A NICER View of the Microquasar Cygnus X-3

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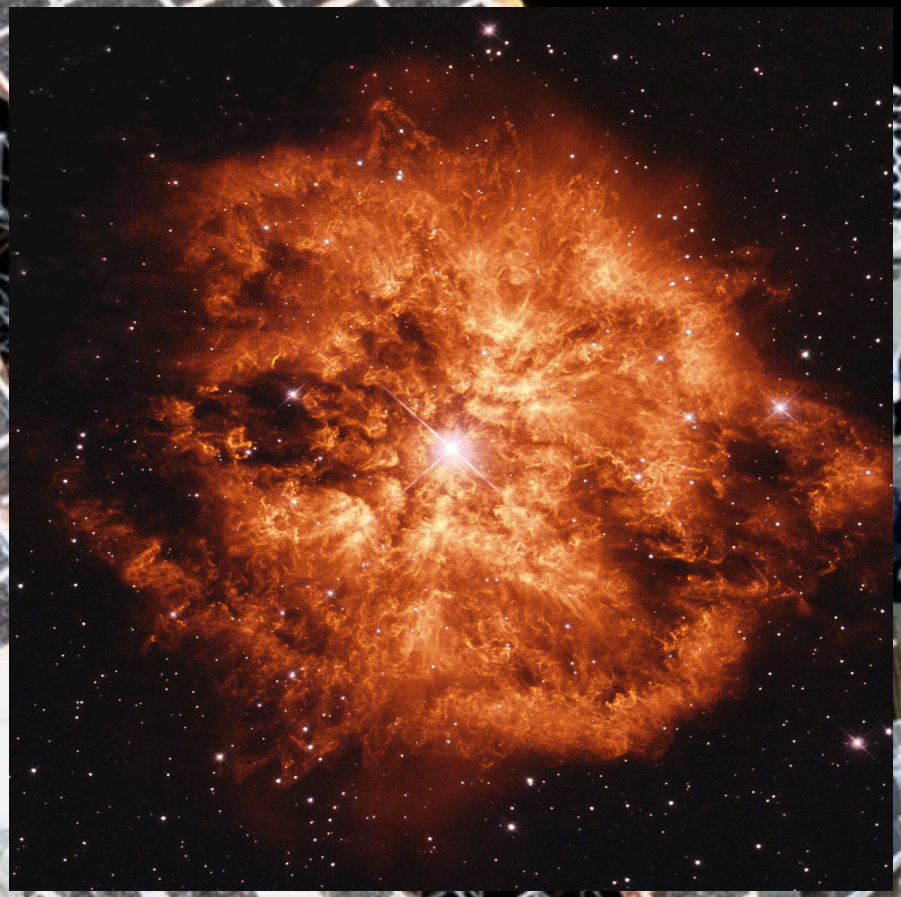
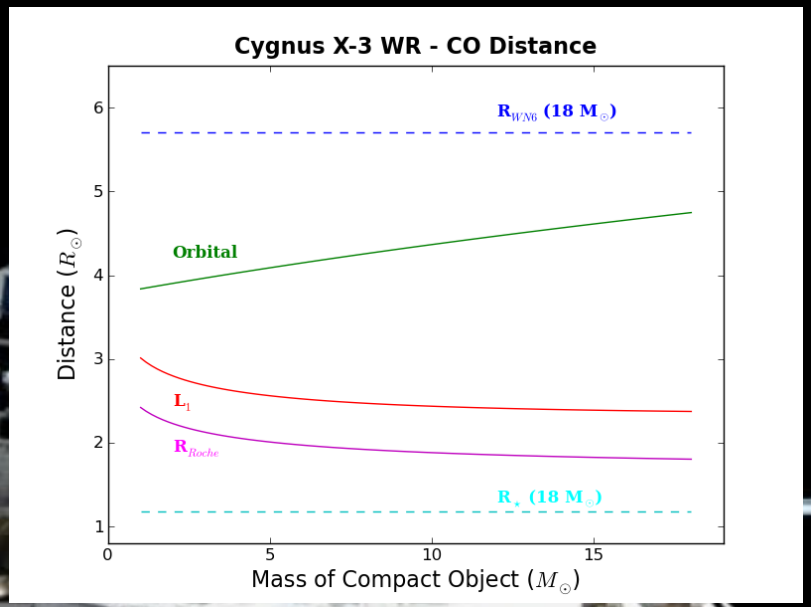
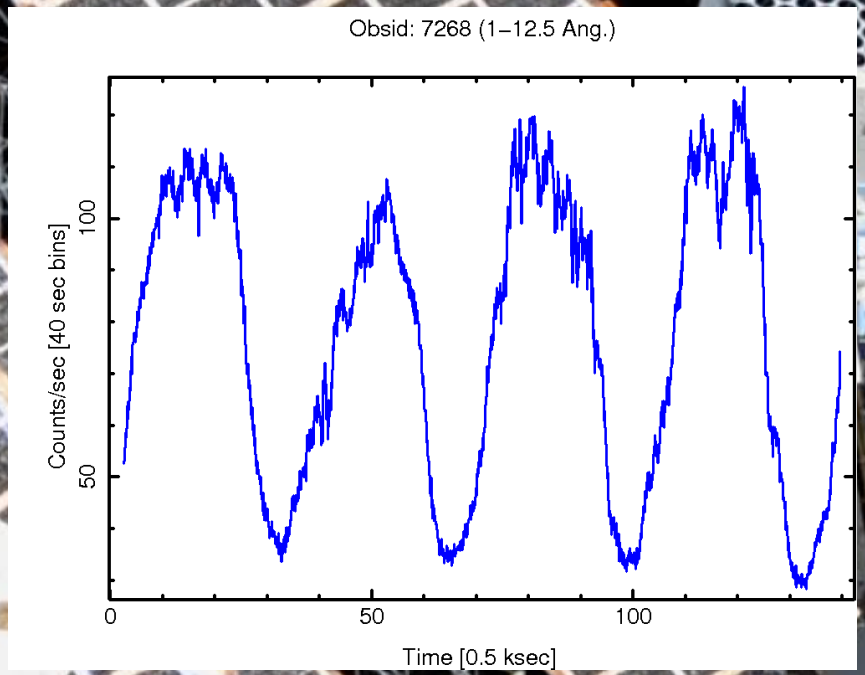
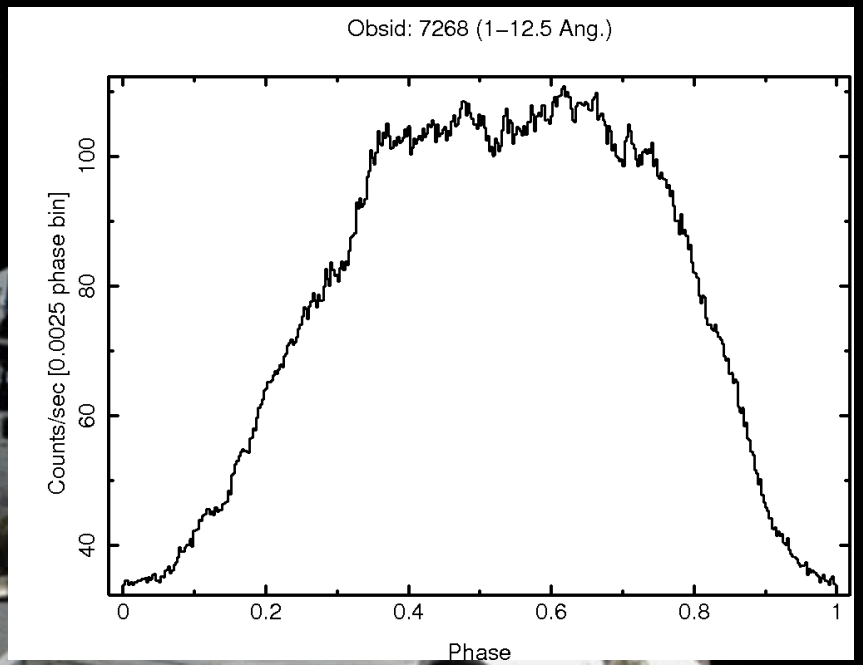
Cygnus X-3: Wolf-Rayet (WN 4-6) XRB





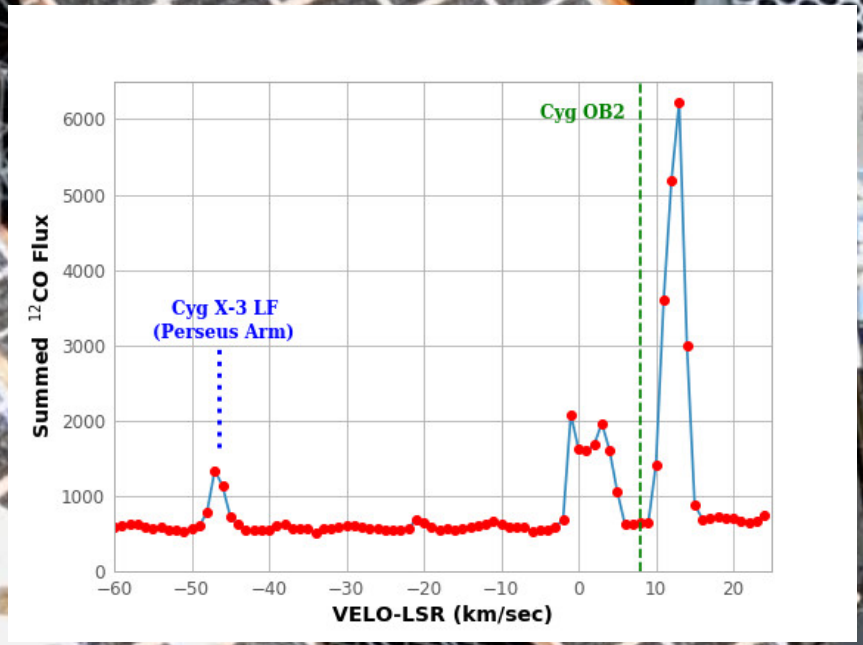
Cygnus X-3: 4.8 hour Orbital Period

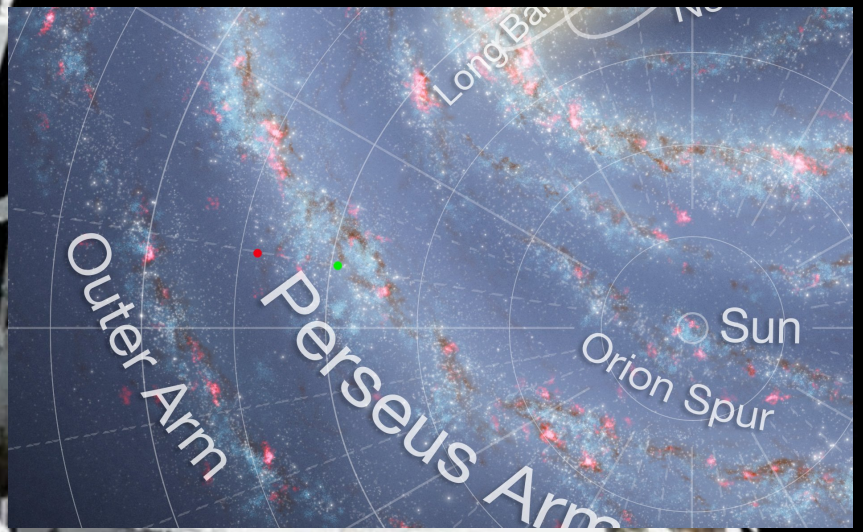




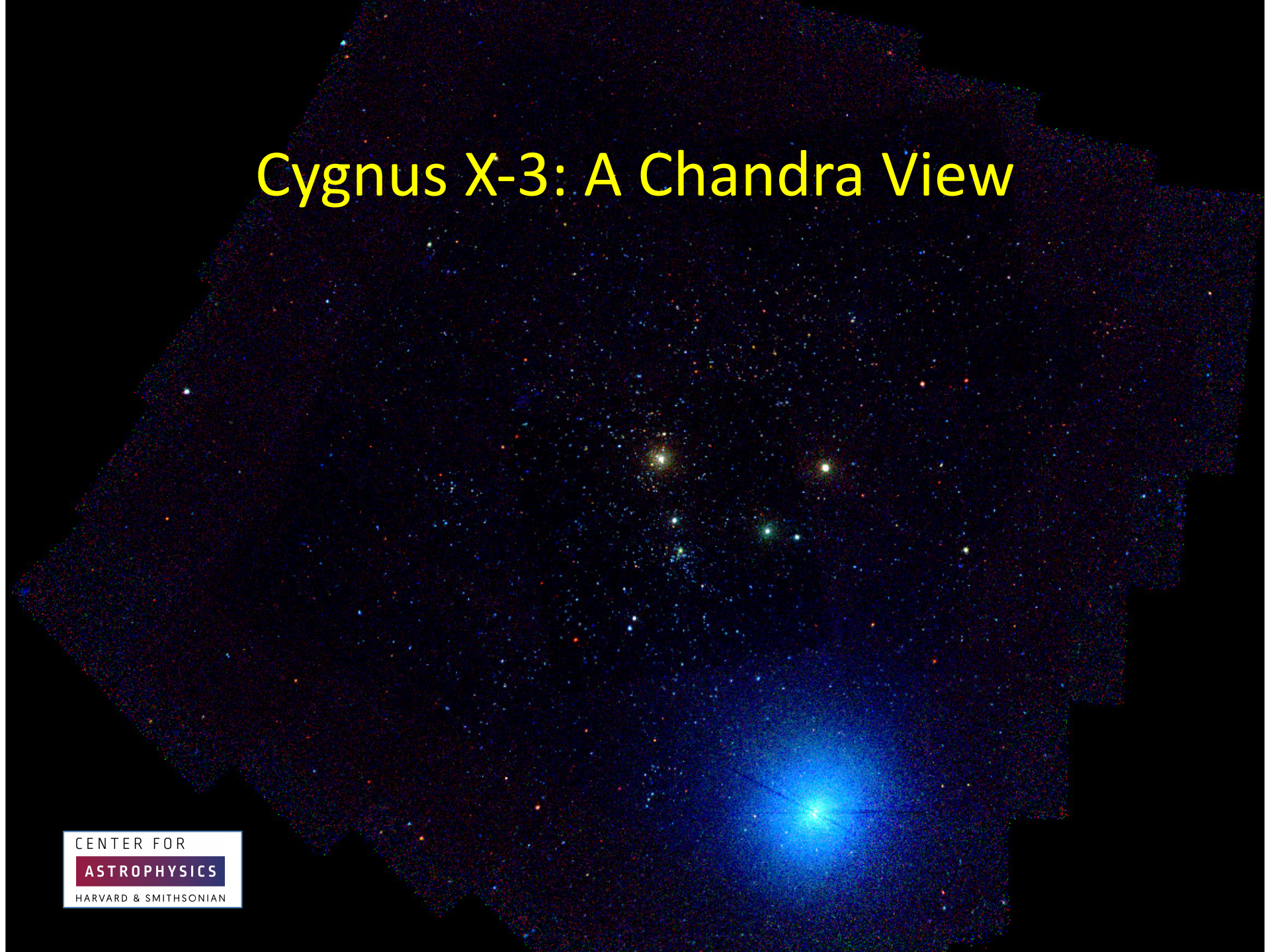
Cygnus X-3: Distance 7.4 +/- 1.1 kpc

(McCollough, Corrales, & Dunham 2016)





Cygnus X-3: A Chandra View



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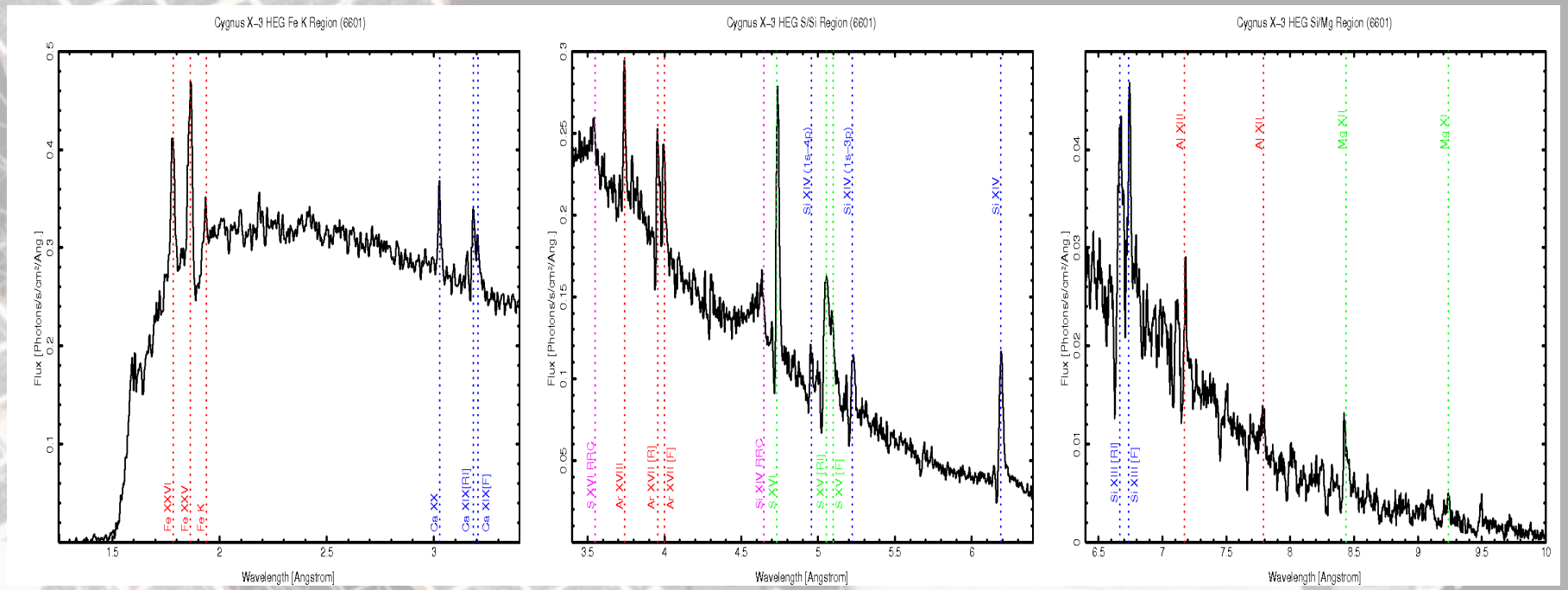
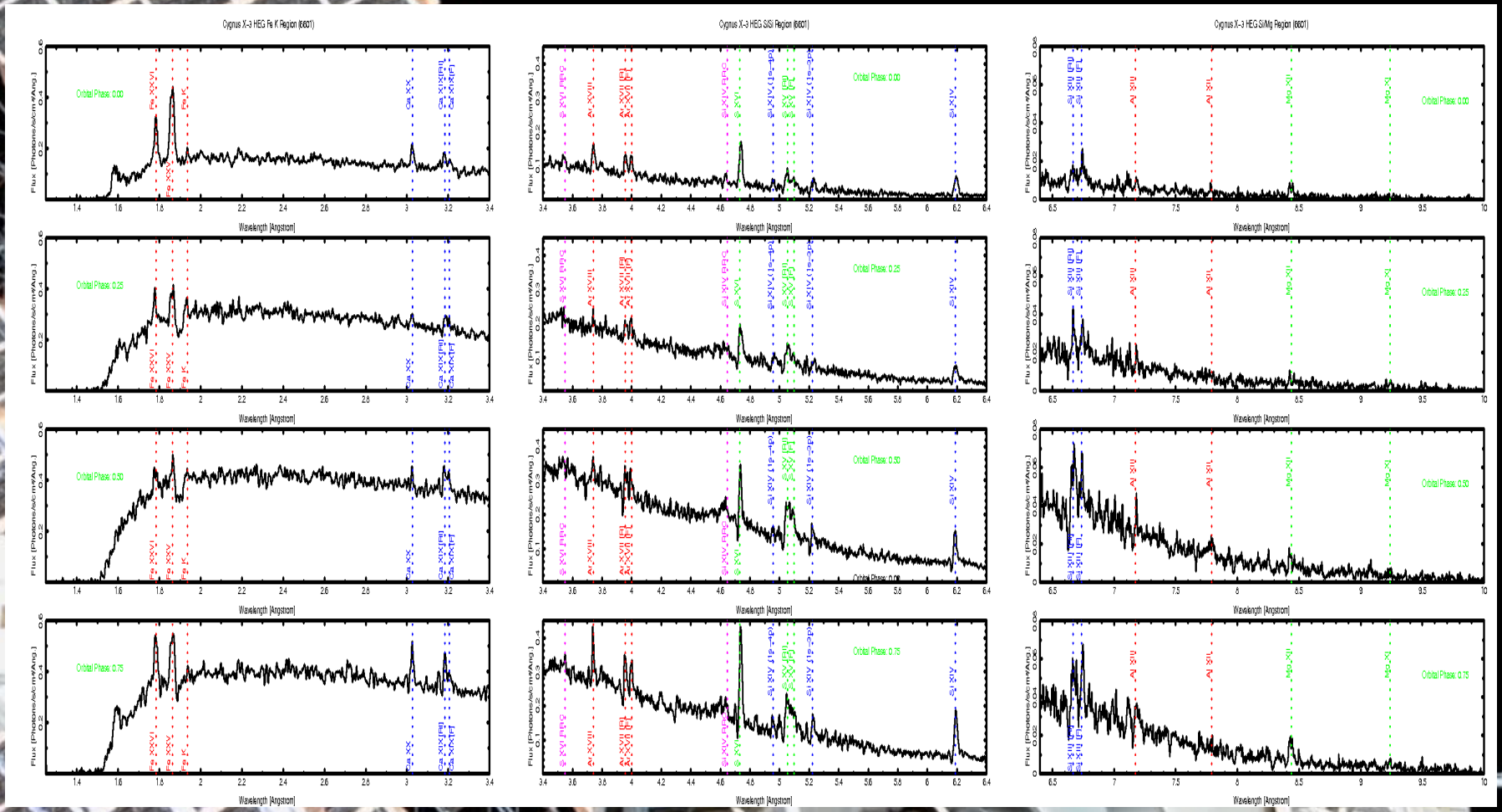
Cygnus X-3: HETG Spectrum (Kallman, McCollough, et al. 2019)

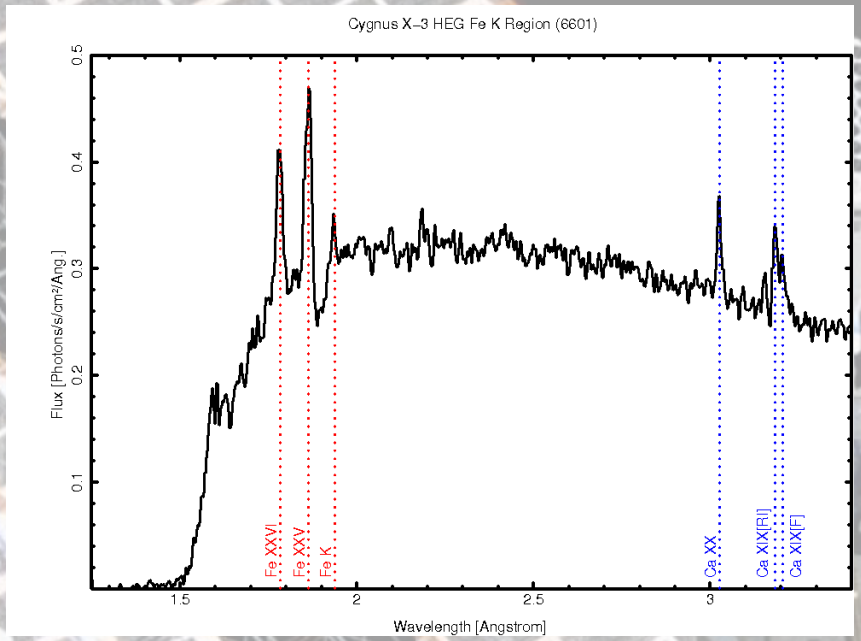


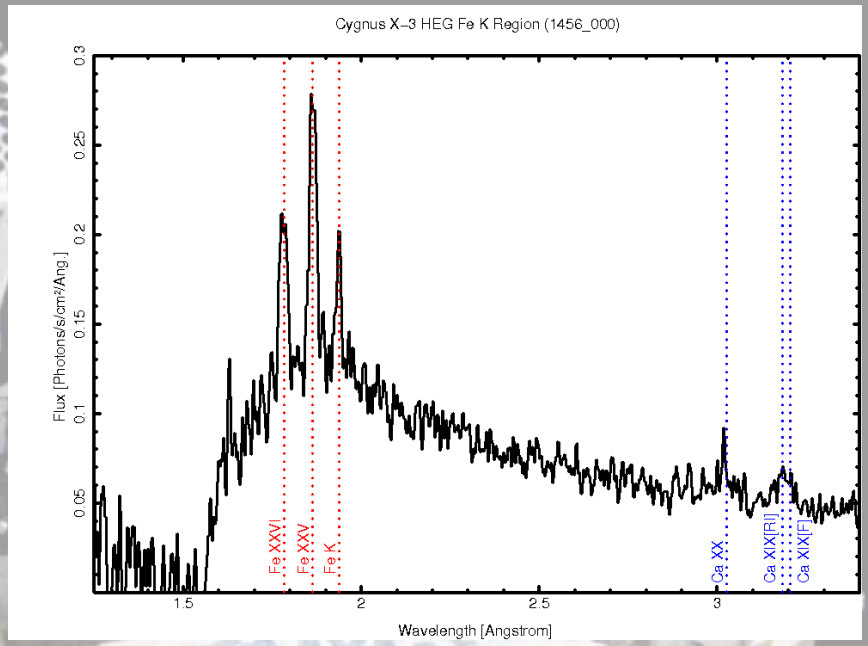
What is strange about this spectrum?

Cygnus X-3: Phase Resolved HETG Spectra



Cygnus X-3: State Changes





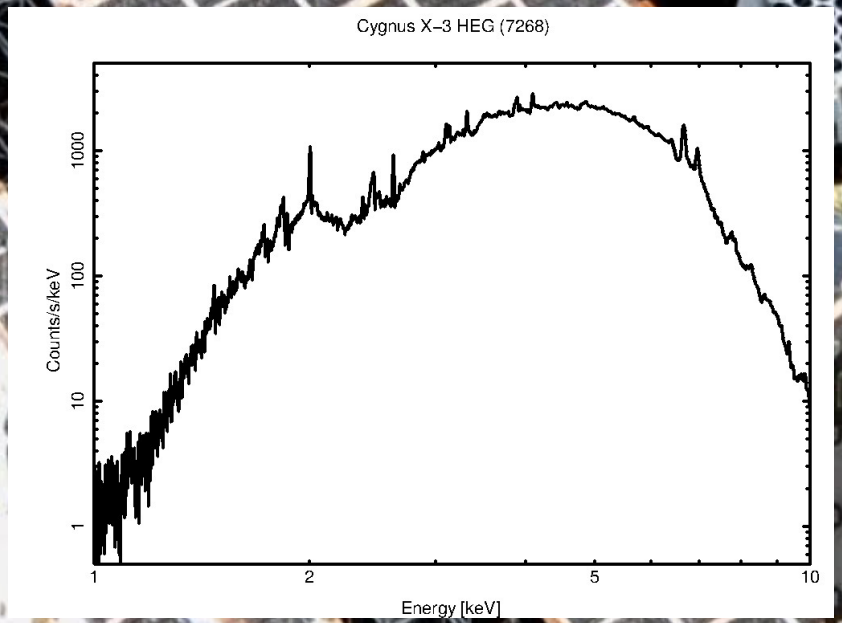
Quenched/Hypersoft vs. Quiescence

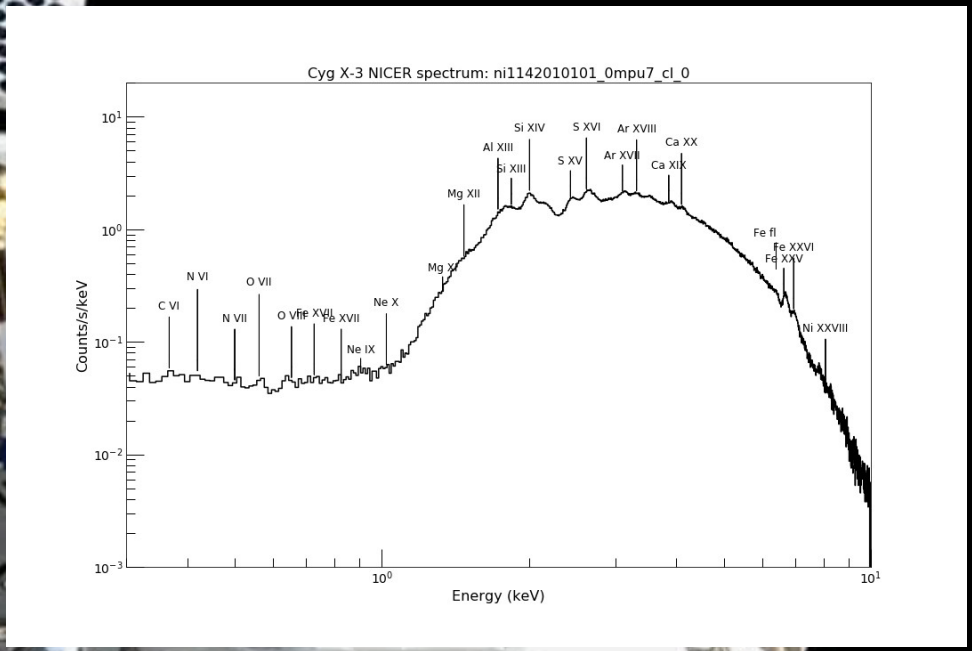
Spectrum Fit | Orbital Variation

- Cold absorption
- Notch absorbing Fe
- Photoionized nebular emission with log(ξ) ~ 2-3
- 6.4 keV Gaussian emission
- Photoionized nebular emission with log(ξ) ~ 4-5
- Wind emission
- Diskbb
- Blackbody

- Diskbb component peaks at phase 0.5. Closest to inferior conjunction.
- Photoionized component for all elements lighter than Fe peak at phase 0.75.
- Photoionized component for Fe lines peaks between phases 0.75 – 0.25.
- Notch absorption is needed in all orbital phases. But peaks at 0.5.
- Wind component is detected at all phases with a minimum at 0.5. The wind is anti-correlated with the X-ray continuum.
- The wind, the high ξ, and medium ξ are strongest in 0.75-0.25 phase range.
- The diskbb, Fe Kα, and notch components are strongest at phase 0.5.

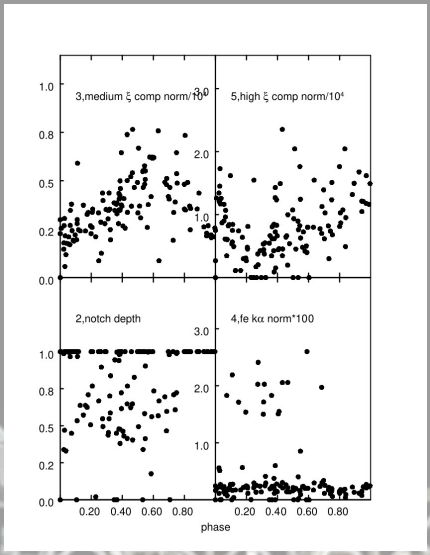
Cygnus X-3 Spectrum: HETG vs. NICER

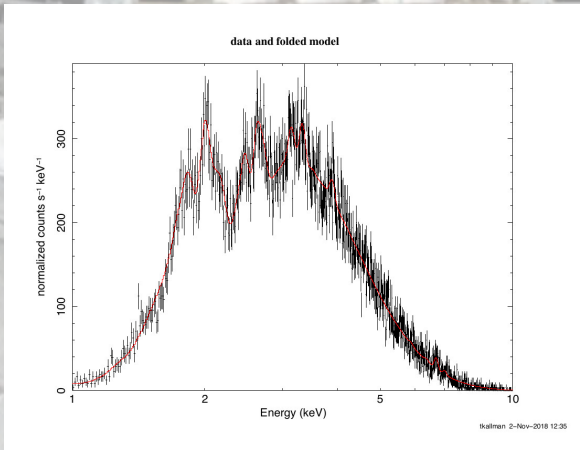




Cygnus X-3: NICER Spectral Fits

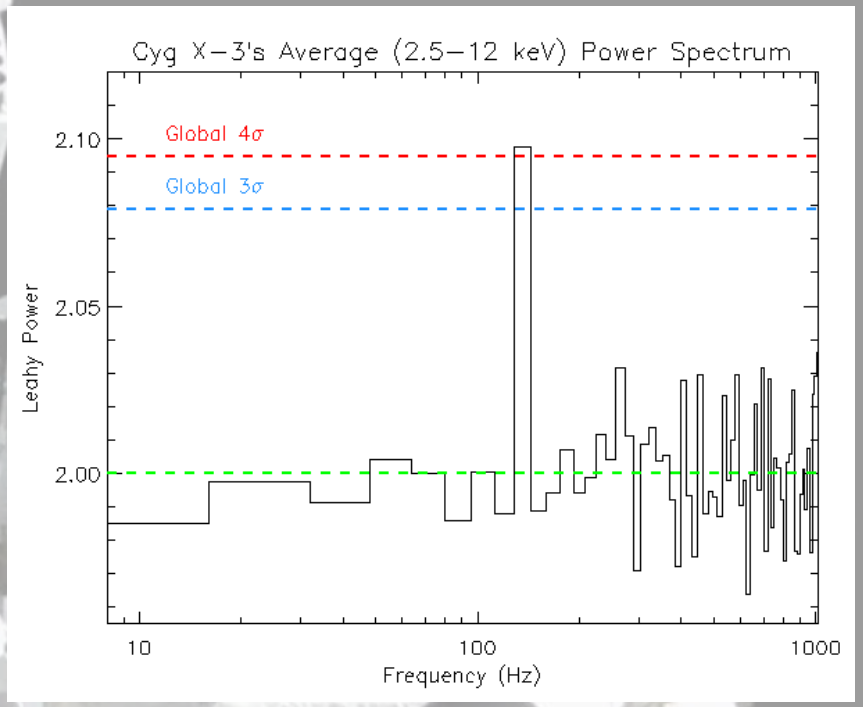
- Spectral fits were made to the NICER data with model to fit the Chandra data.
- No strong correlations found.
- The strongest lines fluxes are correlated with orbital phase.
- Fe XXV, S SVI, Si XIV are strongest near phase 0.5.
- Fe XXVI shows weak evidence for the opposite behavior, and is strongest near phase 0 or 1.
- We as also doing additional fits in which we use different continuum models plus 22 Gaussians to better determine the nature of the continuum emission.



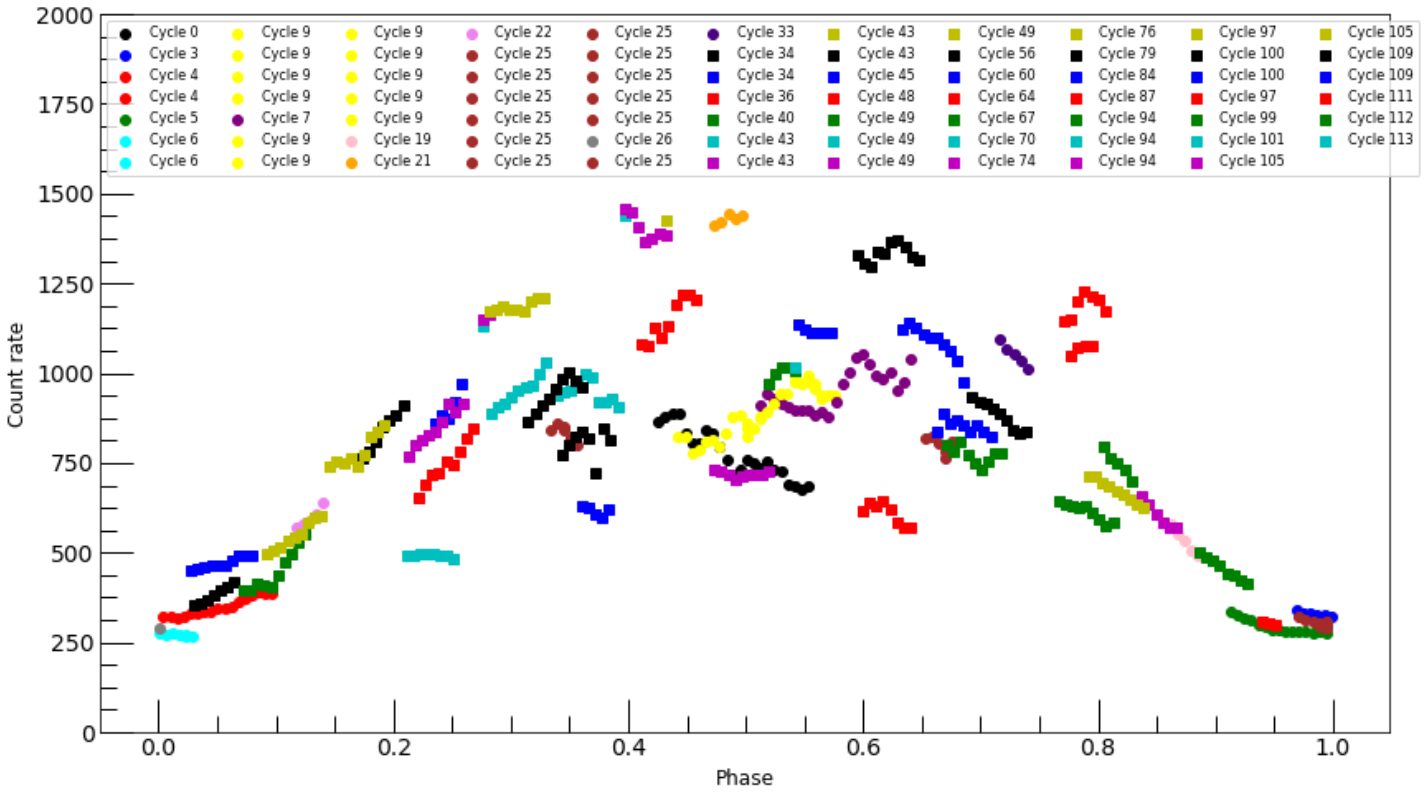


Cygnus X-3: NICER Timing

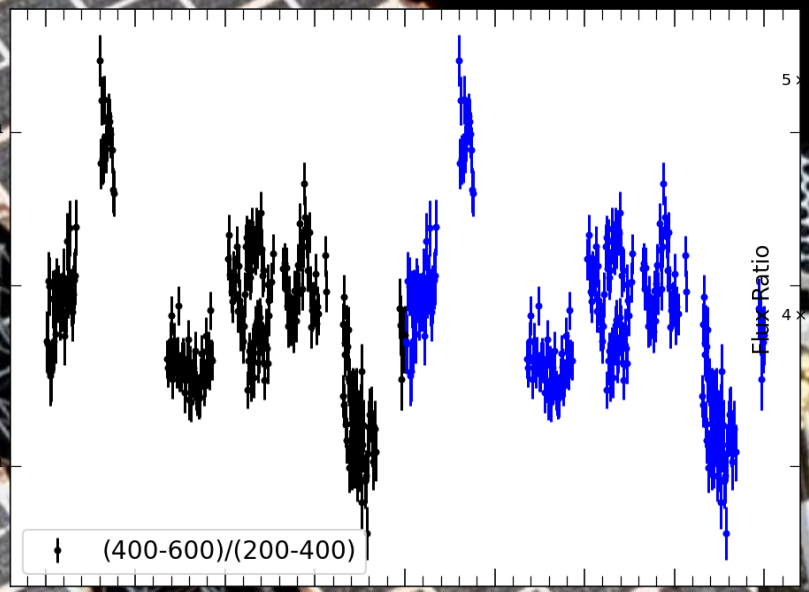
- Cygnus X-3 is known for its lack of high frequency QPOs.
- Low frequency QPOs have been seen during high soft states (during major flares).
- The reason for the lack of QPOs is believed to be do to scattering in winds around Cygnus X-3.
- The first Cygnus X-3 showed a possible QPO!
- A more formal analysis has shown this not to be significant.
- No other NICER observation to date has show evidence for QPOs.
- But other aspects of NICER timing can be important.

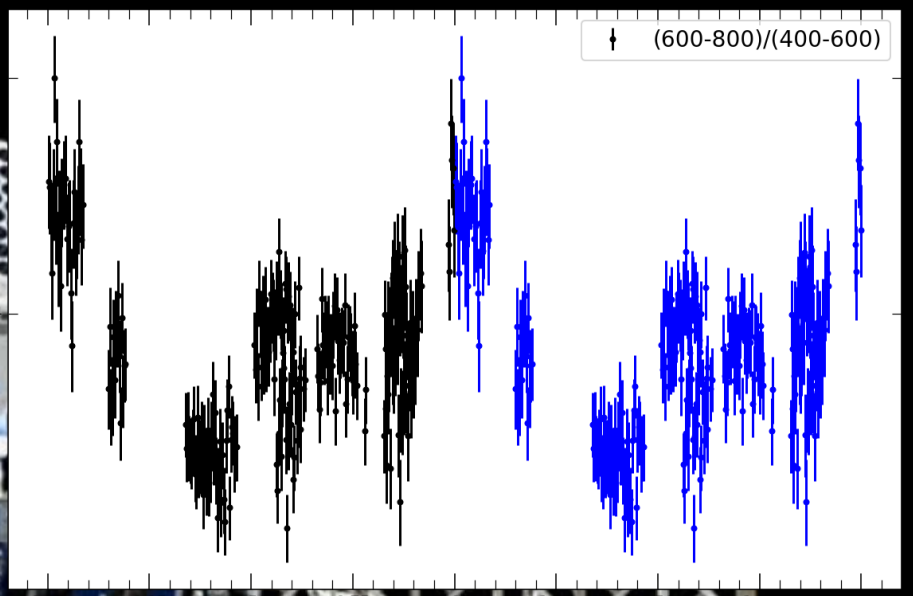


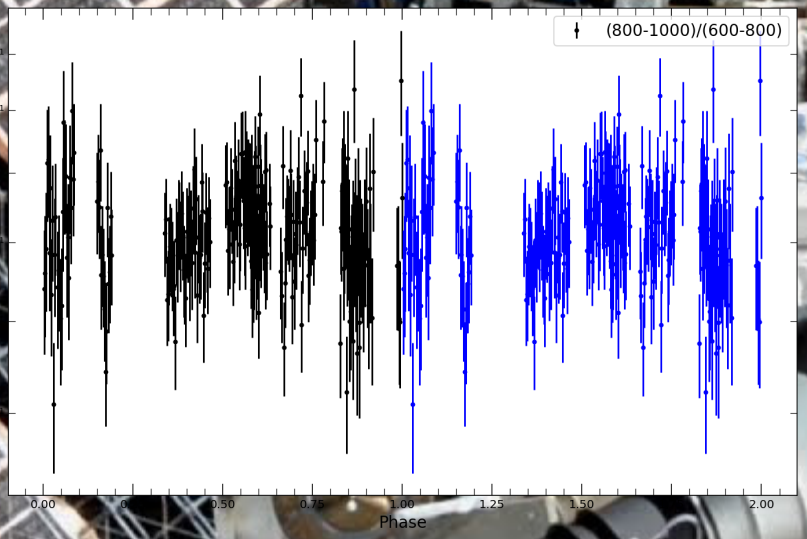
Cygnus X-3: NICER Phase Coverage (2018 Campaign)



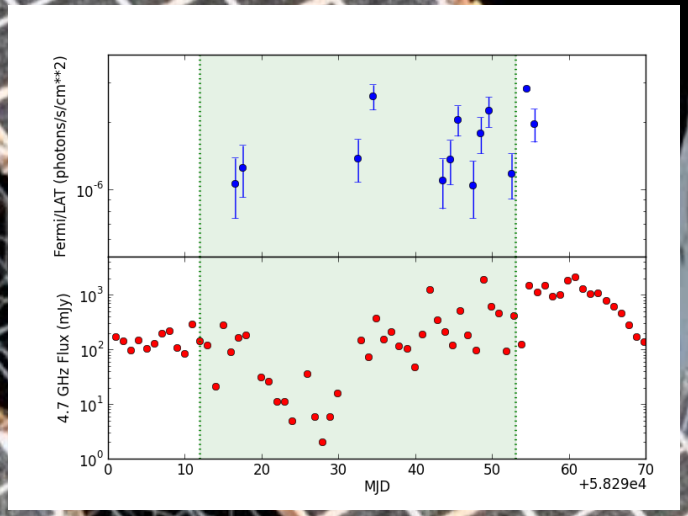
Cygnus X-3: NICER Hardness Ratios

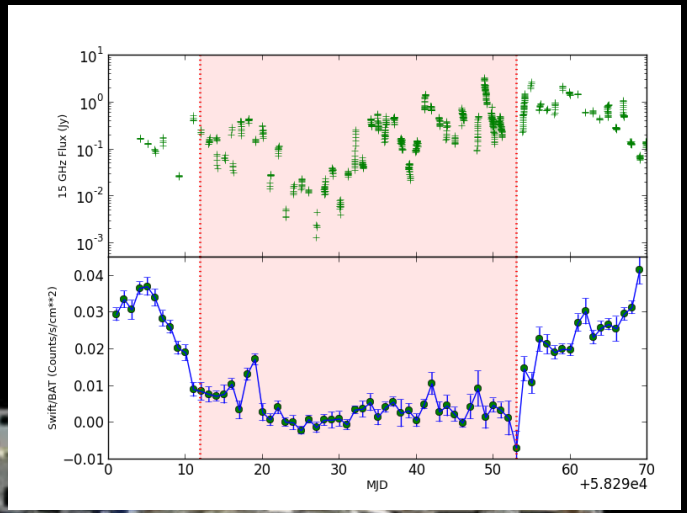


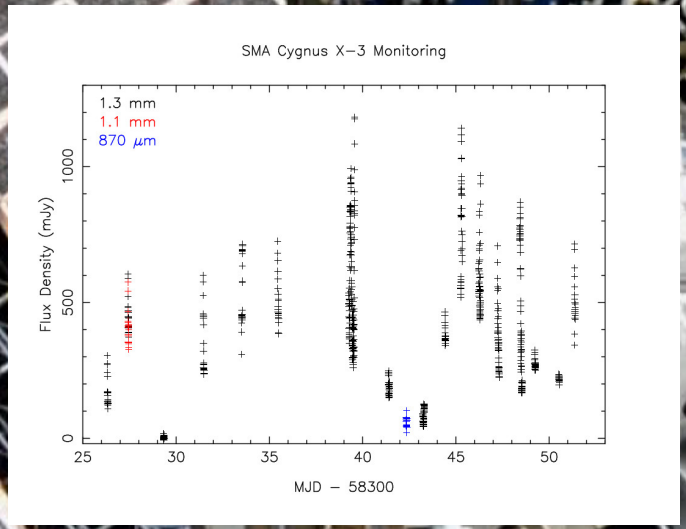




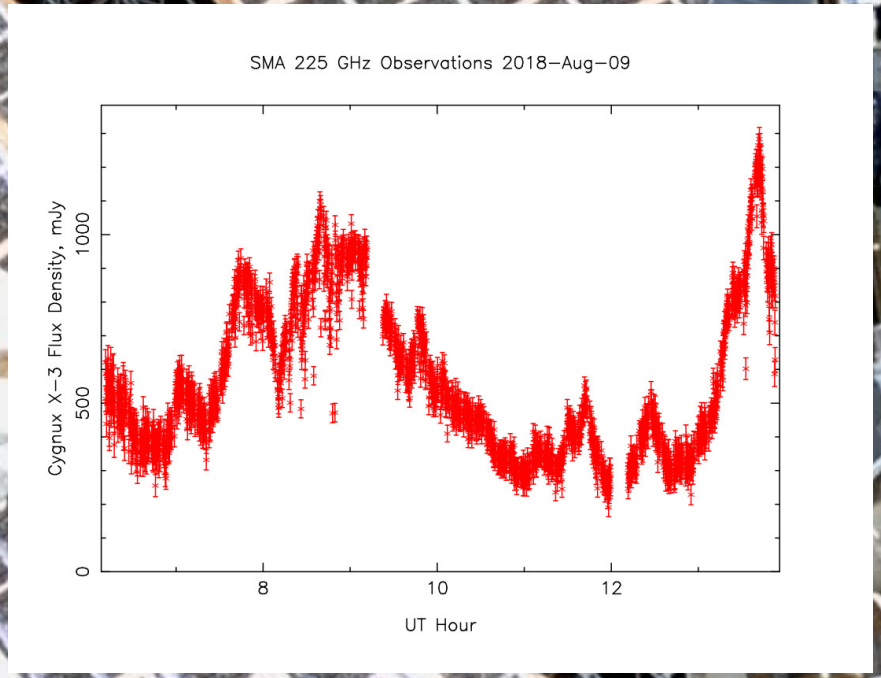
Cygnus X-3: Multi-wavelength 2018 Campaign

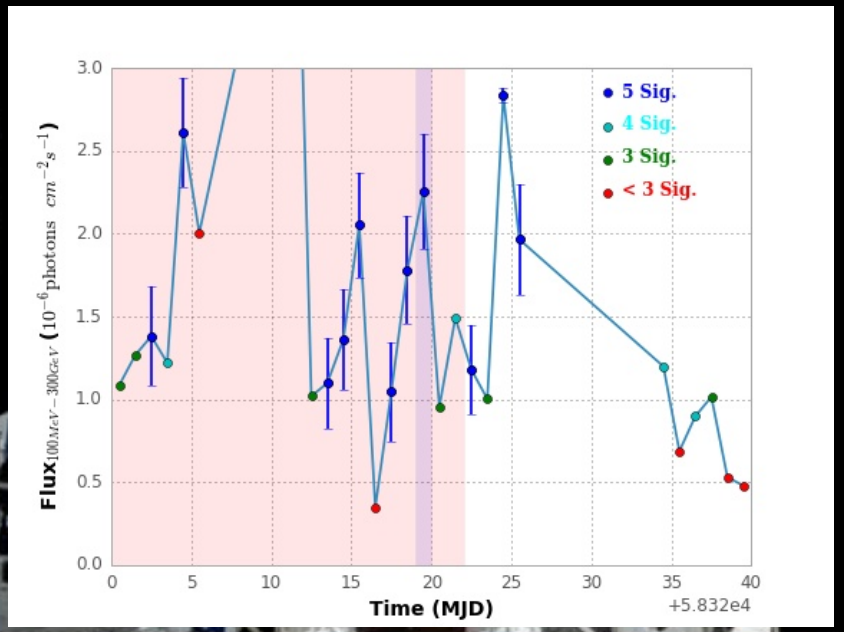




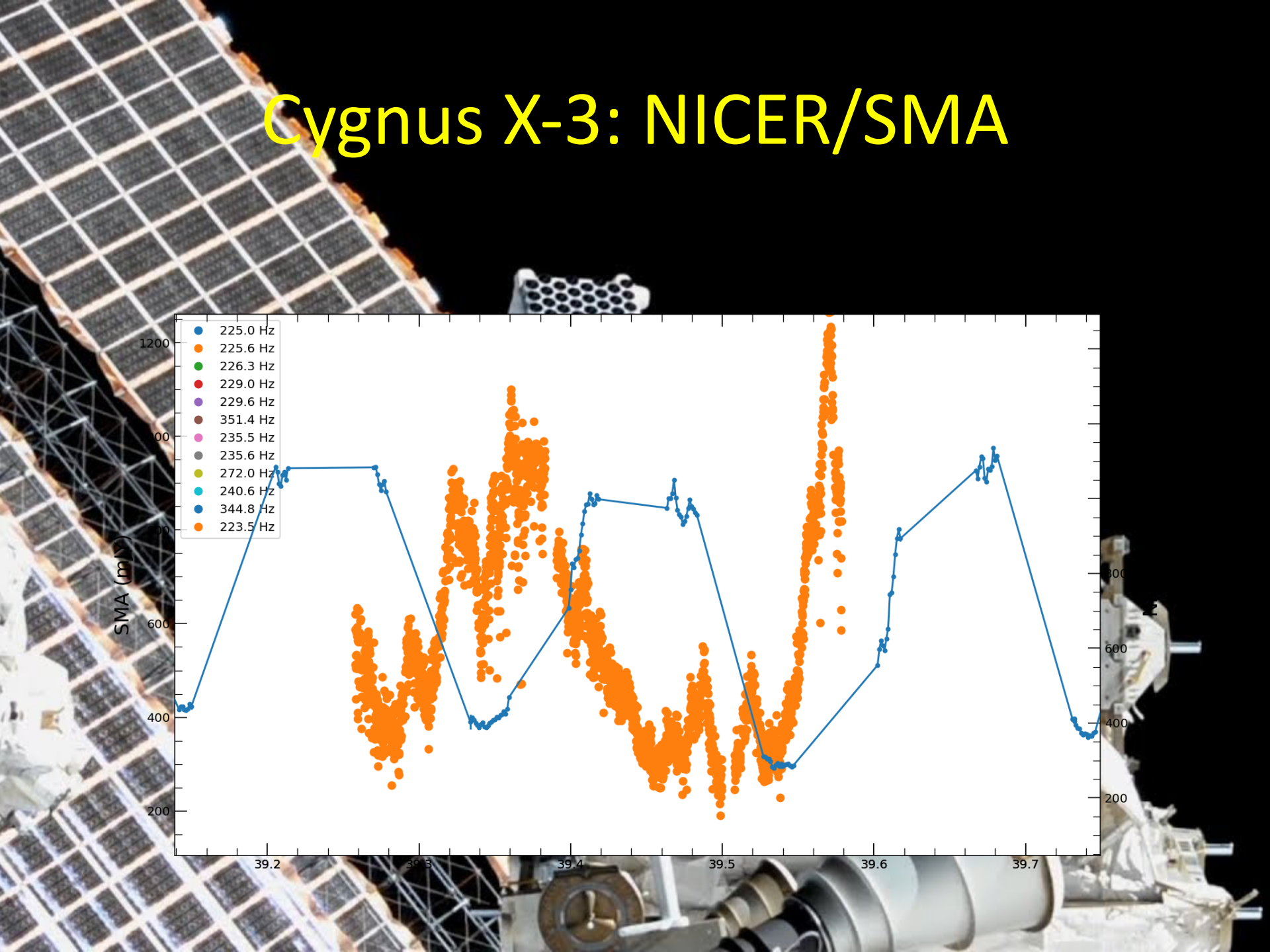


Cygnus X-3: Fermi LAT/SMA



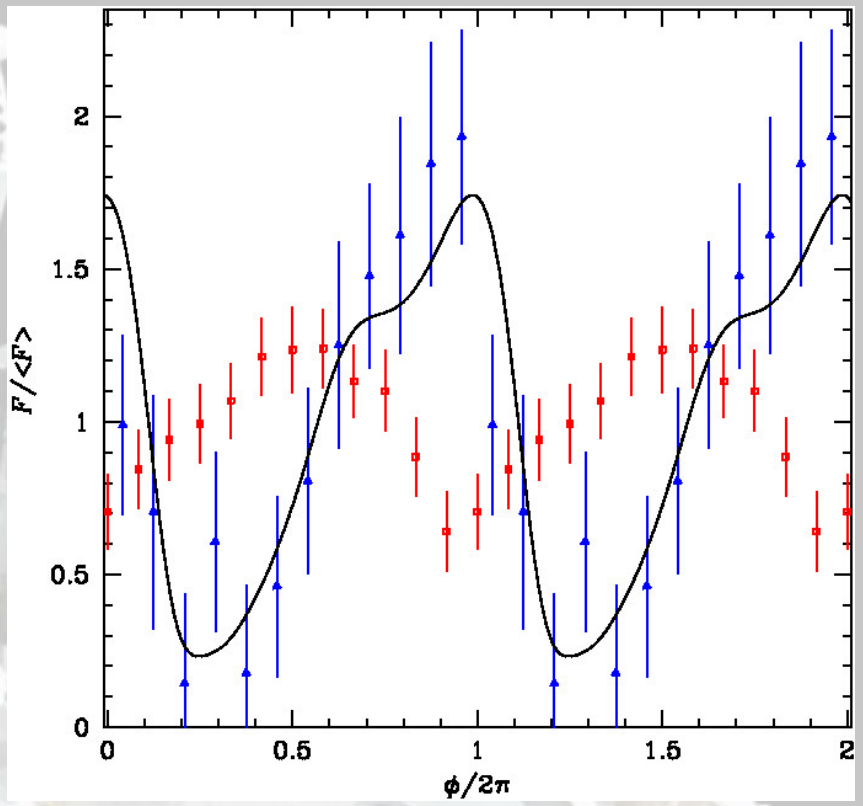


Cygnus X-3: NICER/SMA



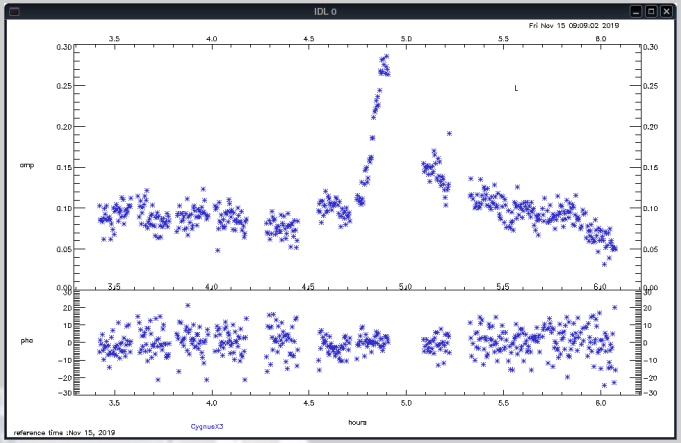
Cygnus X-3: HXR/Fermi LAT

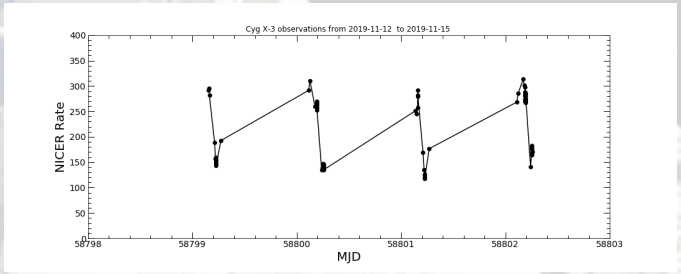
- The appearance of jet launching (at225 GHz) near phase 0/1 may interesting implications.
- In a figure from Zdziarski et al. (2012) we see the hard X-ray (INTEGRAL data in red) phase folded light curve (60-150 keV). The data in blue is Fermi LAT data (> 0.1 GeV) phase folded data.
- Note that the peak in the gamma-ray is shifted by about 0.5 orbital phase.
- The peak in the gamma-ray emission is occurring where it appears we are seeing jet launching occurring in the submillimeter.
- We are continuing to investigate the additional SMA data.

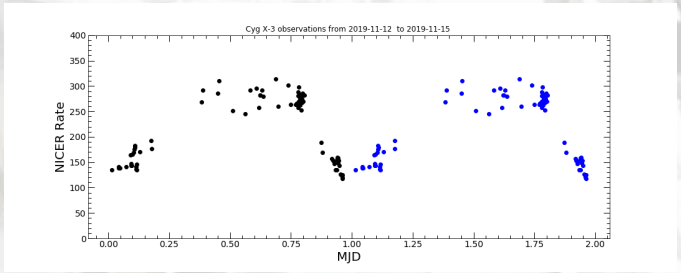


Cygnus X-3: Things to Come!

- Tetarenko, et al. (2019) did a radio/X-ray timing study of Cygnus X-1 and from timing lags to determine the jet velocity.
- In 2019 Alex Tetarenko and I put together a program to do simultaneous high time resolution observations in the radio and X-ray for major radio flare and a quiescent state in Cygnus X-3.
- For both a Cygnus X-3 major flare and quiescent state we did simultaneous observations with the VLA/SMA/JCMT for 4 hours or longer.
- The VLA was broken into three arrays to all simultaneous radio measurements at two frequencies with sub-second time resolution for 4 hours.
- We supported these observations with Swift and NICER observations.
- This work is in progress.








Thank You!
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