Multi-wavelength observations of the candidate redback 4FGL 1702.7-5655

Nazma Islam
Assistant Research Scientist
nislam@umbc.edu

R.H.D Corbet, L. Chomiuk, J.B Coley, G.Dubus, P.G Edwards,
A. Lange, V. McBride, J. Stevens, J. Strader, L. Townsend

11th Fermi Symposium, UMD, 9th Sept 2024

Gamma-ray binaries

- Several gamma-ray binaries discovered from search for periodic modulation of Fermi-LAT light curves. **Check out Robin Corbet's poster no: 43 for more details**.

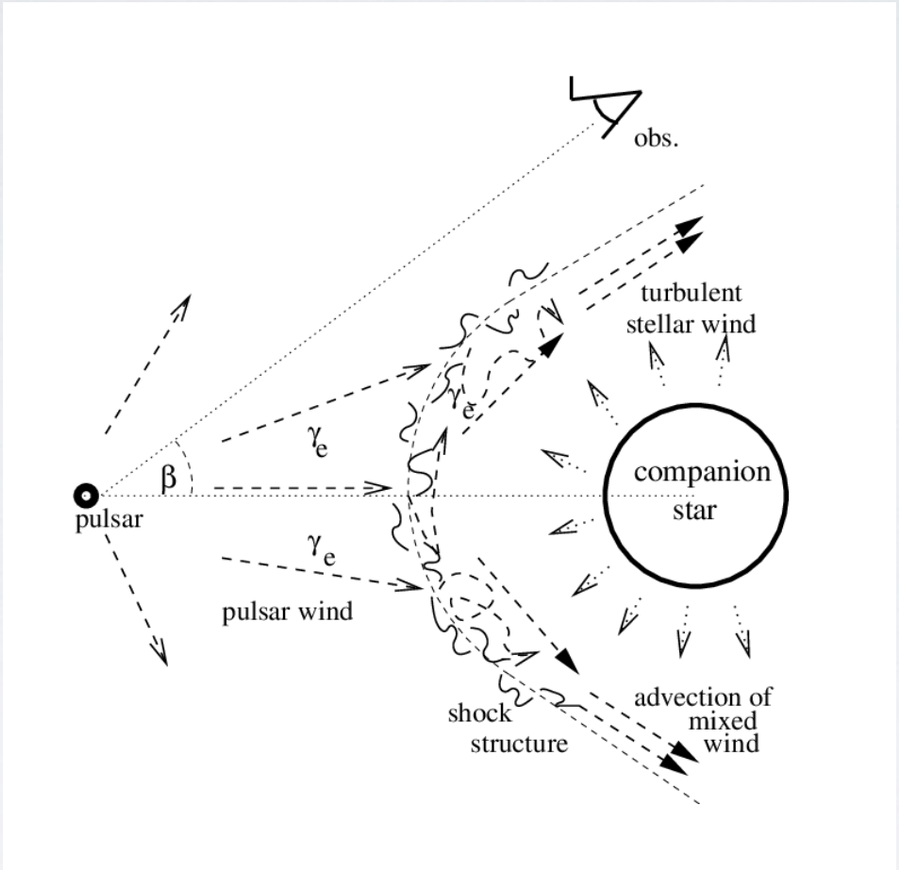
- High Mass Gamma-ray binary: Compact object, most likely a NS, with a massive O or B/Be companion star. **Check out Alex Lange poster no: 44 on 4FGL 1405.1-6119**.

- Millisecond pulsars: short pulse period, descendants of LMXBs. Spider binaries: low mass companion ablated by the pulsar wind.

- Redbacks ~ 0.1-0.4 $M_\odot$. Black widows -> low mass degenerate companion star < 0.04 $M_\odot$

- 'Transitional' -> Switch between powered by rotational powered and accretion powered state.

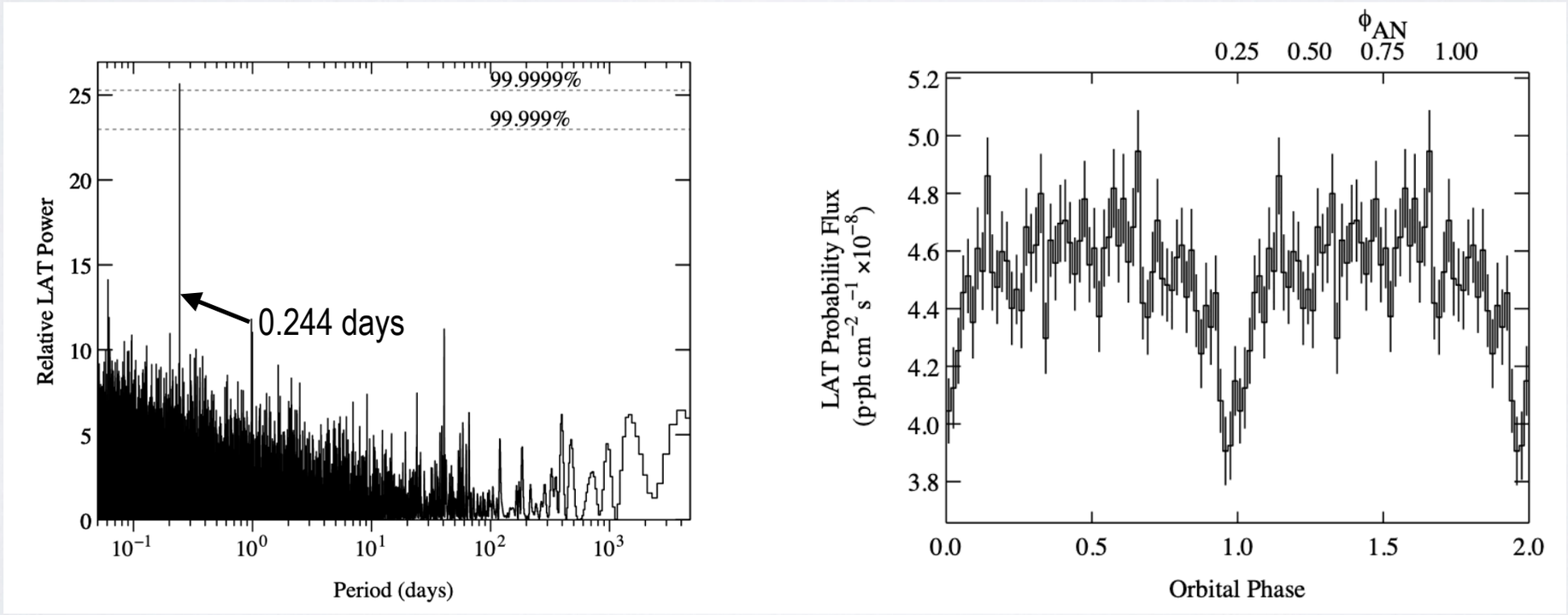
Intra-binary shock



Intra-binary shock (IBS) between pulsar wind and radiatively driven companion stellar winds. Important site of emission. Anisotropic geometry of the pulsar wind suggests it is equatorially concentrated. Ref: Bednarek 2013, Kandel et al. 2019

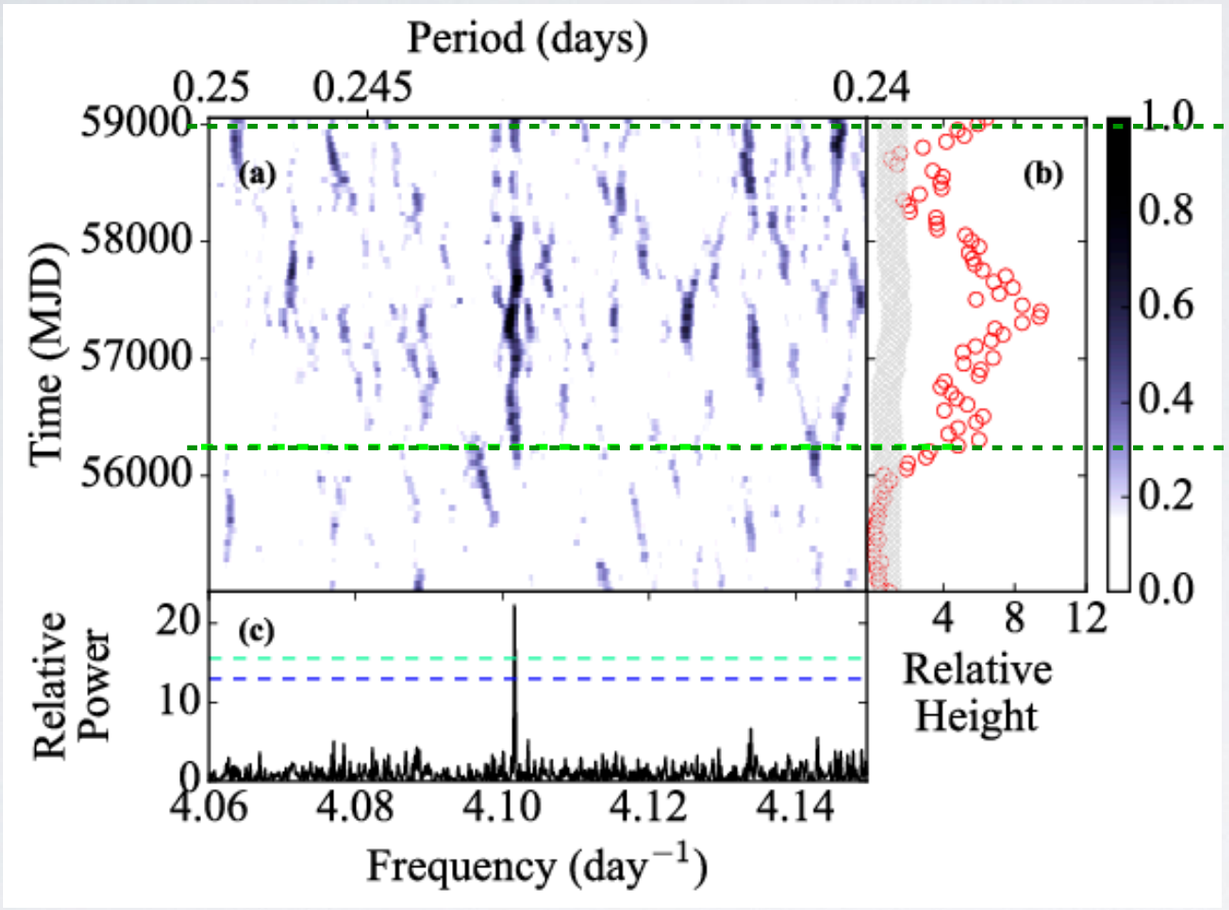
Gamma-ray binary 4FGL 1702.7-5655

- Known LAT source, perhaps associated with AGILE gamma-ray source 2AGL J1703-5705.
- Classified as a candidate MSP. No pulsations found with LAT (gamma-ray) or Parkes (radio).
- Power spectrum with LAT lightcurve show modulations at ~0.244 days (5.85 hrs). Folded LAT lightcurve shows an eclipse in gamma-rays => candidate redback



Corbet et al. 2022

Dynamic Power Spectrum



Part 2: MJD 56,345-59,445

Part 1: MJD 54,682-56,345

a) Dynamic power spectrum of the probability-weighted aperture photometry LAT lightcurve of 4FGL 1702.7-5655 b) Relative peak at the orbital period to the mean power of the values shown in panel (a) c) Coherent power spectrum of the entire lightcurve.

Gamma-ray Eclipses

- **Part 1: MJD 54,682 - 56,345**

- No orbital modulation present in the dynamic power spectrum

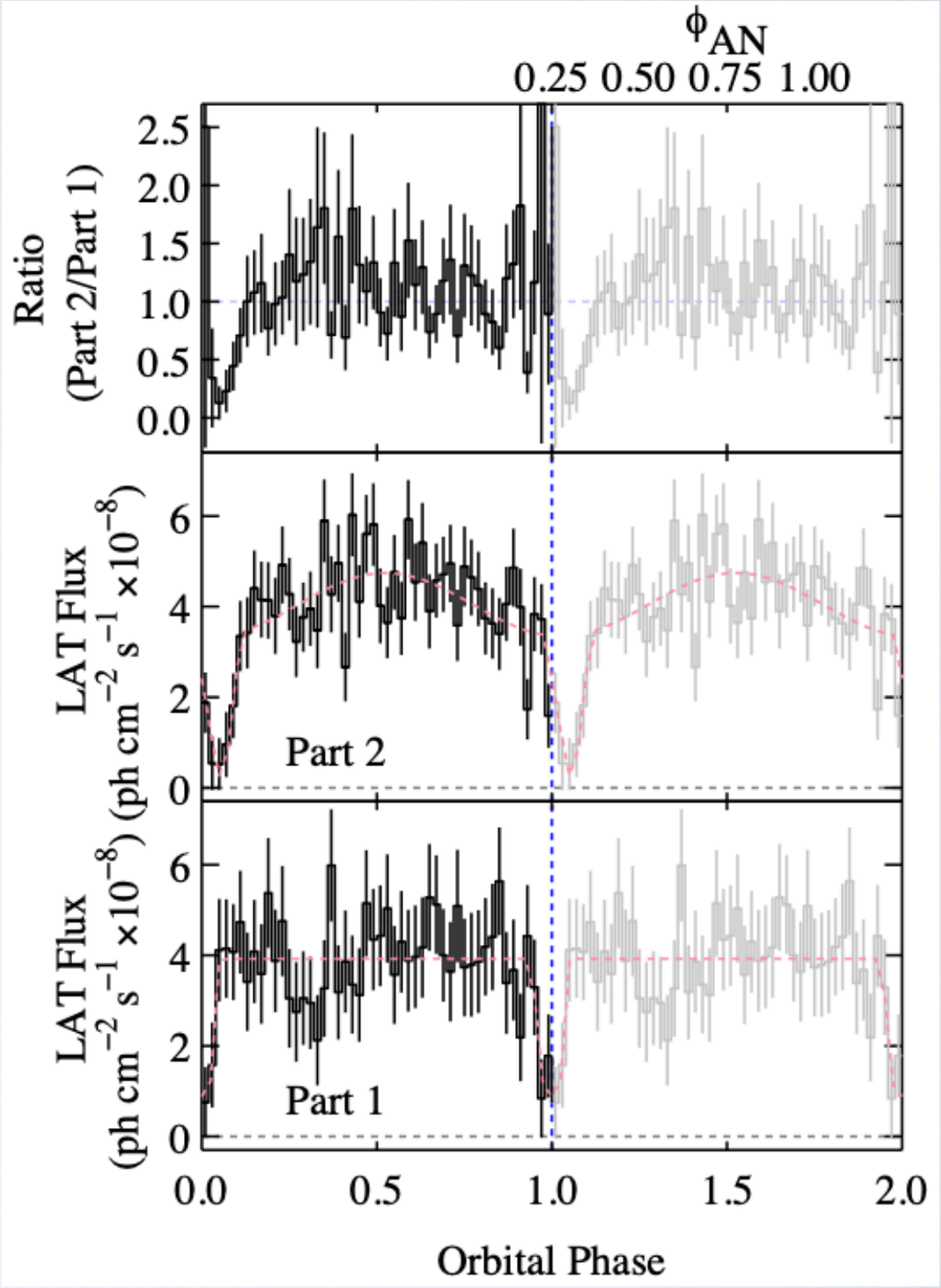
- Deep narrow eclipse

- **Part 2: MJD 56,345 - 59,445**

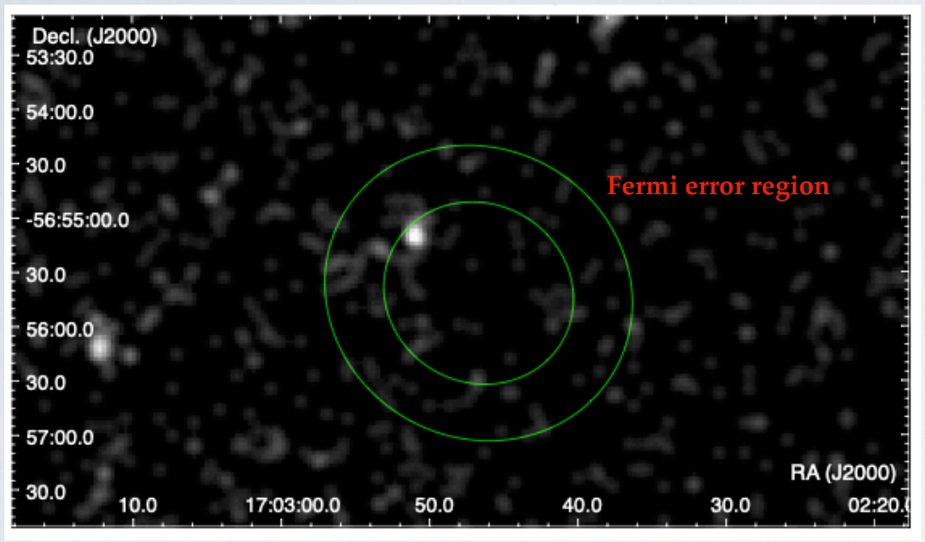
- Orbital modulation present in the dynamic power spectrum. Eclipse profile + sine component.

- Eclipse shifts to ~0.06 is phase.

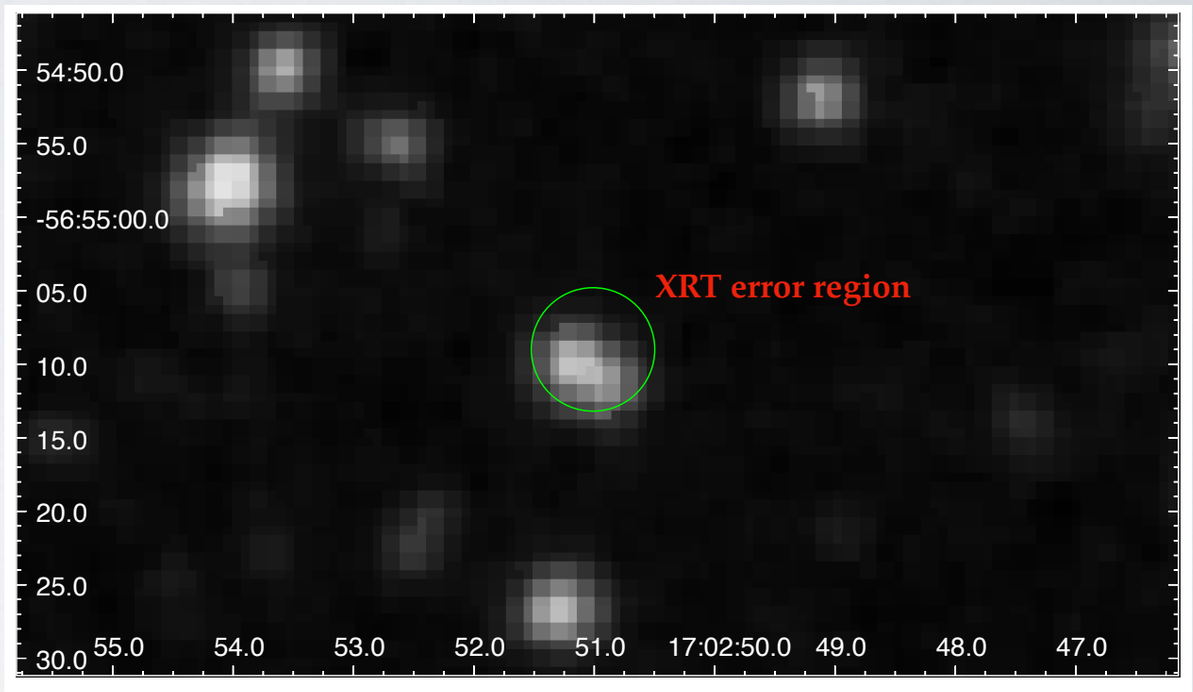
- Sine wave component is maximum at the inferior conjunction



Optical and X-ray counterpart



Smoothed Swift-XRT of the region around 4FGL J1702.7-5655, showing the 68% and 95% confidence region of LAT. The candidate X-ray counterpart is the brightest source within 68% region.



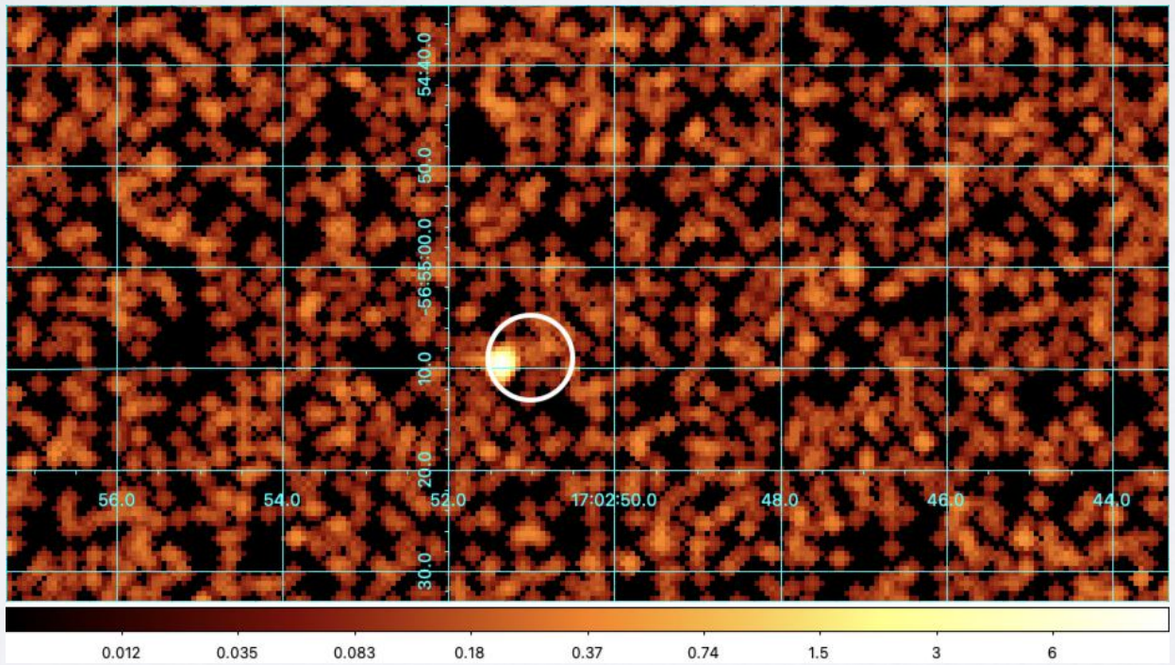
Deep Sky Survey 2 red image of the region around the possible XRT counterpart of 4FGL J1702.7-5655.

ATCA observations: No radio source were detected within the LAT error region.
Upper limits of 60 μJy

X-ray observations

- Chandra observation carried out for 22 ks ~ 1 orbital cycle

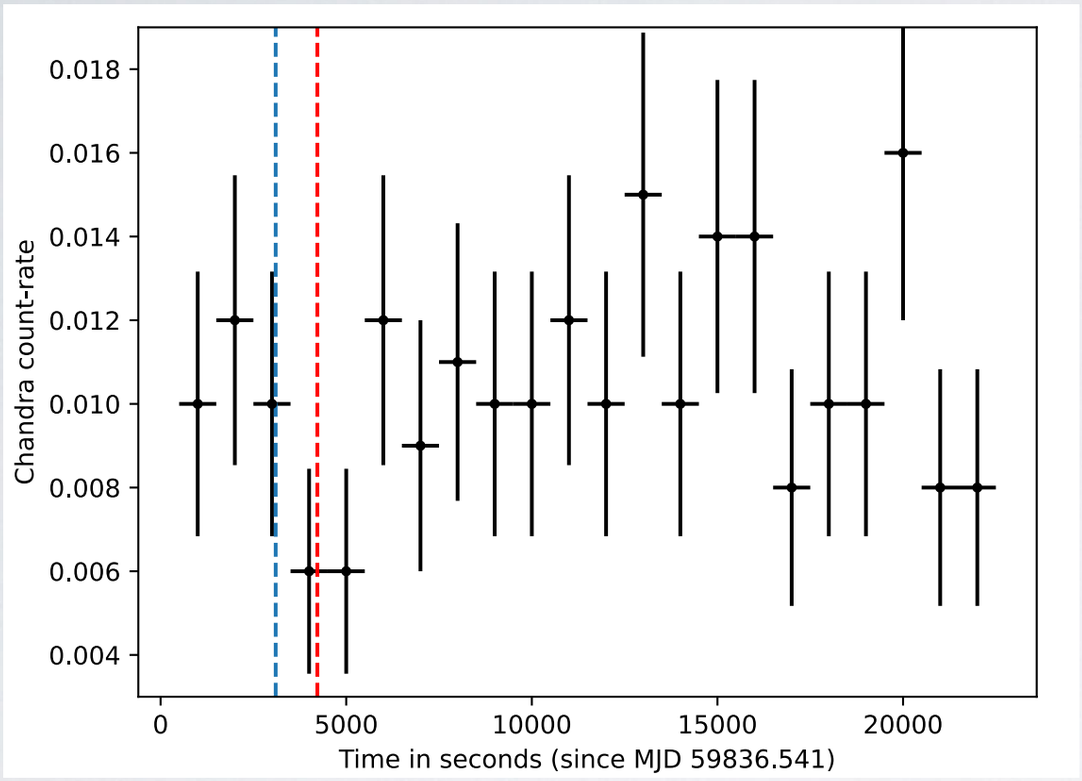
- XMM observation carried out for 45 ks ~ 2 orbital cycles.

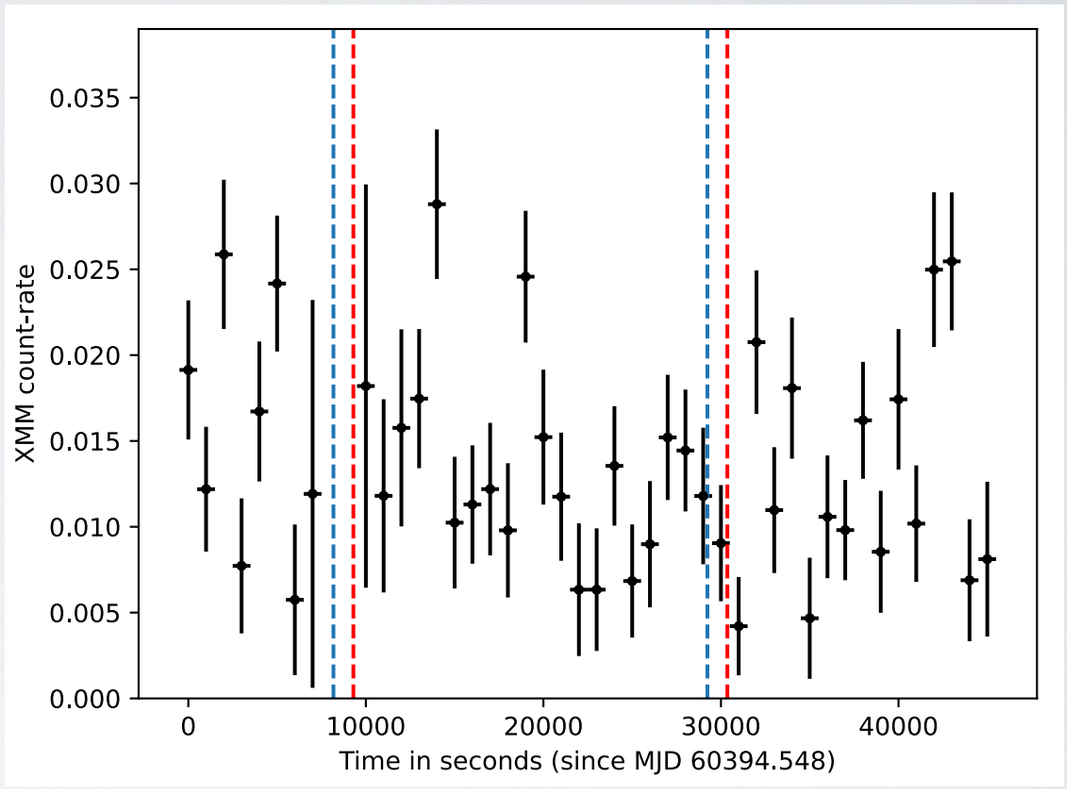


Smoothed X-ray image from the Chandra observation. The white circle shows the location of the X-ray source detected previously with the Swift XRT observations and the radius denotes the uncertainty in the Swift XRT position

Preliminary

X-ray light curves

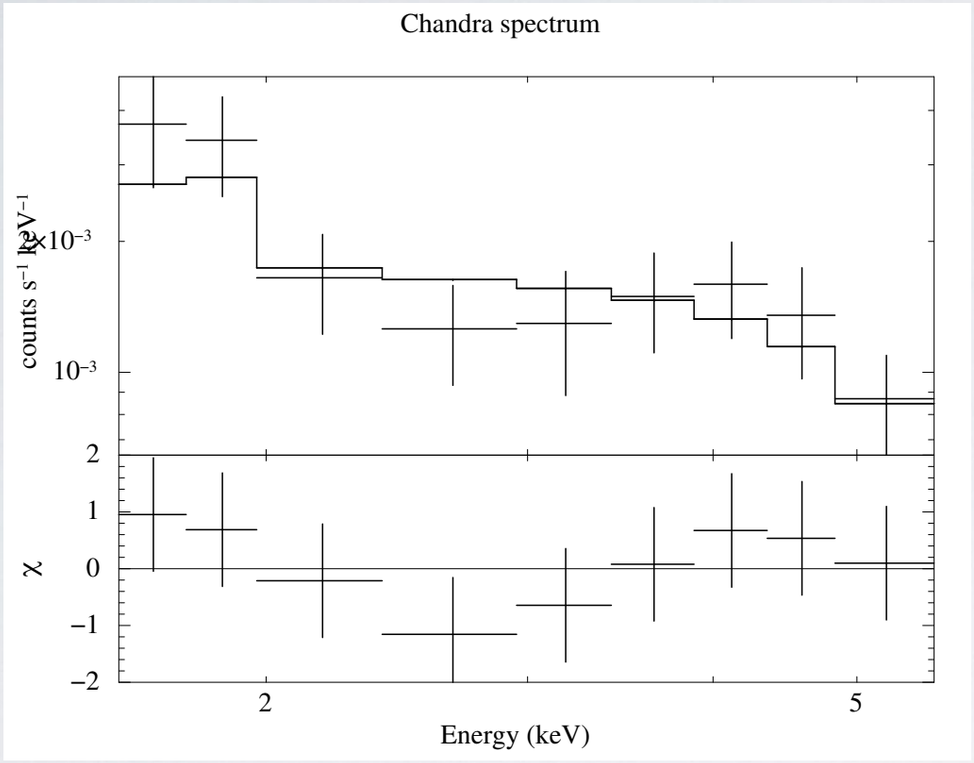




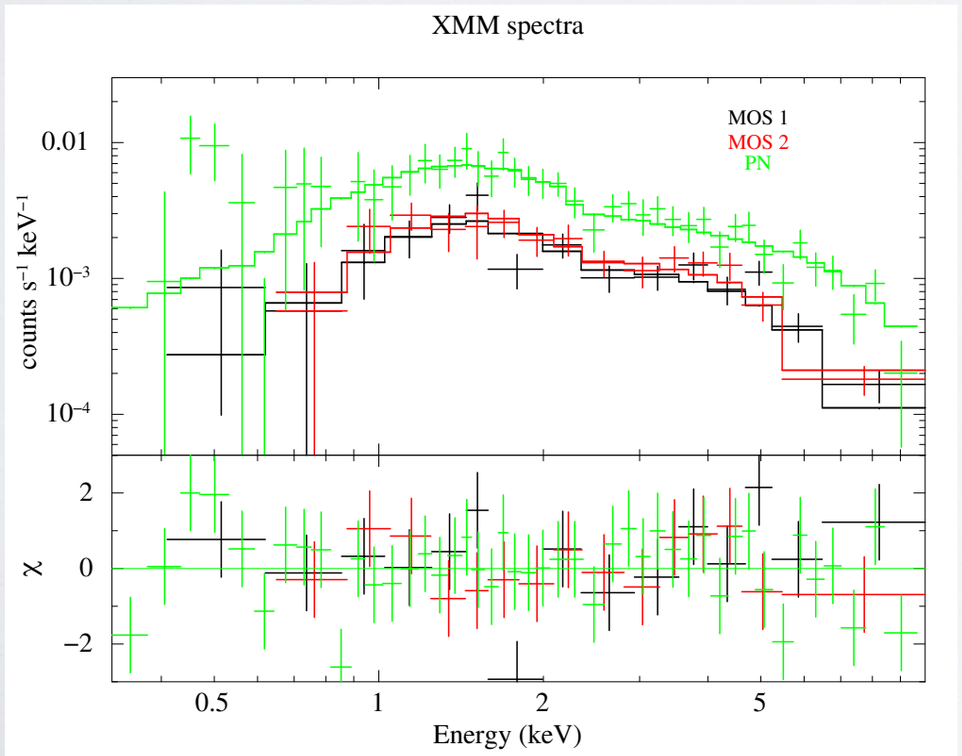
Background subtracted lightcurve obtained with Chandra ACIS observation in 0.3-8.0 keV energy-band (left panel), and with XMM in 0.3-10 keV (right panel), binned by 1000 s. The blue dashed lines denotes the center of the expected gamma-ray eclipse using epoch of Part 1 and the red dashed lines for Part 2.

Preliminary

X-ray spectrum



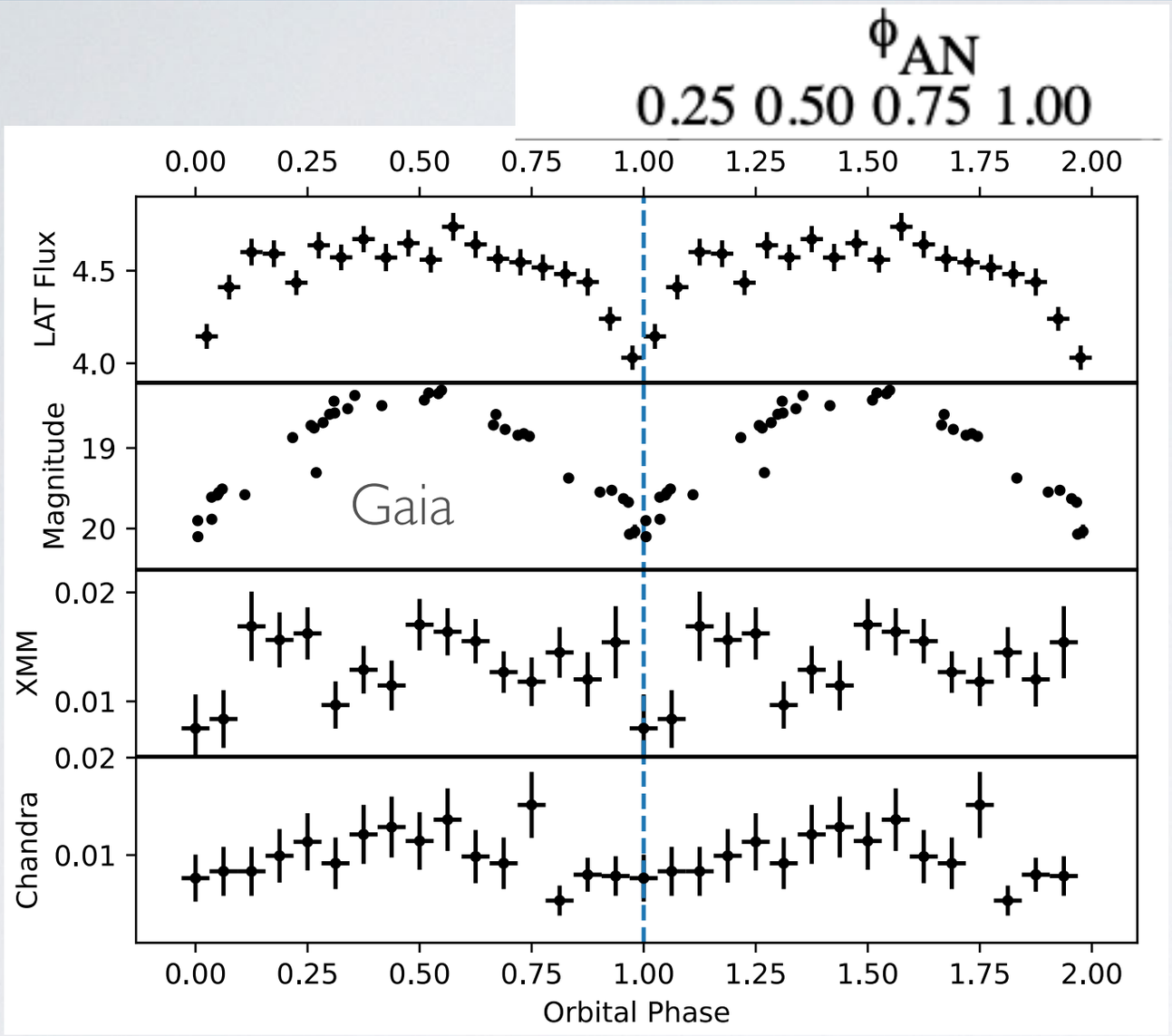
- Photon -index ~0.7.
- X-ray flux (0.5-8.0 keV) = 1.6 x 10^{-13} erg/s/cm^2



- Photon -index ~0.8.
- X-ray flux (0.5-10.0 keV) = 2 x 10^{-13} erg/s/cm^2
- N_H ~ 0.3 x 10^{22} cm^{-2}

Preliminary

Multi-wavelength Orbital intensity profile



Eclipses seen in gamma-rays, optical and in XMM light curves.

No X-ray eclipse in Chandra light curves => photon limited statistics

Higher flux at the inferior conjunction (compact object nearest to us)

Lightcurves of LAT (gamma-rays), Gaia (optical), XMM and Chandra (X-rays) folded using the orbital period of 0.244 d and the center of the gamma-ray eclipse defined for Part II

Preliminary

Summary

- Unique gamma-ray eclipse seen in 4FGL 1702.7-5655. Changes in LAT orbital profile not accompanied by large changes in gamma-ray flux or spectrum.

- Eclipses seen in LAT, Gaia DR3 and XMM light curves at similar phase. Likely heating dominated optical lightcurve.

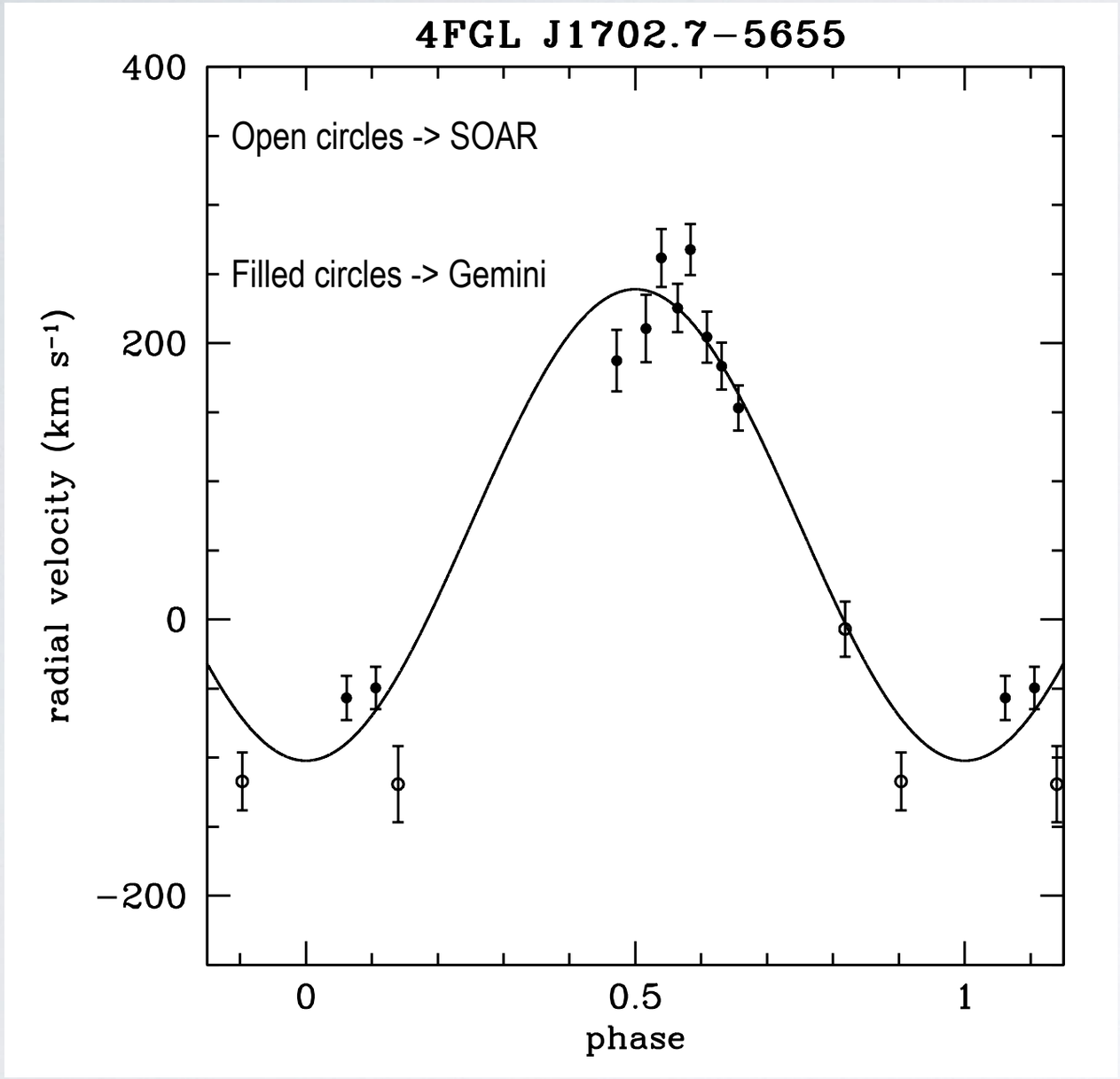
- X-ray spectrum is an absorbed power law with photon-index of 1.0. Low X-ray flux of 10^{-13} erg/s/cm^2 => tMSPs in sub-luminous disk state?

- No pulsations found in the X-ray observations.

- Changes in the orbital modulation related to IBS => constraining the geometry of IBS

Thank You

Radial velocity curve



Preliminary

- Circular fit: Mass function ~ 0.13 $M_\odot$
- Massive secondary > 0.4 $M_\odot$ or higher inclination.