Winds and jets in XRBs

M. Diaz Trigo (ESO)

L. Boirin, S. Migliari, J. Miller-Jones, A. Parmar

With thanks to C. Done, J. Kaastra, T. Kallman, M. Mendez, L. Sidoli

What you should remember from this talk

- Photoionised plasmas
  - Equatorial & (most likely) ubiquitous in LMXBs
- Winds
  - Consistent with a thermal launching mechanism except maybe in one case
- Wind/jet anti-correlation
  - Still an open question

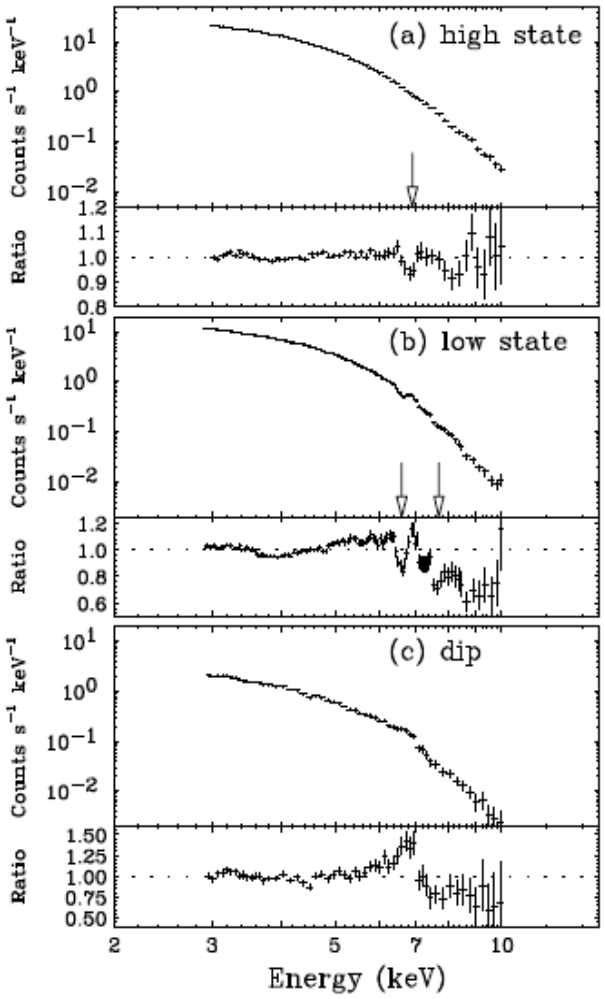
WINDS

Winds present in all kinds of accretion powered objects

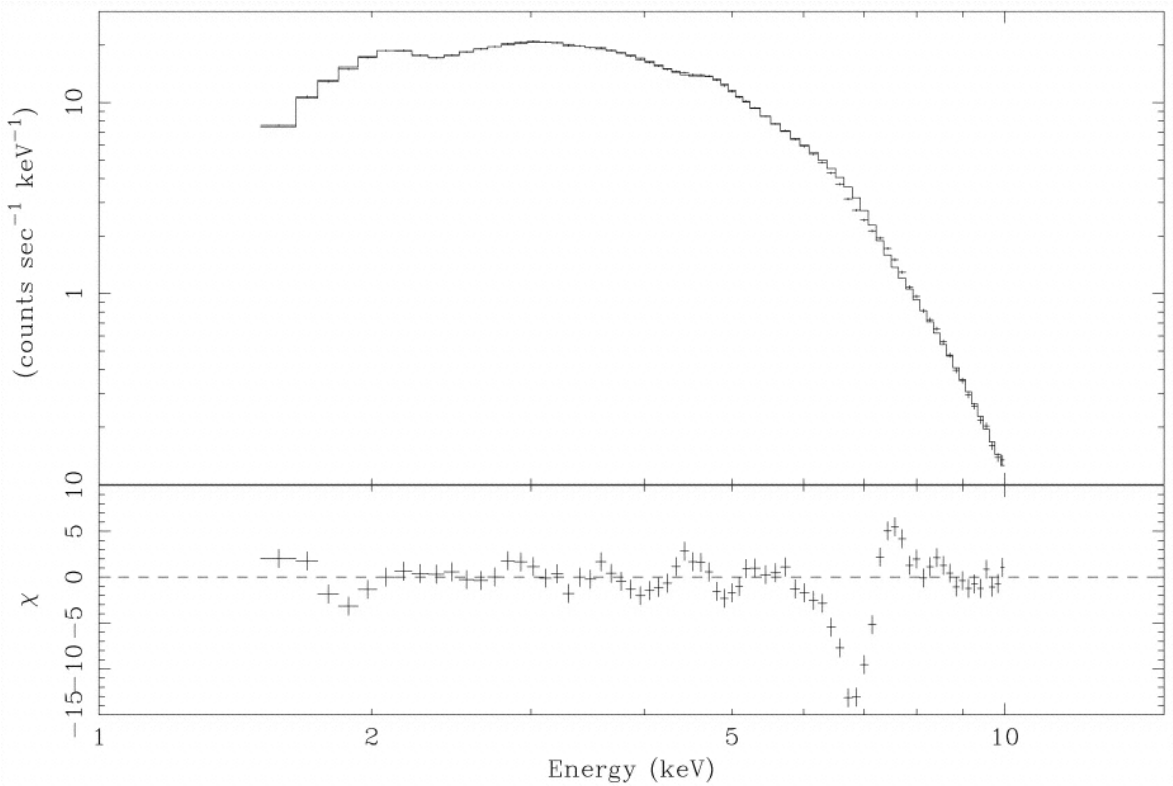
Importance of characterising the outflows:

- Dynamics of the system
- Feedback to their environment

The first warm absorbers

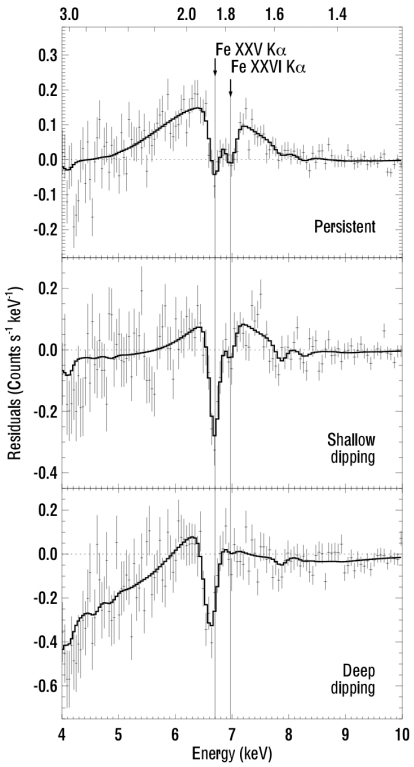


GRO J1655-40, Ueda et al. 1998

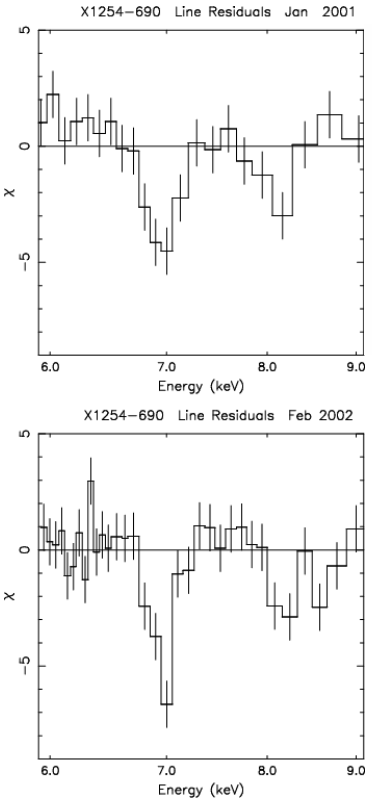


GRS 1915+105, Kotani et al. 2000

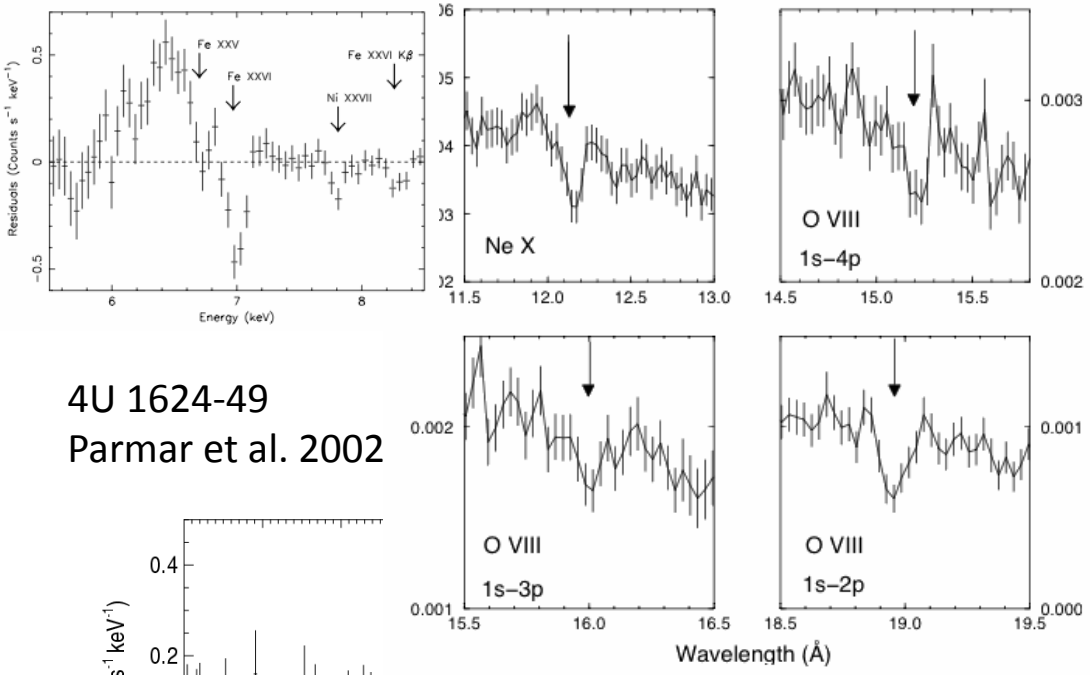
Warm absorbers everywhere…



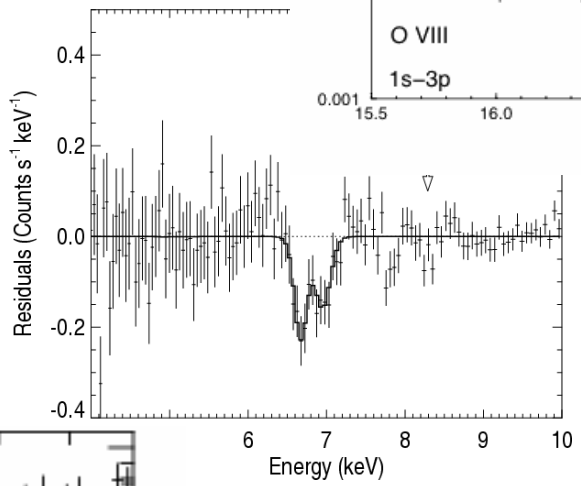
4U 1323-62
Boirin et al. 2005



4U 1254-69
Boirin & Parmar 2003

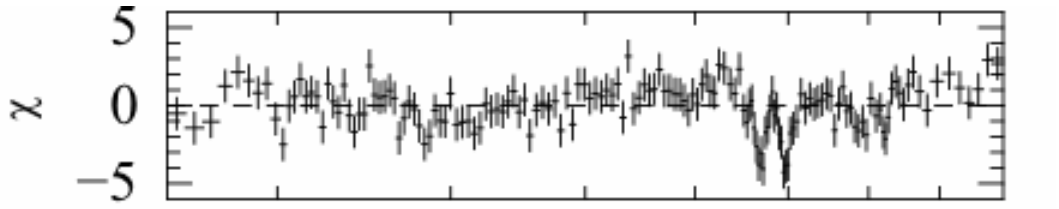


4U 1624-49
Parmar et al. 2002



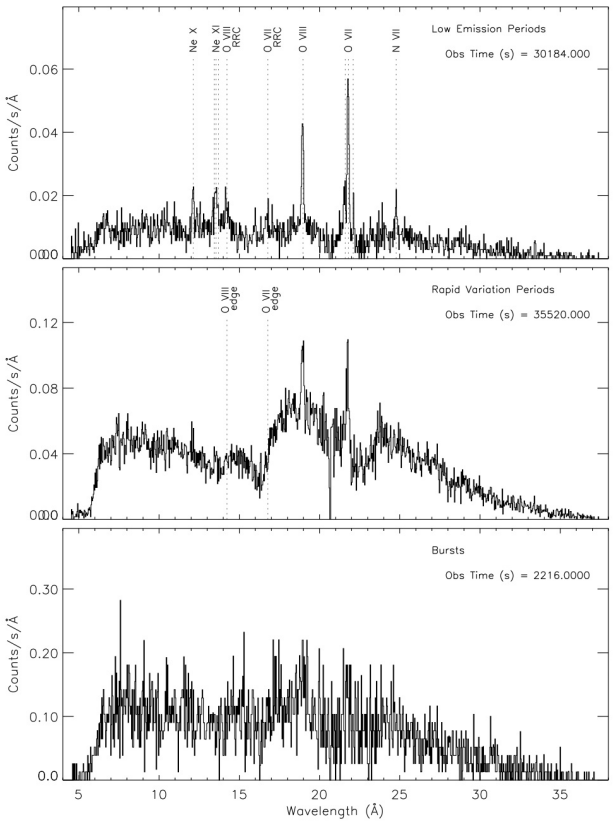
MXB 1659-298
Sidoli et al. 2001

4U 1916-15
Boirin et al. 2004

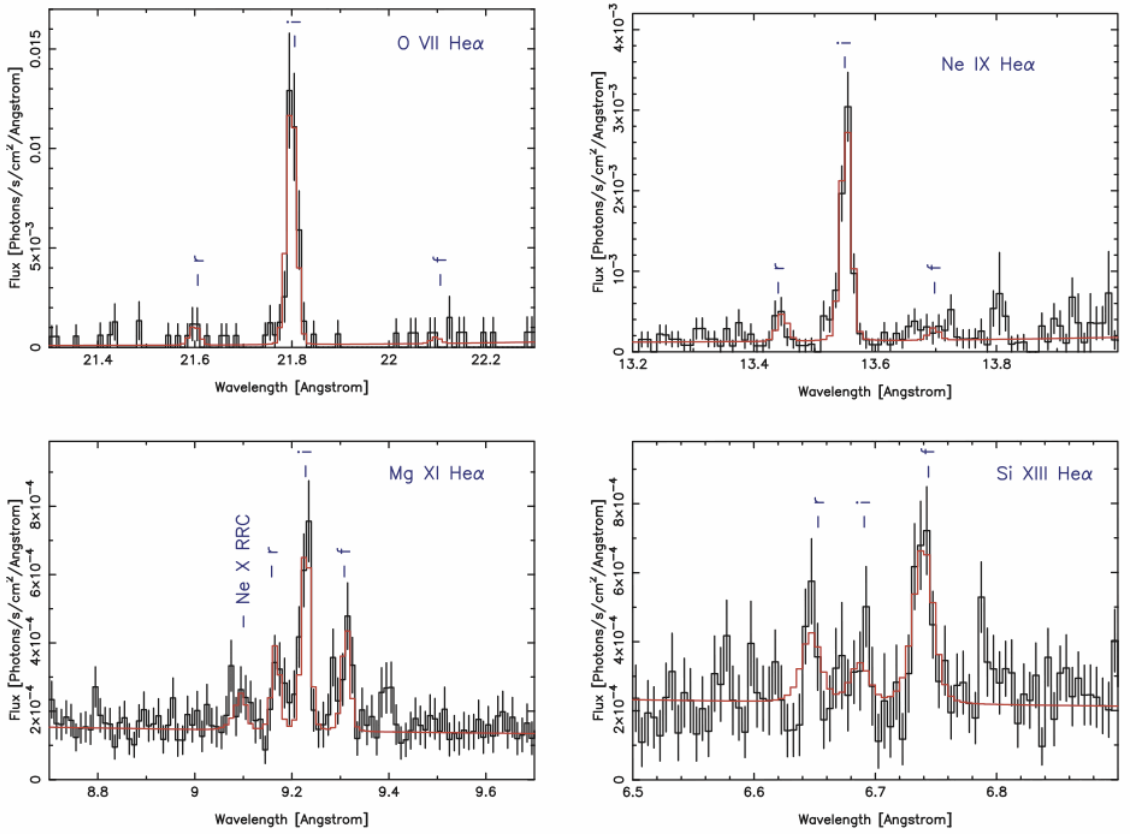


AX J1745.6-2901
Hyodo et al. 2008

… but also emitting plasmas…

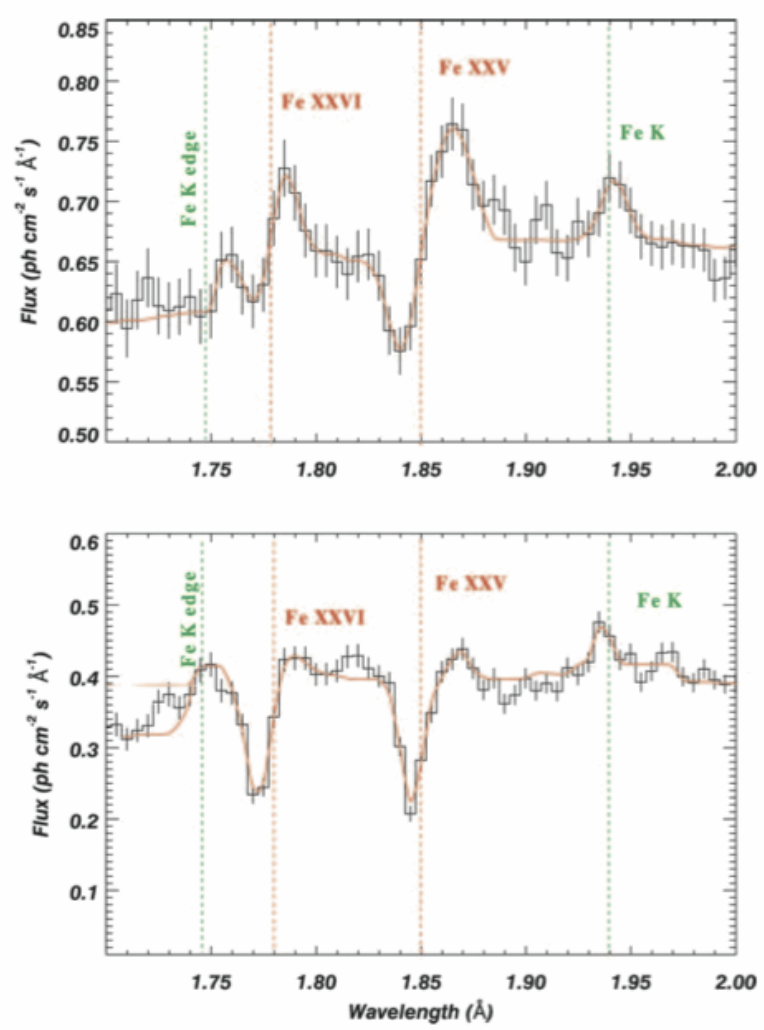


2A 1822-371, Cottam et al. 2001

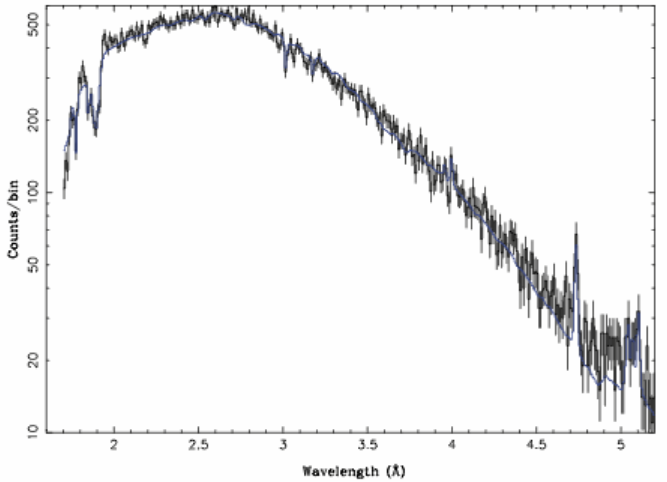


Her X-1, Jimenez-Garate et al. 2005

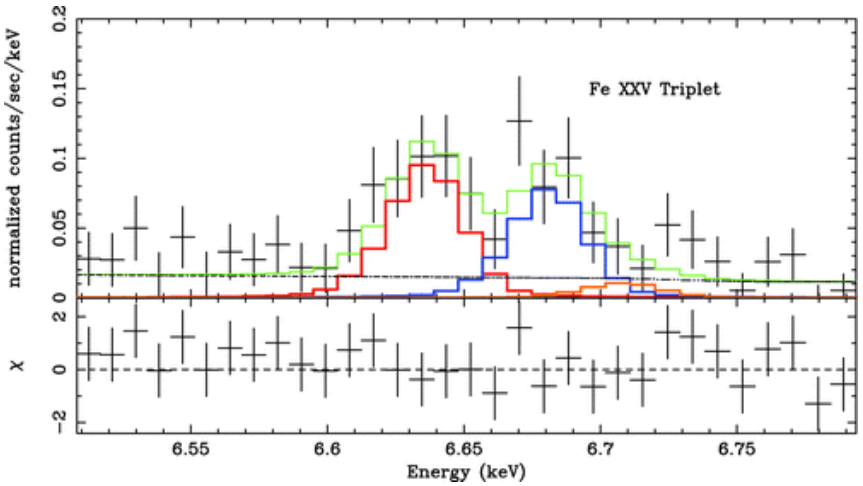
… and outflows



Circinus X-1, Schulz & Brandt 2002



Circinus X-1,
Schulz et al. 2007

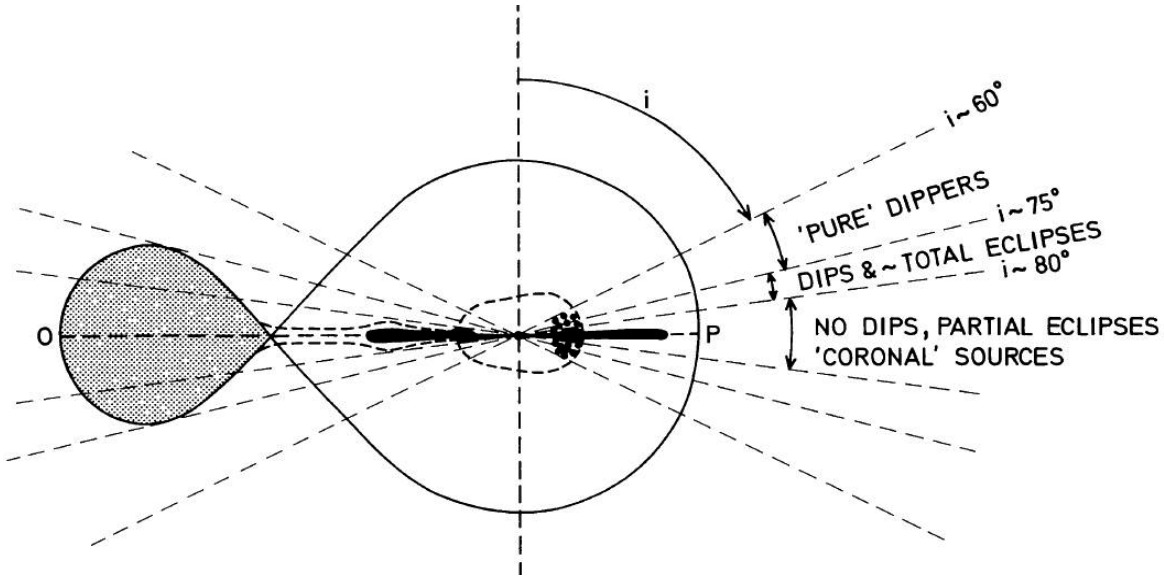


Circinus X-1, Iaria et al. 2008

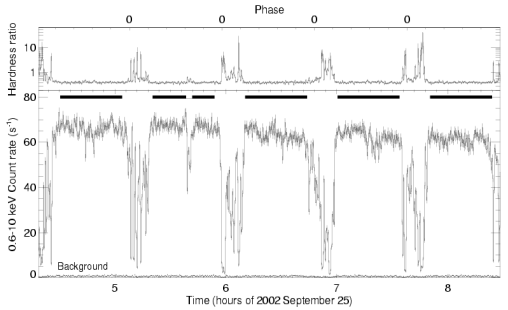
Characteristics of the plasma

- **Highly ionised**: often only Fe XXV and Fe XXVI are present
- **Photoionised** (based on responses to changes in continuum, triplet ratios in emitting plasma, recombination edges)
  - 2 cases of likely "hybrid" plasmas: EXO 0748-676 (van Peet et al. 2009) and Cir X-1 (Schulz et al. 2008, Iaria et al. 2008)
- **Changes** in the plasma not only due to the change in **continuum**, but also **phase-dependent** plasma changes in column density and degree of ionisation in dipping sources
- **Flat ("pancake") geometry** above the disc => probably ubiquitous to all XRBs
- Distance to the central source $\approx 10^{10}$-10^{13} cm
- Outflows preferentially detected in BHs (200-1500 km/s)

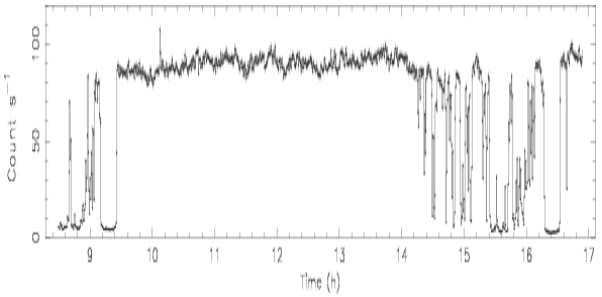
Geometry



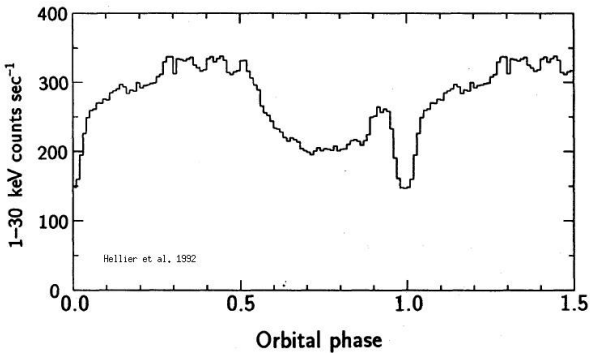
Frank et al. 1987



60-75 deg. 'Pure' dippers

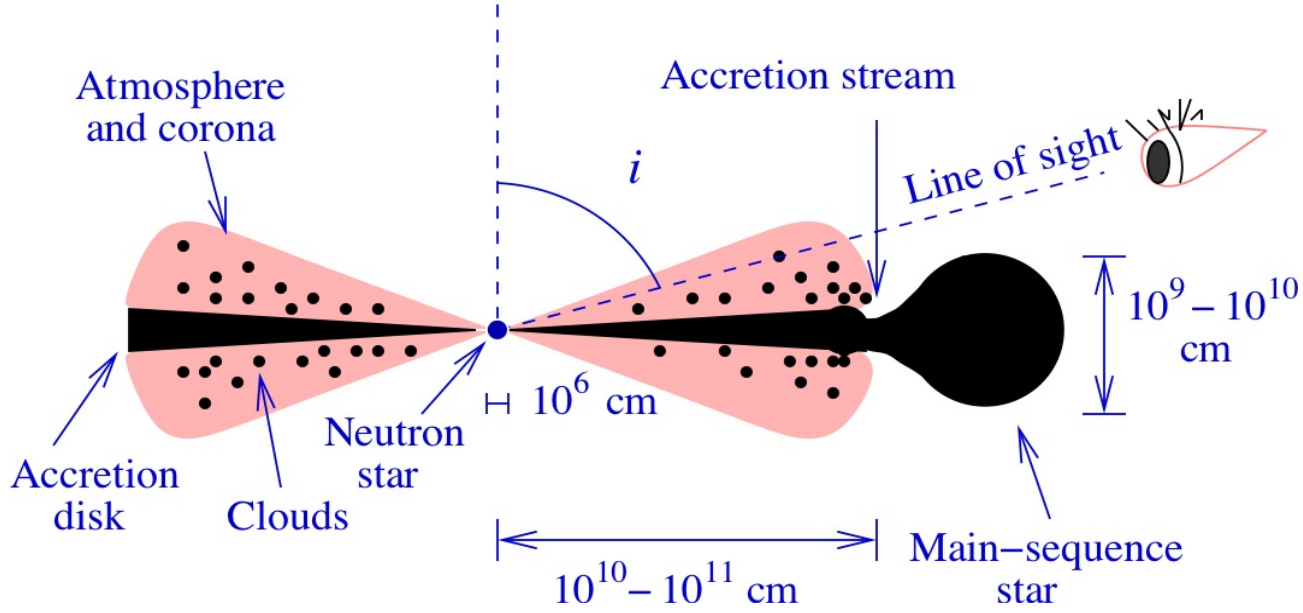


75-80 deg. Dips & ~'total' eclipses



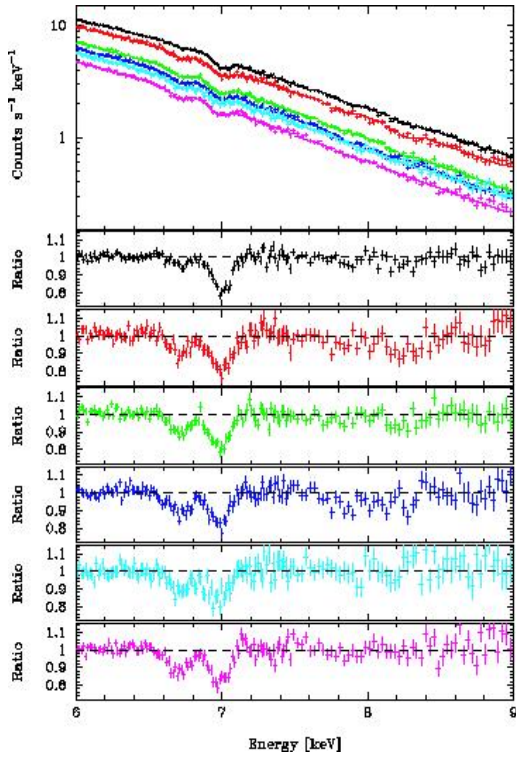
80-90 deg. No dips, partial eclipses

Geometry

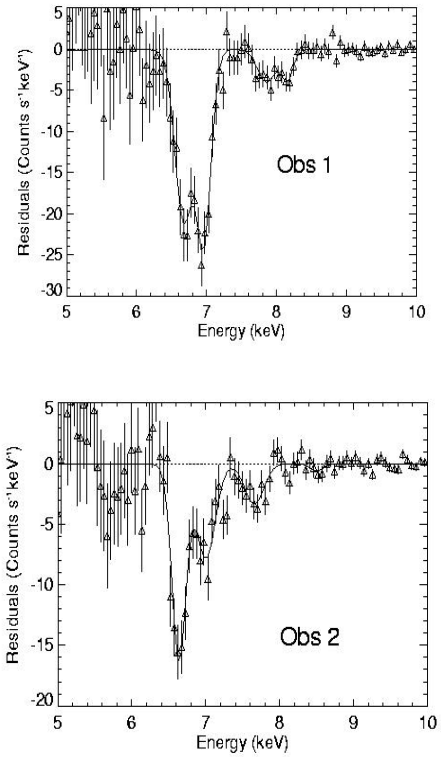


Jimenez Garate et al. 2002

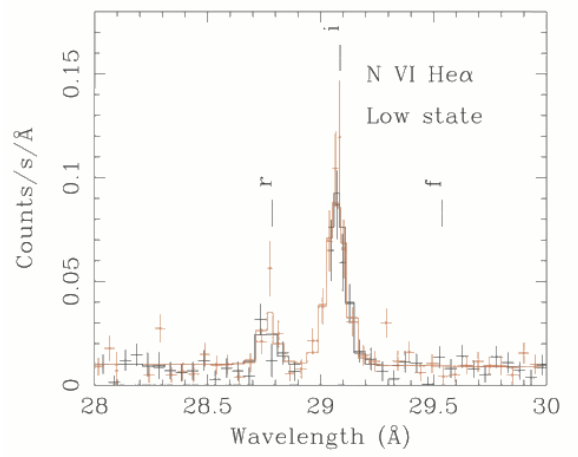
Photoionised plasma

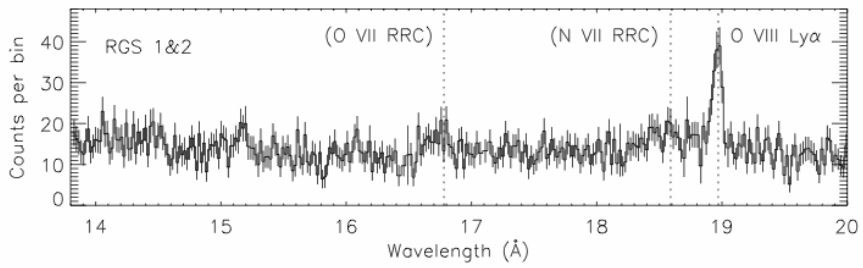


4U 1630-472
(Kubota et al. 2007)



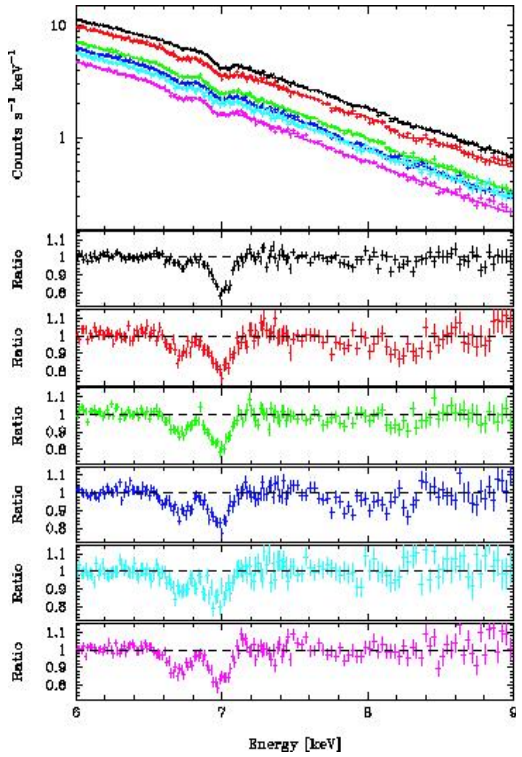
GRO J1655-40
(Diaz Trigo et al. 2007)



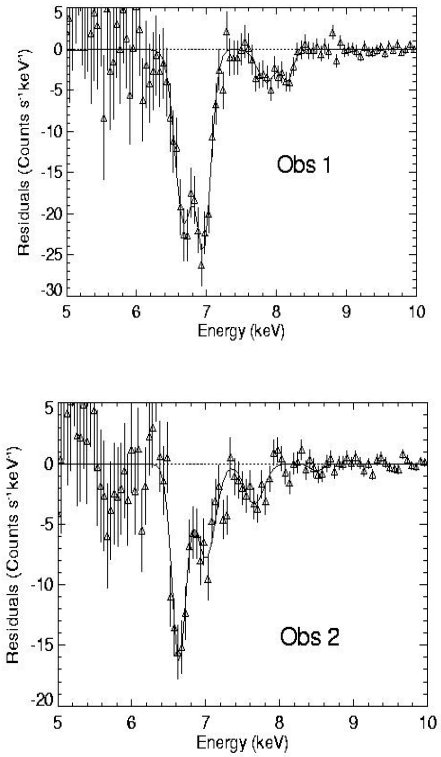


Her X-1
(Jimenez-Garate et al. 2001)

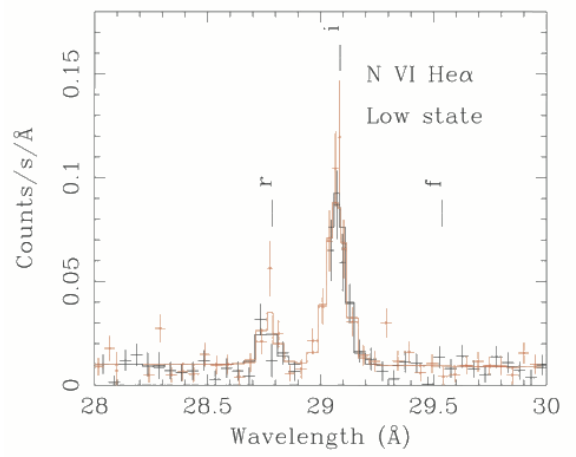
Photoionised plasma

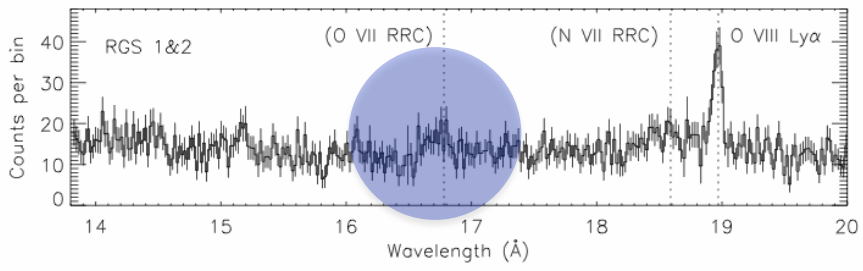


4U 1630-472
(Kubota et al. 2007)



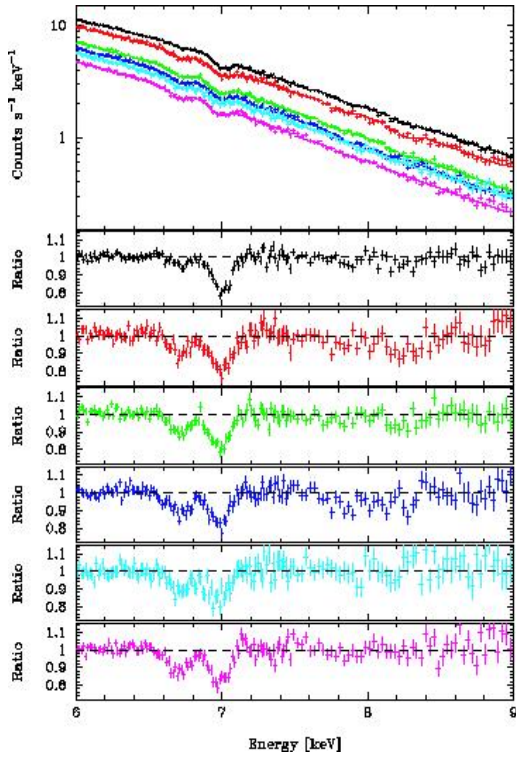
GRO J1655-40
(Diaz Trigo et al. 2007)



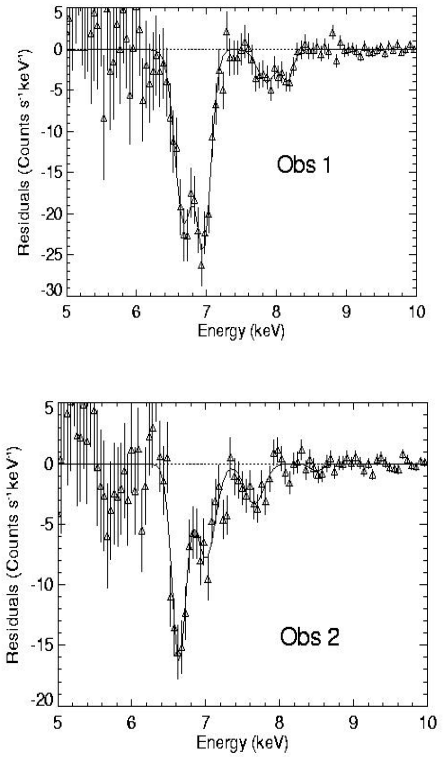


Her X-1
(Jimenez-Garate et al. 2001)

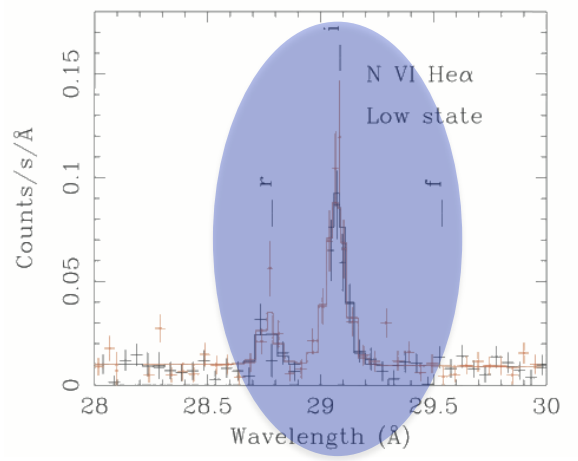
Photoionised plasma

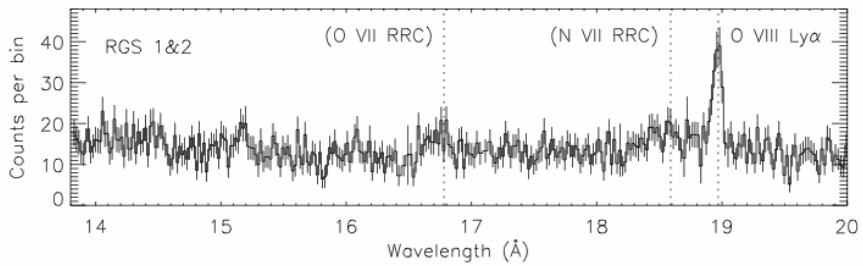


4U 1630-472
(Kubota et al. 2007)



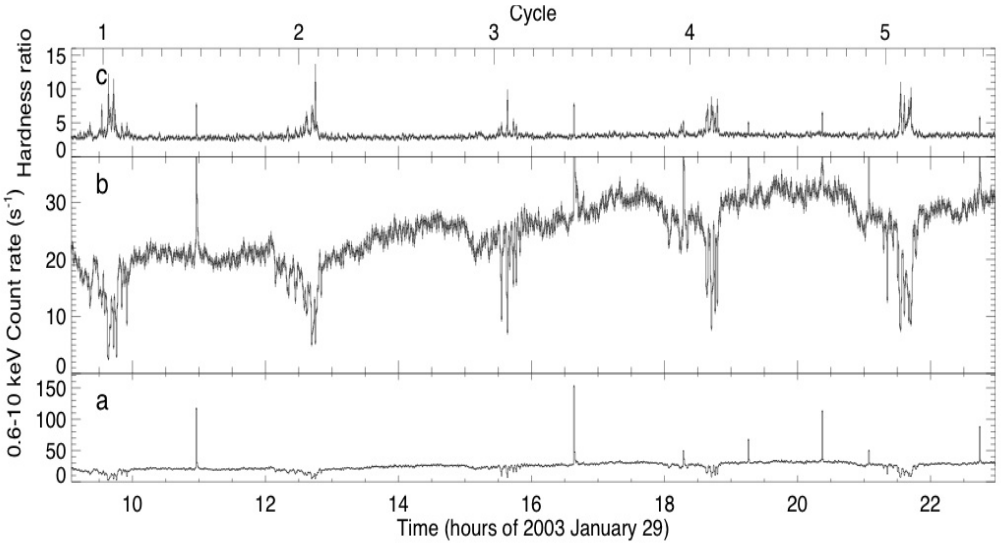
GRO J1655-40
(Diaz Trigo et al. 2007)



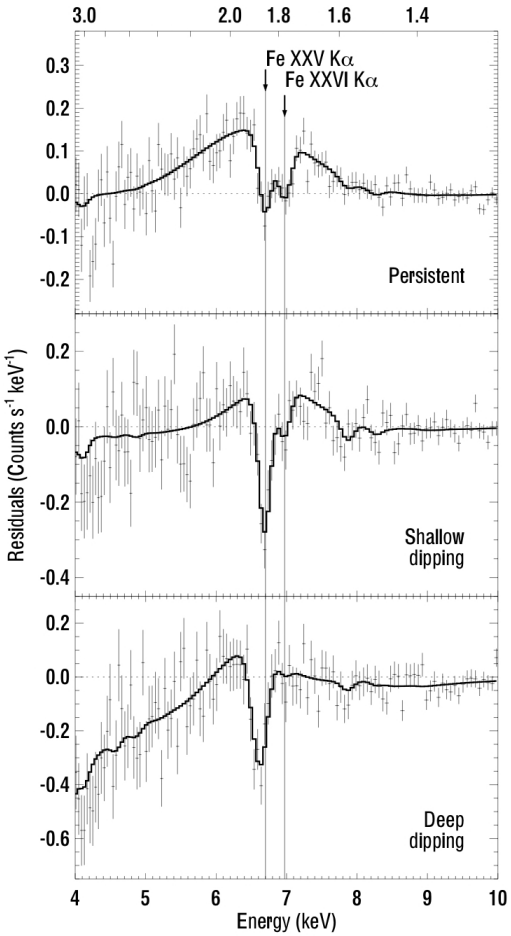


Her X-1
(Jimenez-Garate et al. 2001)

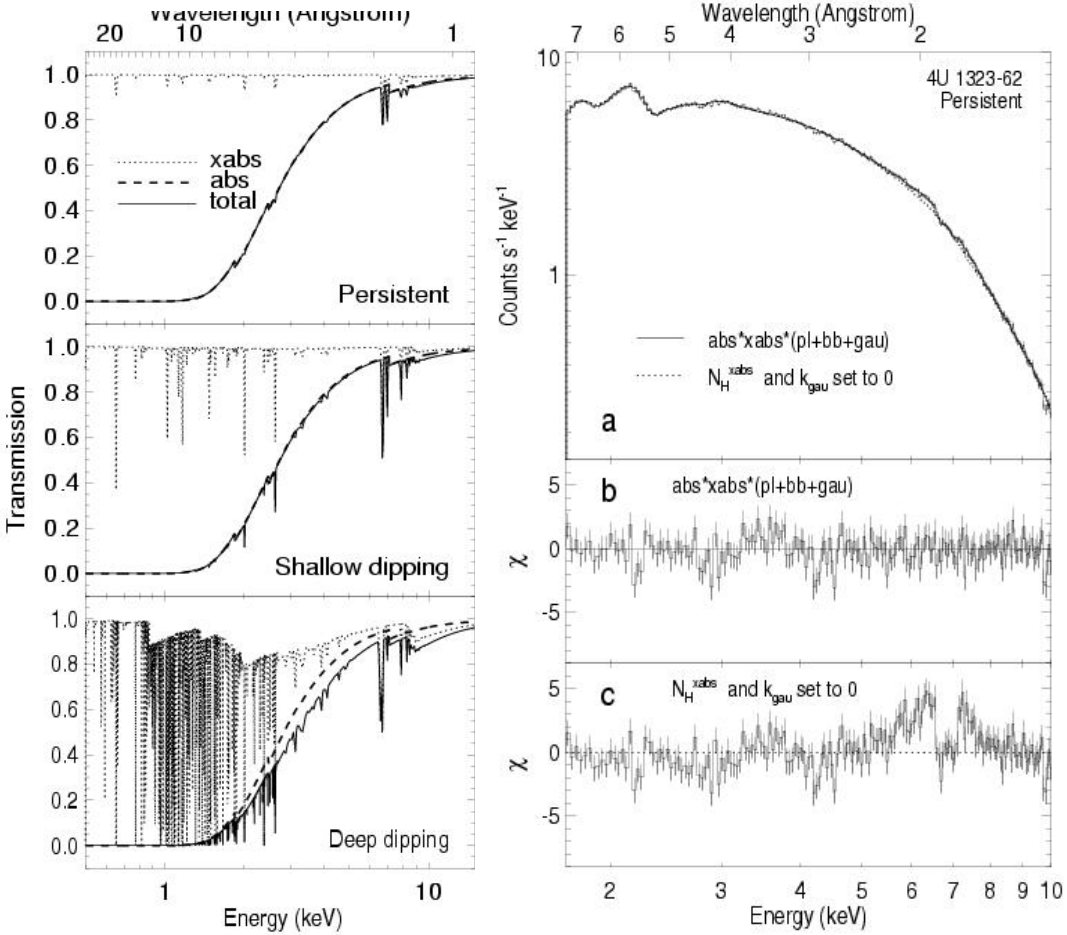
Phase dependence in dippers



Boirin et al. 2005



Phase dependence in dippers

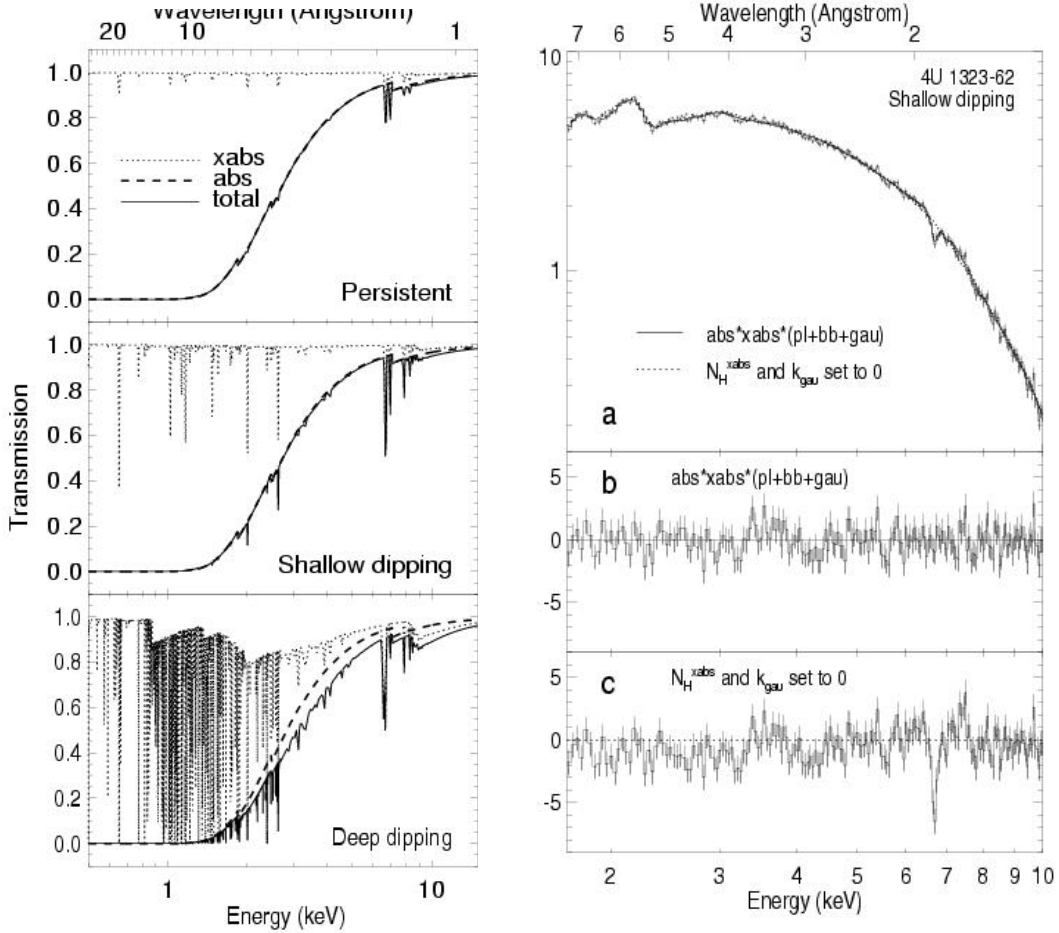


The properties of the warm absorber change during dipping:

- ionization stage decreases
- column density increases

Boirin et al. 2005, Diaz Trigo et al. 2006

Phase dependence in dippers

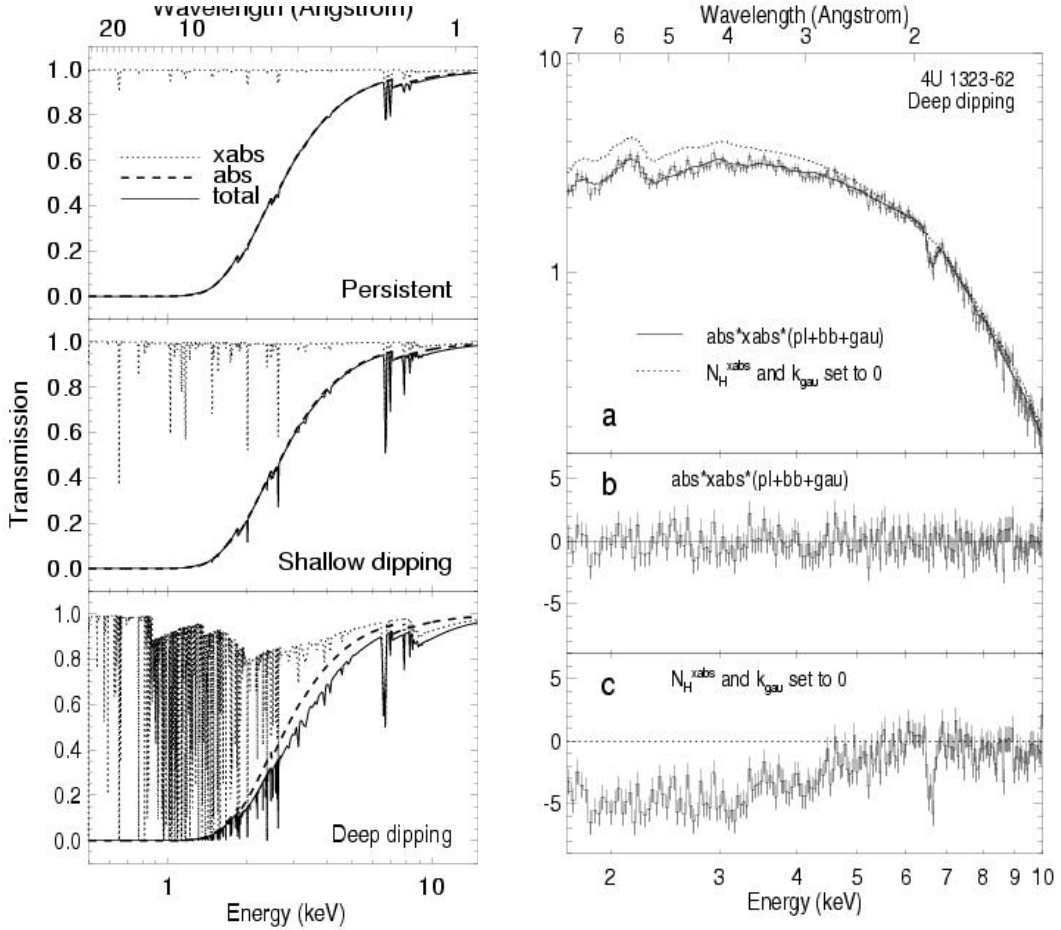


The properties of the warm absorber change during dipping:

- ionization stage decreases
- column density increases

Boirin et al. 2005, Diaz Trigo et al. 2006

Phase dependence in dippers

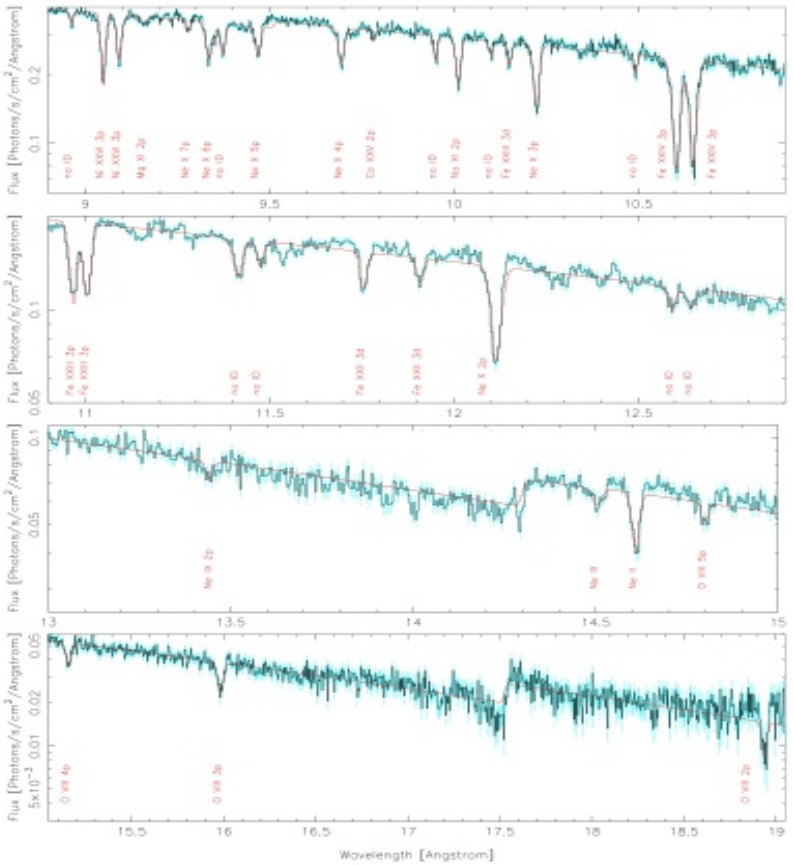


The properties of the warm absorber change during dipping:

- ionization stage decreases
- column density increases

Boirin et al. 2005, Diaz Trigo et al. 2006

Outflows preferentially detected in BHs
(but see Cir X-1, GX 13+1 & IGR J17480−2446)



GRO J1655-40, Miller et al. 2006

Outflow velocities ≈ 300-1000 km/s

mass outflow rate ≤ mass accretion rate

This component certainly plays an important role in the overall properties of the system and in its evolution.

Different phenomenon to WAs?

What do we want to learn?

- Launching mechanism (we need to know the launching radius):
  - Magnetic
  - Thermal
  - Line-driven (UV radiation pressure)
- Feedback:

  Is the mass expelled important enough to affect the dynamics of the system or the environment?

What do we want to learn?

$$\xi = L / n_e r^2$$

If the flux varies on a certain time the variability of the WA provides a lower limit on the density => Upper limit on the distance

Other methods: detection of excited levels associated with a given collision strength and decay rate or metastable levels

$$n_e \approx 10^{12} - 10^{13}\ cm^{-3}$$

$$r \approx 10^{10} - 10^{12}\ cm$$

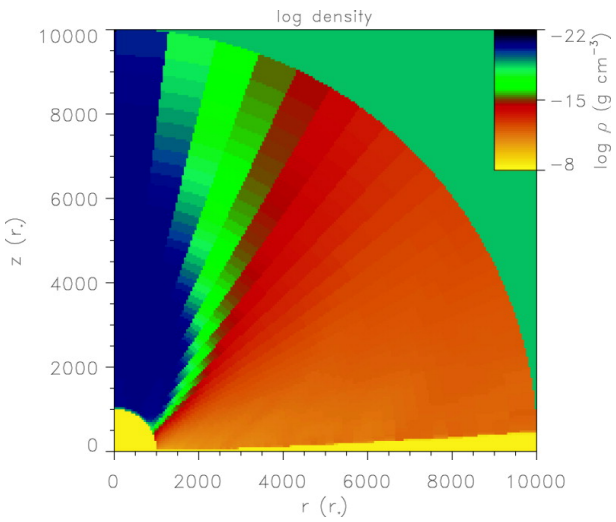
What do we want to learn?

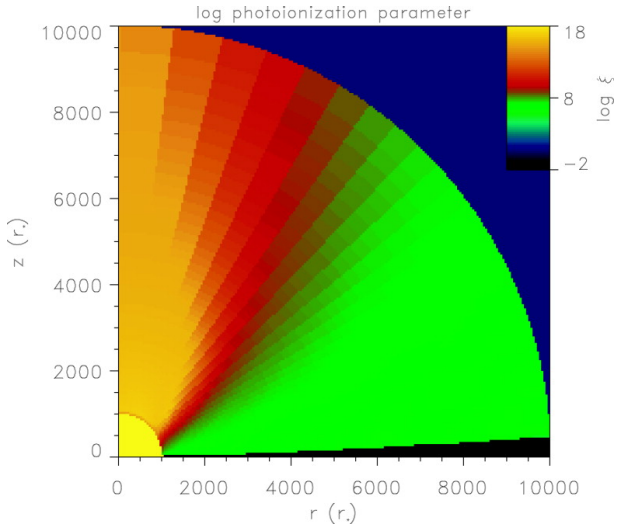
- Launching mechanism (we need to know the launching radius):
    - Magnetic
    - Thermal
    - Line-driven

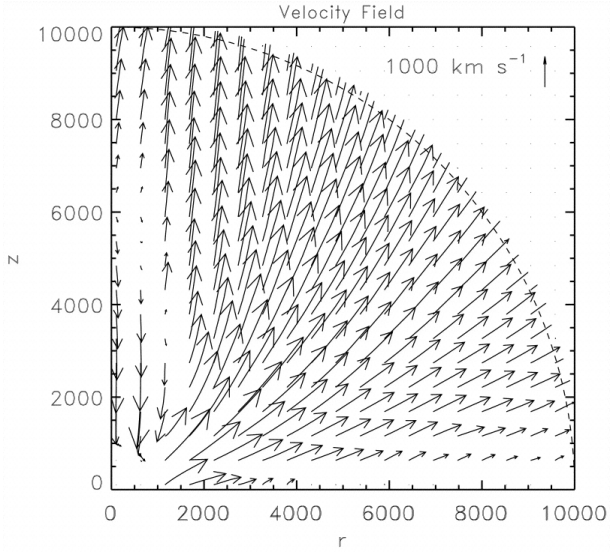
What do we want to learn?

- Launching mechanism (we need to know the launching radius):
  - Magnetic
  - Thermal
  - ~~Line-driven~~ (Proga & Kallman 2002)

Thermal winds

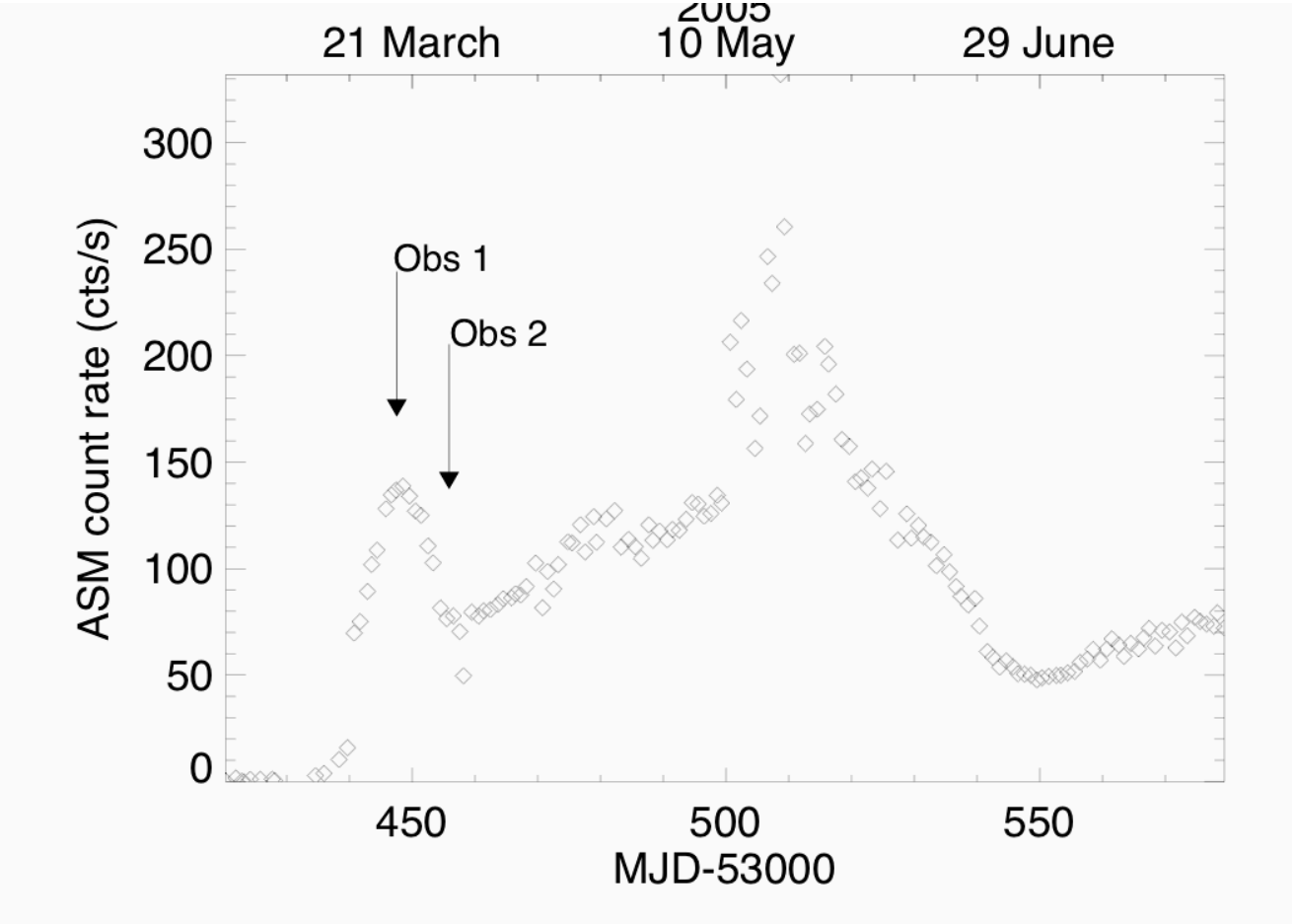






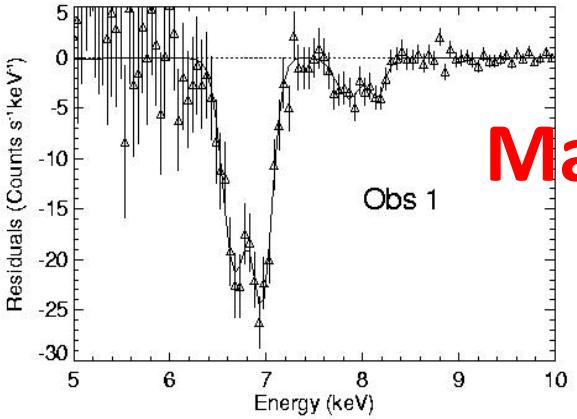
Proga & Kallman 2002

GRO J1655-40

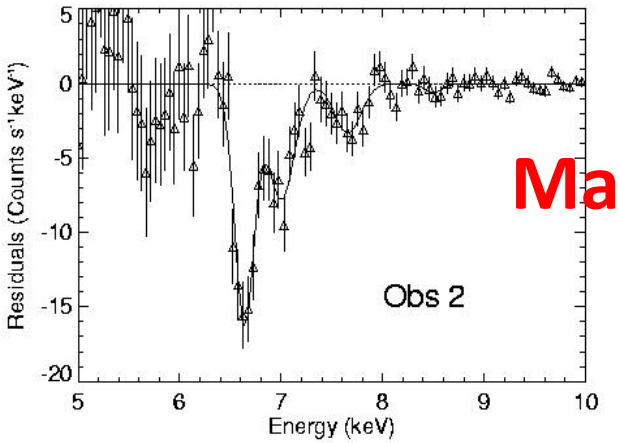


Diaz Trigo et al. 2007

GRO J1655-40

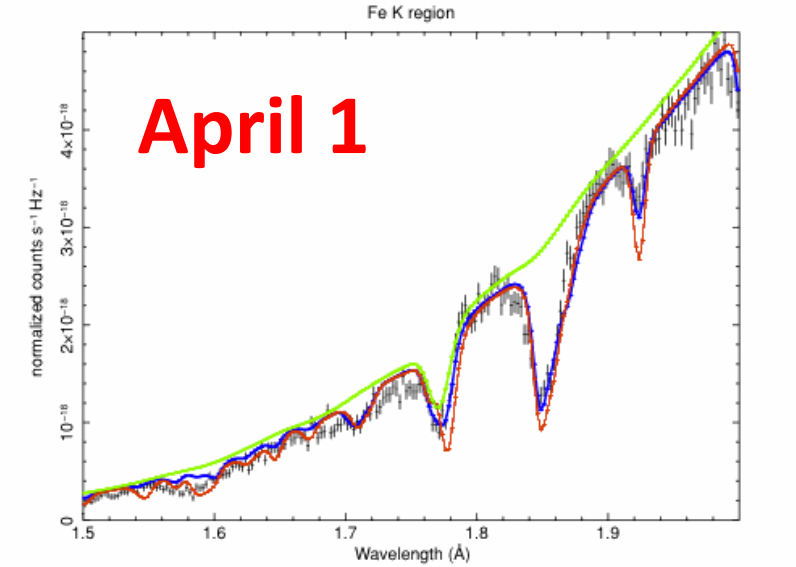


March 18



March 27

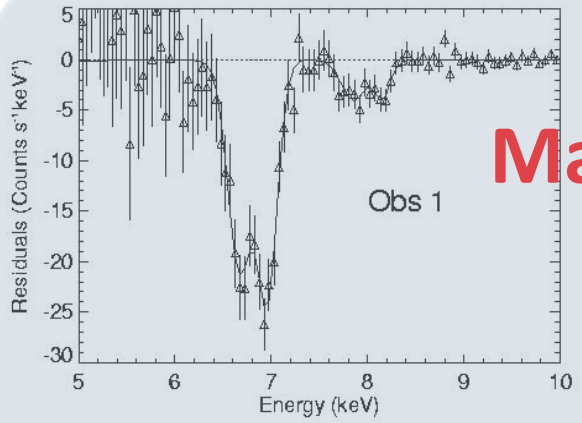
Diaz Trigo et al. 2007



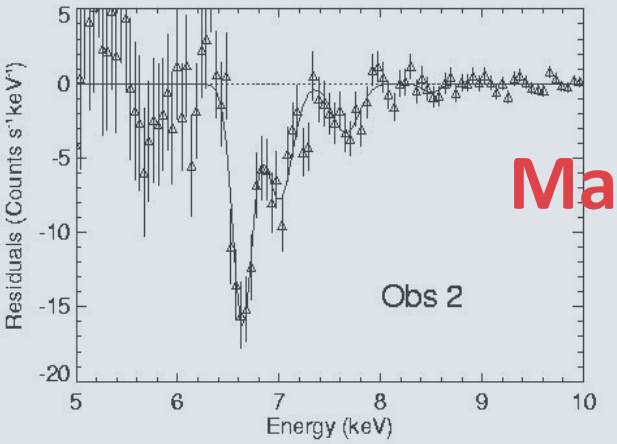
April 1

Miller et al. 2006, Kallman et al. 2009
(see also Netzer 2006, Luketic et al. 2010)

GRO J1655-40

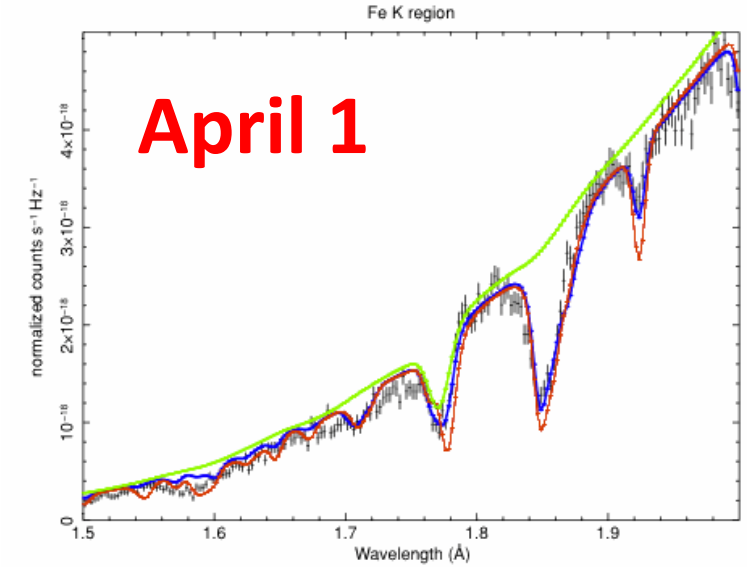


March 18



March 27

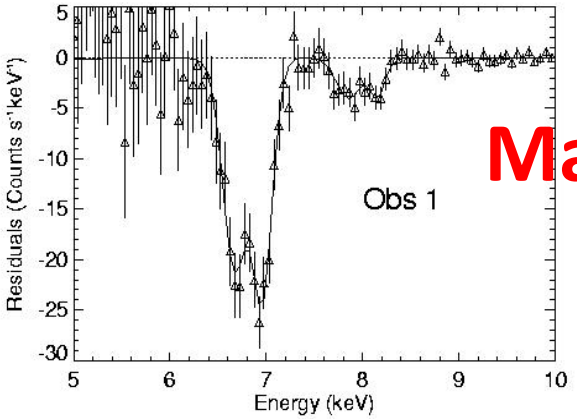
Diaz Trigo et al. 2007



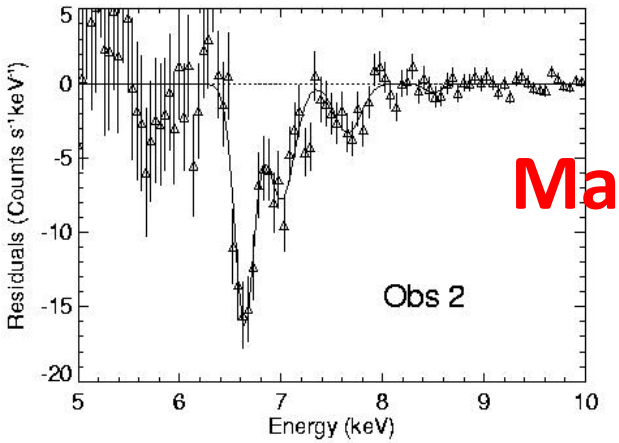
April 1

Miller et al. 2006, Kallman et al. 2009
(see also Netzer 2006, Luketic et al. 2010)

GRO J1655-40

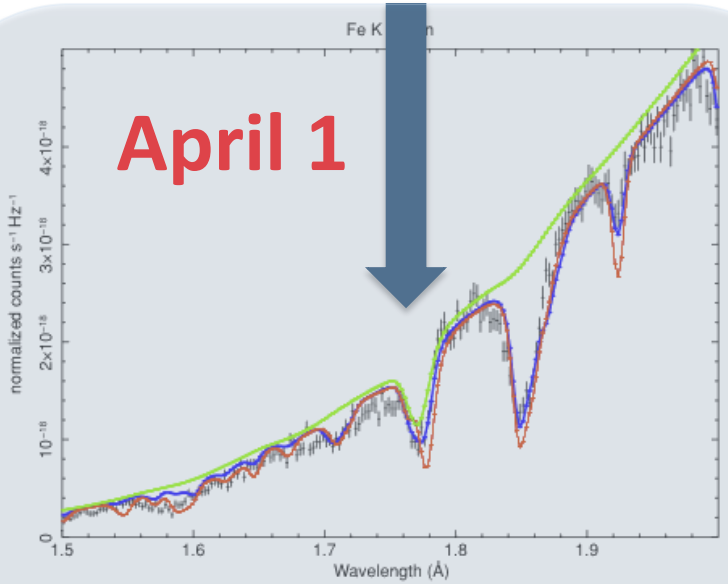


March 18



March 27

Diaz Trigo et al. 2007



Miller et al. 2006, Kallman et al. 2009
(see also Netzer 2006, Luketic et al.2010)

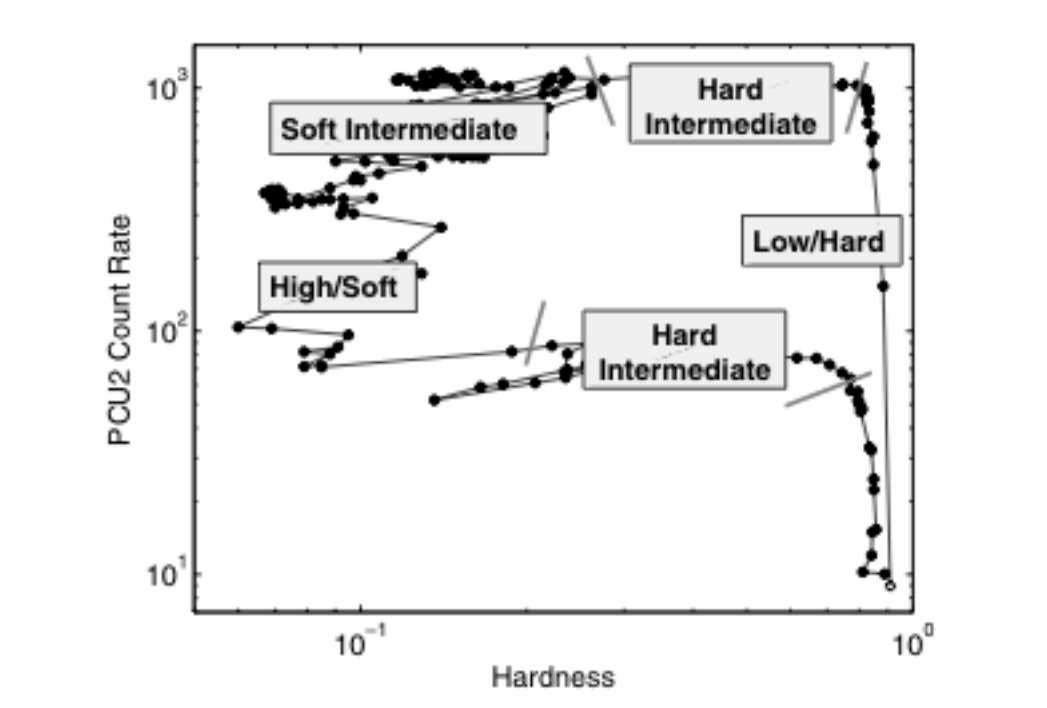
$r < 2 \times 10^9$ cm => Magnetic driving (Miller et al. 2006)

$r \approx 10^{11}$ cm => Thermal driving (Netzer et al. 2006)

JETS

Relation between winds and jets

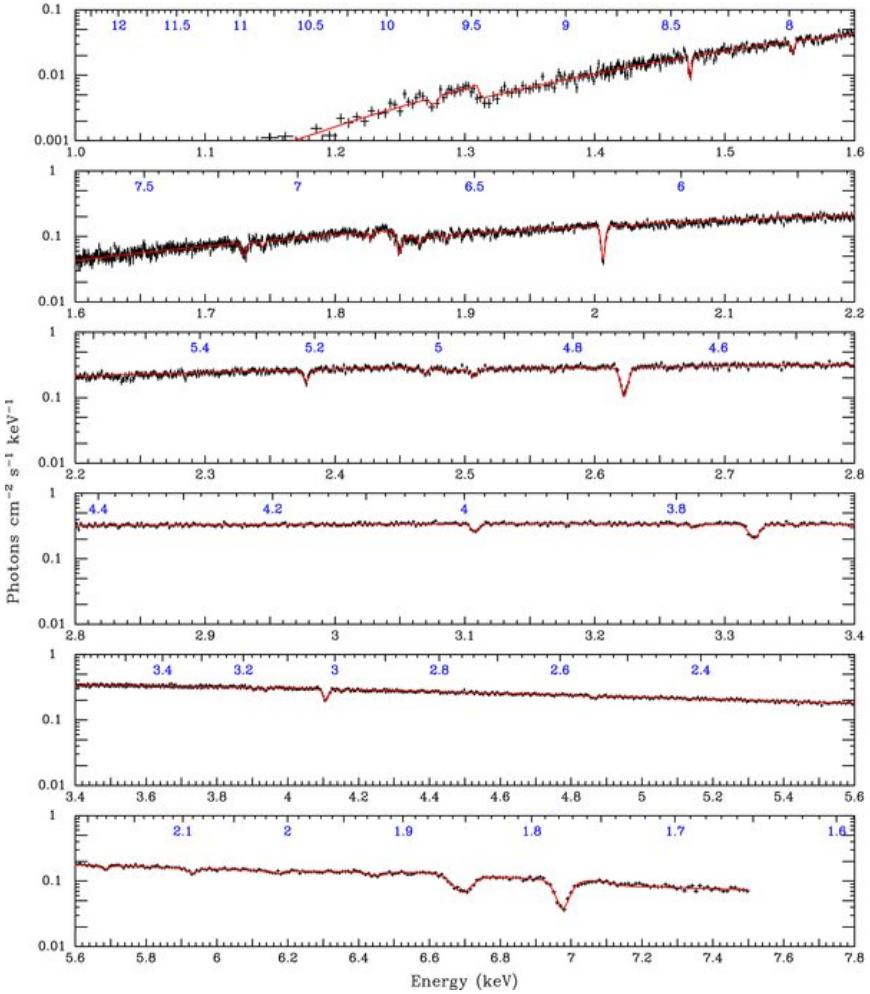
Winds



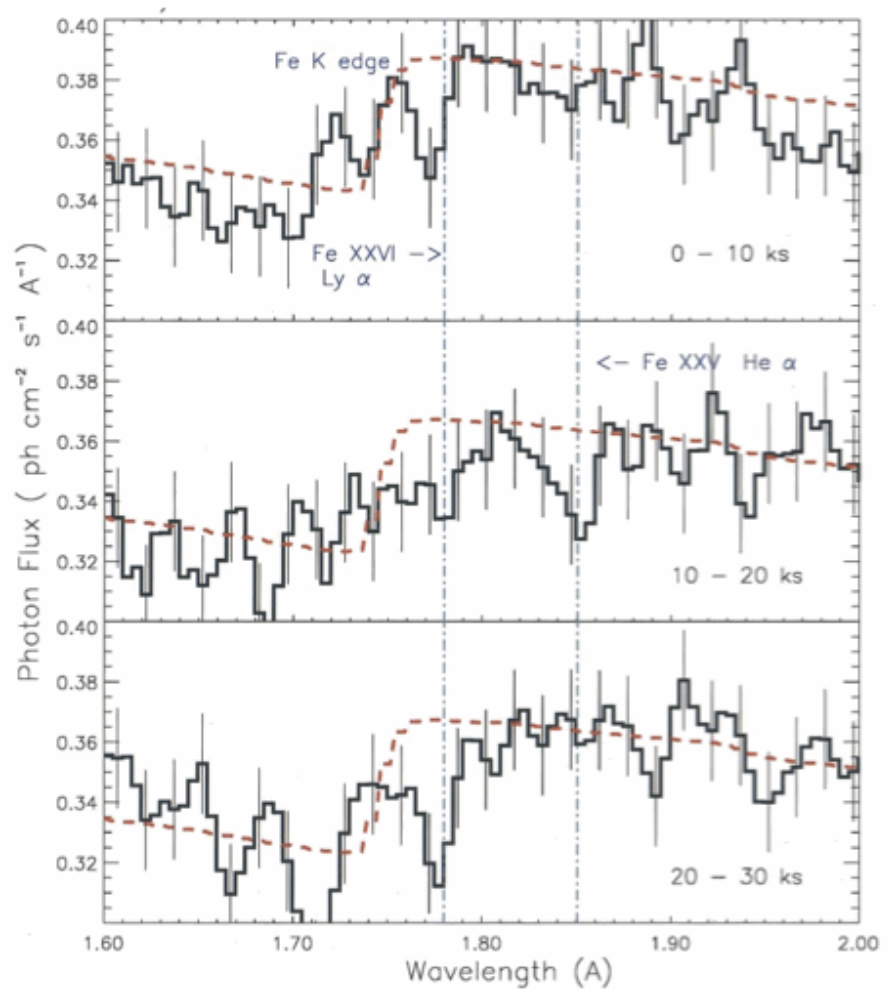
Jets

Homan & Belloni 2005

The case of GRS 1915+105

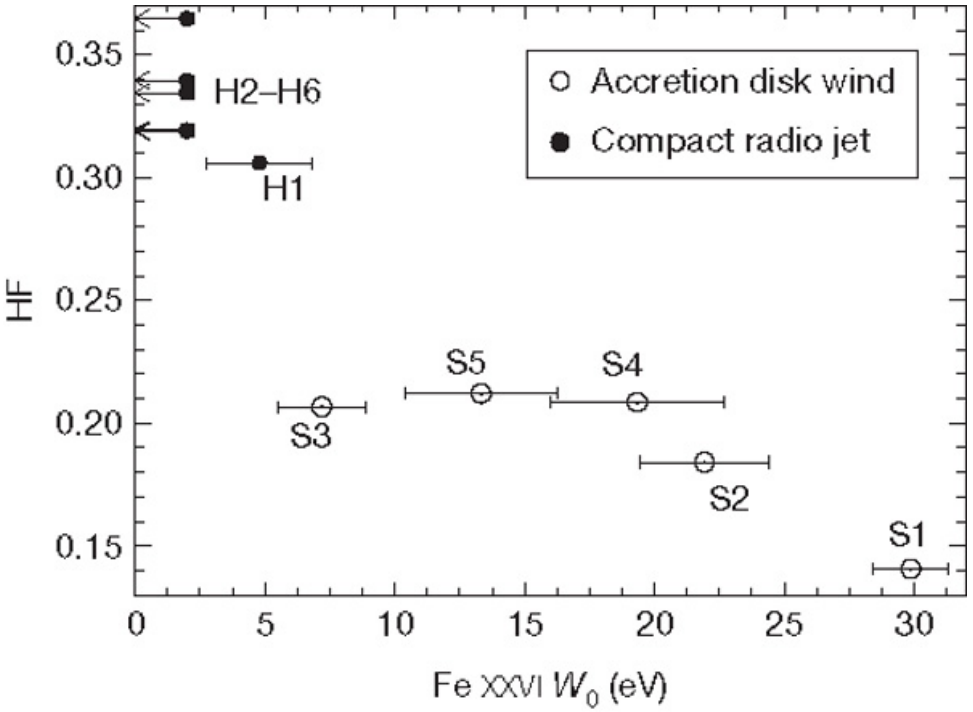


Ueda et al. 2009 (Soft, “A”, state)

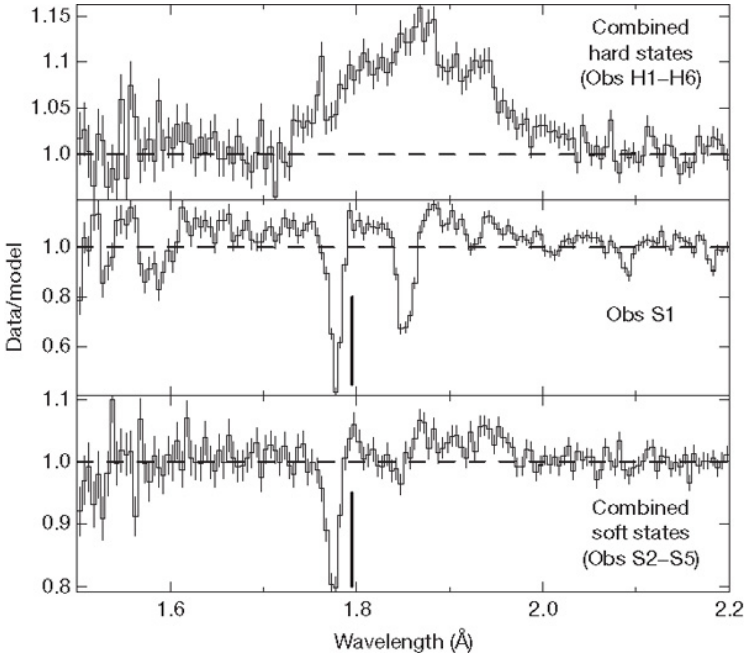


Lee et al. 2002 (Hard, “C”, state)

The case of GRS 1915+105

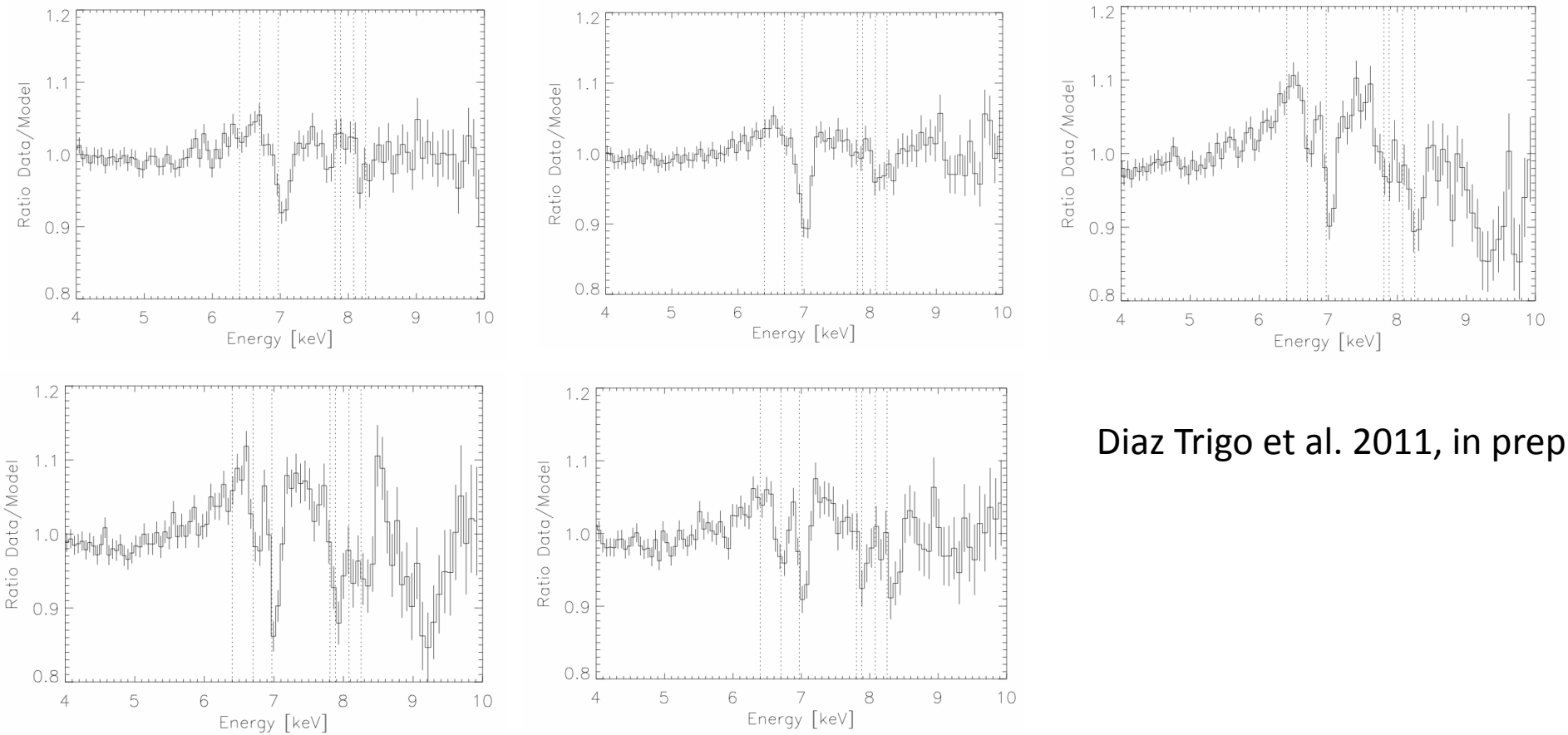


Neilsen & Lee 2009



Does the wind suppress the jet?

Is GRS 1915+105 a general case?



Diaz Trigo et al. 2011, in prep.

Broad Fe line co-exists with strong wind

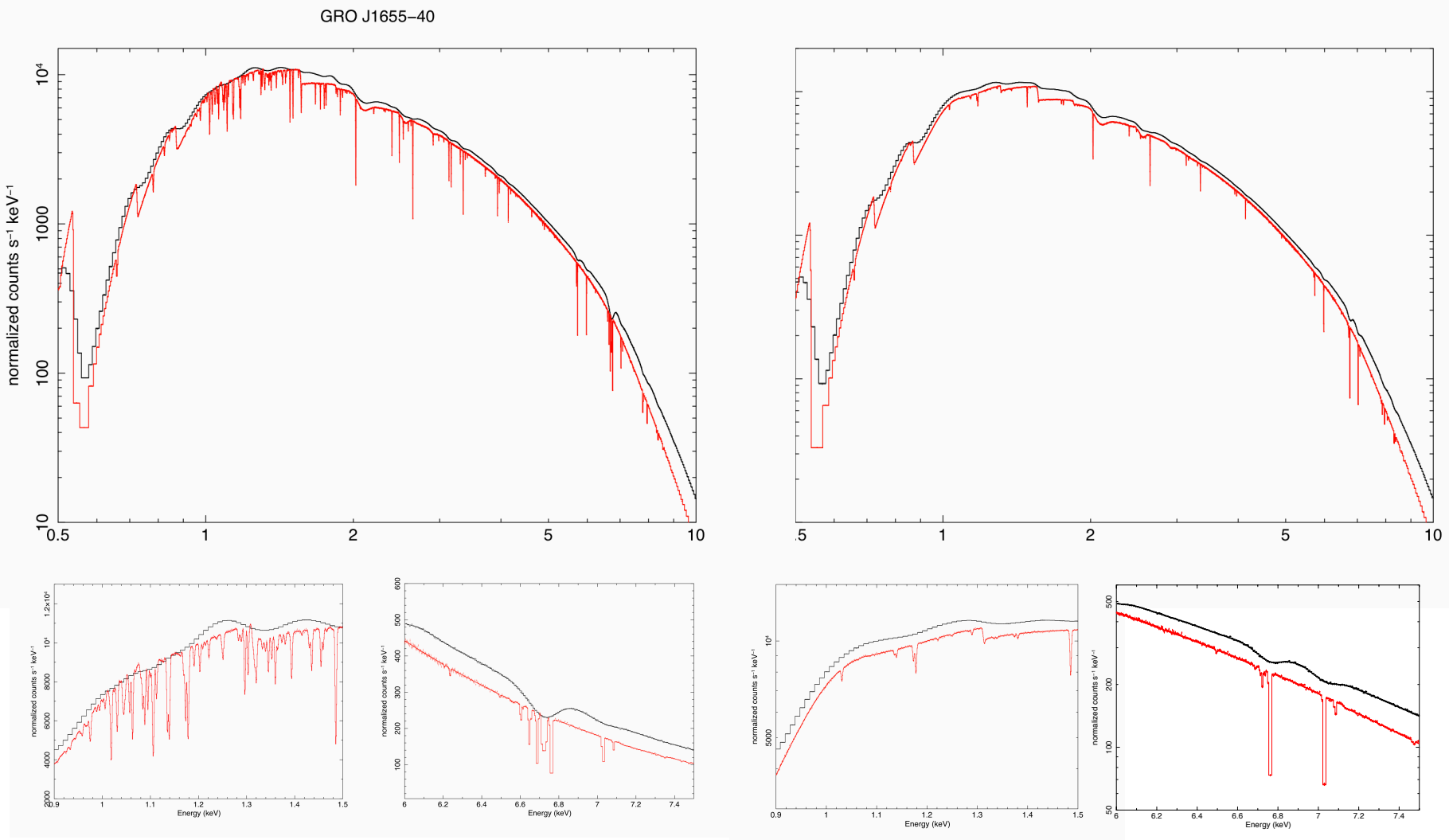
Interpretations for the wind/jet relation

- The wind suppresses the jet (Neilsen & Lee 2009)
- The wind is fully ionised in the hard state (e.g. Ueda et al. 2010)
- The scale height of the wind may be too low to be observed (Ueda et al. 2010)

Open issues

- To which extent is the hard X-ray flux responsible for the disappearance of the winds?
- Are winds and jets really exclusive?
- What is the launching mechanism of the wind?

The future



Conclusions

- A highly ionized atmosphere or wind is present above the accretion disc in LMXBs
- It is detected as a warm emitter and/or absorber in many LMXBs seen relatively close to edge-on.
- Photoionisation is the dominant ionization mechanism.
- The bulge where the accretion stream impacts the disk is seen as a less strongly ionised absorber in dippers
- Winds are consistent with a thermal launching mechanism except for GRO J1655-40
- Correlation between winds and jets is being investigated

Warnings

- The availability of high resolution spectra impacts our ability to probe the physical conditions around the compact object.

- Ionised absorption should be properly accounted for to correctly model the continuum emission, any broad Fe emission line and any soft excess in LMXBs.