The Unusual Broadband X-ray Continuum Variability seen from ULXs (well, NGC1313 X-1)

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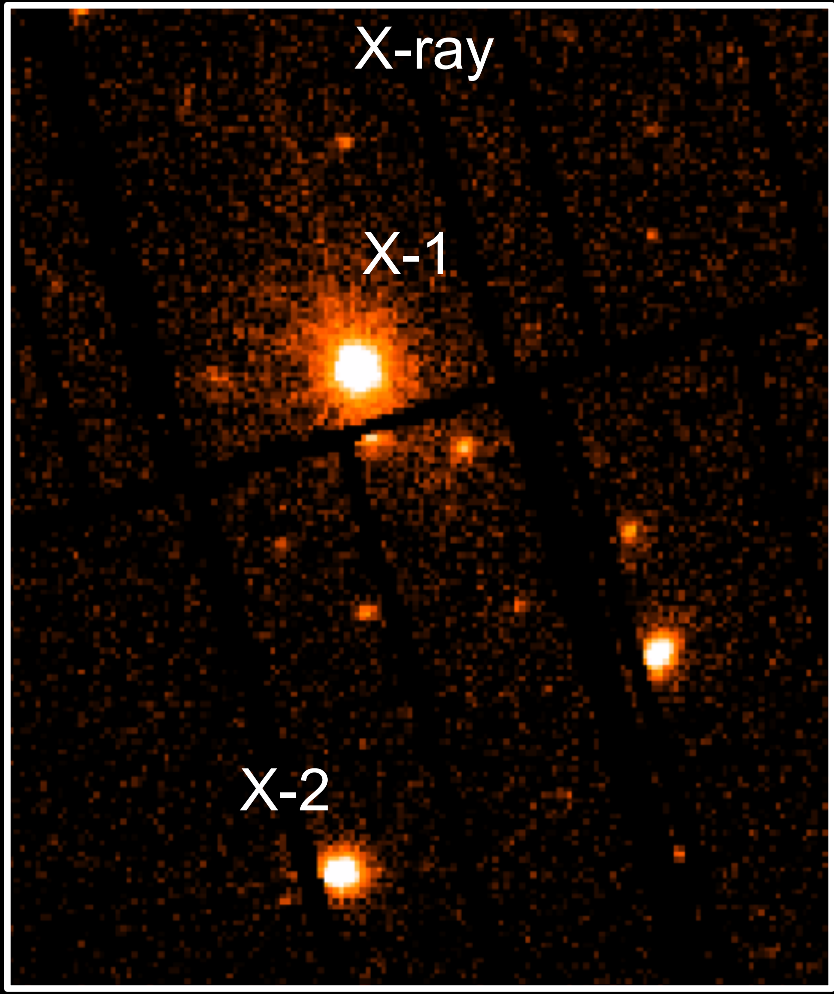
NGC1313



Nearby barred spiral galaxy, hosts two well-known ULXs with peak $L_X \sim 10^{40}$ erg/s

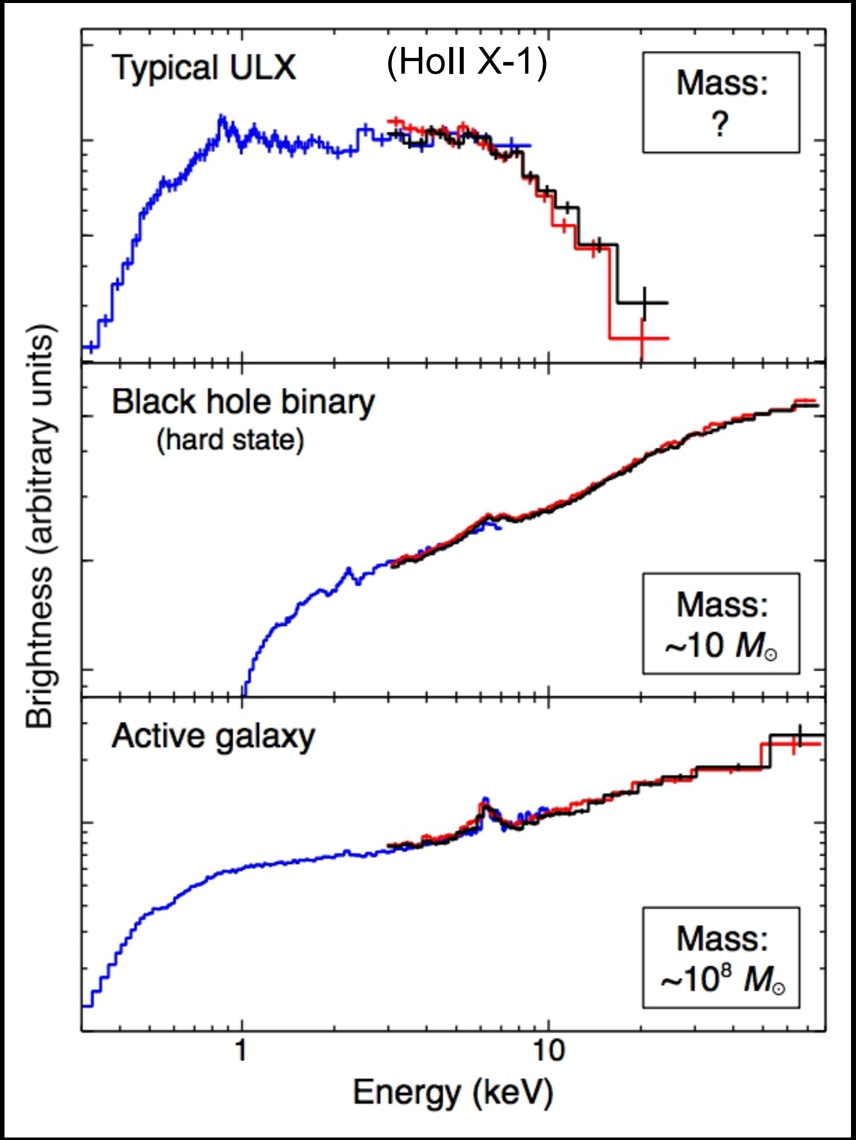
Ultraluminous X-ray Sources

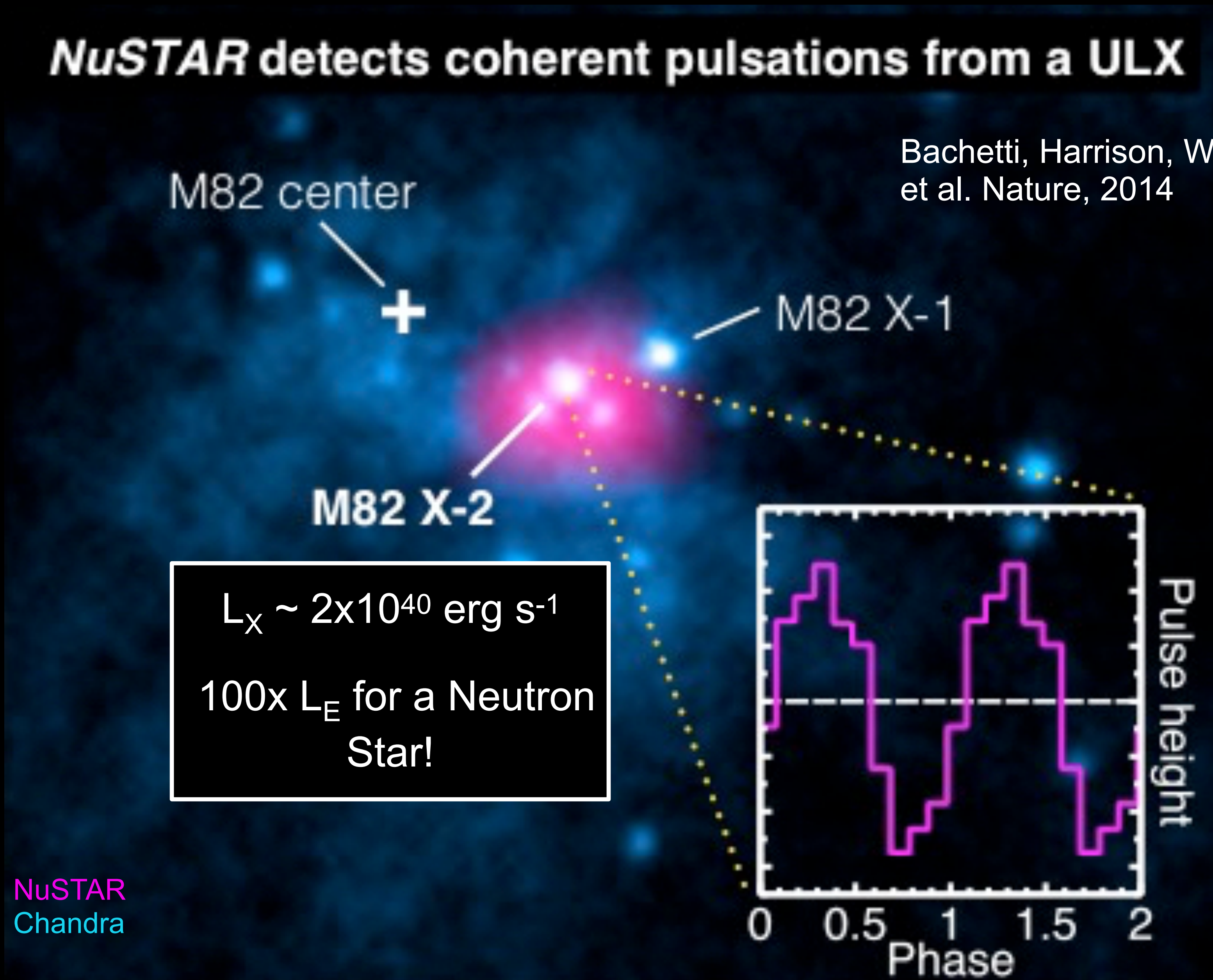
Ultraluminous X-ray sources (ULXs) are off-nuclear point sources with luminosities in excess of 10^{39} erg s^{-1} ($\sim L_E$ for a 10 M_{sun} black hole)

Explanations for these extreme luminosities include:

- Larger black holes (possibly 'intermediate mass' black holes with $M_{BH} \sim 10^{3-4}$ M_{sun})
- Super-Eddington accretion onto stellar remnants

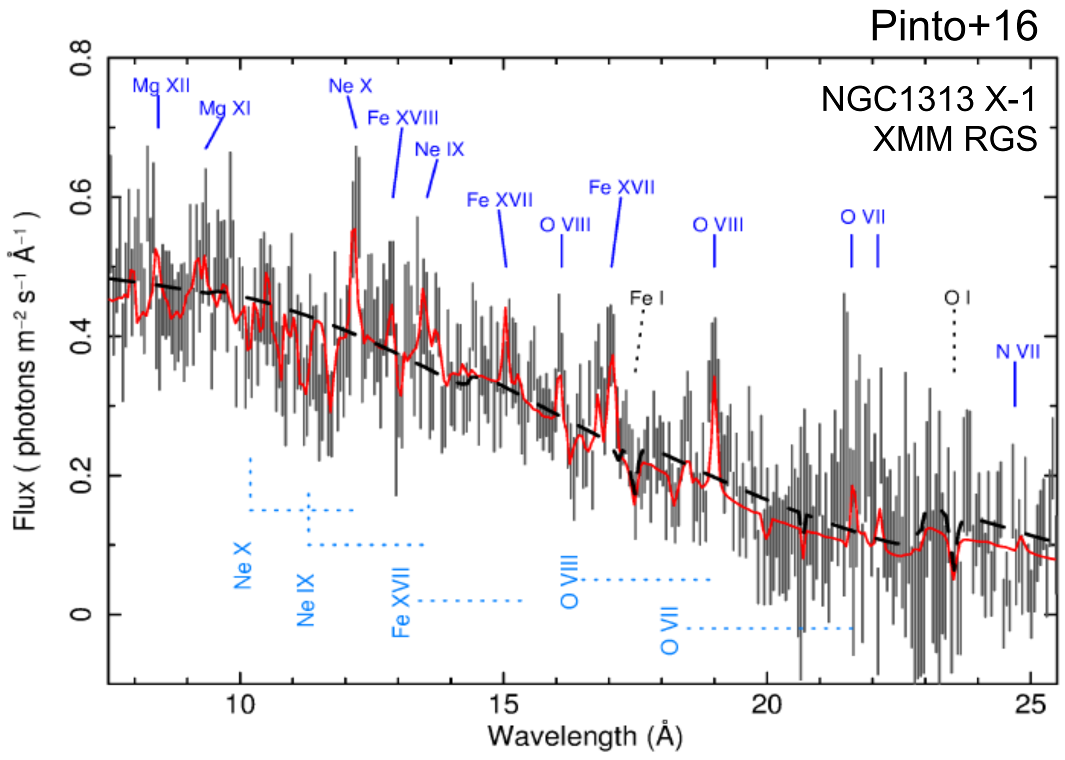
Now believe most ULXs are super-Eddington accretors

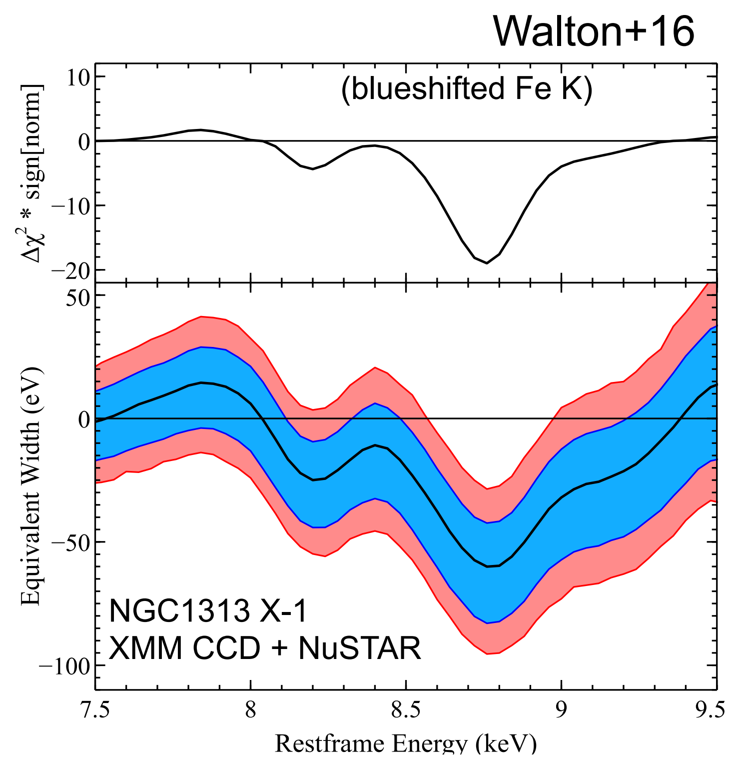




(Pulse period = 1.4s)

Ultrafast Outflows in ULXs

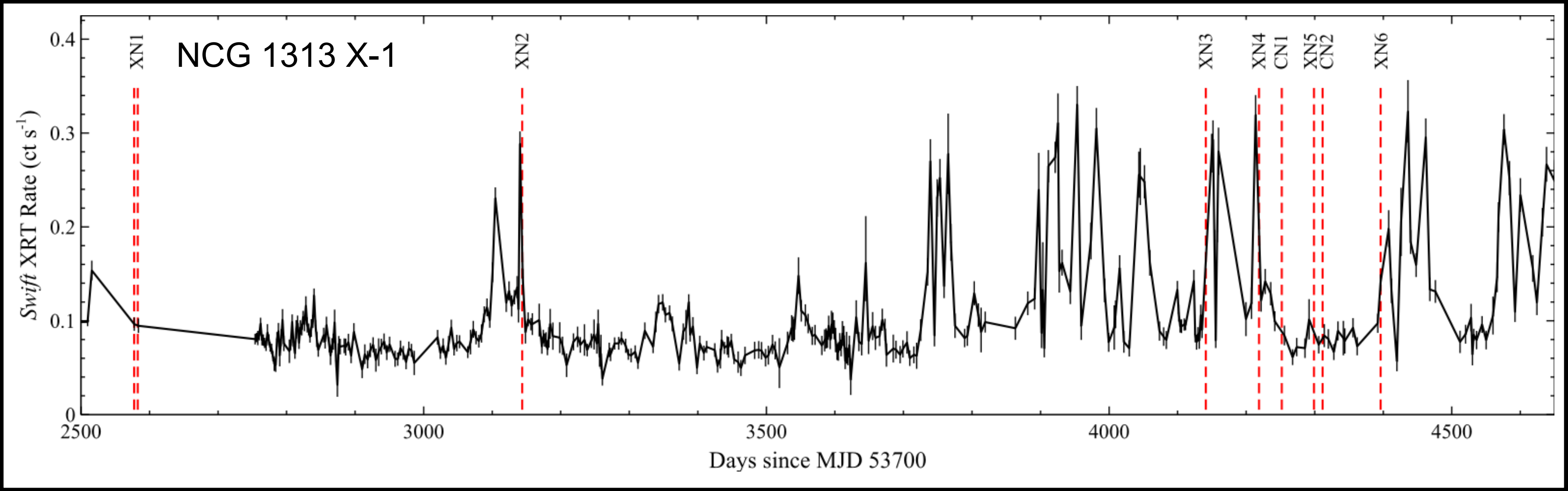




NGC1313 X-1: an ultrafast outflow with v_{out} ~ 0.25c seen in a ULX for the first time, combining XMM-Newton and NuSTAR

Strong outflows a ubiquitous prediction of super-Eddington accretion

NGC1313 – 2017 Campaign

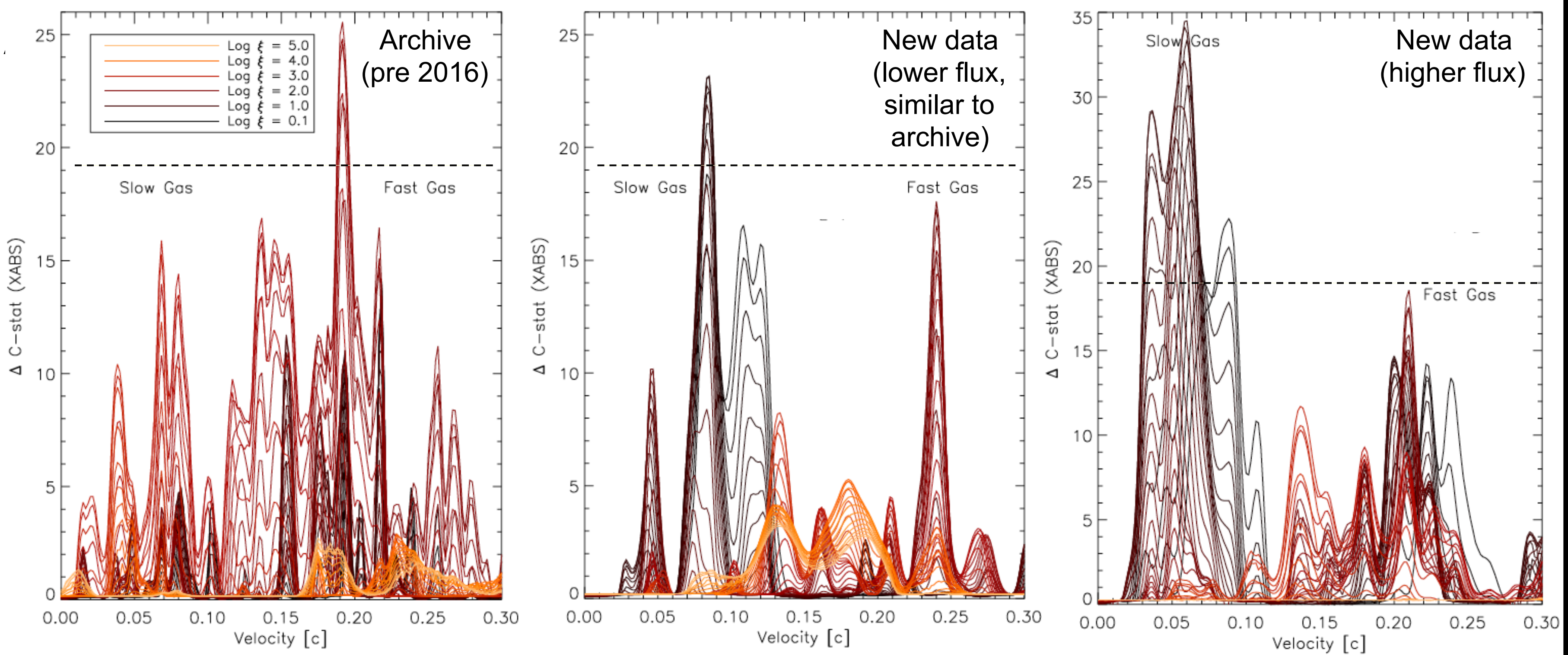


Major observational program in 2017 to study variability in the wind seen in X-1:

XMM-Newton – 750 ks, performed as 3x250 ks observations spread over ~6 months
Chandra – 500 ks, spread over the same period (using HETG)
NuSTAR – 375 ks, coordinated with XMM-Newton and Chandra; 5x75 ks

Combined with XMM-Newton + NuSTAR observations in the archive, we now have nine distinct broadband spectra of X-1

NGC1313 X-1 – Winds



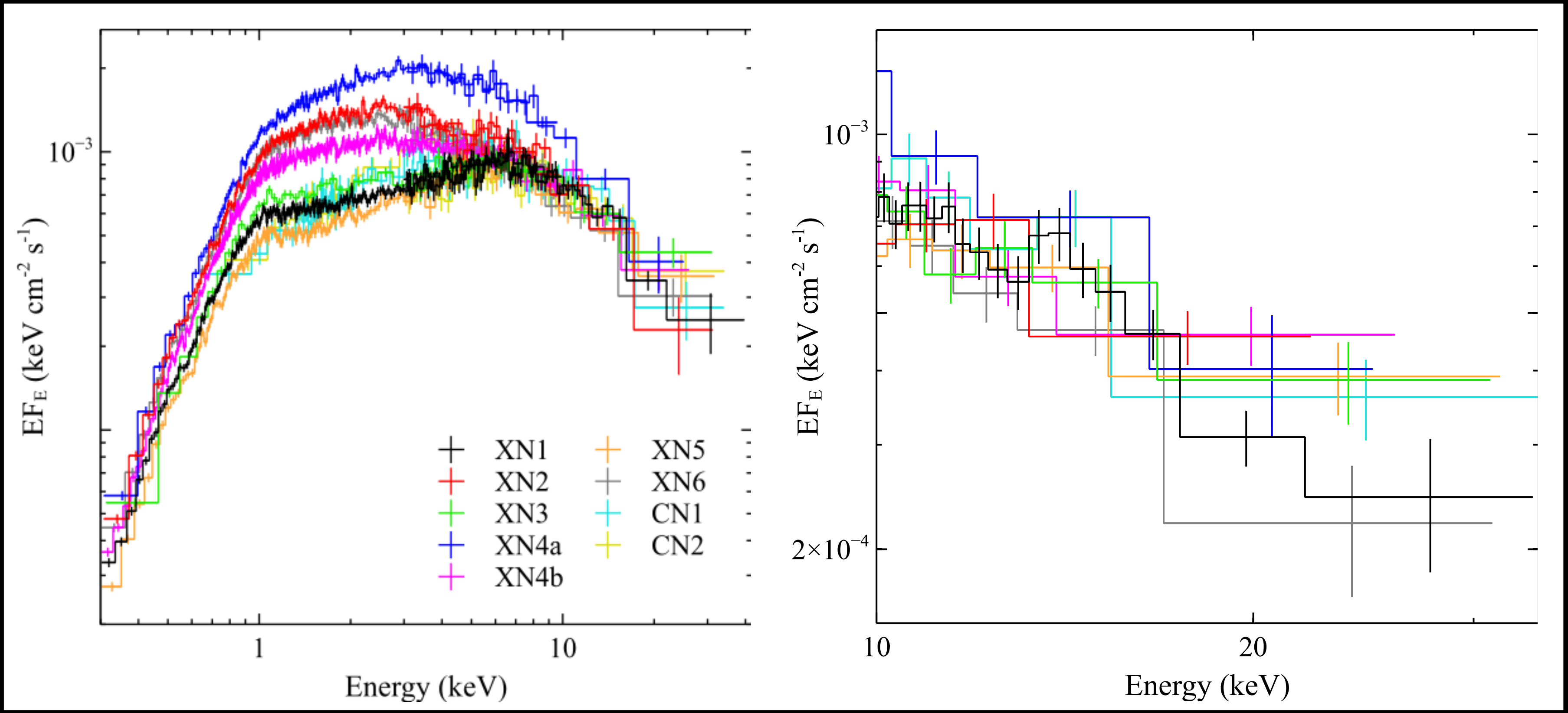
ΔC ~ 20 => ~3-σ significance (MCMC sims); Pinto et al. 2019 (in prep.)

Current wind analysis has focused on XMM-Newton data (Nowak to lead Chandra)

Lower velocity/ionisation component is present in the new data, not significantly detected seen in the archival data

The wind in NGC1313 X-1 is complex, components vary with both time and flux

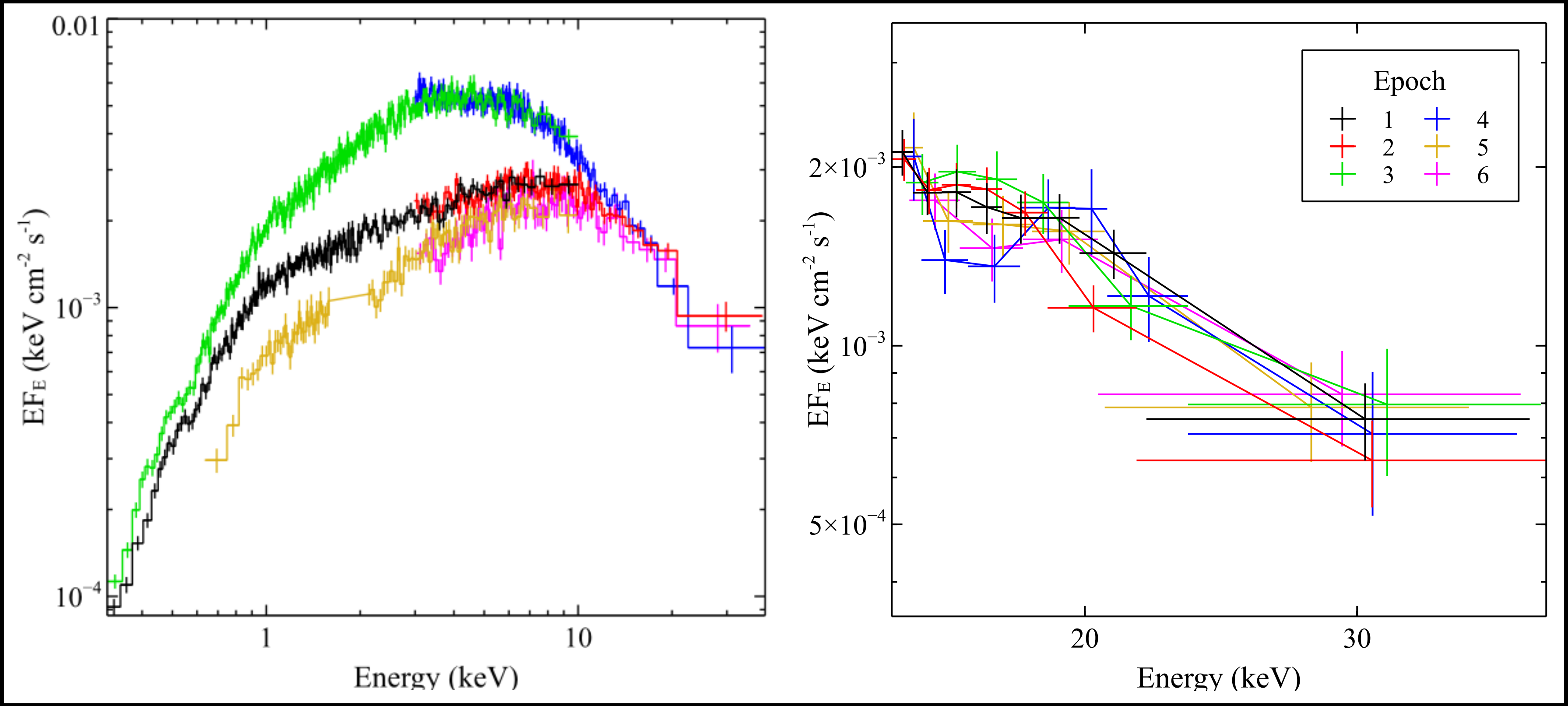
NGC1313 X-1 – Spectral Variability



High-energy (>10 keV) NuSTAR data shows remarkable consistency

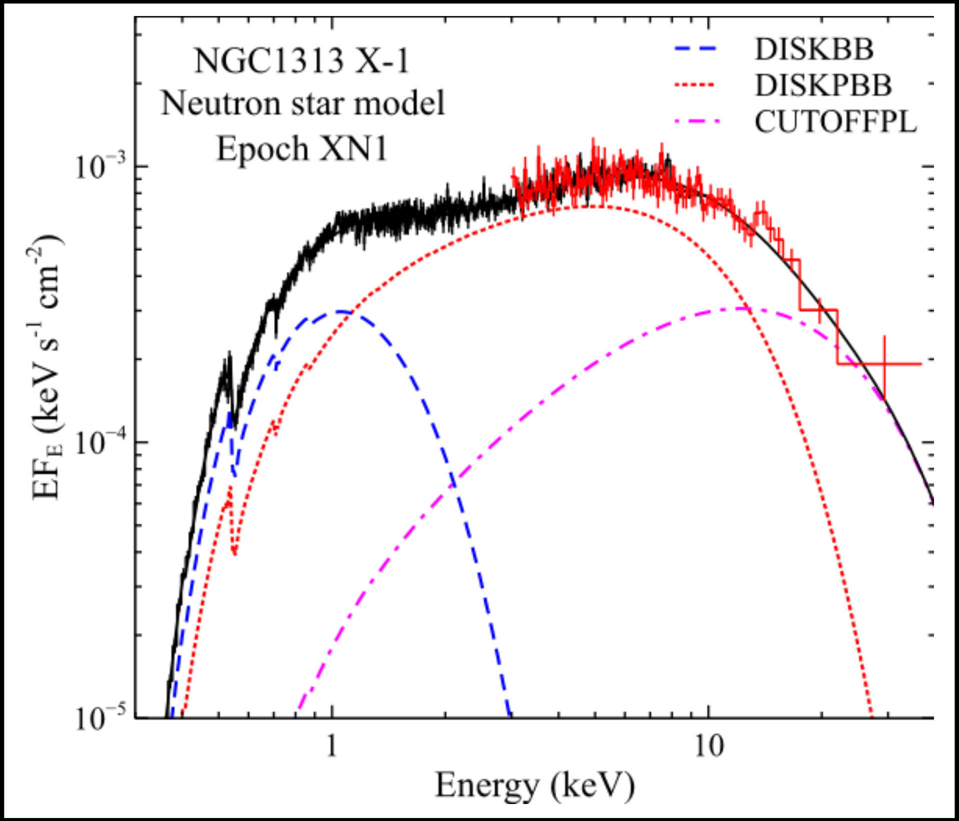
Powerlaw model gives Γ ~ 3.2 with flux variations at the ~50% level (10-40 keV), despite changes by up to a factor of ~3 at energies below 10 keV.

HoIX X-1 – Spectral Variability



Very similar to the behaviour seen from Holmberg IX X-1!
(Walton+17)

NGC1313 X-1 – Continuum Modeling



Fit the data with standard models used previously, allowing for the possibility of both a BH and NS accretor; both scenarios work similarly well.

BH case: high-energy = corona → model = DISKBB + (SIMPL x DISKPBB)

NS case: high-energy = column → model = DISKBB + DISKPBB + CUTOFFPL

(cutoffpl params set to average seen from known ULXPs in the NS model: Γ = 0.6, E_{cut} = 8 keV)

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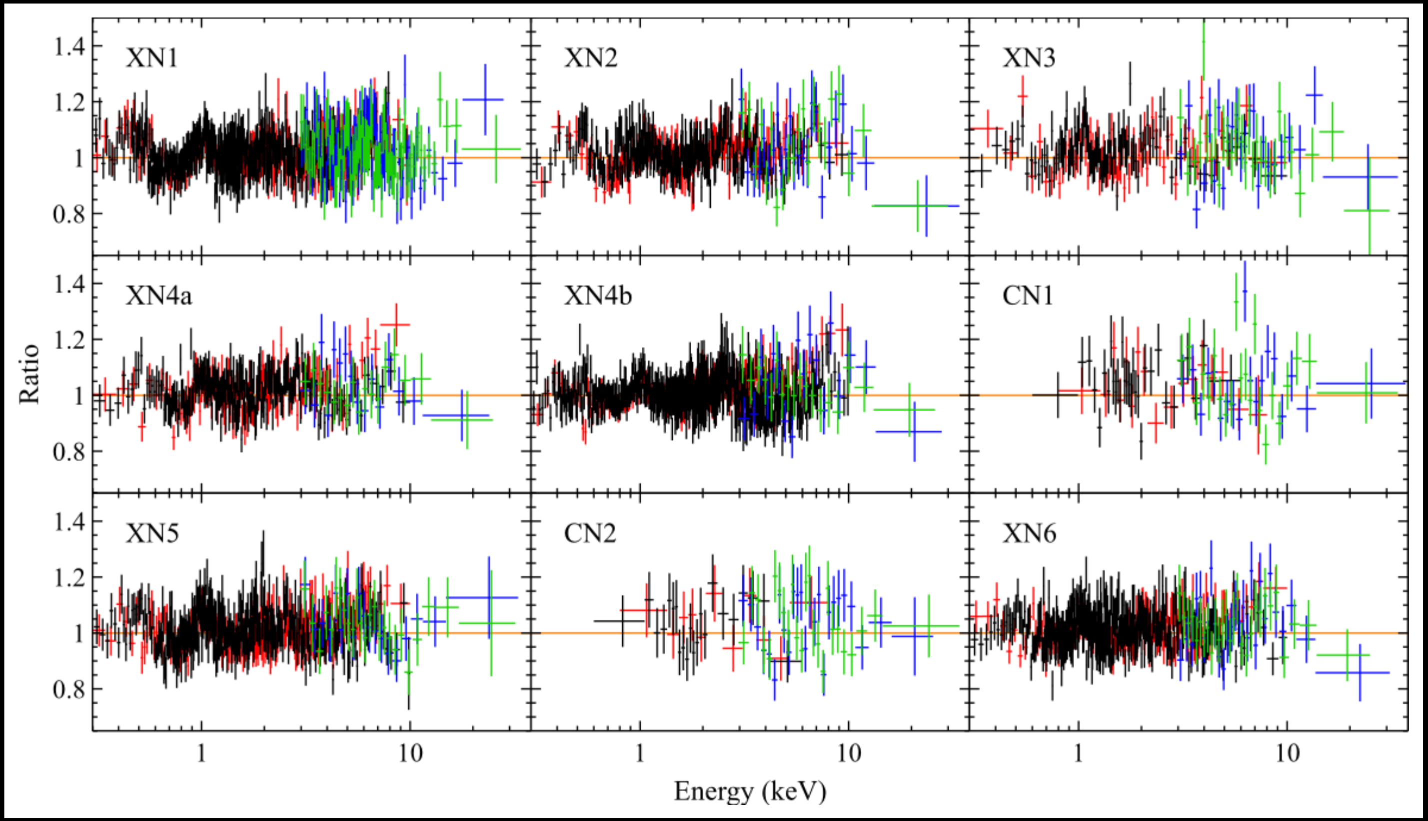

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NGC1313 X-1 – L vs T

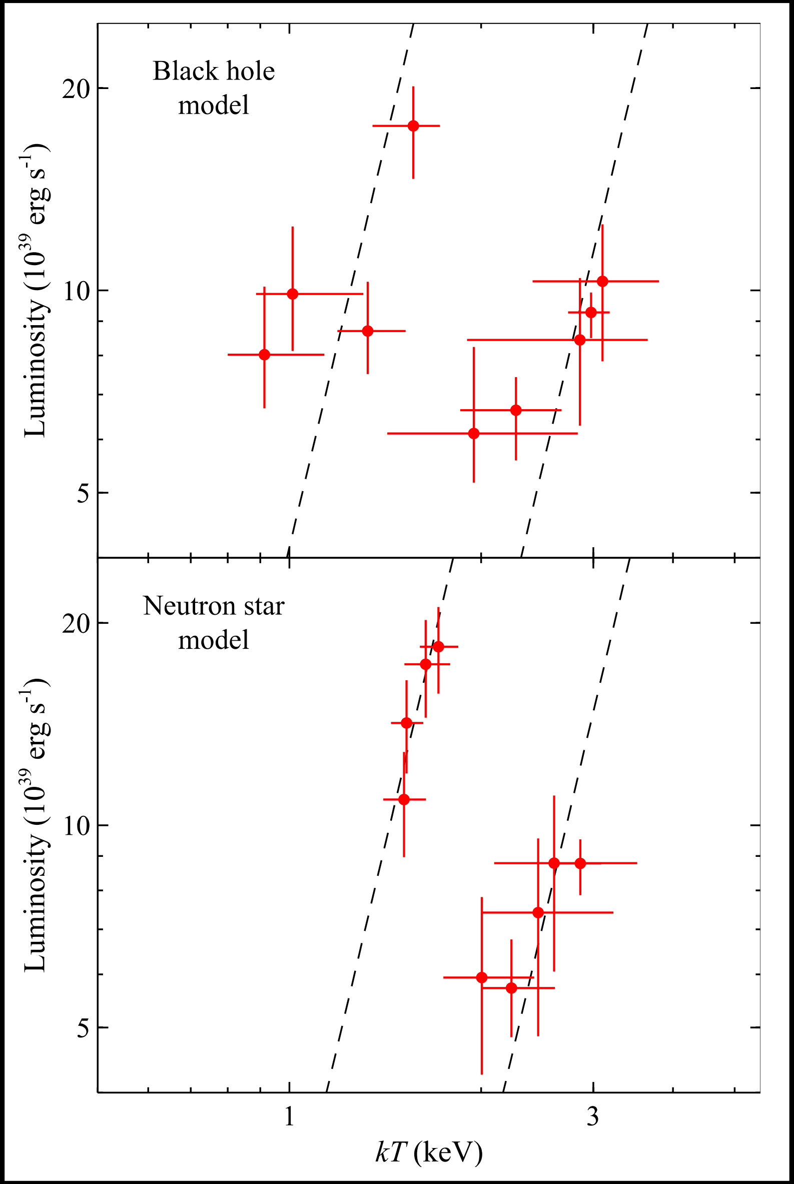
Luminosity vs temperature results for DISKPBB (the dominant thermal component) cluster into two groups for both models

Each appears to follow its own $L \propto T^4$ track!

Implies two distinct, stable radii, which differ by a factor of ~4

(assuming no change in inclination or colour correction; Walton et al. 2019, in prep.)

What does this mean?!



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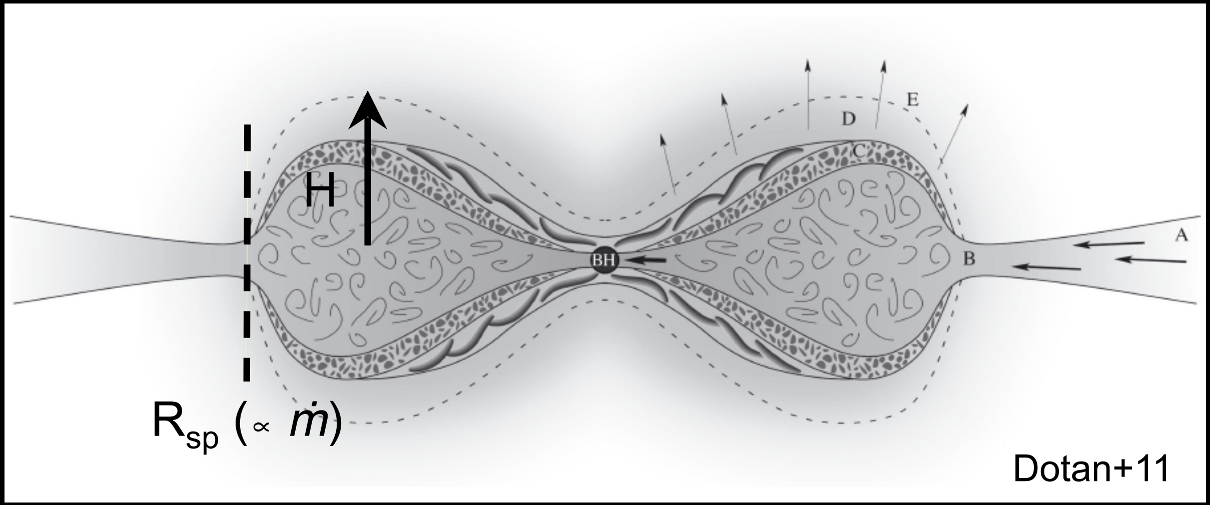
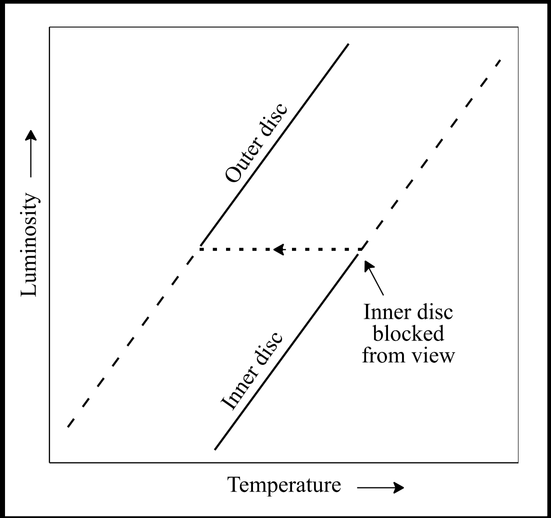
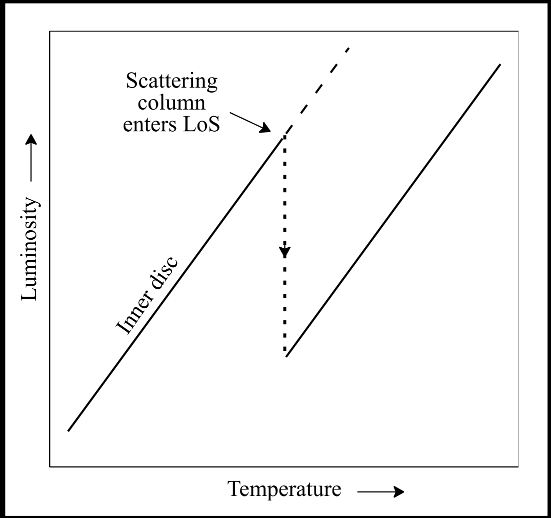


<u>Geometric obscuration</u>



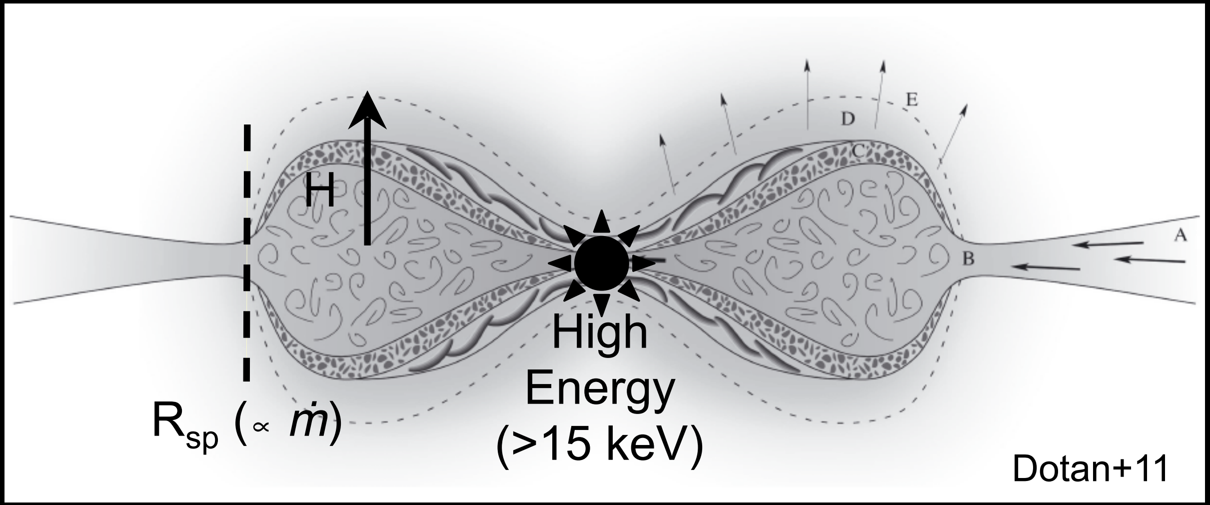
Hard to explain constant R_{outer}

<u>Scattering (by wind?)</u>



Need constant N_H of ~3×10^{24} cm^{-2}

NGC1313 X-1 – L vs T



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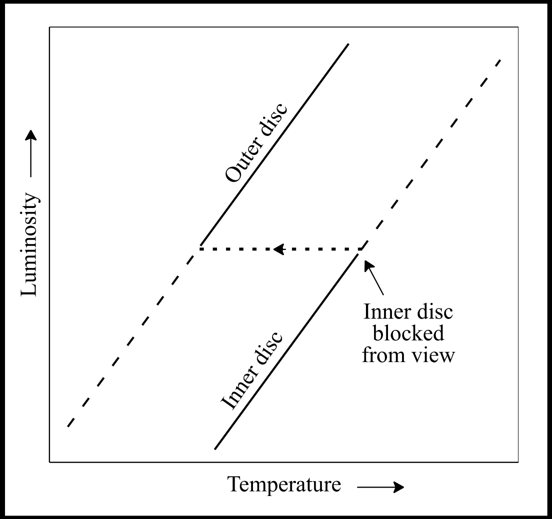

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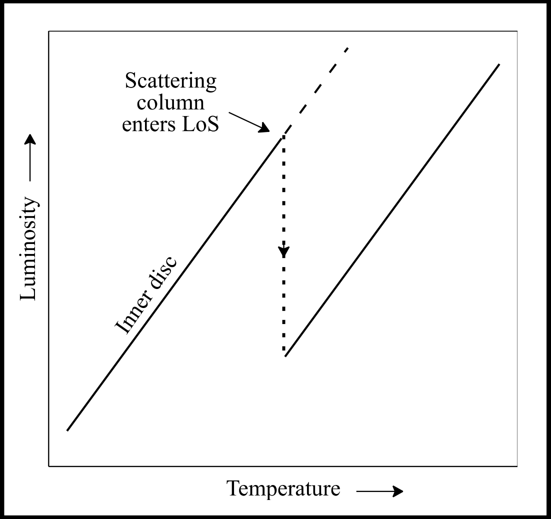

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Summary

- We undertook a major observing program on NGC1313 in 2017 to study its ULXs (X-1 and X-2, both of which have $L_{X,peak} \sim 10^{40}$ erg/s), including: XMM-Newton (750 ks), Chandra (500 ks) and NuSTAR (400 ks)

- The new observations show clear evidence that the extreme wind seen in NGC1313 X-1 is complex, showing multiple velocity components that vary with time and/or flux (Pinto+19; poster 239)

- Lower energy (<10 keV) data for X-1 shows strong variations, while higher energies (>15 keV) remain reasonably stable (similar to Holmberg IX X-1)

- Application of disc models reveals that NCC1313 X-1 shows evidence for two stable radii which differ by a factor of ~4

- Difficult to simultaneously explain these two radii and the stability of the high-energy emission if the latter arises close to the accretor (i.e. in a compact corona or an accretion column)