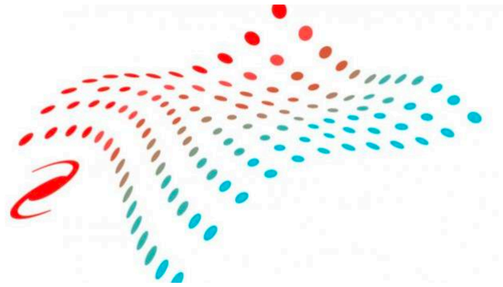
CENTER FOR
ASTROPHYSICS
HARVARD & SMITHSONIAN



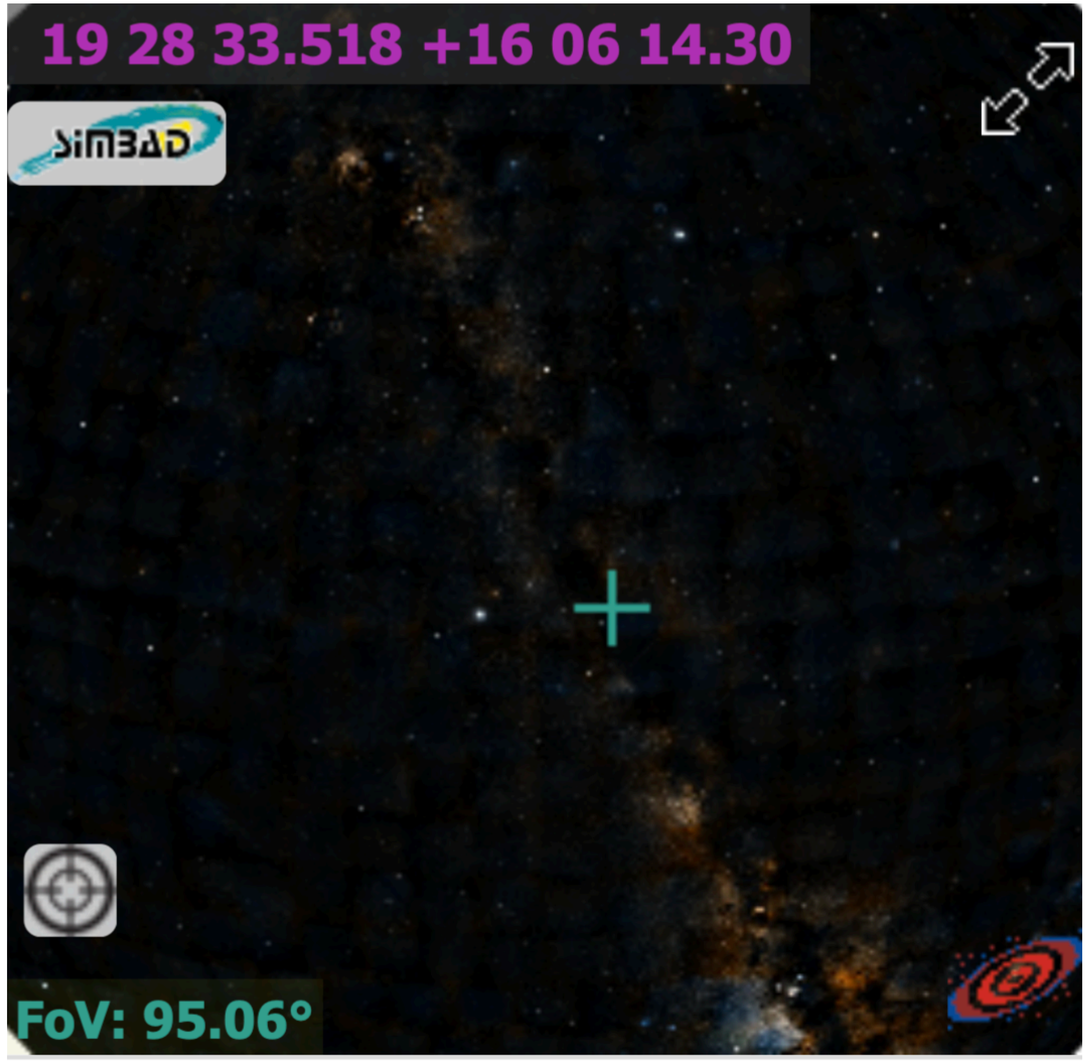
ORBITAL VARIATION OF GALACTIC PULSAR 4U1907+09

Jun Yang

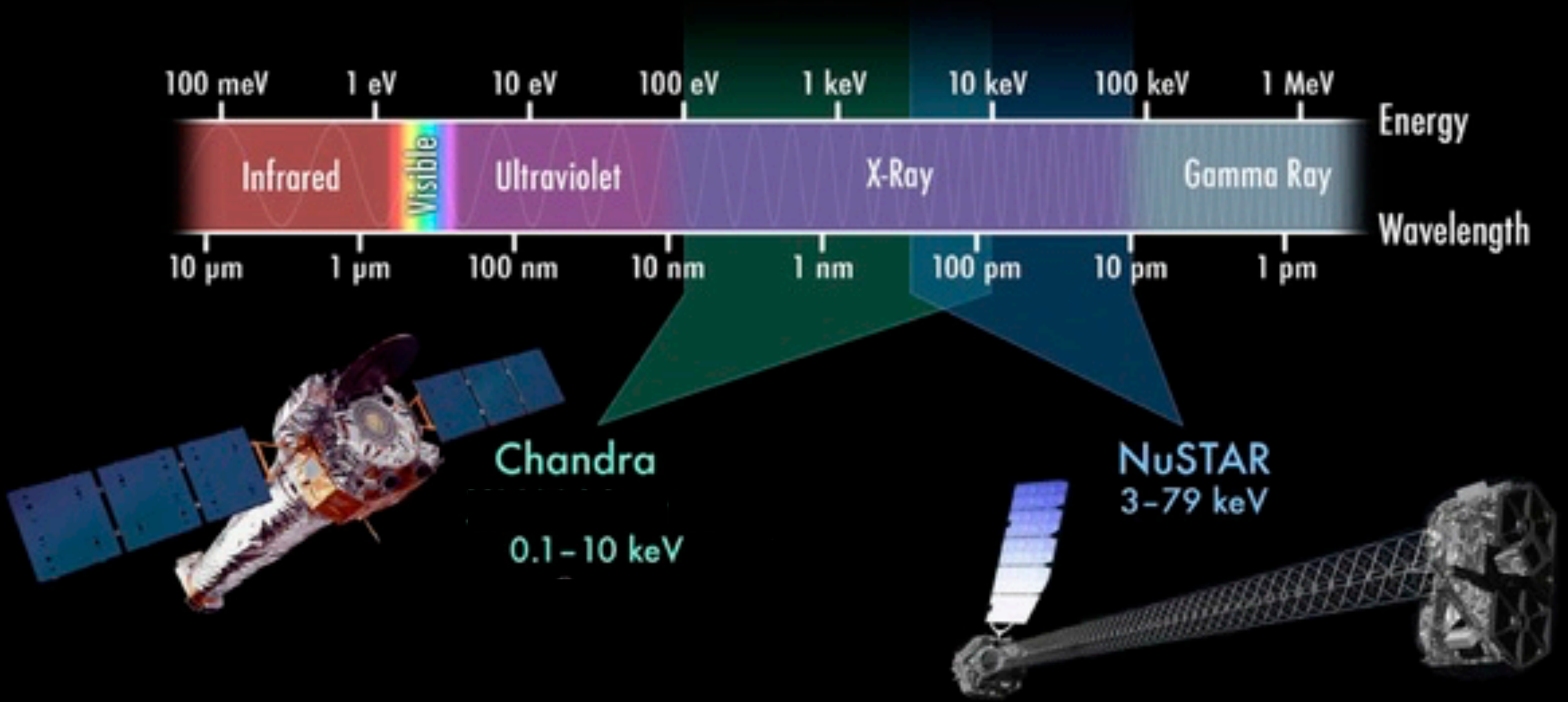
Paul Hemphill, Norbert S. Schulz, Jose M. Torrejon, Claude R. Canizares

GALACTIC PULSAR 4U1907+09 NEAR THE GALACTIC PLANE

- One of ~35 high-mass X-ray binaries with known high magnetic field strength



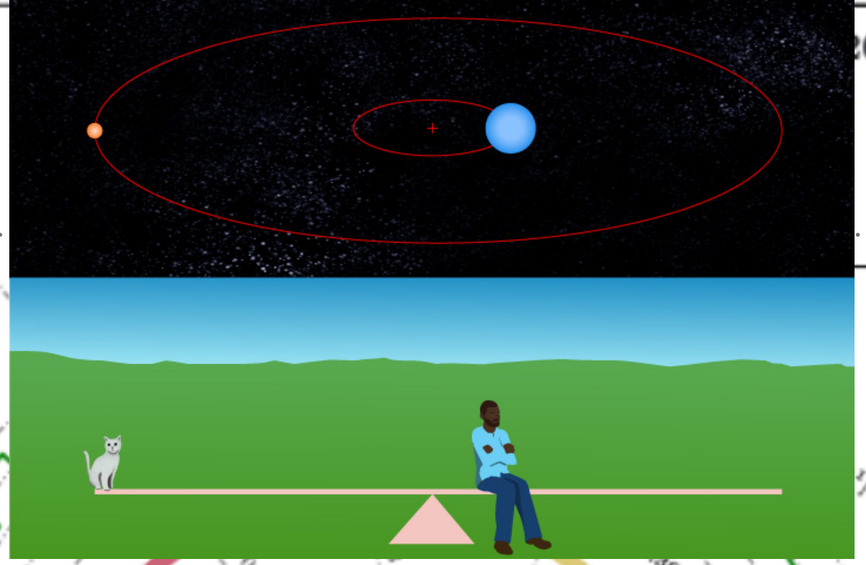
X-Ray Telescopes & the Electromagnetic Spectrum



CHANDRA (~140 KS) AND NUSTAR (78 KS)

4U1907+09

- (~440 s) X-ray pulsar
- accreting, stellar wind, an O8/9 supergiant.
- ~8.37 d orbit (e ~ 0.28) around its donor



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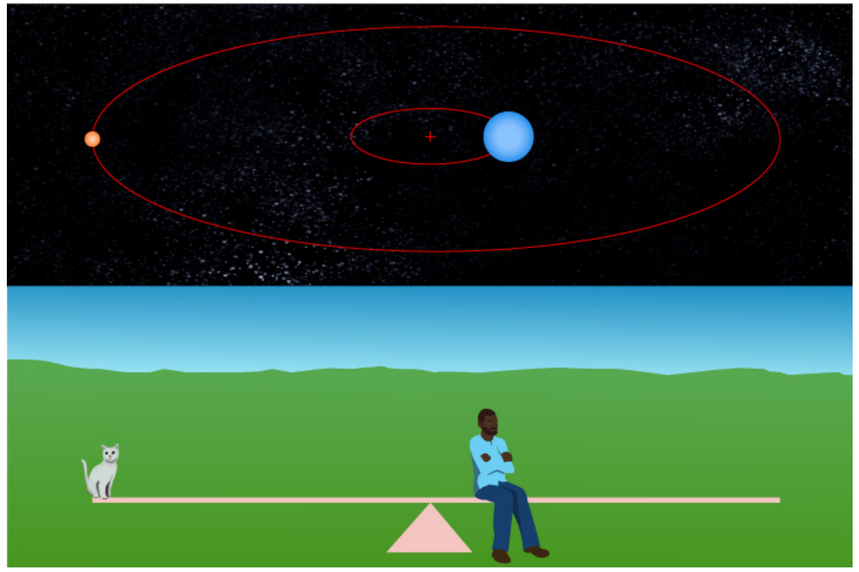
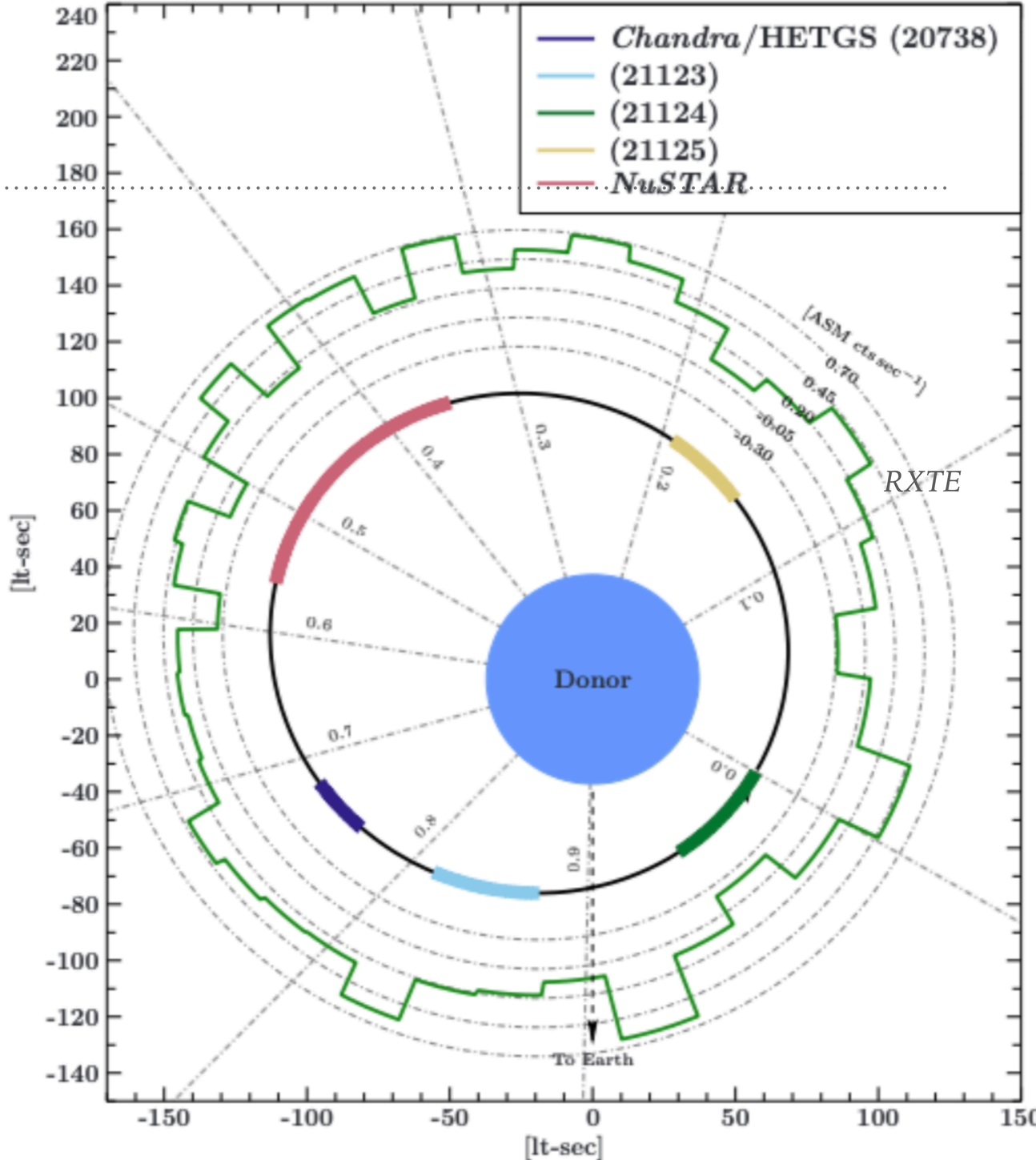
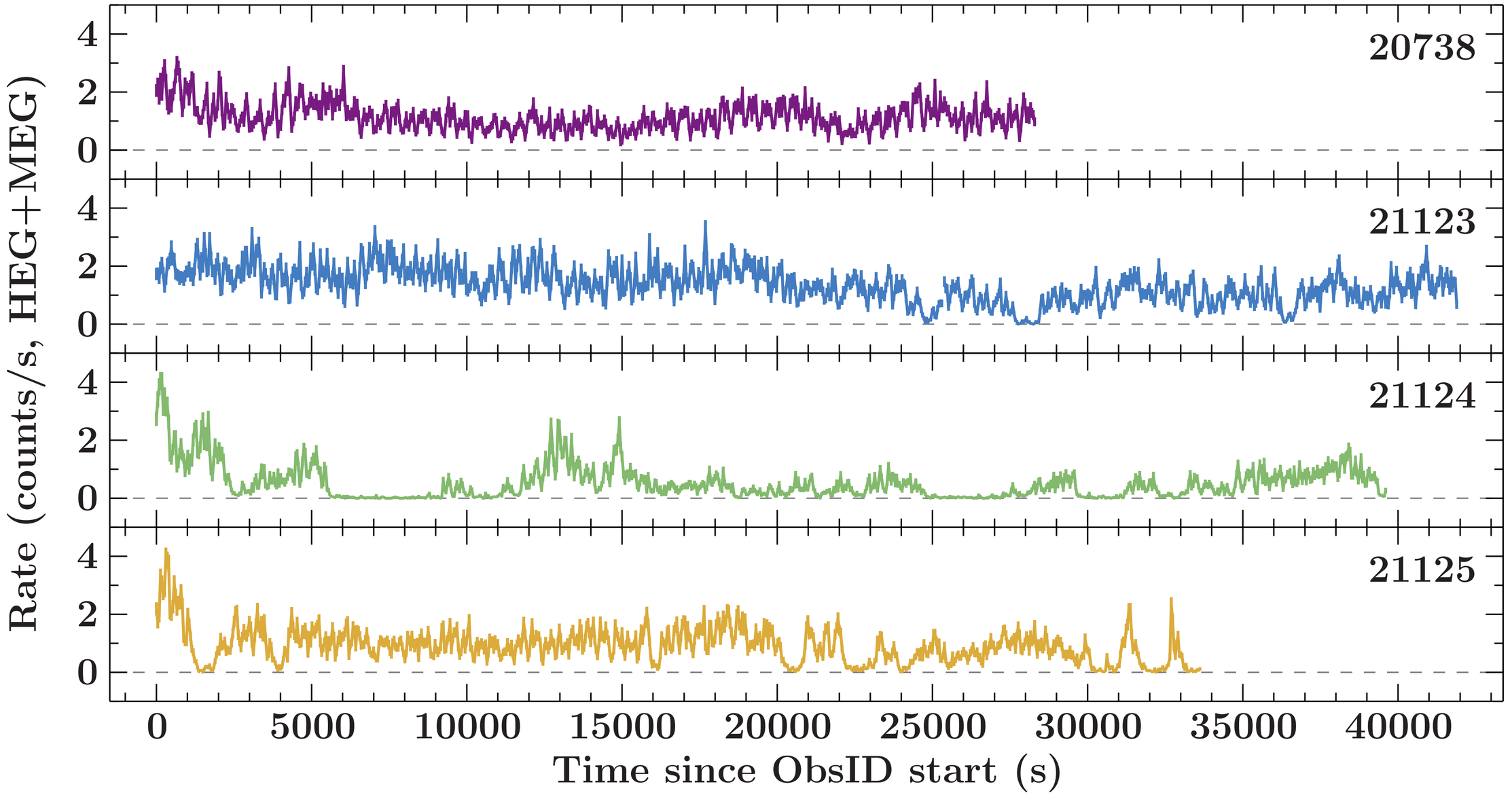


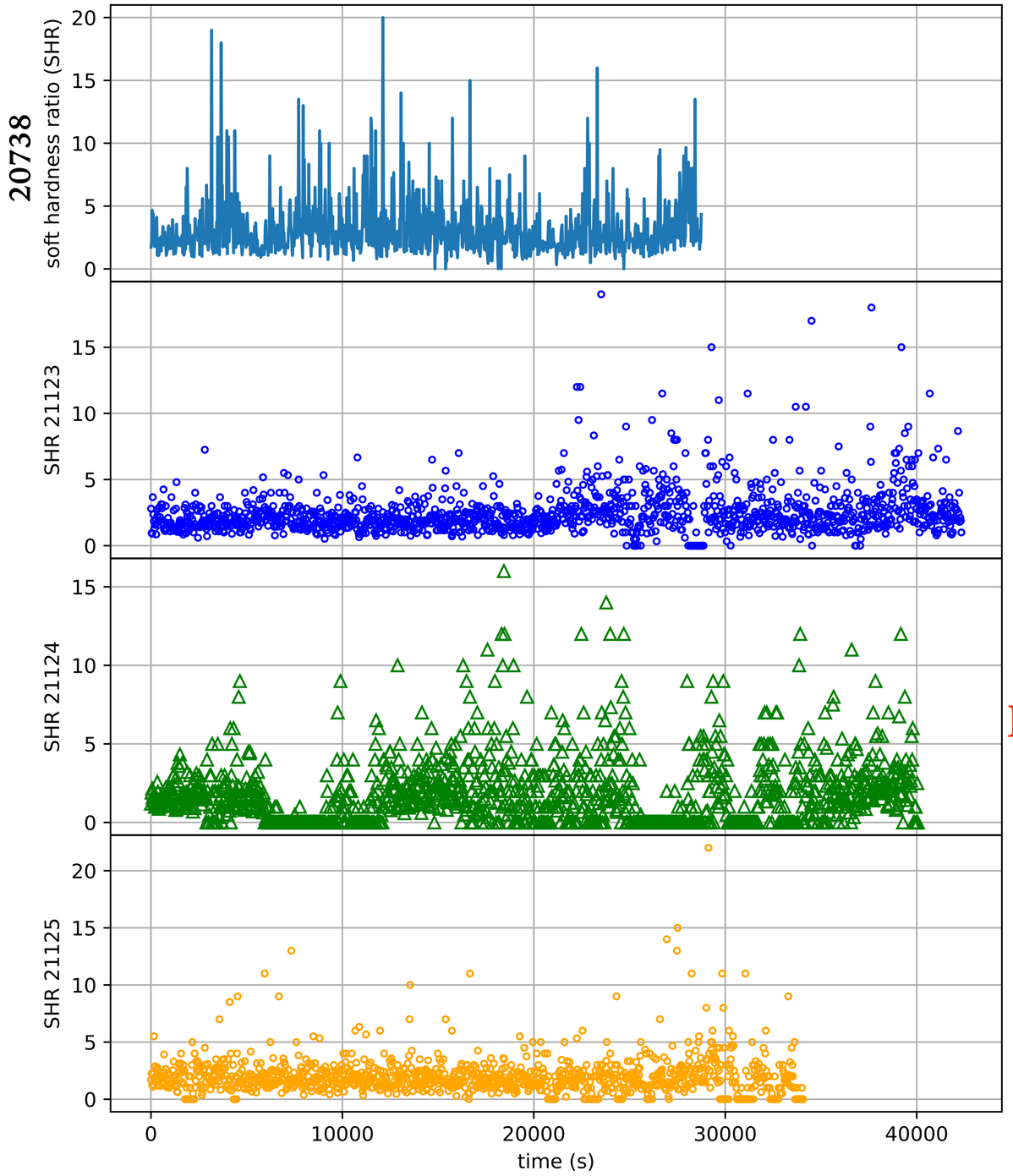


LIGHT CURVES OF 4U1907+09 WITH CHANDRA HETG



HARDNESS RATIO IN SOFT BAND (SHR)

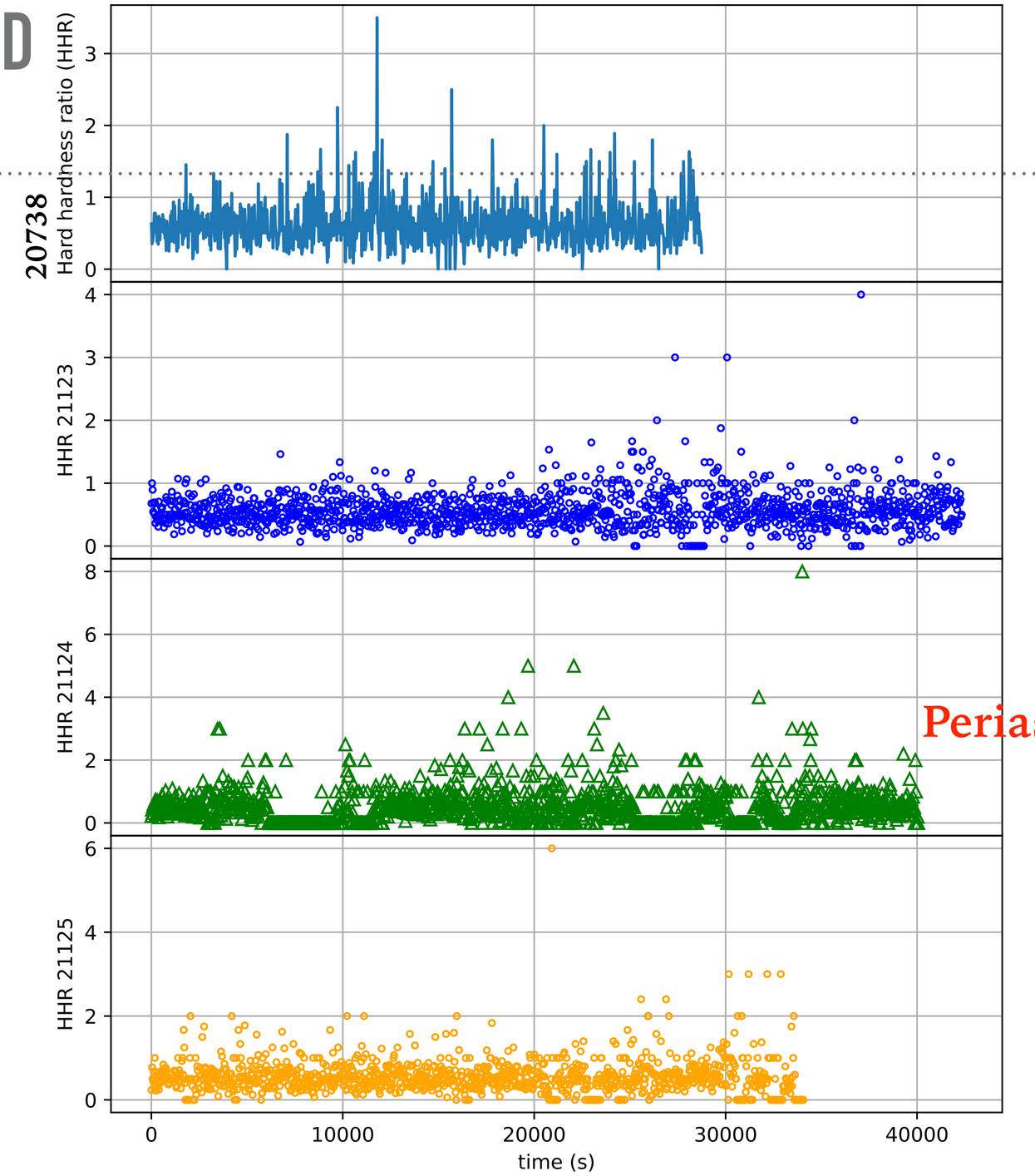
$$\frac{\text{Count rate (2.5}\sim\text{4.5 keV)}}{\text{Count rate (0.5}\sim\text{2.5 keV)}}$$



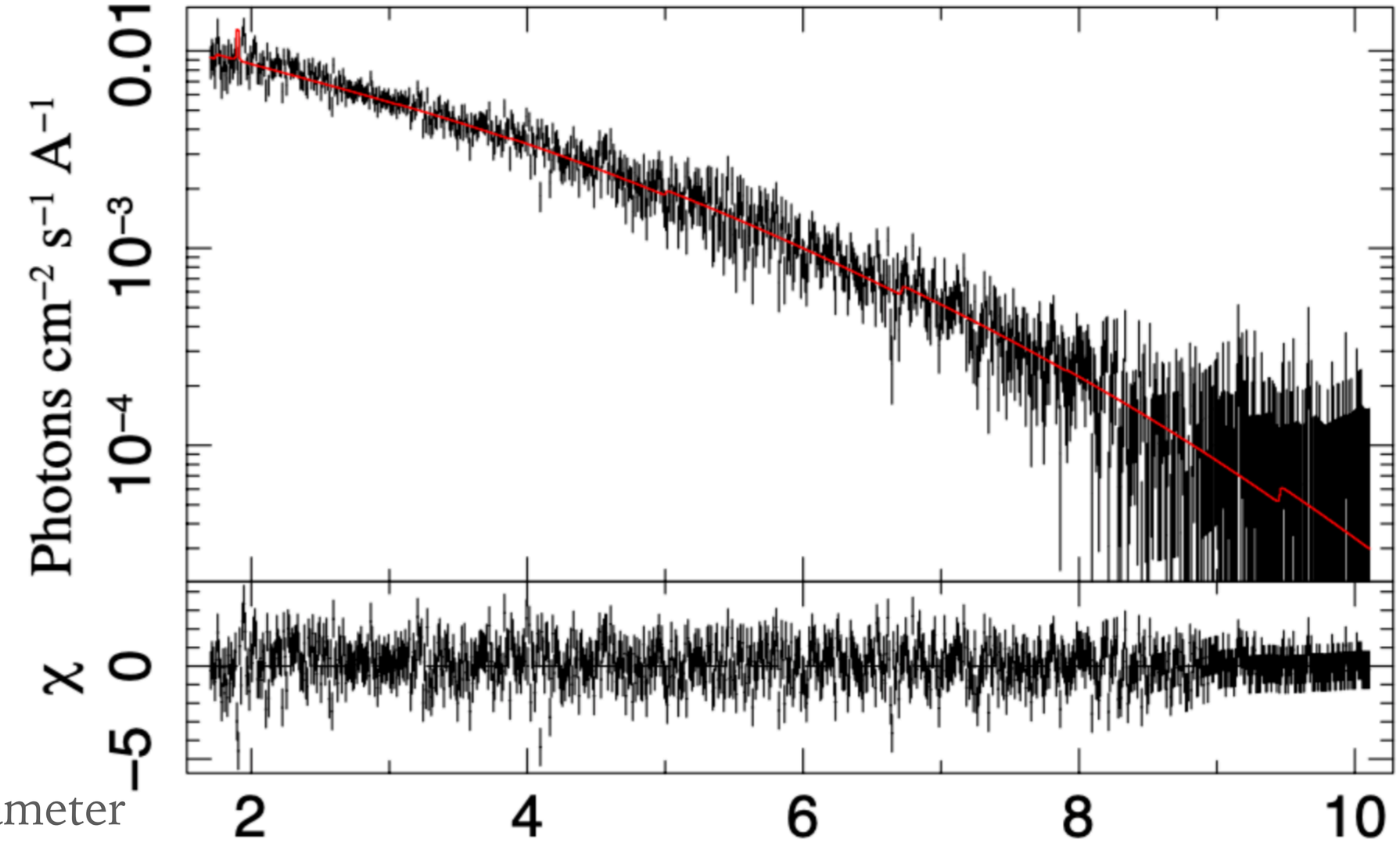
Periastron

HARDNESS RATIO IN HARD ENERGY BAND (HHR)

$$\frac{\text{Count rate (4.5}\sim\text{8 keV)}}{\text{Count rate (2.5}\sim\text{4.5 keV)}}$$



CHANDRA HETG SPECTRUM OF 4U1907+09 FROM OBSERVATION ID 20738



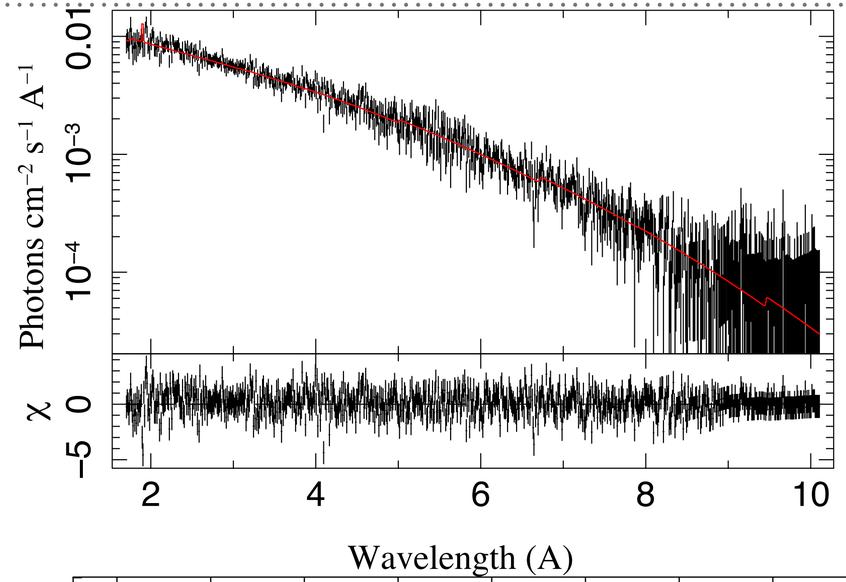
PowerLaw

partial covering fraction parameter

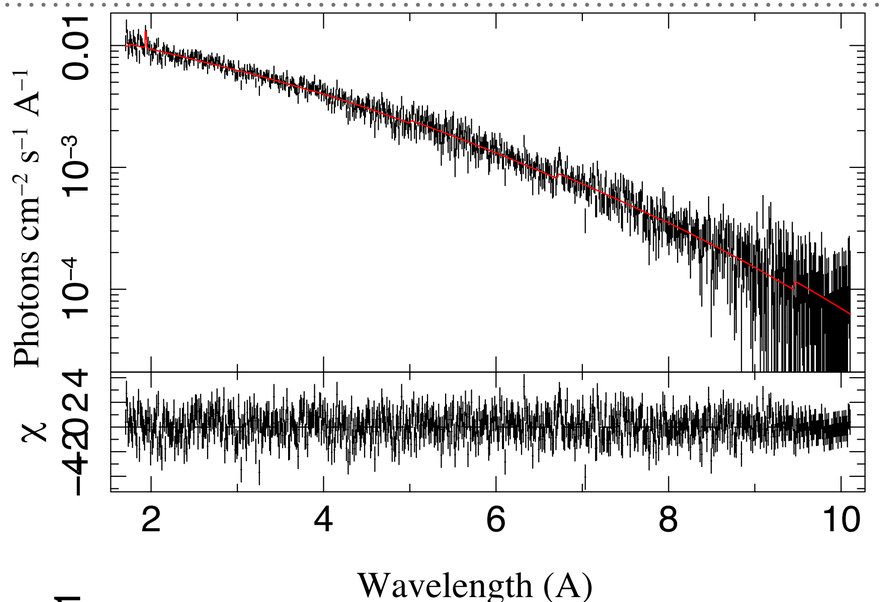
ISM grain absorption model tbpcf

SHAPE OF SPECTRAL CONTINUUM WITH RESPECT TO ORBITAL PHASE

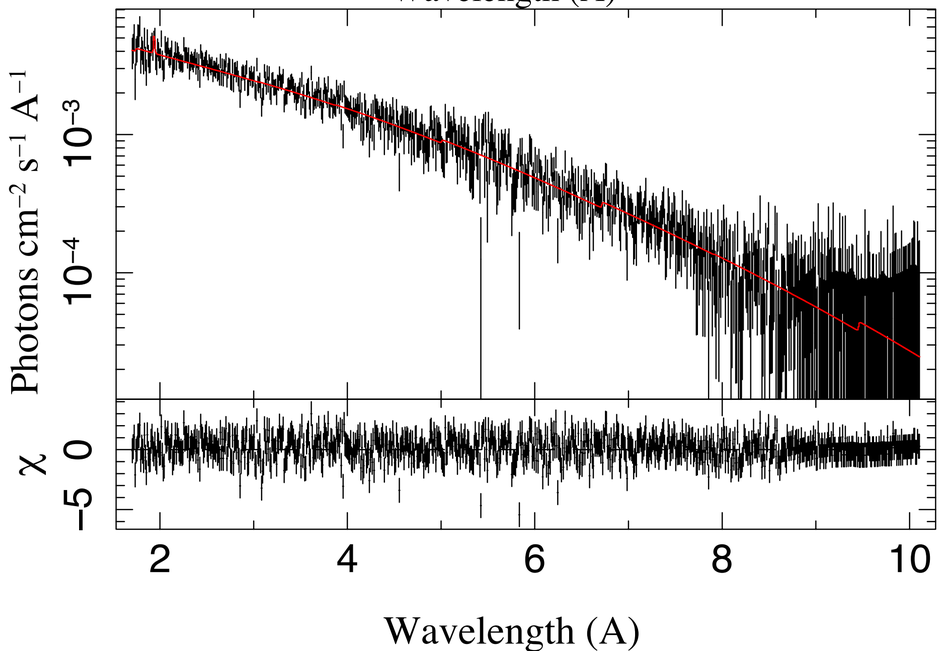
*powerlaw (the core emission model) and the absorbing functions (TBfeo and TBpcf): TBfeo*TBpcf*powerlaw.*



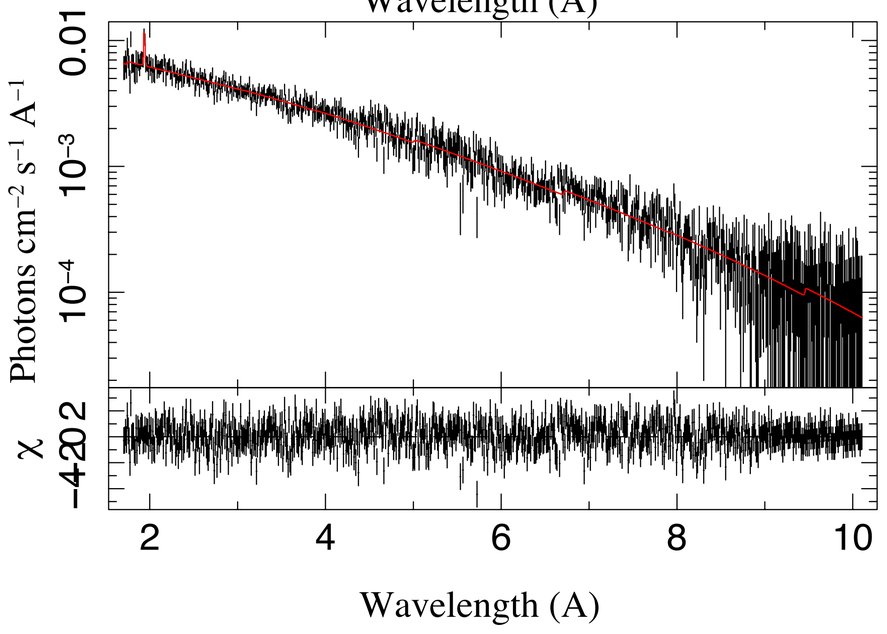
20738



21123



21124



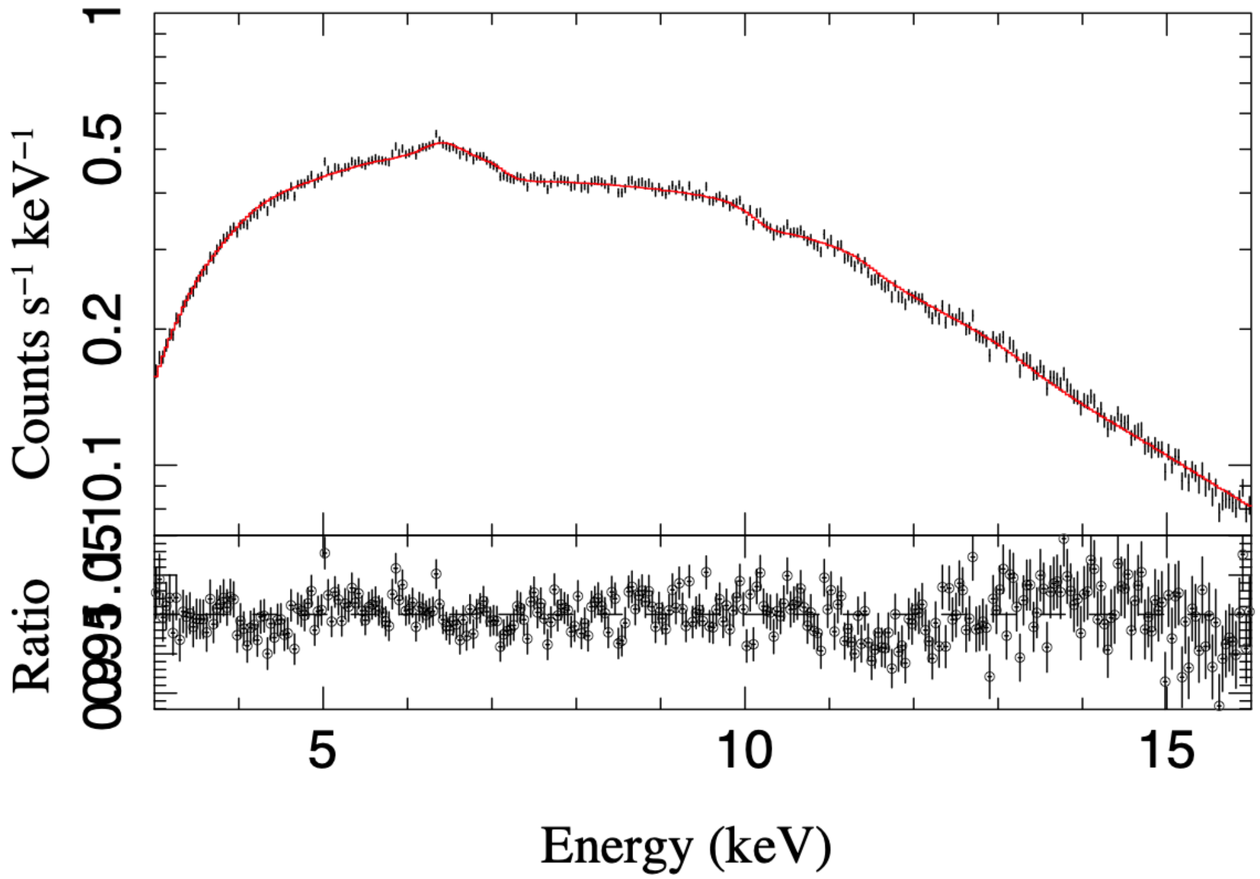
21125

NUSTAR SPECTRA

- *powerlaw*highecut*

fitted with a high energy cut-off continuum,

The extra absorption around 12.2 keV in the residuals is due to the *highecut* model's cutoff energy at 12.2 keV.



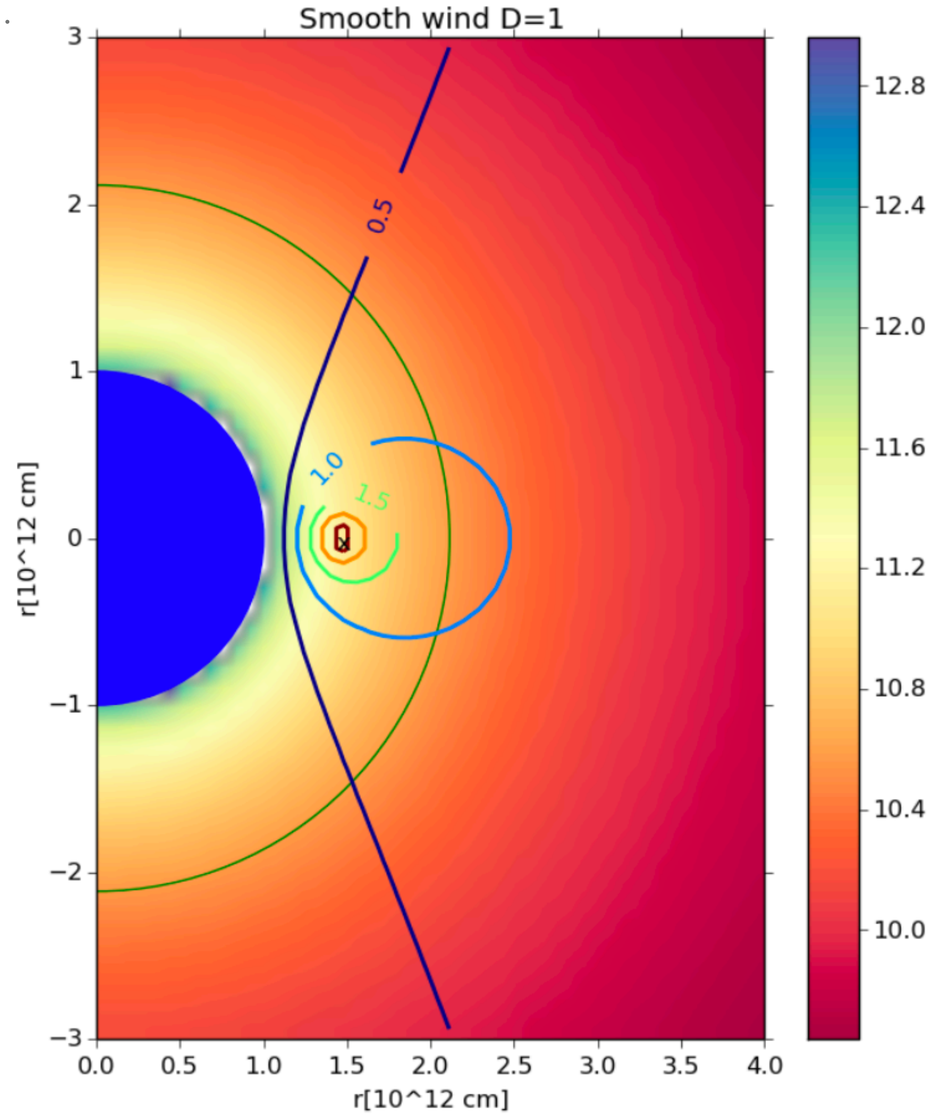
SHAPE OF SPECTRAL CONTINUUM WITH RESPECT TO ORBITAL PHASE

Continuum and iron Kα fits to *Chandra*-HETGS and *NuSTAR* observations

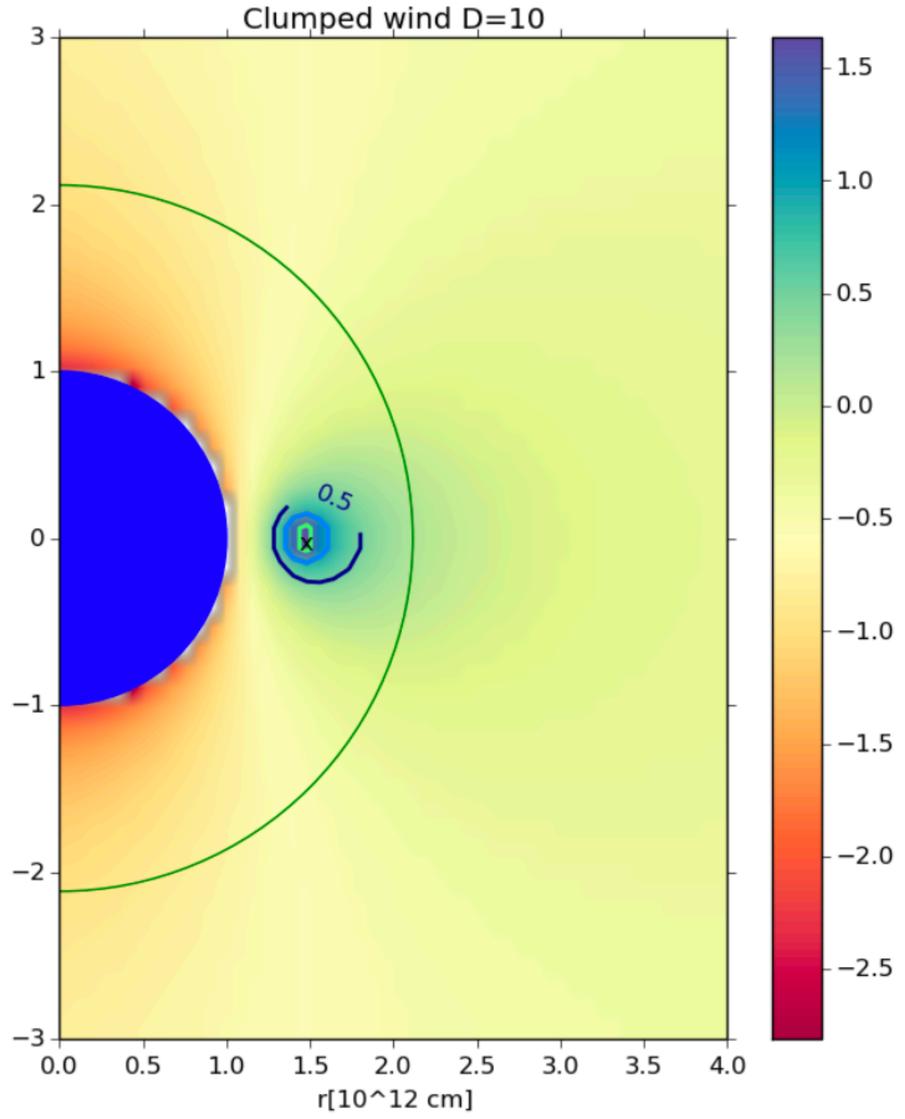
		20738	21123	21124	21125	*NuSTAR*
$N_{\rm H,full}$	10^{22} cm^{-2}	$3.2^{+0.1}_{-0.2}$	$2.7^{+0.1}_{-0.1}$	$2.8^{+0.1}_{-0.2}$	$2.4^{+0.1}_{-0.1}$	$5.5^{+0.4}_{-1.8}$
PL norm	10^{-2} ph cm^{-2} s^{-1}	$2.5^{+0.1}_{-0.3}$	$2.7^{+0.1}_{-0.2}$	$1.0^{+0.1}_{-0.2}$	$1.6^{+0.1}_{-0.2}$	$2.1^{+0.1}_{-0.1}$
Γ		$1.15^{+0.02}_{-0.08}$	$1.15^{+0.03}_{-0.04}$	$1.07^{+0.08}_{-0.05}$	$1.04^{+0.07}_{-0.03}$	$0.95^{+0.2}_{-0.2}$
$A_{\rm FeK\alpha}$	10^{-5} ph cm^{-2} s^{-1}	8 ± 4	7 ± 4	2.0 ± 1.9	9 ± 3	15 ± 3
$\lambda_{\rm FeK\alpha}$	Å	$1.9428^{+0.0098}_{-0.0004}$	$1.939^{+0.004}_{-0.010}$	$1.939^{+0.004}_{-0.010}$	$1.938^{+0.005}_{-0.006}$	1.93
$\sigma_{\rm FeK\alpha}$	Å	0.001	0.001	0.001	0.001	0.042
f_x [2 - 10 keV]	10^{-10} erg cm^{-2} s^{-1}	2.1	2.3	0.9	1.5	2.3
L_x [5 kpc]	10^{35} erg s^{-1}	6.2	6.9	2.7	4.6	7.0
reduced χ^2		0.97	1.08	0.95	0.95	1.33

Periastron

4U 1907–09 IONIZATION AT THE PERIASTRON

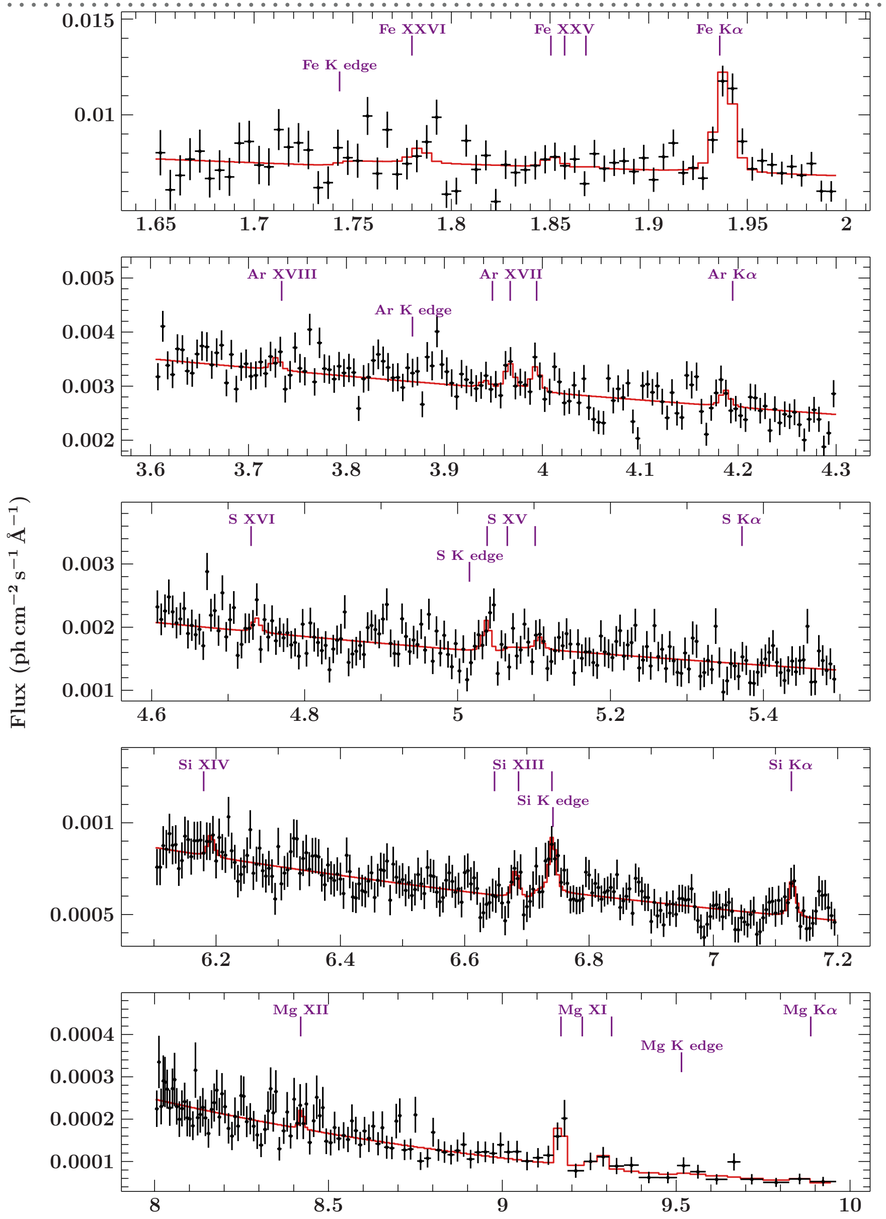


Smooth plasma



Clumped wind

COMBINED CHANDRA HETG SPECTRA



Cool and dense material in the wind: clumps

Spectrum fitting with Fe Kα line

Kα lines of Si and Ar

SUMMARY: PULSAR 4U1907+09 IN DEPENDENCE OF BINARY ORBIT

Chandra: ~**140 ks** & **NuSTAR: 78 ks**, at **different orbital phases,** to probe the variation of **flux, brightness**, the **absorbing column** around the orbit.

1. Zero flux: **ultra-dense material** at periastron
2. Fe Kα fluorescence: various forms of clumps in the wind

X-ray study -> severe wind clumps in the innermost companion, variability in dependence of stellar radius

dense clumps within 1.5 R of the massive companion star