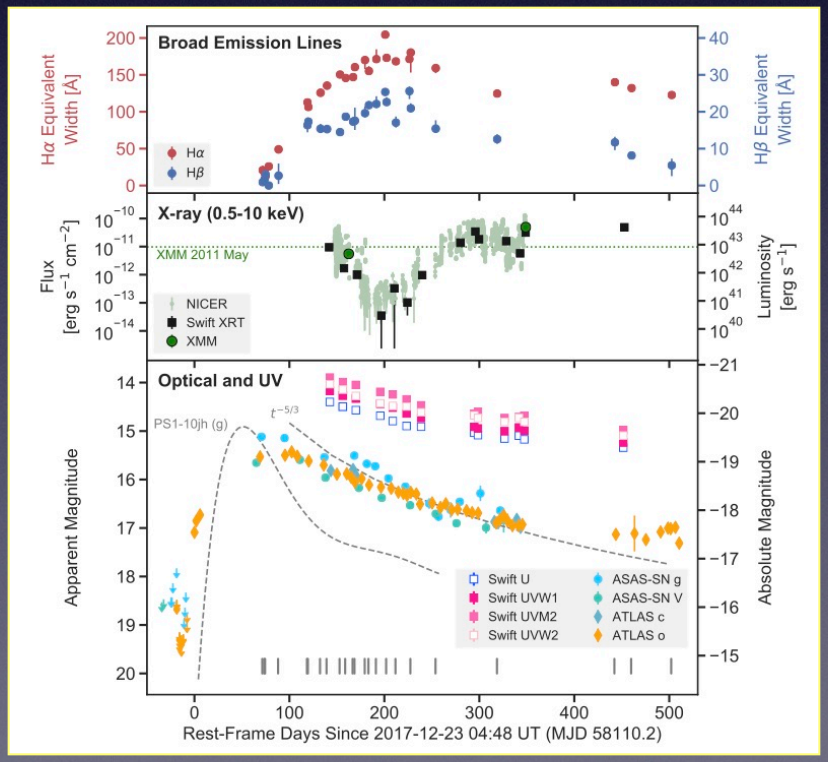
-TDEs in already-active galaxies

Observational properties of both TDEs and AGN/quasars

1ES1927+654 (Trakhtenbrot+ 2019b; Ricci+2020); Neustadt+ (2020), Frederick+ (2021)



(Trakhtenbrot+ 2019b)

Open questions….

How do the various emission components (disk, BLR, X-ray corona, soft X-ray excess) interact with each other, and respond during major changes in L_{Bol}/L_{Edd}?

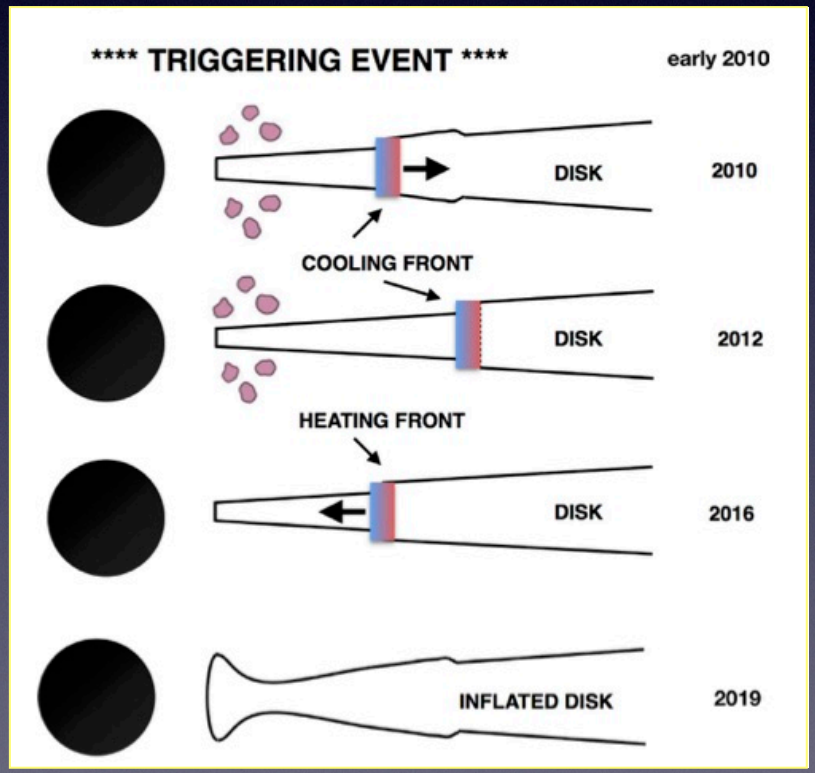
Which mechanisms are at work?

Disk instability, e.g., radiation-pressure limit-cycle instability (Eardley & Lightman 1974, Saxton+ 2015, Śniegnowska+ 2022)?

Propagating hot/cold fronts in inner disk? (Ross+ 2018):

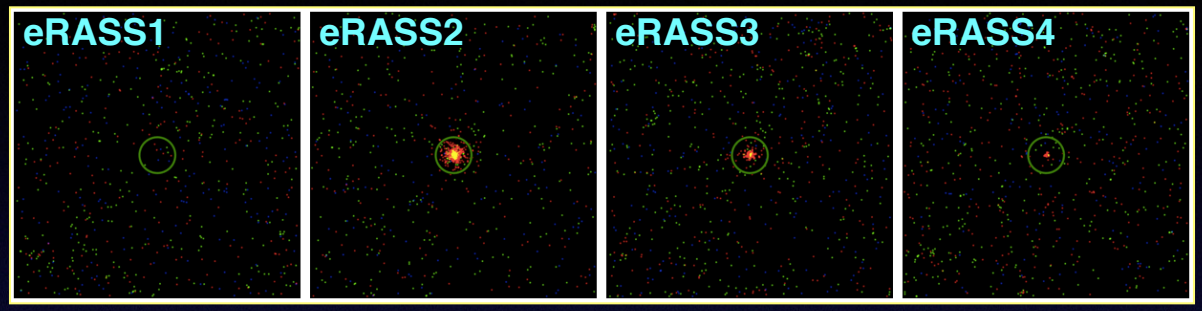
eROSITA: channel to detect *events as they are occurring* via major changes in X-ray flux between eRASS scans

Dedicated multi-λ followups for selected individual targets ⟶ **track response/ formation of flow components (corona, disk, BLR)**

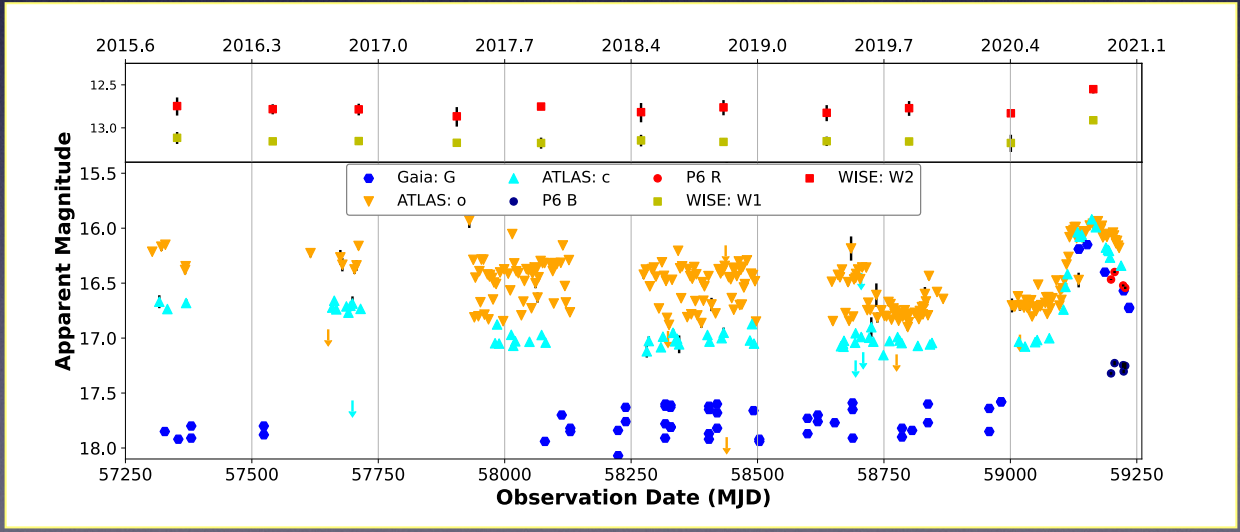


(Ross+ 2018)

1) Very luminous transient: TDE-in-an-AGN?
D. Homan+ (2023, A&A, 672, A167); A. Malyali+ (in prep.)



The most luminous extragalactic transient so far in eRASS; F(0.2-2 keV) ~ 1.8 $\times 10^{-11}$ erg cm^{-2} s^{-1}.
X-ray flaring coincides with optical brightening/plateau/decay detected with GAIA, late 2020.



(Homan+ 2023)

1) Very luminous transient: TDE-in-an-AGN?
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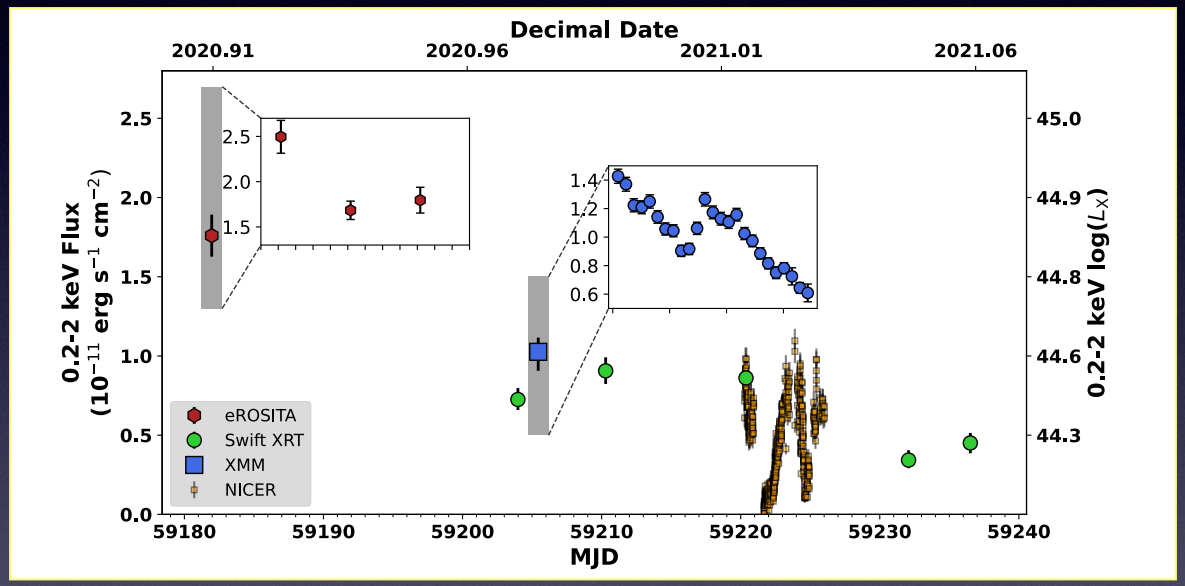
Characteristics of a TDE in X-rays:

Ultra-soft X-ray spectrum (Γ~5) ; rapid flux decay



(Homan+ 2023)

Characteristics of an AGN in optical:

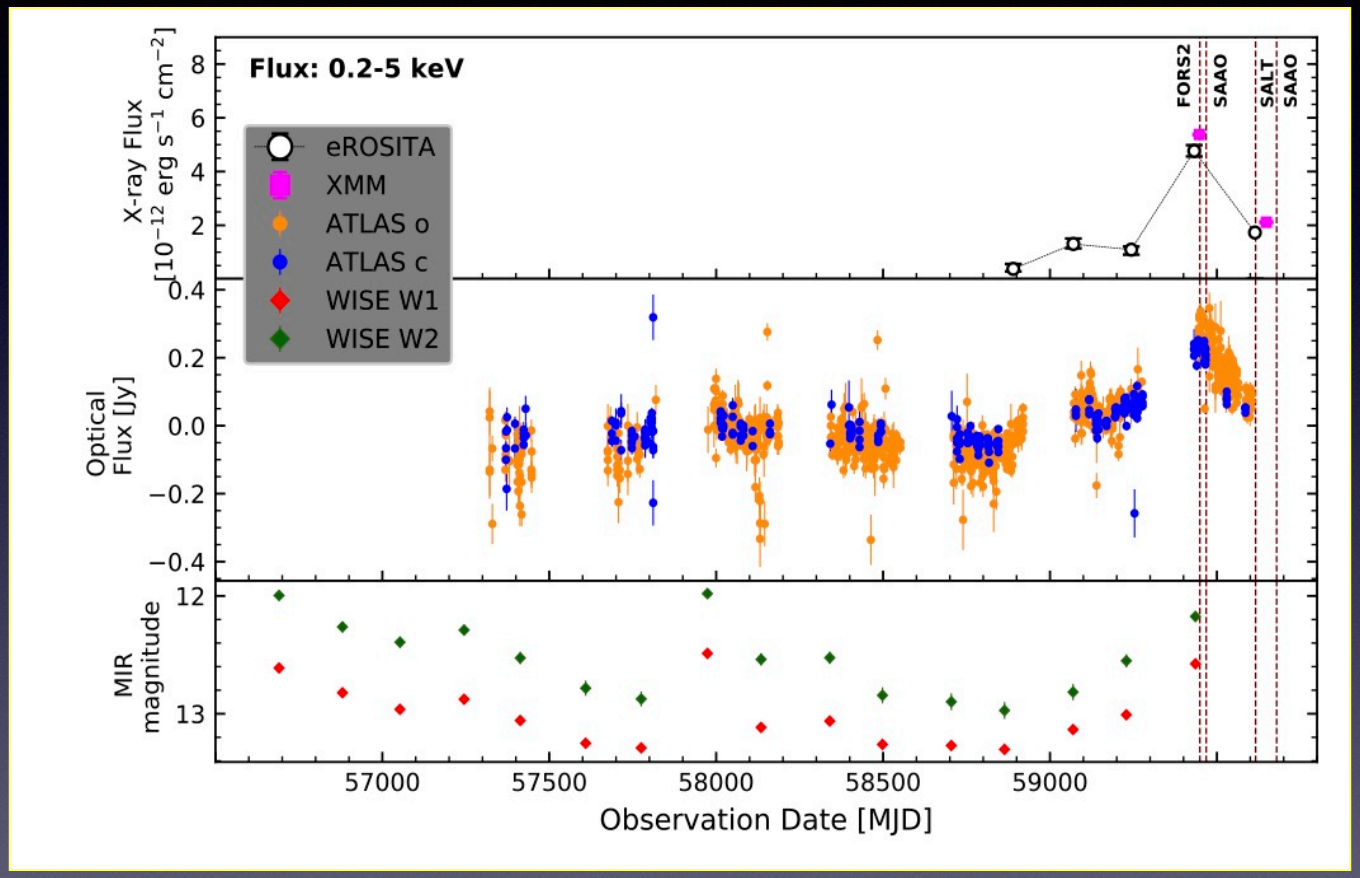
Broad Balmer lines

Strong [O III], [N II], [SII]: recent past AGN activity

TDE-like accretion in a low-luminosity AGN?

2) Comptonization-driven flaring event (S. Krishnan+, in prep.)

eRASS 3→4: F(0.2-5 keV) increased by 6
eRASS 4→5: F(0.2-5 keV) decreased by 3; UVM2 drops by 4

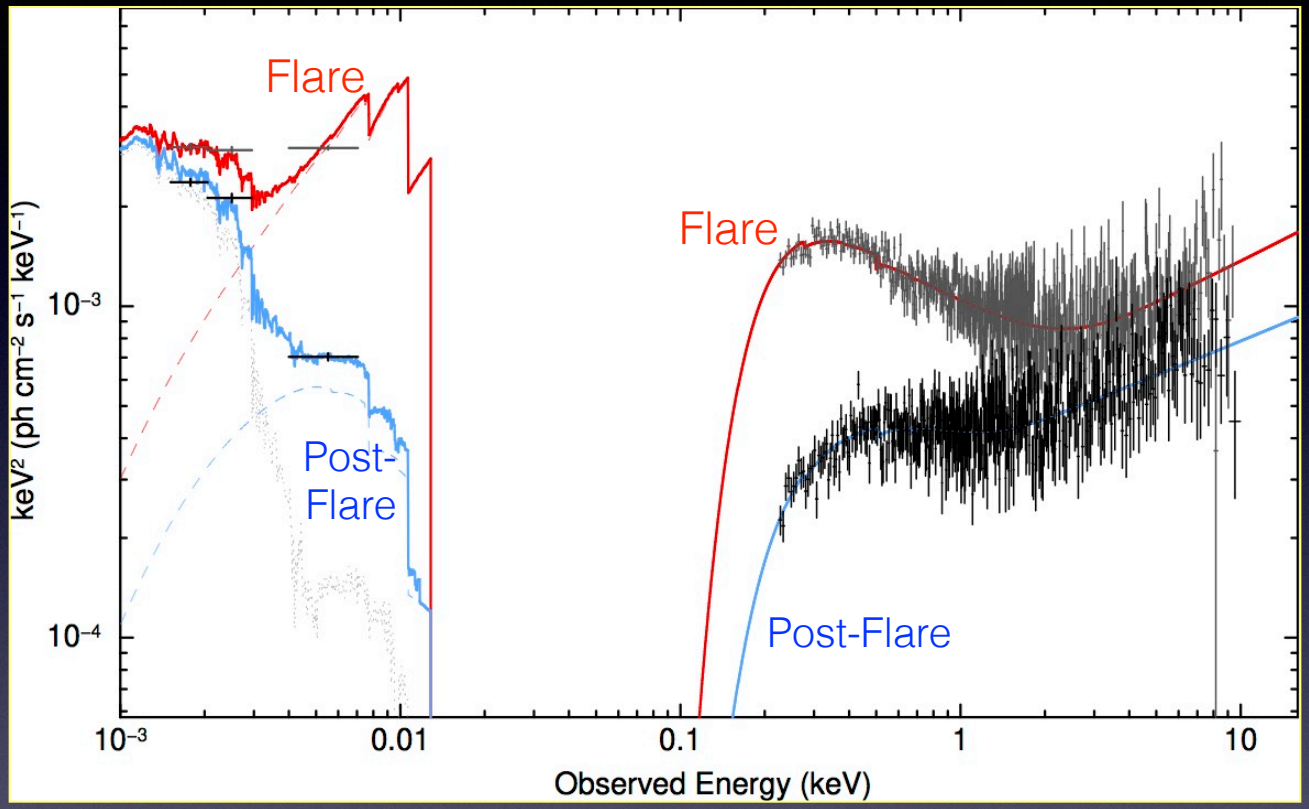


(Krishnan+, in prep.)

Flare in an already persistently-accreting Seyfert
Followups with XMM, NICER, optical spectroscopy (SAAO, SALT, VLT)

2) Comptonization-driven flaring event (S. Krishnan+, in prep.)

Opt/UV/X SED fits with “AGNSED” warm+hot Comptonization model:



(Krishnan+, in prep.)

L_{Bol}/L_{Edd} drops by ~4 :

Major spectral variability in soft X-ray warm-Comptonized component

Warm Comptonized corona: optical depth increases by ~1.5;

Geometric extent of coronae increase

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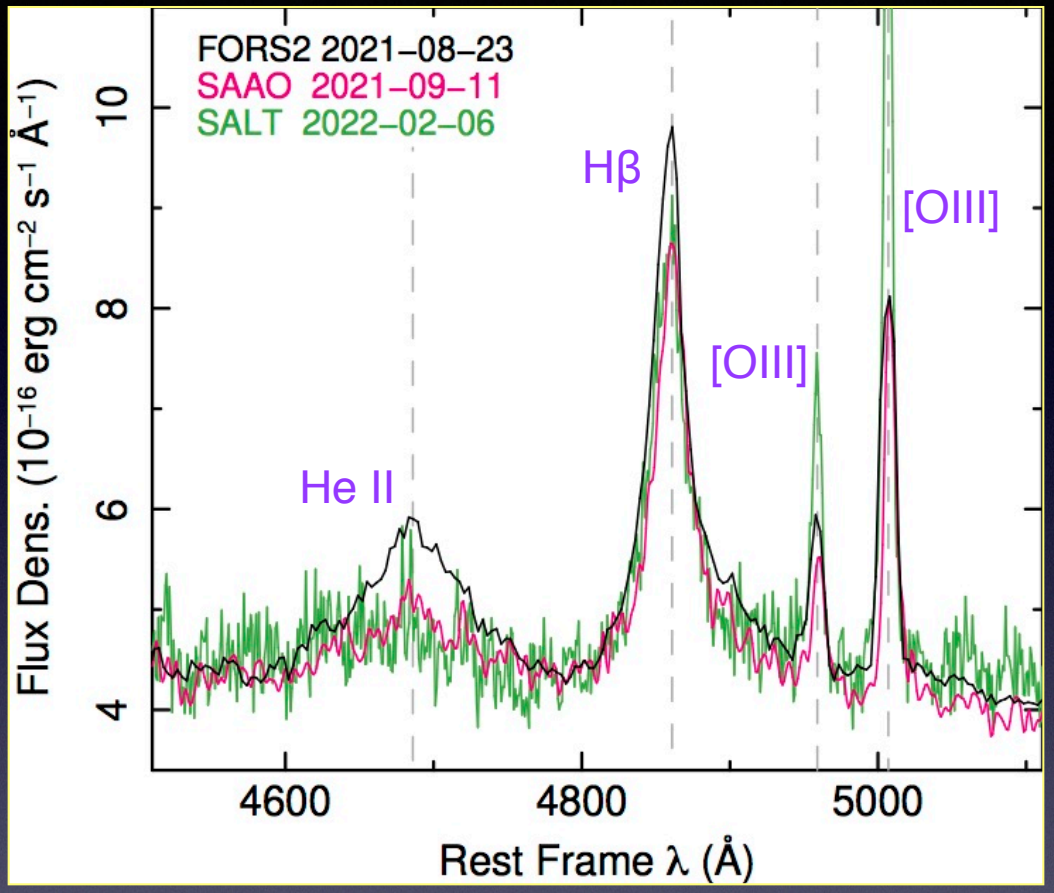

(Krishnan+, in prep.)

He II λ4686: originates at smaller radii than Balmer lines (stronger “responsivity”)

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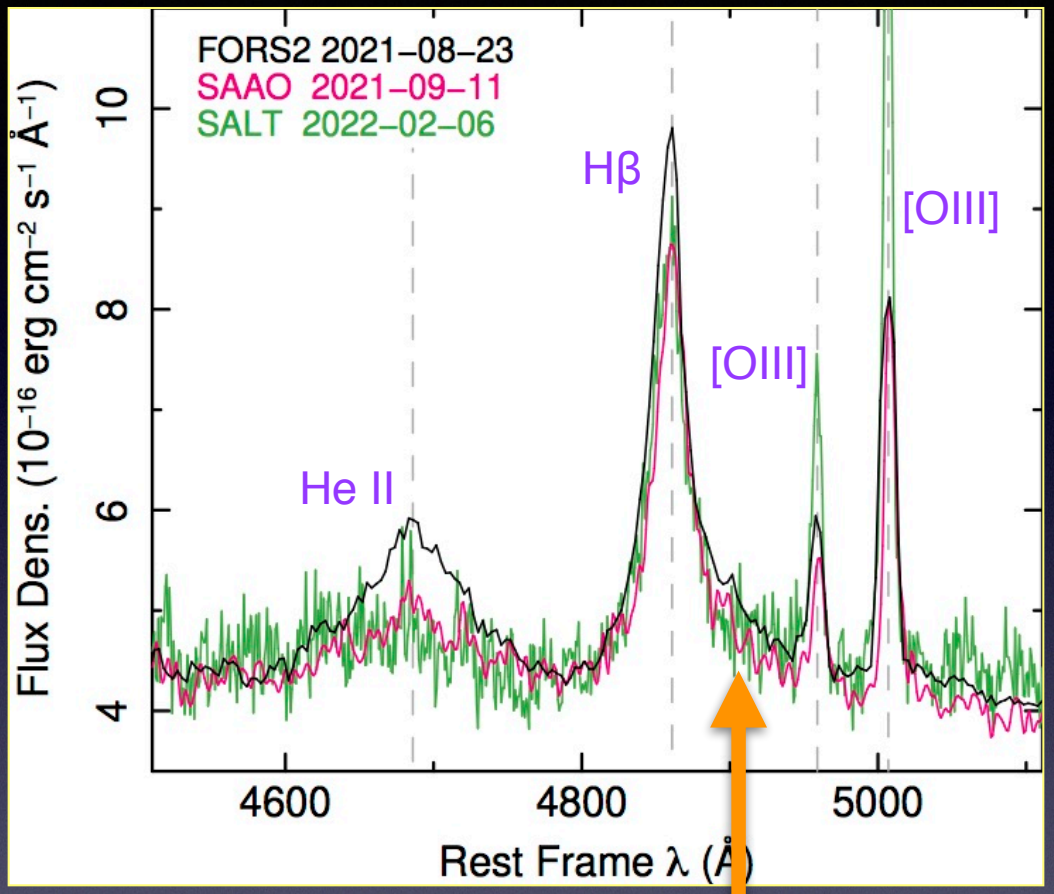
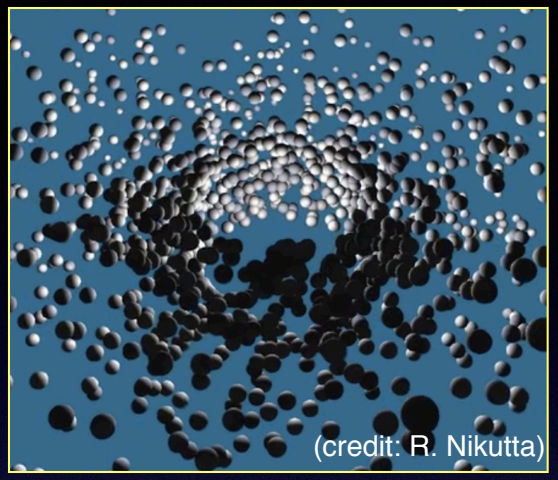


(Krishnan+, in prep.)

Transient Hβ red wing

He II λ4686: originates at smaller radii than Balmer lines (stronger “responsivity”)

Changing-Obscuration/ Changing X-ray-Look AGN


(credit: R. Nikutta)

Evolution of torus models from "smooth donut" to cloudy" (see review by Ricci & Trakhtenbrot 2022)

IR:

SED modeling of dust (Ramos Almeida+ 2011, 2014)
Emission/absorption distributions of 9.7 & 18 um Si features (e.g., Hatziminaoglou+ 2015)

X-rays:

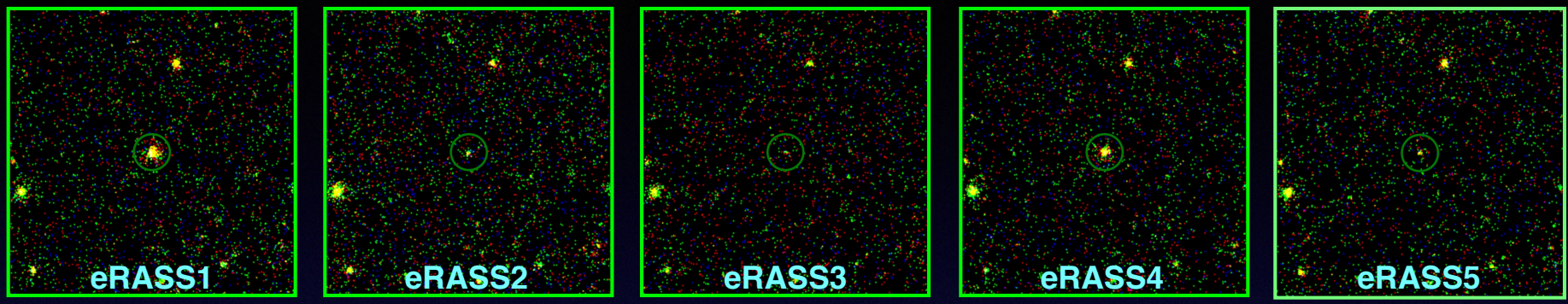
Major changes in soft X-ray flux associated with variable line-of-sight obscuration

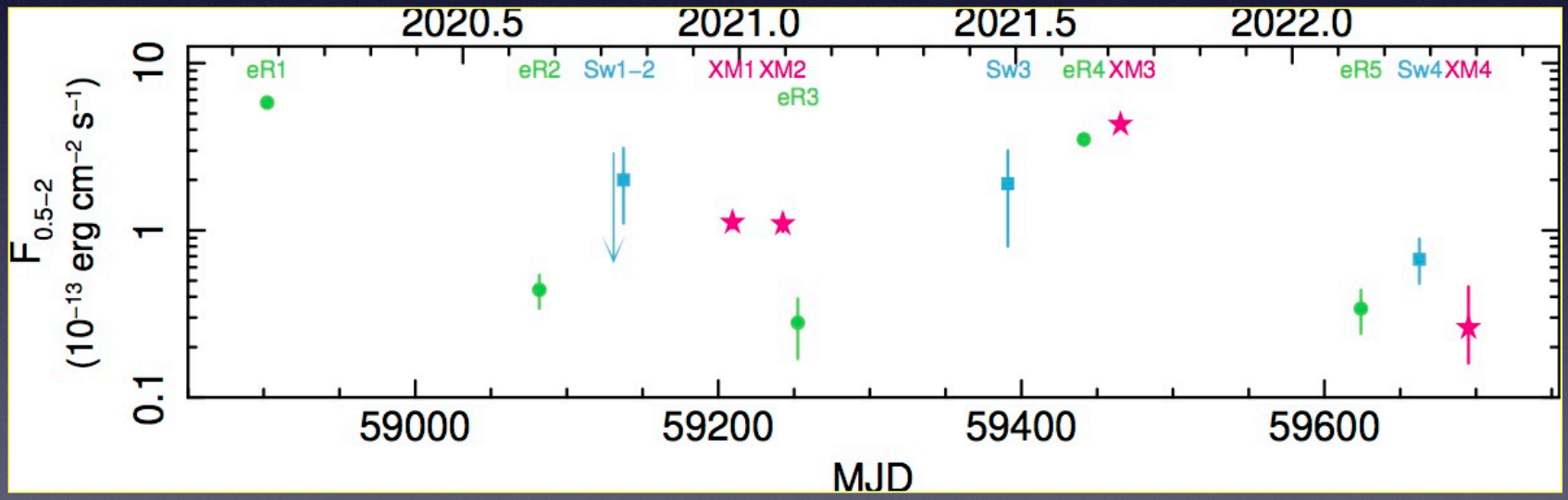
Column density N_H confirmed to vary on timescales from hours to years in a couple dozen Seyferts so far — both optical types 1 & 2
(Risaliti+ 2002, 2009, 2011; Markowitz+ 2014; Zaino+ 2020, A. Gonzalez's talk Monday; *many others!*…)

Unobscured ⟷ Compton-thin obscured ⟷ Compton-thick obscured

Xray var.: Probes connections between BLR & dusty torus structures (Elitzur+ 2007)

3) First AGN Cloud Occultation Events discovered with eROSITA: Markowitz+ (in prep.)





Soft X-ray variations by >10 on timescales of 6-12 months
Followups with XMM, Swift, B-band, SALT, VLT, SAAO

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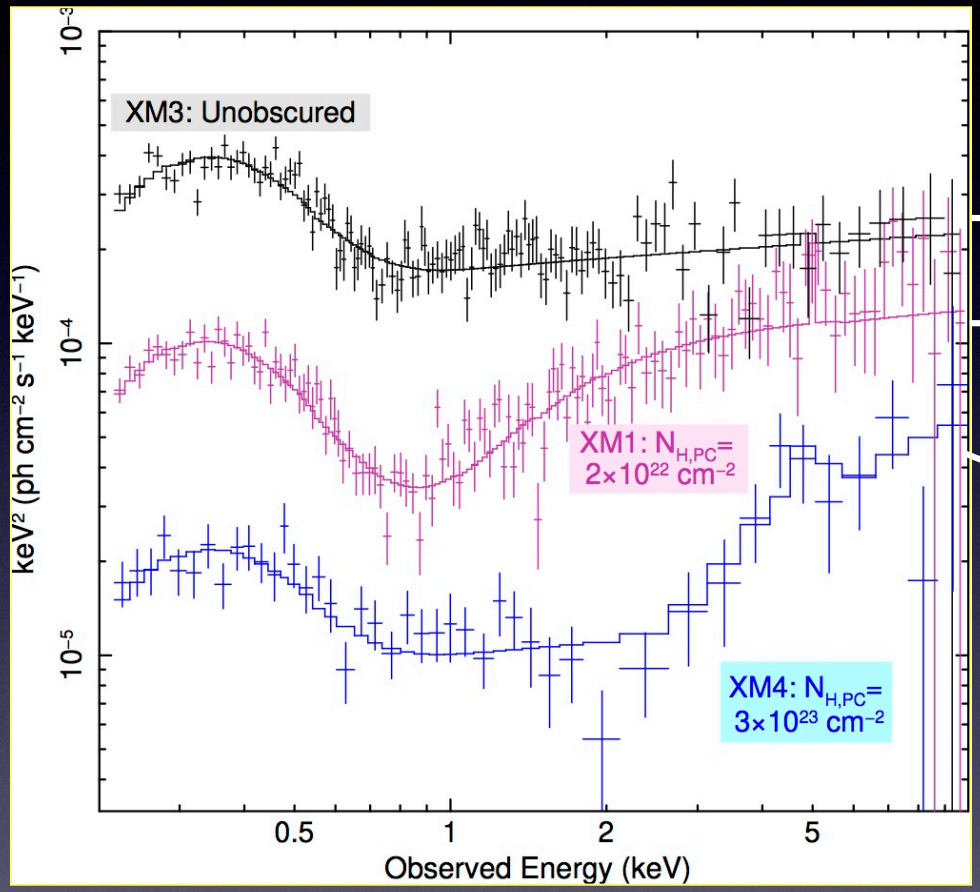


XMM follow-up spectra:

High state / eRASS4: Unobscured

1st dip / eRASS2-3: **Compton-thin partial-covering** obscuration

2nd dip/ eRASS5: **Moderately Compton-thick partial-covering obscuration**

1st occultation: N_H ~ 8e21 cm^{-2}, f_{cov} ~ 65%, 310 d < ΔT < 540 d
2nd occultation: N_H ~ 2e23 cm^{-2}, f_{cov} ~ 75%, ΔT > 410 d

3) First AGN Cloud Occultation Events discovered with eROSITA: Markowitz+ (in prep.)

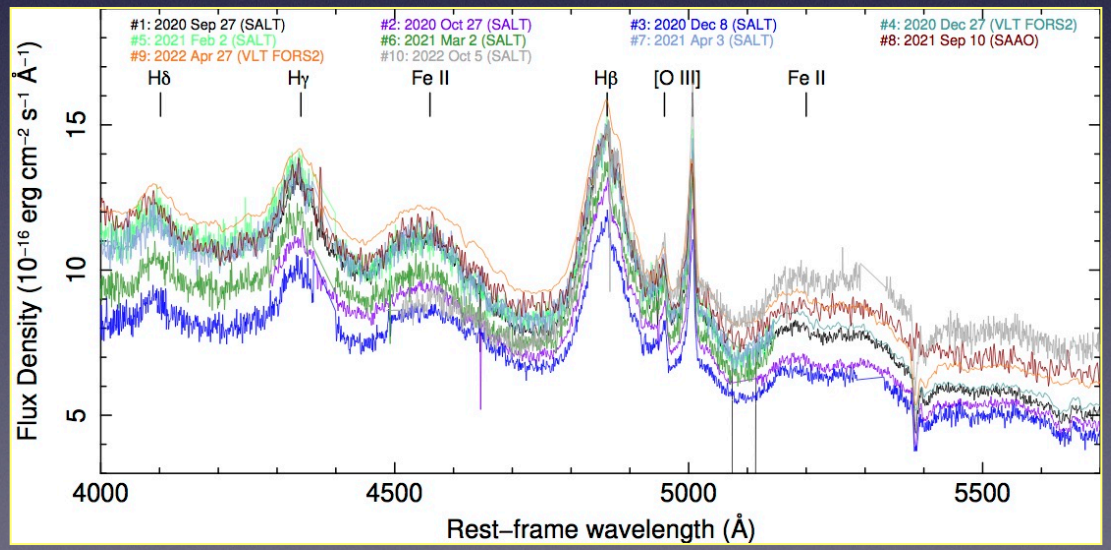
Optical/UV SED: No reddening due to dust

Optical spectra (SALT, VLT, SAAO-1.8m): no change in Balmer decrement

Hβ width → M_{BH} = 4e9 $M_\odot$
R_{BLR}(Hβ) ~ 110 lt. days

Constraints on ξ, $\Delta T \longrightarrow R_{cloud}$ ~ 170 lt-days

Transits by compact, non-dusty clouds commensurate with optical BLR in a high-mass Seyfert.



Work done or in progress for individual transient events:

TDE in a low-luminosity AGN: (D. Homan+, 2023, A&A, 672, A167)
Characteristics of both accretion channels simultaneously.
The boundary between “TDE accretion” and “AGN accretion” can be blurred!

Flare in a RQ Seyfert: (S. Krishnan+, in prep.)
Confirming thermal Comptonization driving variable soft excess
Changing-look broad He II λ4686 line; transient Hβ inflow?

Multi-band flaring RQ Seyfert/CLAGN: (T. Saha+, in prep.)
CLAGN: Sy 1.9 → 1 →1.9 during a temporary flare; diskline accretion geometry
No soft X-ray excess!
IR dust echo!
SEE POSTER!

A Changing-Obscuration Seyfert 1: (A. Markowitz+, in prep.)
Supporting clumpy-torus models; likely tracking individual BLR clouds
First (likely) BLR cloud occultation events in an ultra high-mass AGN

Other targets: we continue follow-up monitoring programs, constrain response timescales, track BLR/disk/corona evolution…