# Timing the warm absorber in NGC4051


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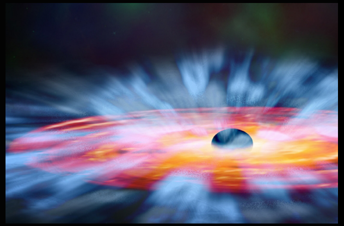
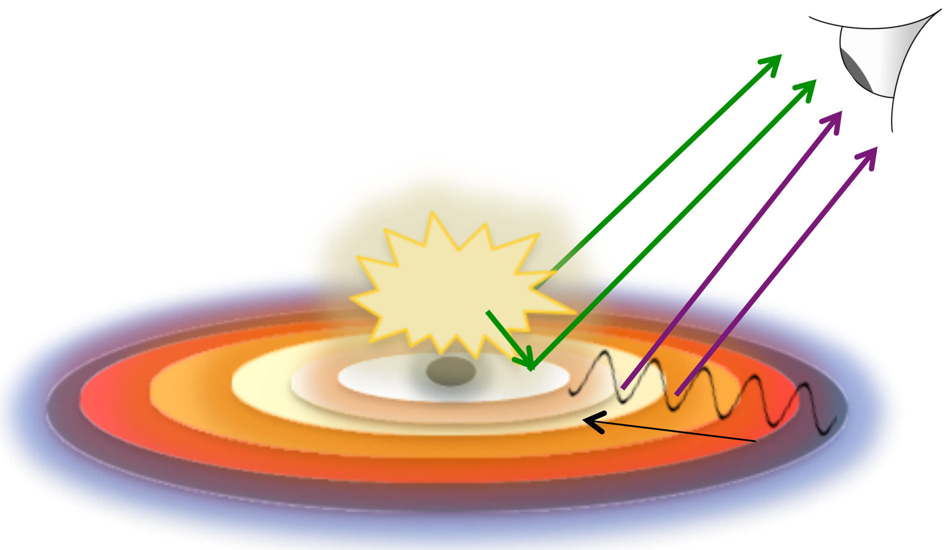
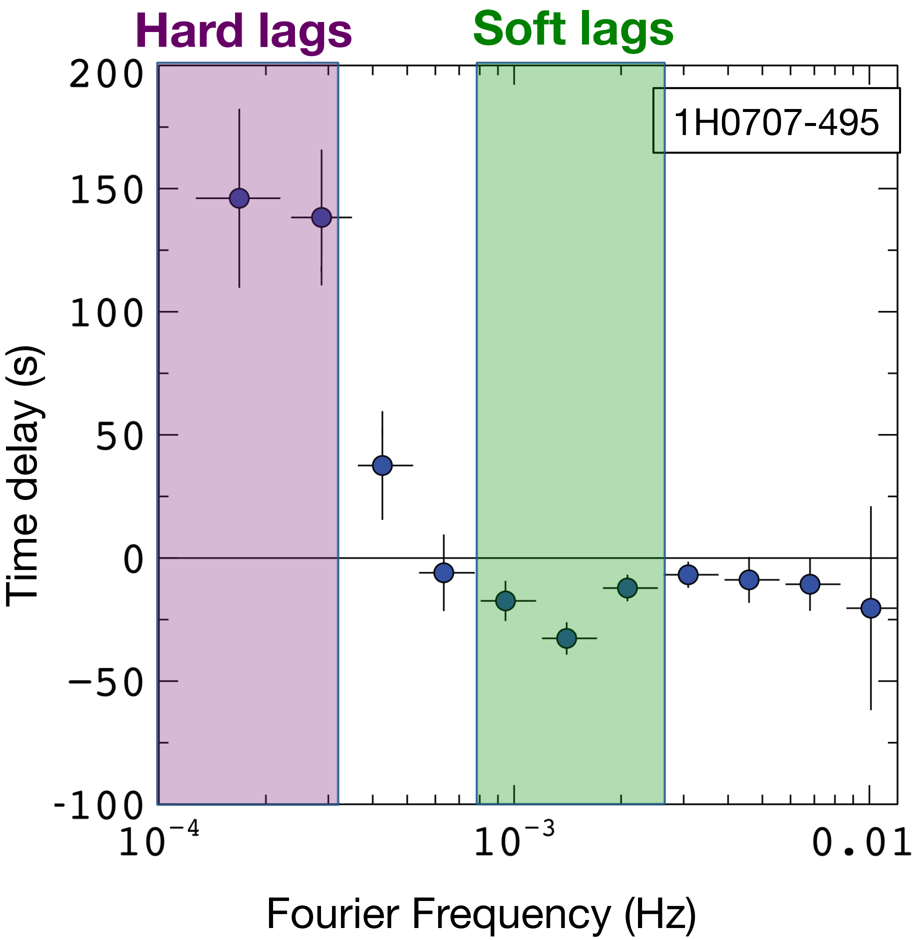
# X-ray time lags



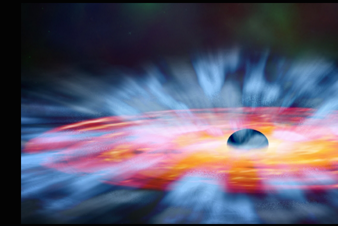




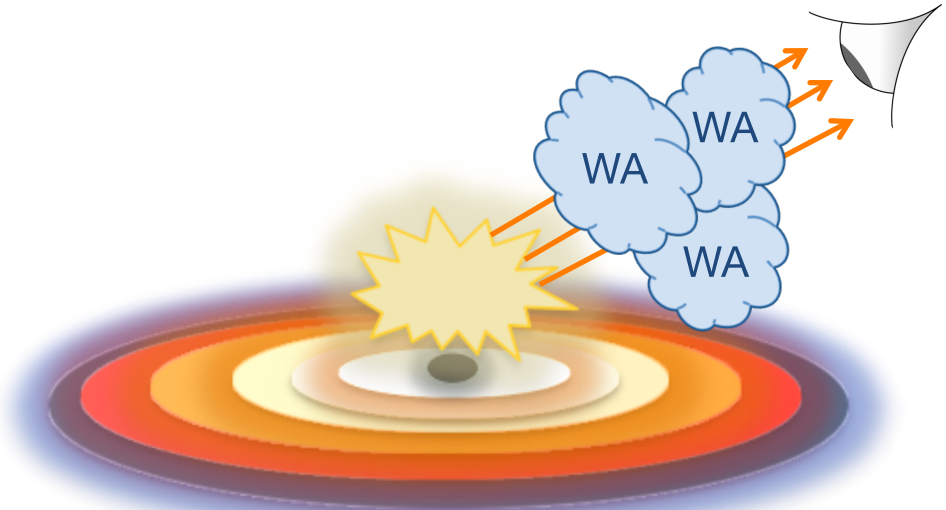

For a review of X-ray spectral timing analysis in BHBs and AGN see Uttley et al. 2014.

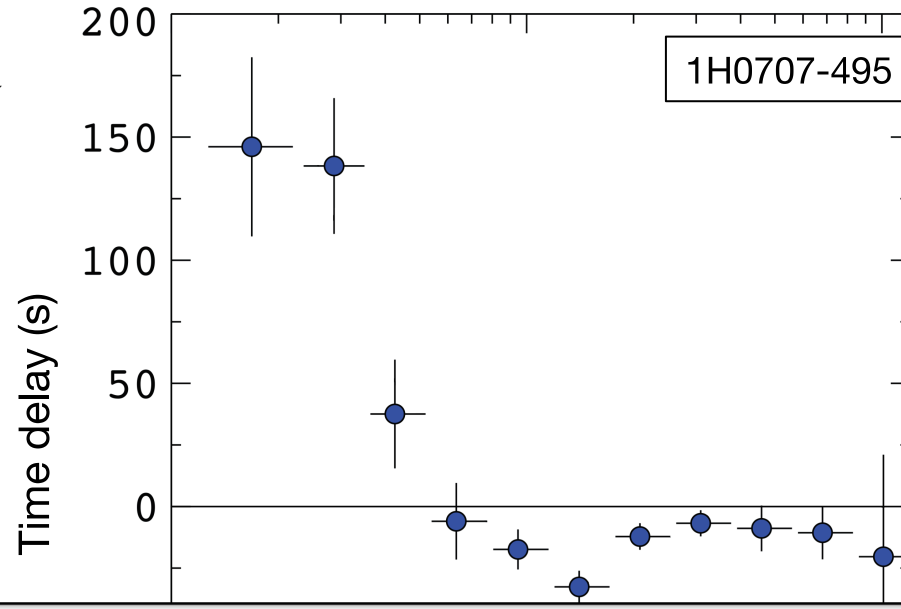
*Zoghbi et al. 2011*

# X-ray time lags



WA detected for ~50% Seyfert 1

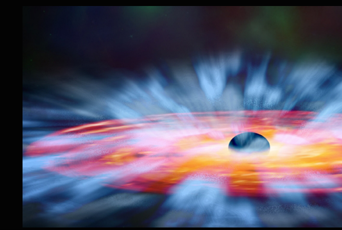


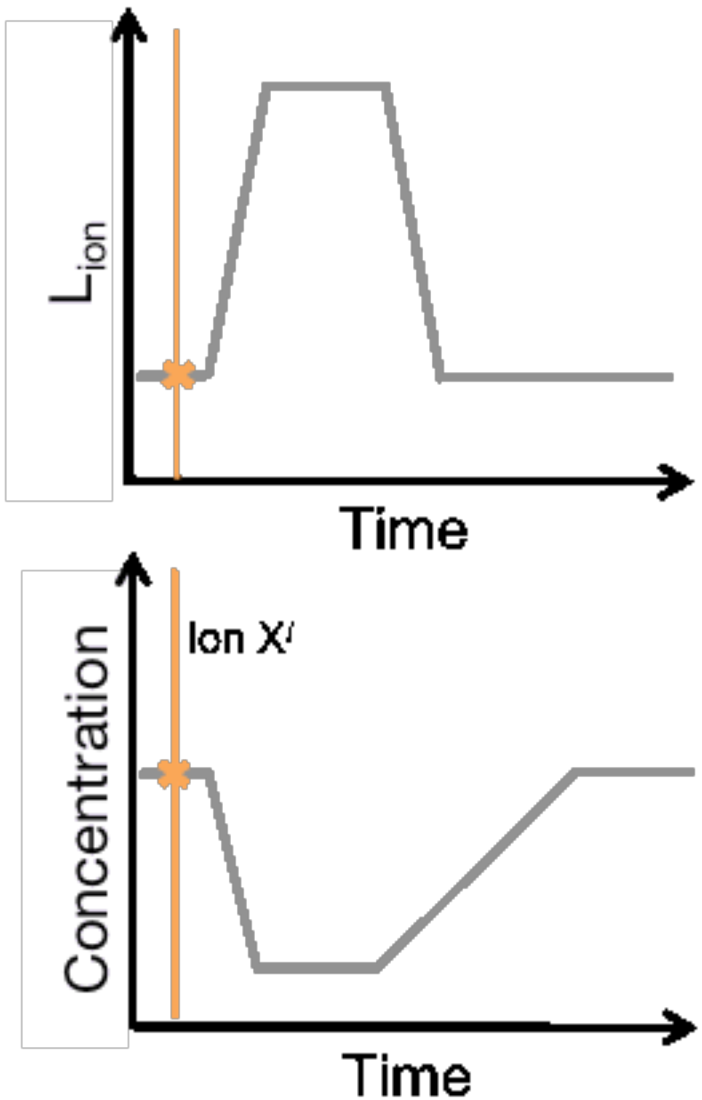



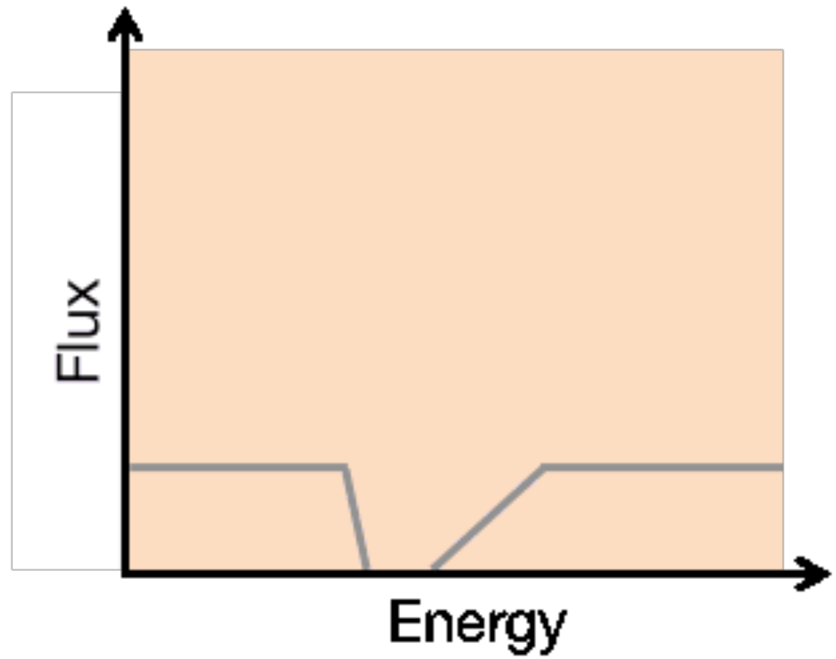

**Does the warm absorber contribute to the observed X-ray time lags?**

**Can we constrain the parameters of the absorber with Fourier timing?**

# Variability and gas response





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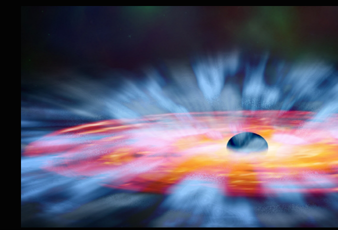

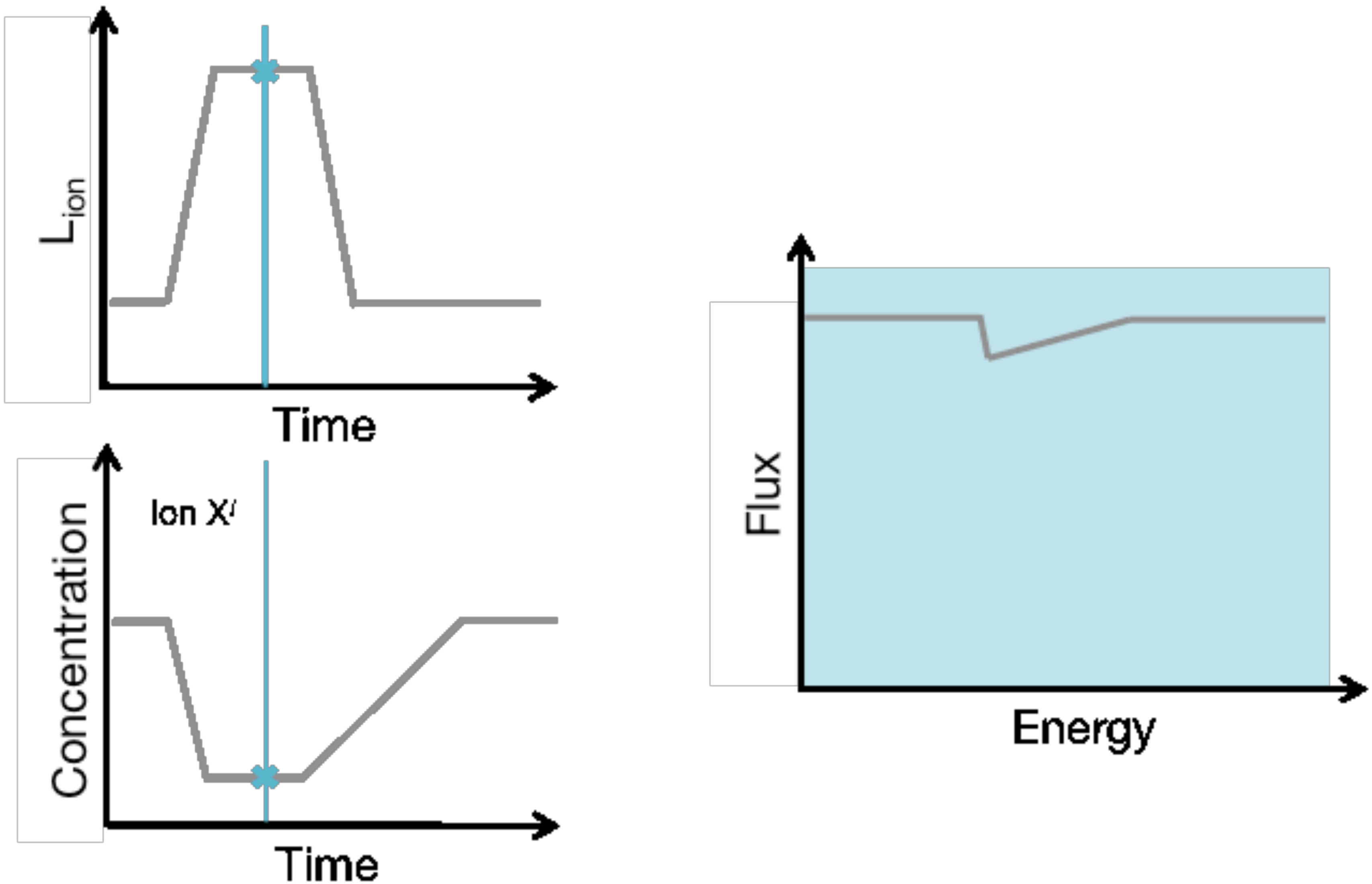

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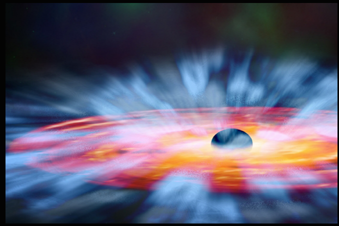

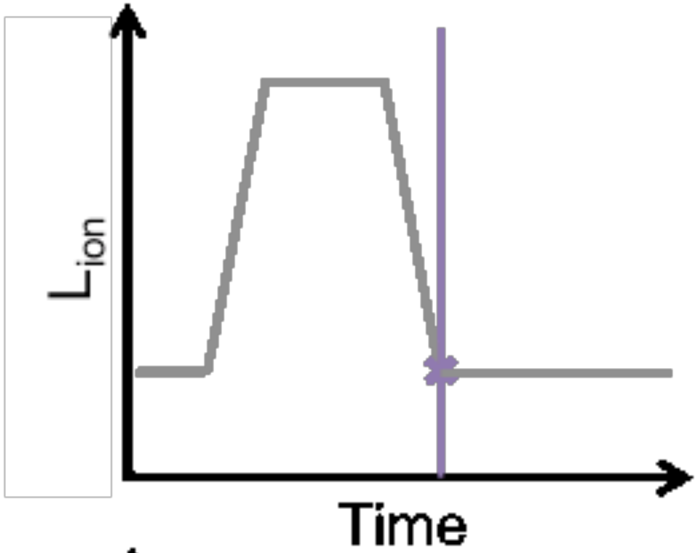


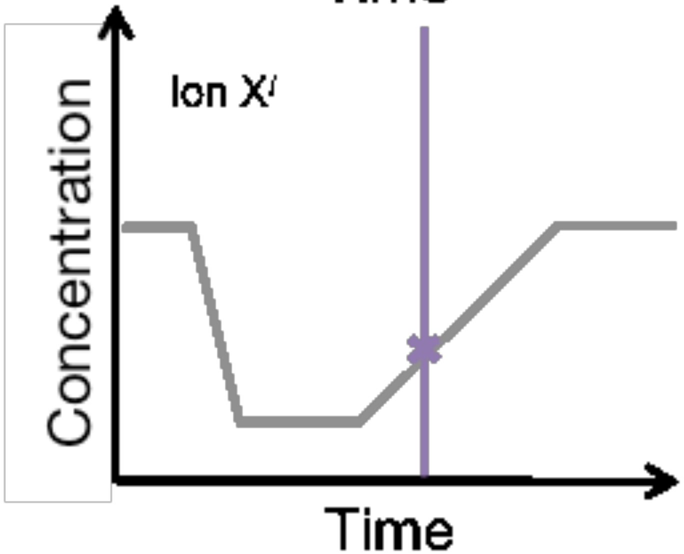


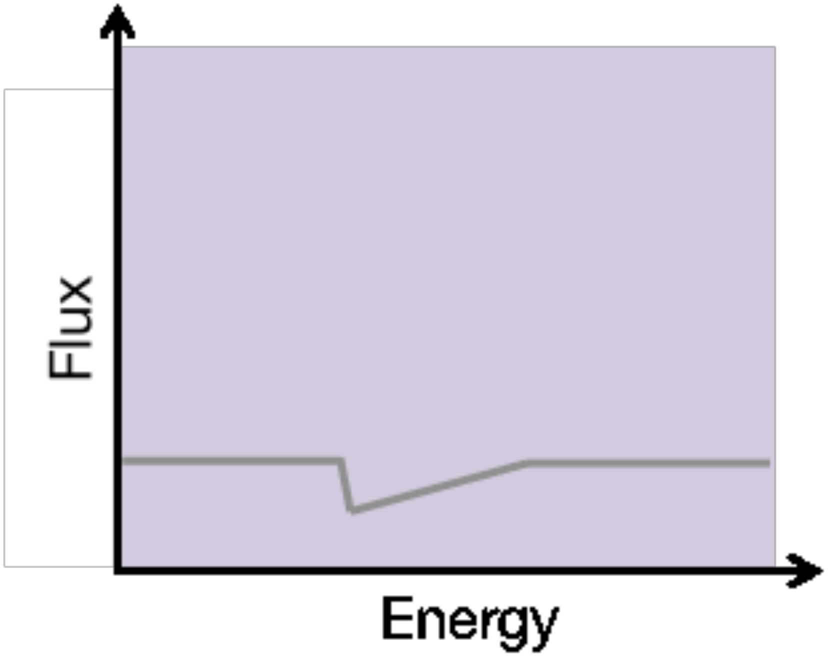

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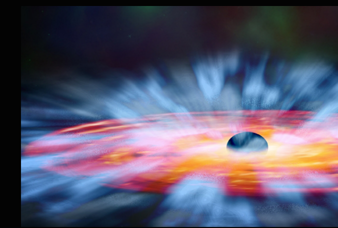

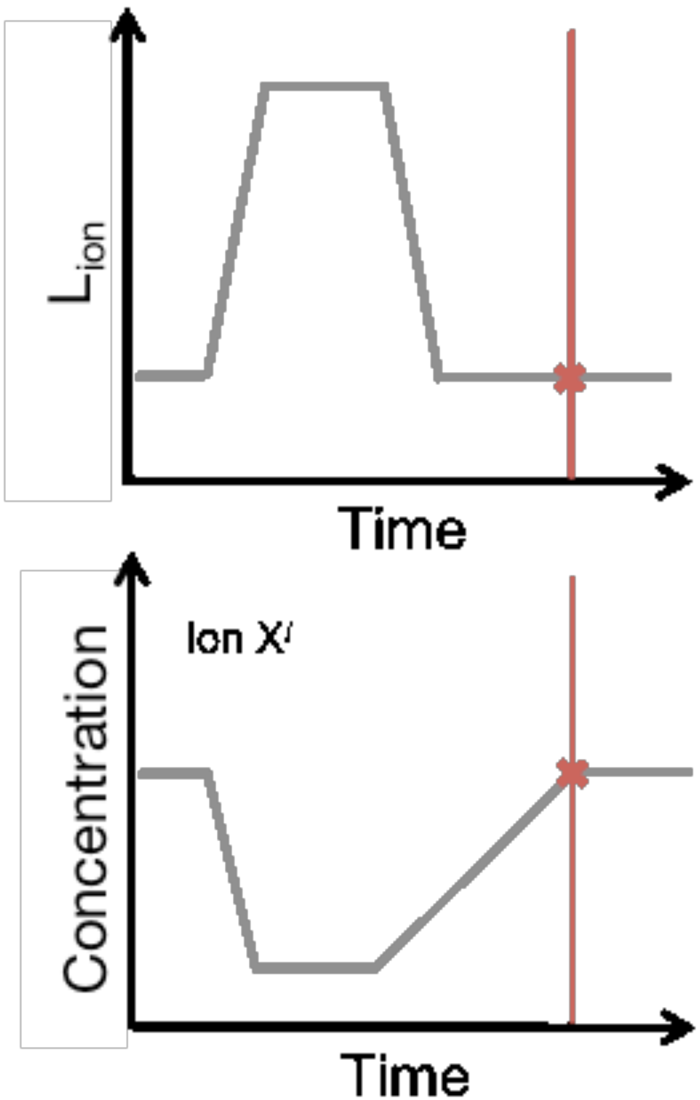


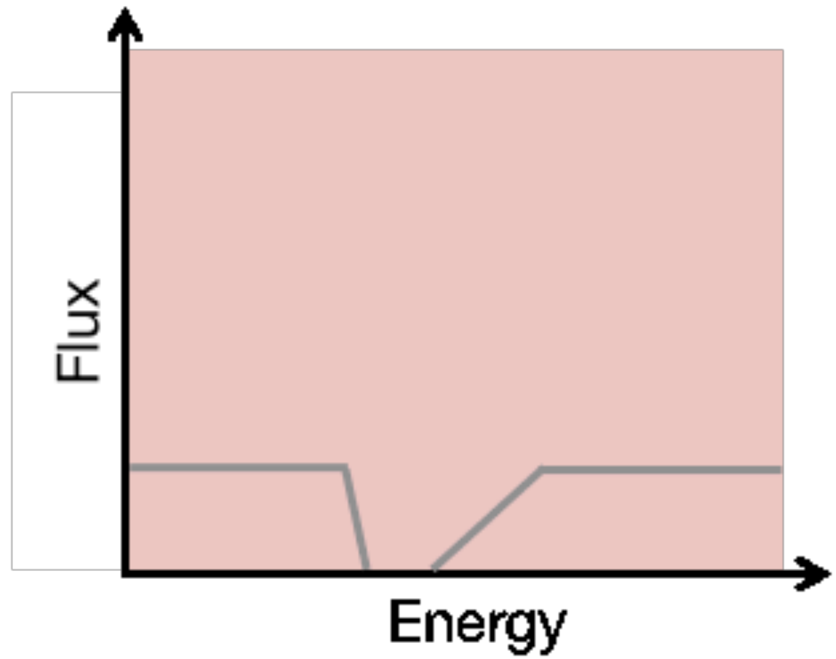

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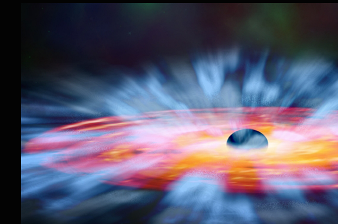
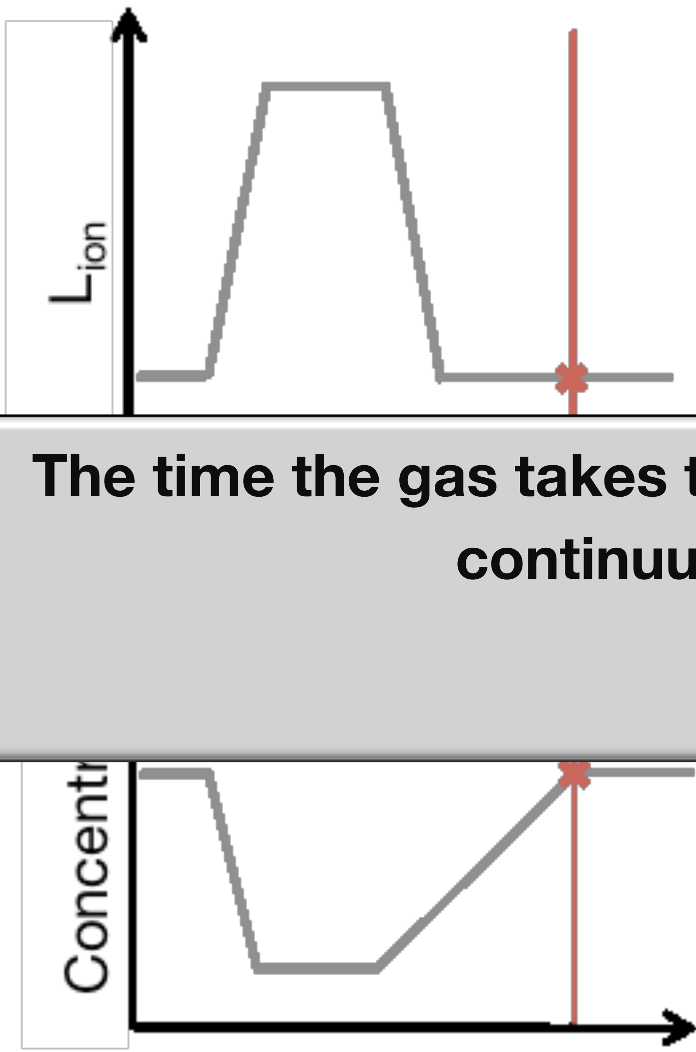
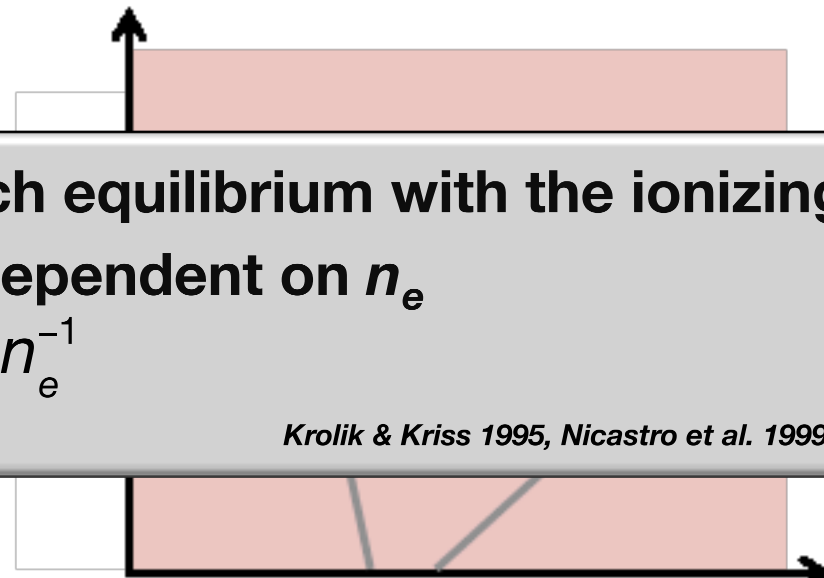




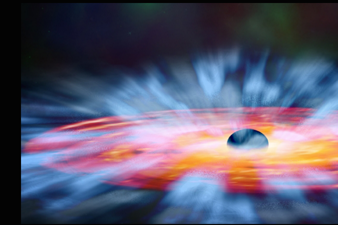




**The time the gas takes to reach equilibrium with the ionizing continuum is dependent on $n_e$**

$$t_{rec} \propto n_e^{-1}$$

***Krolik & Kriss 1995, Nicastro et al. 1999***

# Warm absorbers in AGN

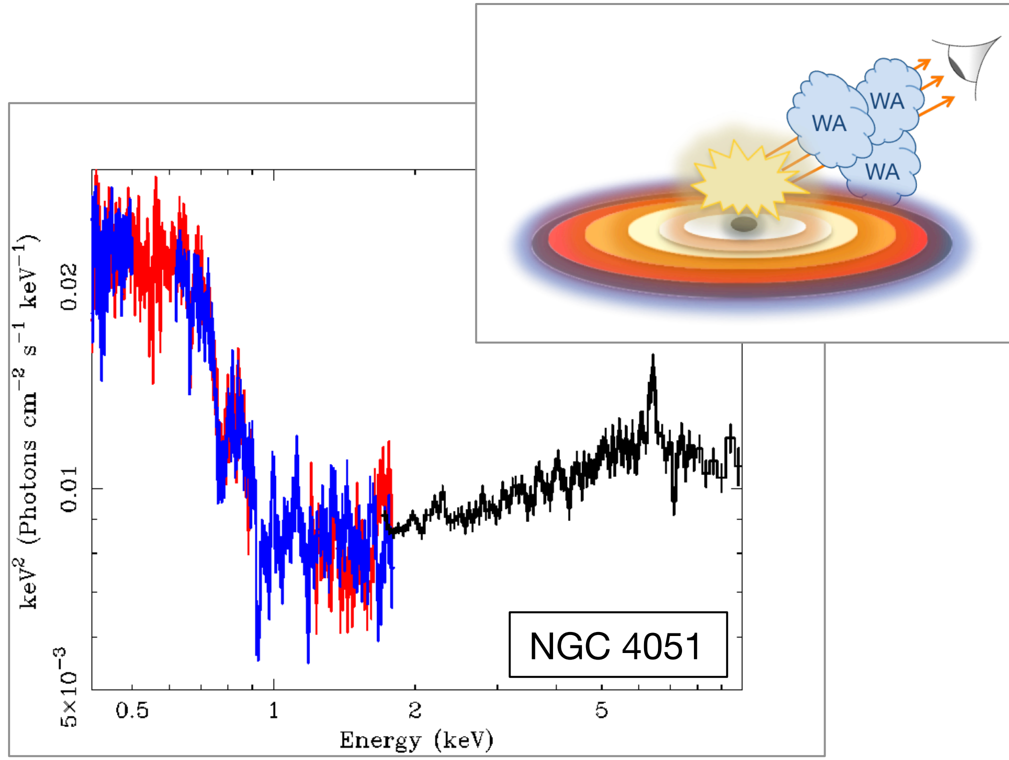


observables

Ionizing luminosity

$$\xi = \frac{L_{ion}}{n r^2}$$

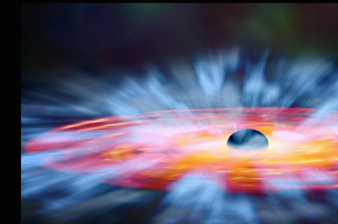
Ionization parameter



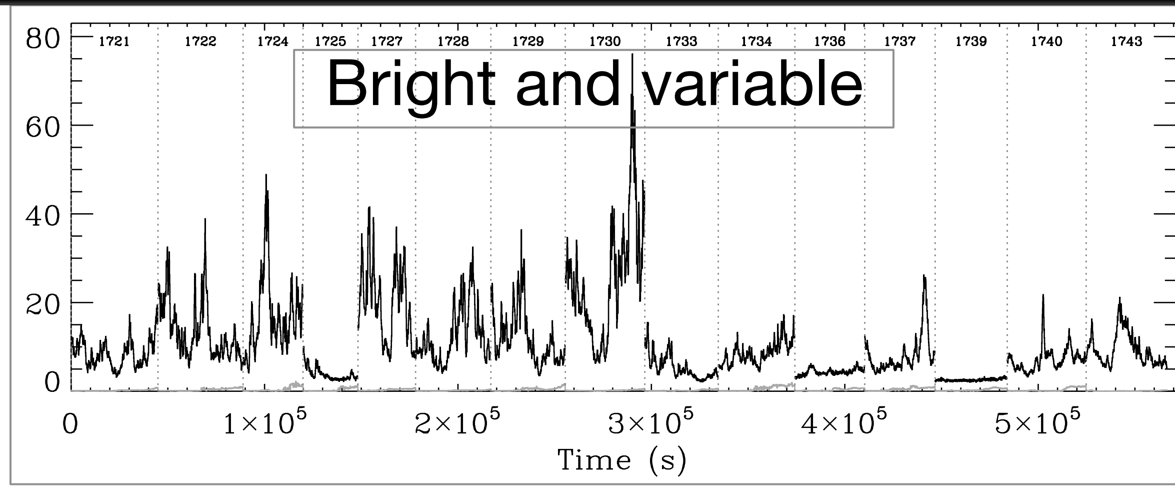

AGN feedback?

**If we obtain the density we can estimate the location of the absorber and its output power**

# NGC4051

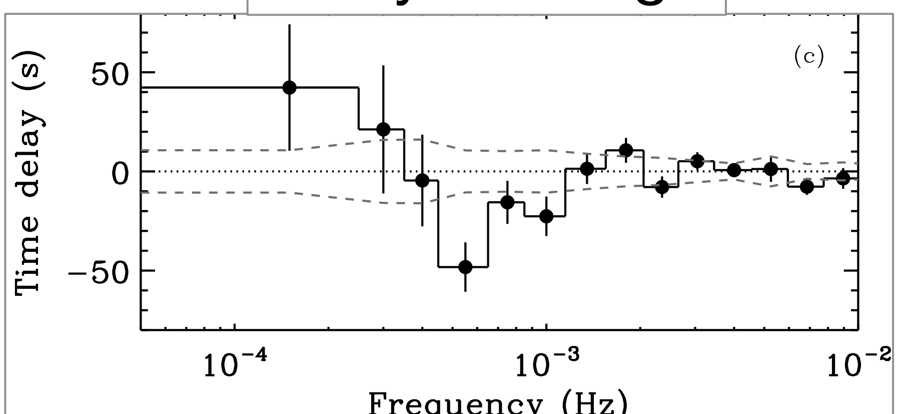


~600 ks data



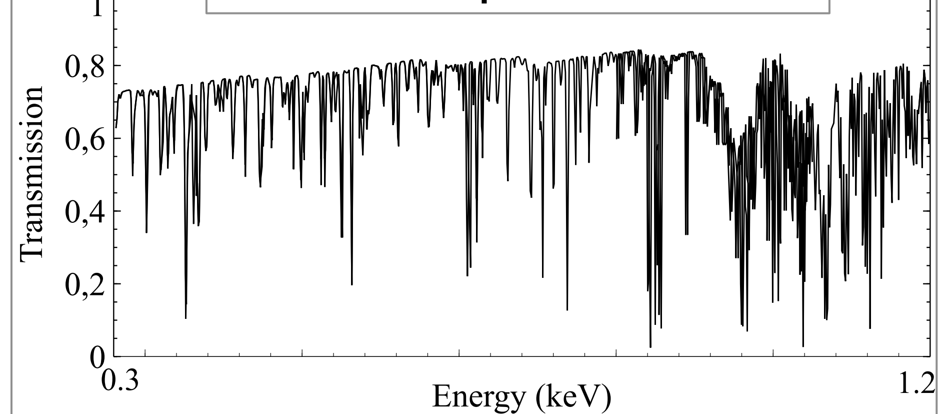

Vaughan et al. 2011

## X-ray time lags




Alston et al. 2013

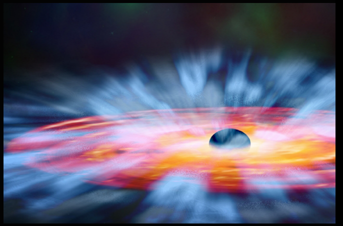
## Multicomponent wind




Silva, Uttley & Costantini (in prep.)

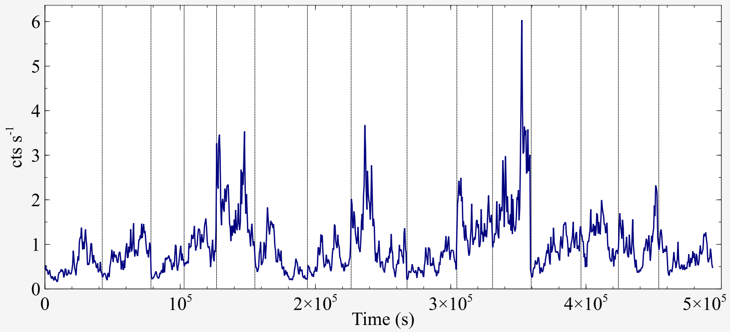
For details see e.g. Pounds & King 2013

# Time dependent photoionization and simulations



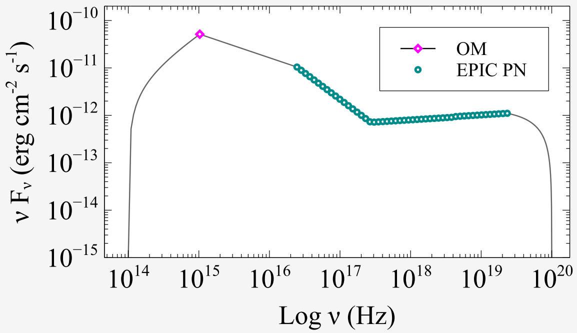
## Simulate light curves from NGC4051 PSD

*Timmer & Konig 1995, Uttley et al. 2005*



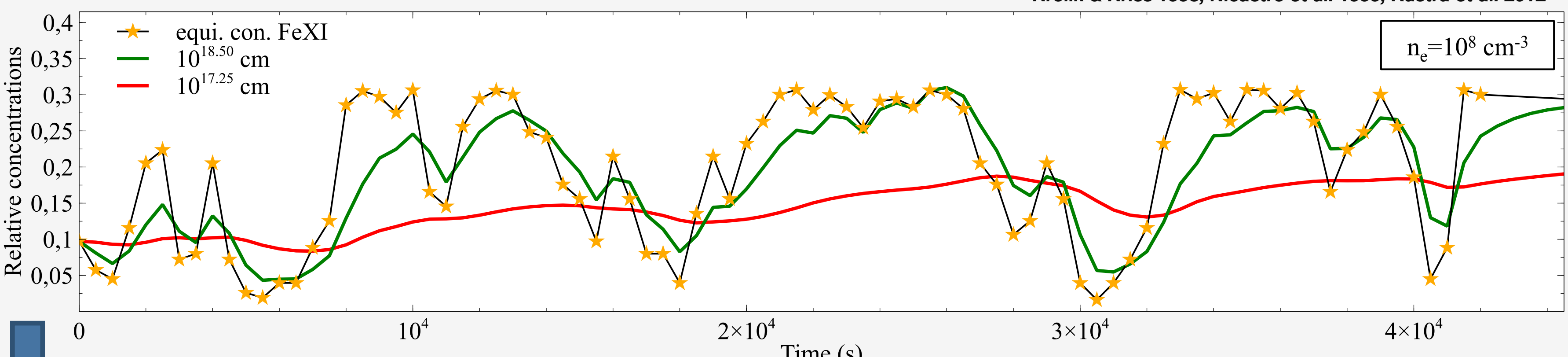

## Recombination and ionization rates for constant SED using CLOUDY

*Ferland et al., 2013*




## Solve time dependent concentrations

*Krolik & Kriss 1995, Nicastro et al. 1999, Kastra et al. 2012*



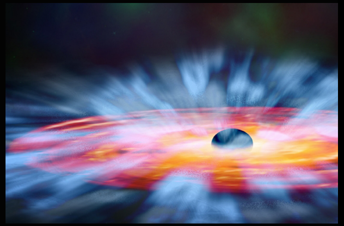

**Simulate spectrum with SPEX**

*Kaastra, Mewe, & Nieuwenhuijzen 1996*

**Light curves only affected by variable WA**

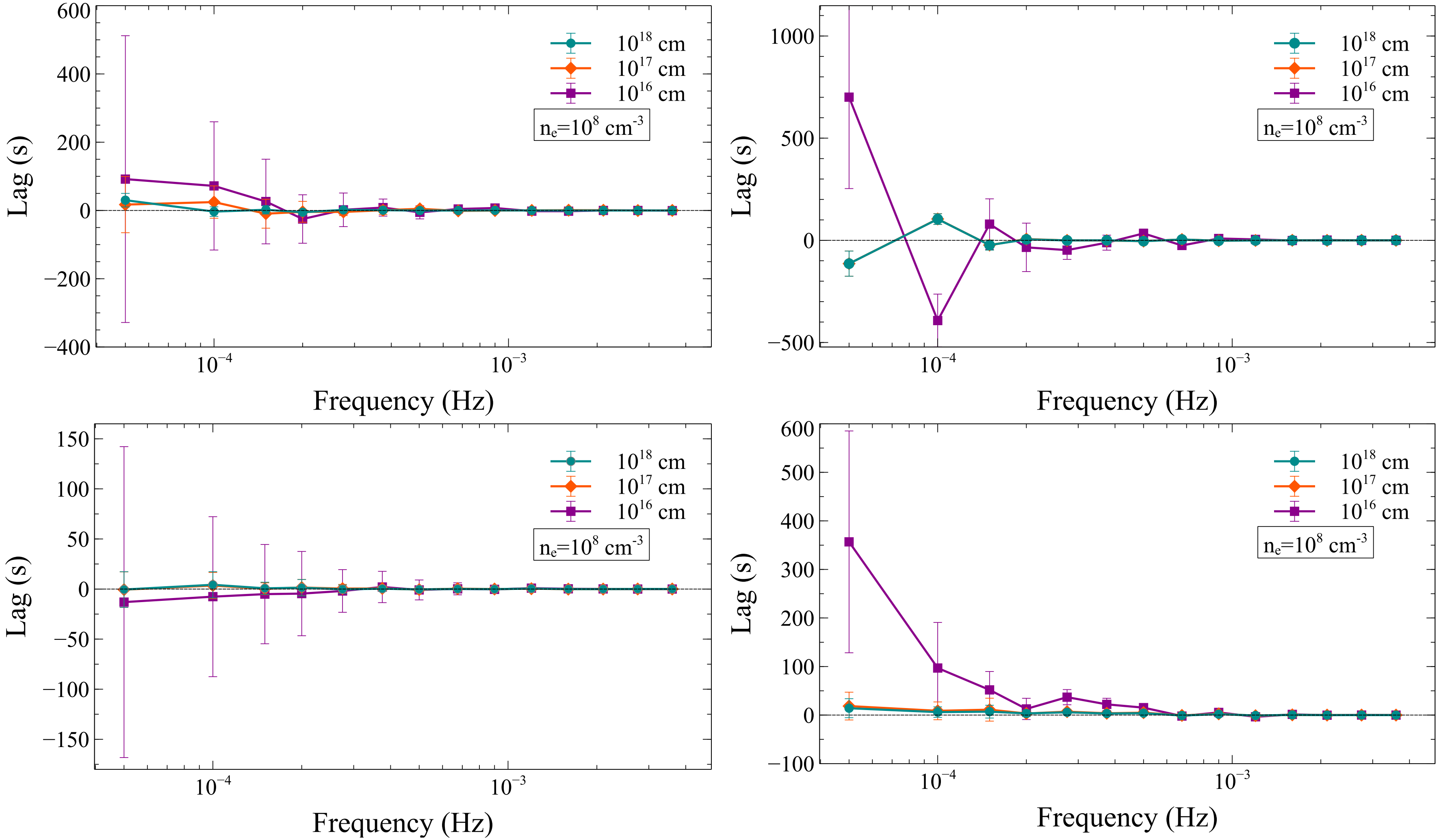
**Timing products**

# Effects on different realizations



**Preliminary results!**

## Soft (0.3-1.0 keV) vs Hard (2.0-5.0 keV)

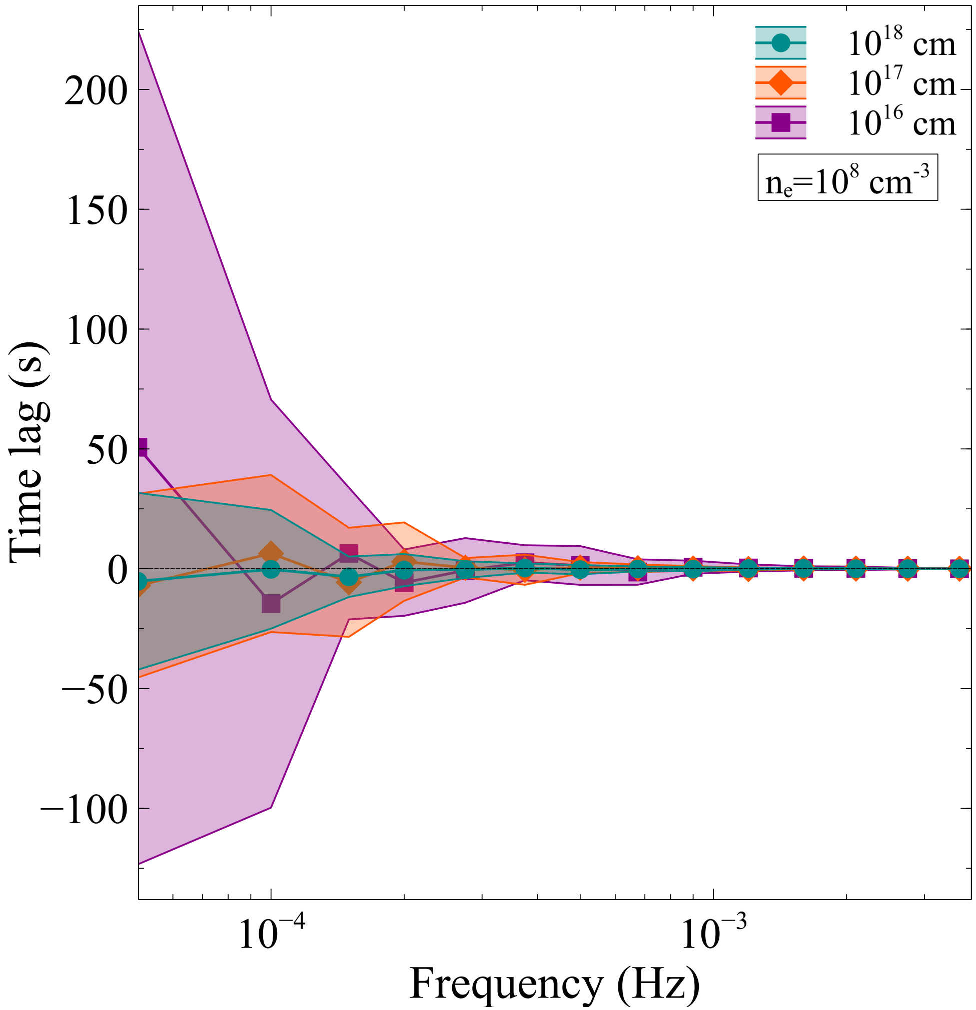


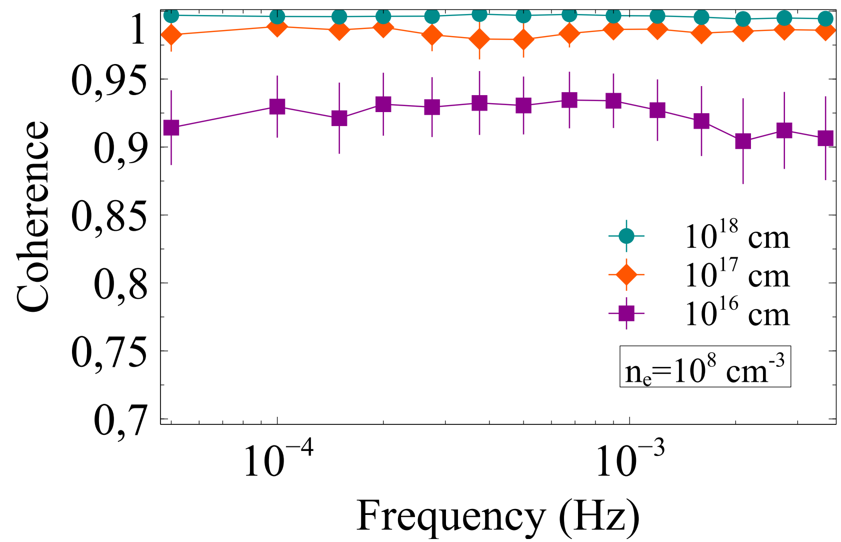

*Silva, Uttley & Costantini (in prep.)*

# Effects on continuum lags

Preliminary results!

Soft (0.3-1.0 keV) vs Hard (2.0-5.0 keV)

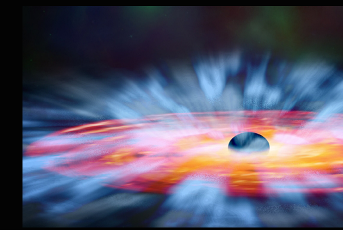



**WA adds to the scatter by reducing the correlation between bands.**

*Silva, Uttley & Costantini (in prep.)*

# Effects on continuum lags



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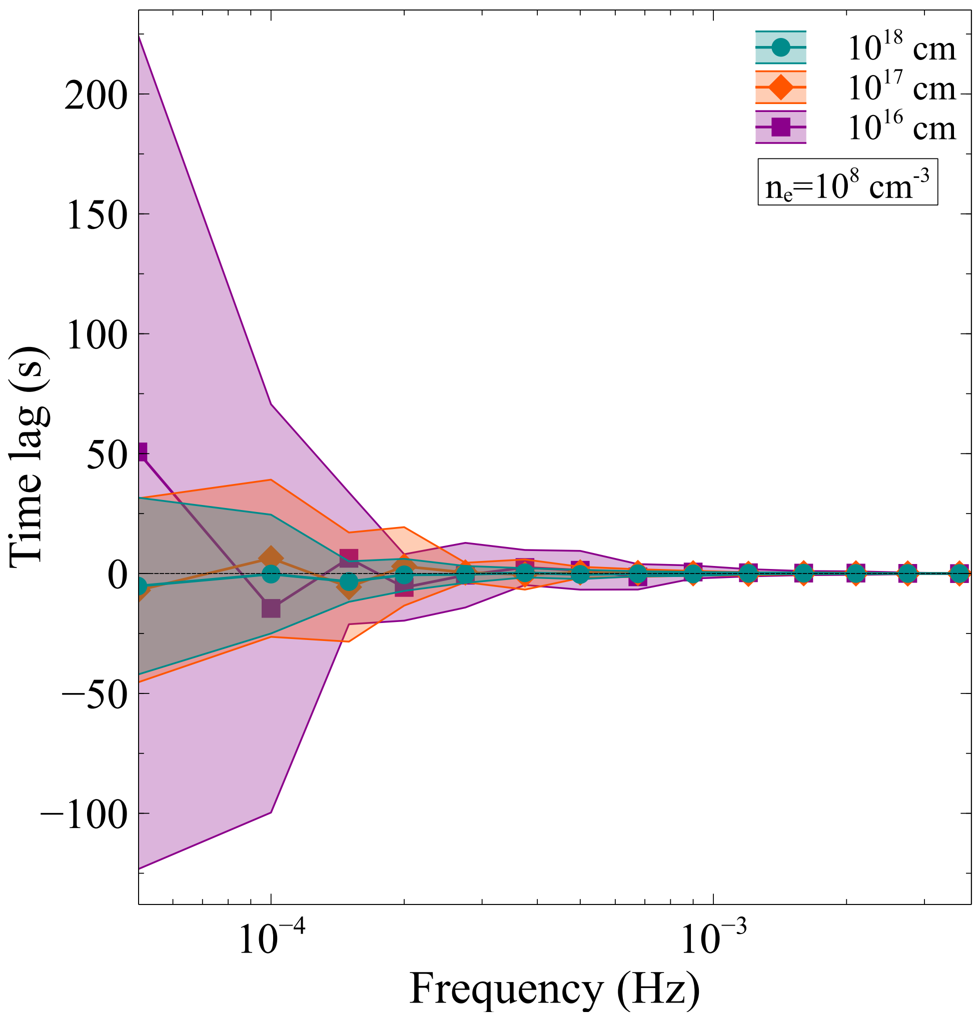


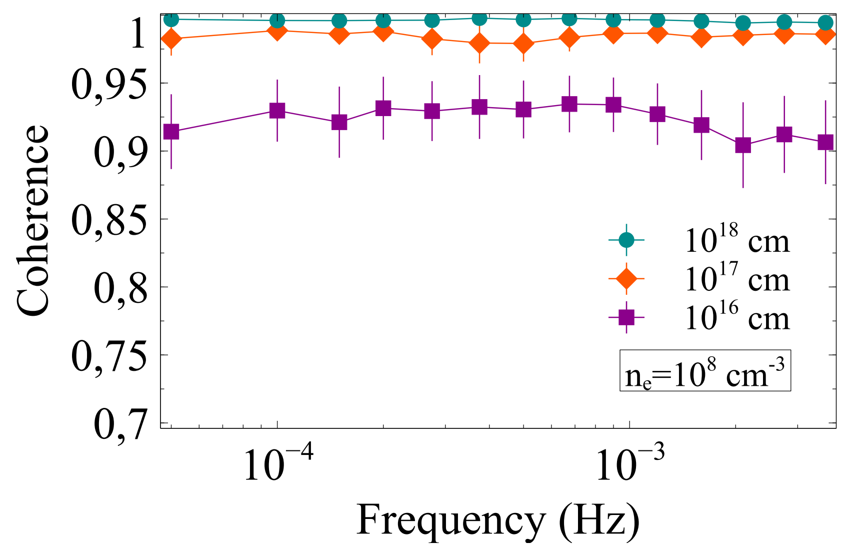


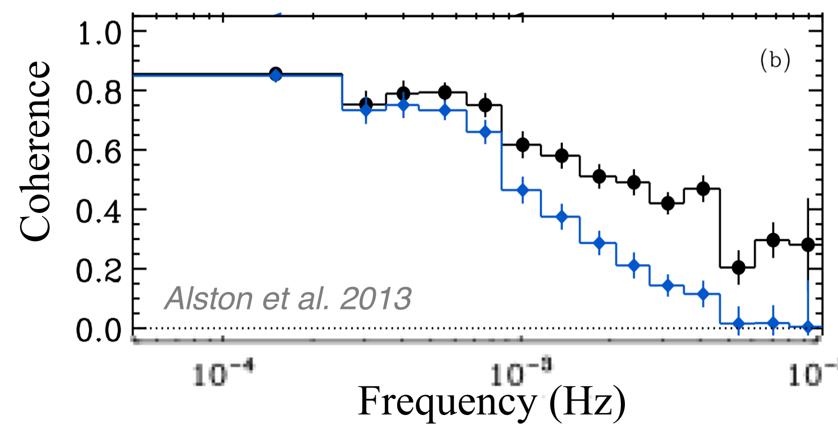

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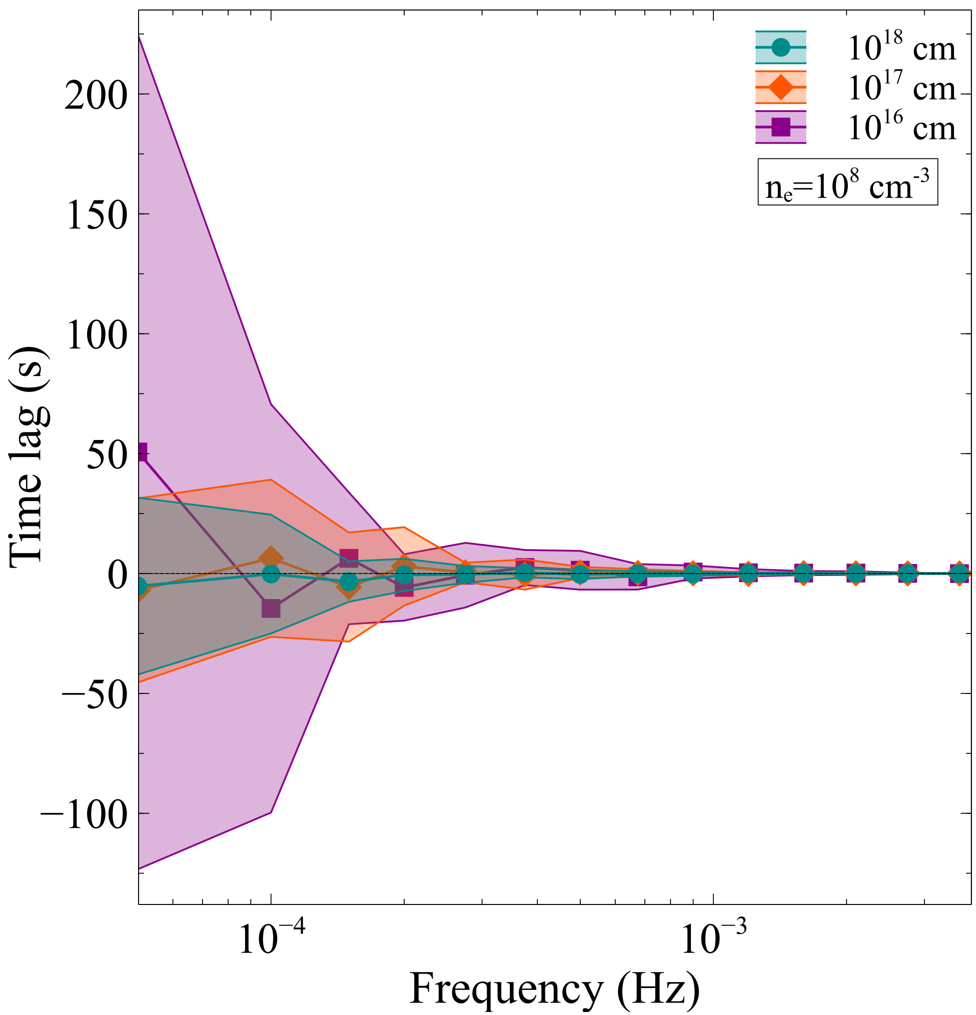
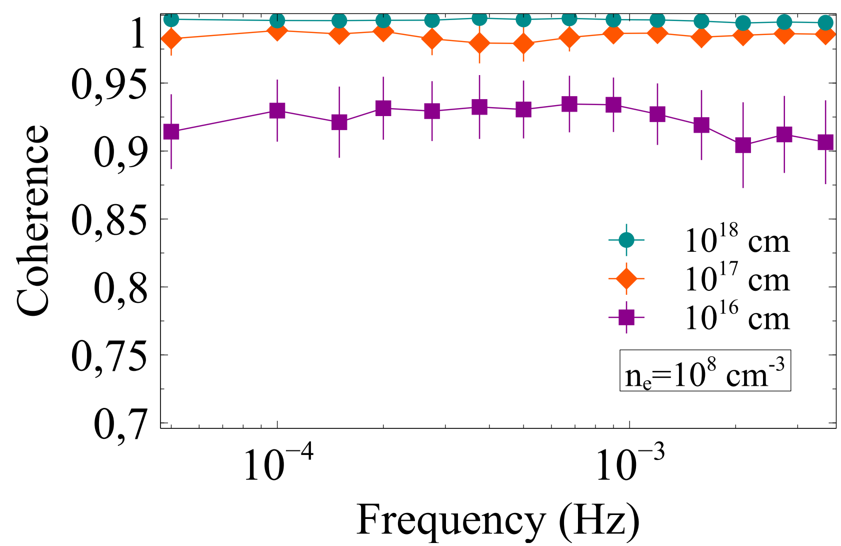
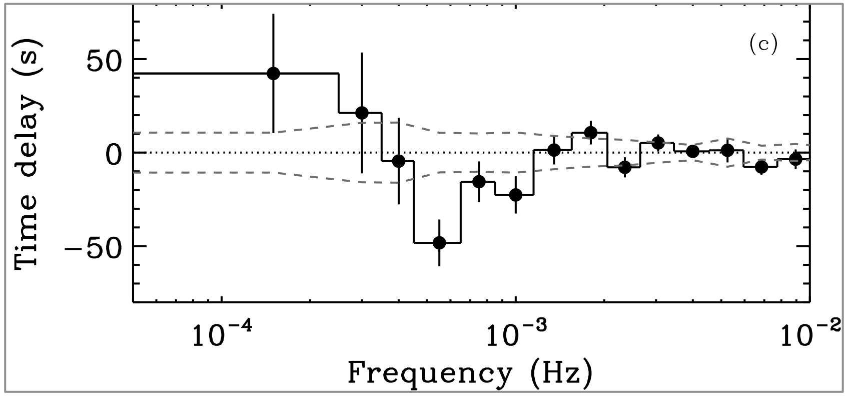
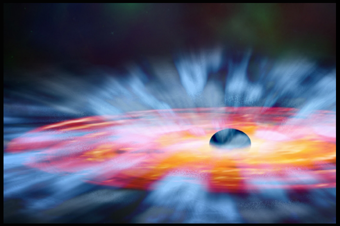



*Alston et al. 2013*

# Summary and conclusions



- ✓ Assessing the contribution of the recombining gas to the time delays is vital for interpreting the continuum lags associated with propagation and reverberation effects in the inner emitting regions.

- ✓ At high enough densities (or close distances), the contribution of a complex WA to the X-ray time lags may not be negligible, in particular at low Fourier frequencies, correspondent to long timescales.

- ✓ WA decreases coherence, but could not cause spurious soft lags that appear significant, so reverberation measurements are secure.

- ✓ Spectral timing is a promising method to constrain warm absorbers.