Unveiling stellar wind structures in HMXBs:
A high-resolution study of Vela X-1 with XMM-Newton

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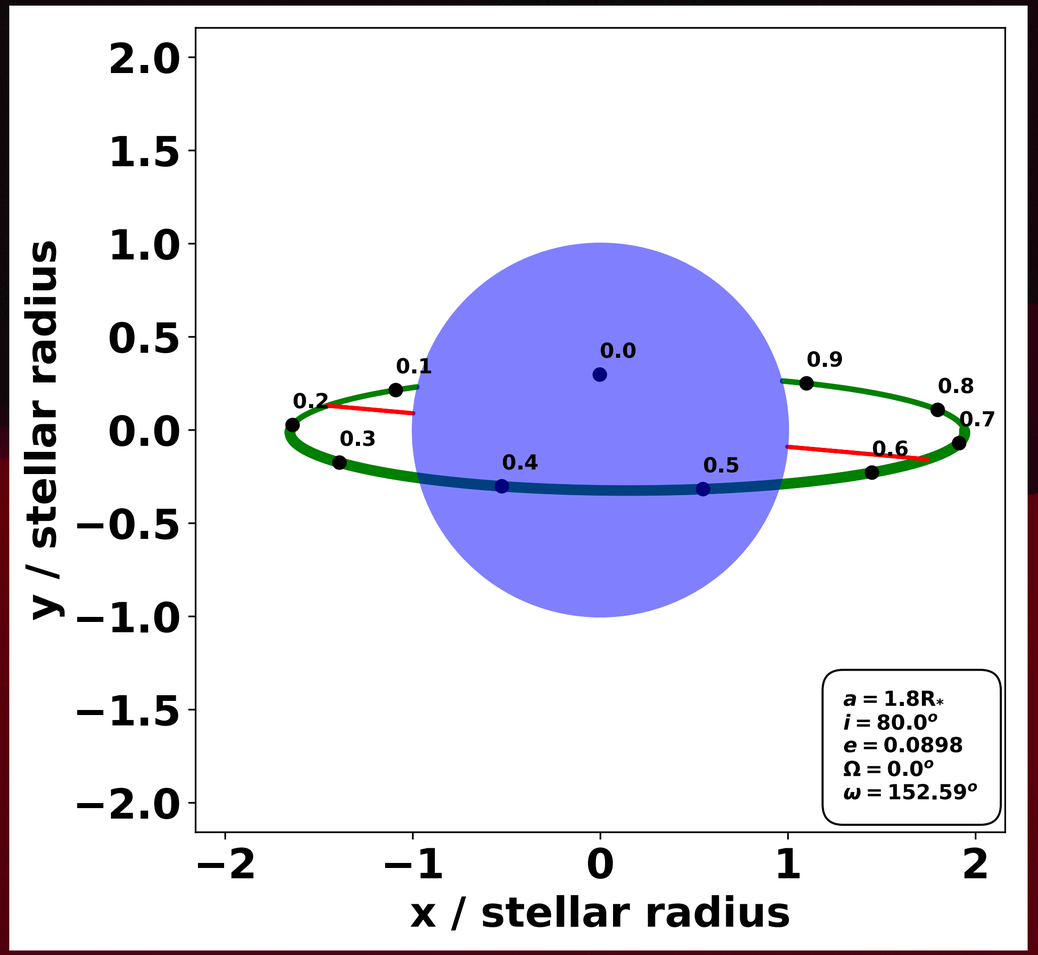
An example: Vela X-1

(1)	Distance	$2.42^{+0.19}_{-0.16}$ kpc
(2)	HD 77581 radius $R_\star$	$31^{+4}_{-3}\ R_\odot$
(3)	HD 77581 mass $M_\star$	$21.5 \pm 4.0\ M_\odot$
(4)	Neutron star mass $M_{\rm NS}$	$\sim 1.8\ M_\odot$
(5)	Orbital period $P_{\rm orb}$	8.964357 ± 0.000029 day
(6)	Semi-major axis $a \sin i$	113.89 ± 0.13 lt-sec
(6)	Eccentricity e	0.0898 ± 0.0012
(6)	Longitude of periastron ω	152.59 ± 0.92
(7)	Inclination i	$> 73^\circ$
(8)	Pulse period	~ 283 sec
(7)	Orbital separation a	$\sim 1.8\ R_\star$

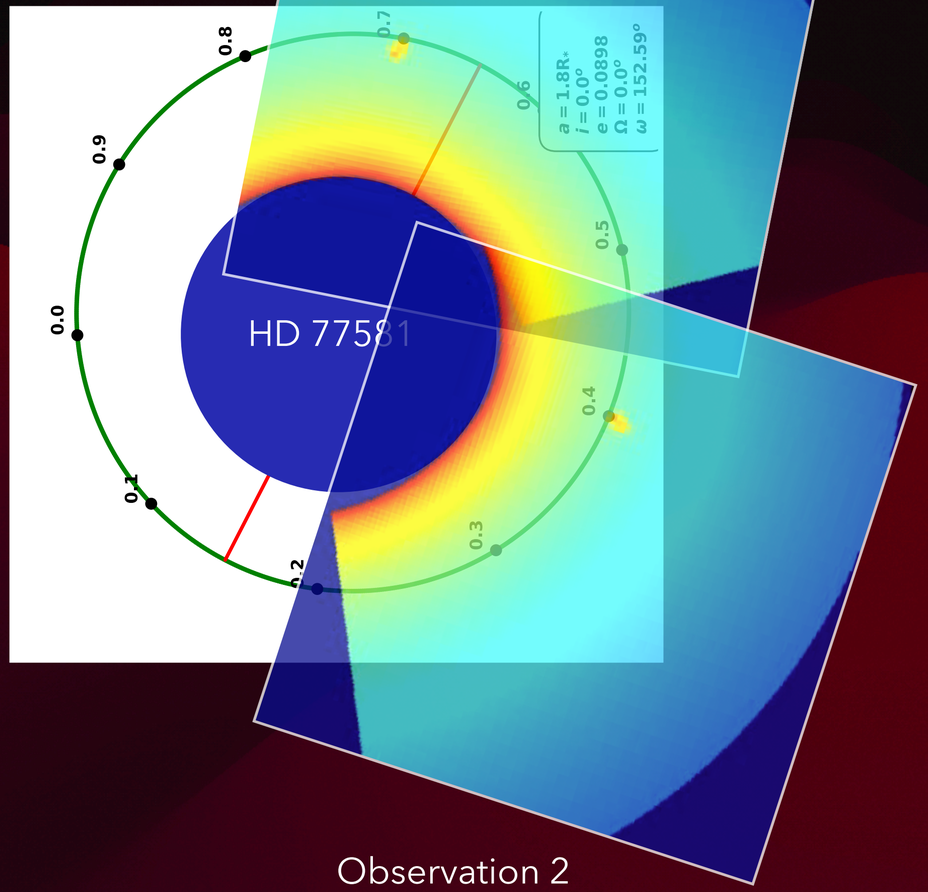


(1) *Bailer-Jones et al. (2018)*
(2) *Joss & Rappaport (1984)*
(3) *Giménez-García et al. (2016)*
(4) *Rawls et al. (2011)*
(5) *Kreykenbohm et al. (2008)*
(6) *Bildsten et al. (1997)*
(7) *van Kerkwijk et al. (1995)*
(8) *McClintock et al. (1976)*

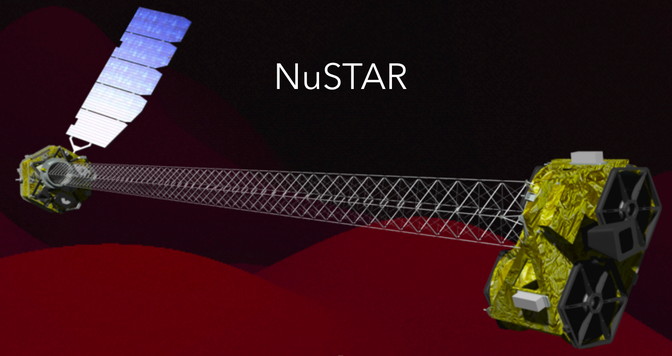
An example: Vela X-1

Observation 1

Kretschmar et al. (2021)



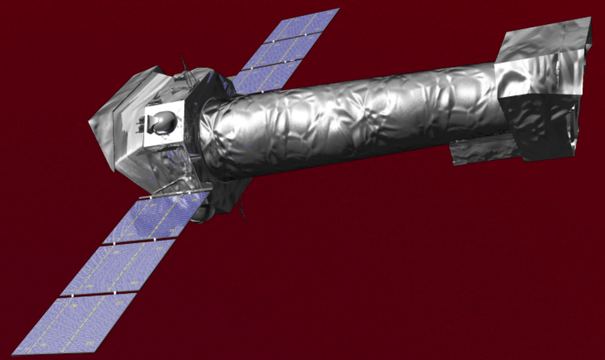
Observation 2



NuSTAR

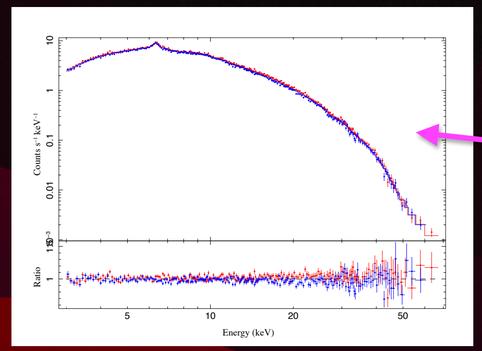
+

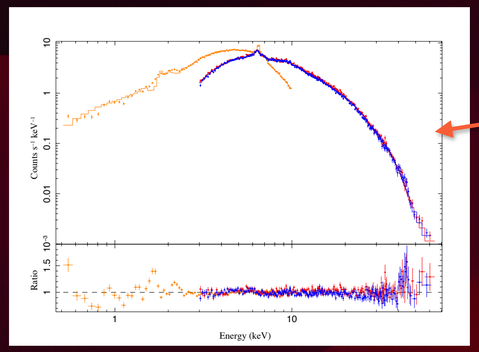
XMM-Newton

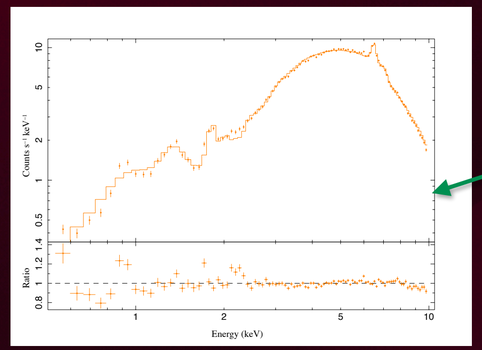


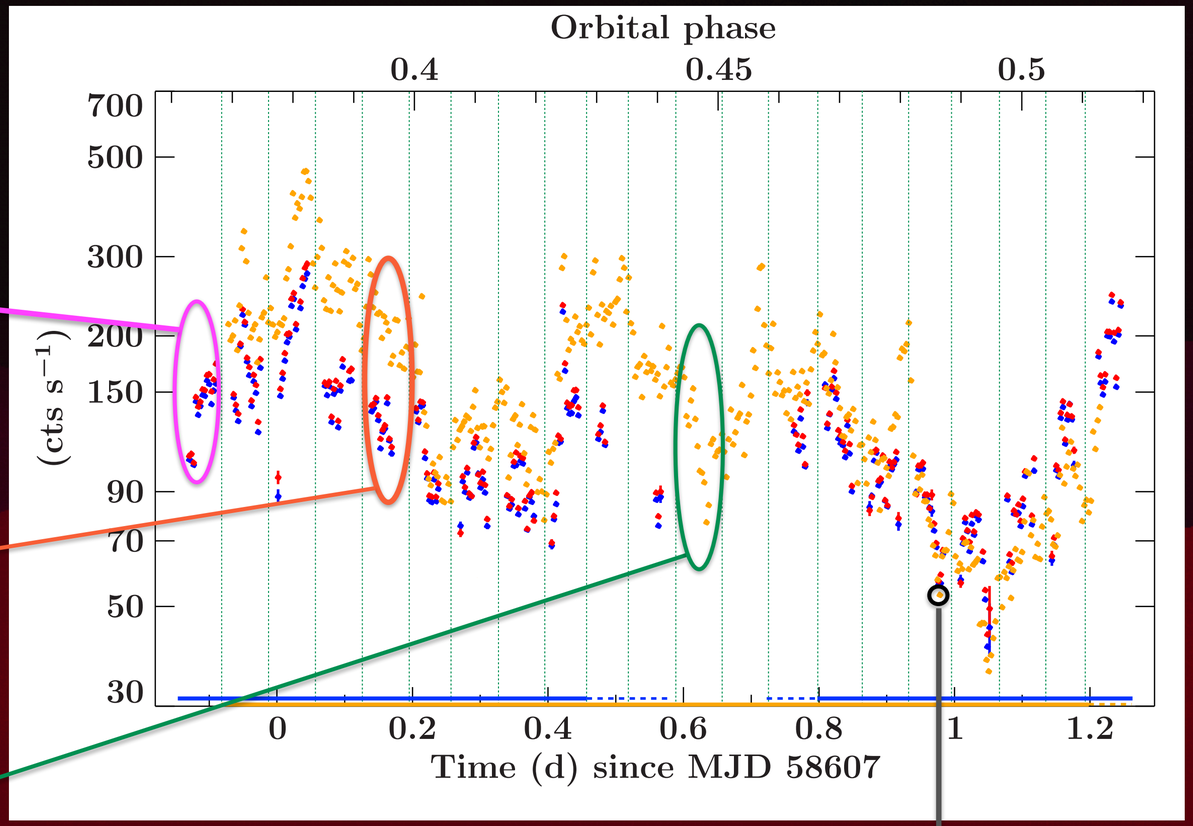
Observation II

NuSTAR + XMM-Newton

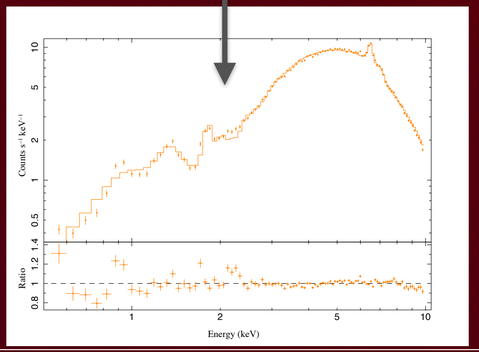




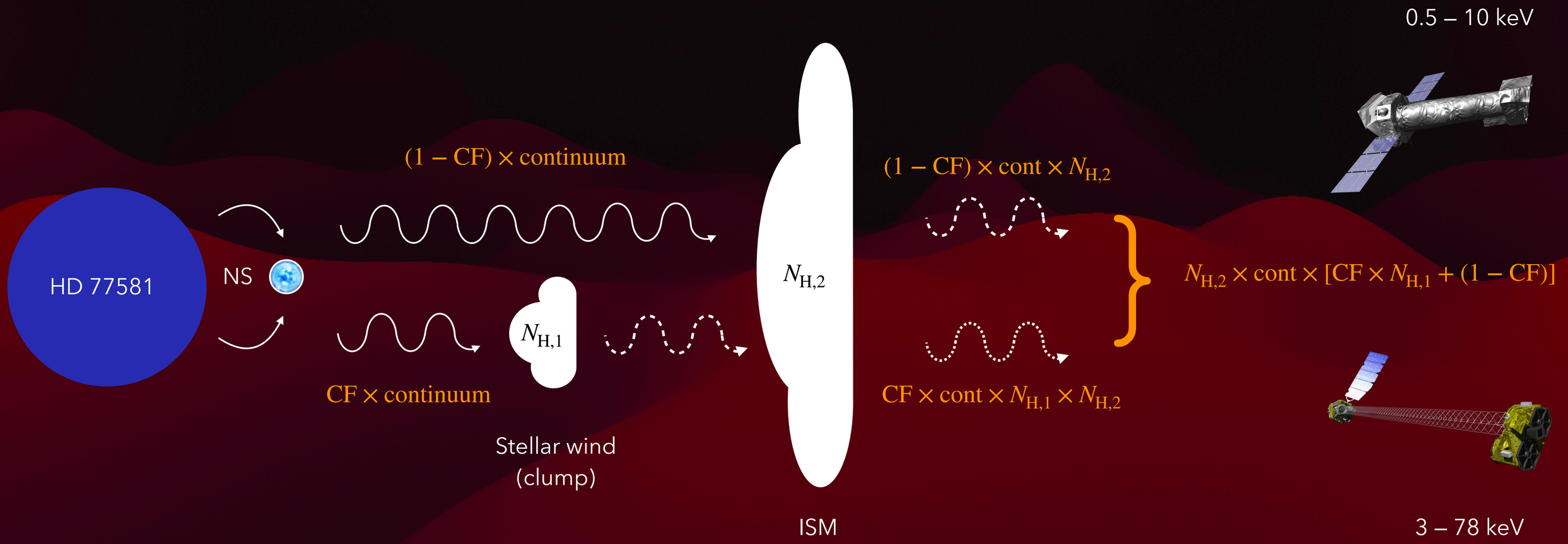




Diez et al. (2023)



Partial Covering Model

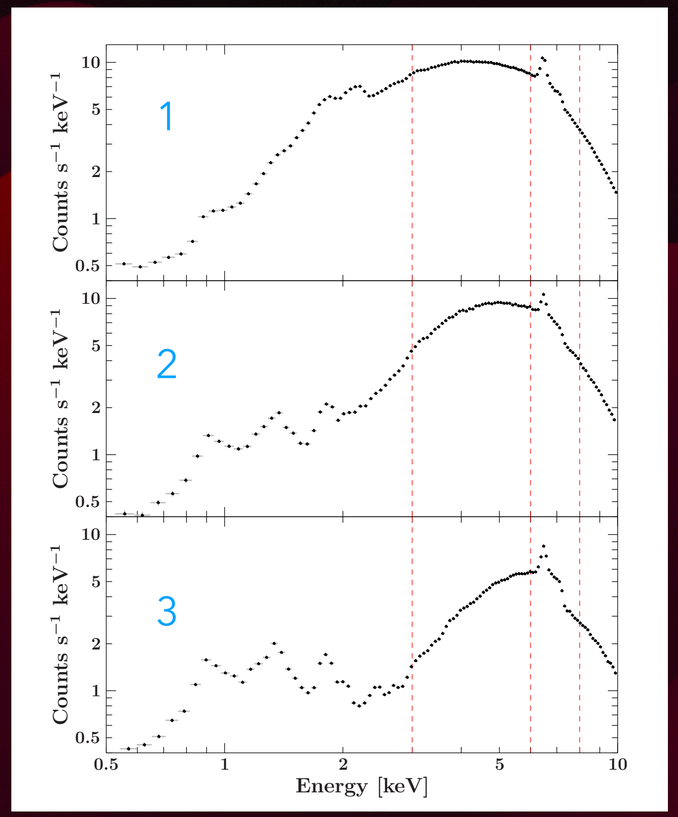


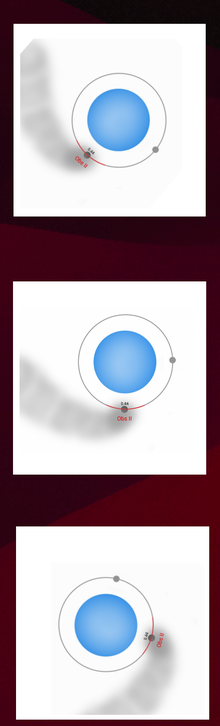
(not to scale)

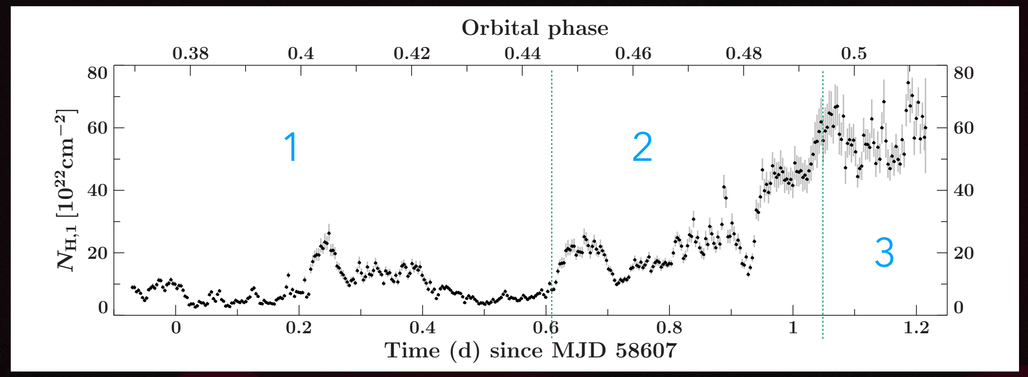
XMM-Newton results (Using constraints obtained with NuSTAR)

Absorption variability + photoionisation of the wind

Diez et al. (2023)



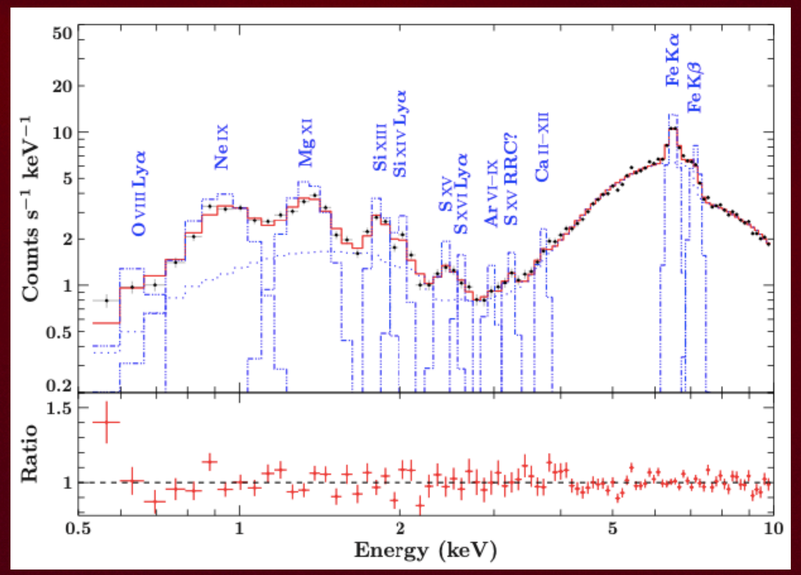




Diez et al. (2023)

- Strong rise of $N_{\mathrm{H},1}$

Diez et al. (2023)



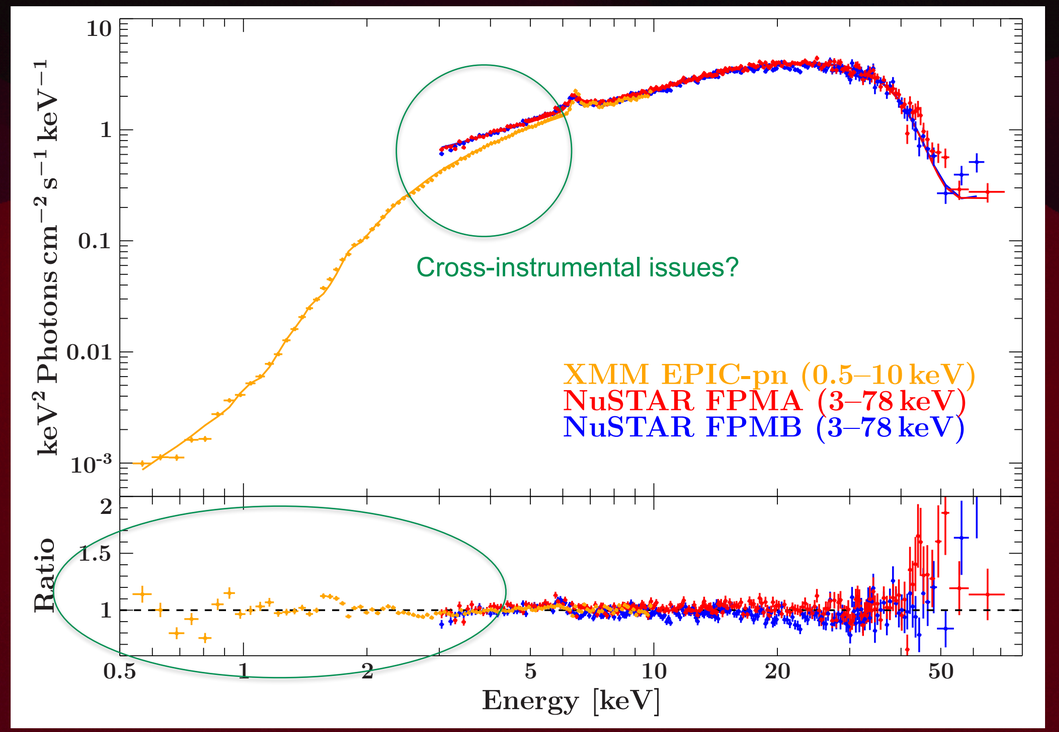
- Photoionisation + lines originate from different regions

Conclusions

- Such a detailed onset of the stellar wind in Vela X-1 on a broad X-ray range for the first time
- Strong photoionisation of the wind
- Robust model for partially covered sources

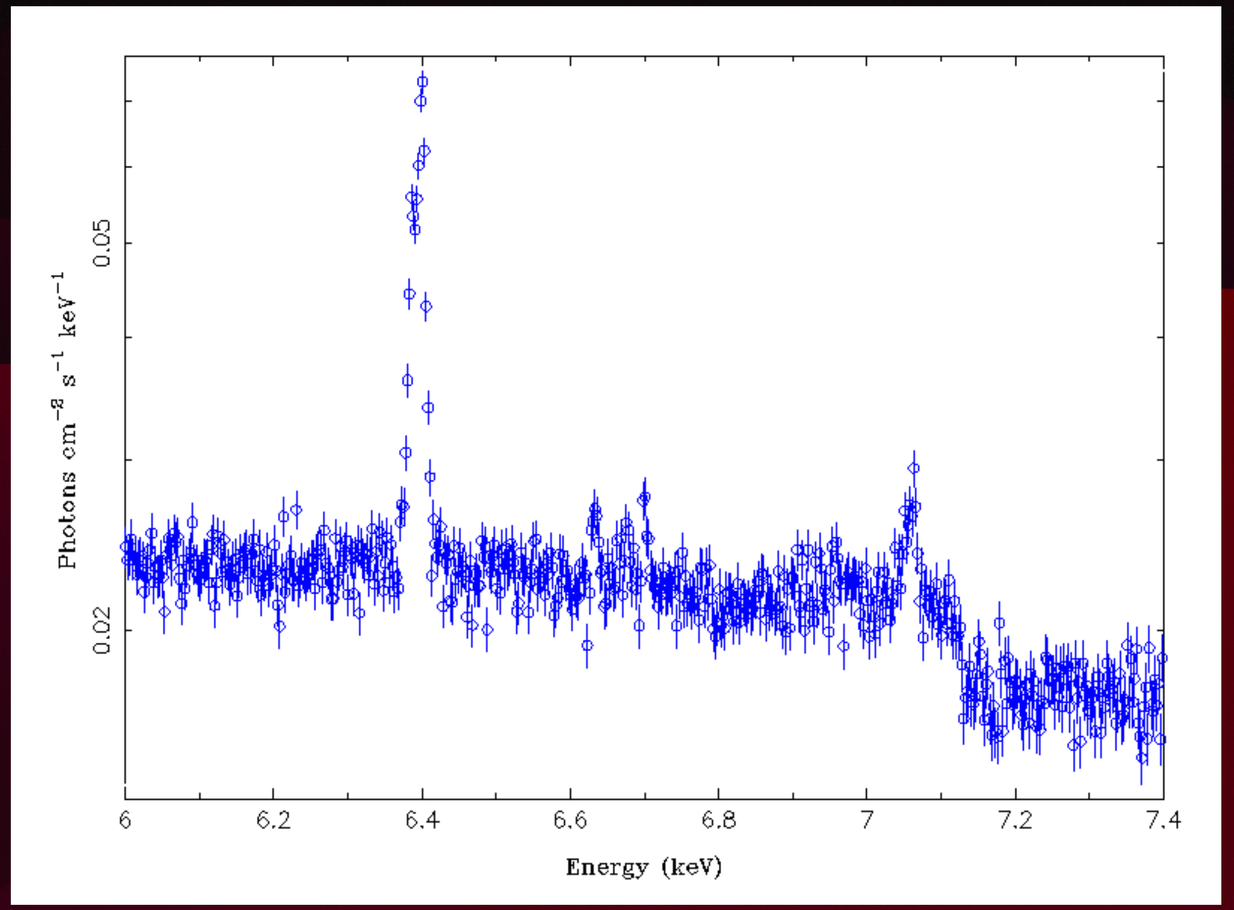
- Cross-calibration issues between XMM-Newton and NuSTAR, seems to be recurrent for piled-up sources

Diez et al. (2023)



Last update with XRISM

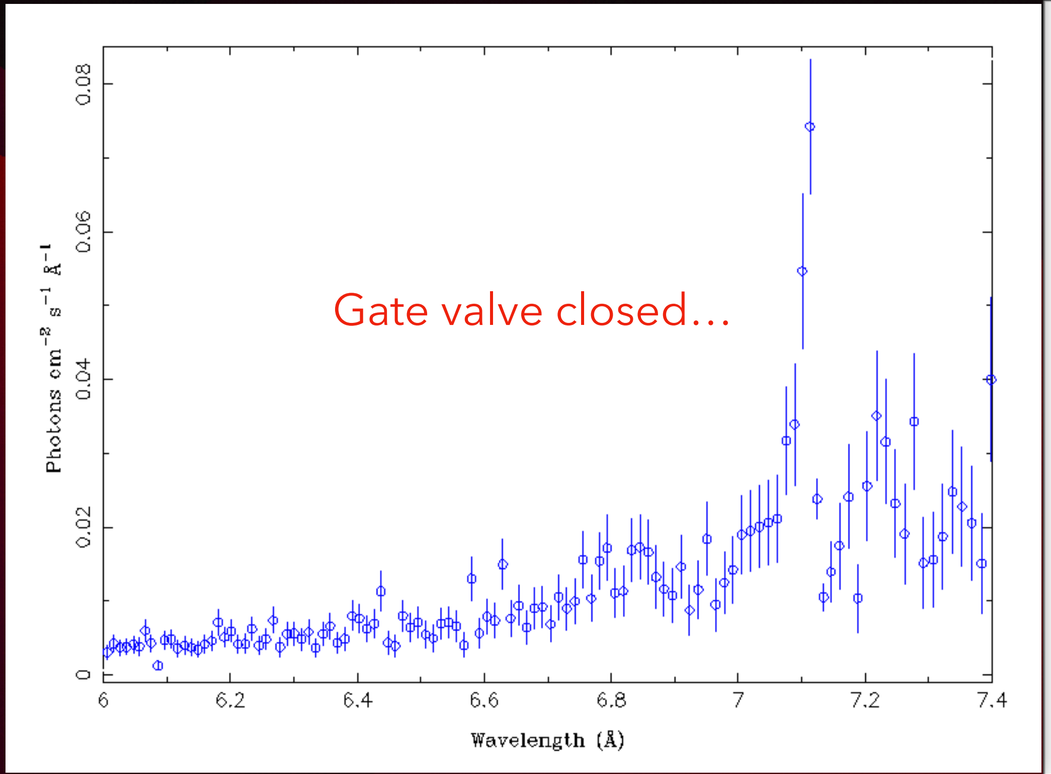
Highly-resolved iron line region



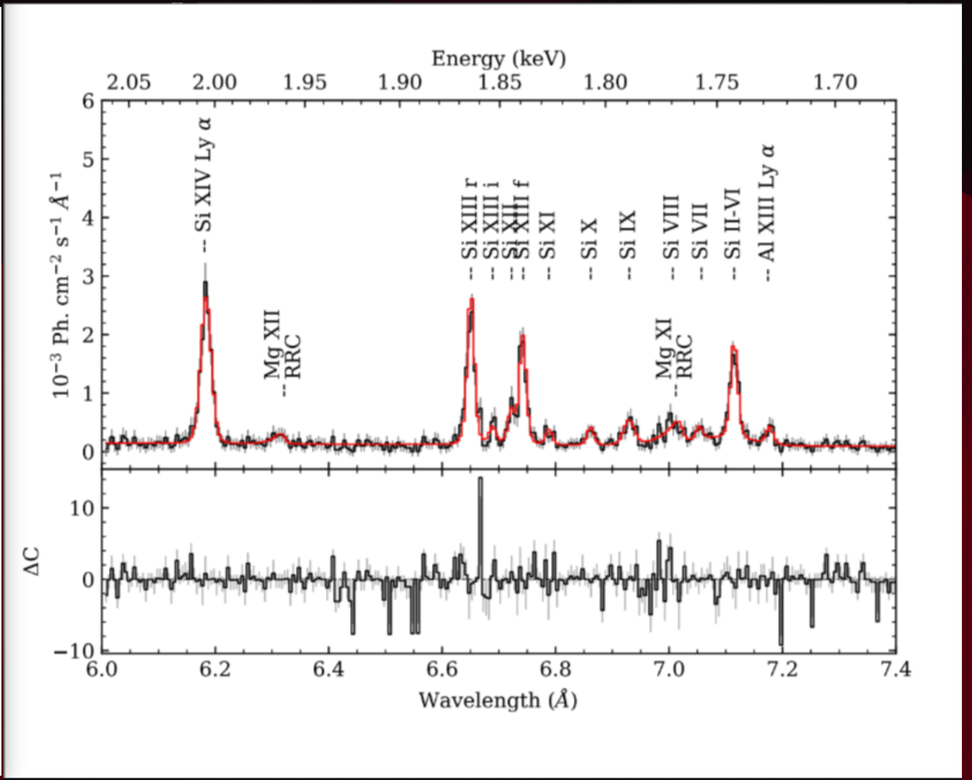
Last update with XRISM

But that's all…

XRISM Resolve



Chandra HETGS

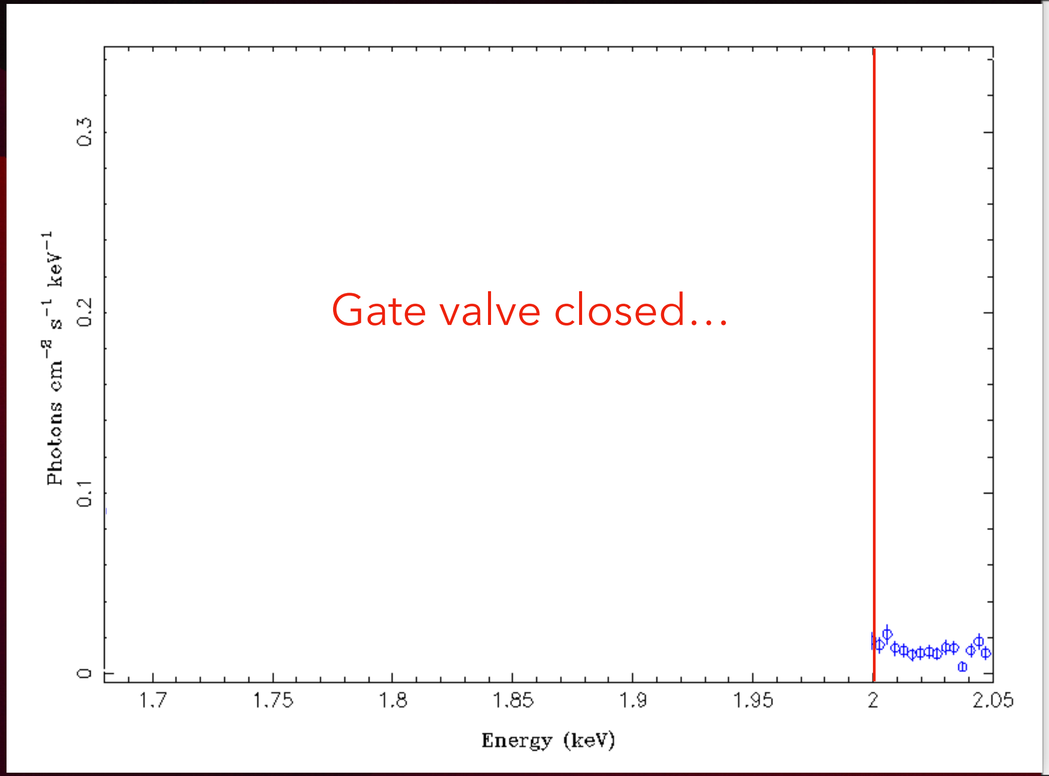


Amato et al. (2020)

Last update with XRISM

But that's all…

XRISM Resolve



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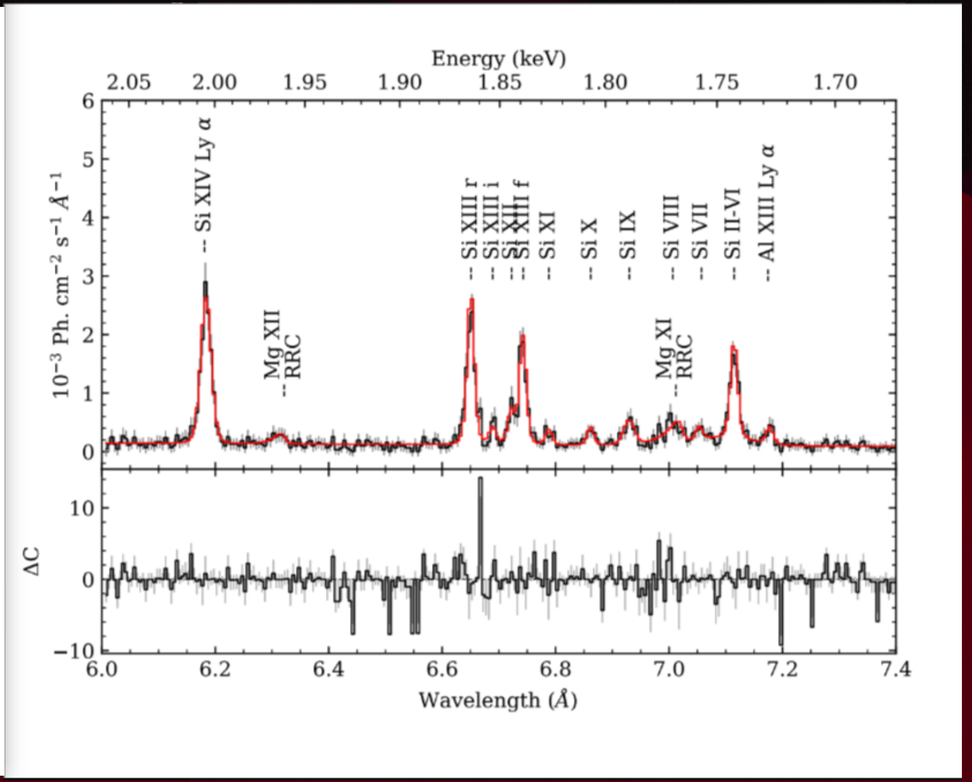

Amato et al. (2020)