

The highly variable story of the Ultraluminous X-ray source NGC 4559 X7

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Collaborators: C. Pinto, S. Motta, G. Israel, G. Rodriguez, R. Salvaterra,
E. Ambrosi, L. Zampieri & many others

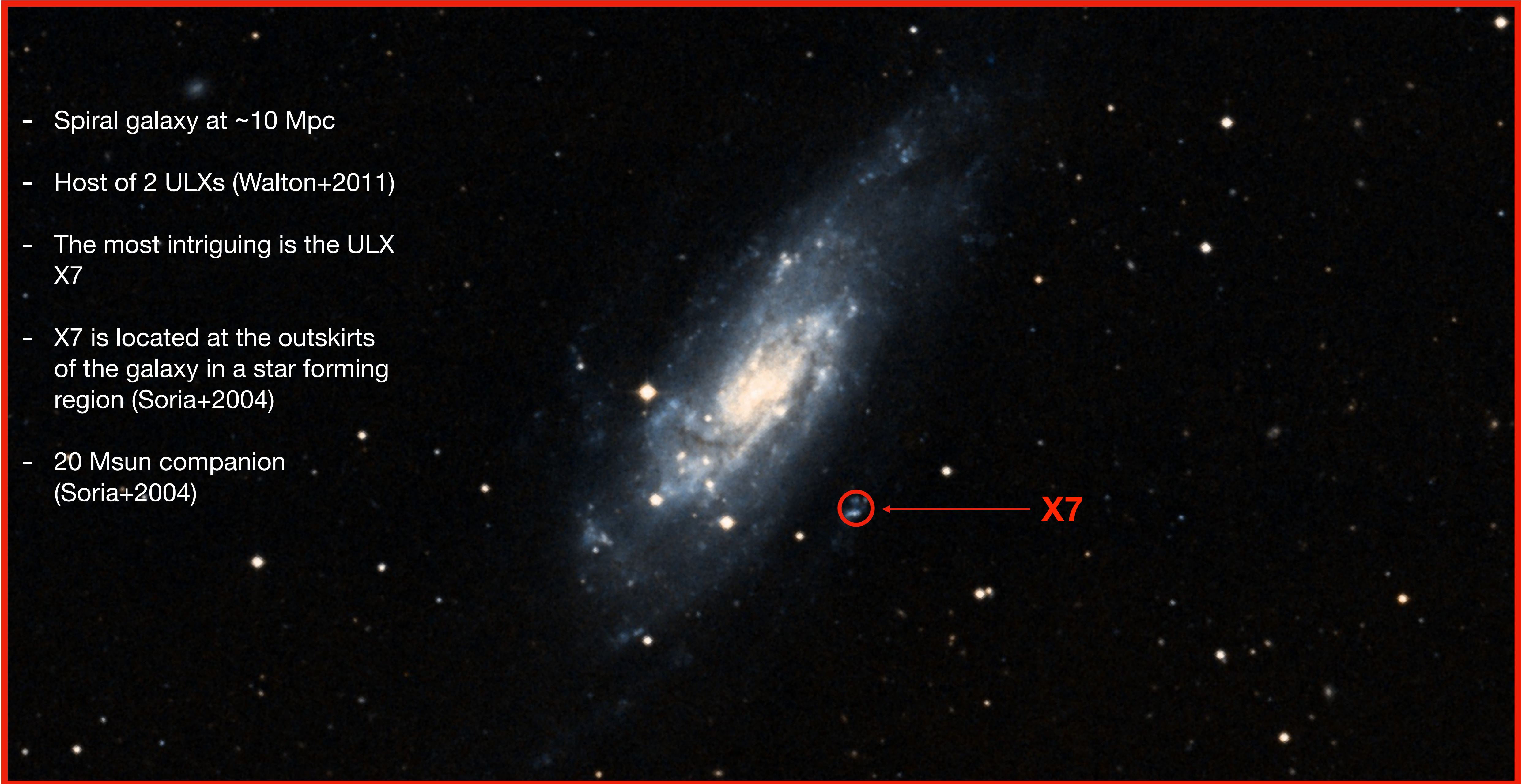


CONGRESSO
NAZIONALE
OGGETTI
COMPATTI

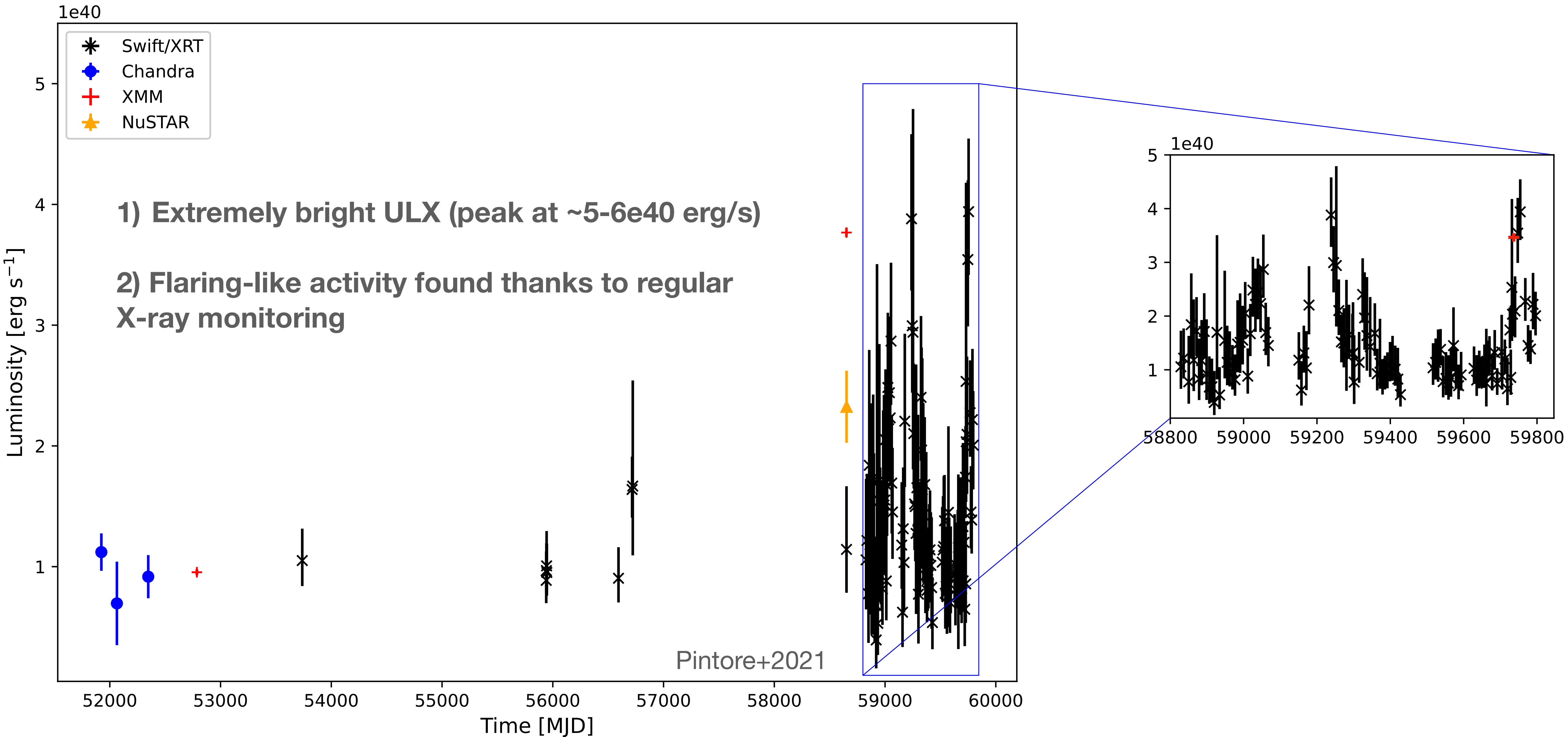


NGC 4559

- Spiral galaxy at ~10 Mpc
- Host of 2 ULXs (Walton+2011)
- The most intriguing is the ULX X7
- X7 is located at the outskirts of the galaxy in a star forming region (Soria+2004)
- 20 Msun companion (Soria+2004)

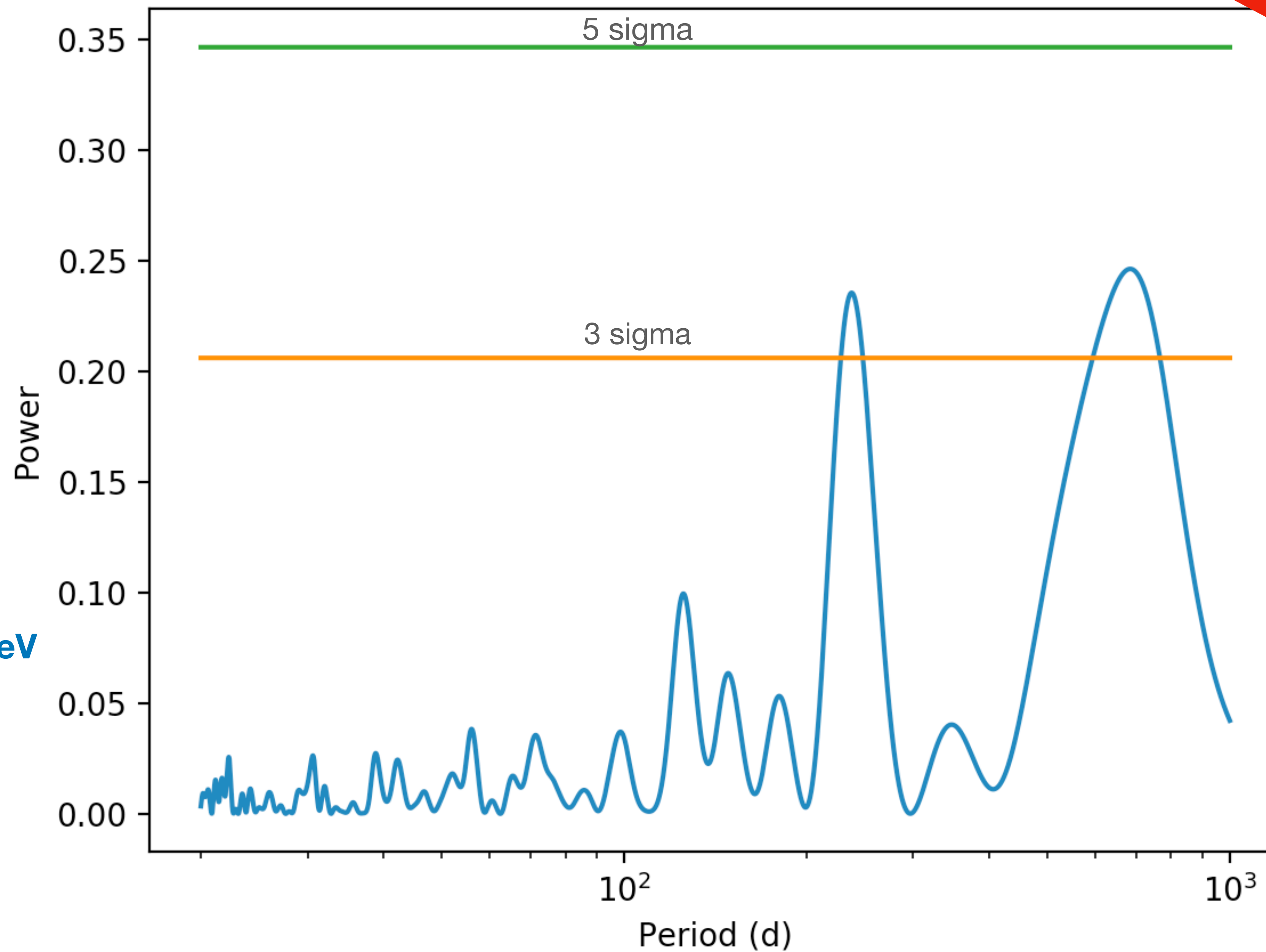


X7: Long-term X-ray lightcurve



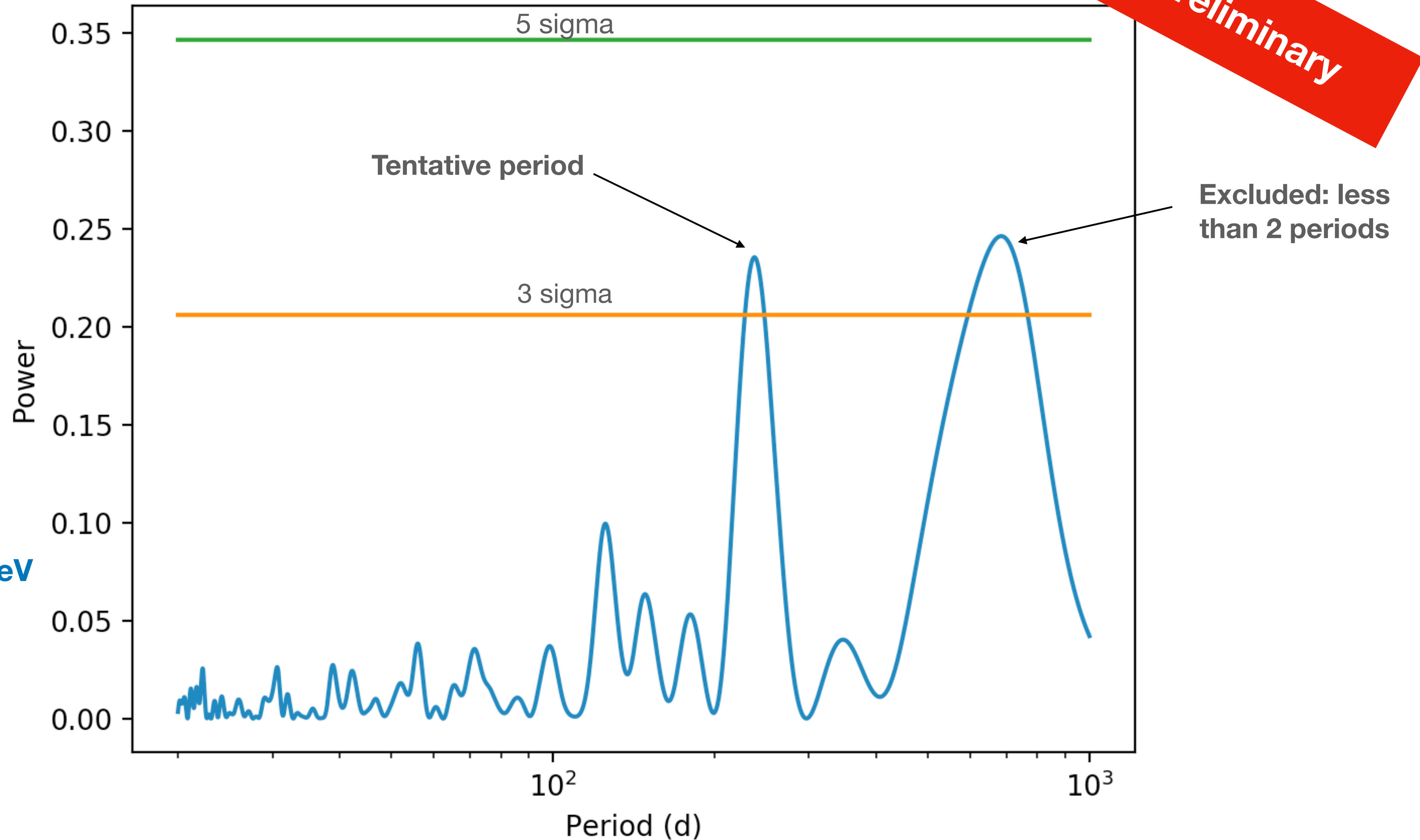
Lomb-Scargle analysis

Preliminary



Swift/XRT: 1-10 keV

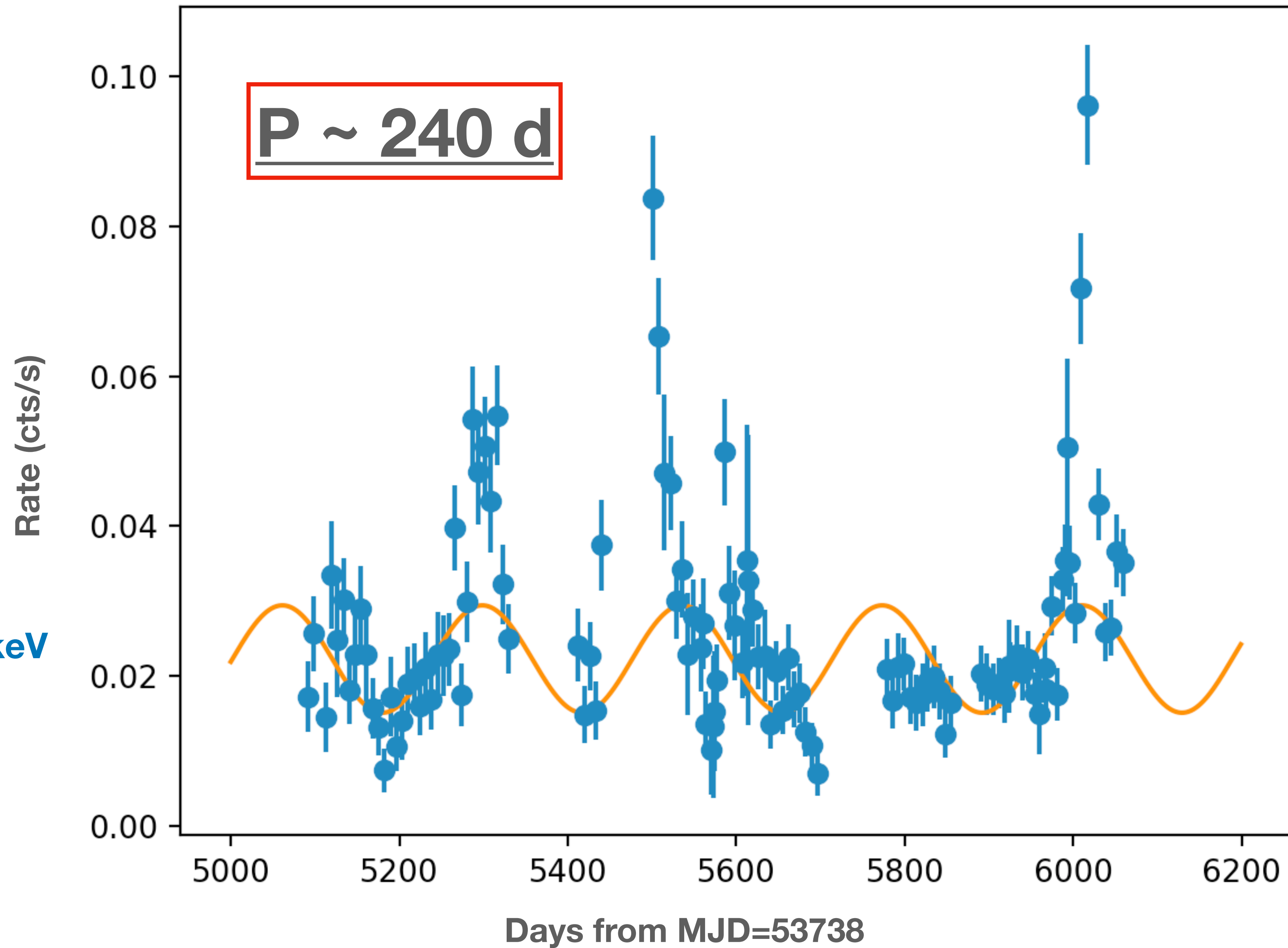
Lomb-Scargle analysis



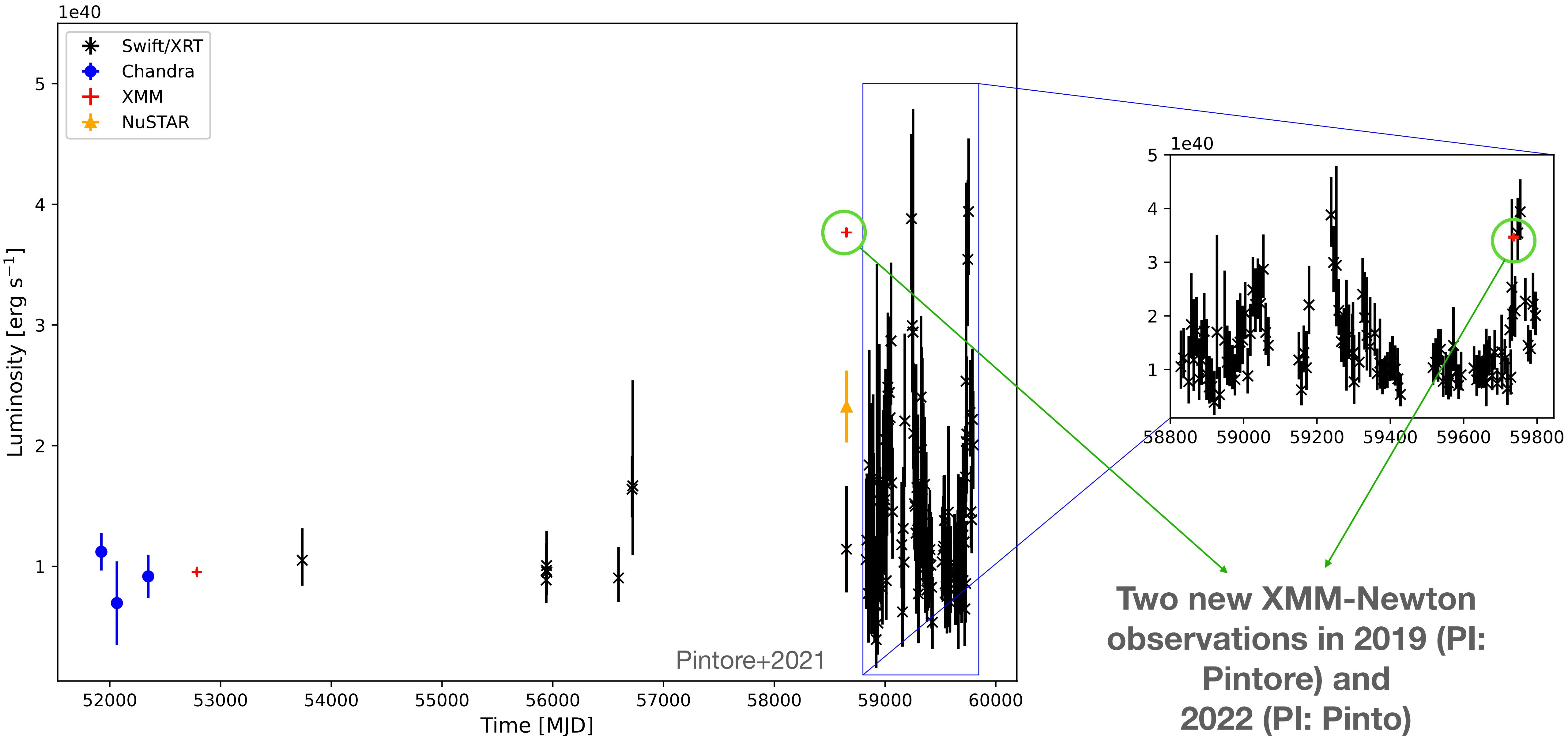
Lomb-Scargle analysis

Preliminary

Swift/XRT: 1-10 keV

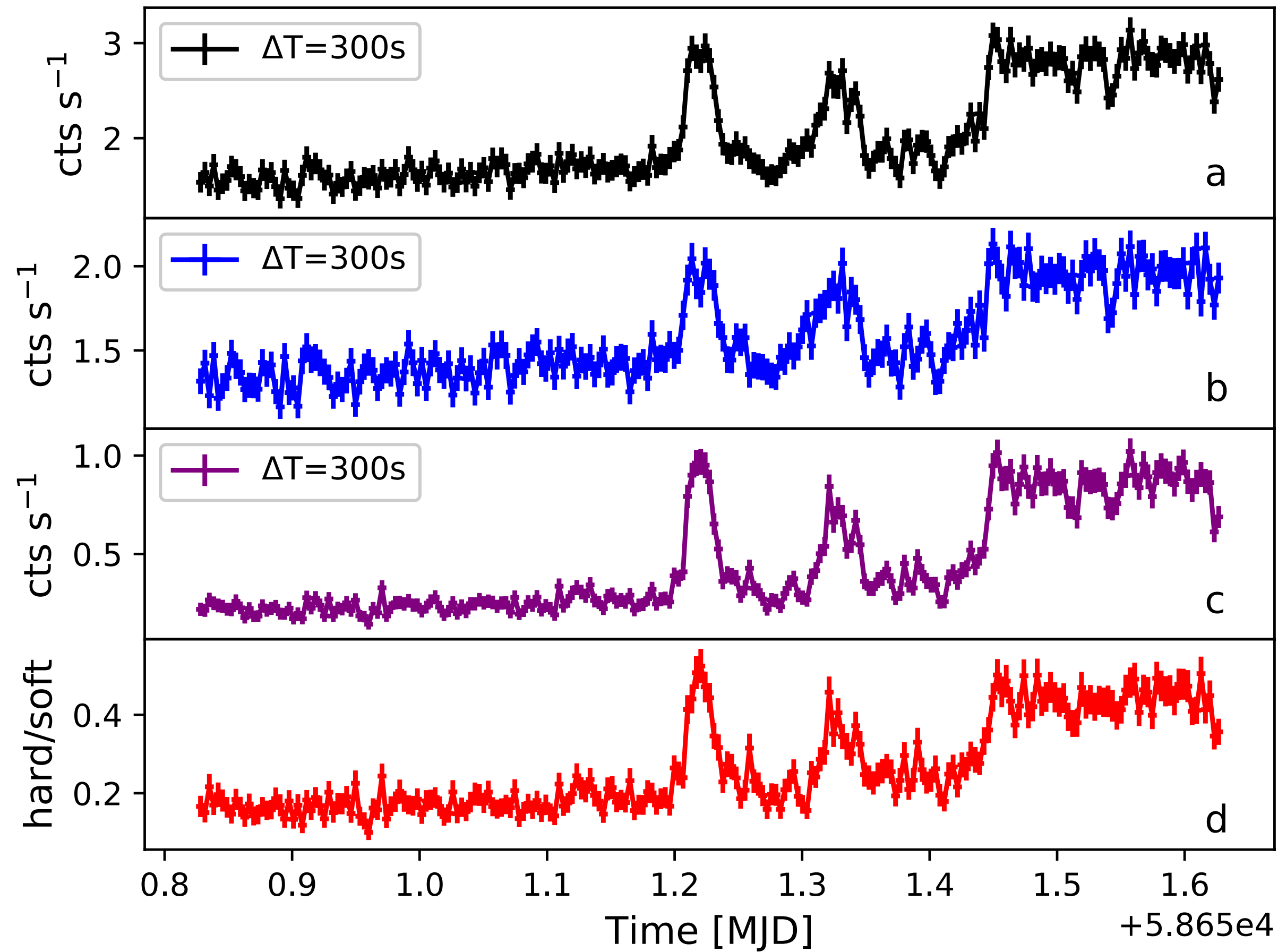


X7: Long-term X-ray lightcurve

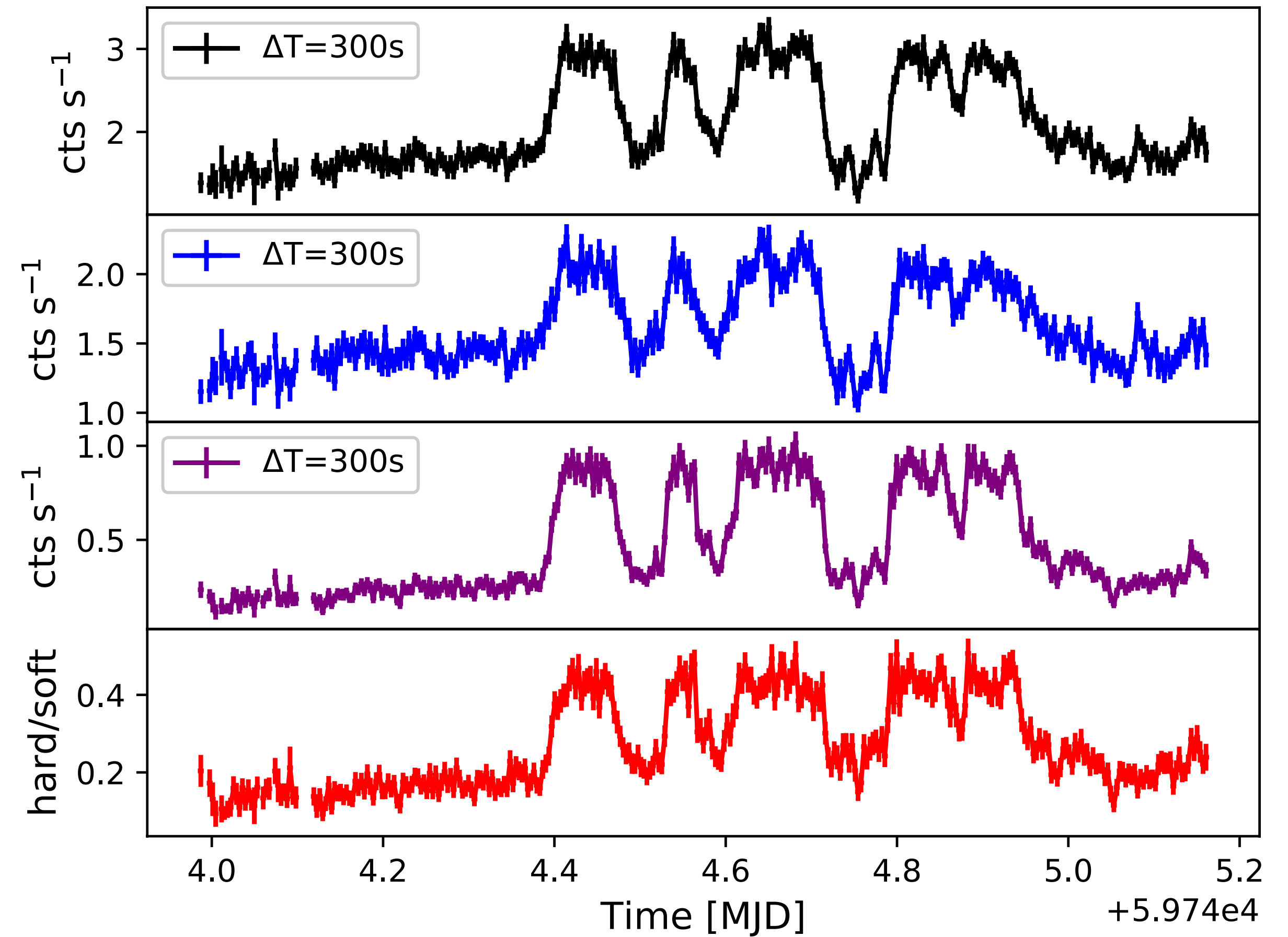


Very rare flaring activity

XMM-Newton (0842340201)
16/06/2019

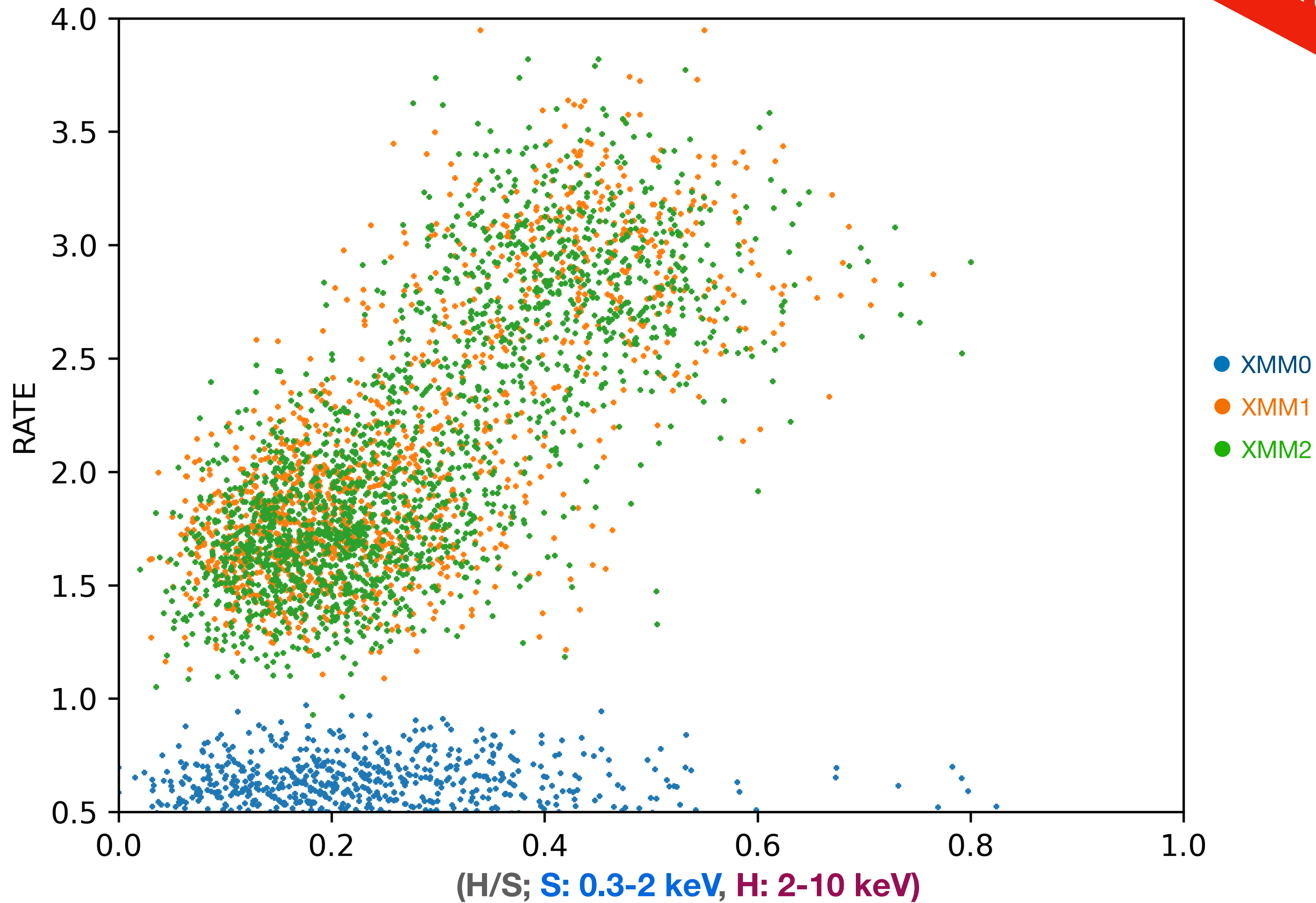


XMM-Newton (0883960201)
13/06/2022



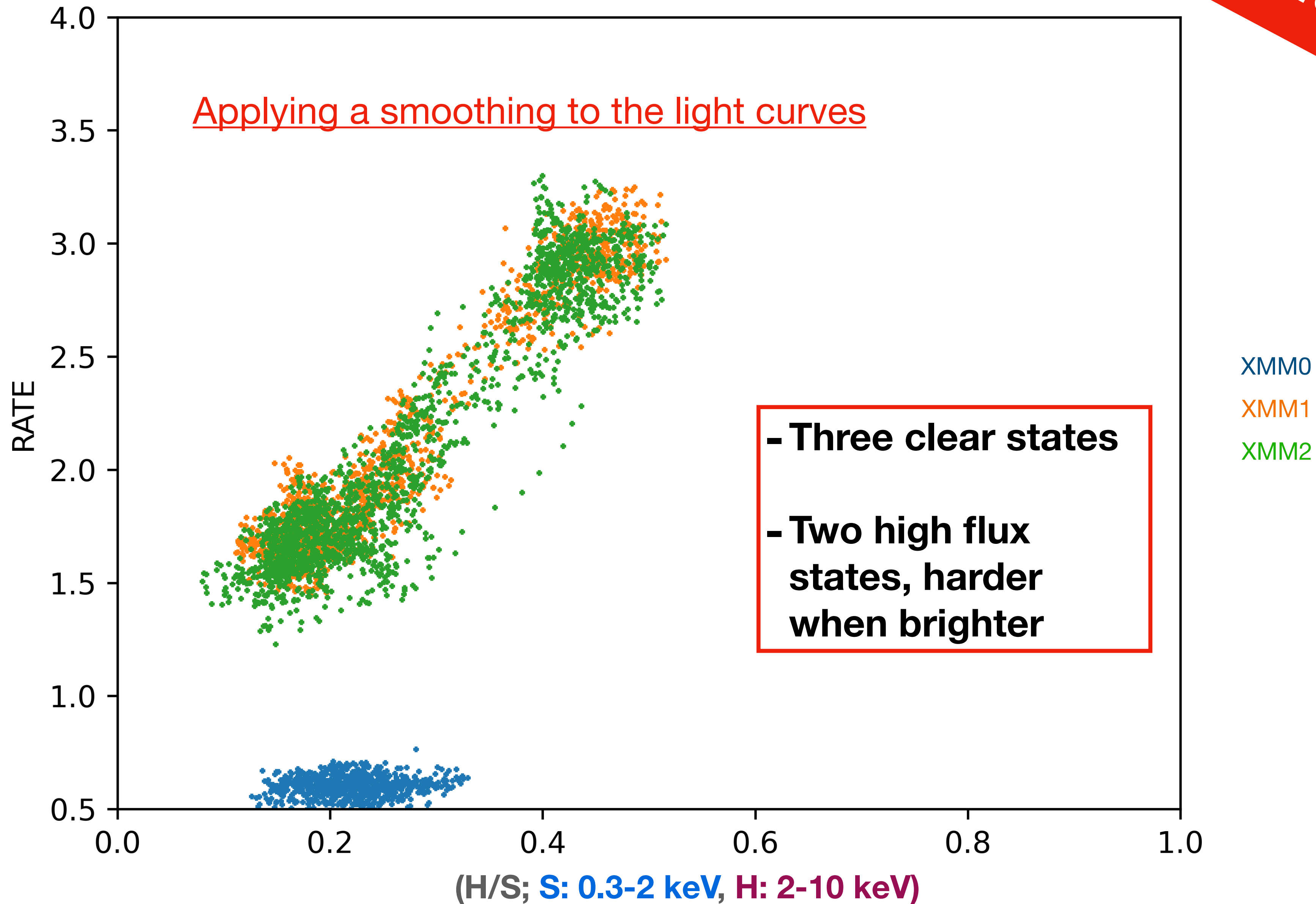
TOT: 0.3-10 keV,
Soft: 0.3-2 keV, Hard: 2-10 keV

Hardness-Intensity diagram

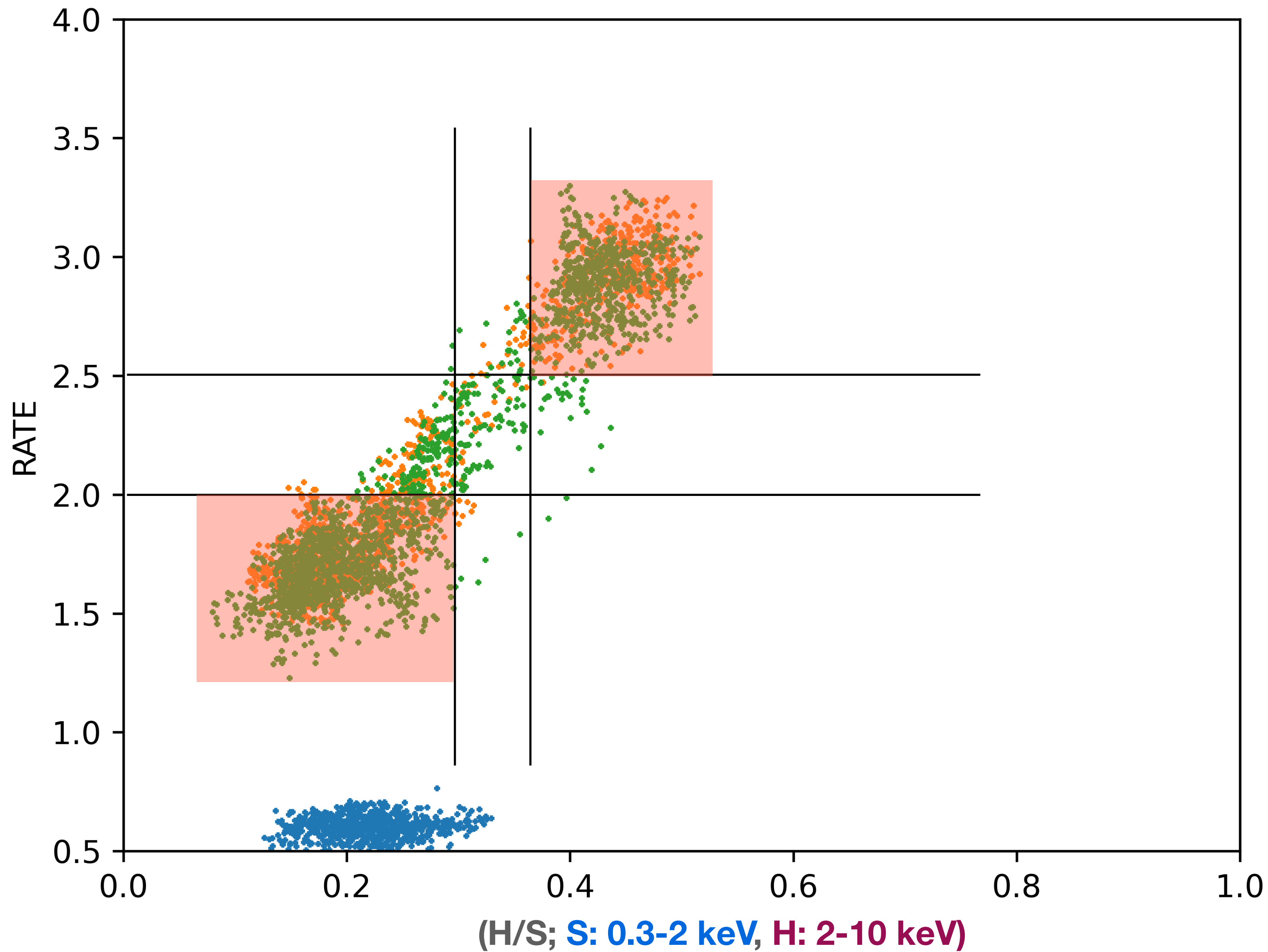


Hardness-Intensity diagram

Preliminary

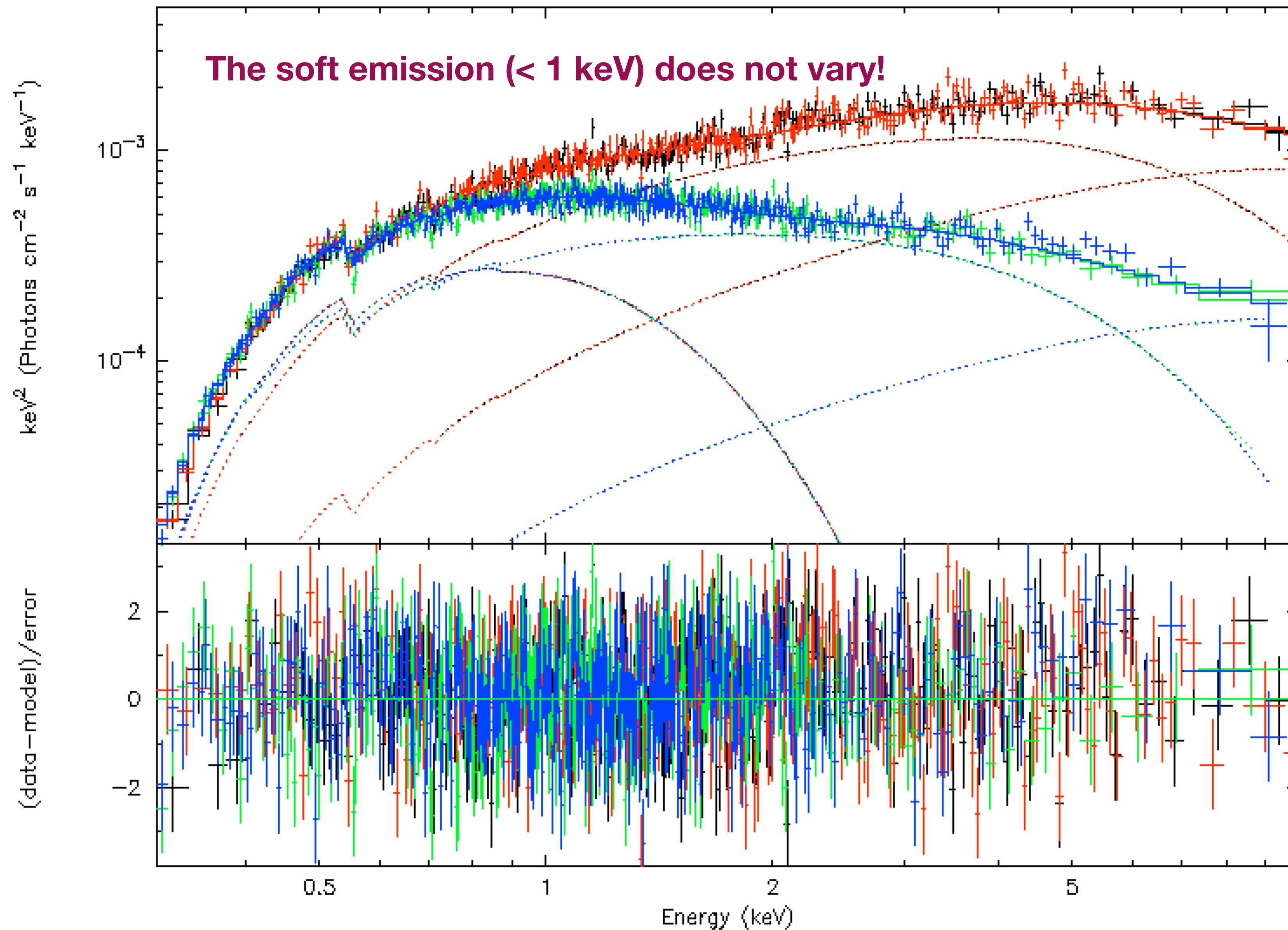


Hardness-Intensity diagram



HID-resolved spectroscopy

Preliminary



Red: pn+mos of the 2019 obs.

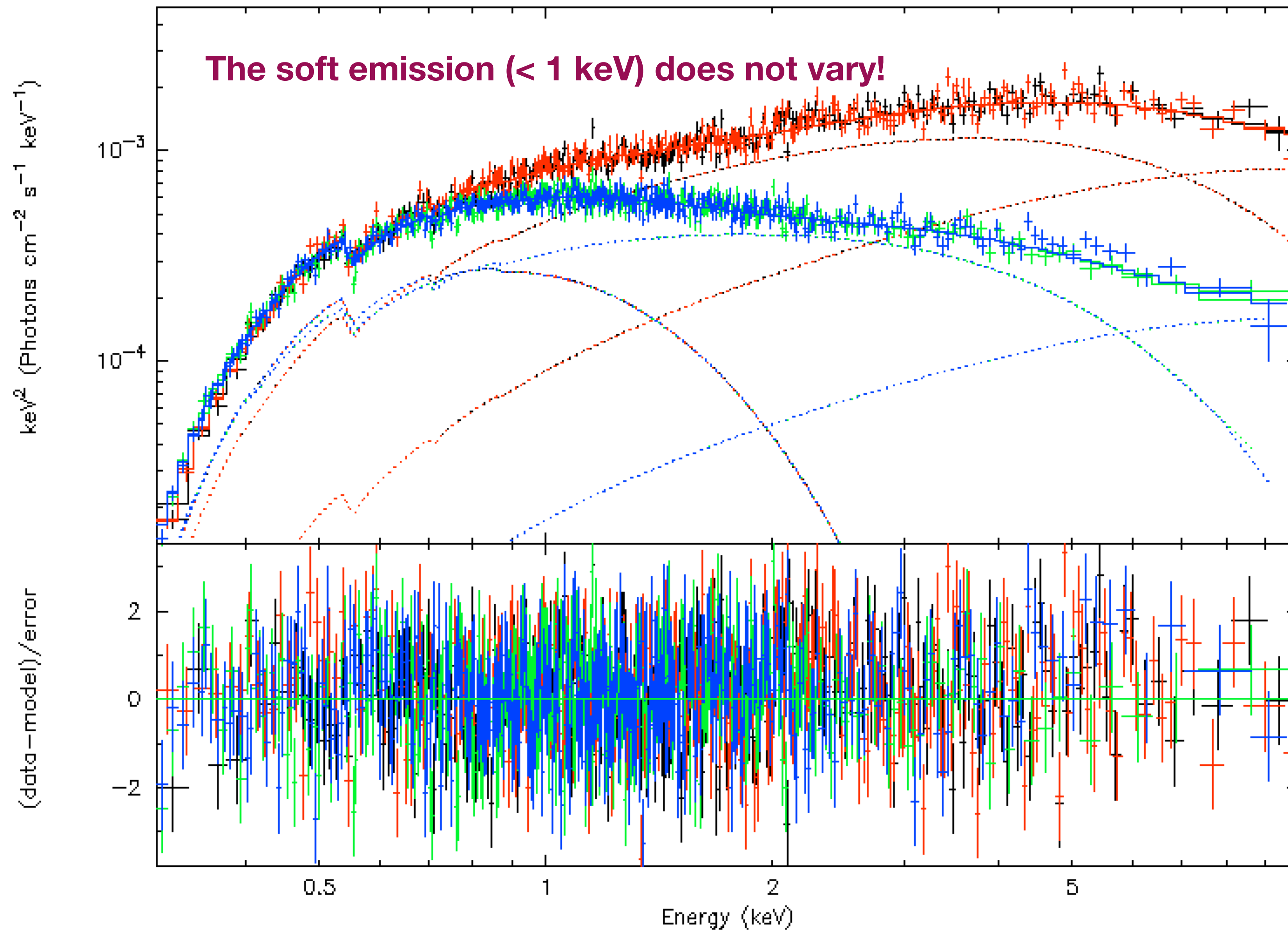
Black: pn+mos of the 2022 obs.

Green: pn+mos of the 2019 obs.

Blue: pn+mos of the 2022 obs.

HID-resolved spectroscopy

Preliminary



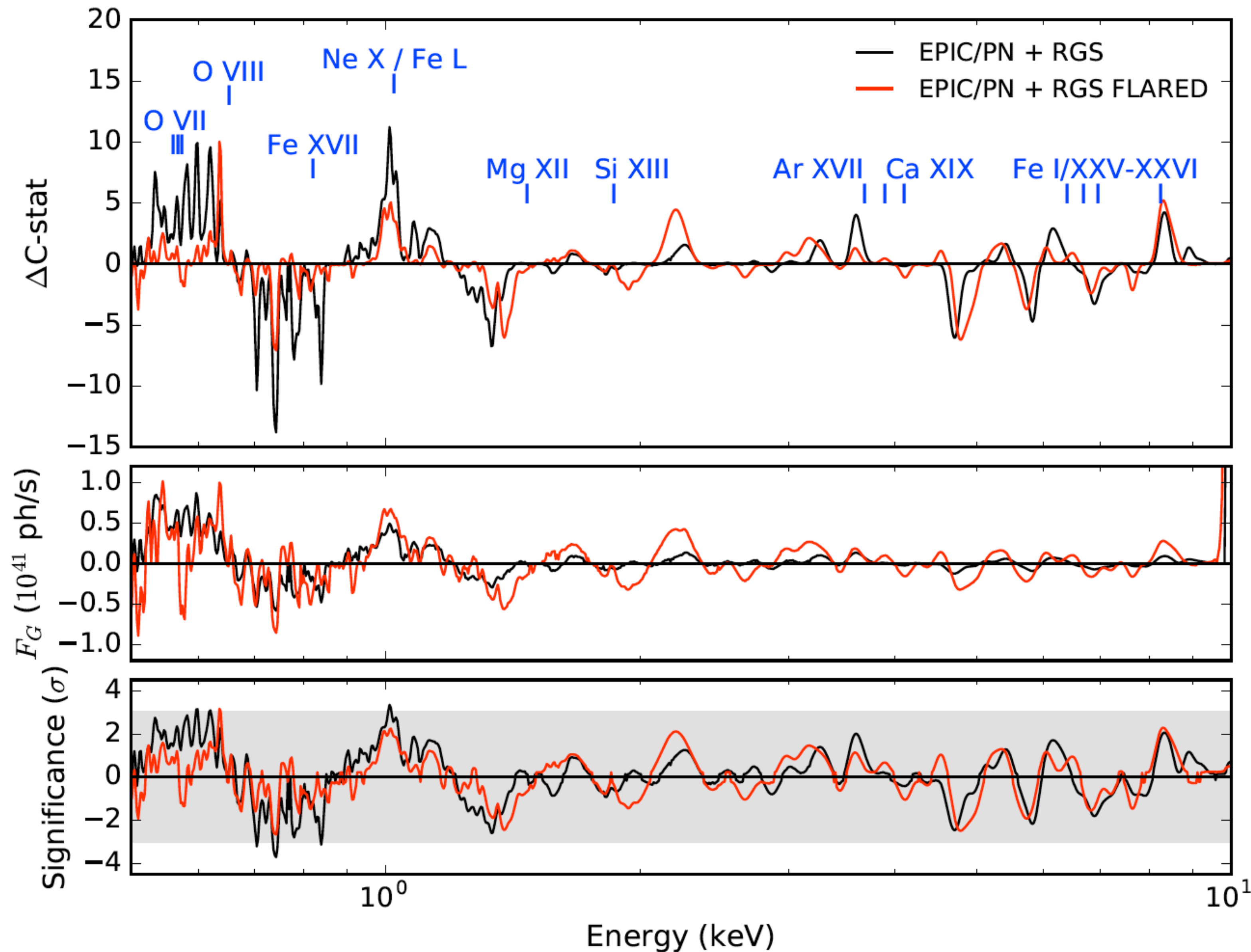
Red: pn+mos of the 2019 obs.
Black: pn+mos of the 2022 obs.

Green: pn+mos of the 2019 obs.
Blue: pn+mos of the 2022 obs.

Best-fit
-soft disk (~ 0.3 keV)
-Hard thick disk ($\sim 1.5/2$ keV)
-Cut-off powerlaw

$L_{\text{x_flare}} \sim 6\text{e}40$ erg/s
 $L_{\text{x_low}} \sim 3\text{e}40$ erg/s

High-resolution spectroscopy

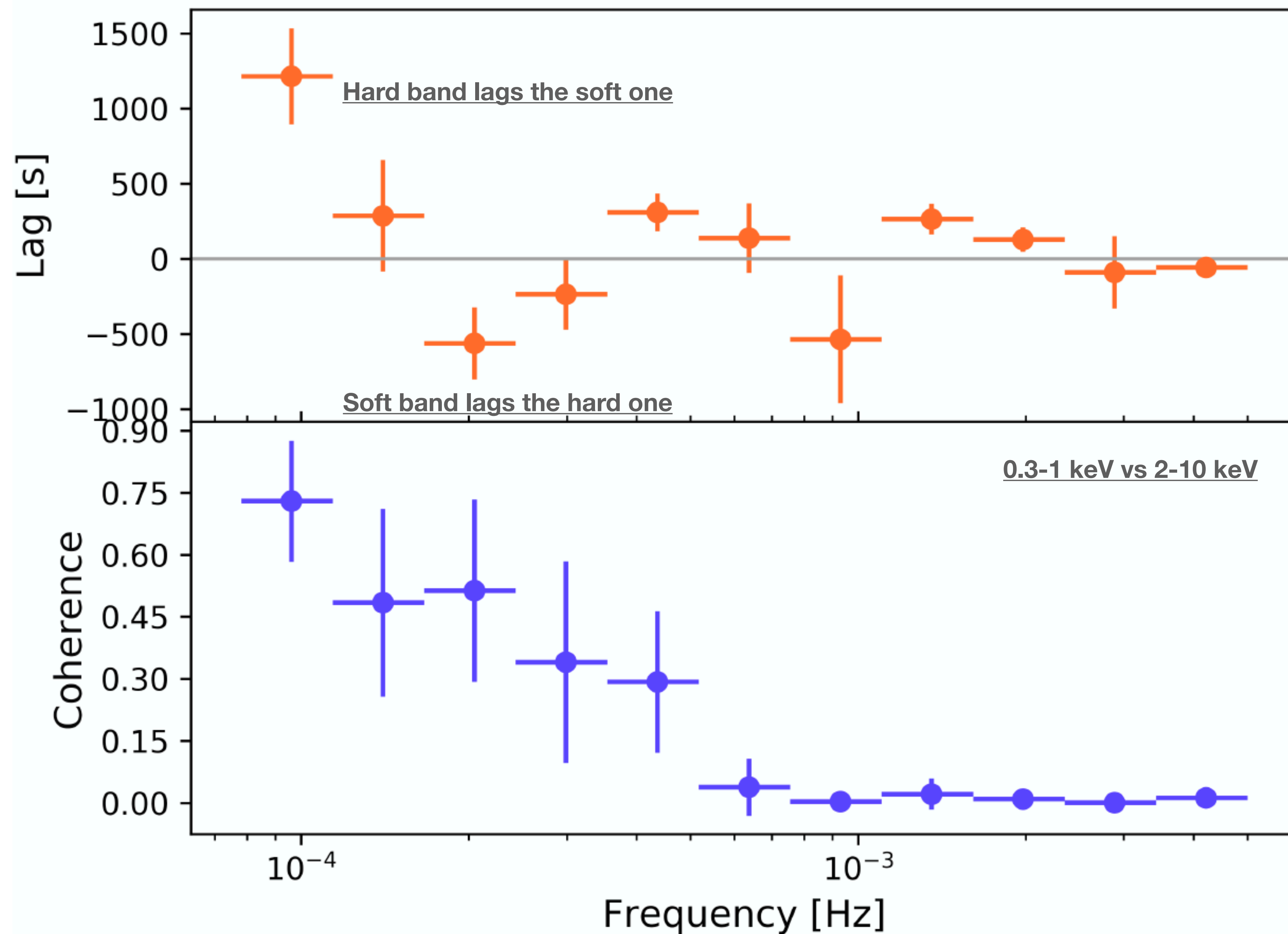


2019 XMM-Newton observation only

2022 observation: to be done!

Narrow absorption and emission lines were found in the RGS spectra, suggesting the presence of an outflow.

Time lags

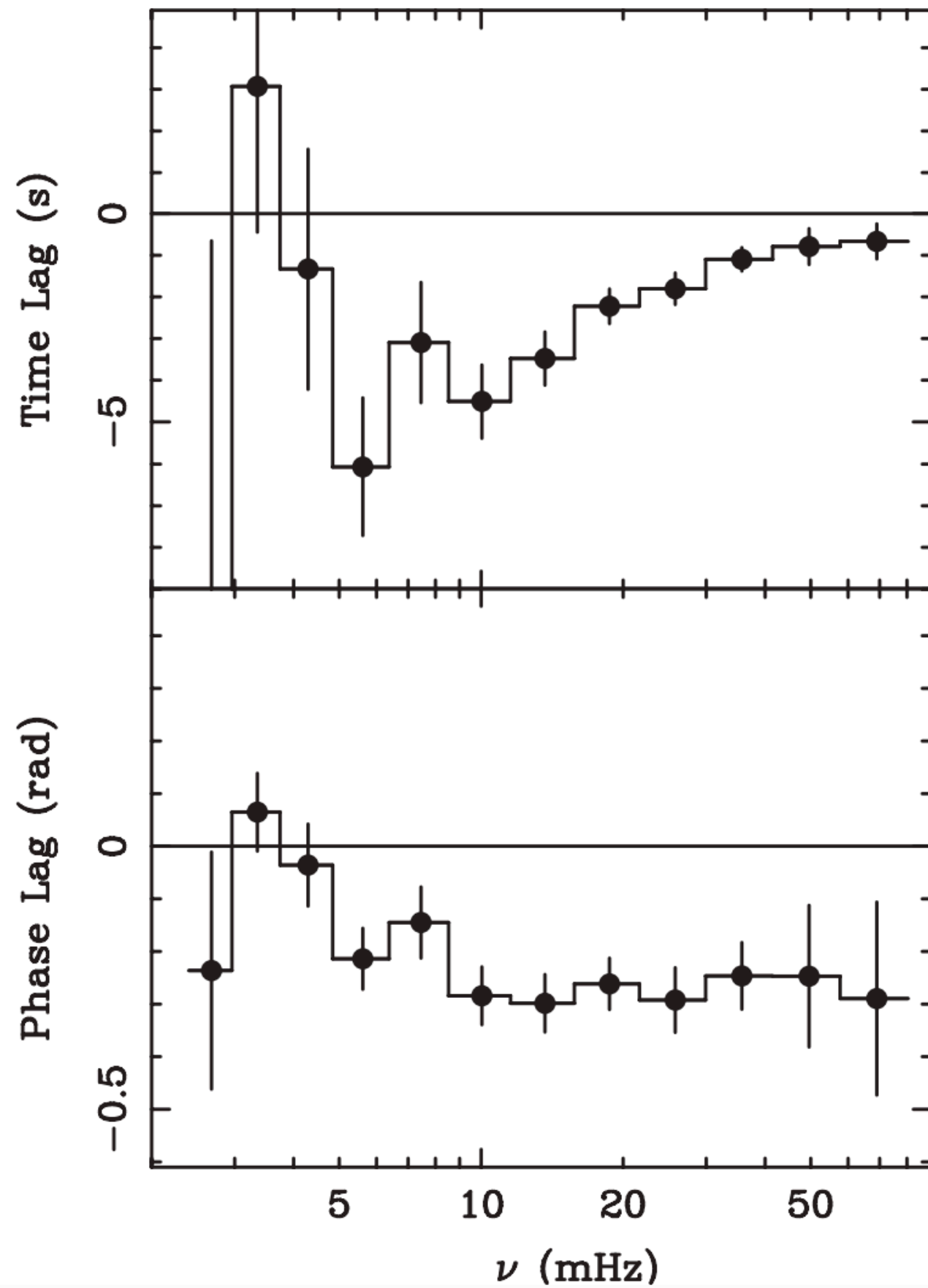


2019 XMM-Newton observation only

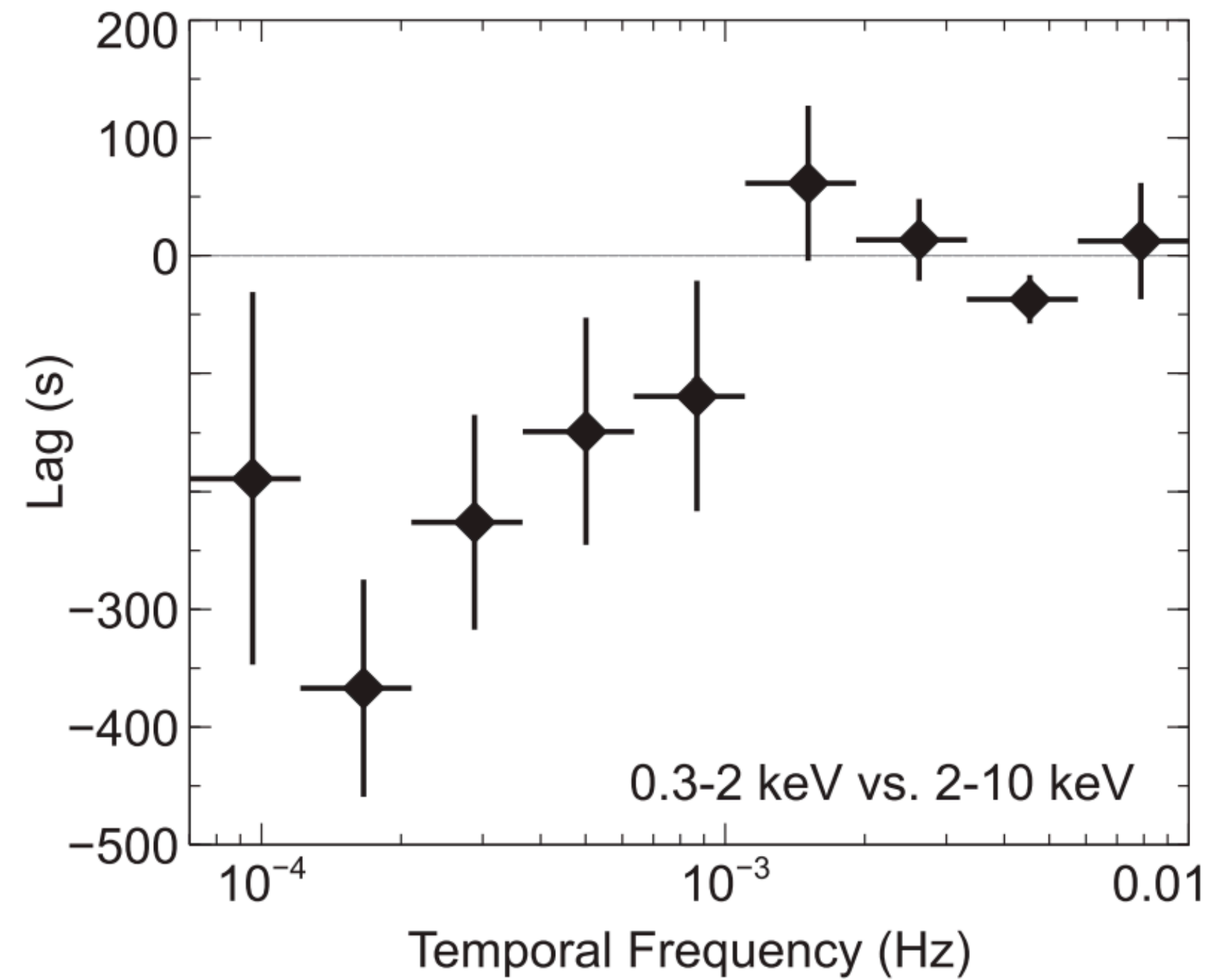
2022 observation: to be performed!

Detection of soft and hard lags of hundreds of seconds

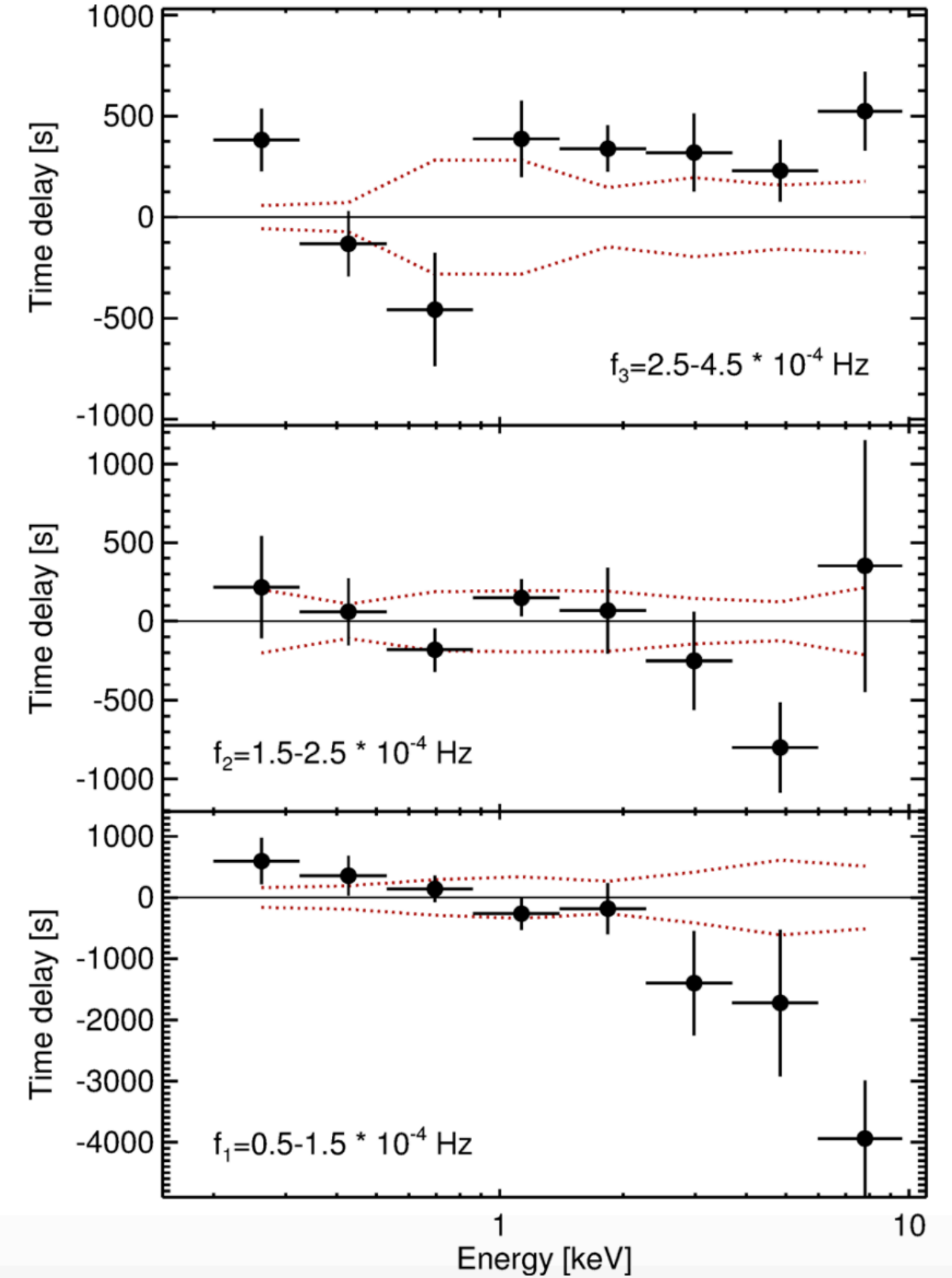
Time lags in other ULXs



NGC 5408 X-1; De Marco+2013



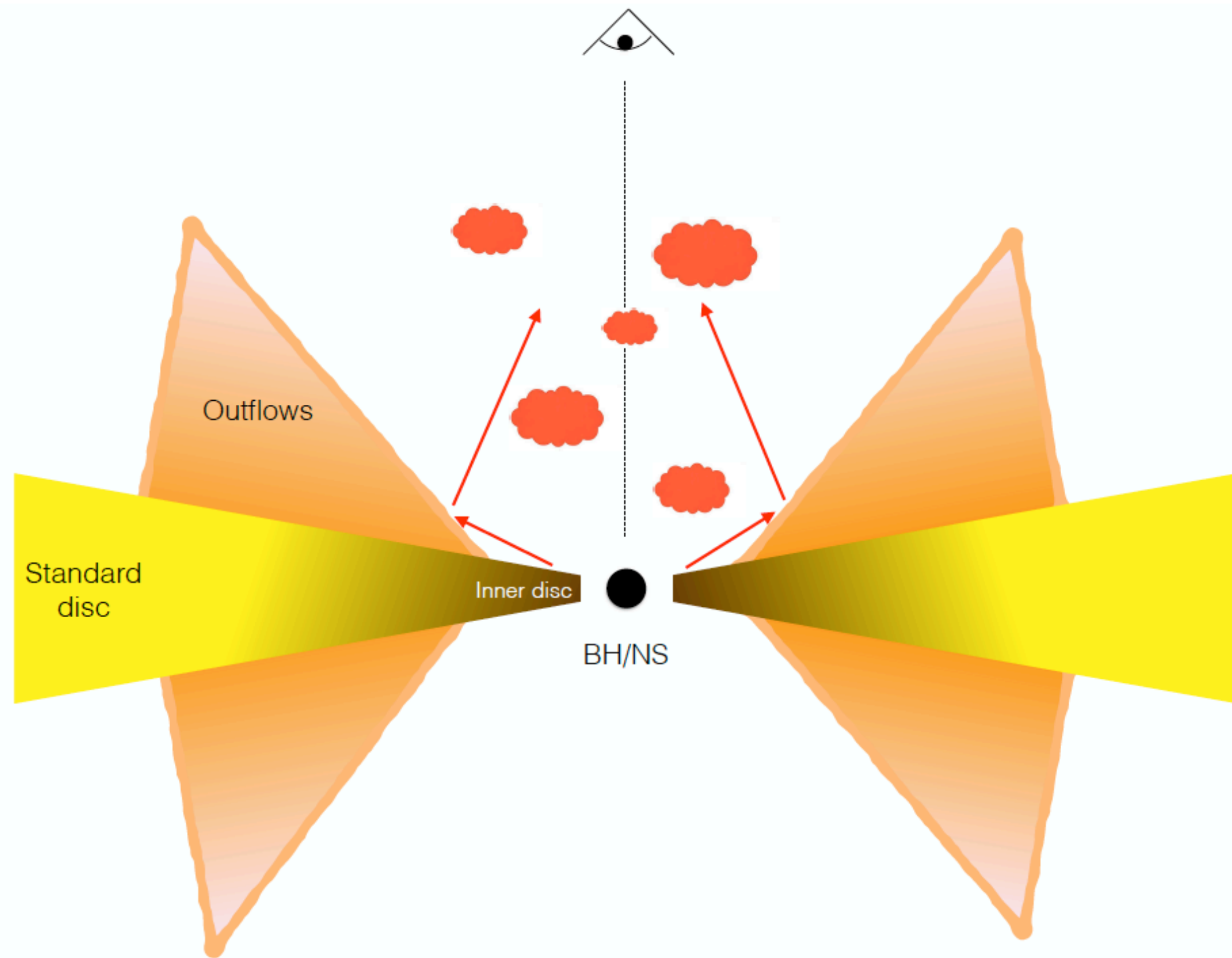
NGC 1313 X-1; Kara+2021



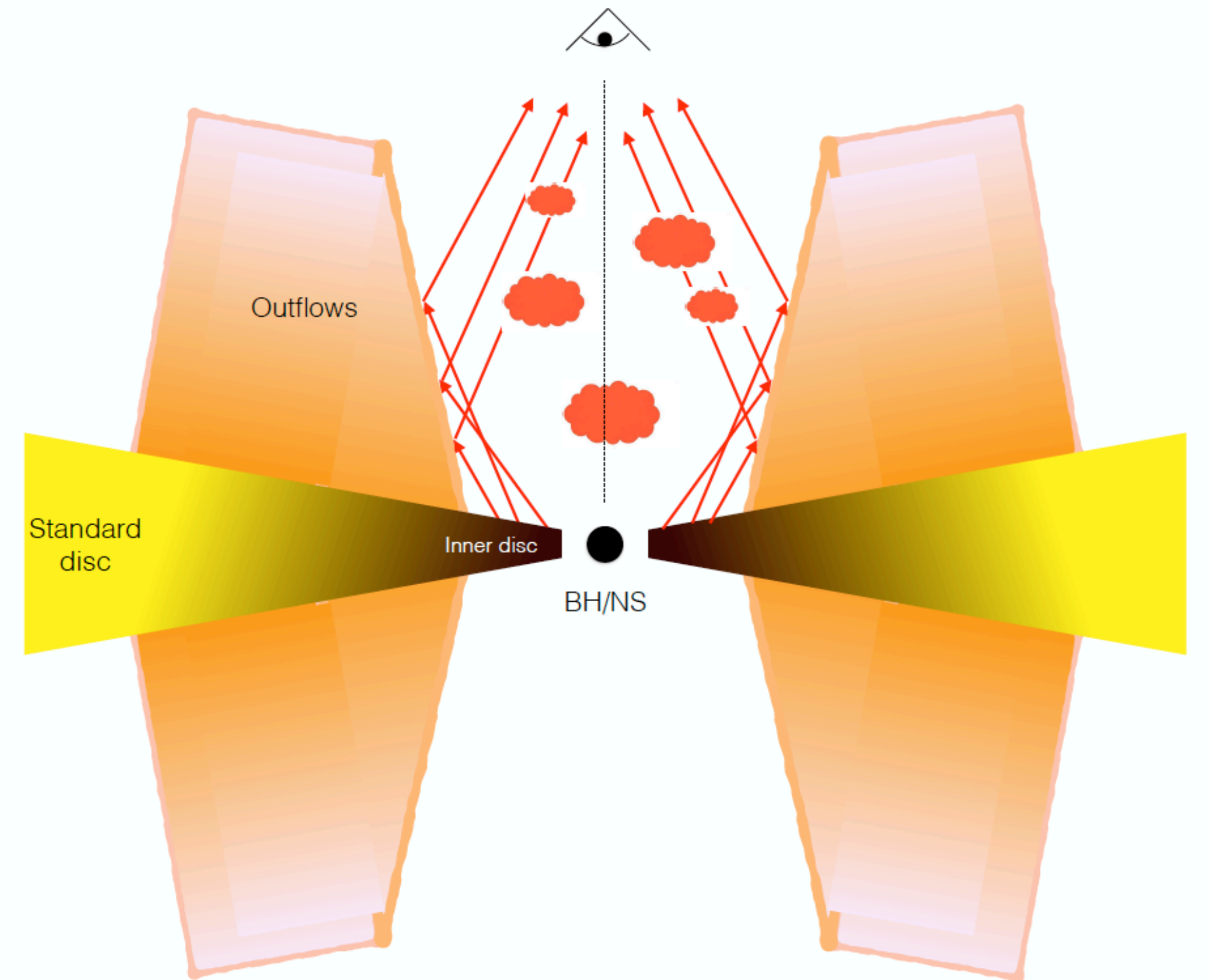
NGC 55 X-1; Pinto+2017

Possible interpretation of NGC 4559 X7

Super-Eddington accretion on a stellar mass compact object



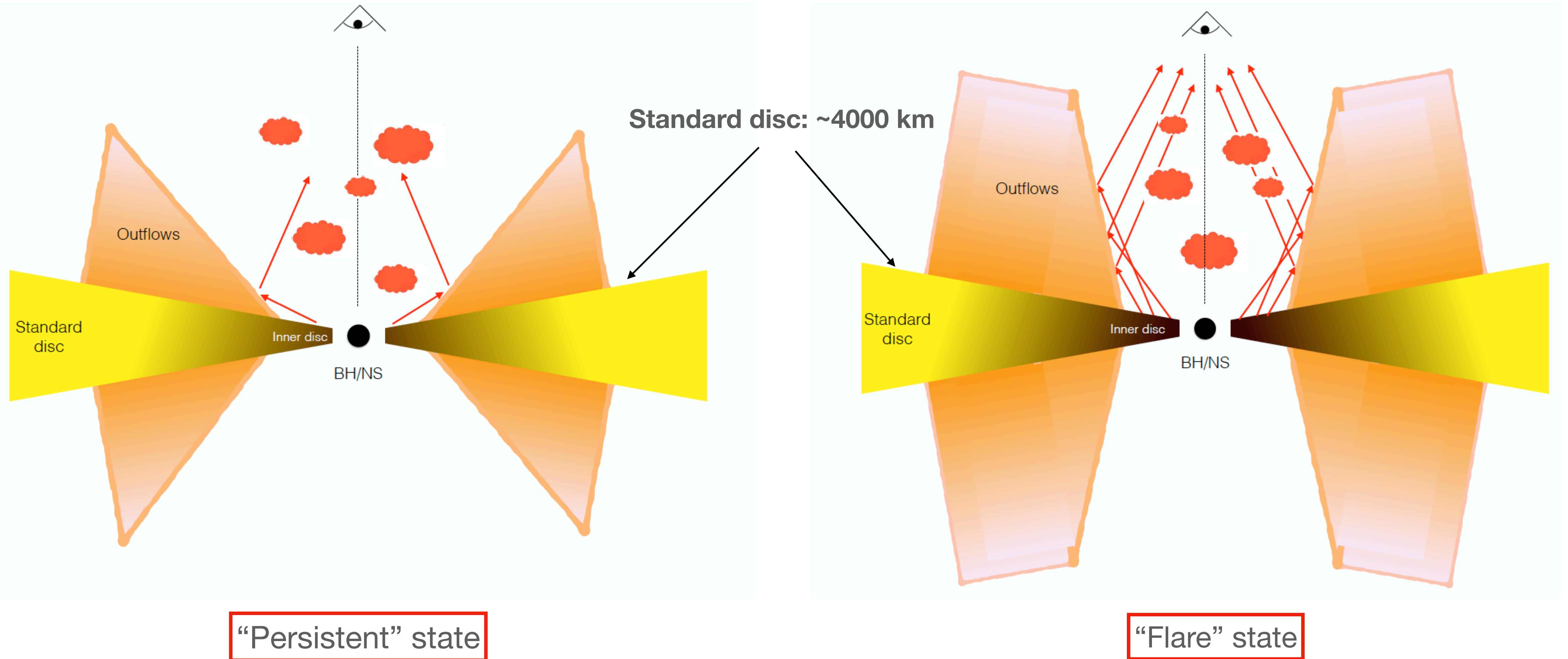
“Persistent” state



“Flare” state

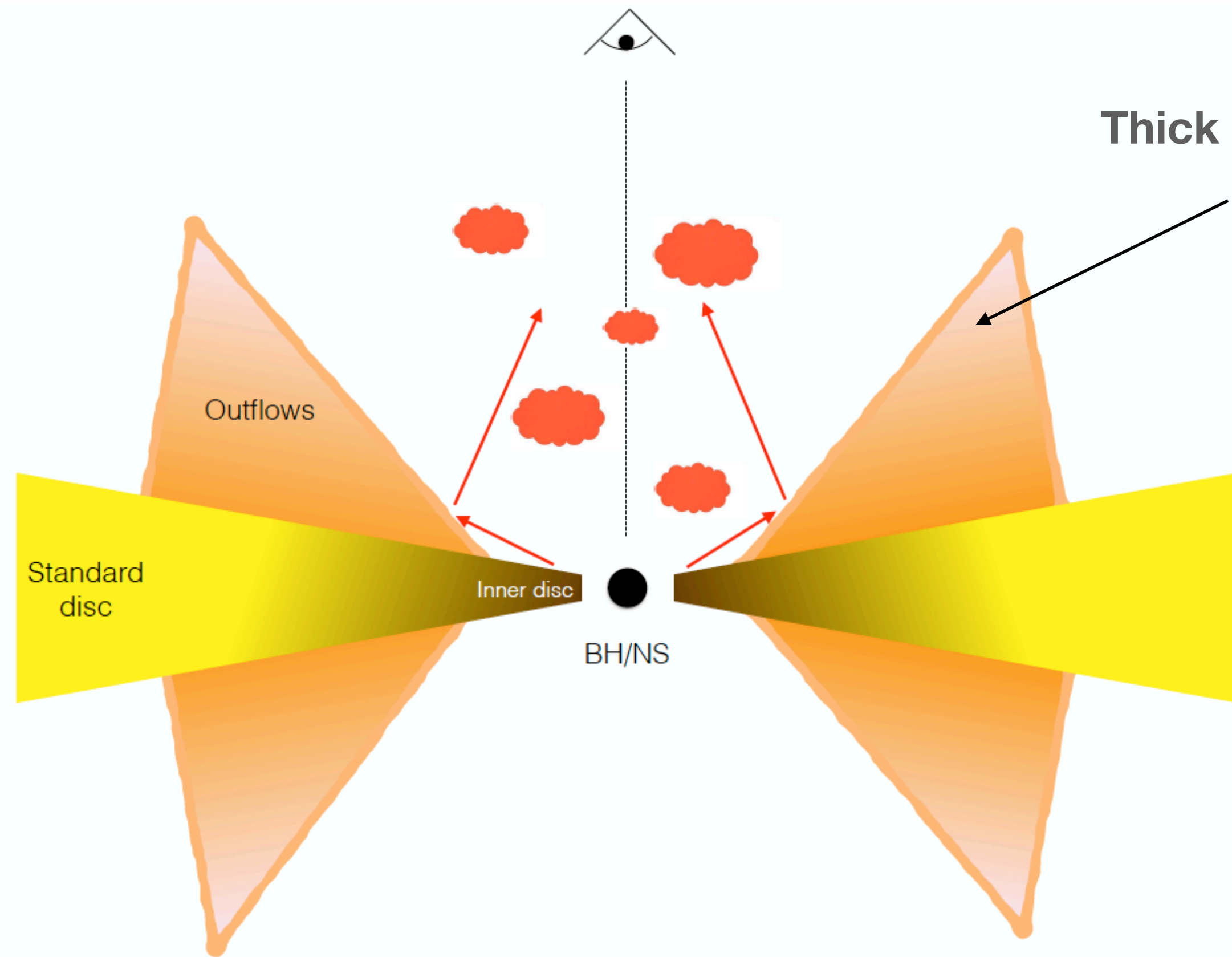
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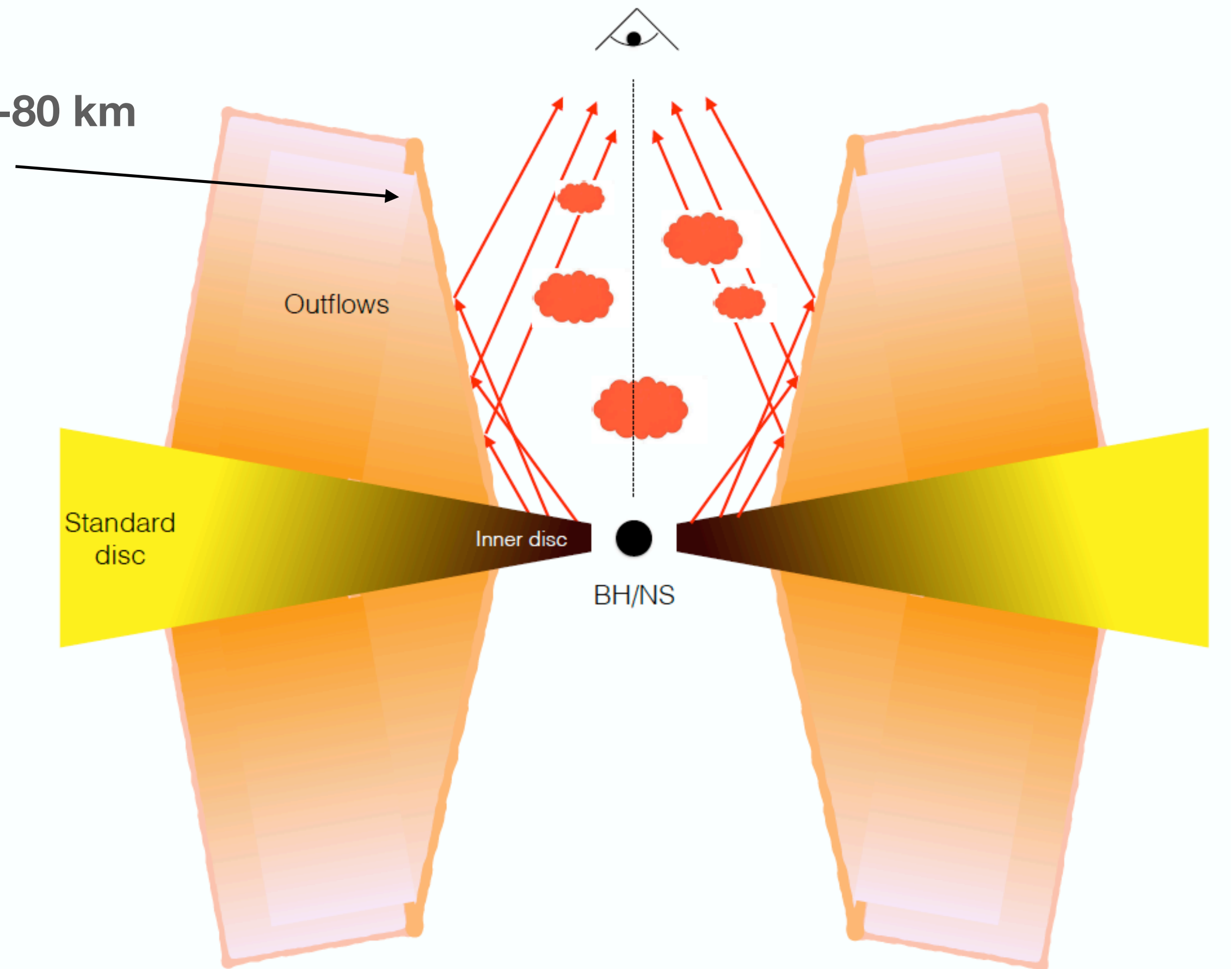


Possible interpretation of NGC 4559 X7

Super-Eddington accretion on a stellar mass compact object



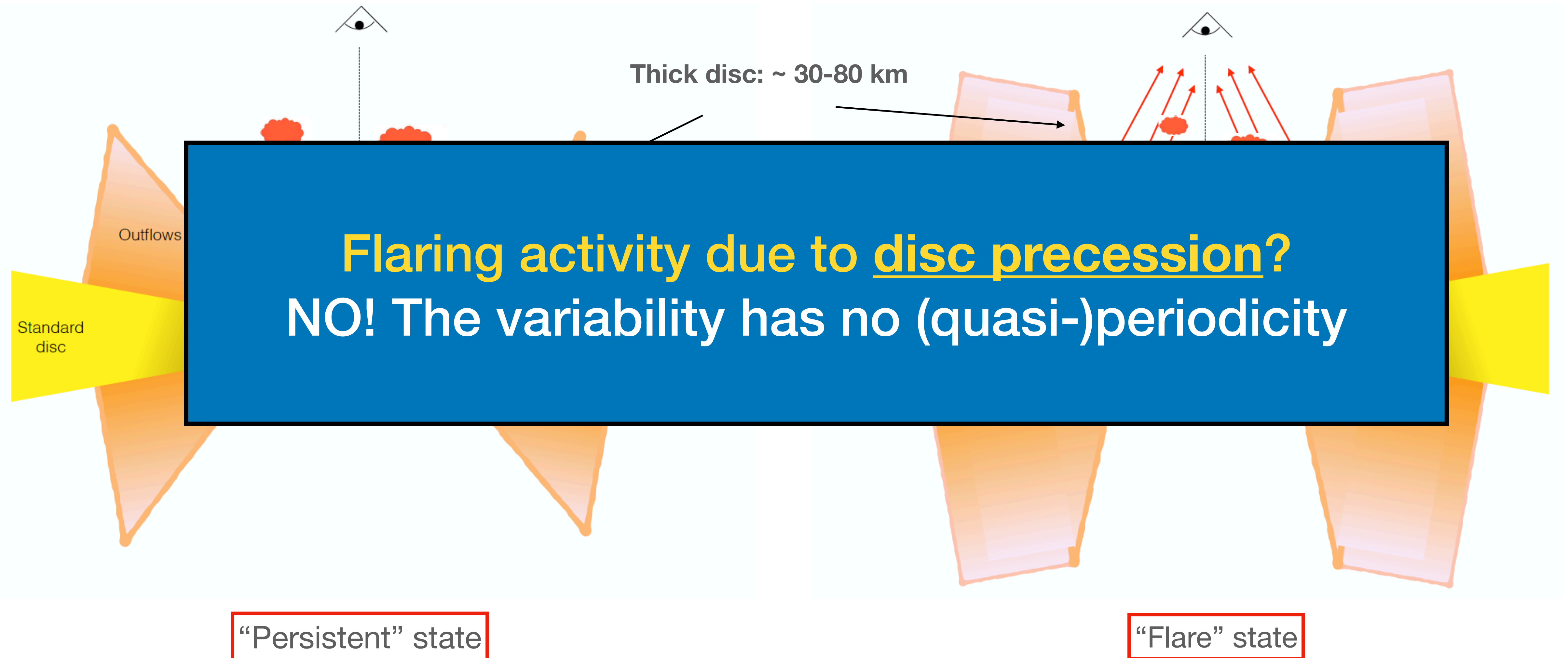
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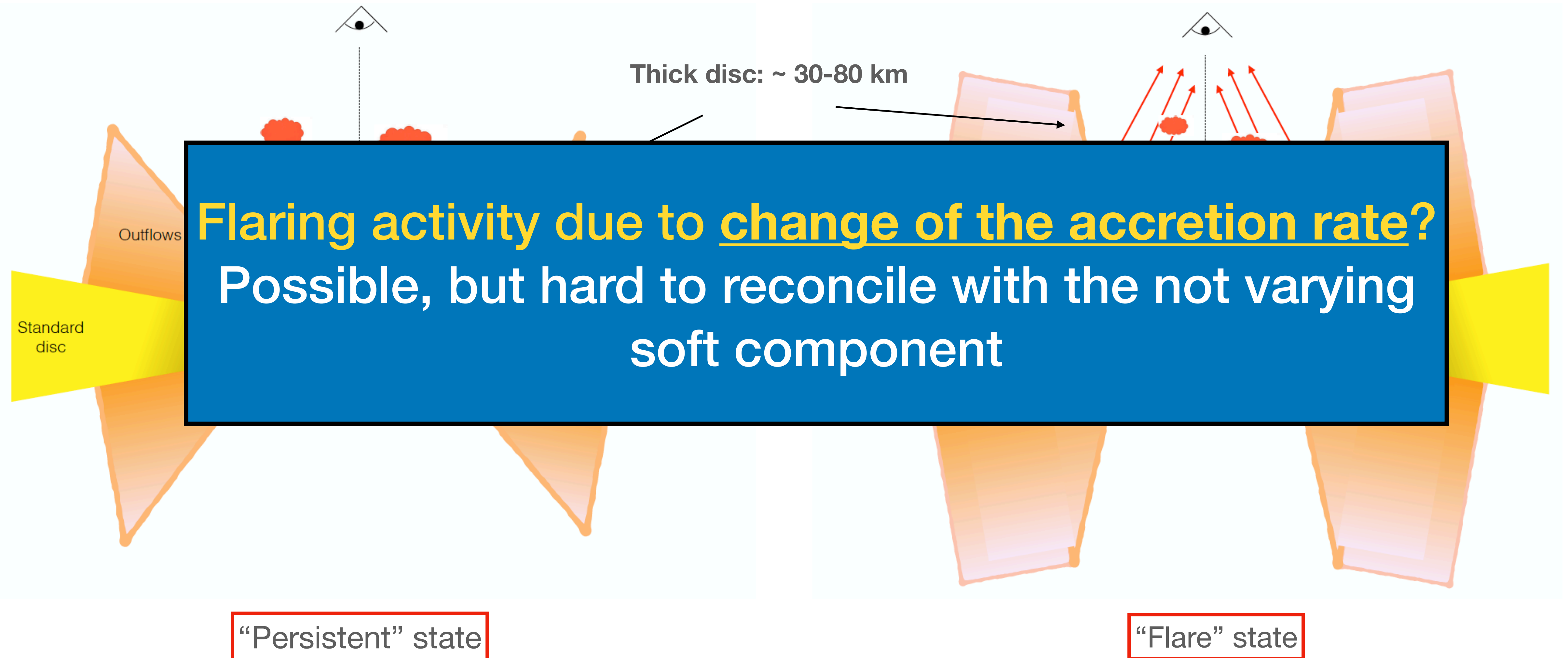
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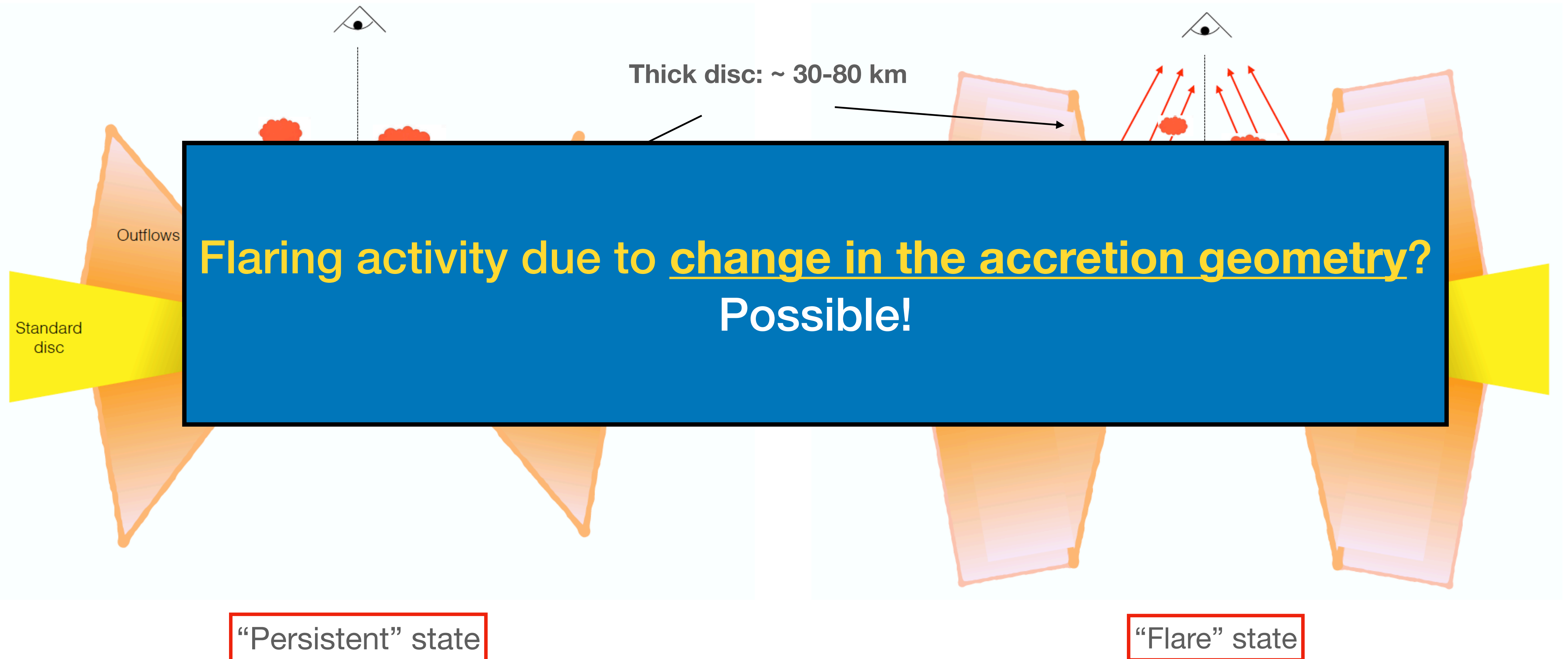
Possible interpretation of NGC 4559 X7

Super-Eddington accretion on a stellar mass compact object



Possible interpretation of NGC 4559 X7

Super-Eddington accretion on a stellar mass compact object



Possible interpretation of NGC 4559 X7

Super-Eddington accretion on a stellar mass compact object

Because of:

- 1) High flux variability (short and long timescales)
- 2) Possible super-orbital periodicity
- 3) Marked spectral variations and very hard spectra

It cannot be excluded NGC 4559 X7 is a new NS candidate

Outflows

Standard
disc

“Persistent” state

“Flare” state

SUMMARY and CONCLUSIONS

NGC 4559 X7

OBSERVATIONAL RESULTS

Remarkable time variability on time-scales from few ks to tens of days

Evidence of two/three spectral states

Possible periodicity of ~240 days

Absorption/emission lines —> outflows

Hard and soft time-lags

INTERPRETATION

Super-Eddington accretion regime assuming low-inclination of the system

Precession of the disc?
Change in the accretion rate?
Change in accretion flow geometry?

Nature of the compact object still uncertain but likely a NS