

# Insights into X-ray-Selected AGN Transient events from eROSITA's All-Sky Surveys

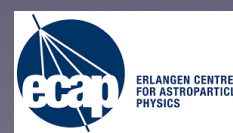
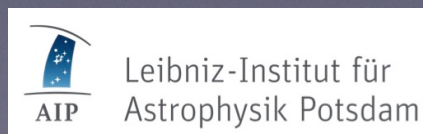
**Alex Markowitz  
(CAMK-PAN, Warsaw  
& UCSD-CASS)**

With:

T. Saha (CAMK-PAN), S. Krishnan (CAMK-PAN/IUCAA);  
D. Homan, M. Krumpe, R. Brogan (Leibniz Inst., Potsdam);  
J. Wilms, S. Haemmerich, A. Gokus (Remeis Obs./ECAP/FAU);  
M. Gromadzki (Warsaw Obs.), M. Schramm (Saitama Univ.),  
A. Rau, A. Malyali, Z. Liu, J. Buchner, T. Boller (MPE);  
*AND OTHERS*



(image credit: MPE/DLR)

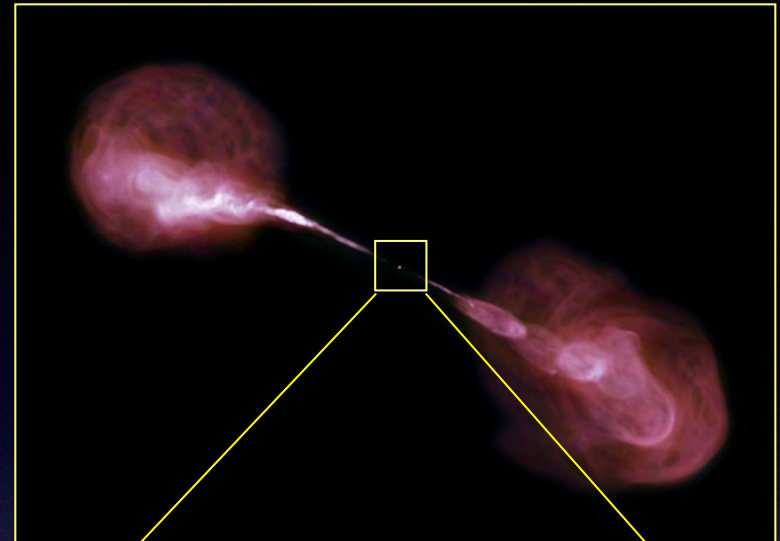




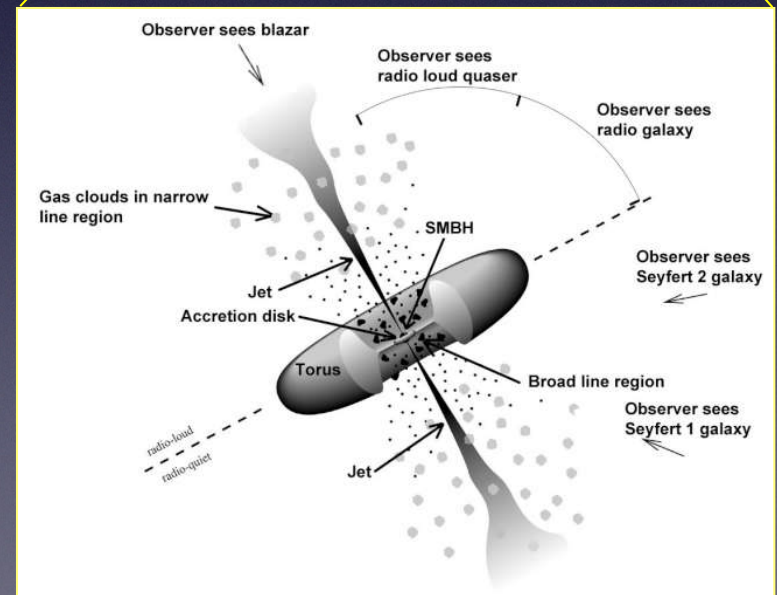
# Active Galactic Nuclei = Accreting SMBHs

Active galaxies/quasars:  
best-studied with multi-wavelength  
approaches

Accretion disk: Opt/UV thermal emission  
Corona: X-ray  
BLR, NLR: Optical spectroscopy  
Torus/circumnuclear dust: IR  
Jets: radio through gamma-rays



B. Saxton, W. Cotton and R. Perley (NRAO/AUI/NSF)



(NASA/HEASARC)



# What we study: Deviations from sustained, persistent accretion onto SMBHs (impacts knowledge on SMBH growth)

Large-area surveys (ZTF, GAIA, PanSTARRS; soon LSST) regularly monitor  $10^N$  AGN, and witness “events” that occur rarely on a per-object basis

“Events = Major changes in accretion due to

- global supply of gas turned on/off
- local mechanisms such as disk instabilities (causing transient flares)
- Tidal Disruption Event-like accretion



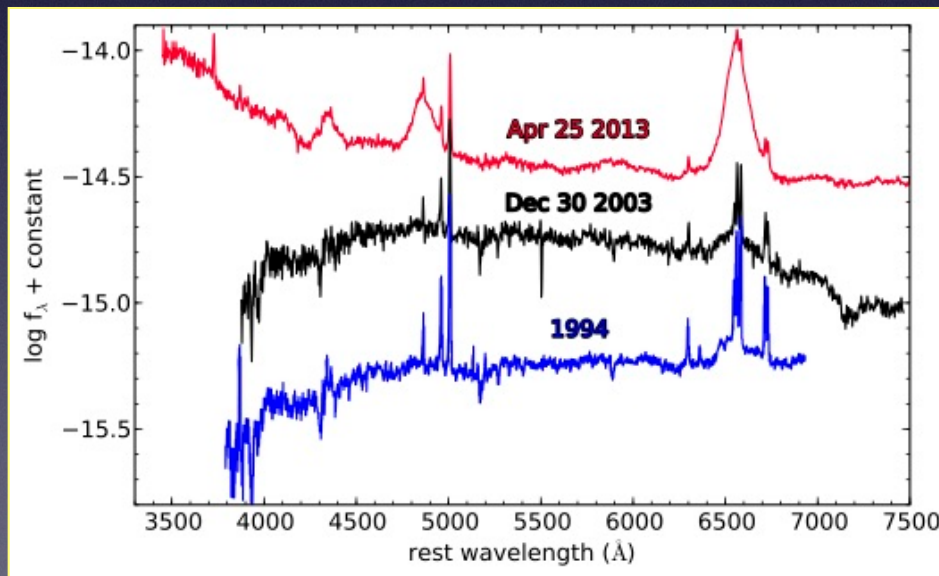
# Changing Look/ Flaring Seyfert AGN (CLAGN)

BLR lines appear/disappear, accompanied by major optical/UV/X-ray continuum variations

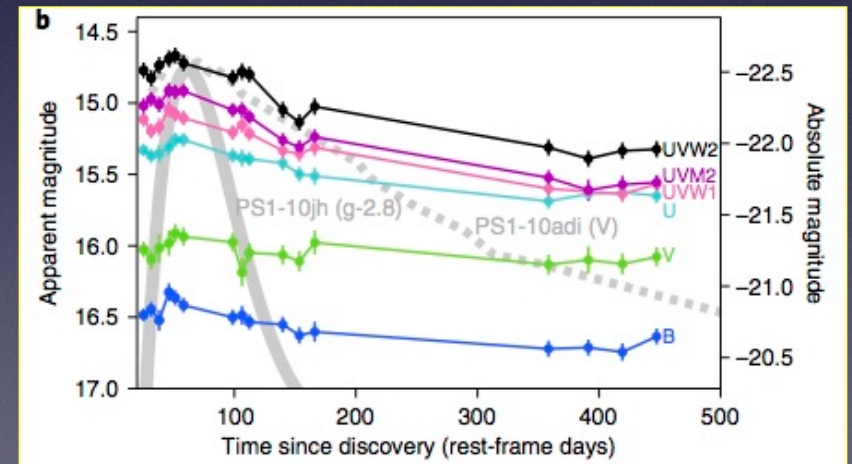
Driven by major changes in accretion rate and disk luminosity

Transitions can take a few years to ~ a decade

Over 150 known so far (Yang et al. 2018)



Shappee et al. (2014)



Transient “Flares” in RQ Seyferts (Trakhtenbrot+ 2019)



# Open questions regarding CL-/flaring AGN

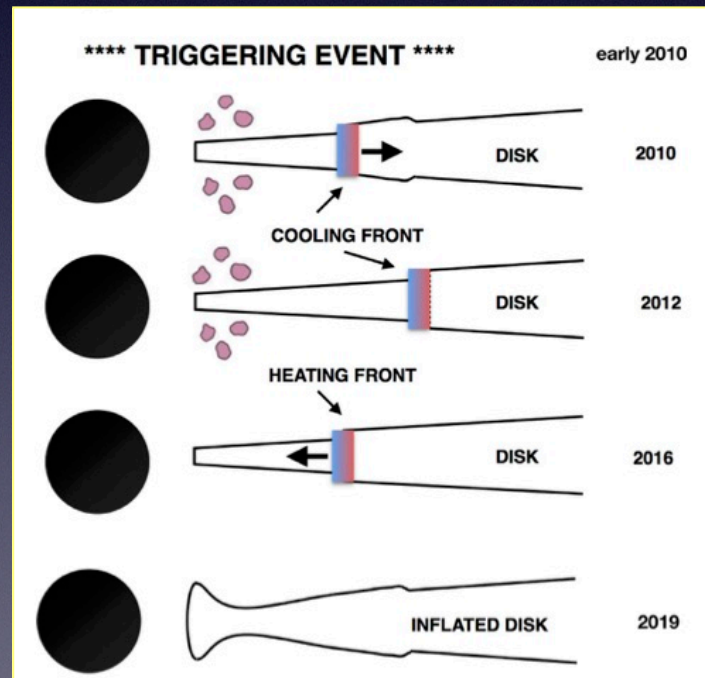
Driven by changes in global or local accretion rate?

How do the various emission components (disk, BLR, X-ray corona) react to changes in accretion rate, and how do they interact with each other?

Which mechanisms are at work?

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

Propagating hot/cold fronts in inner disk? (Ross et al. 2018)





# Introduction to eROSITA

Launched 2019 into L2 orbit aboard *Spektr-R/Gamma*

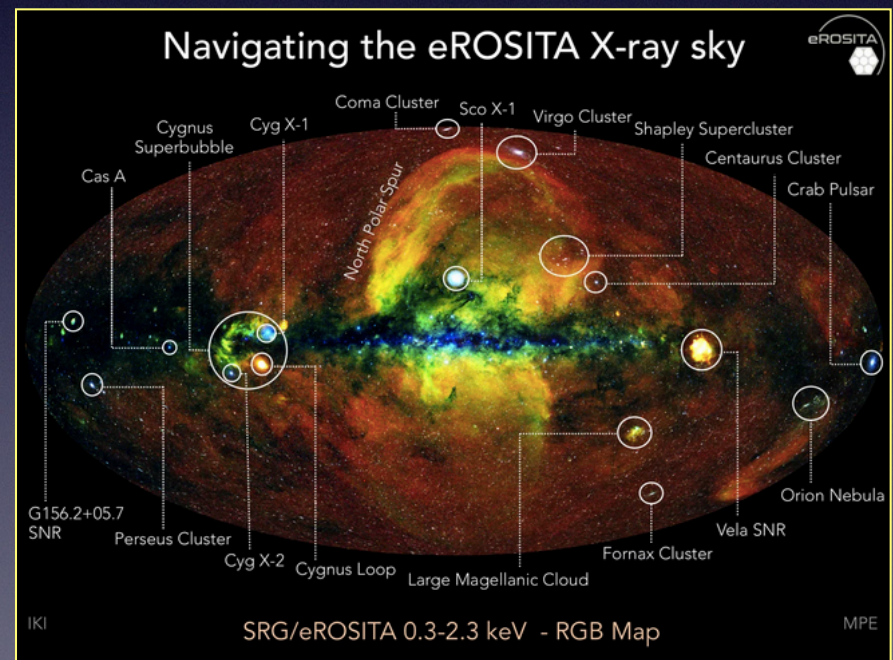
Map hot gas in  $\sim 10^5$  galaxy clusters; trace evolution of large-scale structure across cosmic time.

One all-sky X-ray scan every 6 months

**Monitor over  $10^5$  AGN for major variations in X-ray flux**



MPE/P.Predehl

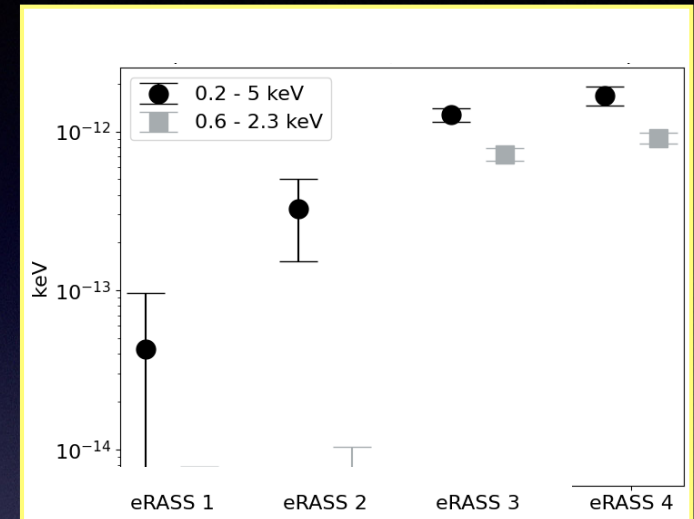
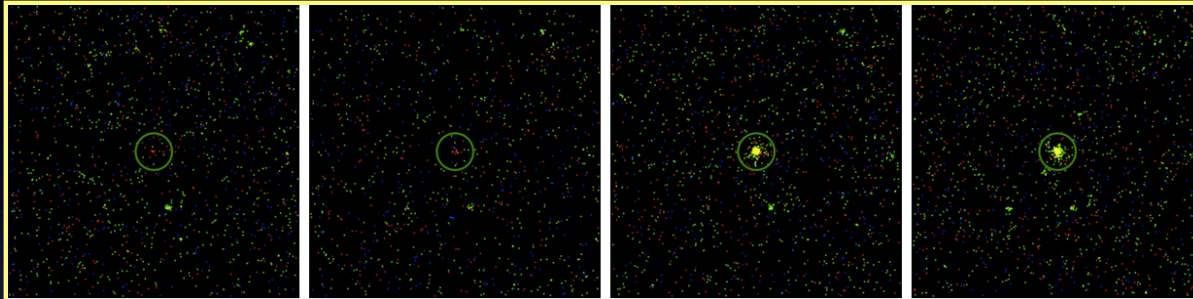


Jeremy Sanders, Hermann Brunner, Andrea Merloni and the eSASS team (MPE); Eugene Churazov, Marat Gilfanov (on behalf of IKI)



# Detecting new CL-/flaring AGN events in-progress

eROSITA: yields first set of X-ray-selected CL-/flaring events



Dedicated multi- $\lambda$  followups for selected individual targets

→ track response/formation of flow components to extreme changes in accretion:

Optical Spectroscopy (SALT, VLT, SAAO) → Broad Line Region

Opt/UV Continuum (Swift-UVOT; ground-based) → Accretion Disk

X-ray (XMM, Swift, NICER) → X-ray corona

IR (WISE) → circumnuclear dust

*The rest of this talk: Results for selected individual targets of interest....*



# 1) Flaring low-lumin. Seyfert — T. Saha+ (A&A, submitted)

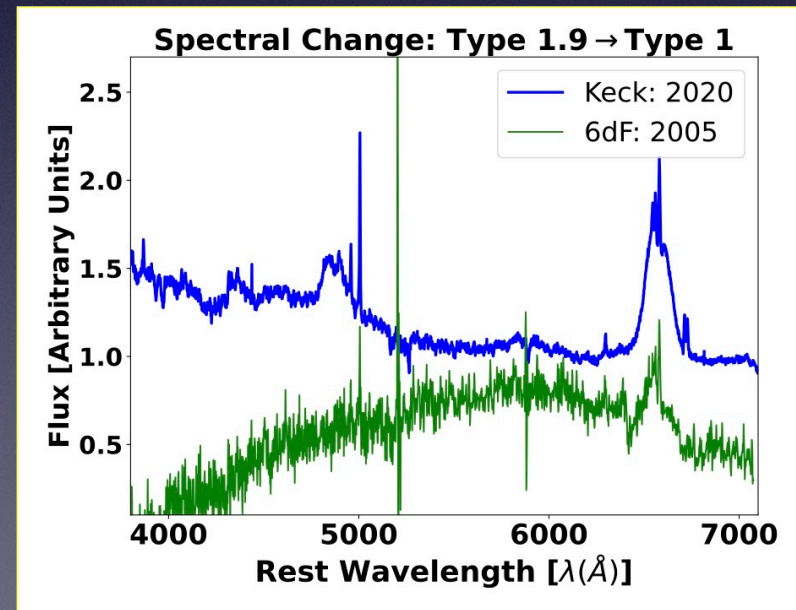
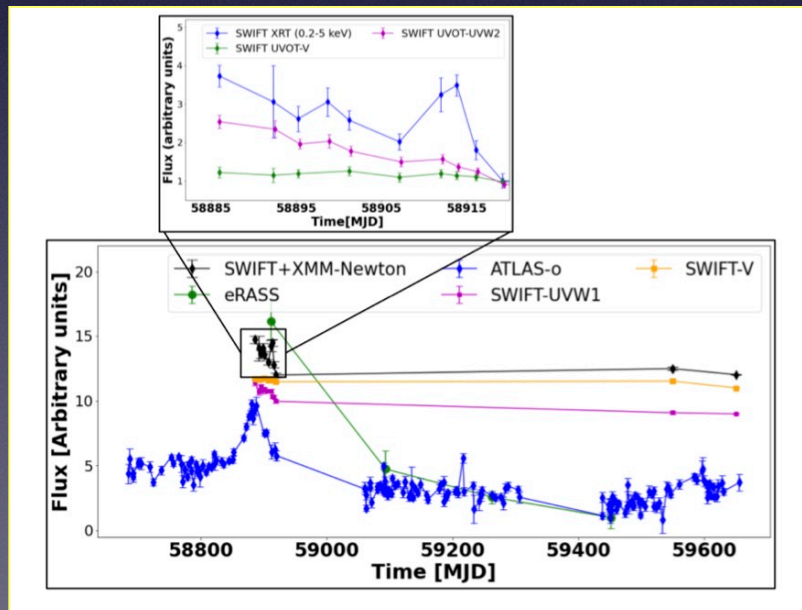
eROSITA & ZTF caught X-ray / optical flaring in 2020-2021  
Followups: Swift, XMM; SALT, VLT, SAAO

Optical spectra: H $\beta$  and a blue continuum appear in 2020-1

Cause: Local thermal instability (rad. press.) in inner disk

→ Spike in optical/UV thermal continuum from the disk

→ Optical/UV emission illuminated X-ray corona, BLR, dust

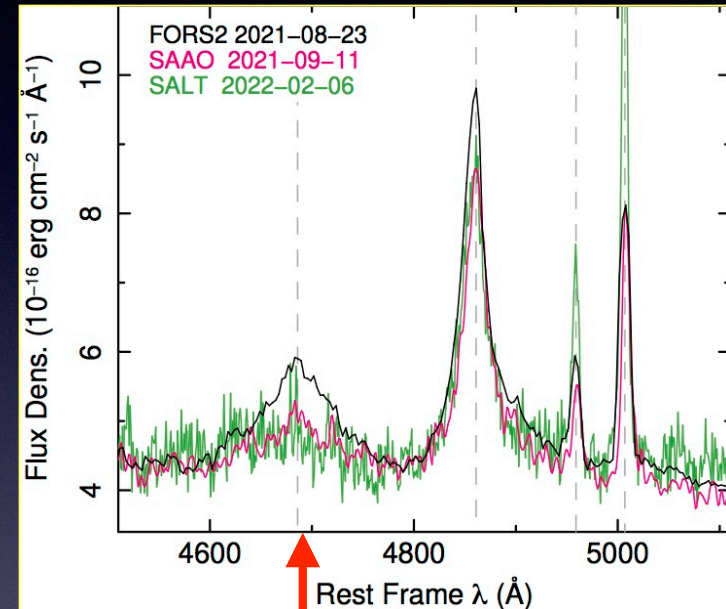
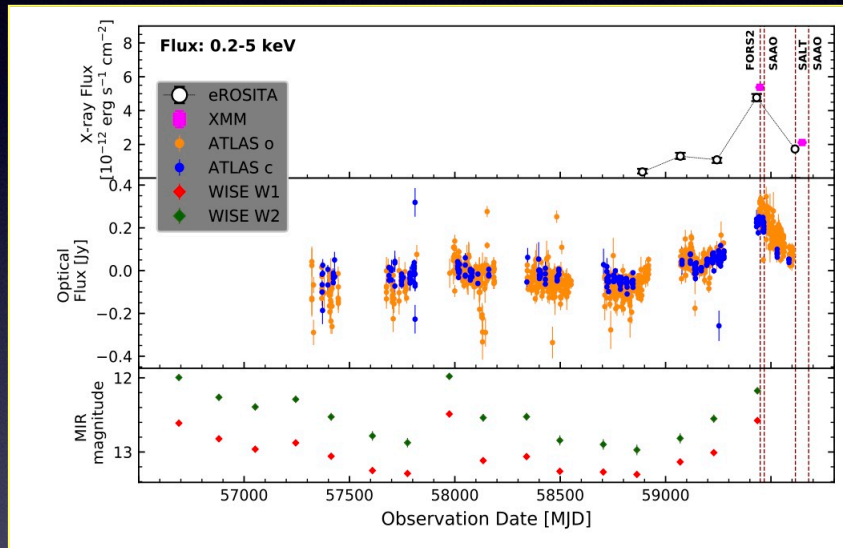




## 2) Another flaring-Seyfert event (S. Krishnan+, A&A, subm.)

eROSITA: increase over 6 months, decrease over 6 months

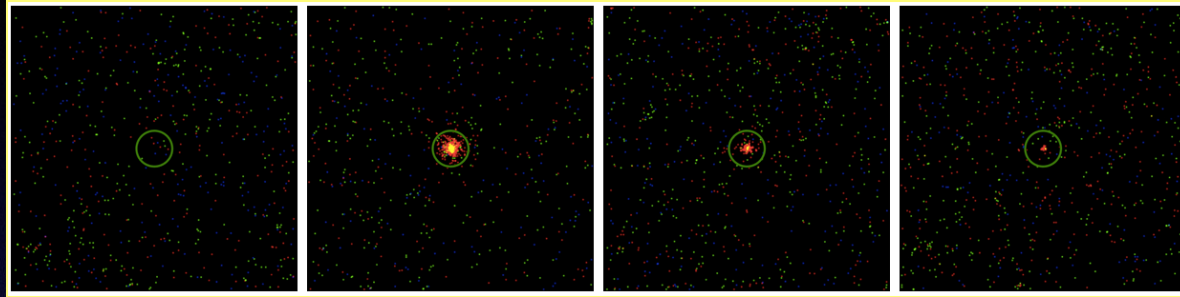
Followups with XMM, NICER, optical spectroscopy (SAAO, SALT, VLT)



Changing-look He II 4686 $\lambda$ : physically distinct origin than Balmer lines?  
AND/OR: He II tracks strongly-variable  $>54 \text{ eV}$  continuum

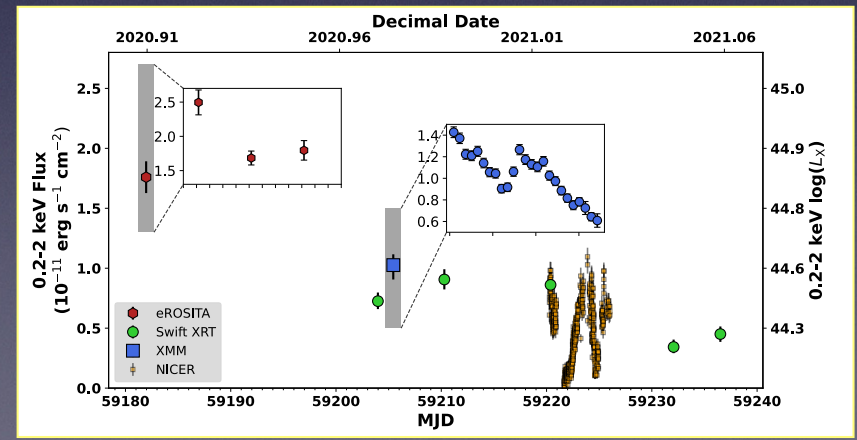
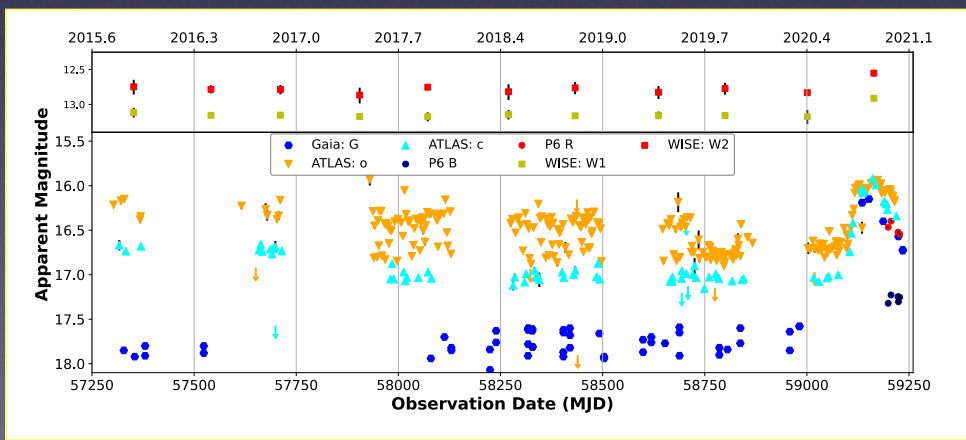


### 3) Very luminous transient: TDE-in-an-AGN? D. Homan et al. (2024, A&A, 672, A167)



X-ray flaring coincides with optical flaring detected with GAIA, late 2020

Characteristics of a TDE: ultra-soft X-ray spectrum ( $\Gamma \sim 5$ ) ; rapid flux decay



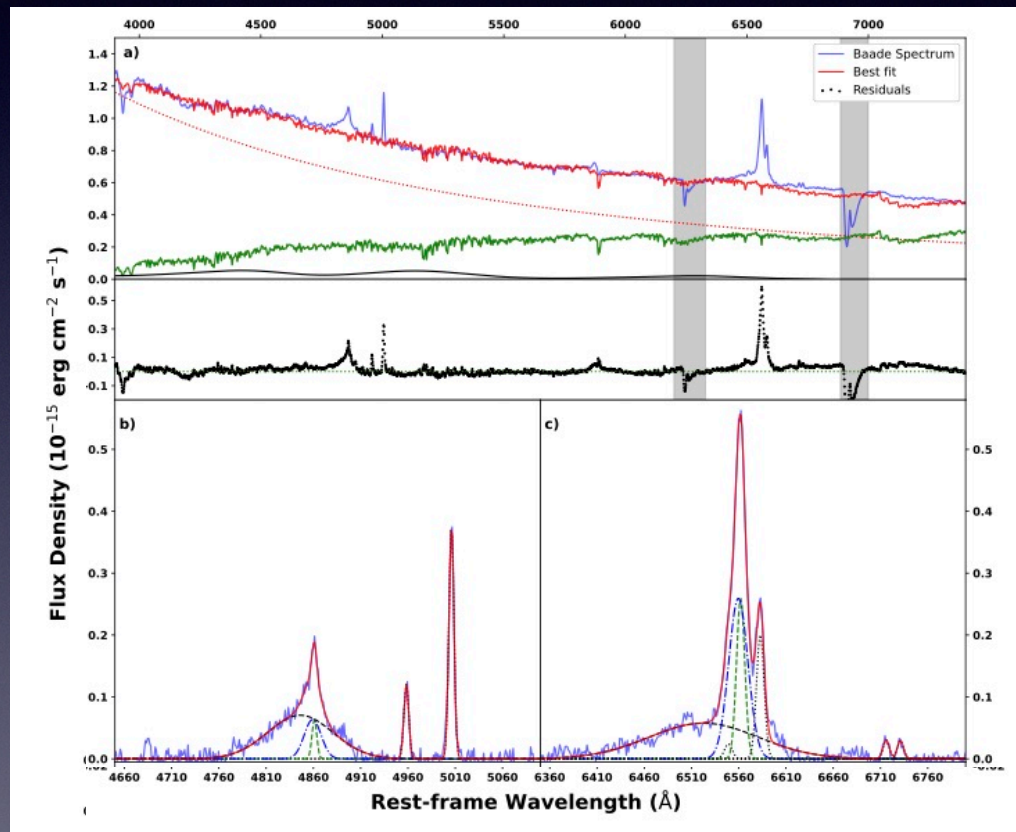


### 3) Very luminous transient: TDE-in-an-AGN? D. Homan et al. (2024, A&A, 672, A167)

Characteristics of AGN accretion:

Broad Balmer lines (with transient blueshifted component!)

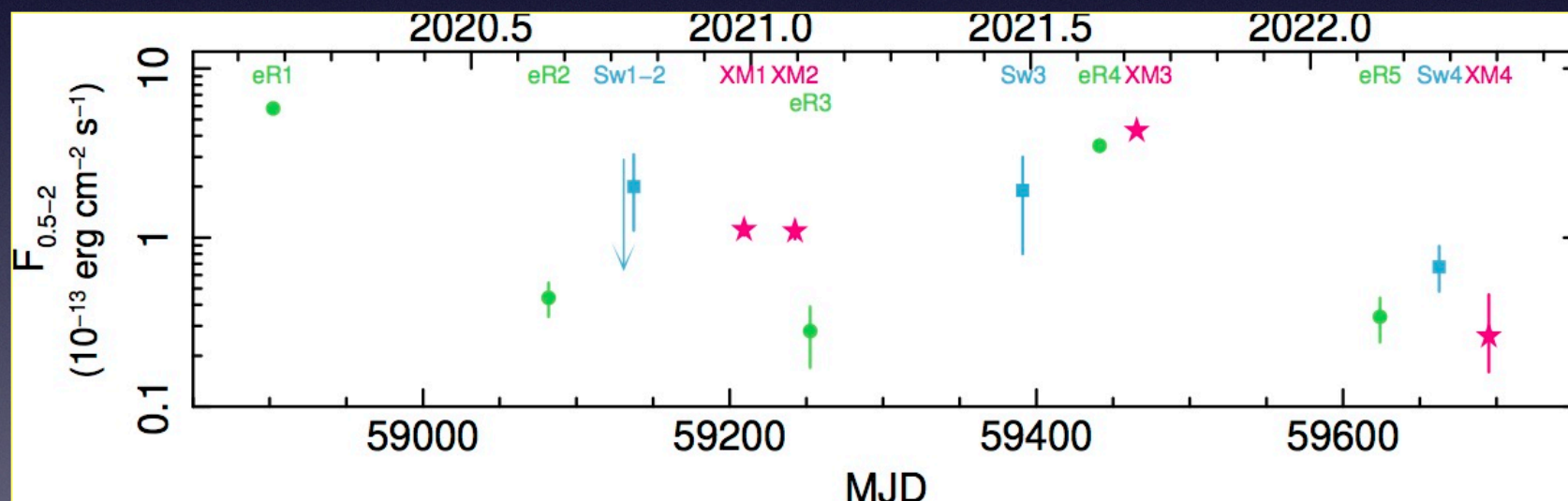
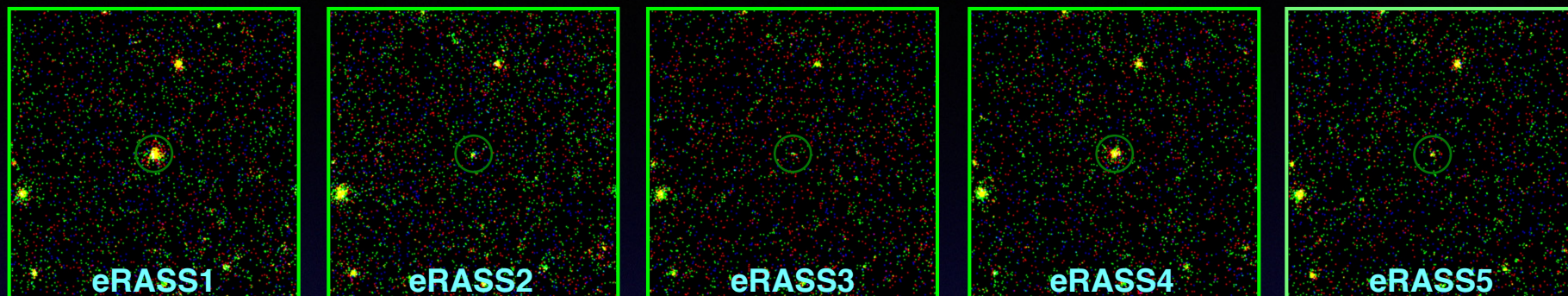
Strong [O III], [N II], [SII]: recent past AGN activity



**Displays both AGN & TDE accretion channels**



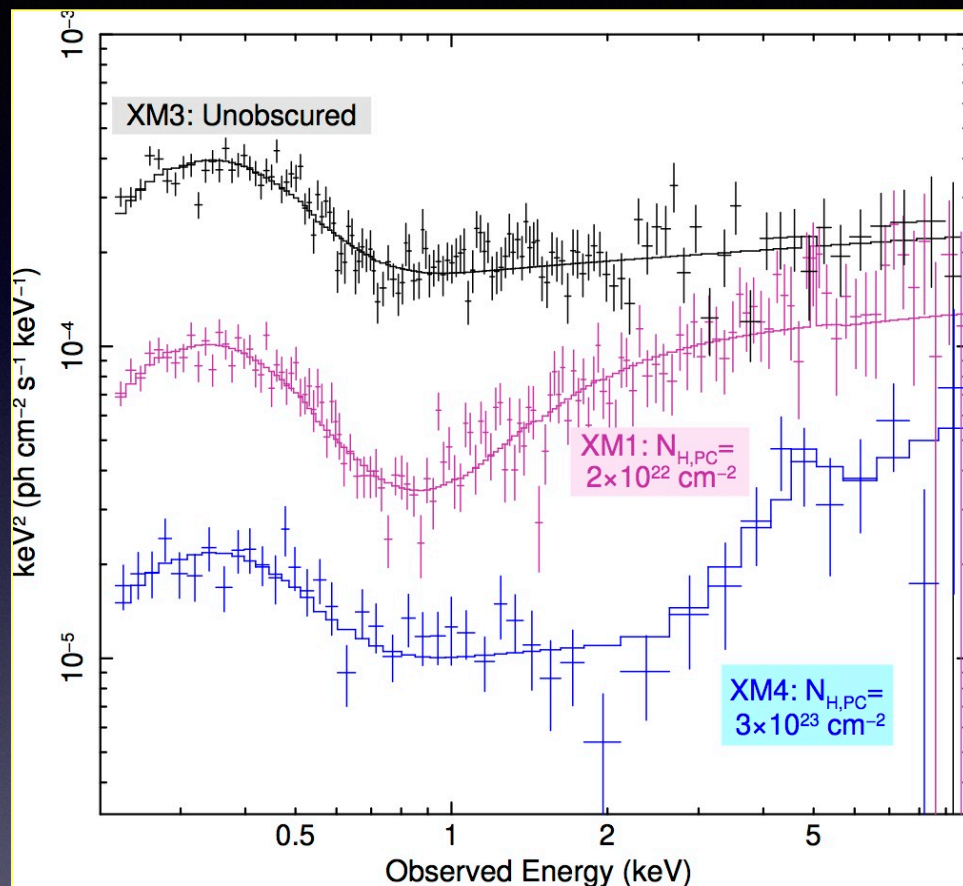
## 4) First AGN Cloud Occultation Events discovered with eROSITA: Markowitz+ (2024, in press.)



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



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



XMM follow-up spectra:

eRASS1,4: Unobscured

eRASS2-3: Moderate partial-covering obscuration

eRASS5: High partial-covering obscuration

Clouds or a clumpy disk wind uplifting from the inner disk



## Work done or in progress for individual transient events:

### Locally-emitted flares in Seyfert accretion disks:

(S. Krishnan et al., A&A, submitted; T. Saha et al., A&A, submitted):

Thermal instability in disk → flaring optical/UV emission

→ illuminated X-ray corona (X-ray flaring) & BLR

### TDE in a low-luminosity AGN: (D. Homan et al., 2024, A&A, 672, A167)

Characteristics of both TDE and AGN accretion channels simultaneously

### A Changing-Obscuration Seyfert: (A. Markowitz et al., A&A, in press)

Supporting clumpy-torus models; possibly tracking inner-disk wind

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



## Future tasks

### Work in progress for the sample:

Quantifying the broad ranges of responses in X-ray, Balmer line profiles/intensities, optical continuum

Statistical survey of obscuration via hardness ratios

X-ray-based estimates of AGN accretion duty cycles

