Chandra Takes on Heavy Jets and Massive Winds in 4U 1630-47

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Abstract

Recently, Díaz Trigo et al. reported the discovery of relativistic baryons in a jet in XMM/ATCA observations of the black hole 4U 1630-47 during its 2012 outburst. We present a search for a similarly massive jet earlier in the same outburst using the *Chandra* HETGS. Instead of evidence for a heavy jet in the X-ray spectrum, we find deep absorption lines from a massive, highly ionized disk wind, whose properties can be probed with detailed photoionization models. We explore several scenarios to explain the two modes of massive outflow in this remarkable black hole system.

The 2012 Outburst

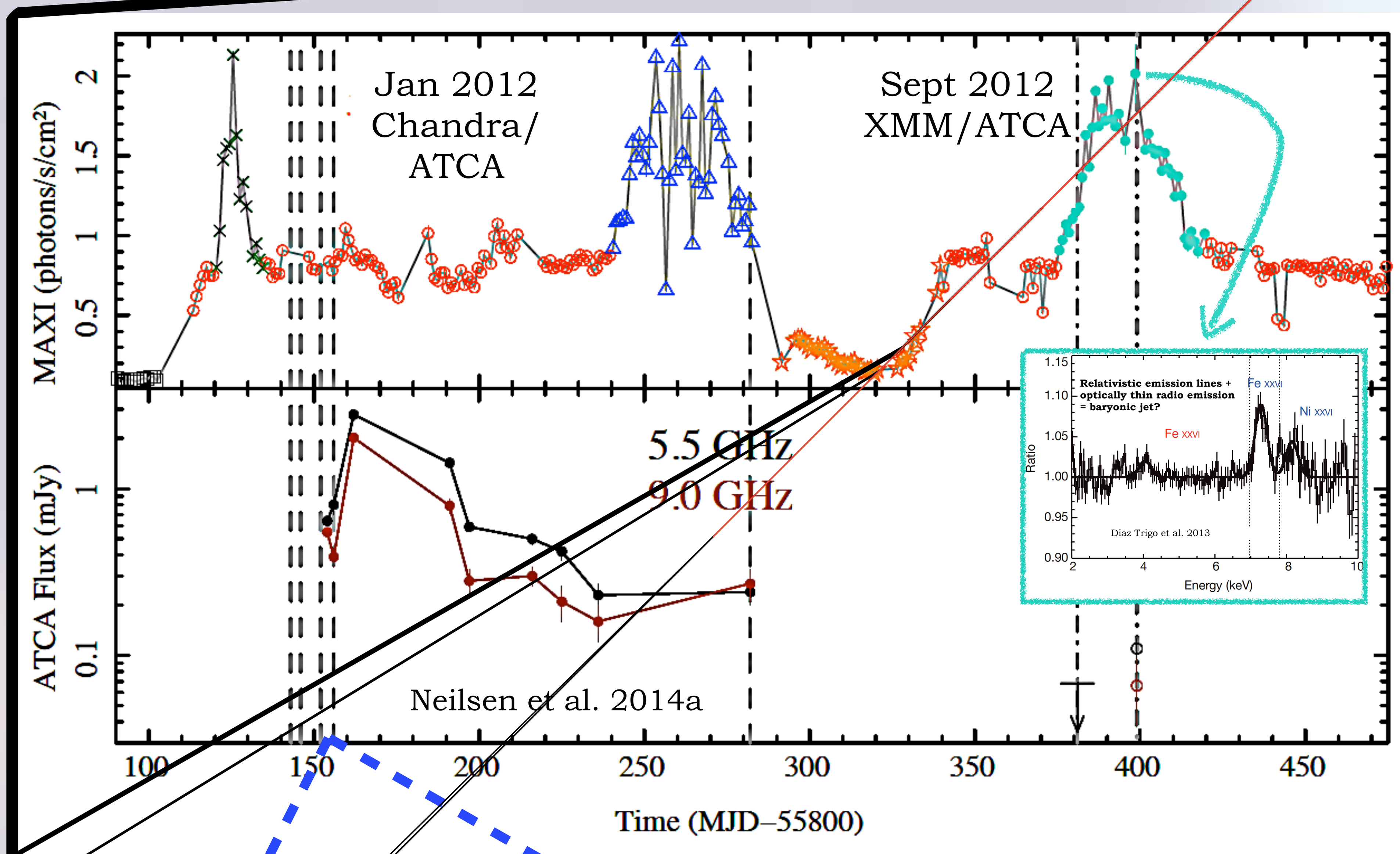

Fig. 1: MAXI (top) and ATCA (bottom) monitoring of the 2012 outburst of 4U 1630-47.

- We observed with *Chandra* HETGS/ATCA in 1/2012; Díaz Trigo et al. (2013; DT13) observed with XMM/ATCA in 9/2012.
- They reported relativistically Doppler-shifted emission lines (see inset) coincident with radio emission: a baryonic jet?

A Heavy Jet for Chandra?

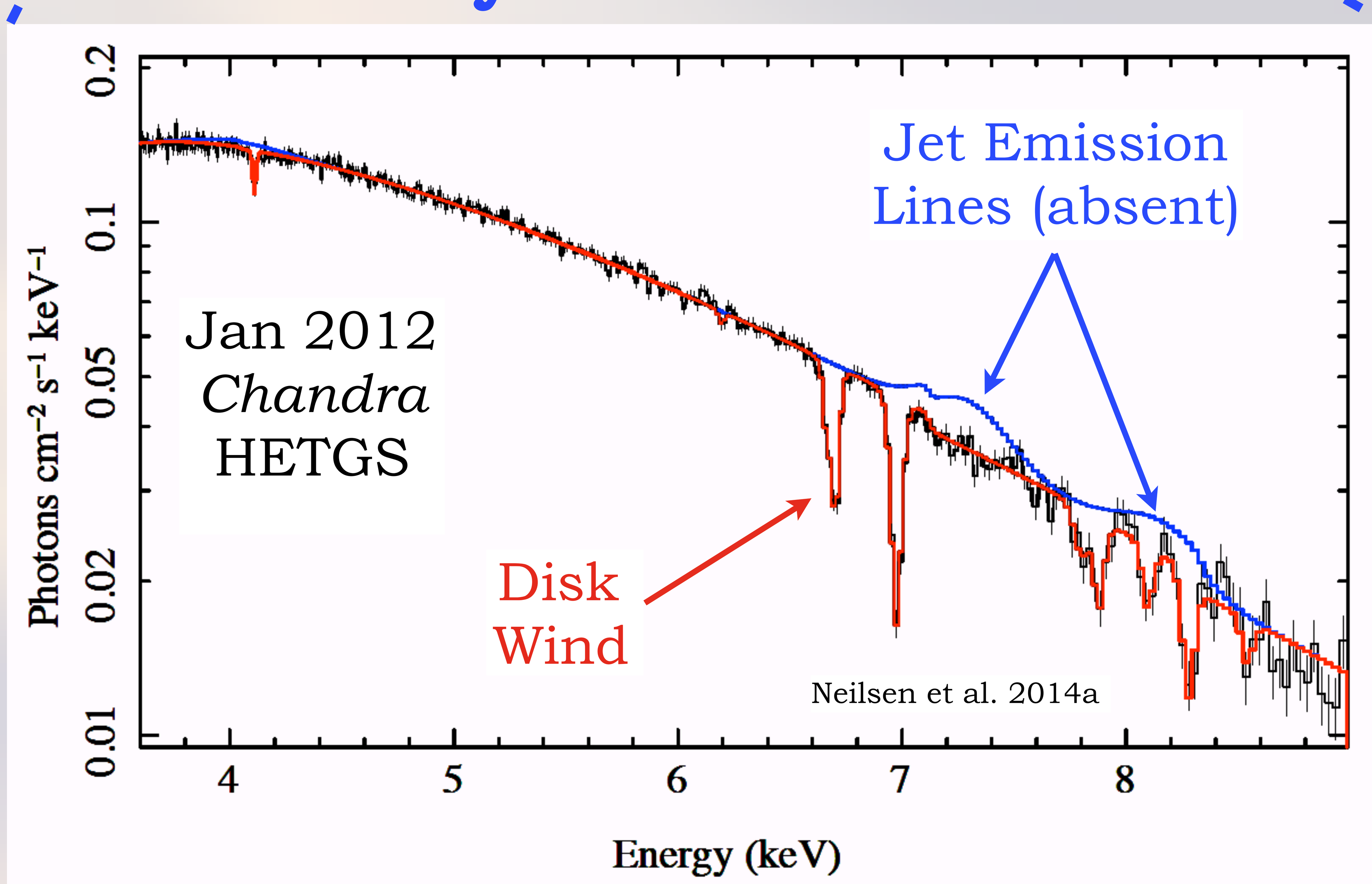

Fig. 2: Chandra HETGS spectrum of 4U 1630-47 from January 2012.

- We do not detect any relativistically-shifted lines from the jet, despite ~5× brighter radio emission (Figure 1).
- Our upper limits ~20× weaker than the DT13 detection in Sept.
- Instead, a strong disk wind is apparent (v ~200-500 km/s).

A Massive Wind for Chandra!

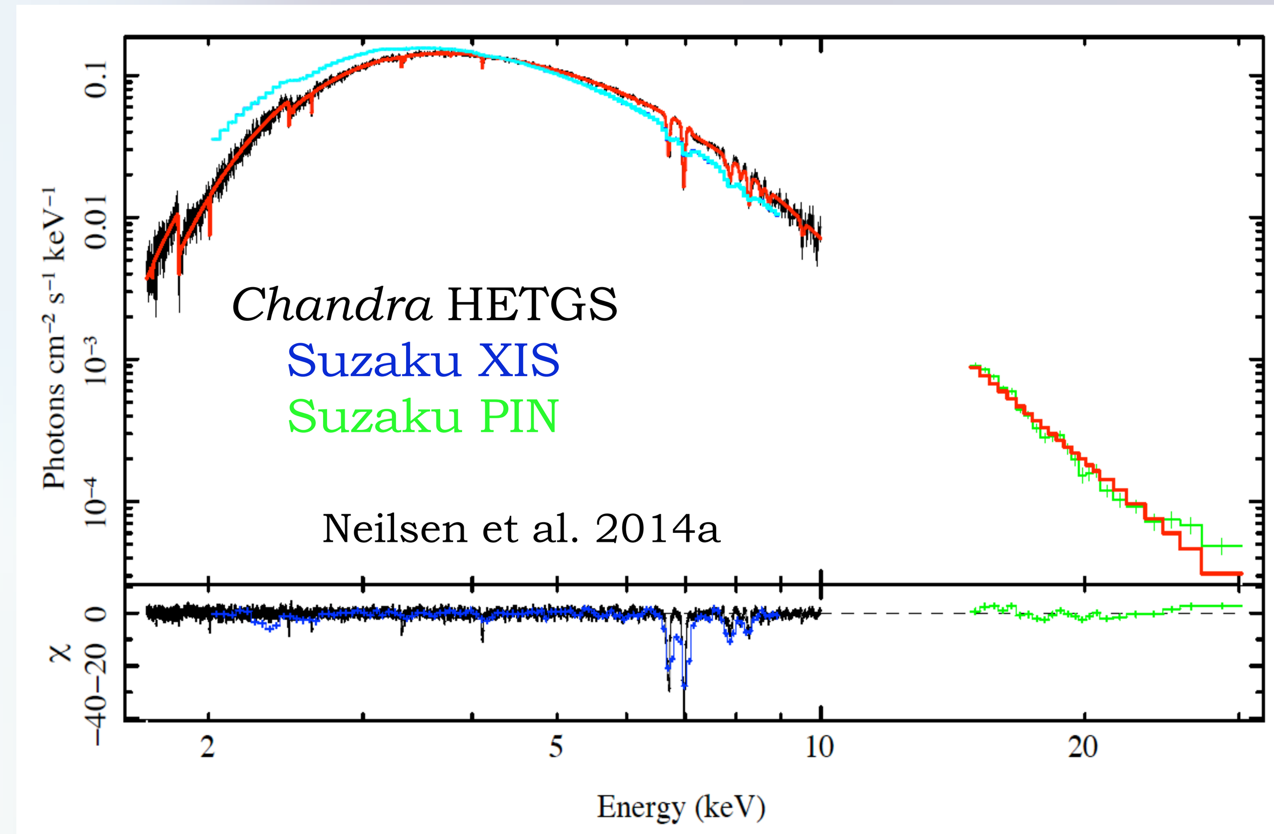

Fig. 3a: spectra of 4U 1630-47.

- Strong absorption lines in all observations
- Mostly thermal emission from the accretion disk, little scattering/reflection
- Use as input for ionization models

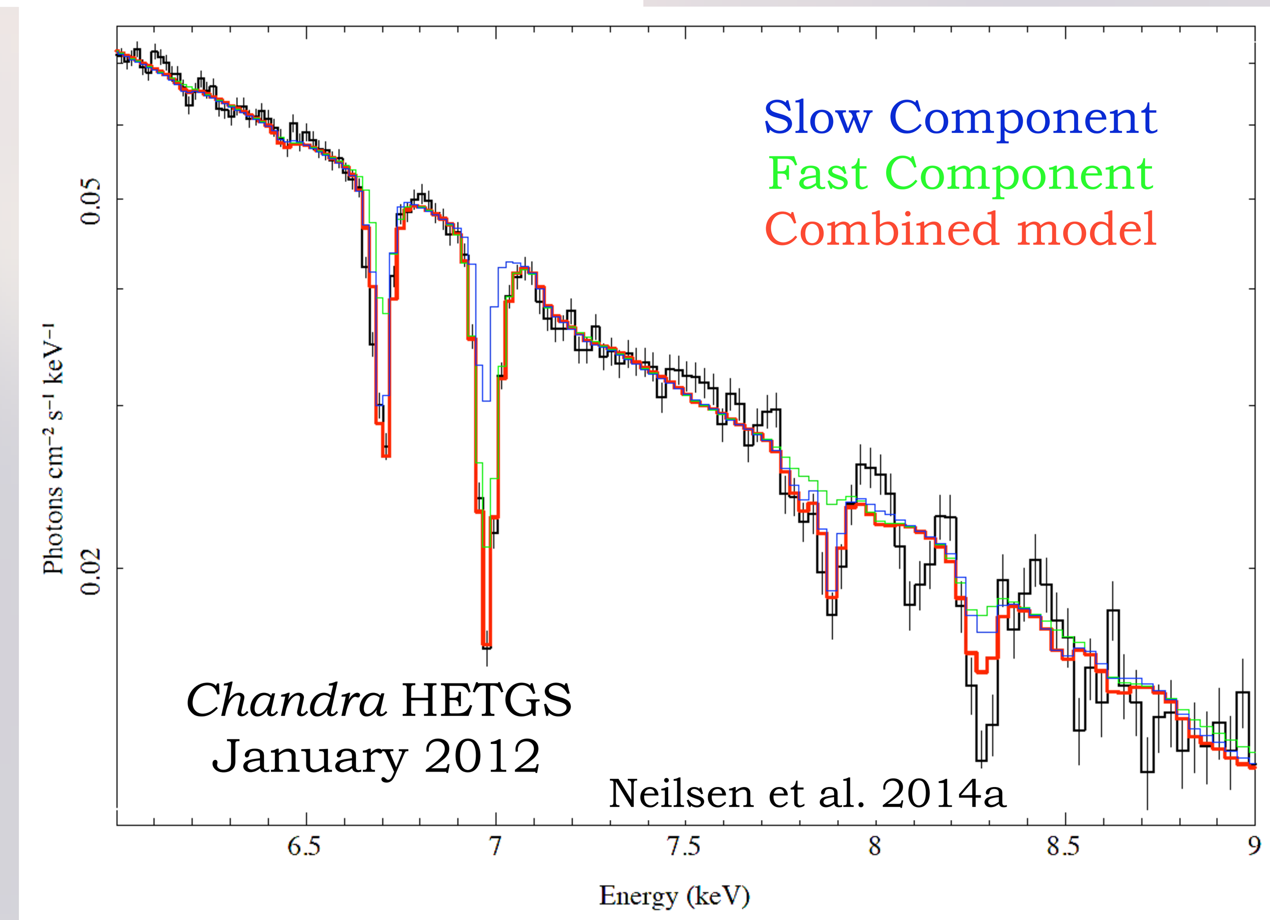

Fig. 3b: XSTAR models for 4U 1630-47.

- Two-components!
- Fast component: v~720±90 km/s, $\log(\xi)=4.75^{+0.2}_{-0.08}$
- Slow component: v~200±40 km/s, $\log(\xi)=3.8\pm0.1$
- $N_H^{ion}=3\times10^{23}$ cm^{-2}
- $\dot{M}_{Wind}\sim10^{18}$ g/s

Discussion

Baryonic Jets:

- Radio emission is not universally associated with relativistic emission lines in 4U 1630-47
- Absence of lines is difficult to explain by atomic effects (i.e., temperature, emissivity variations)
- Radio emission may not have the same origin: possible jet-ISM interaction in January 2012, baryonic jet in September 2012?
- High luminosity in September 2012 partly responsible for lifting baryons into the jet? (Neilsen et al. 2014a)

Accretion Disk Wind

- Appearance predicted based on emerging picture of disk winds in black hole outbursts (Neilsen 2013a, Ponti et al. 2012, Neilsen & Lee 2009)
- Very highly ionized, consistent with high density (n~10^{14} cm^{-3})
- Line variability on time scales of days/weeks indicates clumpy wind, Fe XXVI Lyα likely saturated (Neilsen et al. 2015a)

References

- Diaz Trigo et al., 2013, *Nature,* 504, 260
- Neilsen & Lee, 2009, *Nature,* 458, 481
- Neilsen, 2013, *AdSpR,* 52, 732
- Neilsen et al. 2014, *ApJ,* 784, L5
- Ponti et al. 2012, *MNRAS,* 422, L11