

Extreme variability in AGN detected with eROSITA

Insights from eROSITA's All-Sky Surveys and multi-wavelength follow up

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eROSITA_DE

Restless Nature of AGN, Naples, June 2023

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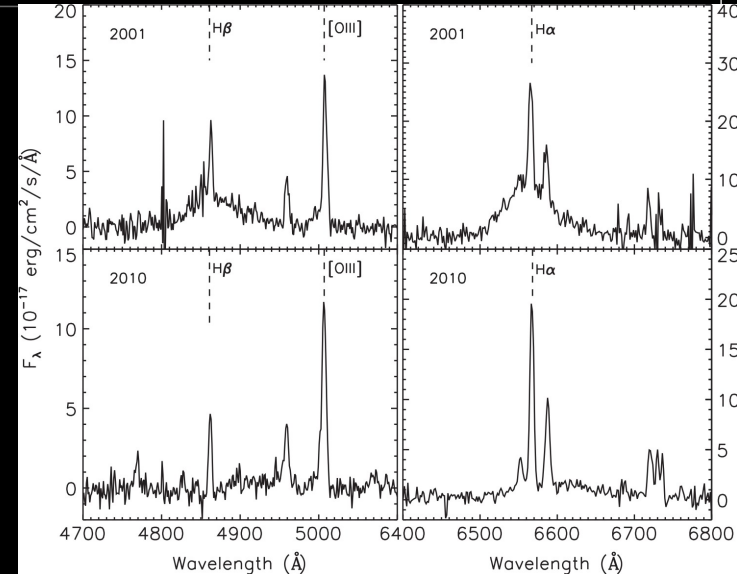


Extreme AGN variability with eROSITA

- I) AGN variability & 'changing look'
- II) eROSITA & extreme X-ray variability in AGN
- III) The extremely variable AGN sample

I – Changing-State AGN (CSAGN)

- Connection between continuum changes & spectral evolution: ‘changing-look AGN’
 - Changing obscuration (CO)
 - Changing state (CS)



LaMassa et al. 2015

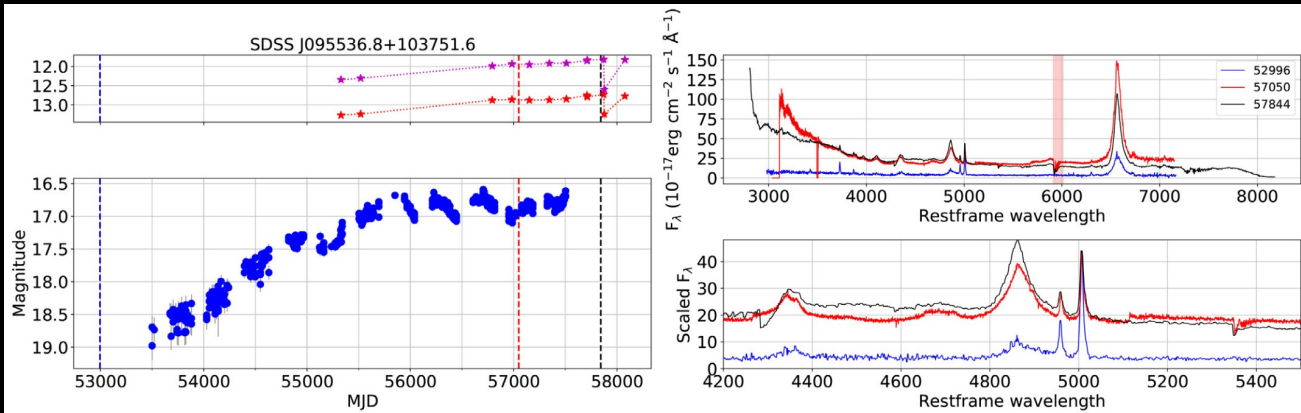
Graham et al. 2020

28 June 2023

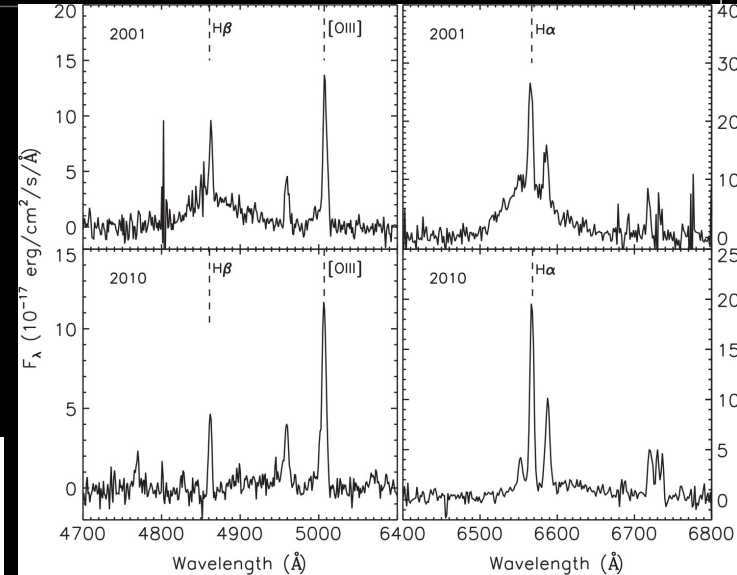
Restless Nature of AGN: Extreme AGN Variability w/ eROSITA

I – Changing-State AGN (CSAGN)

- Connection between continuum changes & spectral evolution: ‘changing-look AGN’
 - Changing obscuration (CO)
 - Changing state (CS)
- CSAGN Primarily detected in optical surveys (e.g. MacLeod et al. 2019, Graham et al. 2020)

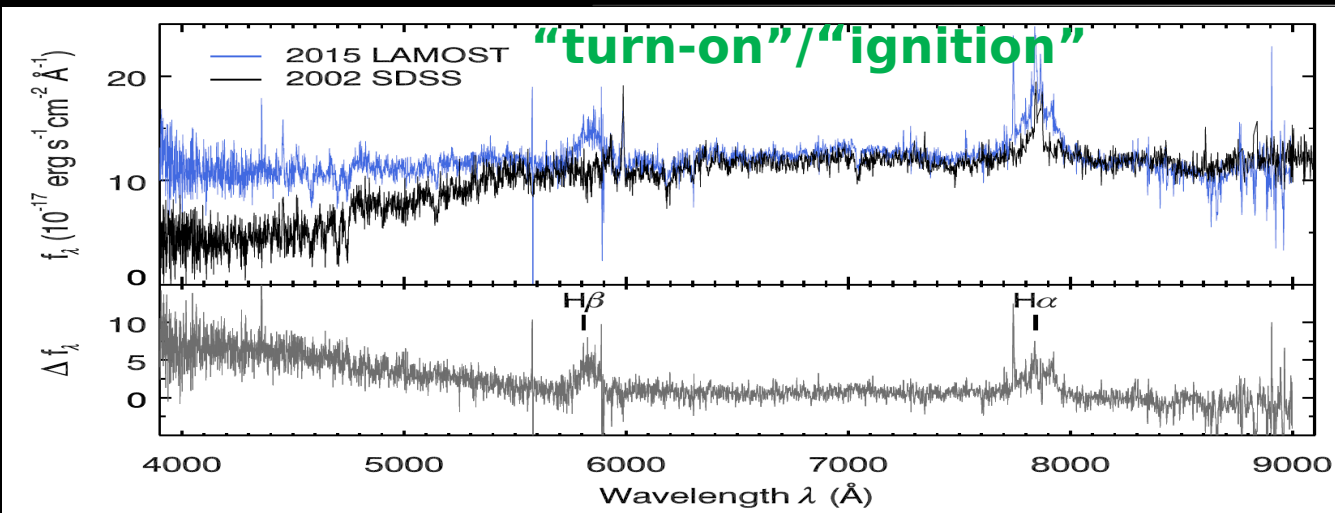


Graham et al. 2020

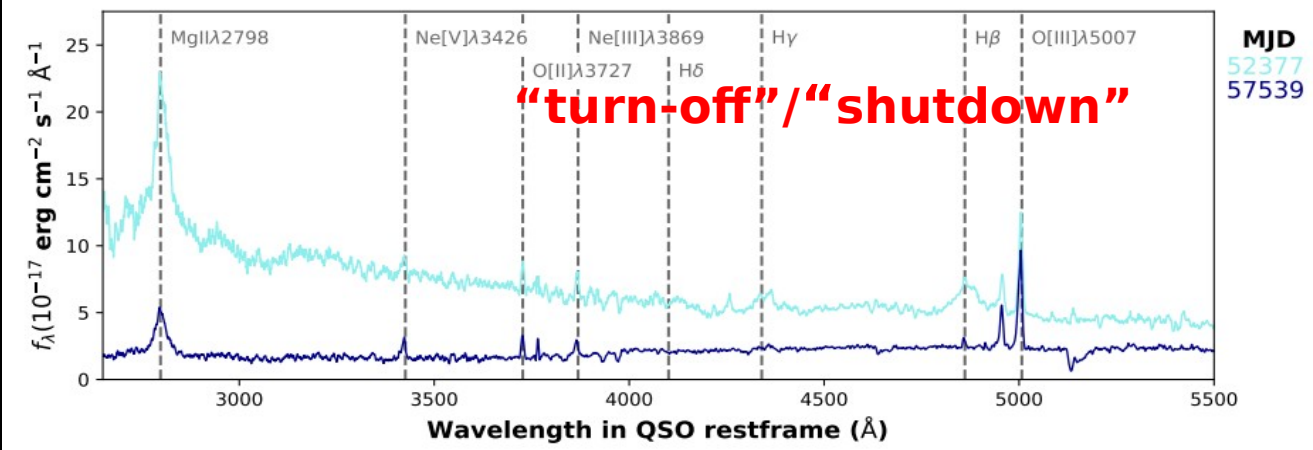


LaMassa et al. 2015

I – CSAGN: Ignitions & Shutdowns



Yang et al.
(2018)

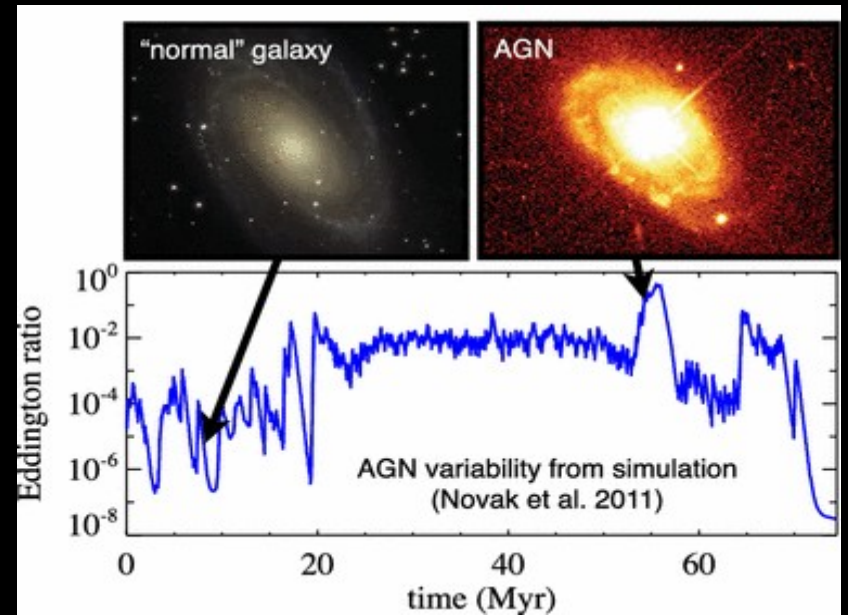


Homan et al.
(2020)

I – Studying extremely variable AGN

What can we learn?

- Transition timescales
- Insights into accretion physics
- Understanding of connection among AGN components
- Statistics for CSAGN sample



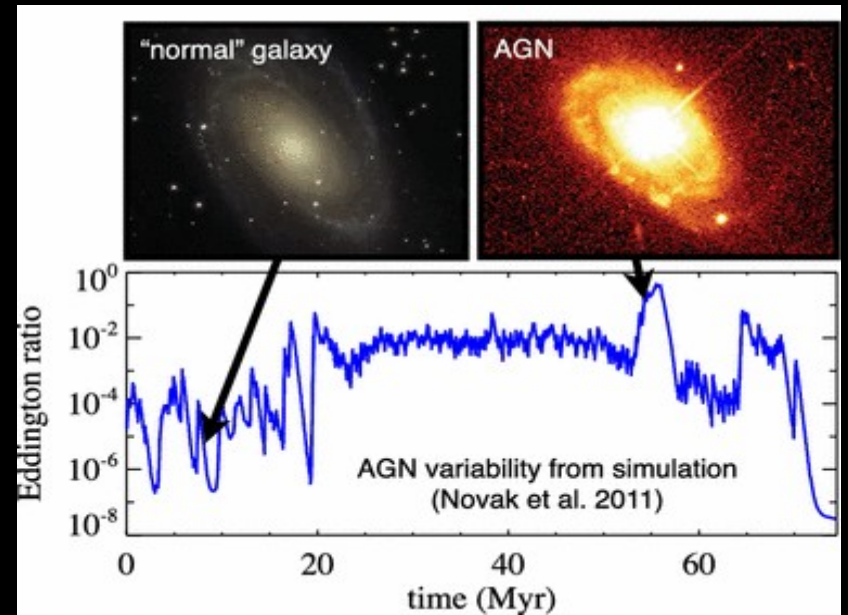
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How do we find them?

- Monitoring the largest possible samples of AGN & galaxies
 - Successful using optical & MIR datasets

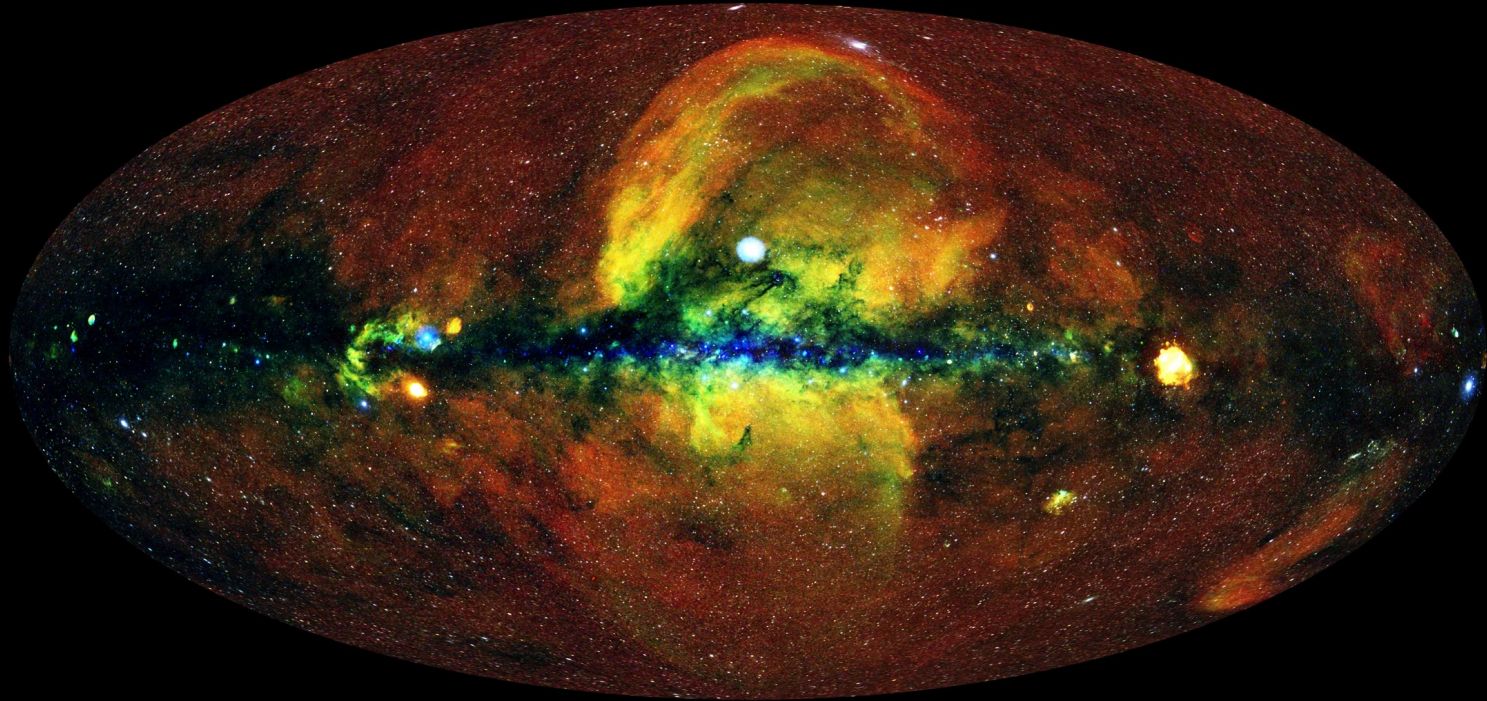


Extreme AGN variability with eROSITA

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- II) eROSITA & extreme X-ray variability in AGN
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II – eRASS

Credit: J. Sanders, H. Brunner, A. Merloni and the eSASS team (MPE); E. Churazov, M. Gilfanov (on behalf of IKI)



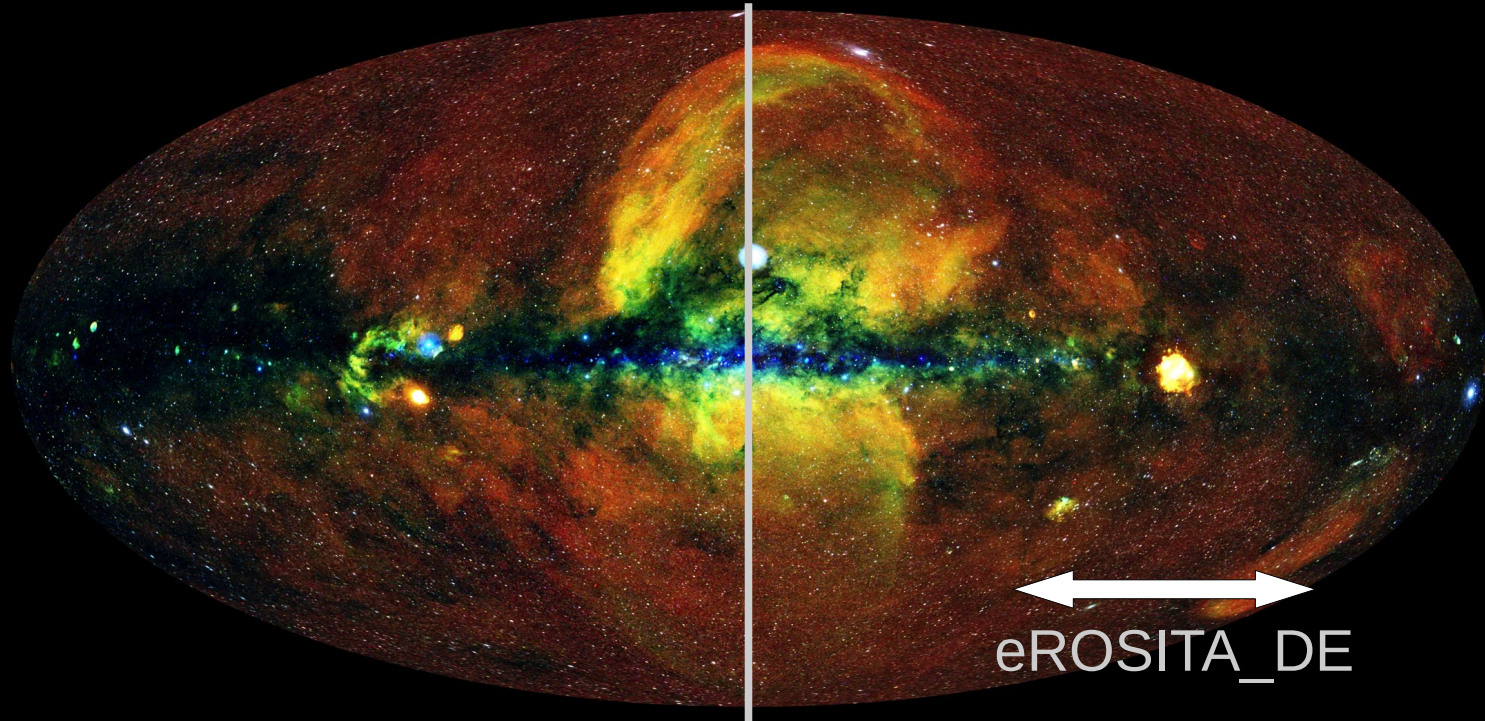
- ~1 million extragalactic point sources
- Repeated every 6 months

28 June 2023

Restless Nature of AGN: Extreme AGN Variability w/ eROSITA

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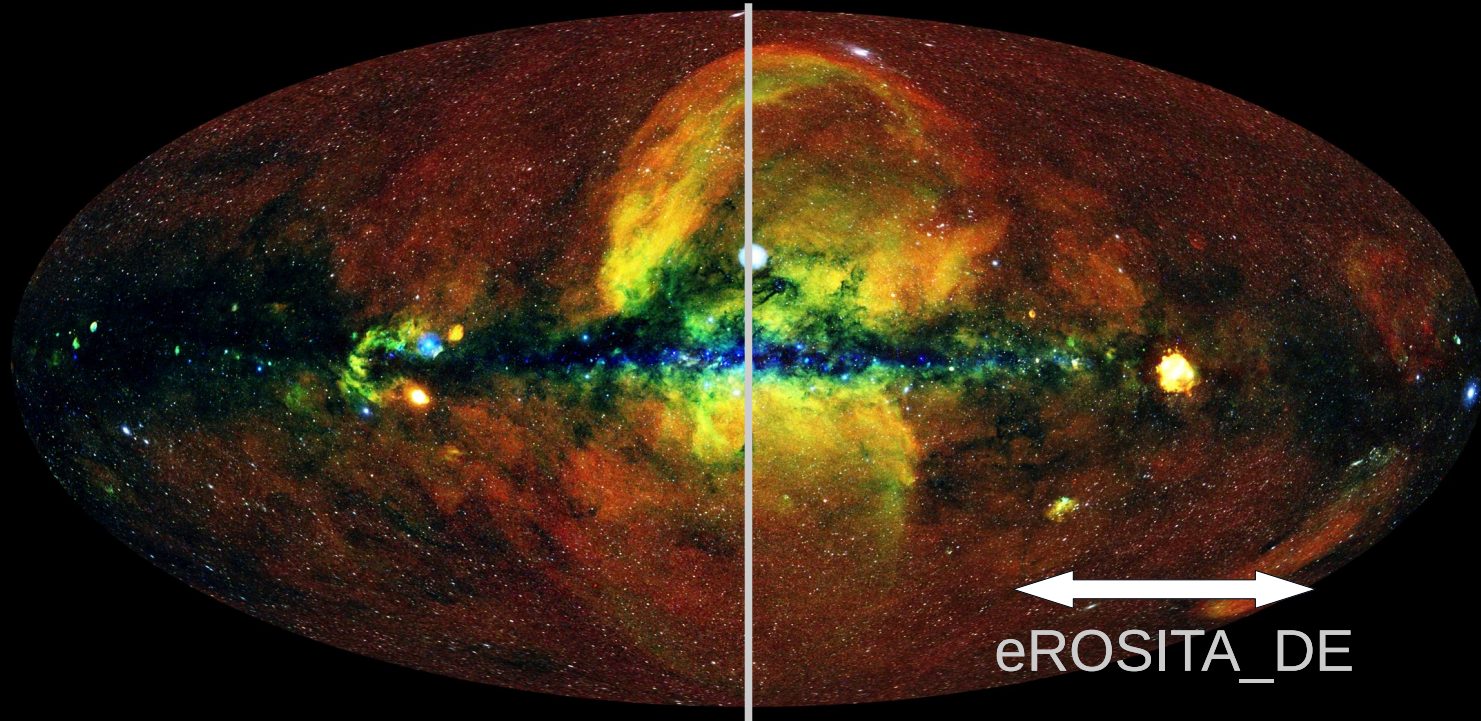
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- ~1 million extragalactic point sources
- Repeated every 6 months
- Four completed all-sky scans (eRASS)
- The instrument has been in safe mode since March 2022

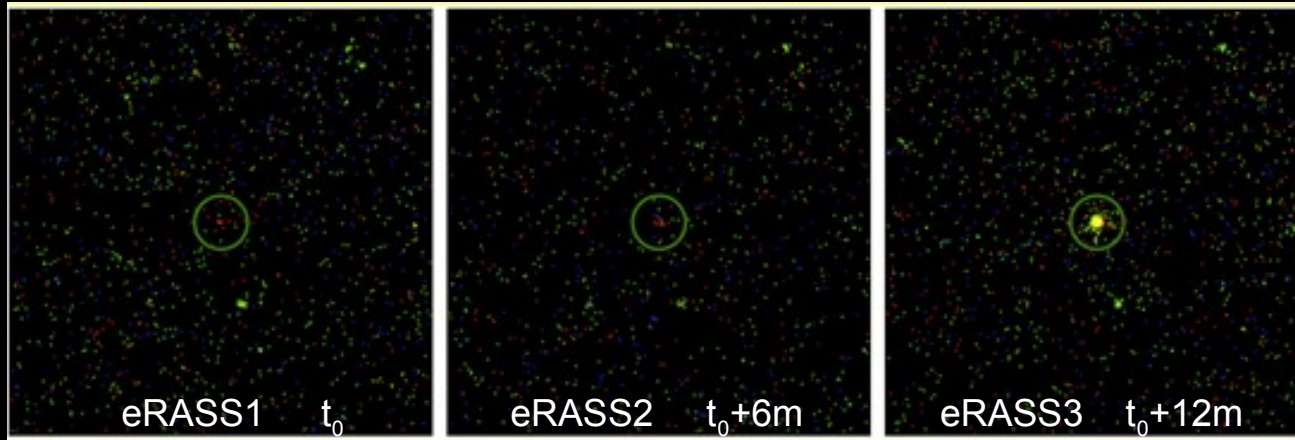
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Restless Nature of AGN: Extreme AGN Variability w/ eROSITA

II – Selection of X-ray changing-state AGN

1. Compare point-source catalogs between different eRASS scans

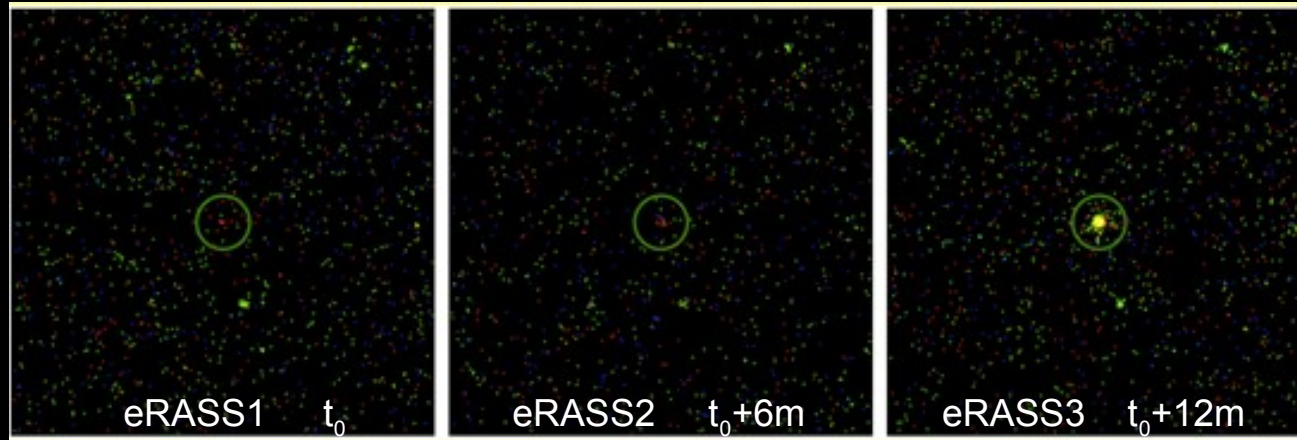
- crossmatch with Gaia: no proper motion or parallax
- X-ray flux change >8 (at least 3σ significance) *in one energy band*
- visual inspection of X-ray images



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2. Multi-wavelength archival search

- redshift, spectra (e.g., SDSS, 6dF) -> exclude stars, blazars, NLSy1
- X-ray, optical, IR light curve

II – Multi-wavelength Followup

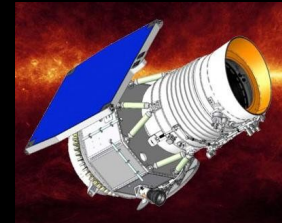
X-ray & UV



optical (photom. & spectra)



IR



II – Multi-wavelength Followup

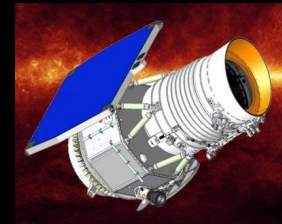
X-ray & UV



optical (photom. & spectra)



IR



Ignitions: Do we see the occurrence of AGN-typical features (optical spectrum)?
Do we see an overall long-term increase in the luminosity?

Shutdowns: Do we see how an AGN transforms into an inactive galaxy (optical spectrum/X-ray flux/IR flux)?


Extreme AGN variability with eROSITA

- I) AGN: structure, variability & 'changing look'
- II) eROSITA & extreme X-ray variability in AGN
- III) The extremely variable AGN sample

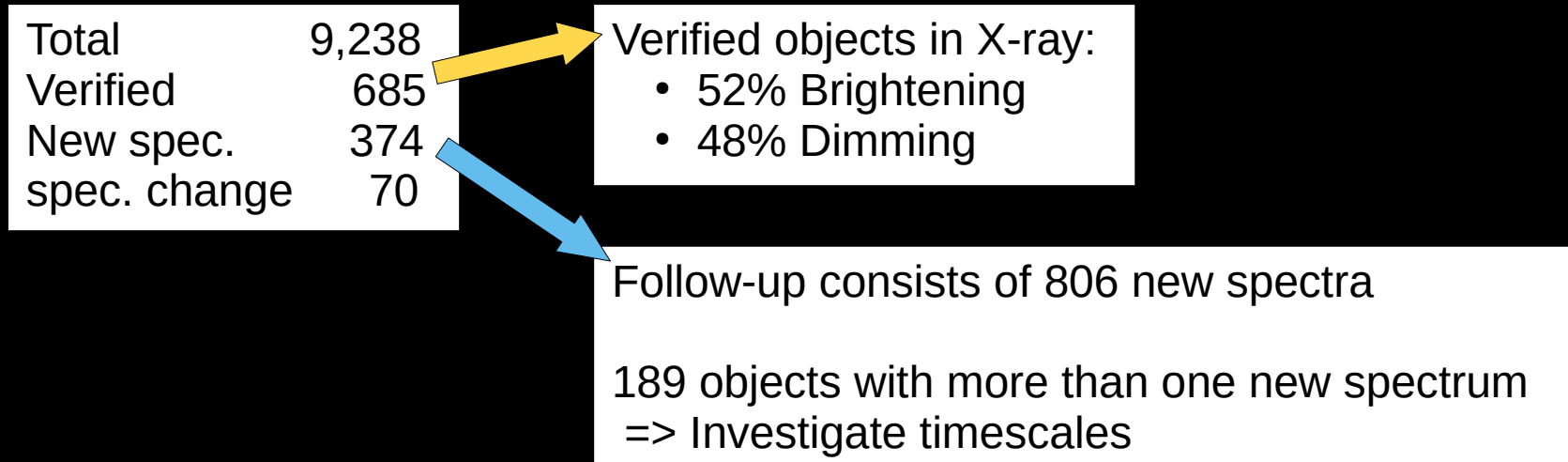
III – Sample (eRASS1-eRASS5)

Total	9,238
Verified	685
New spec.	374
spec. change	70

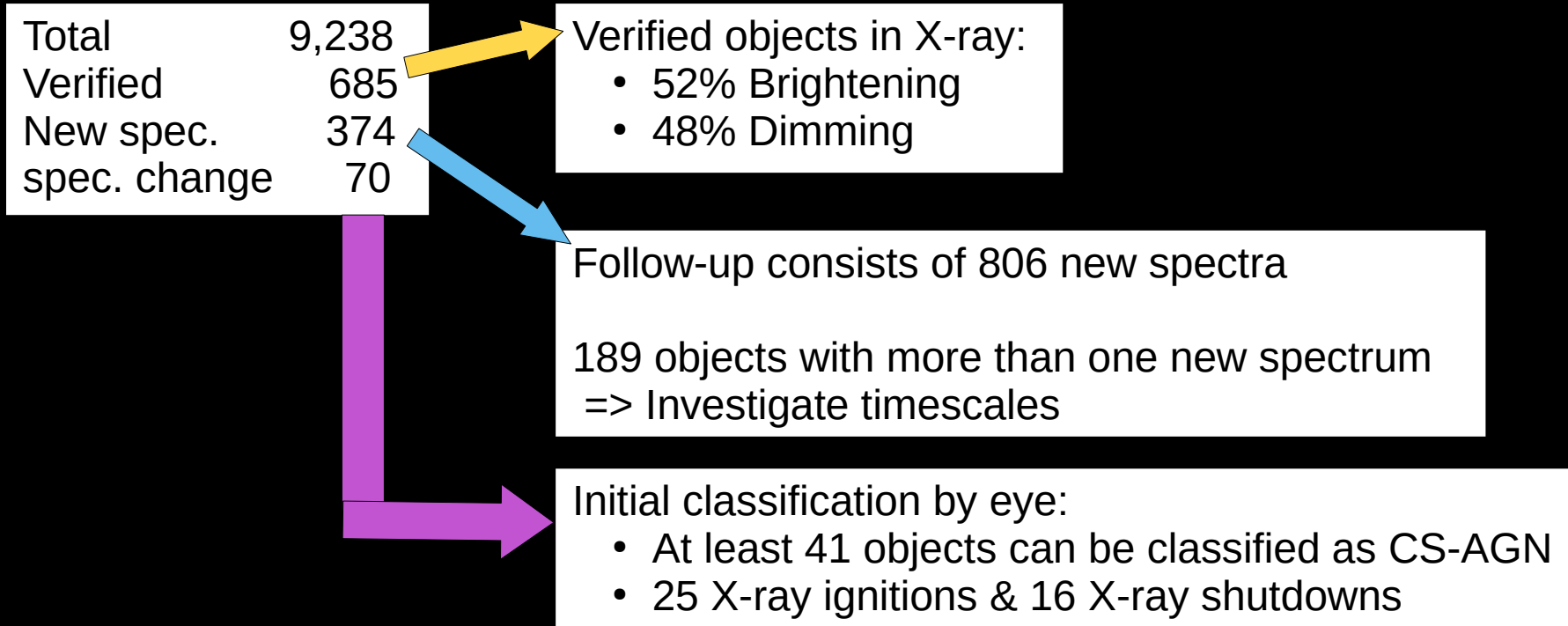
III – Sample (eRASS1-eRASS5)

Total	9,238		Verified objects in X-ray:
Verified	685		<ul style="list-style-type: none">• 52% Brightening• 48% Dimming
New spec.	374		
spec. change	70		

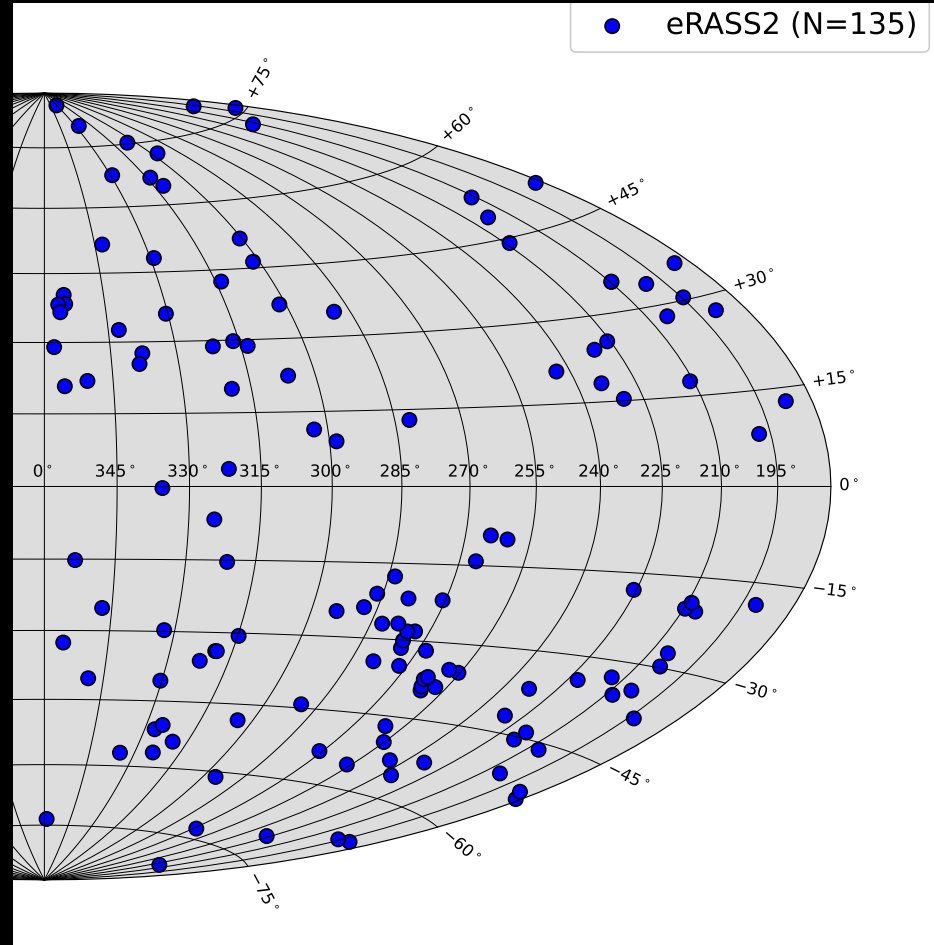
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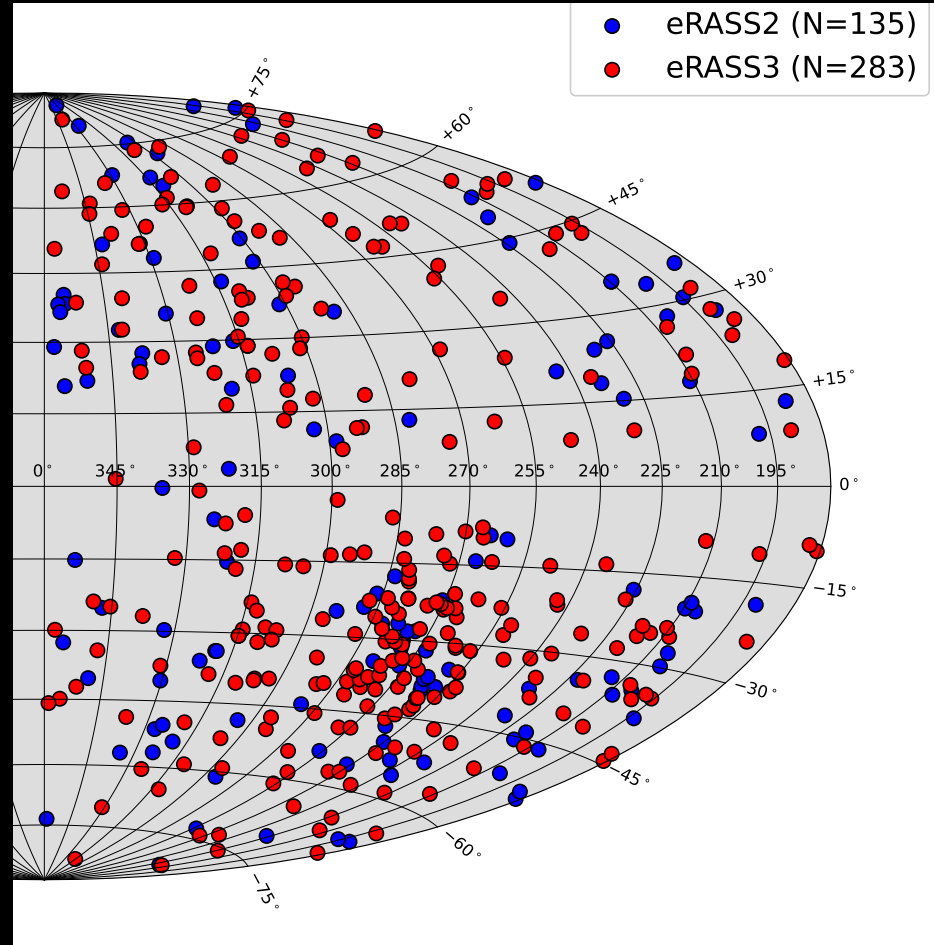
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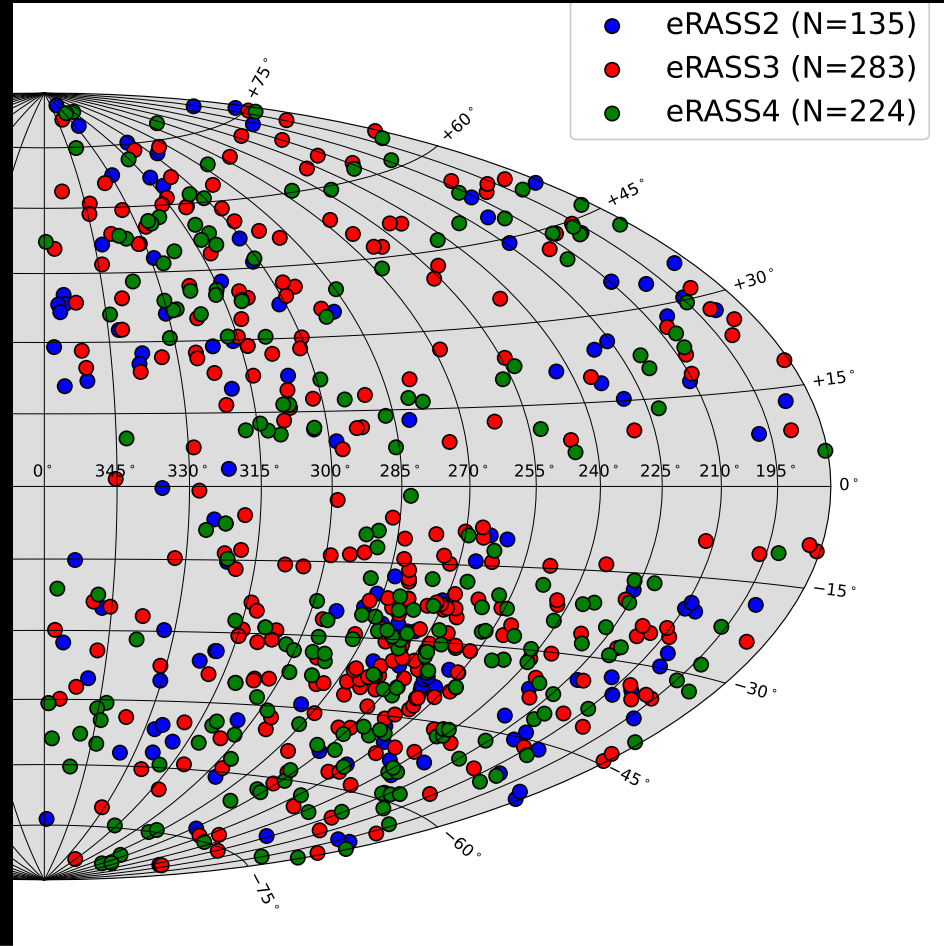
III – Expanding the sample with each eRASS



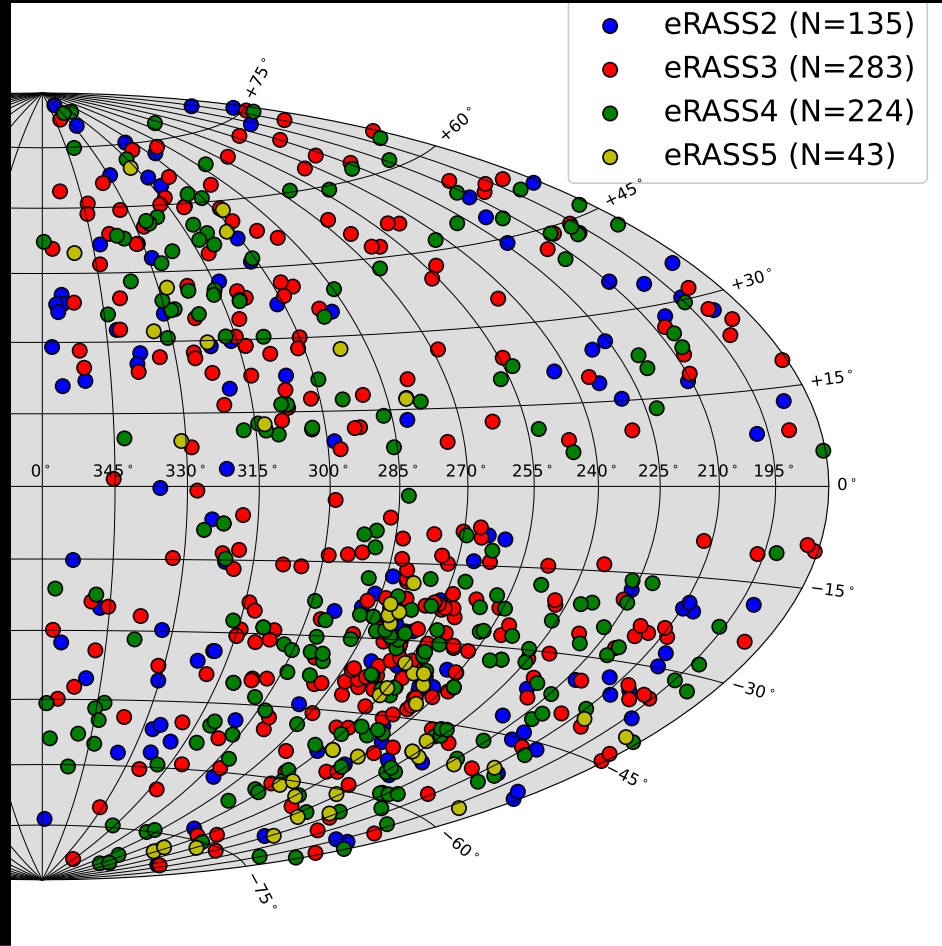
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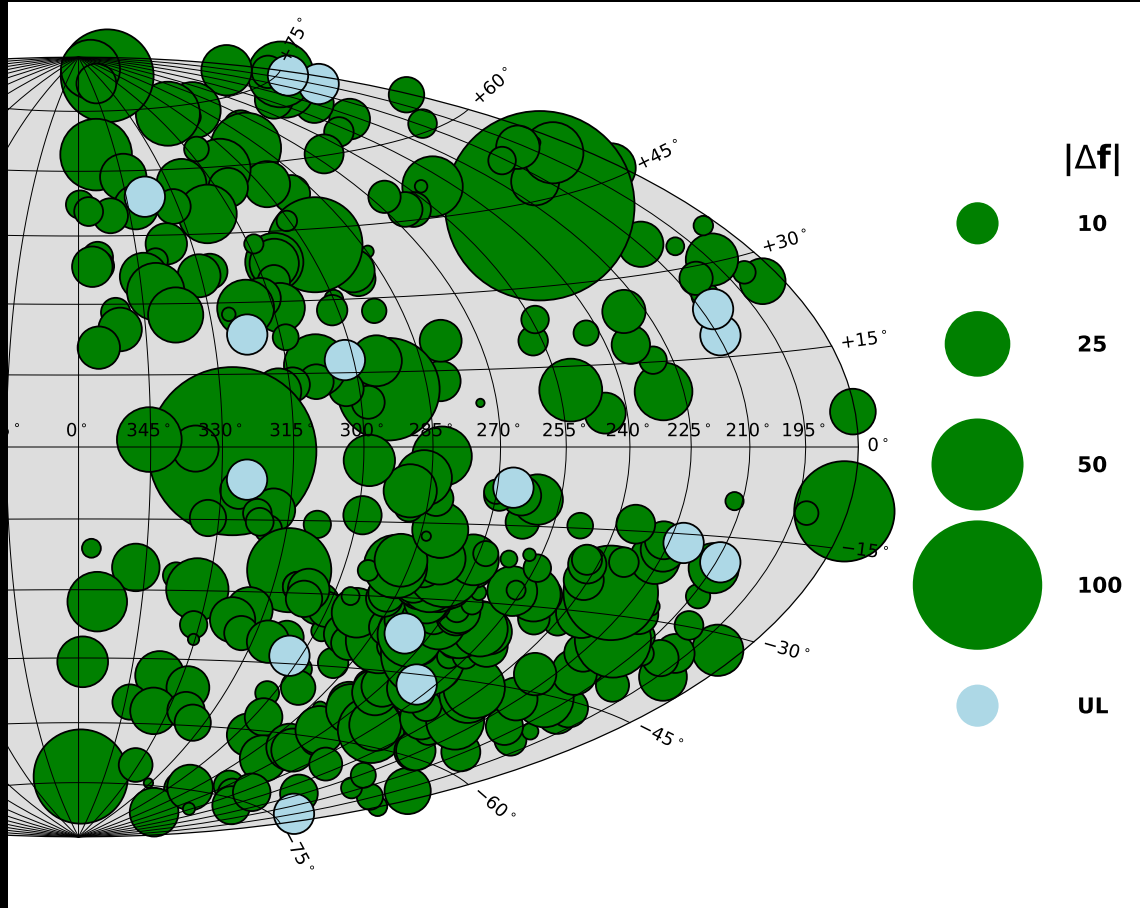
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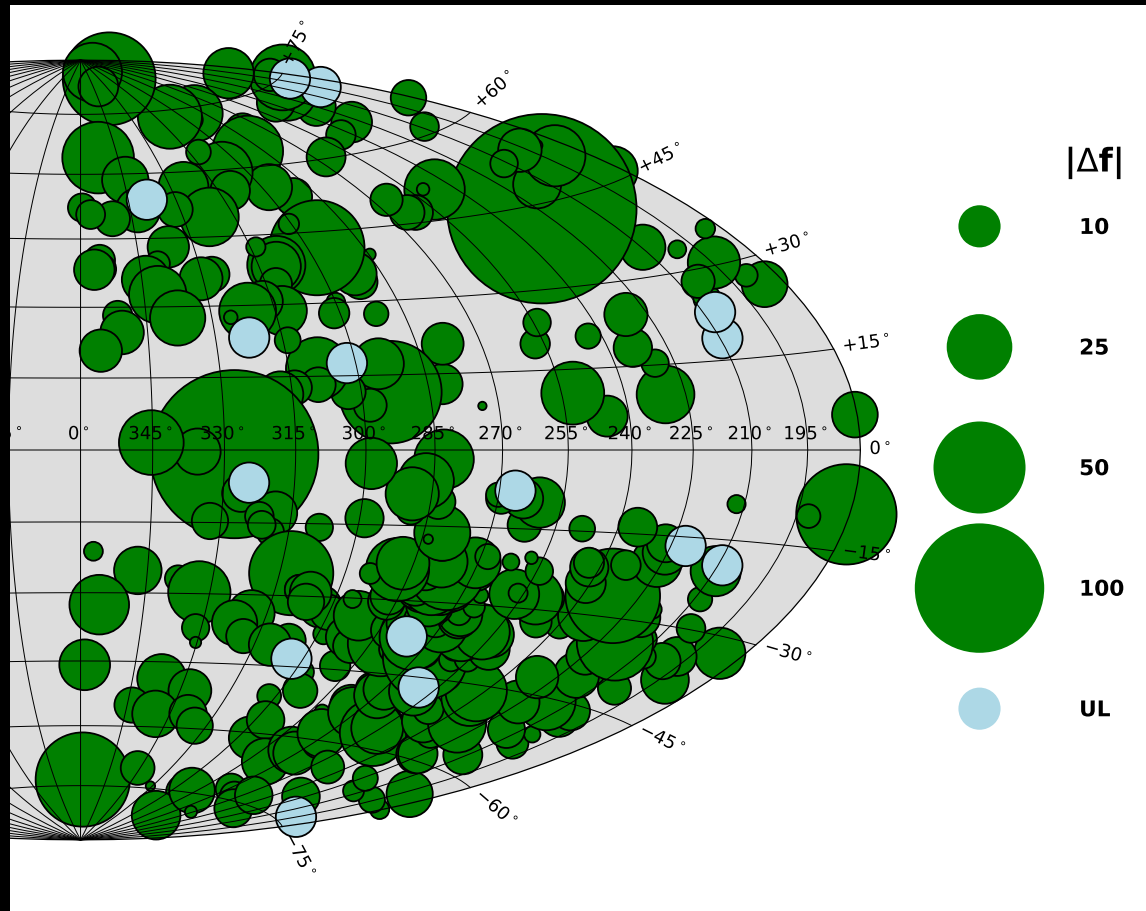
III – Ignitions



Ignition Events:

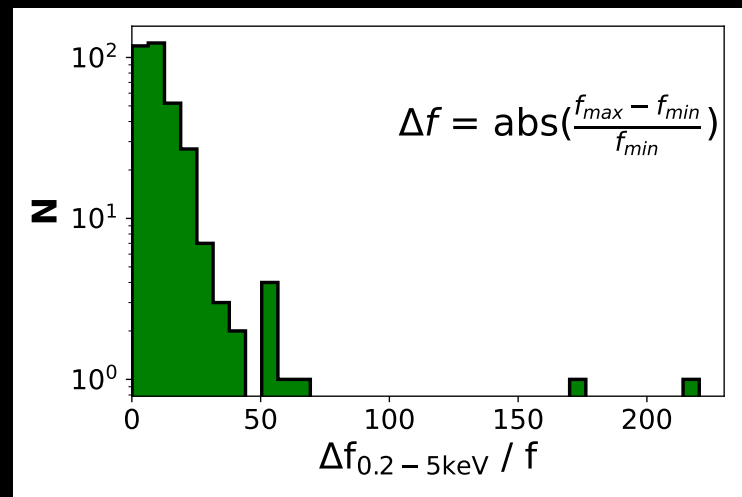
- N=355
- Flux change 0.2-5 keV:
$$\Delta f = | (f_{\max} - f_{\min}) / f_{\min} |$$
- In many cases we use Upper Limits

III – Ignitions

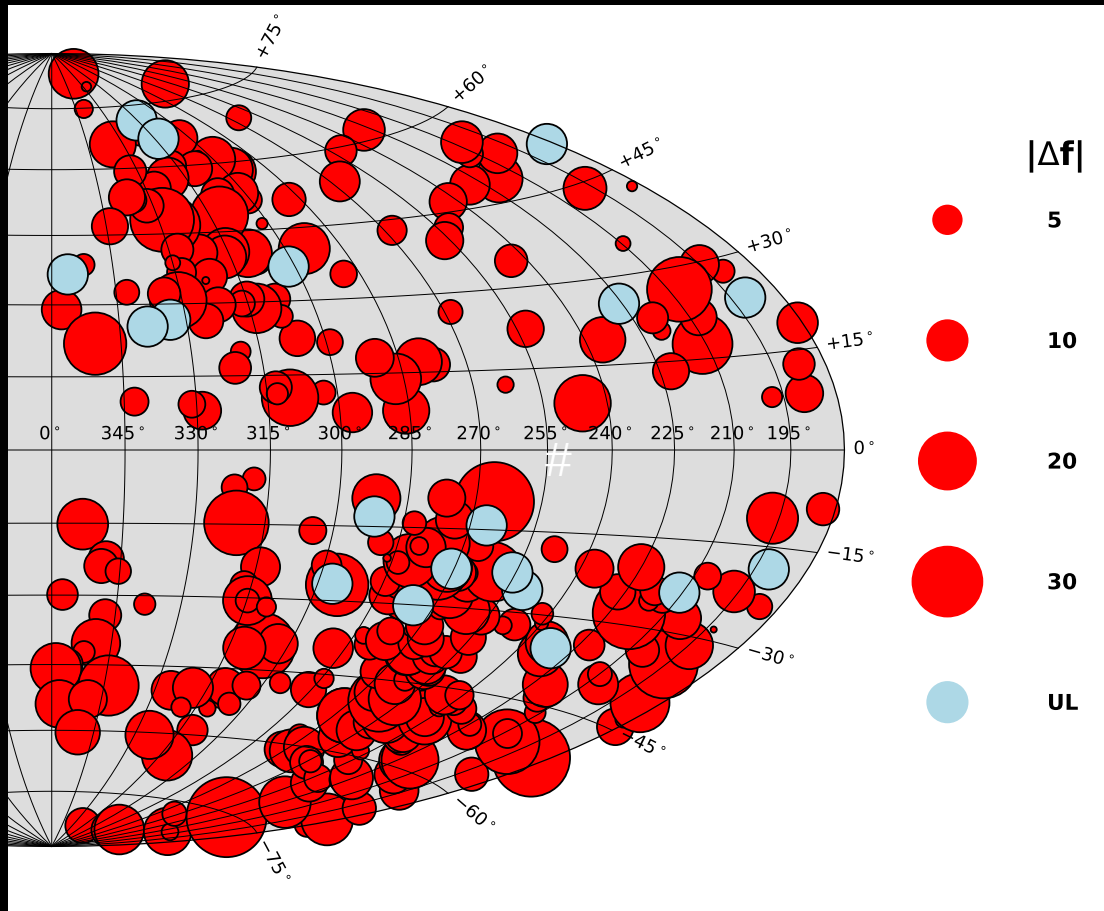


Ignition Events:

- N=355
- Flux change 0.2-5 keV:
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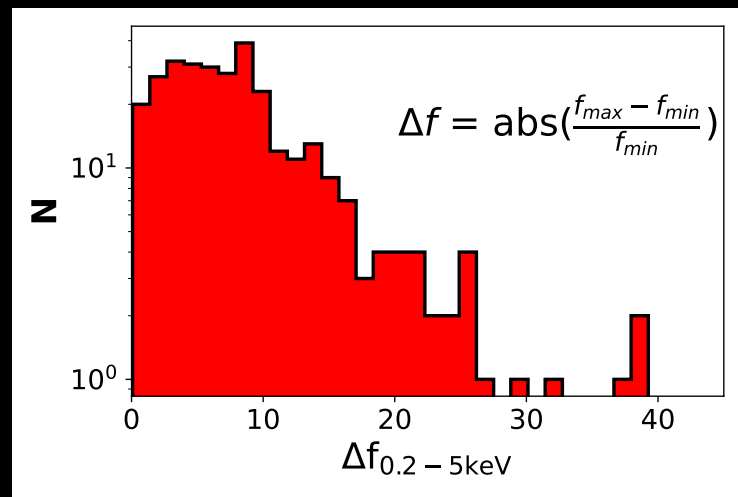


III - Shutdowns



Shutdown Events:

- N=330
- Lower fractional change (avg.) than ignitions



III – Spectroscopic followup

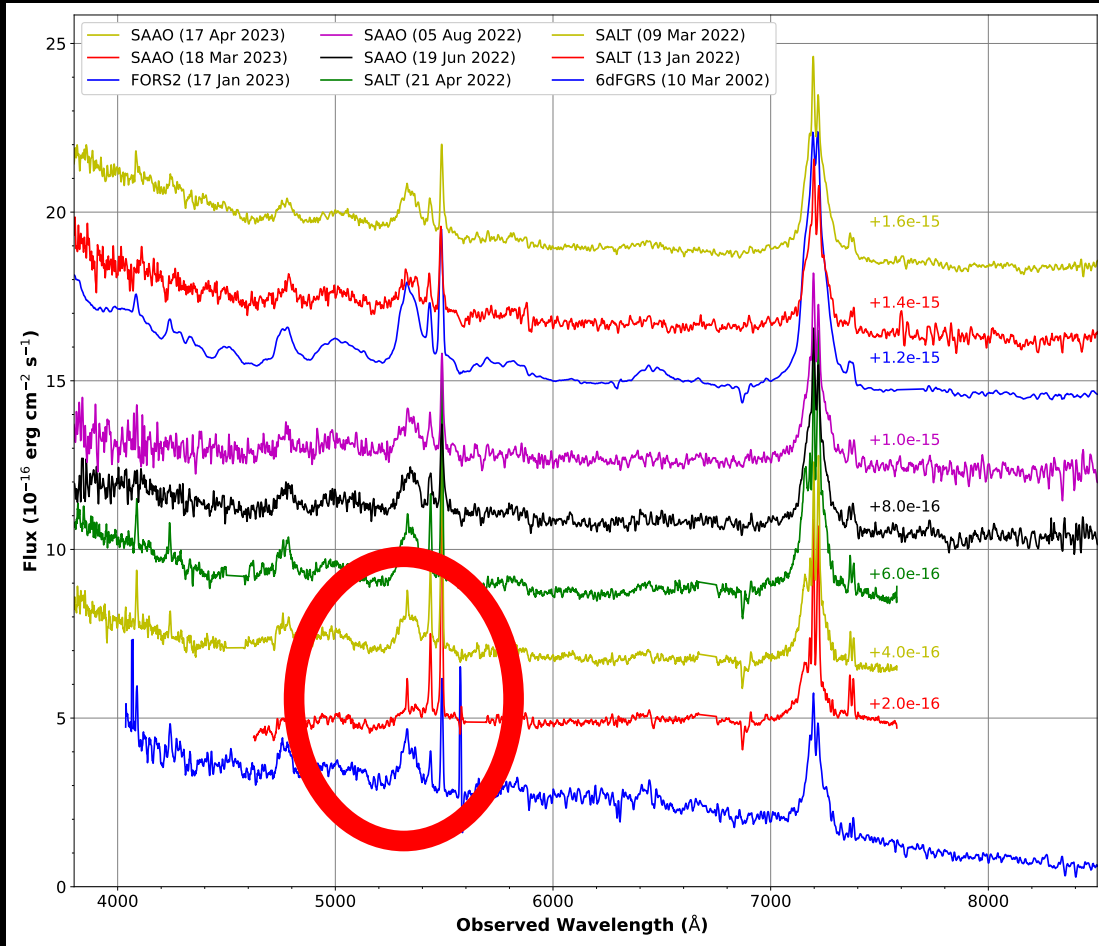
Total	9,238
Verified	685
New spec.	374
Spec. + X-ray	26
spec. change	70

→ large variety of X-ray transients:

- “simple” X-ray increases/decreases
- short-term X-ray transitions for 6 – 18 months (e.g., first increase then decrease)

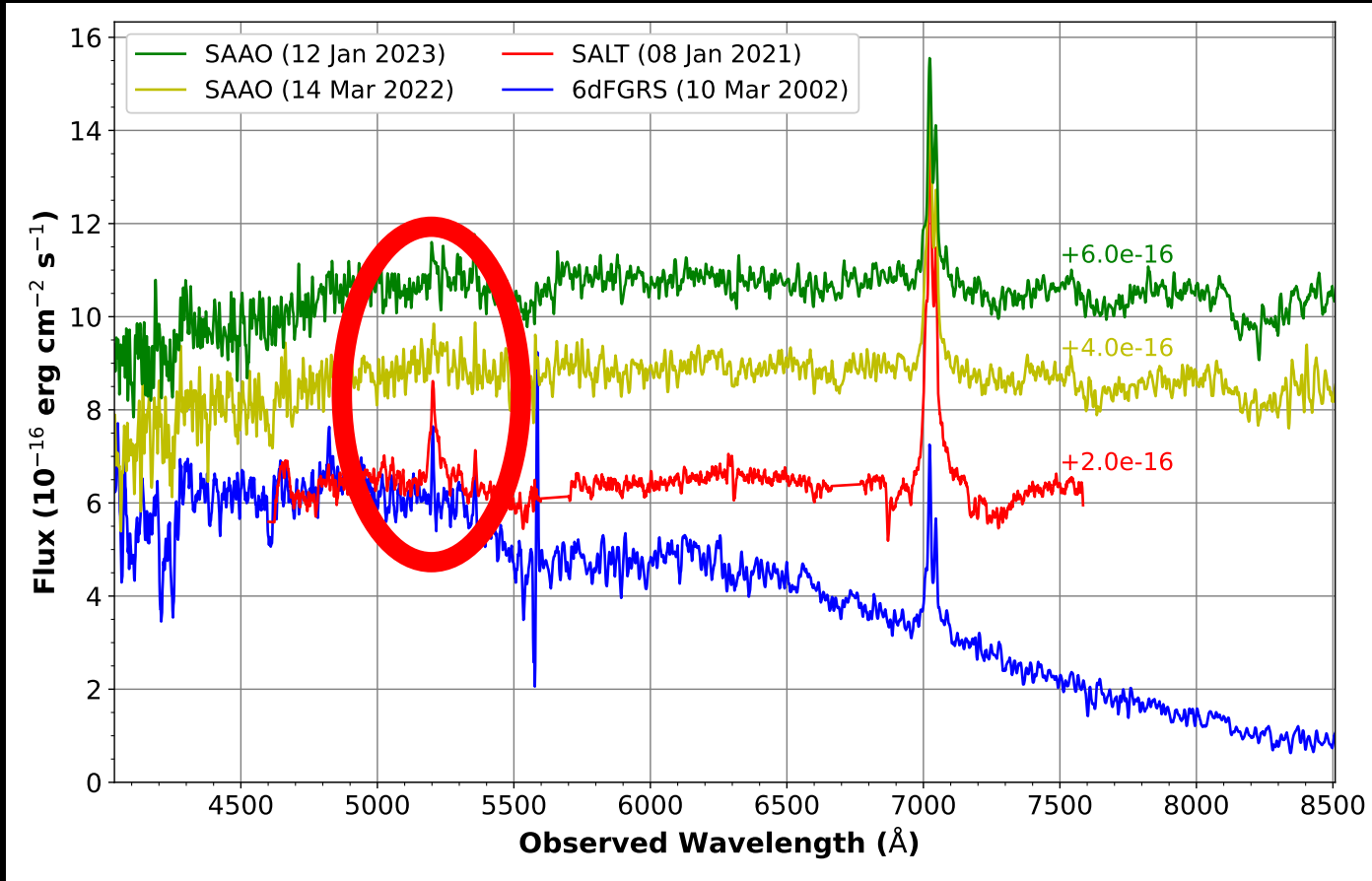


III – Spectroscopic followup



H β develops rapidly
Evolution on timescale
of weeks

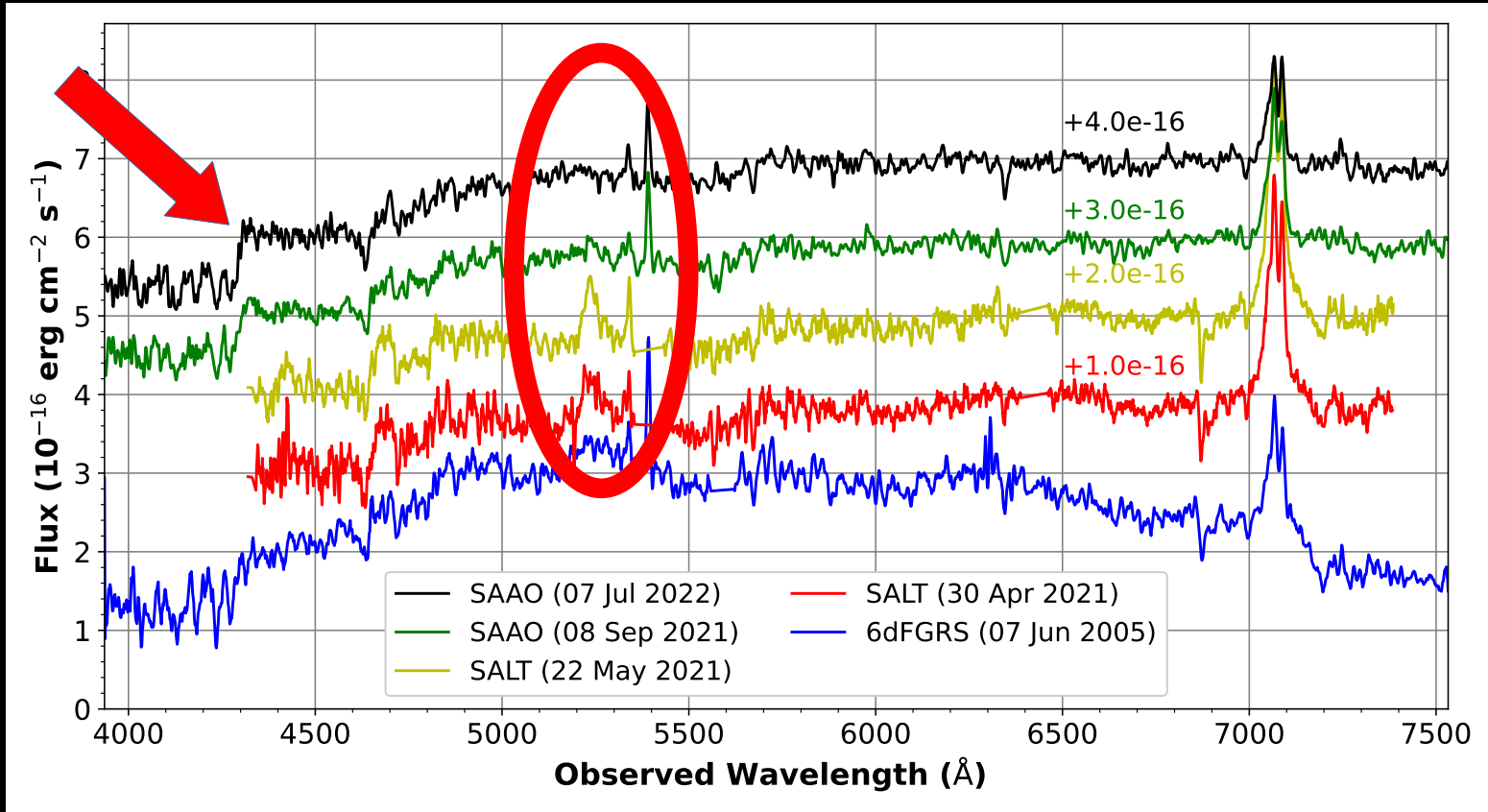
III – Spectroscopic followup



**SALT spectrum
~month after
ignition**

**Hbeta quicky
dissipates**

III – Spectroscopic followup

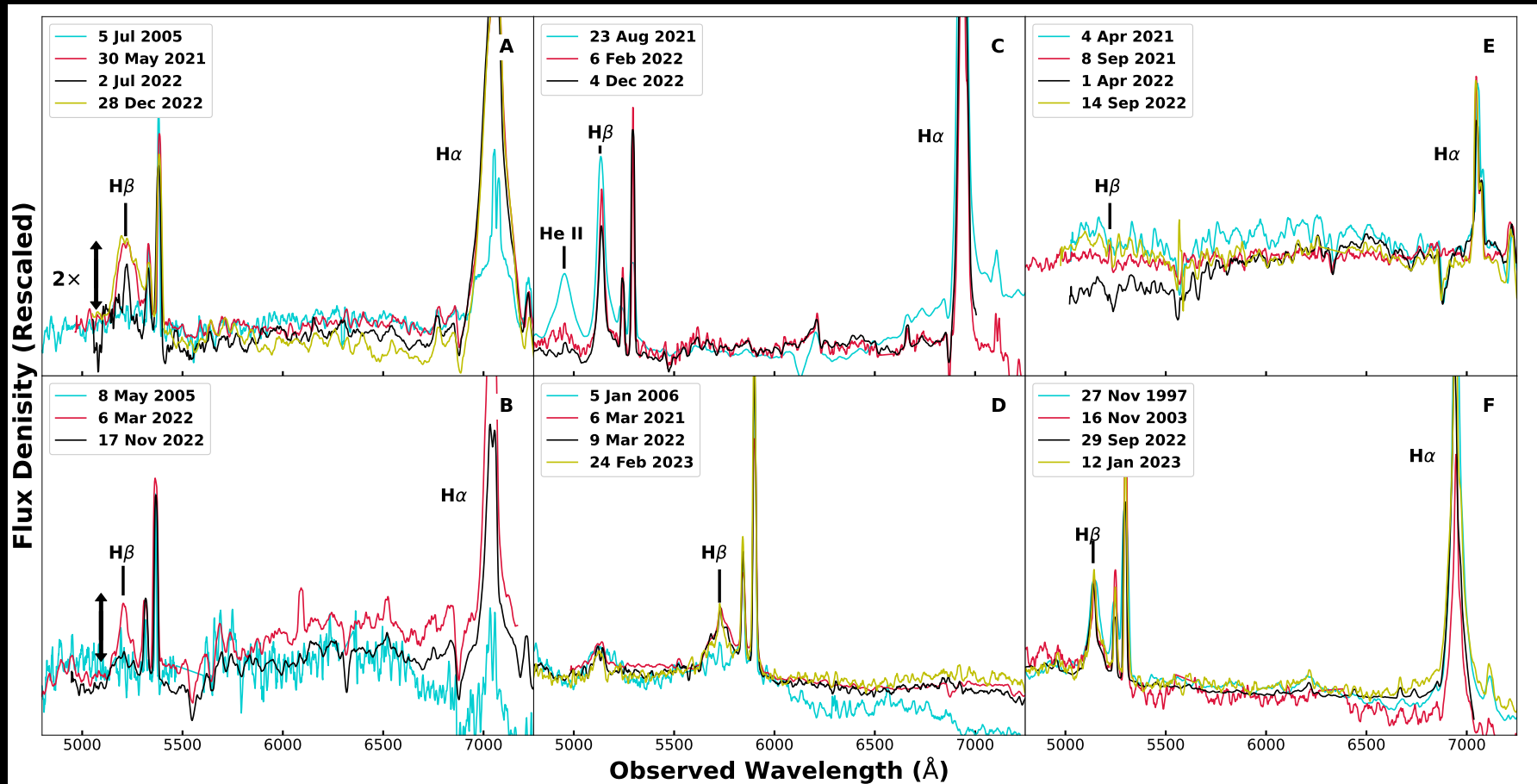


H β disappears ~months; no blue AGN continuum develops

III – Spectroscopy: Range of observed behaviours

X-ray
ignition

X-ray
shutdown



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Restless Nature of AGN: Extreme AGN Variability w/ eROSITA

Summary

extreme AGN variability: - changing-look/changing-state AGN
- timescales: as low months-years
- no “full” AGN ignition/AGN shutdown (?)

- I. Large variety of transients and timescales (weeks, months, years)
- II. Connection between X-ray var. & optical change shows wide range
- III. High-cadence studies of individual sources

=> Talk by A. Markowitz & Poster by T. Saha

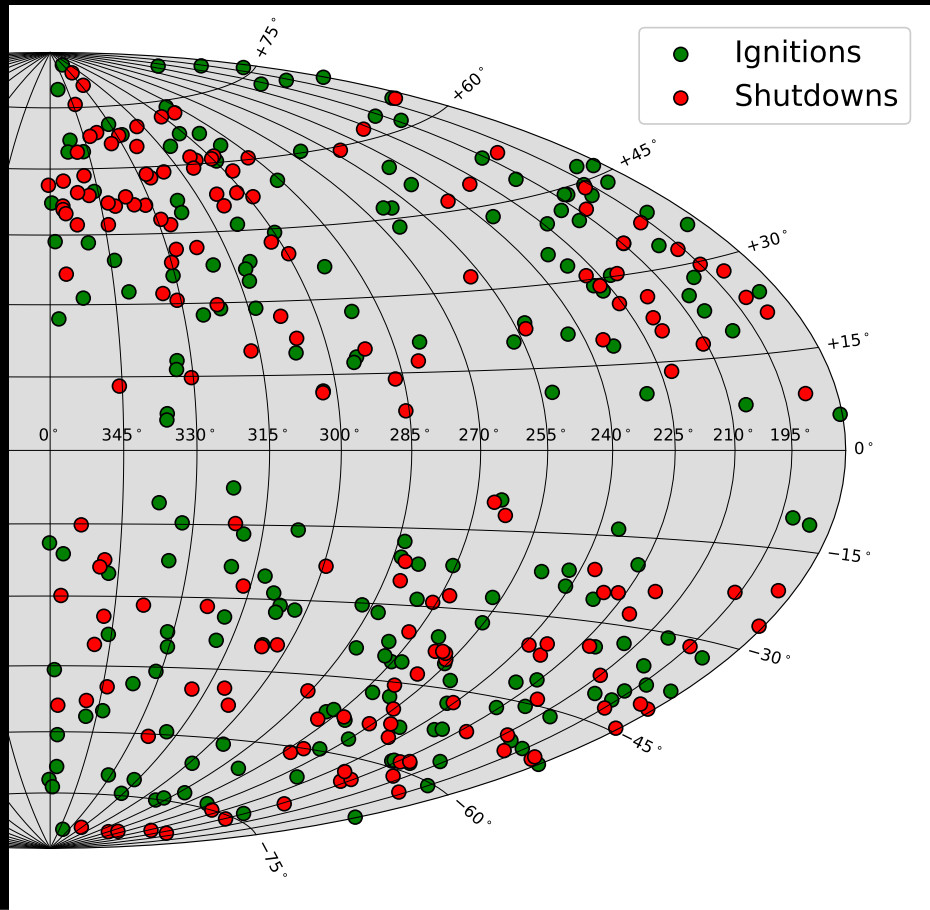
Extra Slides



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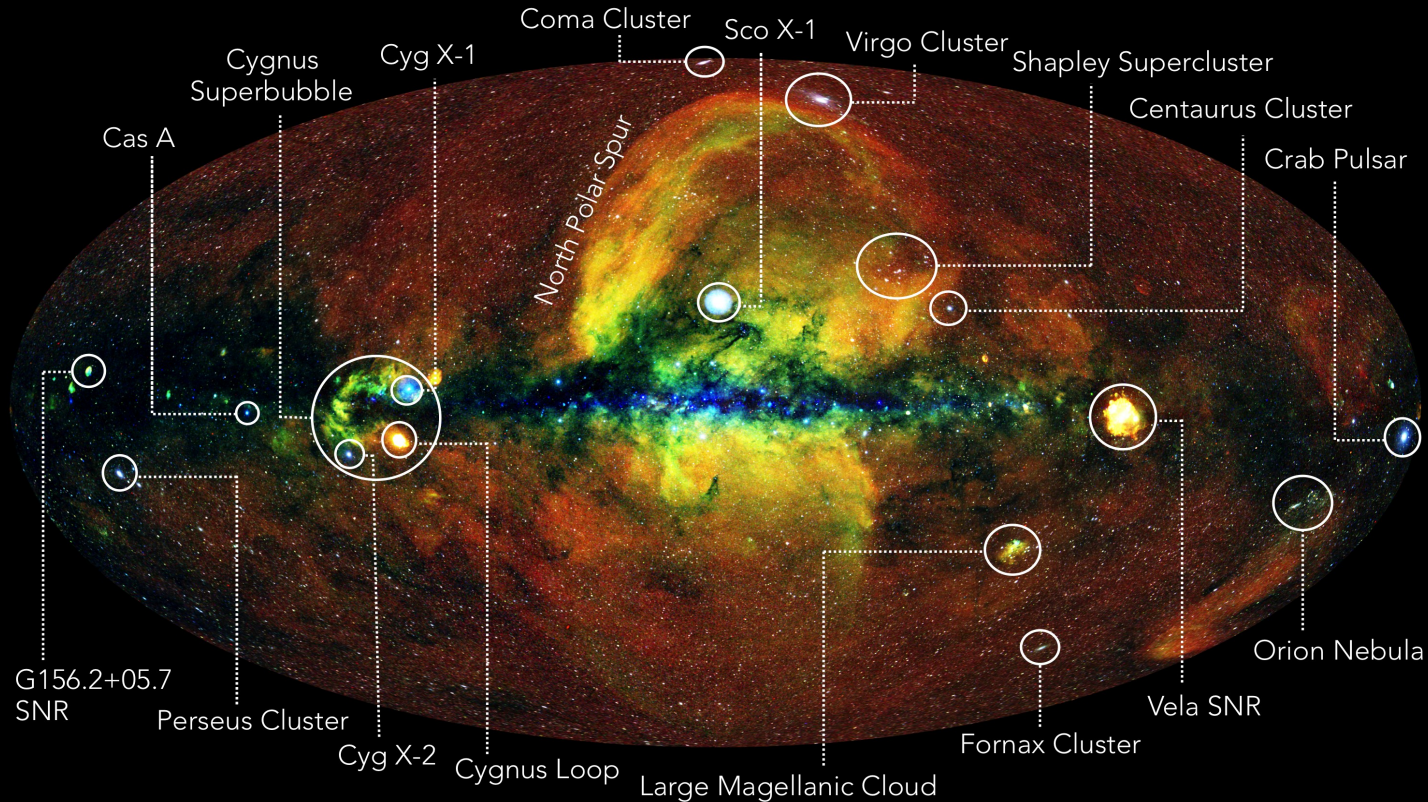
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Extra – Distribution Sources with Spec. Follow-up

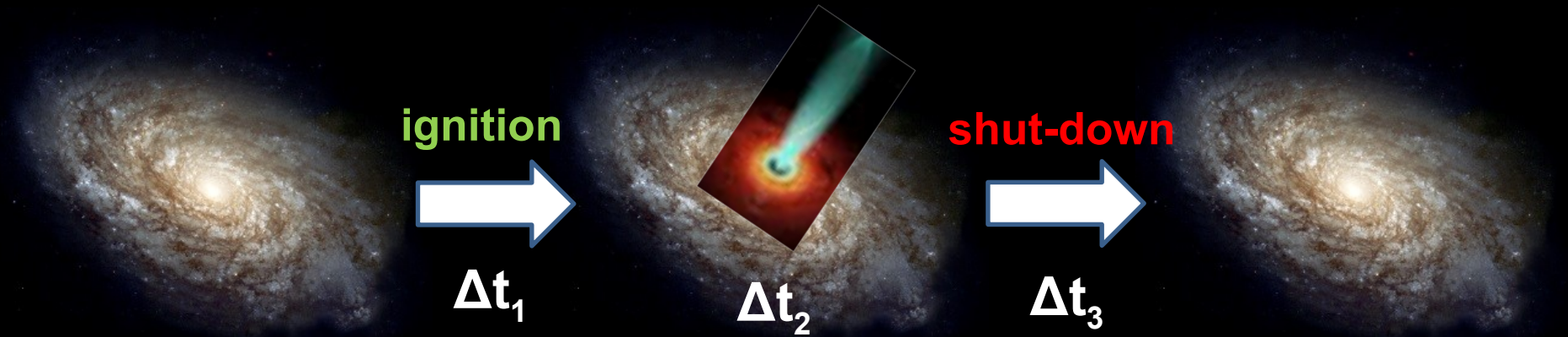


Extra - eRASS1 combined and annotated

Navigating the eROSITA X-ray sky

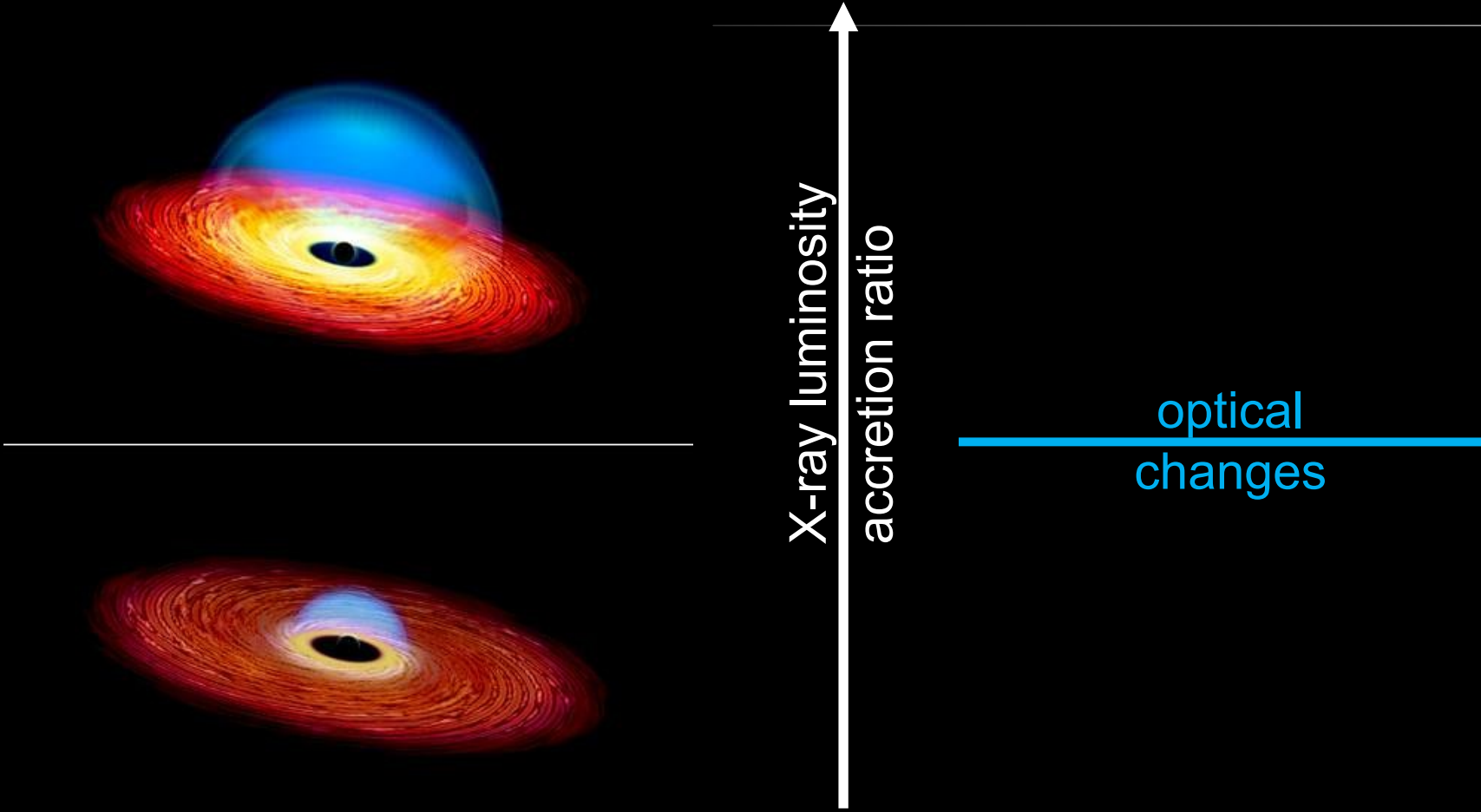


I – The extreme end of AGN variability (?)

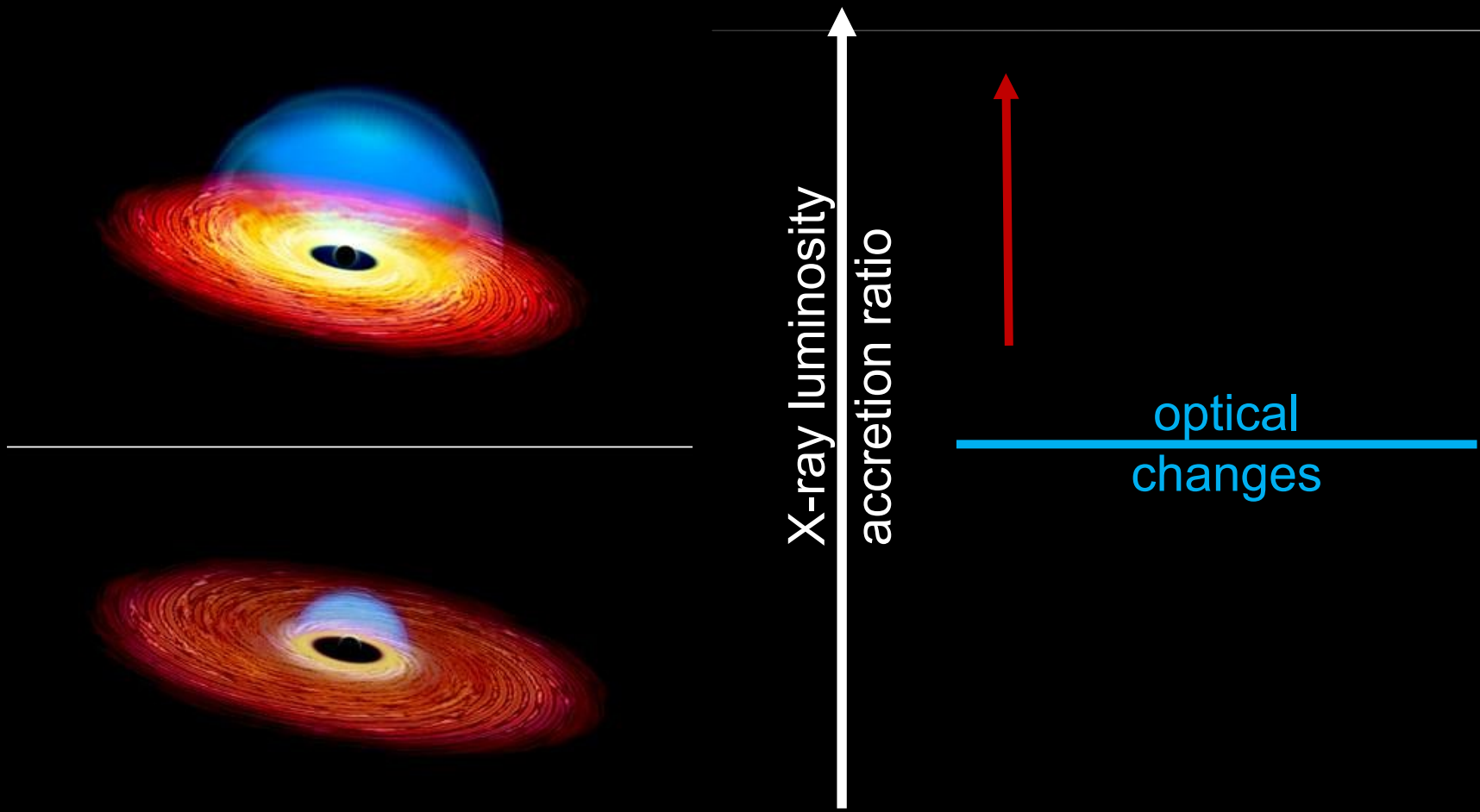


- AGN represent phases in the evolution of galaxies
 - AGN duty cycle poorly constrained
- Changing-state transitions can help us constrain Δt_1 & Δt_2

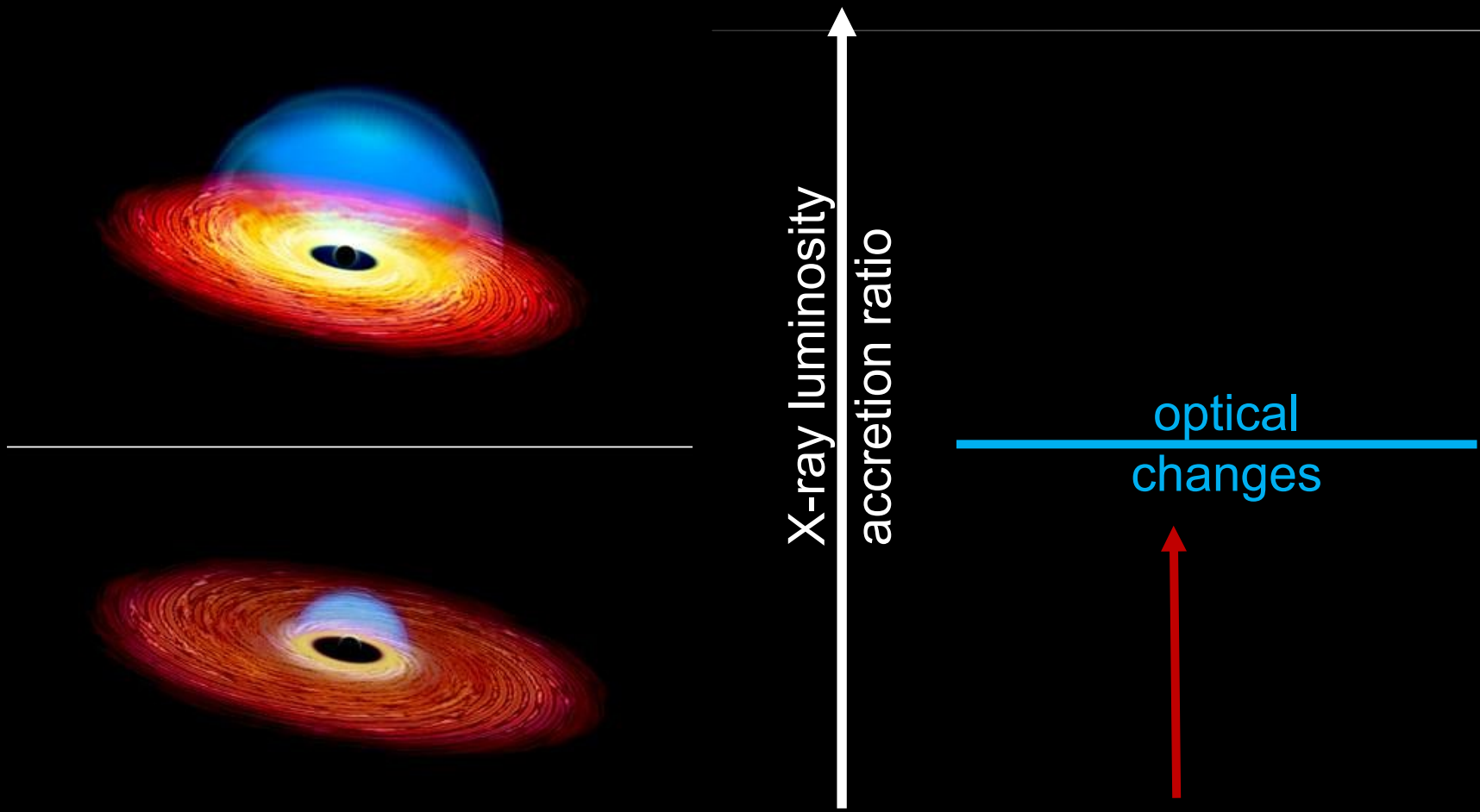
Changing state and Changing look



Changing state and Changing look



Changing state and Changing look



Changing state and Changing look

