, D. (2002). Artist's impression of XMM-Newton. In *European Space Agency*. https://www.esa.int/ESA_Multimedia/Images/2000/09/Artist_s_impression_of_XMM-Newton

X-ray Flickering of a Galactic Black Hole

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Introduction

- Black holes are remnants of massive stars after they explode in a supernova. If a black hole is orbited by a companion star, material from the star can fall toward the black hole and emit radiation through a process called accretion. Such systems are called X-ray binaries.
- X-ray binaries spend most of their time in a "quiescent" state, where they emit low levels of radiation. We expect the amount of X-ray emission to vary, or flicker, over time. Previously, the level and timescale of this flickering has been constrained in only one quiescent X-ray binary, the system V404 Cygni [2].
- BW Cir is another quiescent X-ray binary in our galaxy, containing a black hole that weighs at least 8 times the mass of our Sun and is orbited by a Sun-like star about every 61 hours [3].
- Here, we provide X-ray variability constraints on BW Cir, which will provide information to current models on accretion physics in quiescence, particularly on the distance from the black hole where most of the radiation is liberated, as we expect a faster and larger amount of variability to occur from regions closer to the black hole.

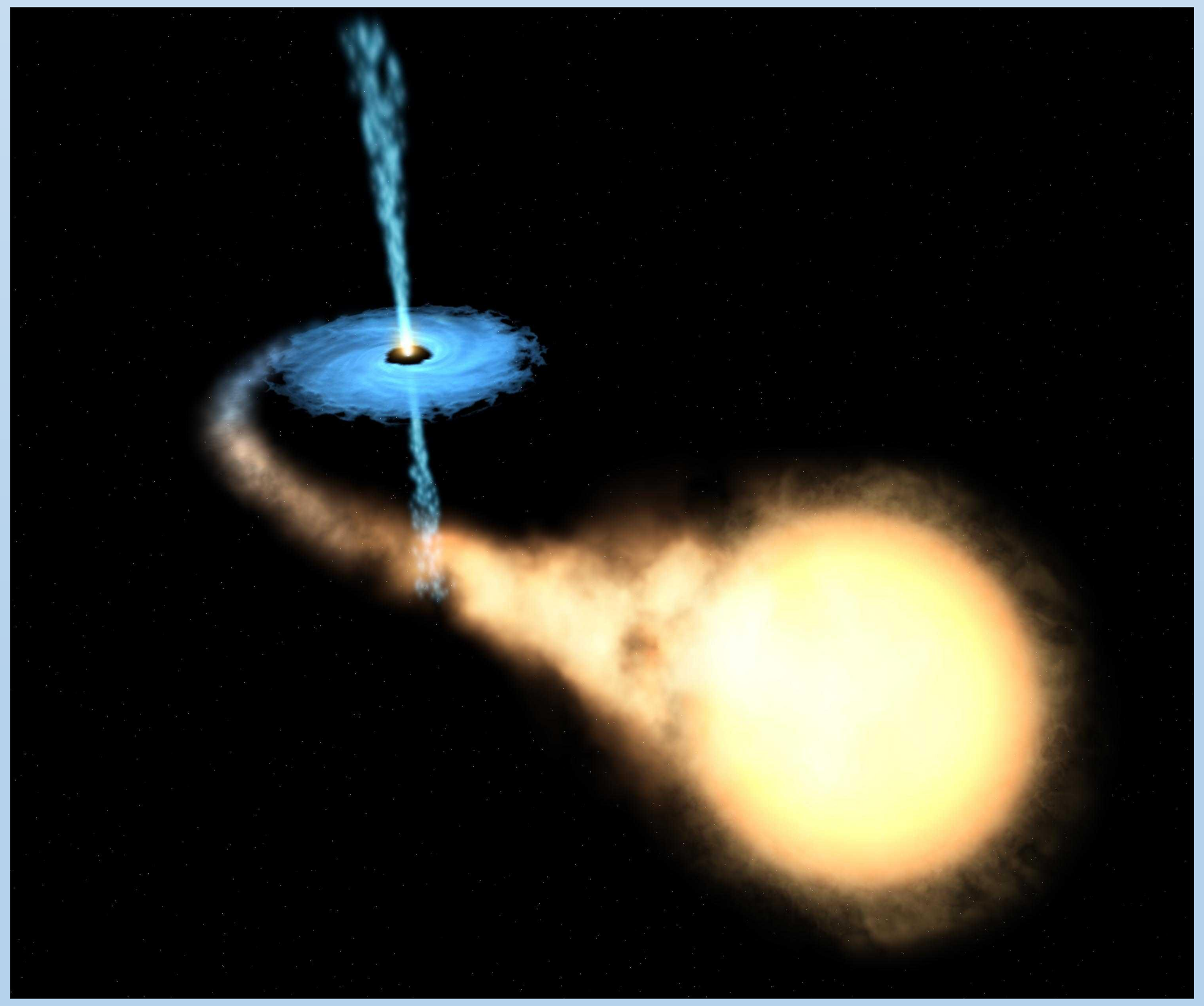

Figure 1: An artist's rendition of an X-ray binary featuring a black hole being orbited by a companion star [1].

Methods

- We examined 8 different X-ray observations of BW Cir with the space-based XMM-Newton Observatory, taken over the course of two months, from July through September of 2025 (see Figure 2). Data was processed using standard tasks through XMM-Newton's custom Scientific Analysis Software (SAS). While observations were taken using three detectors, we focused on data from the European Photon Imaging Camera (EPIC) PN camera on board XMM-Newton.
- After filtering for background flares and applying standard reduction steps, we produced images for each observation. The net counts of photons detected from BW Cir were measured from a 20 arcsecond aperture centered on the known location of BW Cir, after subtracting the expected number of background counts in the source aperture, as measured using the average count per pixel from two nearby regions of blank sky (Figure 3).

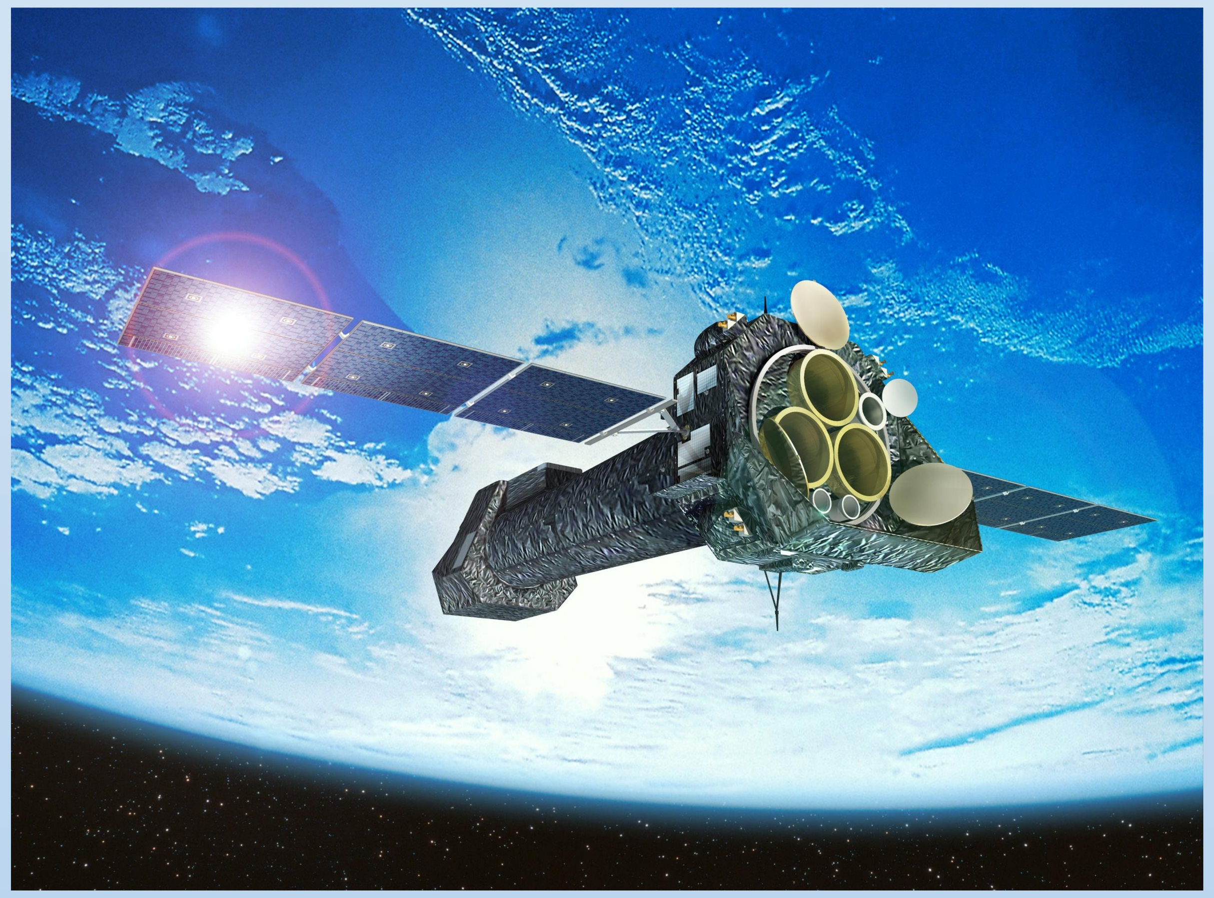

Figure 2: An artist's rendition of the XMM-Newton Space Observatory [4].

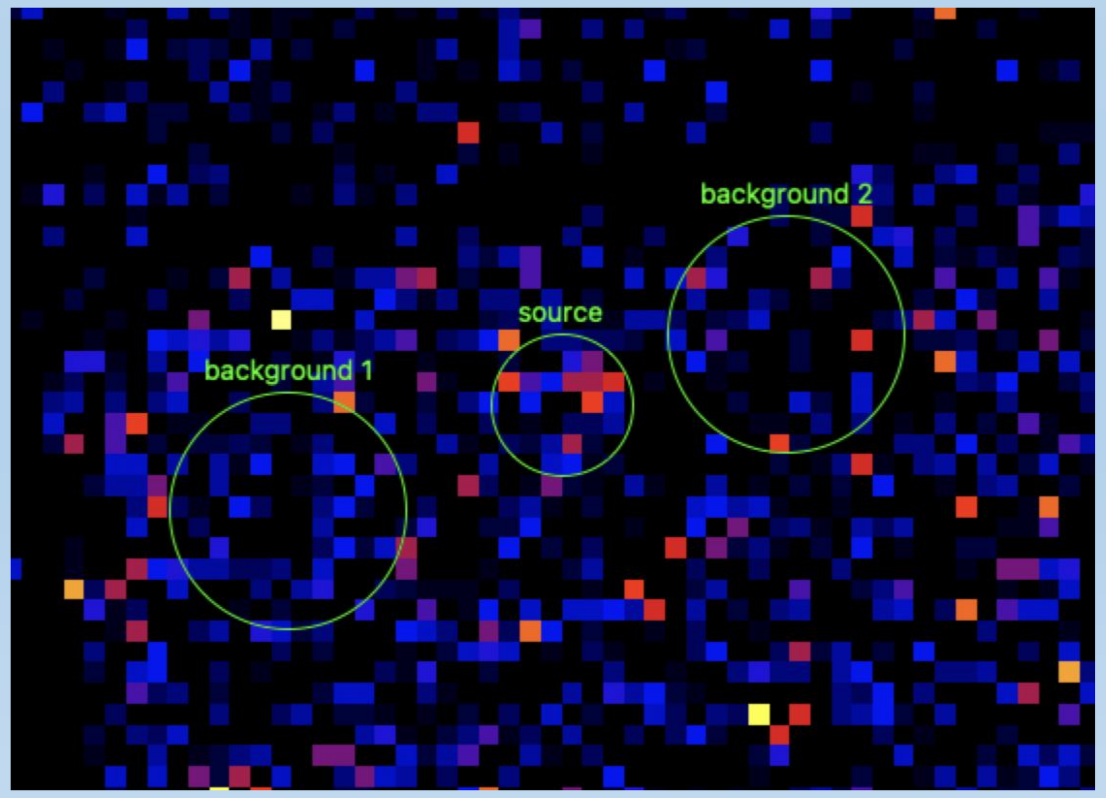

Figure 3: The source and background regions drawn for the 8th image taken using the PN detector. The warmer the color of the pixel, the more photons detected by that area of the detector.

Results

- Our observations probed BW Cir over timescales of 4 to 48 days.
- We did not find significant variability in excess of the measurement uncertainties (see the light curve in Figure 4).

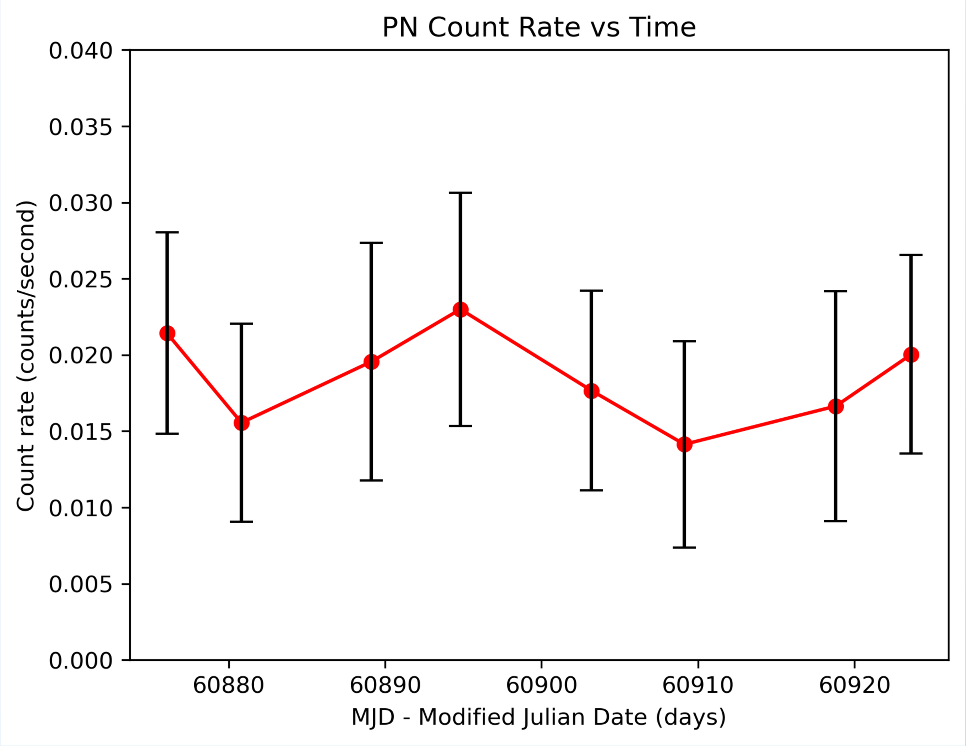

Figure 4: The change in X-rays emitted from BW Cir observed by the PN detector over a period of two months.

Conclusion

- The data shown above is an initial look at a subset of 8 observations from a larger dataset of 13 observations. We reduced data from only one of three cameras on XMM-Newton's EPIC detector.
- Next semester, we will complete the reduction for all 3 cameras over all 13 observations, thereby improving our statistics and error analysis. Looking at the other 2 cameras may also reveal variability in our light curve that the PN detector is not sensitive enough to detect by itself.
- The lack of detected variability may imply that variations occur on timescales shorter than 5 days or longer than 45 days. Shorter timescales imply that most of the radiation emitted is very close to the black hole, while longer timescales imply the radiation emitted is at a much larger distance.
- Next semester, we will quantify the amplitude and timescales of variability through time-series analyses of irregularly sampled data. We will also perform an X-ray spectral analysis, to determine if the shape of the X-ray spectra changes over time. This will help us identify the density of the accretion flow.

References

- [1]: Illustration Credit: ESA, NASA, and Felix Mirabel (French Atomic Energy Commission and Institute for Astronomy and Space Physics/Conicet of Argentina)
- [2]: Bernardini, F., & Cackett, E. M. (02 2014). Characterizing the quiescent X-ray variability of the black hole low-mass X-ray binary V404 Cyg. *Monthly Notices of the Royal Astronomical Society*, *439*(3), 2771–2780. doi:10.1093/mnras/stu140
- [3] J. Casares *et al* 2009 *ApJS* **181** 238
- [4] Ducros, D. (2002). Artist's impression of XMM-Newton. In European Space Agency. https://www.esa.int/ESA_Multimedia/Images/2000/09/Artist_s_impression_of_XMM-Newton