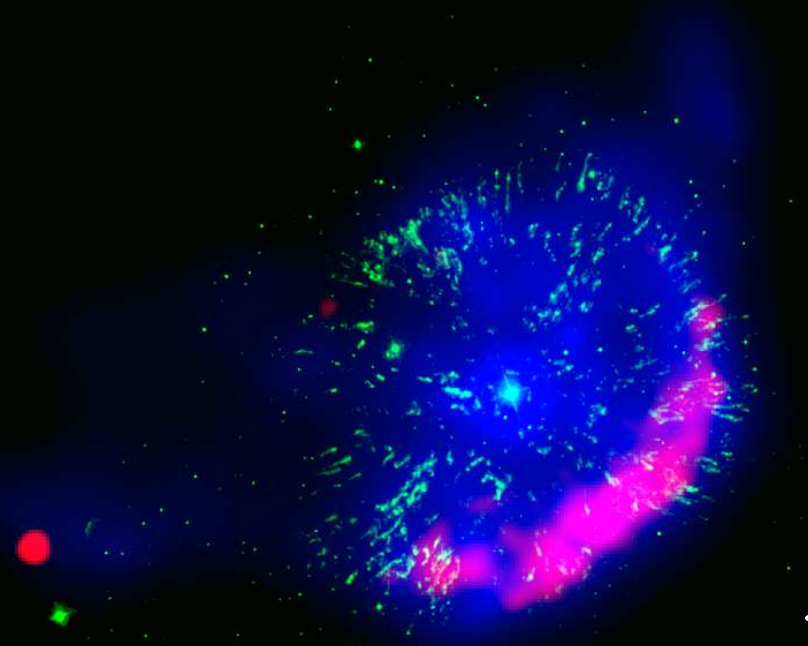


# Multi-mission observations of the old nova GK Per during the 2015 outburst

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Marina Orío<sup>2, 3</sup>, G. J. M. Luna<sup>4</sup>

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VLA / HST / Chandra



Takei et al., ApJ, 2015



INAF - Osservatorio Astronomico di Padova



Dipartimento di Fisica e Astronomia  
G. Galilei

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DEGLI STUDI  
DI PADOVA



Comune di Padova

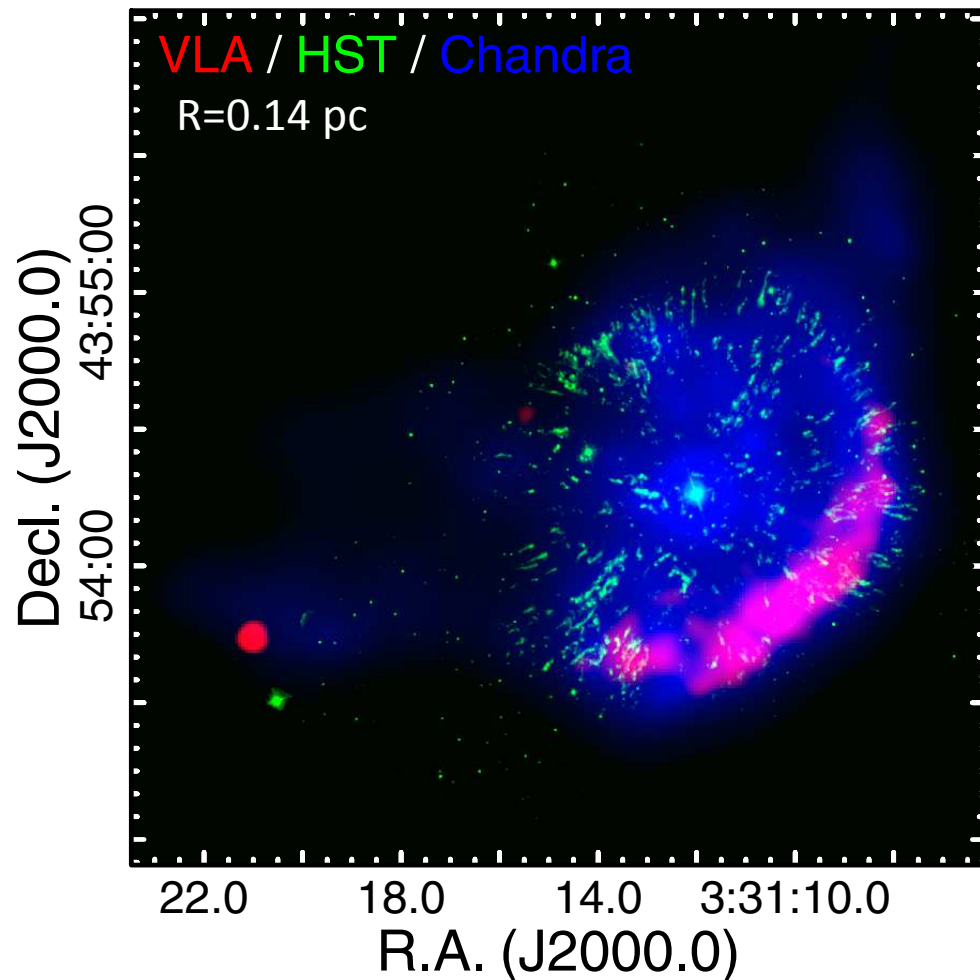


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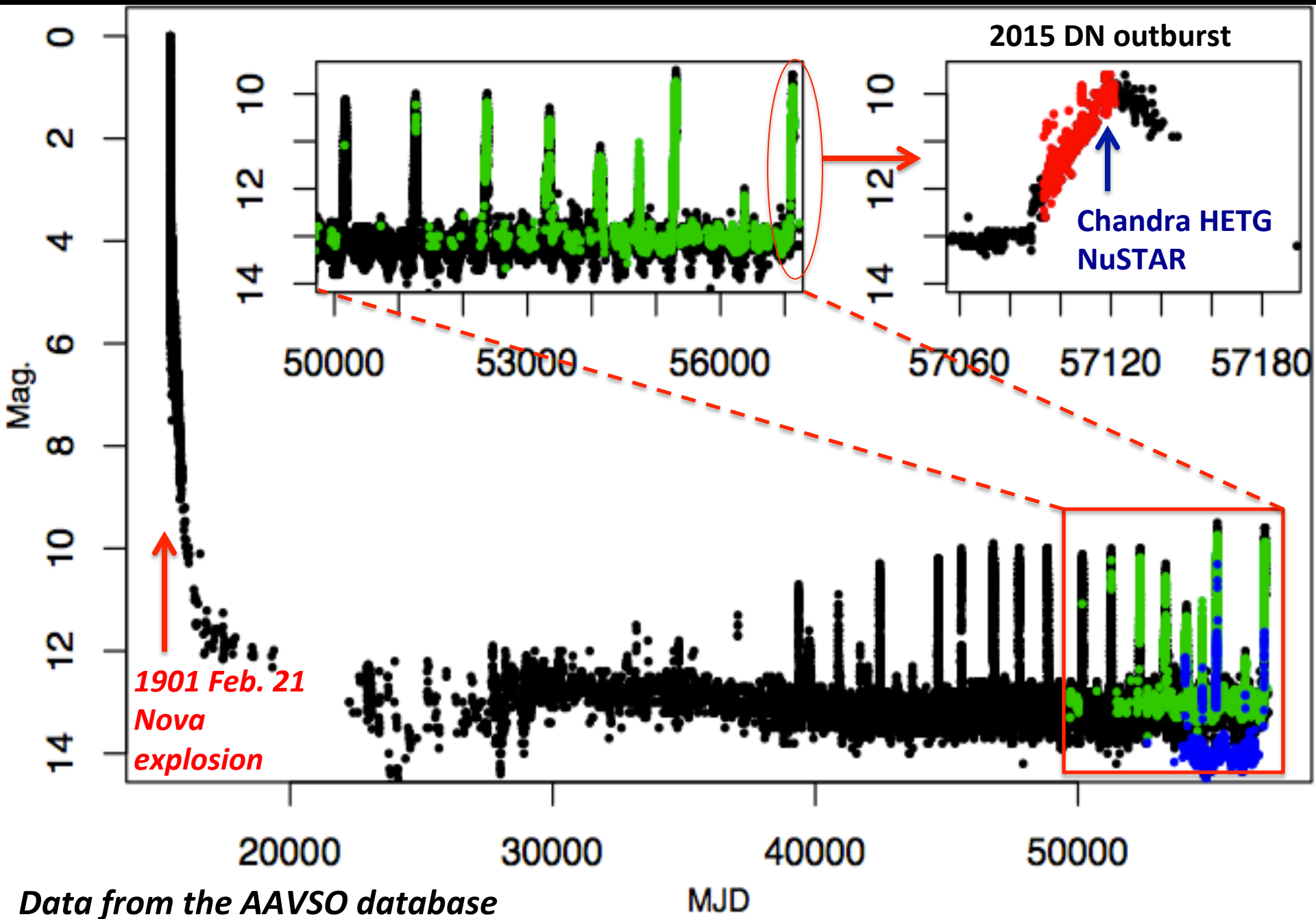
# GK Per

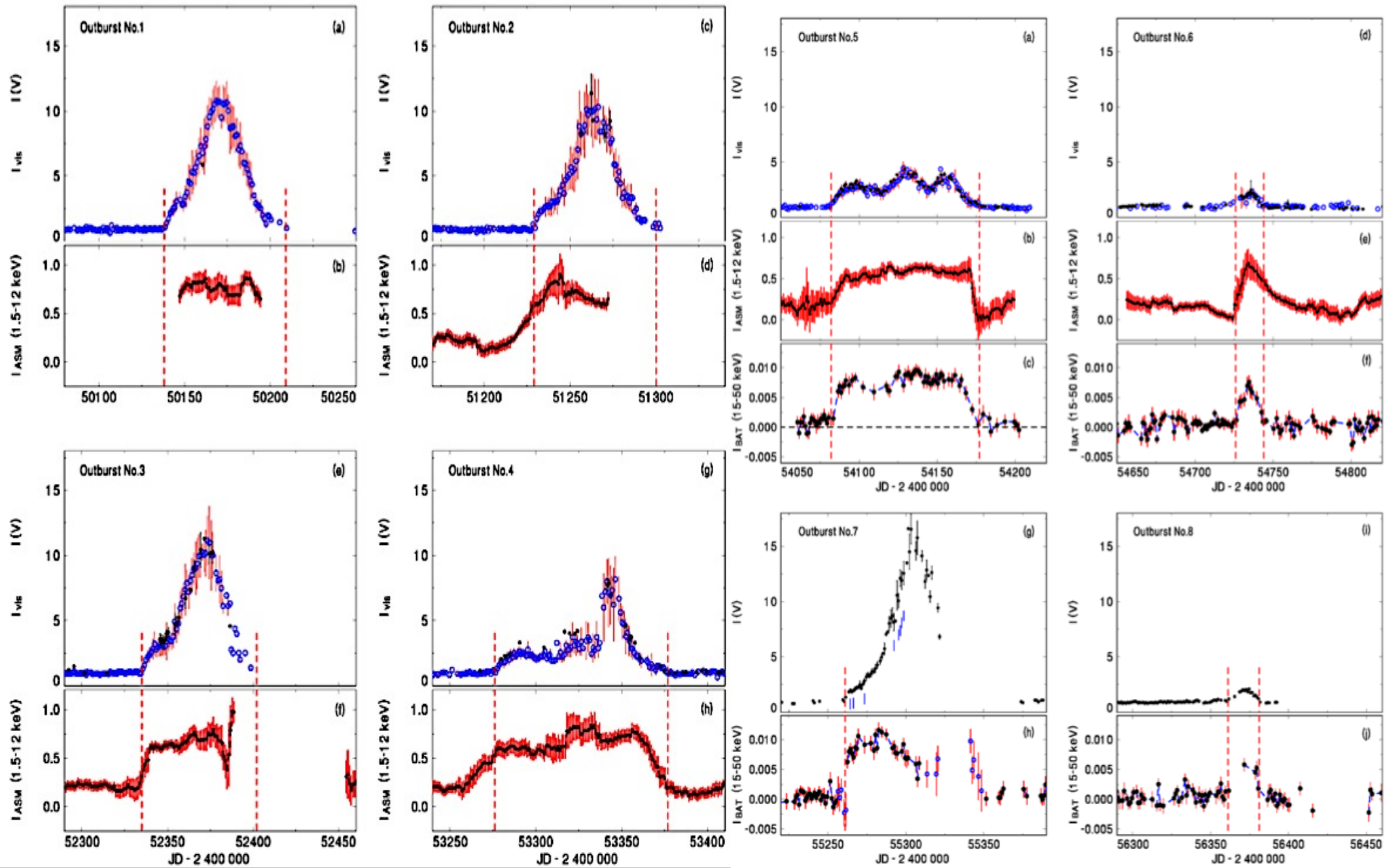


- Magnetic WD accreting from a red dwarf secondary
- $P_{\text{orb}}$  is  $\sim 2$  days
- WD spin period is 351 s
- The distance is 470 pc
- Hosts the largest known X-ray emitting nebula centered on a WD binary
- Is detected with the Swift BAT and INTEGRAL during DN outbursts



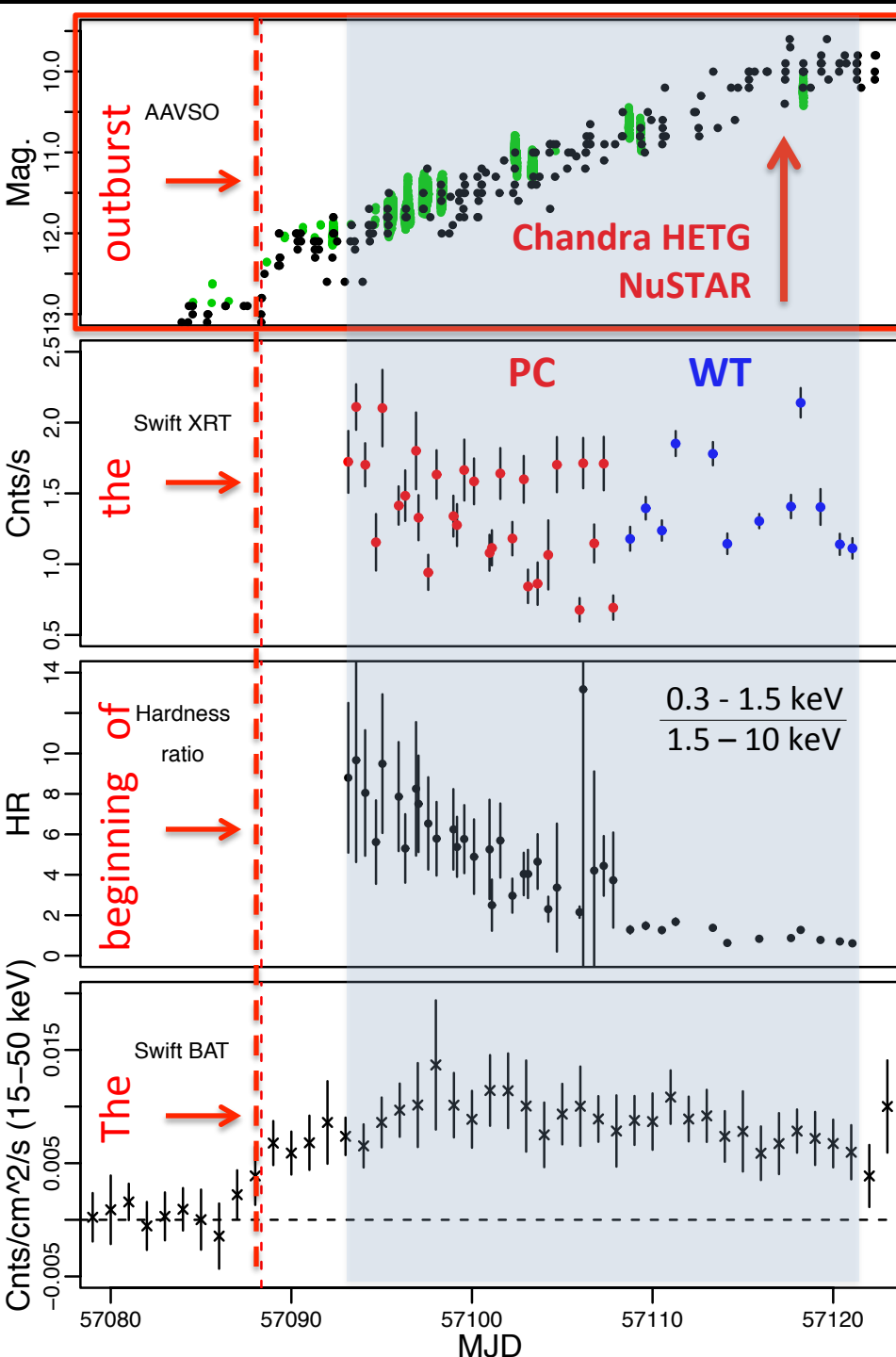
Takei et al., ApJ, 2015





Šimon, A&A, 2015. Comparison of the AAVSO, RXTE and Swift BAT light curves.

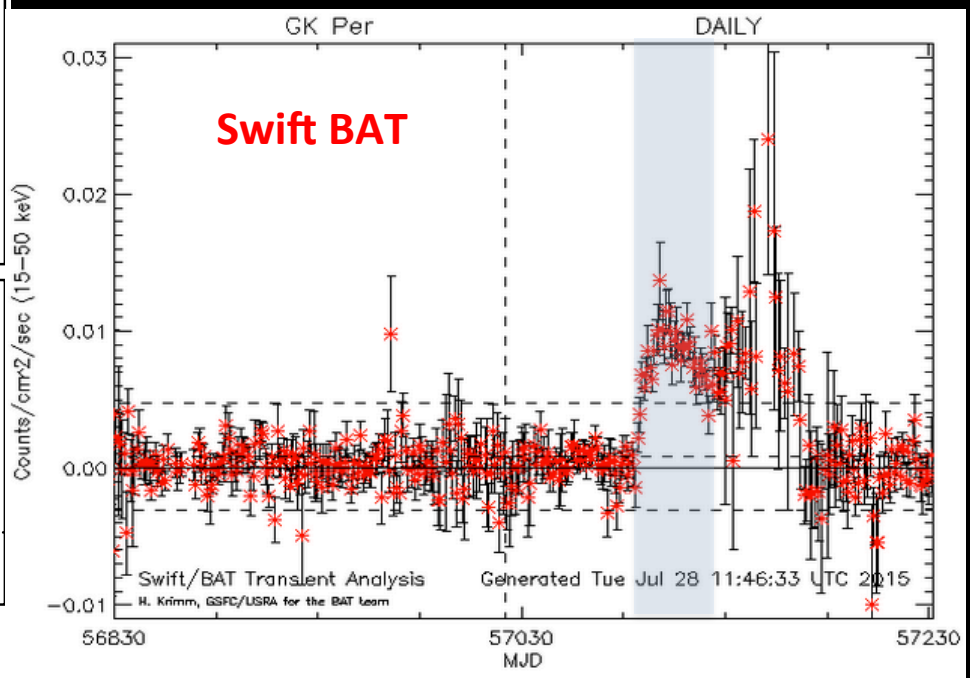
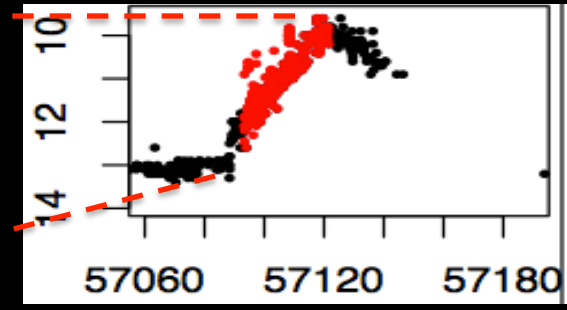
- Slow rise and decline in optical.
- A long-lasting plateau phase in the X-rays.

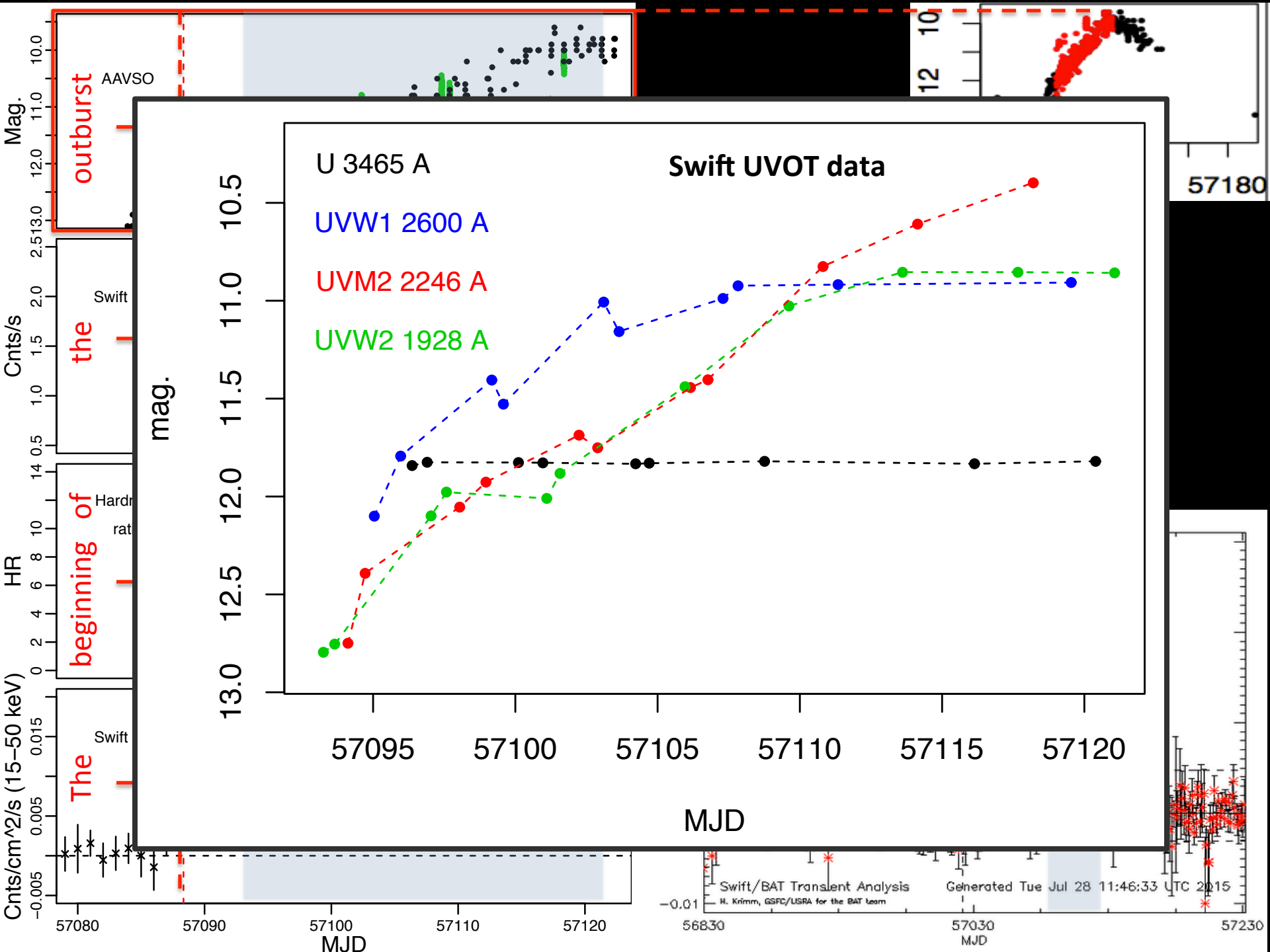


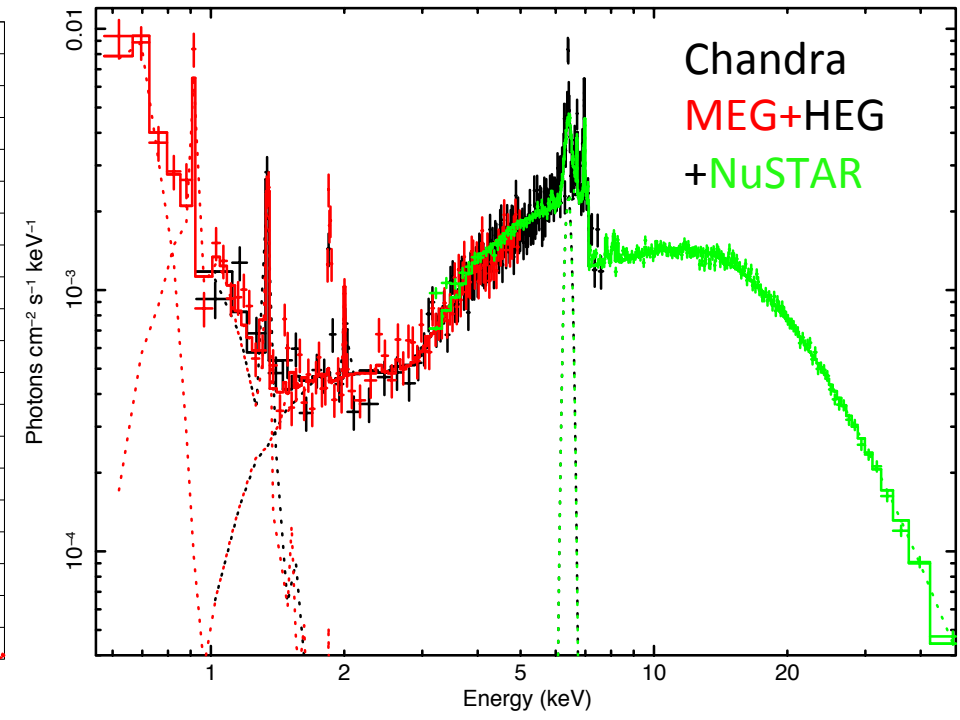
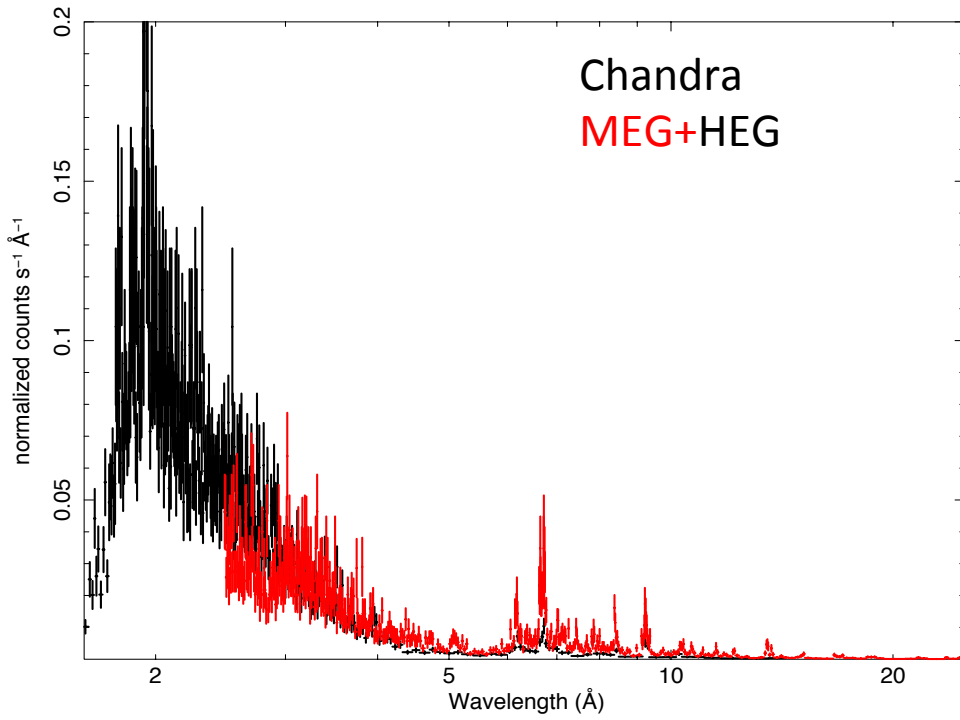
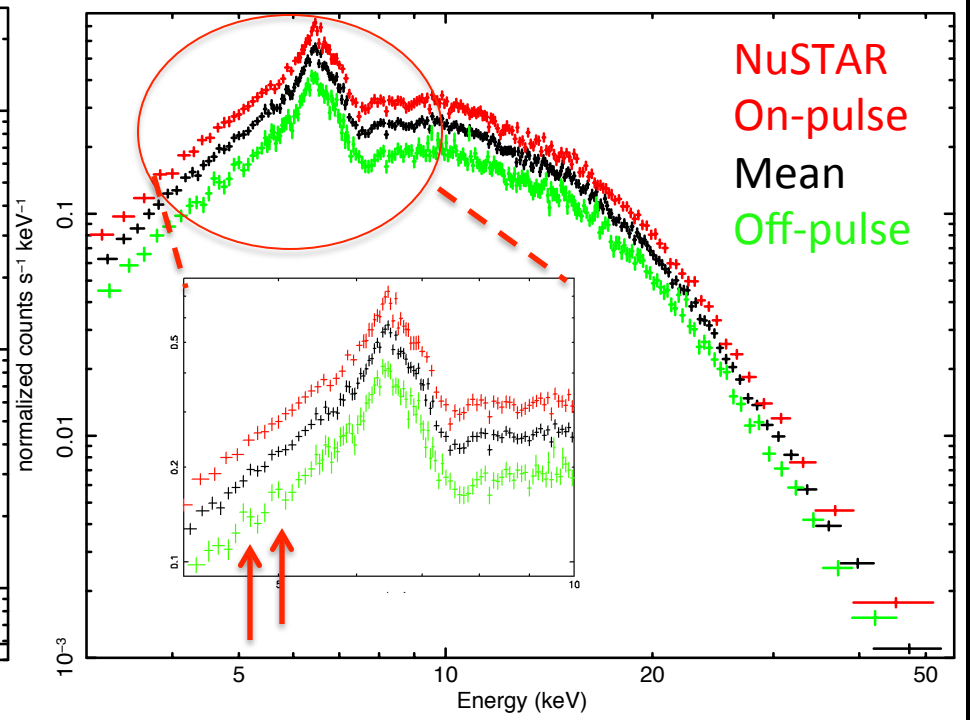
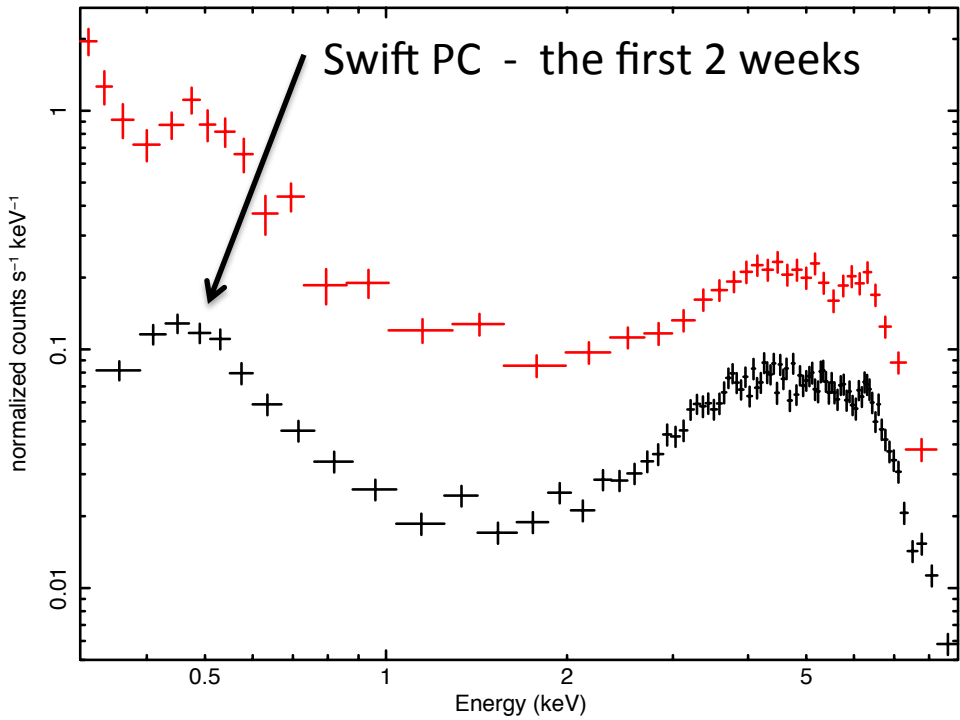
**Swift:**

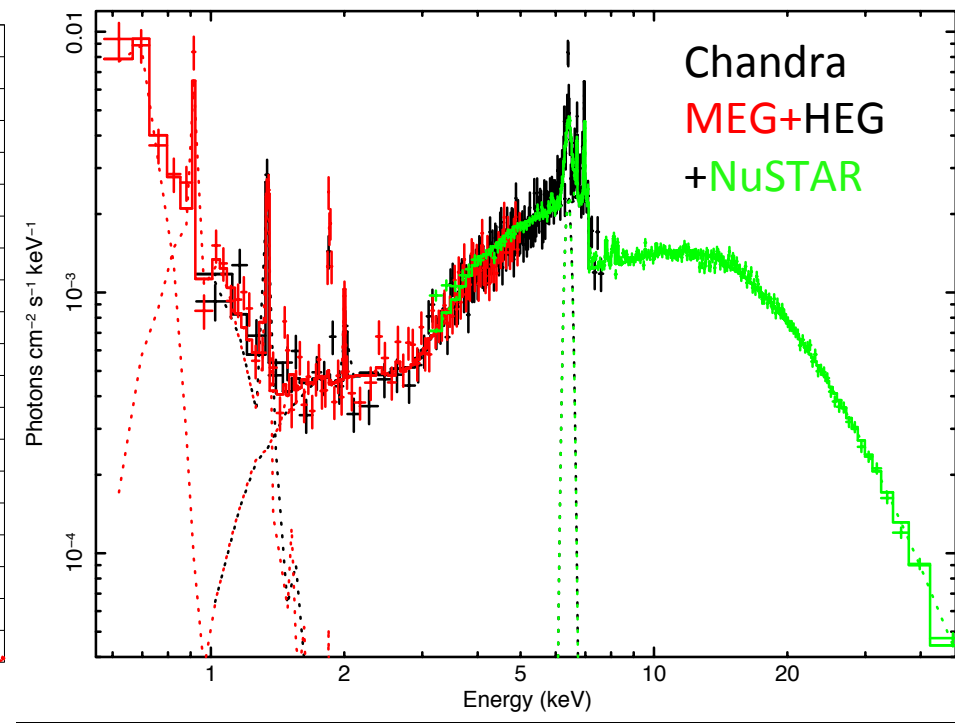
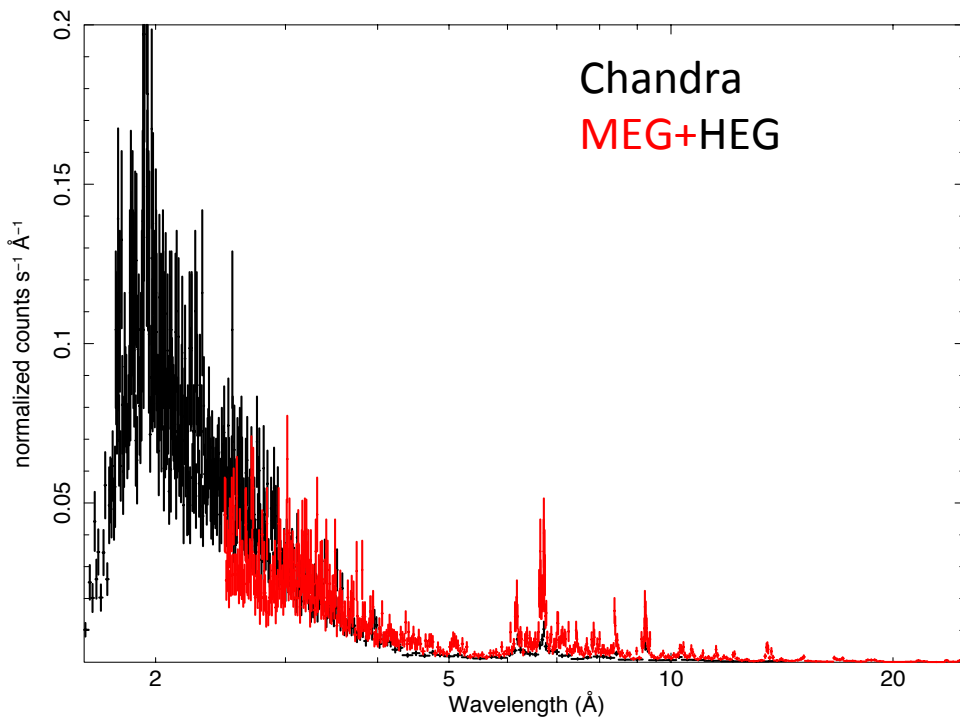
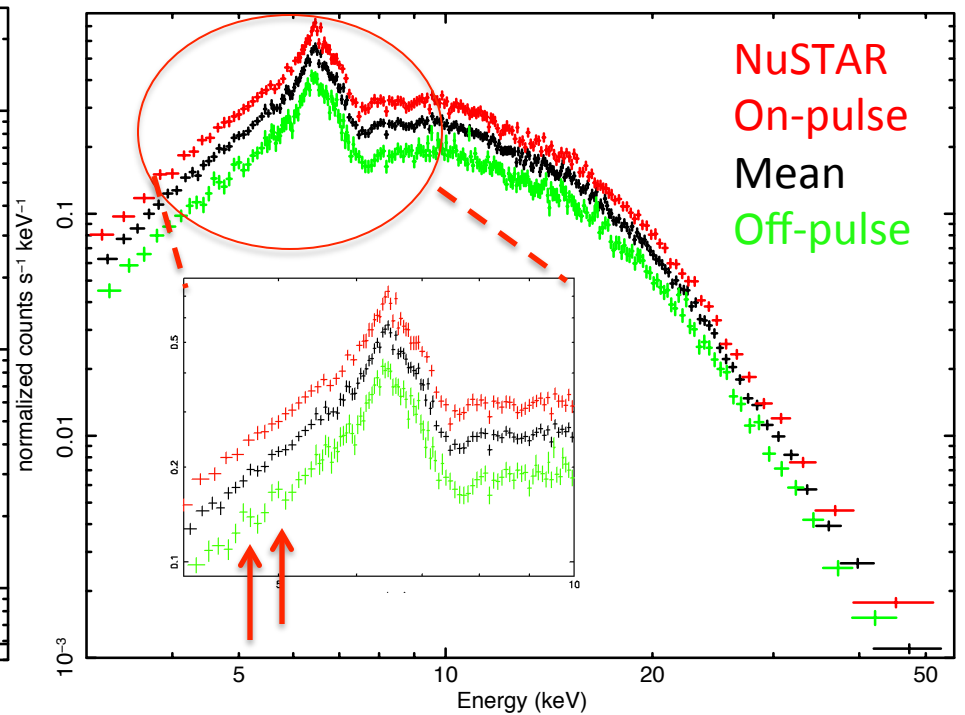
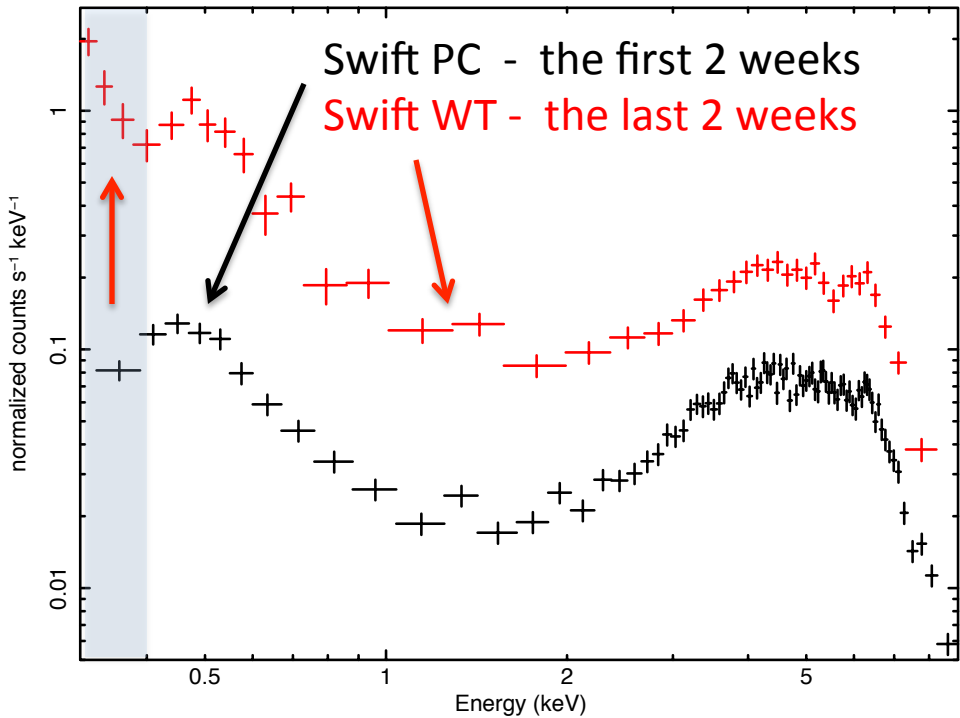
Two exposures per day ~1ks for 2 weeks  
 One exposure per day ~1ks for 2 weeks

**Chandra HETG:** 69 ks  
 HEG: 0.120+/- 0.013 cnts/s  
 MEG: 0.0749+/- 0.0010 cnts/s  
**NuSTAR:** 42.3 ks  
 3.622+/- 0.009 cnts/s

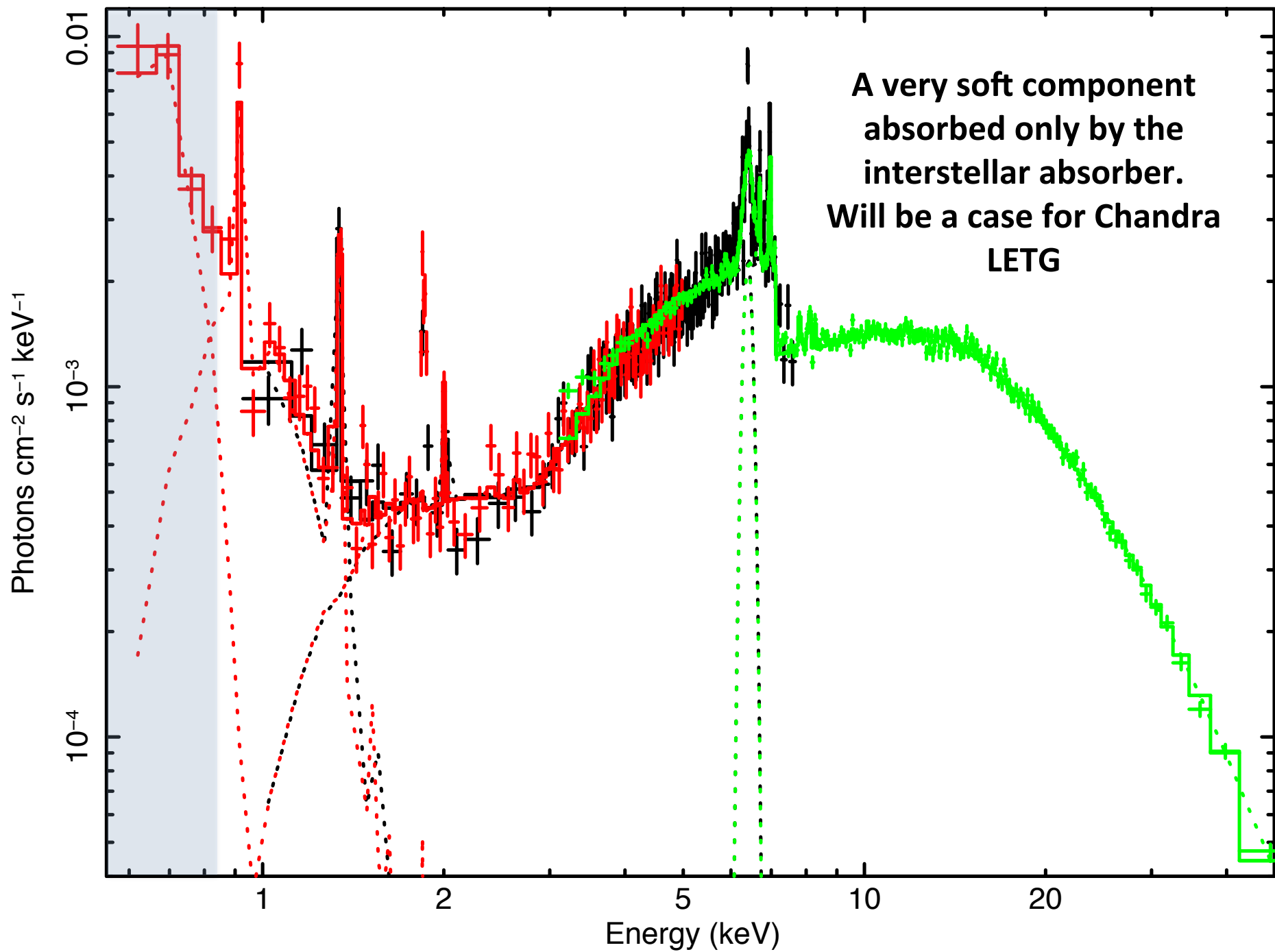


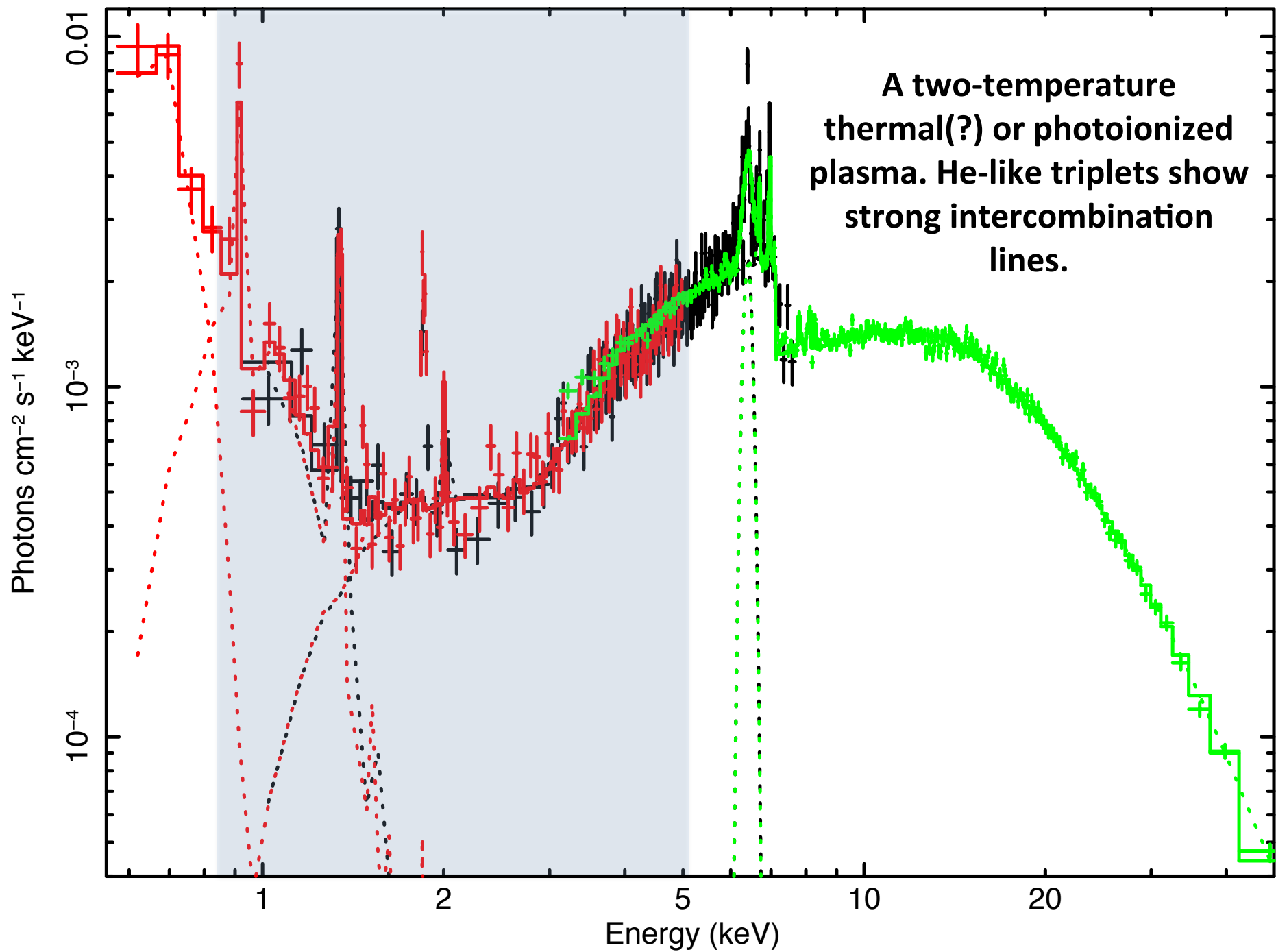


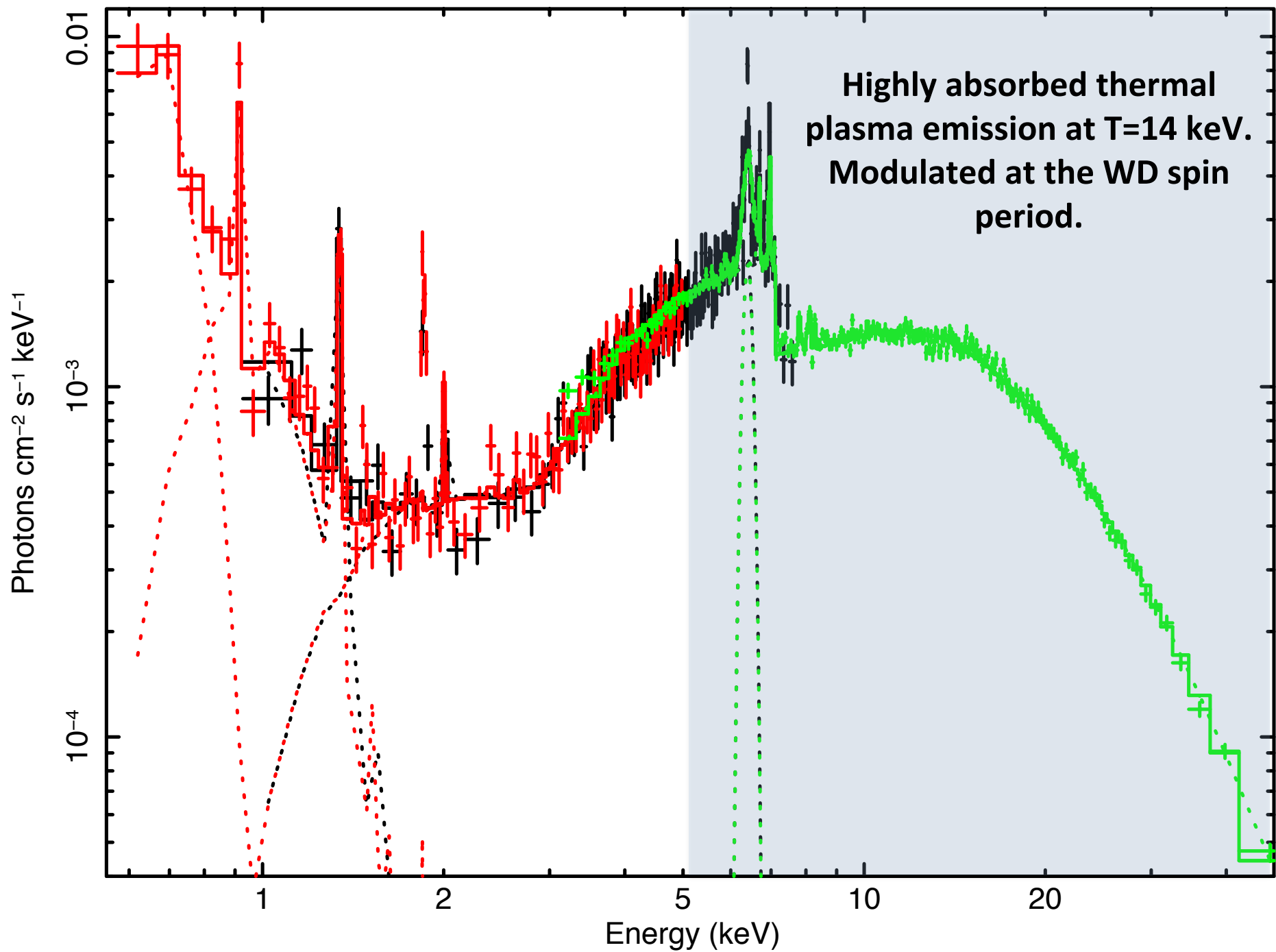


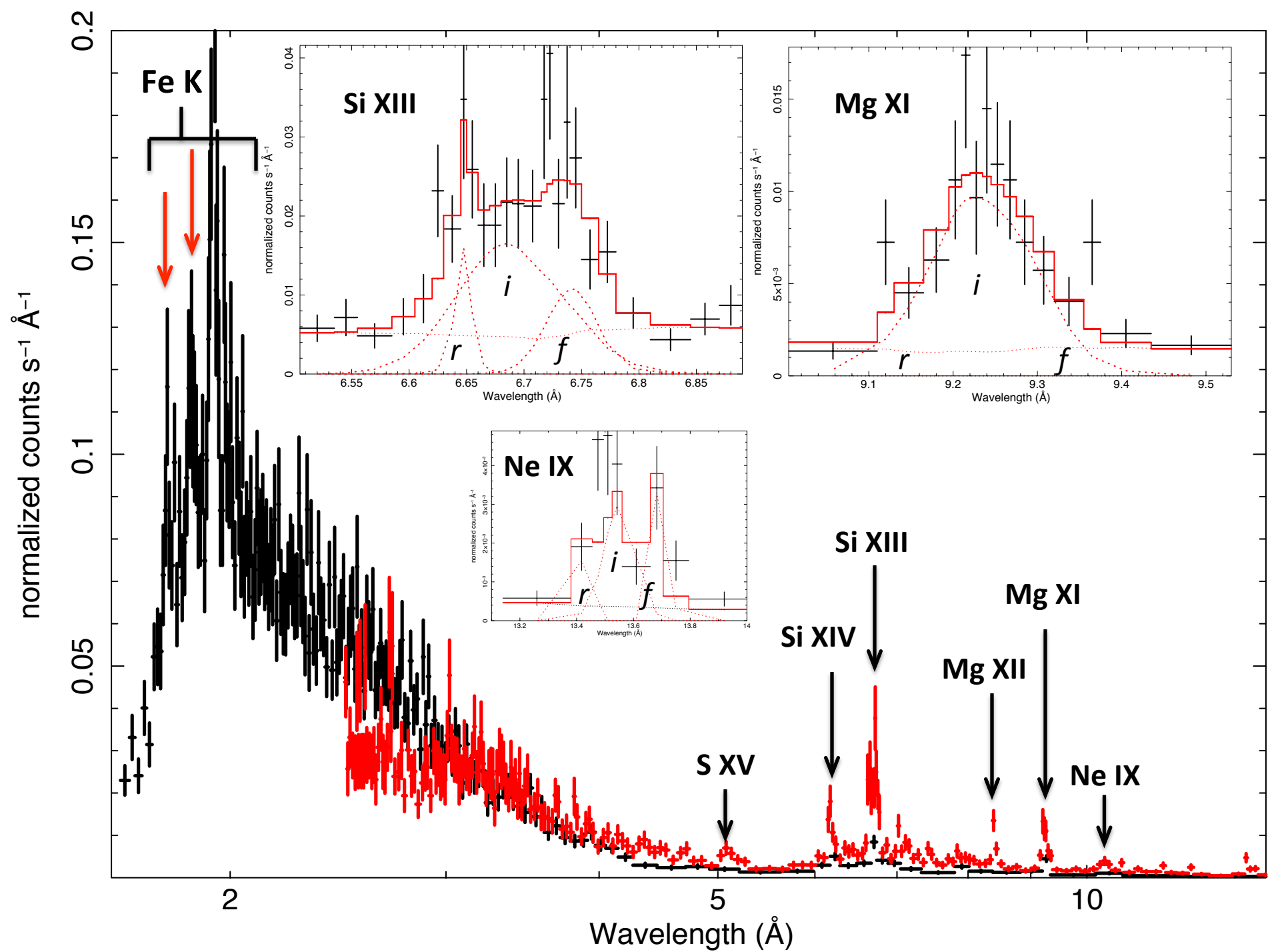


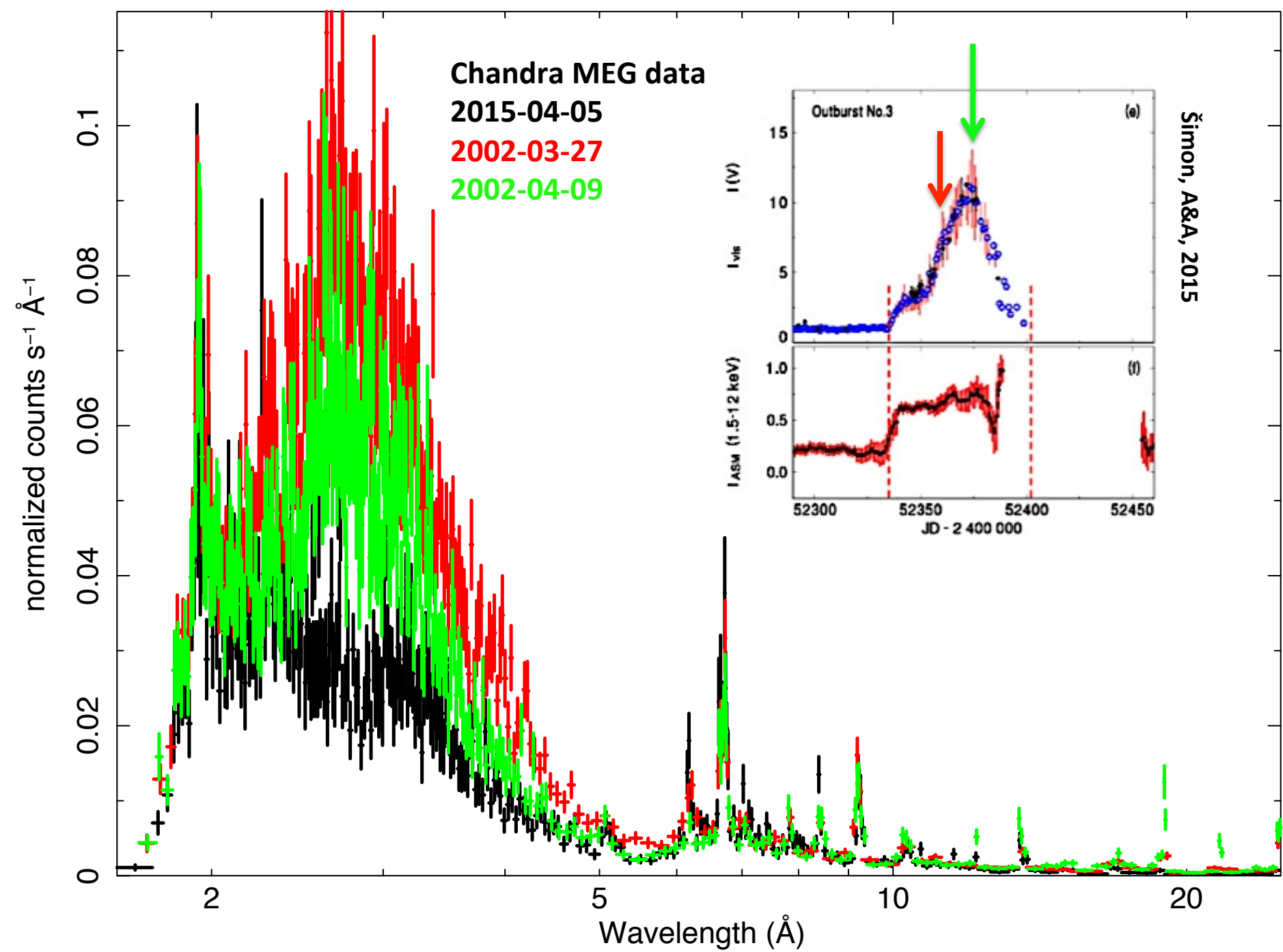


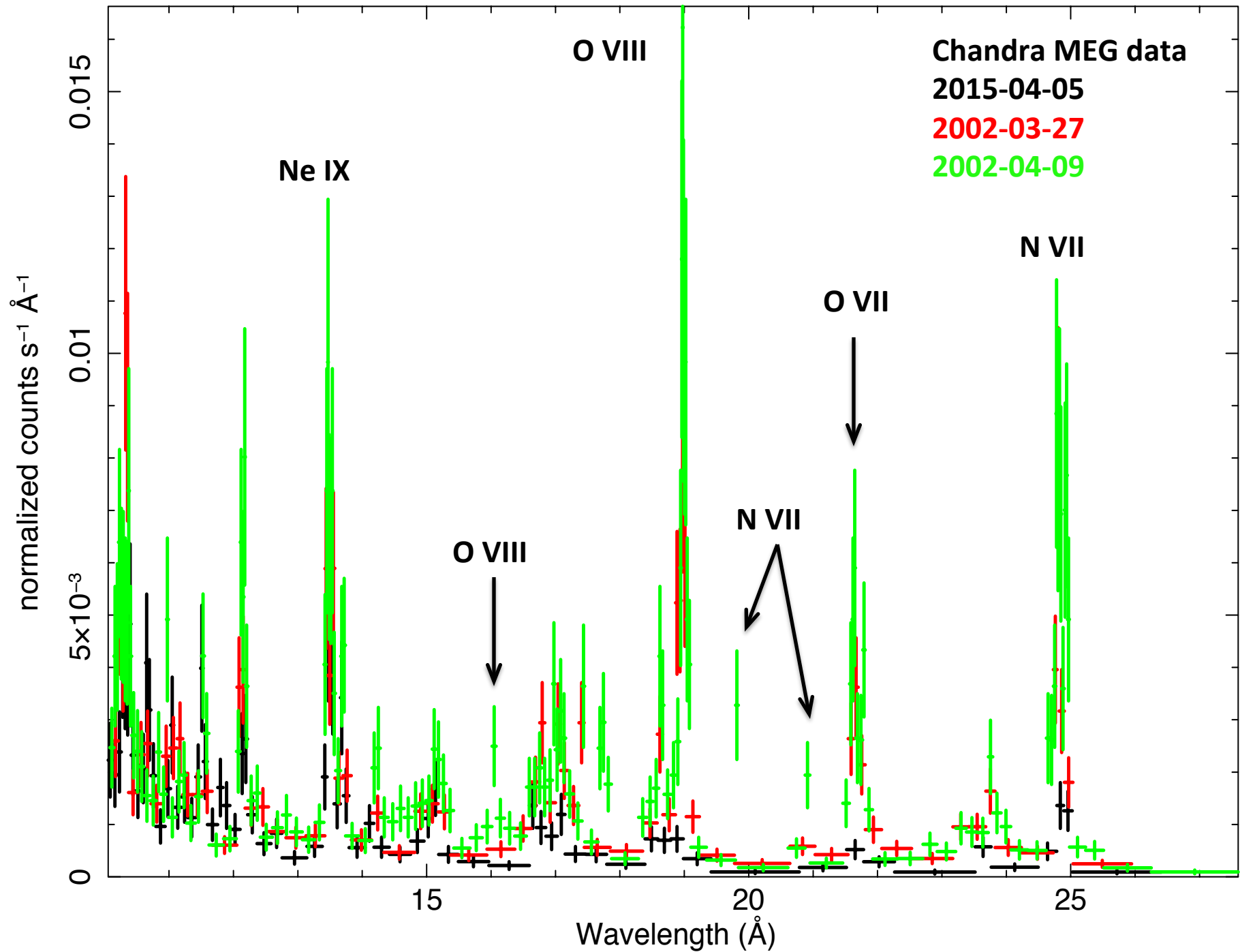


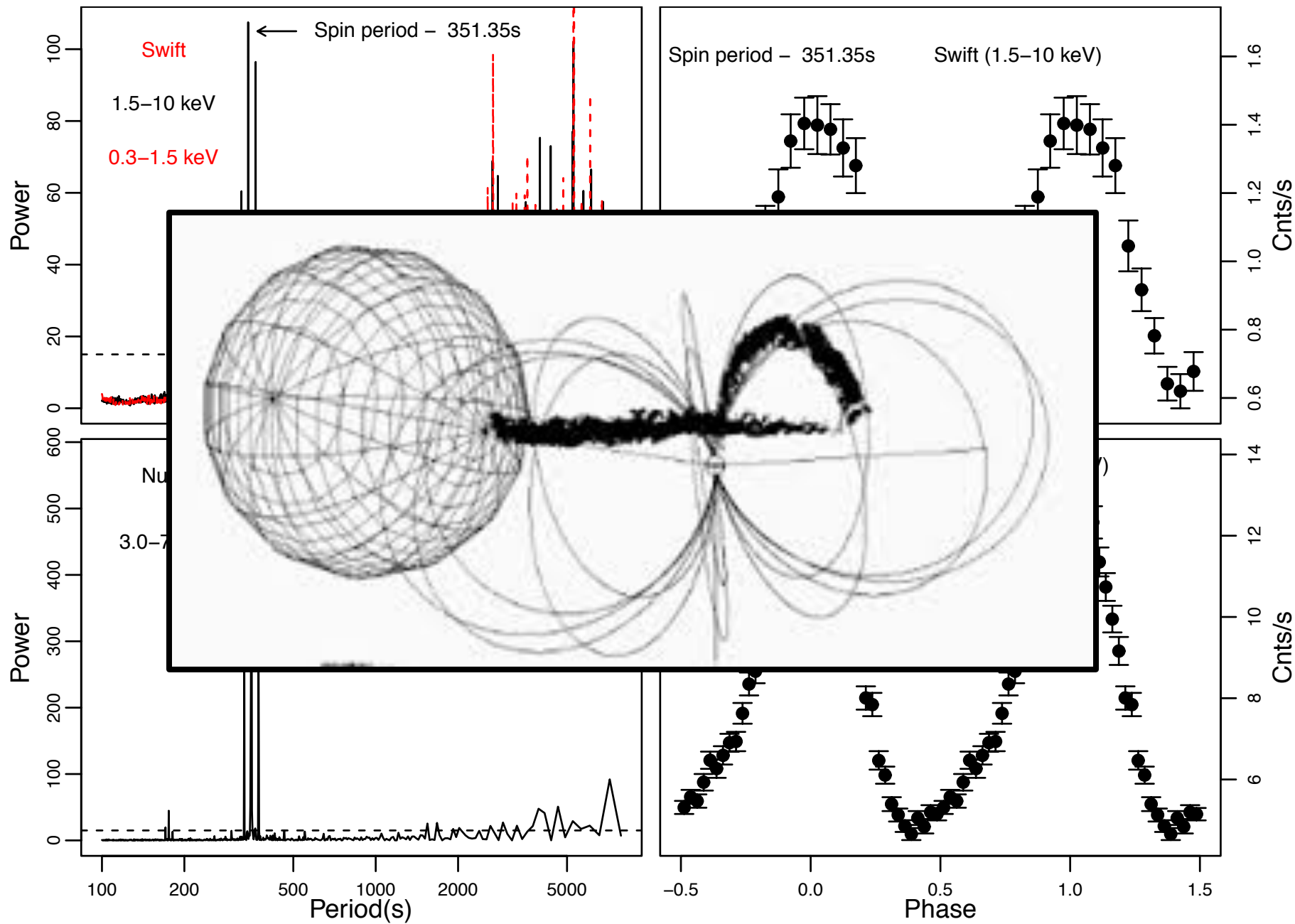


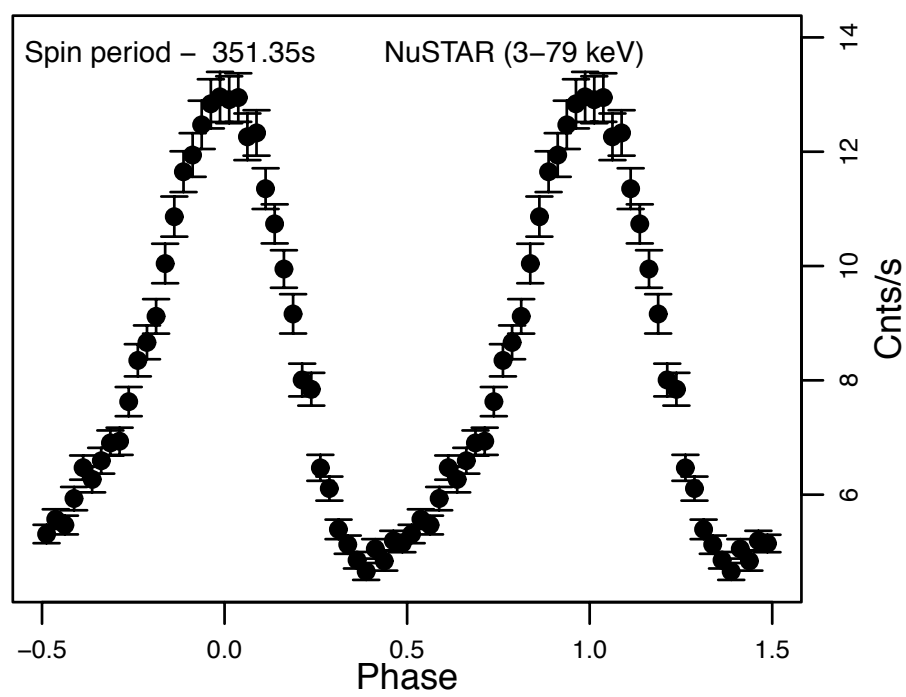
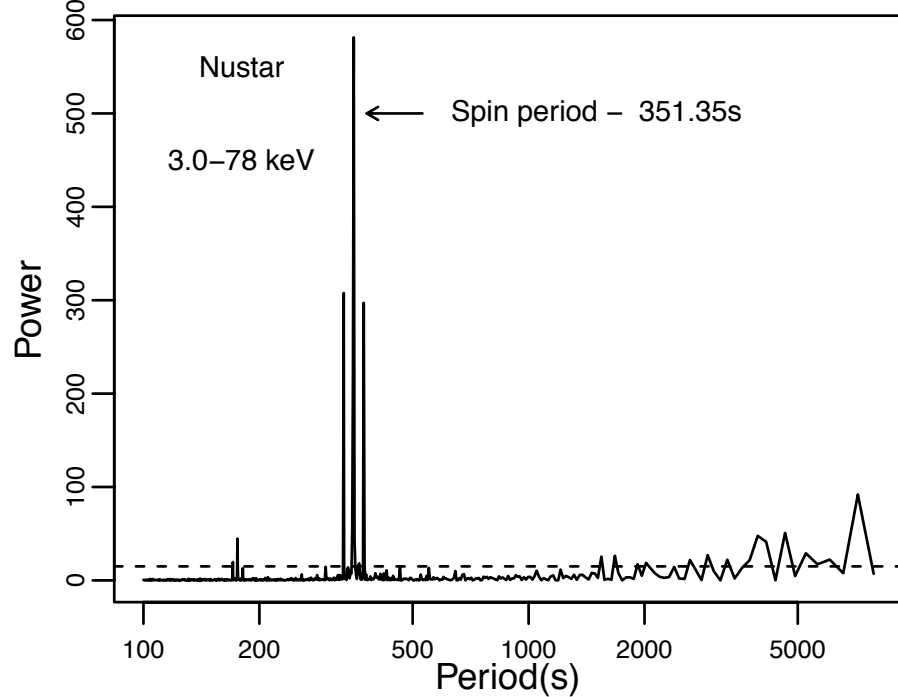
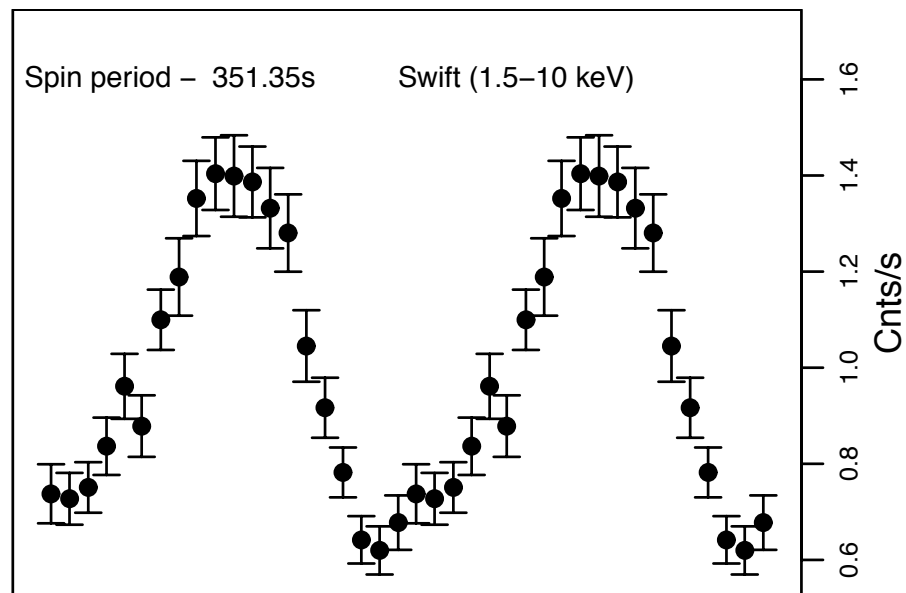
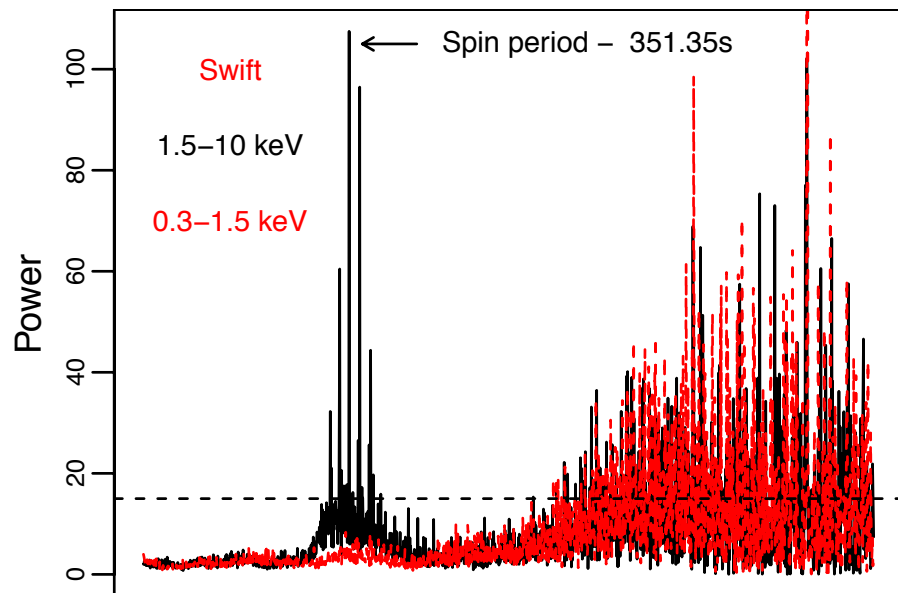






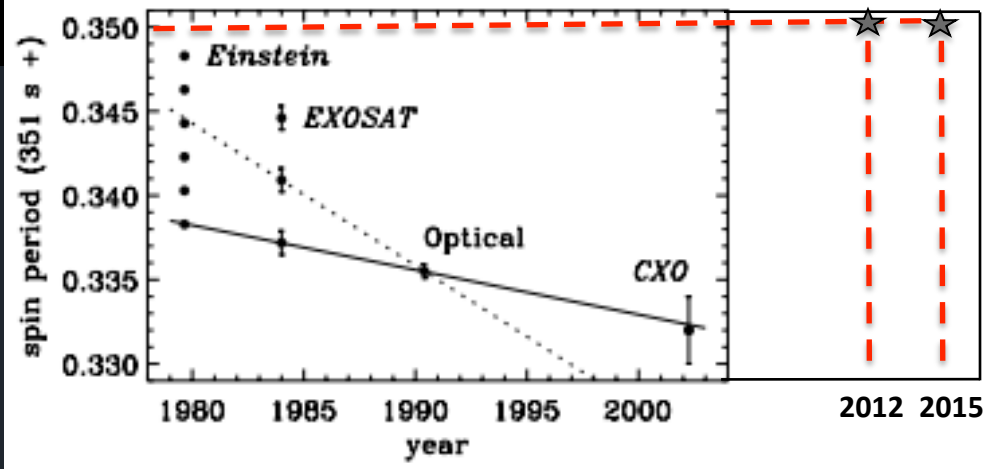




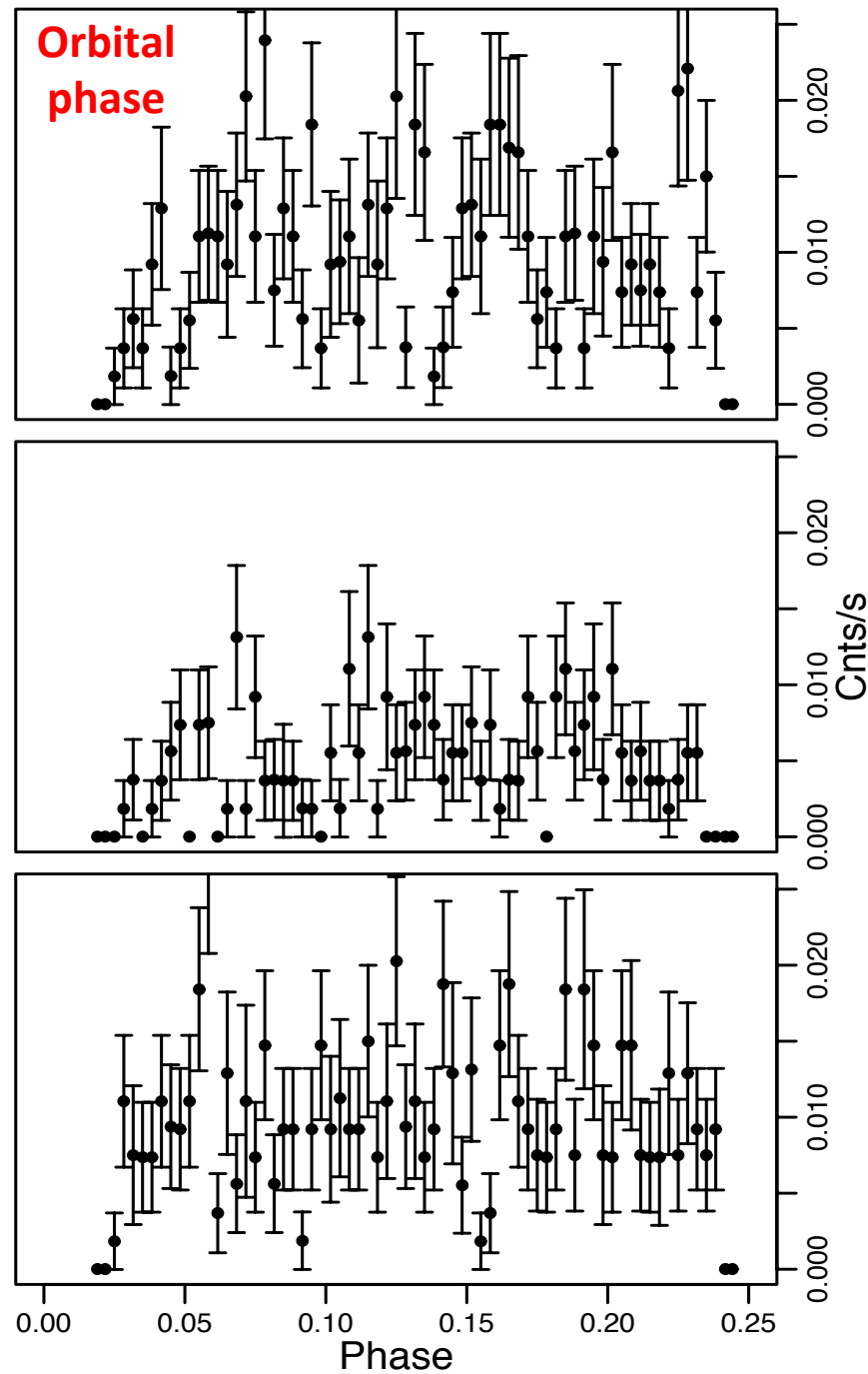
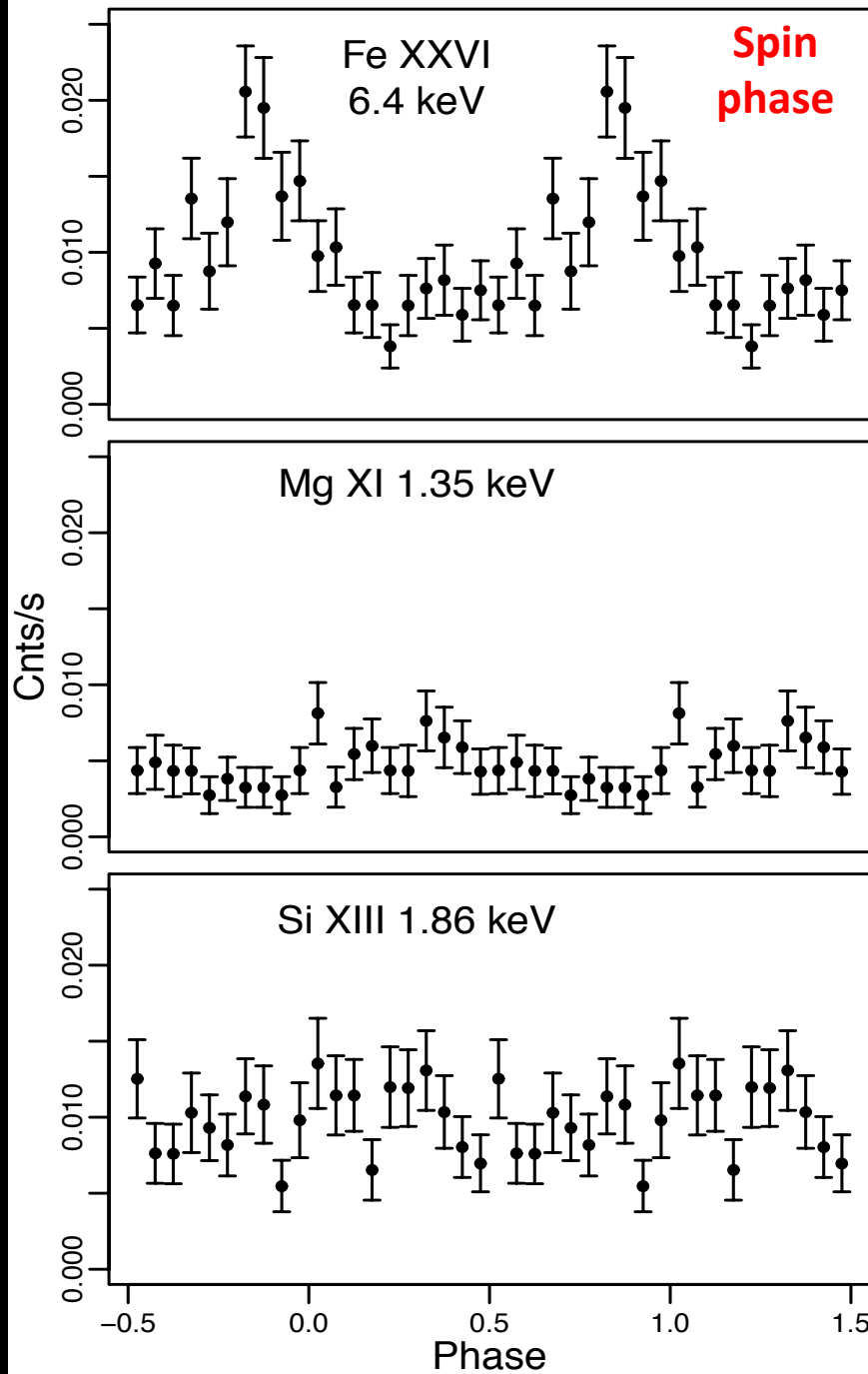




Period	Nustar	Swift >1.5 keV	Swift <1.5 keV
351.357 s	7.86	0.72	<b>The WD spin period</b>
7102 s	2.42		
210.2 min	2.2		
175.7 s	1.86		
4610 s	1.6		<b>First harmonic</b>
2893 s	1.3		
3942 s	1.2		
101 s	1		
2367 s	1		
3718 s	0.9		
2930 s	0.8		
1552 s	0.7		
142 m	0.7		
5797 s	0.7		
2672 s	0.6		
2026	0.6		
6358 s	0.6		
4193 s	0.6		
4708 s	–	0.38	
5920 s	–	0.34	
180 min	–	0.30	
5027 s	–	0.30	
5973 s	–	0.30	<b>QPOs</b>
1378 s	–	0.22	
293 s	–	0.20	
190 min	–	–	0.15
184 min	–	–	0.14
1168 s	–	–	0.1



- The spin period is longer comparing with previous observations.
- There are no common spikes in the LSPs, corresponding to different data (except for the spin period).



# Conclusions:

The obtained data reveal several distinct regions in the X-ray spectrum:

- a very soft ( $<0.8$  keV) at  $T_{\text{bb}} \sim 25$  eV
- a soft X-ray component at  $T \sim 0.1$  keV  
these components do not show spin modulation
- a hard thermal X-ray component at  $T \sim 14$  keV, modulated at the spin period.

The amplitude of the spin pulse is the highest ( $> 10$  cnts/s) in the Nustar energy range  $\rightarrow$  the modulation is not due to an absorption

The spin period is slightly longer than in previous observations. The proposed spin up is not confirmed.

QPOs are observed in all the data in all energy ranges.

A vibrant, abstract background composed of overlapping, wavy, organic shapes in shades of orange, yellow, green, and blue. The overall effect is reminiscent of a stained-glass window or a digital art piece. In the center-right, a single blue puzzle piece is placed, containing the text "Thank you" in white, sans-serif font. The puzzle piece is slightly offset from the grid, creating a focal point.

**Thank  
you**