



UNIVERSITY OF  
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## Reverberation Lags in AGN

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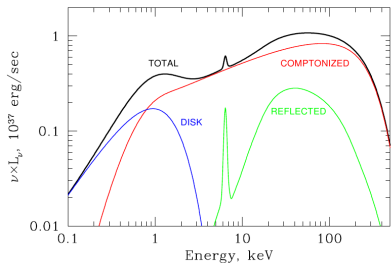
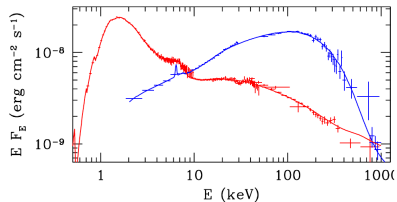
05 April 2011

Andy Fabian, Phil Uttley

# Outline

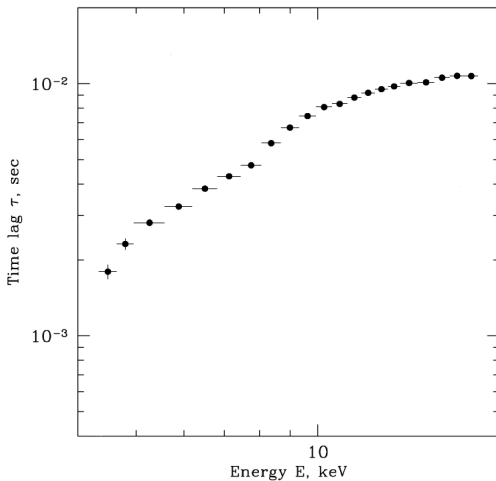
- 1 Lags in Galactic black holes?
- 2 Low frequency lags in AGN
- 3 High frequency lags in AGN
- 4 Conclusion

# Energy spectra in GBH.



e.g. Remillard & McClintock 06, ARAA

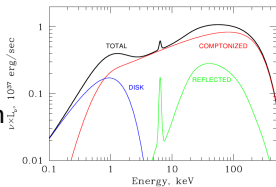
# Lags in GBH.



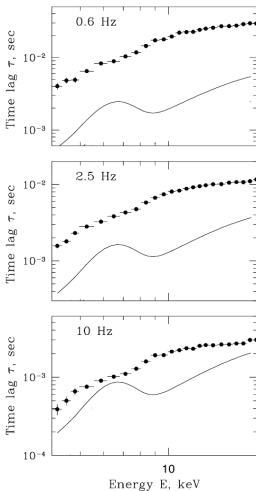
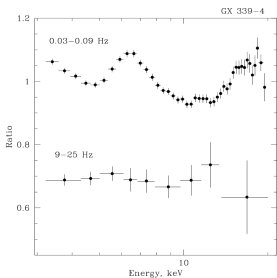
Miyamoto(89), Nowak et al. (99), Kotov et al. (01)

# Lags in GBH.

Energy Spectrum



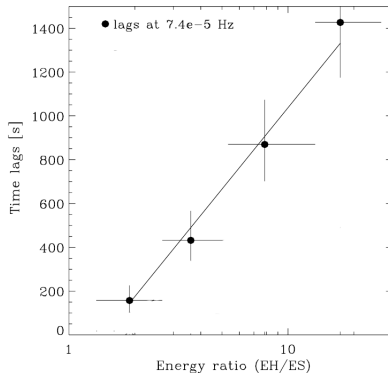
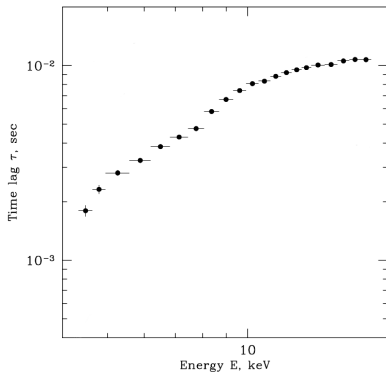
Power Spectrum



Lag Spectrum

Revnitsev et al. (99,01), Kotov et al. (01)

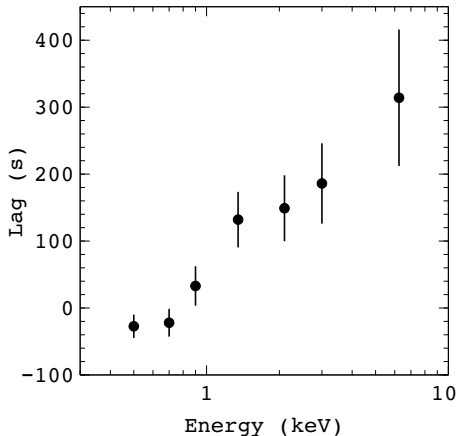
## Lags in GBH vs AGN.



Kotov et al. (01), McHardy et al (04,07), Arevalo et al. (06),

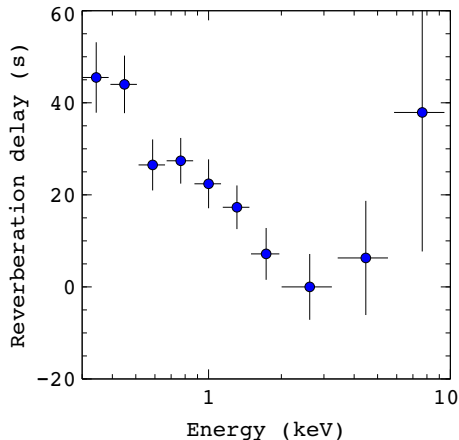
## Similarities between GBH and AGN.

1H0707-495 at low frequencies: **Similar to BHB**



## Low vs High frequency lags.

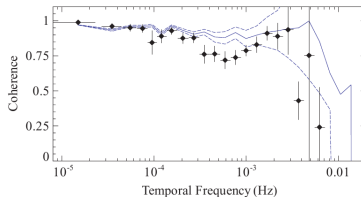
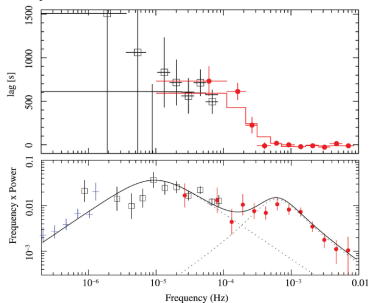
1H0707-495 at high frequencies: **different**





# Lags in BH binaries.

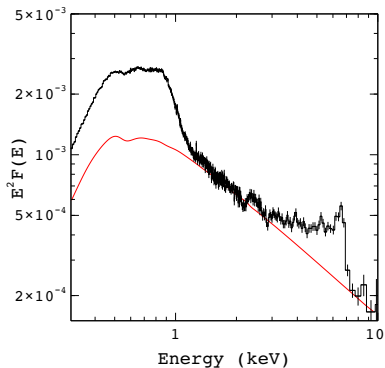
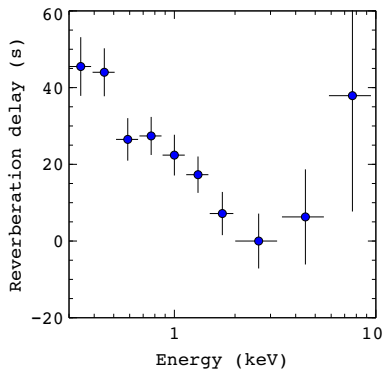
There are **two** component of variability at low and high frequencies.



McHardy et al. (07), Zoghbi et al (10)

## High frequency lags and the energy spectrum.

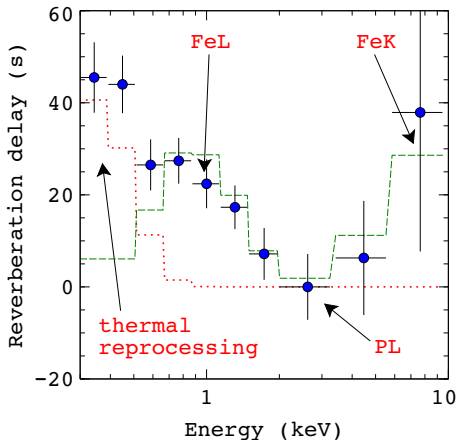
To understand it we need the spectrum.



Fabian et al. (09), Zoghbi et al. (10,11)

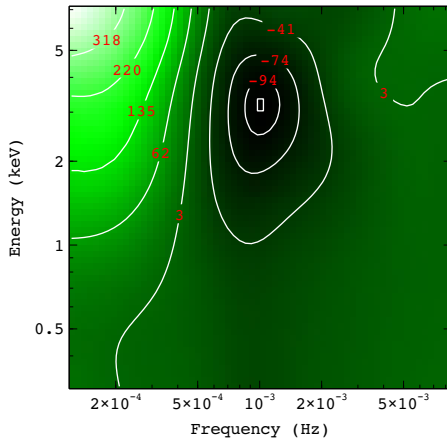
## Modelling the high frequency lags.

The lag spectrum matches the spectrum very well.



## Energy-frequency plot.

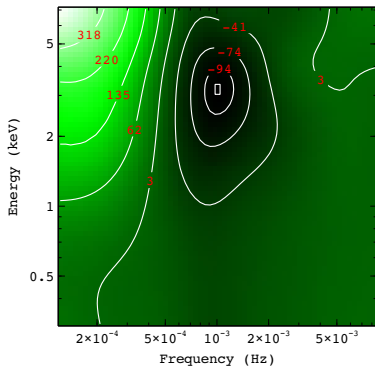
Another way of looking at it.



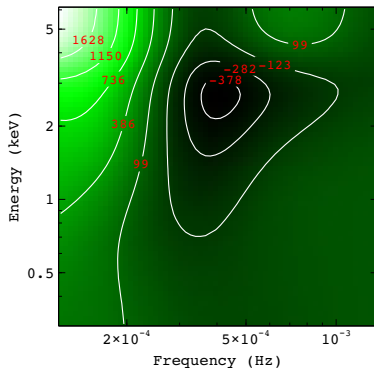
## Energy-frequency plot.

1H0707 is not the only source.

1H0707-495



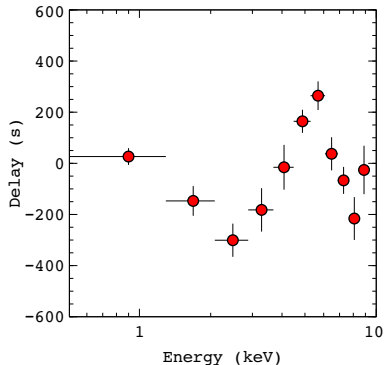
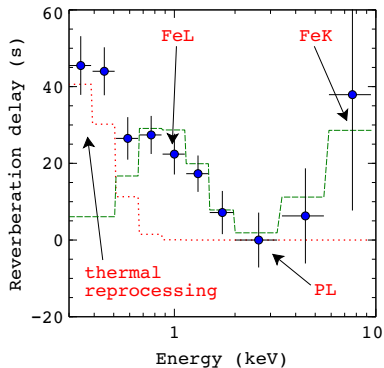
RE J1034+396



Zoghbi et al. (11b)

## More on high frequency lags.

1H0707 is not the only source. When we have better data ...



Zoghbi et al. (in prep.)

## Conclusion.

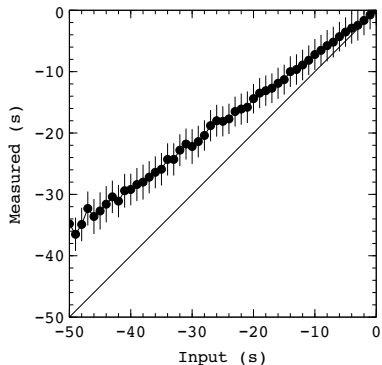
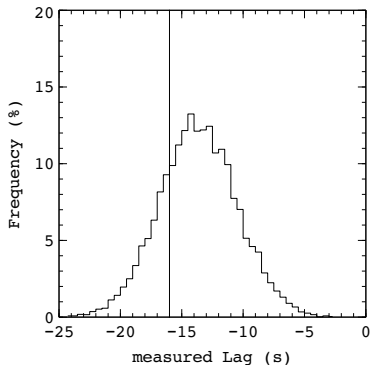
- From GBH: Low frequency lags are in the Comptonization component and **not** the distant reflection.
- The **same** low frequency component is present in AGN.
- In AGN, there is also **another** high frequency variability component with characteristic frequencies of few  $R_g$ , with different lag properties.
- The high-freq component is fully consistent with reverberation in the inner few  $R_g$ .

Lags in Galactic black holes?  
Low frequency lags in AGN  
High frequency lags in AGN  
**Conclusion**



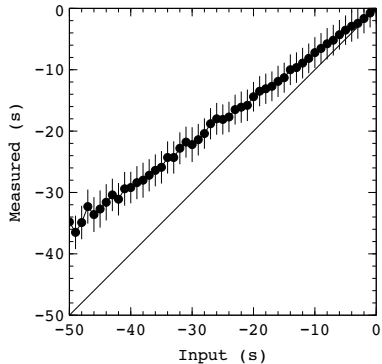
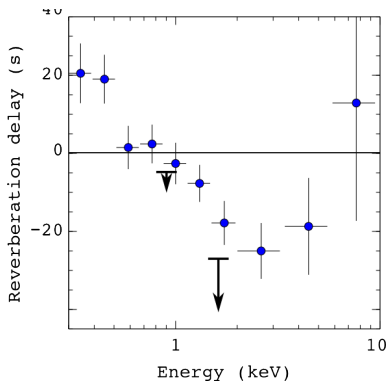
Lags in Galactic black holes?  
Low frequency lags in AGN  
High frequency lags in AGN  
**Conclusion**

## Statistics and systematics.



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The shape is not altered, but stretched.



# RE J1034+396

