



# Probing the masses of WDs in CVs with NewAthena

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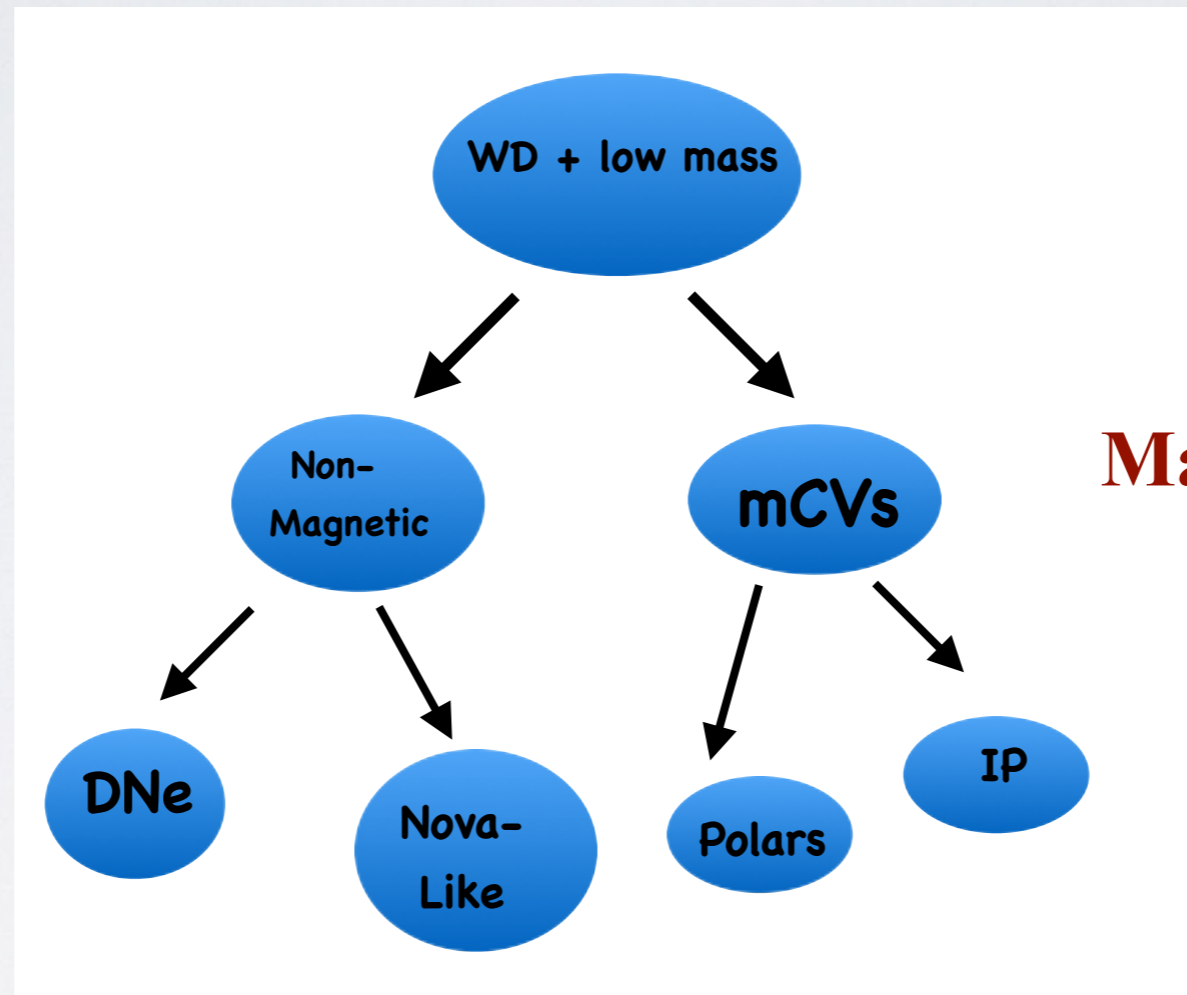
# NewAthena Special Issues

**Mapping the environment around compact objects in binaries with NewAthena:** 5 merged abstracts, 40+ co-authors

**New physics of nova outbursts, accreting white dwarfs, and planetary nebulae with NewAthena:** 2 merged abstracts, 10+ co-authors

# Accreting WD systems

- **Cataclysmic Variables:** Binary systems with a WD accreting matter from a low mass companion star ( $< 1 M_{\odot}$ ).

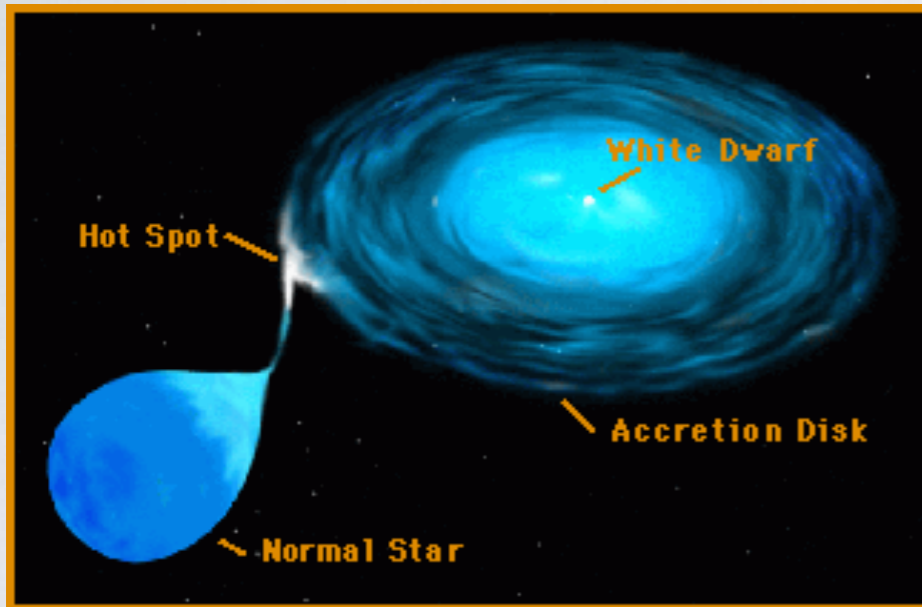


**Magnetic field  
of WD**

- Other CV subclasses: Symbiotic stars with WD (novae), Be + WD systems (gamma Cas analogous)

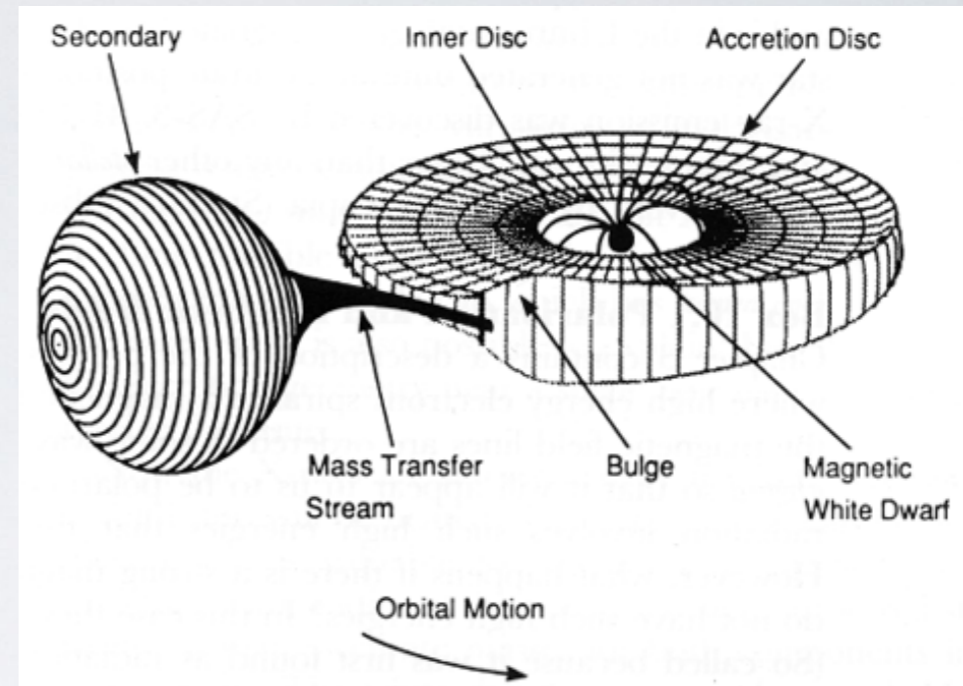
# Types of CVs

## Non-magnetic



- ❖ **Nova-like variables:** Accretion disks around non-magnetized WD.
- ❖ Accretion occurs via the formation of an accretion disk with the primary site of X-ray emission considered to be the boundary layer between the accretion disk and the WD.

## Magnetic



- ❖ **Intermediate Polars:** Truncated accretion disks by magnetized WD.
- ❖ X-ray emission occurs from accreted matter shock heated to high temperatures  $kT \sim 10-50$  keV. Emission lines from medium Z elements like Ar, Si, S, Fe

# Methods to estimate mass of WD in CVs

## Masses of WD are important to understand the formation and evolution of CVs:

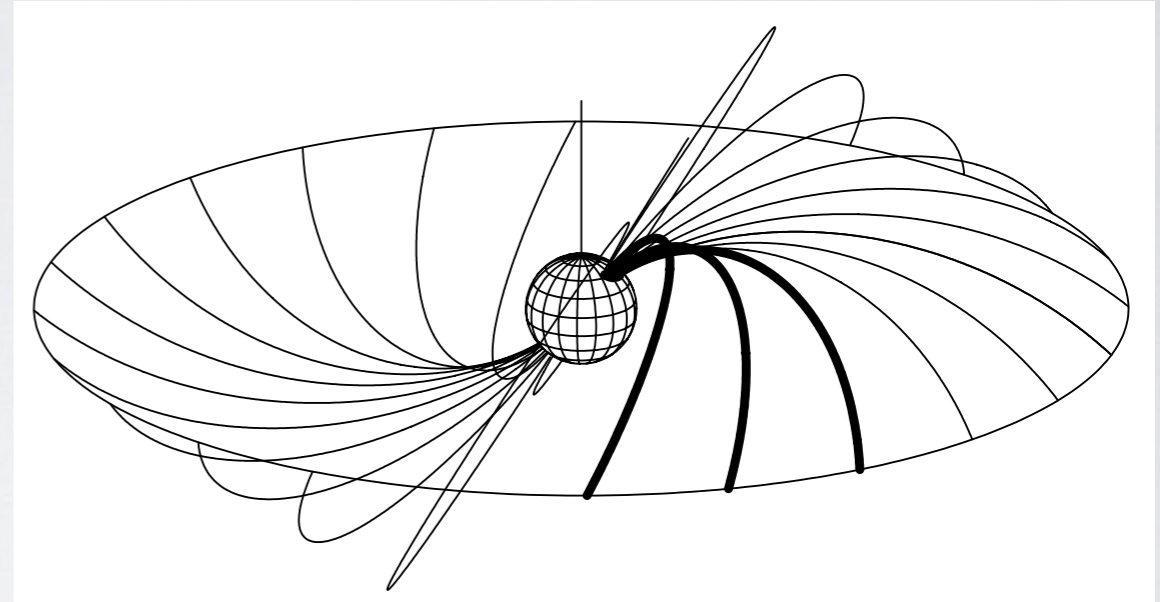
Isolated WD versus WD in binaries, progenitor channel for Type Ia supernovae

- ❖ Radial velocity measurements
- ❖ Eclipse mapping -> [Islam et al. 2026 ApJ](#) for eclipsing source UU Aqr
- ❖ Optical/UV modelling of the absorption and emission lines from the WD
- ❖ X-ray shock temperatures of mCVs are related to the mass-radius ratio of the WD -> Shaw et al. 2020 for mCVs and Yu et al. 2018 for non-magnetic CVs
- ❖ [Gravitational redshift of various emission lines enables us to measure directly WD mass - radius ratio](#)

$$v_g = cz = \frac{c\Delta E}{E_{rest}} = 0.635 \frac{M_\odot}{R_\odot}$$

# V2400 Oph (also RX J1712.6-2414)

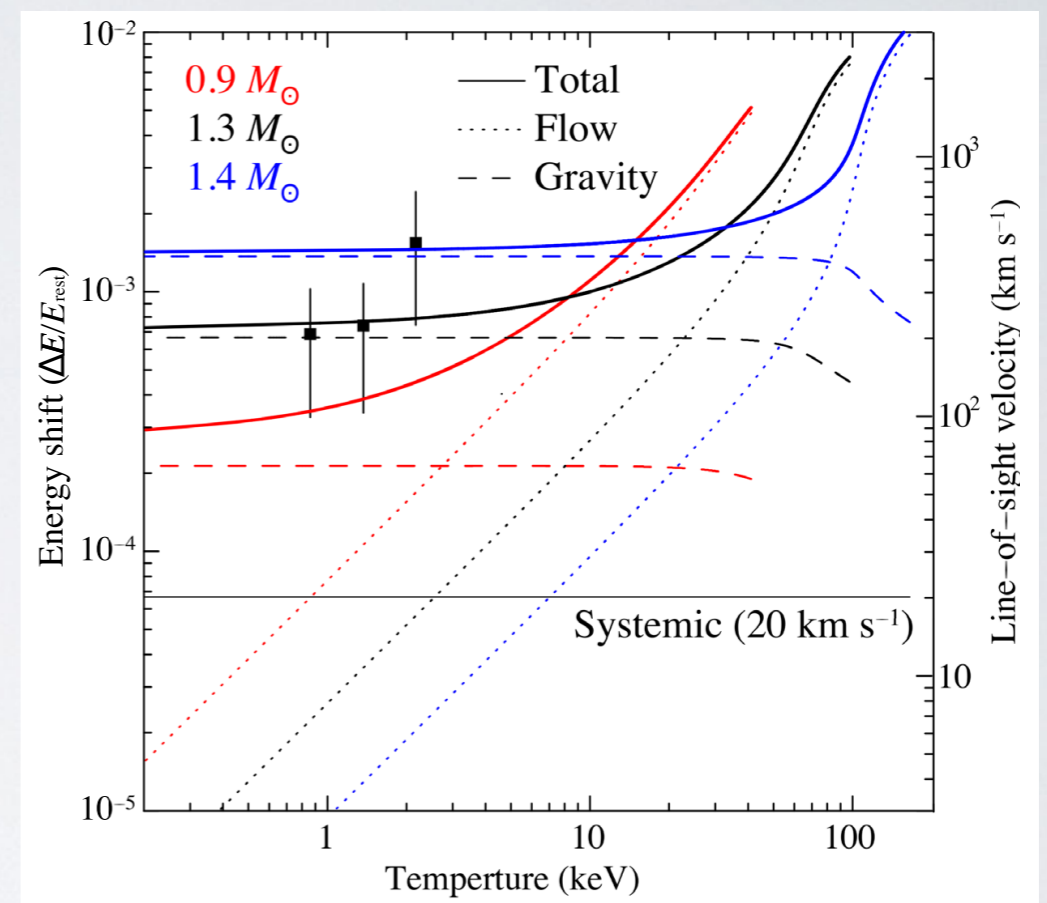
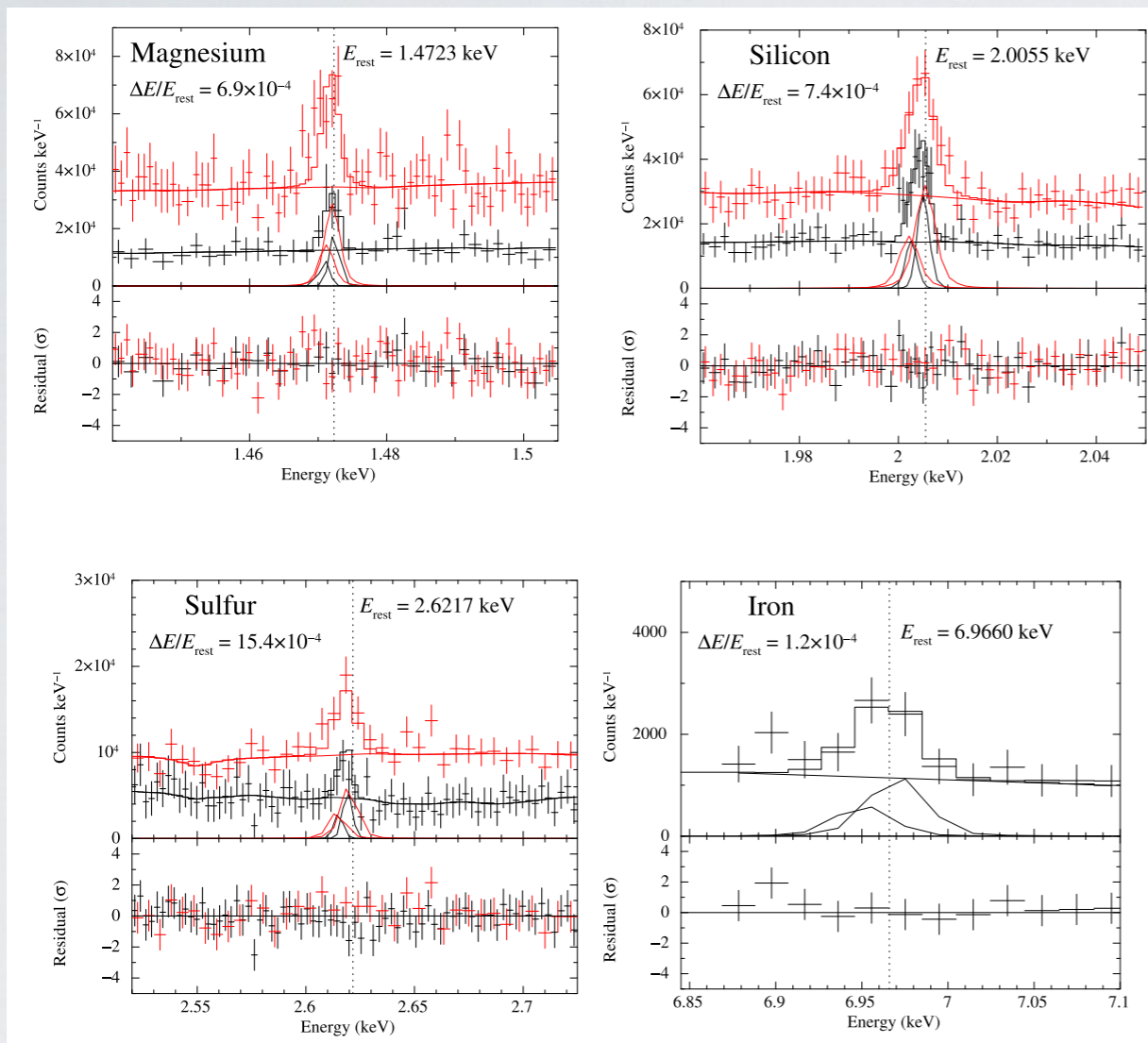
- ❖ Diskless IP. 3.42 hr orbital period and 927 s spin period.
- ❖ Distance of 709 pc from Gaia EDR3.
- ❖ Highly magnetized WD 9-27 MG. Only one magnetic pole is observed, at low inclination of  $10^\circ$
- ❖ 200 ks of Chandra HETG observation calculated the energy shifts of medium Z lines.



**Schematic diagram.**

**Ref: Hellier & Beardmore 2002**

# Energy shifts of Emission lines in CVs



Chandra HEG (black) and MEG (red) spectra of IP V2400 Oph around H like  $K\alpha_1$  &  $K\alpha_2$  lines of Mg, Si, S & Fe

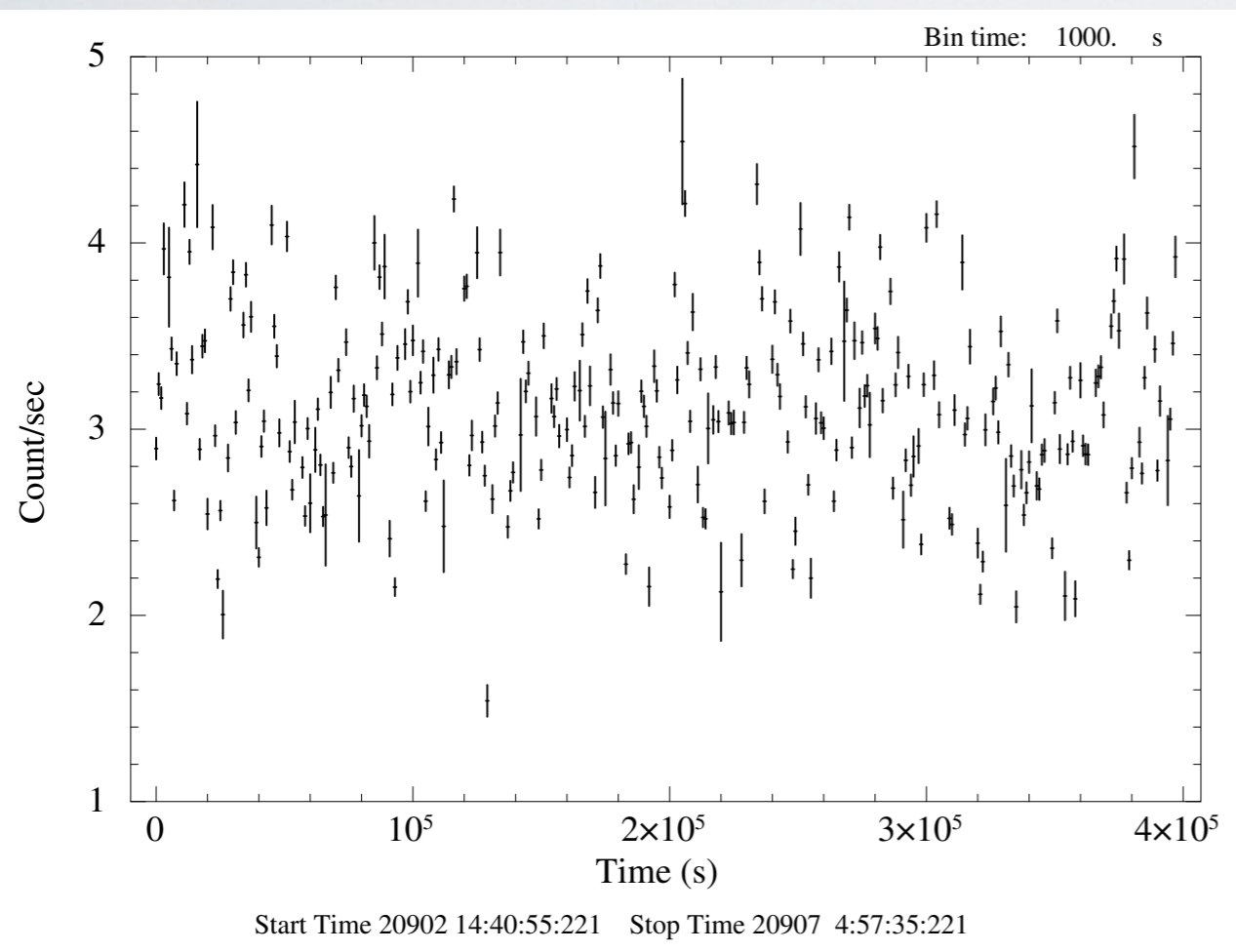
Mass of the WD in V2400 Oph  $> 0.9 M_{\odot}$

# XRISM observation of V2400 Oph

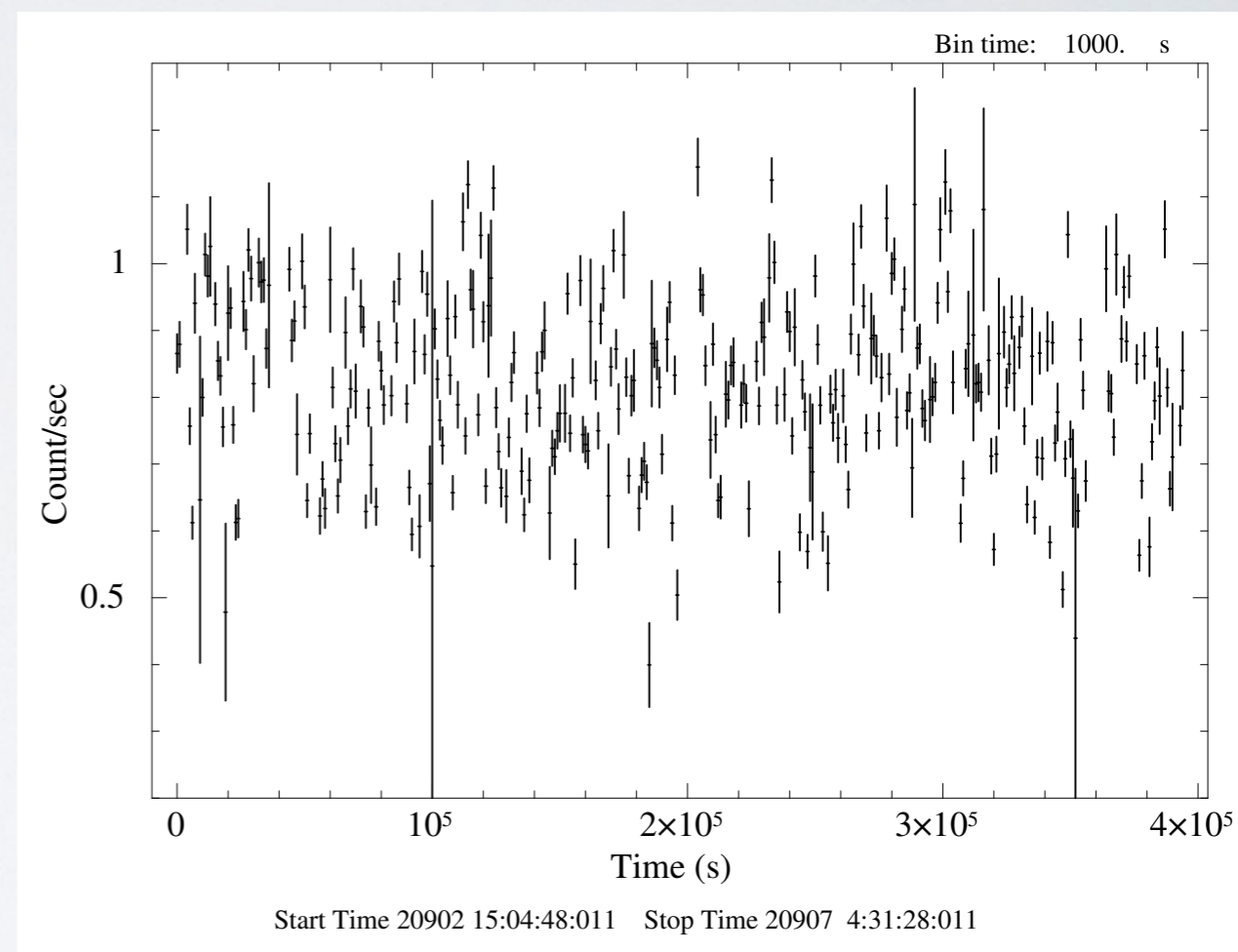
300 ks of XRISM observation of V2400 Oph in AO Cycle 1.

PI and Lead author: N. Islam

Preliminary



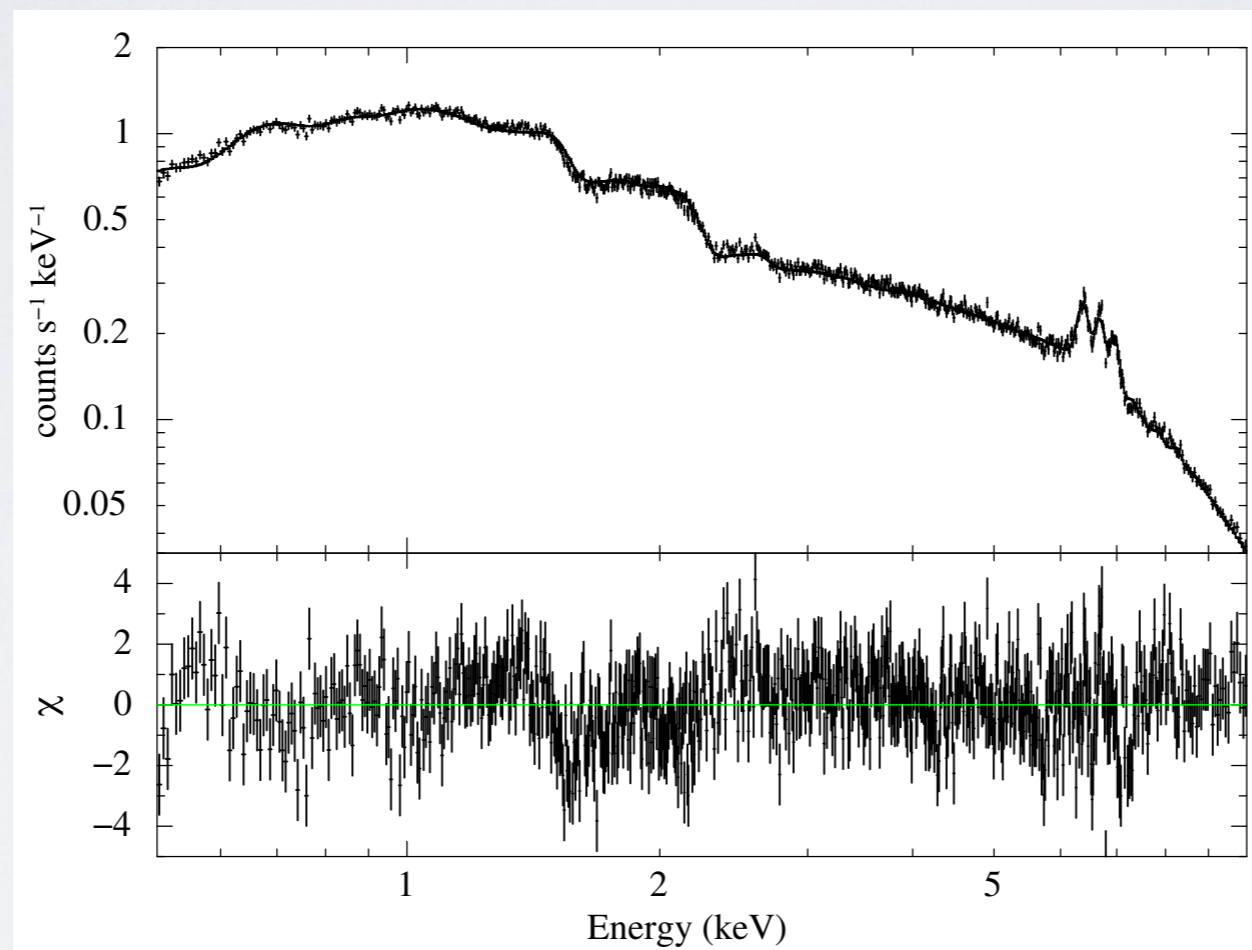
XTEND lightcurve



Resolve lightcurve

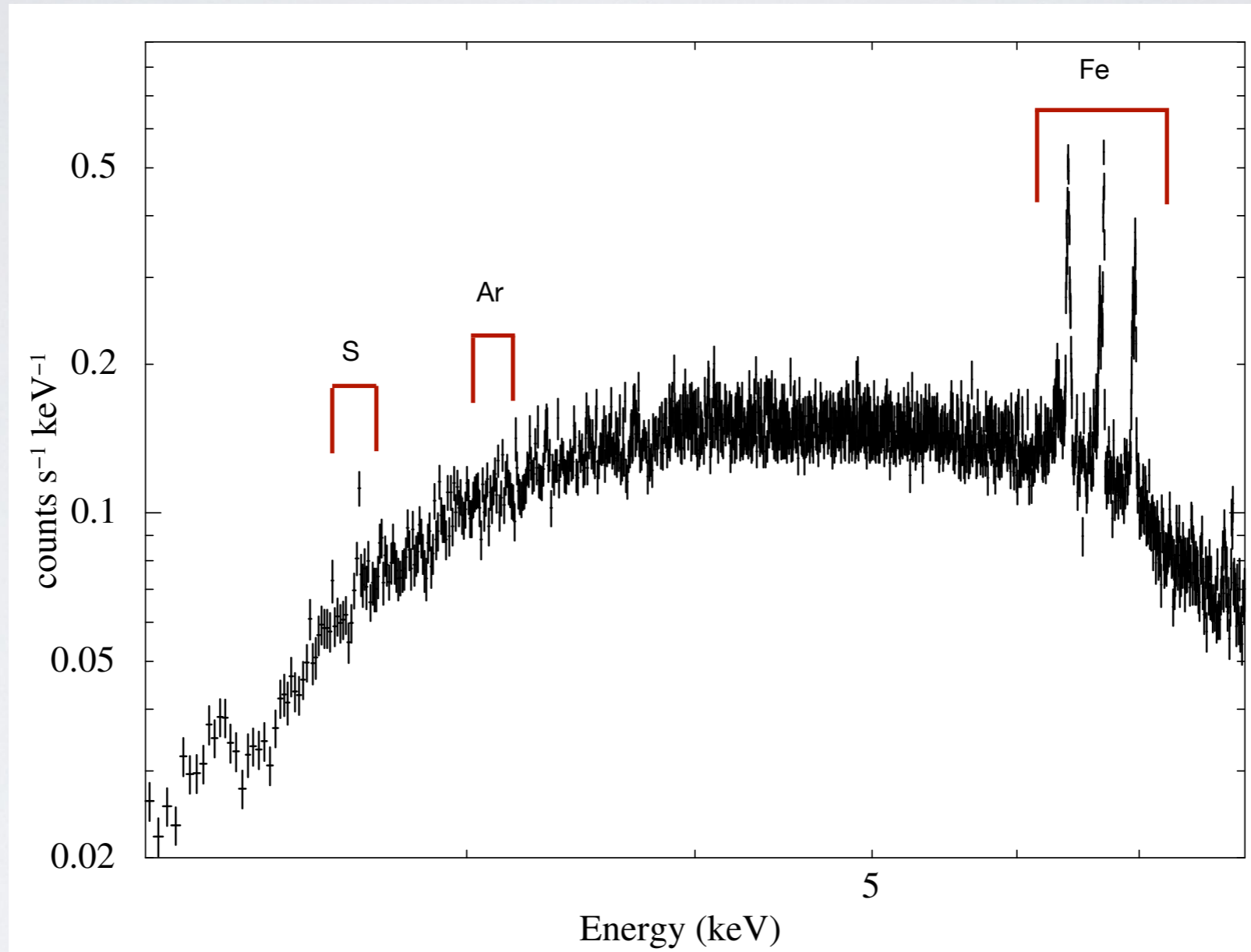
# XTEND X-ray spectra

Cooling flow model coolflow with an ionized absorber model zxipab plus a blackbody of 0.1 keV



Absorbed X-ray luminosity of  $10^{33}$  erg/s

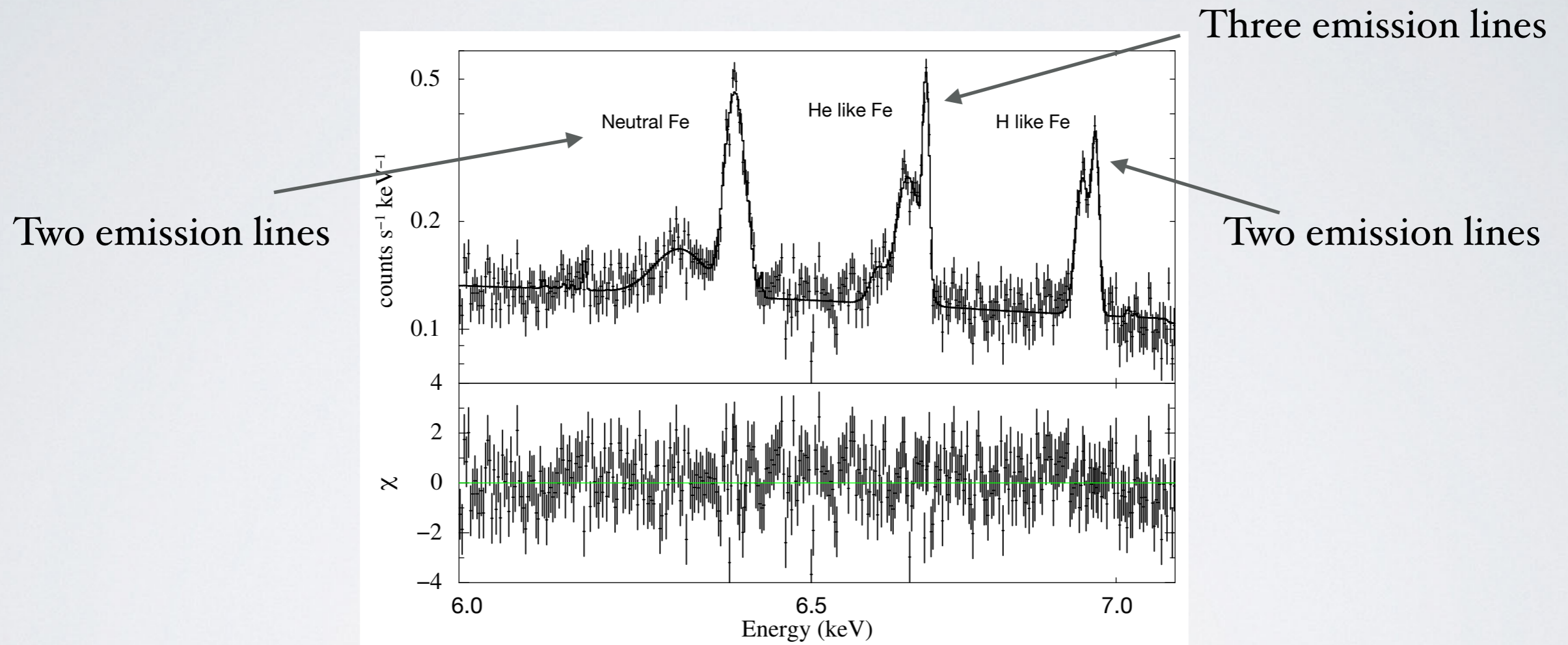
# Resolve X-ray spectra



Absorbed X-ray luminosity of  $10^{33}$  erg/s

# Resolve X-ray spectra

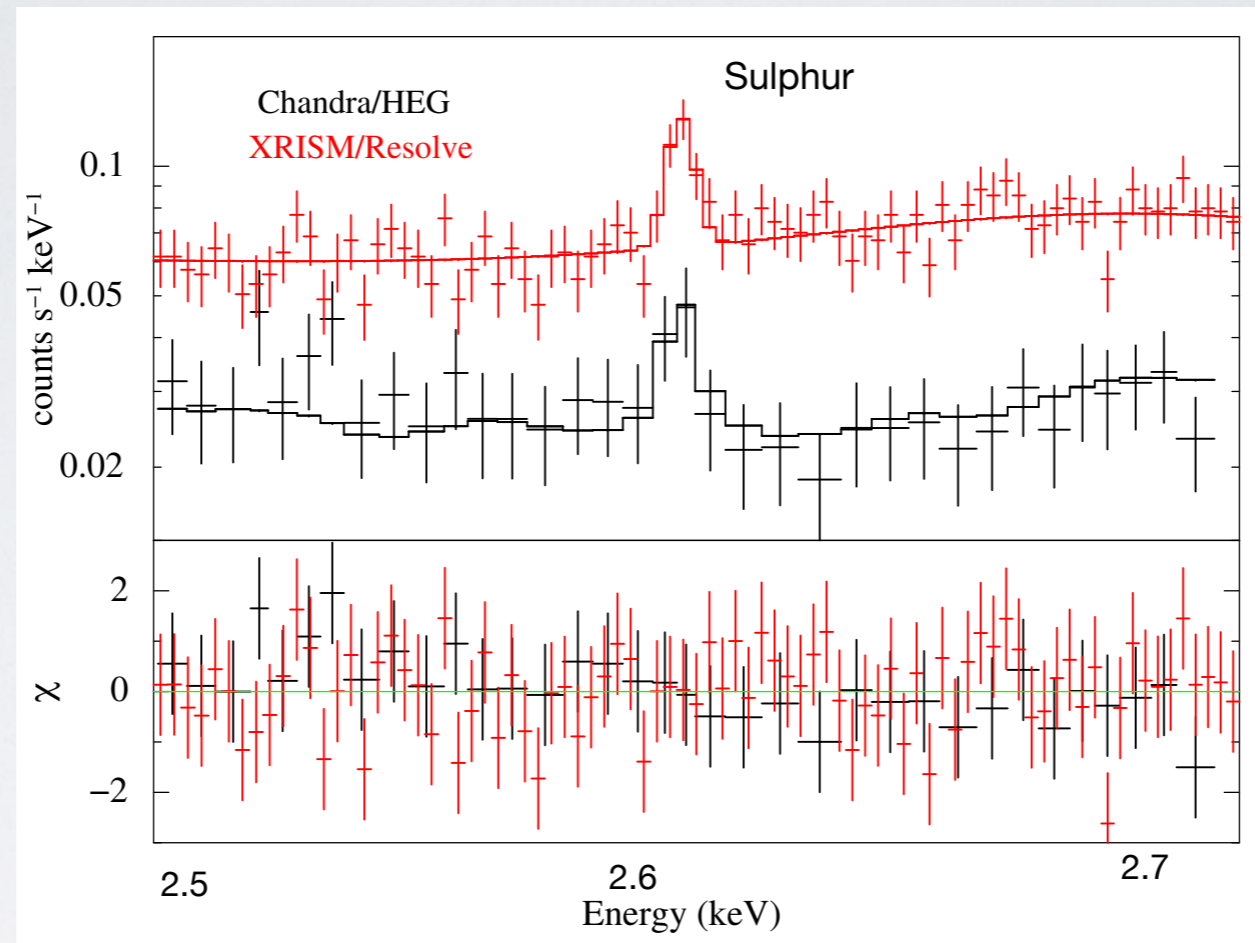
Large width of the neutral Fe K $\alpha$  line (40 eV) compared to the narrow lines observed in RT Cru and T CrB ( $\sim 12$  eV)



Absorbed X-ray luminosity of  $10^{33}$  erg/s

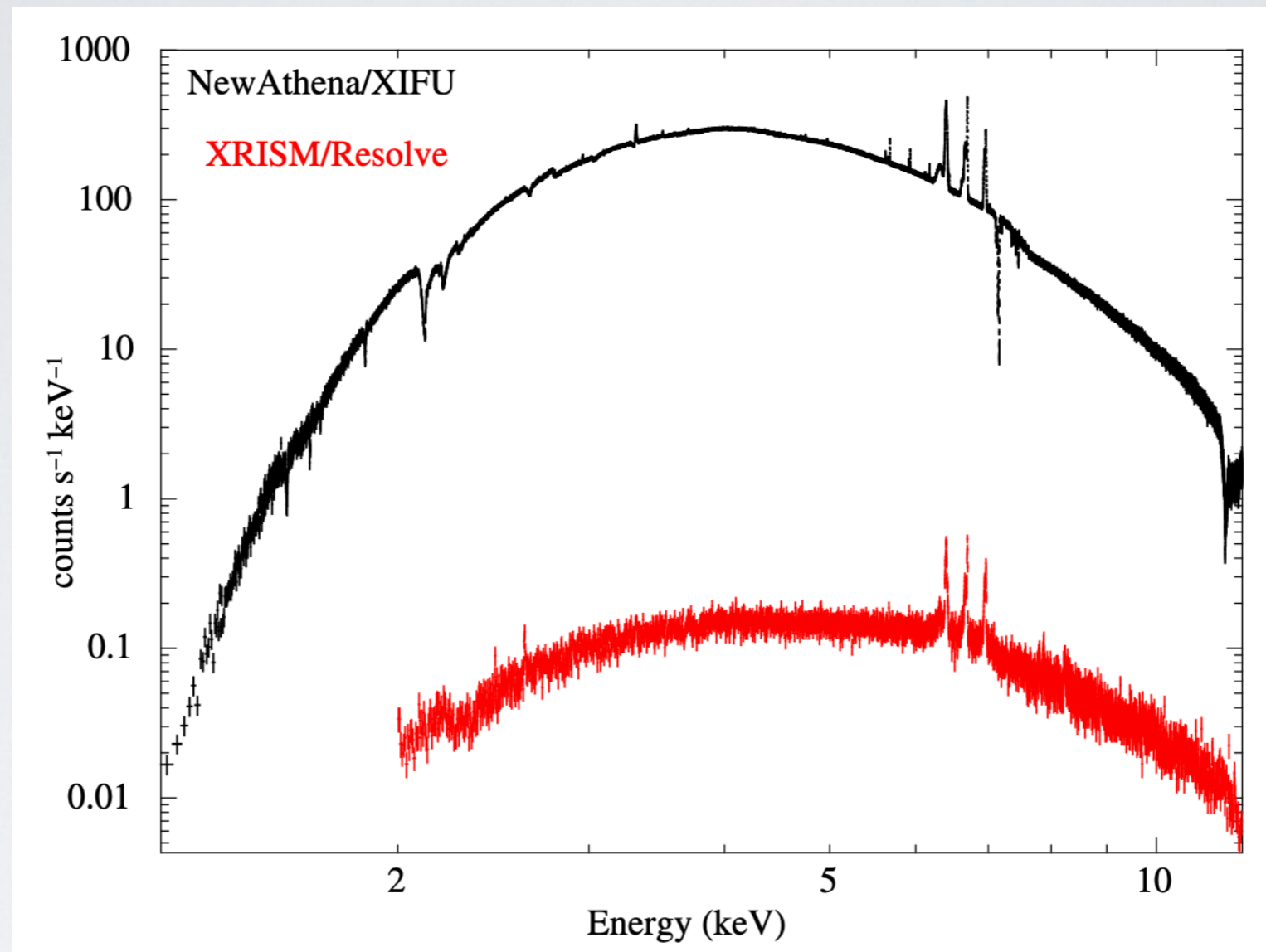
zgauss model  $z \sim 10^{-3} = \Delta E/E_{\text{rest}}$

# HETG and Resolve X-ray spectra



Comparable numbers from HETG and Resolve spectral fits

# XIFU X-ray spectra simulations



50 ks XIFU observation compared with a 300 ks Resolve observation

# Summary

- ❖ Masses of WDs are important in understanding the formation and evolution of these systems.
- ❖ Gravitational redshift of various emission lines enables us to measure directly WD mass - radius ratio
- ❖ Previous HETG observation of V2400 Oph, an IP, estimated the mass of the WD to be  $> 0.9 M_{\odot}$ .
- ❖ XRISM observation allows us to probe the Fe line regions in more detail. **Broad, redshifted Fe  $K\alpha$  line likely related to a combination of the pre-shock flow and the reflection from the slowly spinning WD surface.**
- ❖ NewAthena XIFU observations would provide an excellent sample for measuring masses of WD from the gravitational redshifts of various emission lines, especially Fe  $K\alpha$  line. Important for faint sources.

**Thank you**