

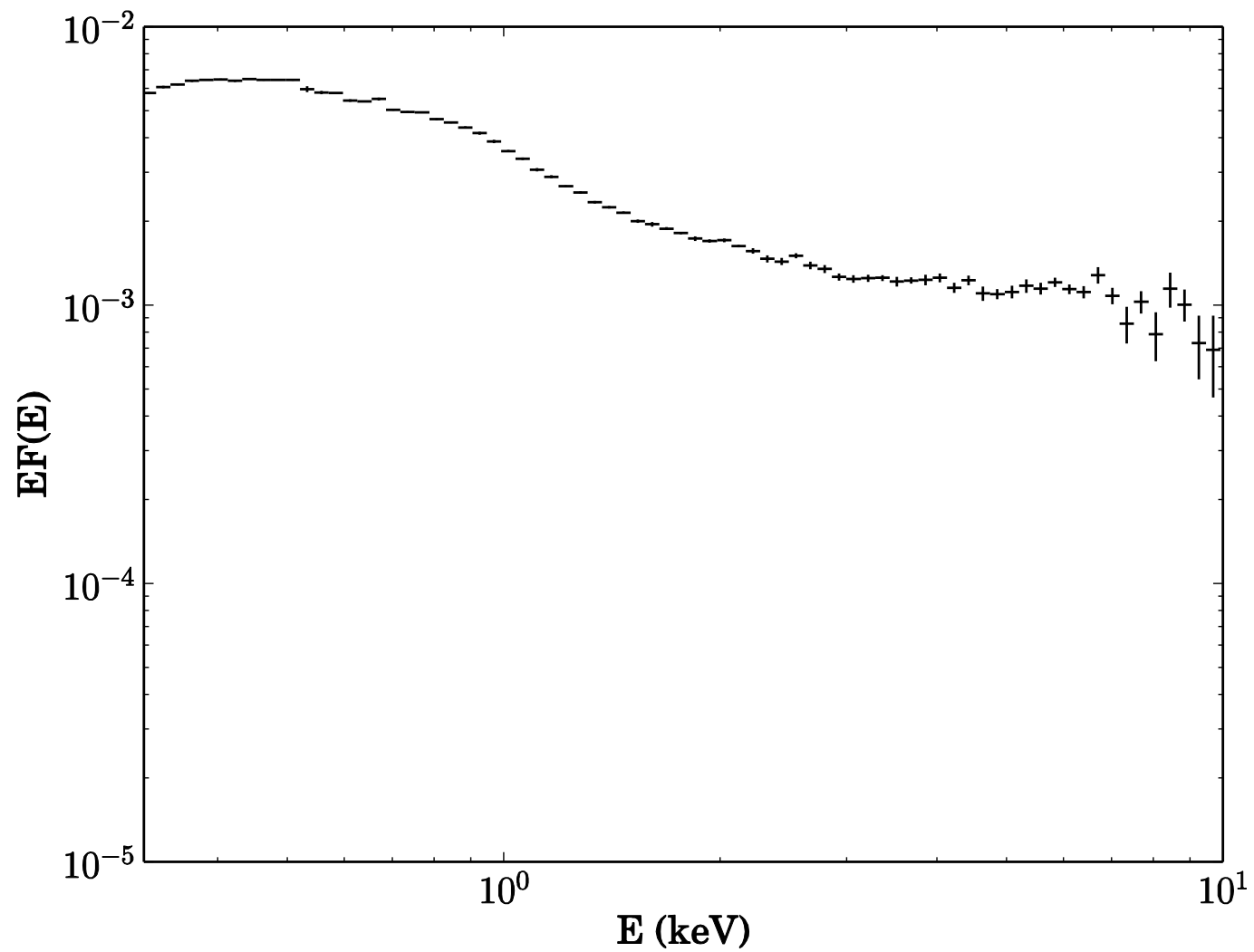
A Physical Model for the X-ray Time Lags of NLS1s

Emma Gardner & Chris Done

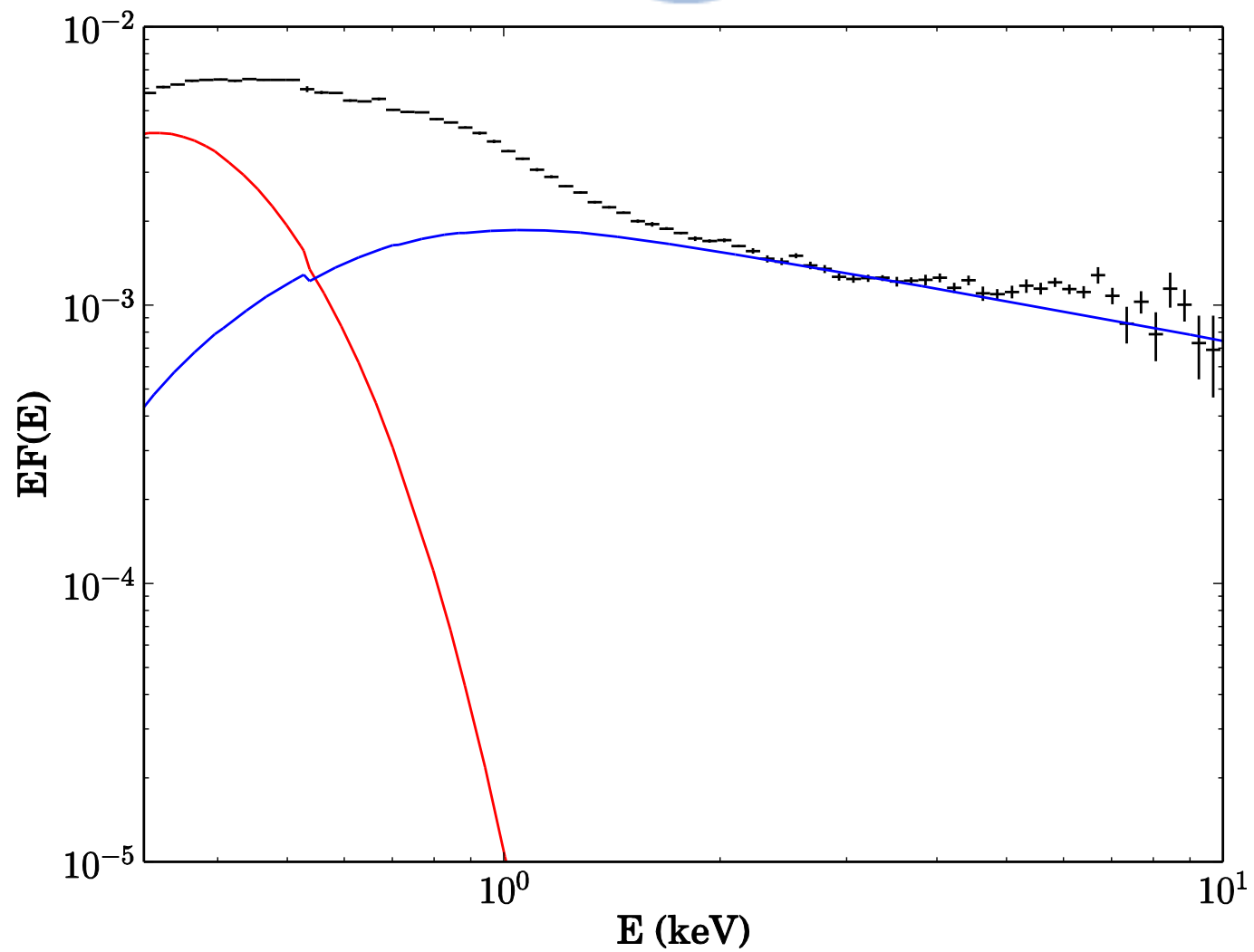
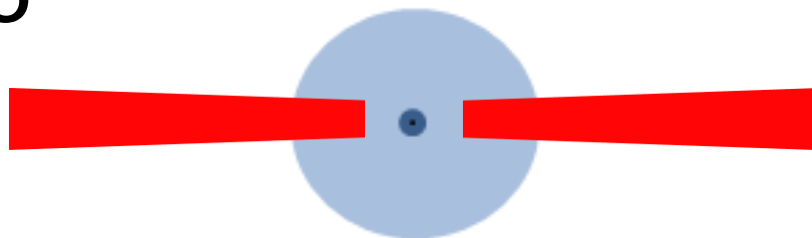
Durham University



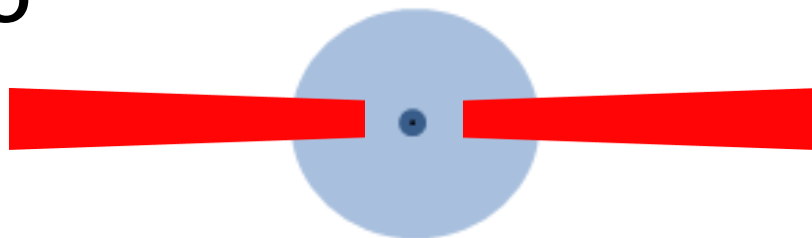
PG1244+026



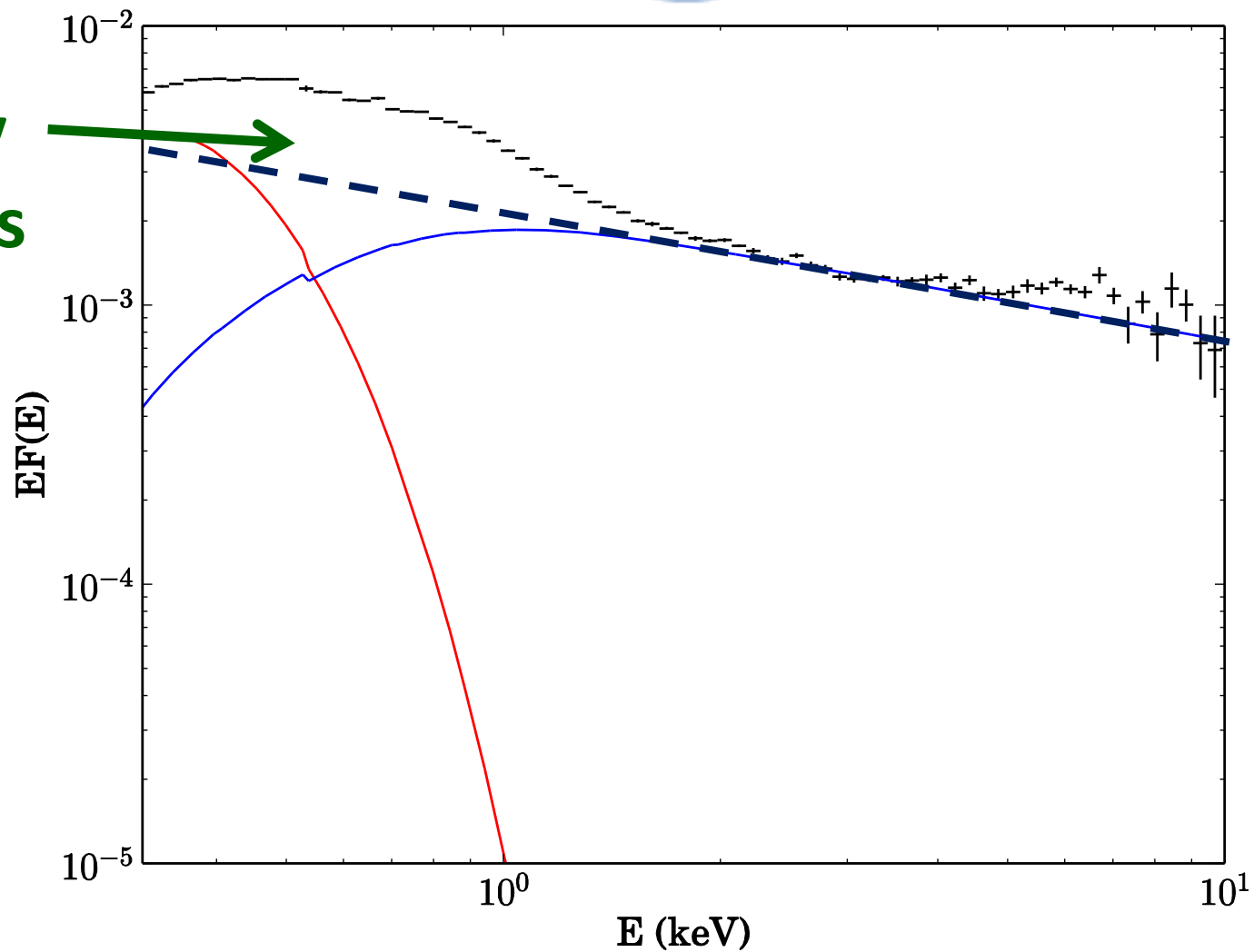
PG1244+026



PG1244+026

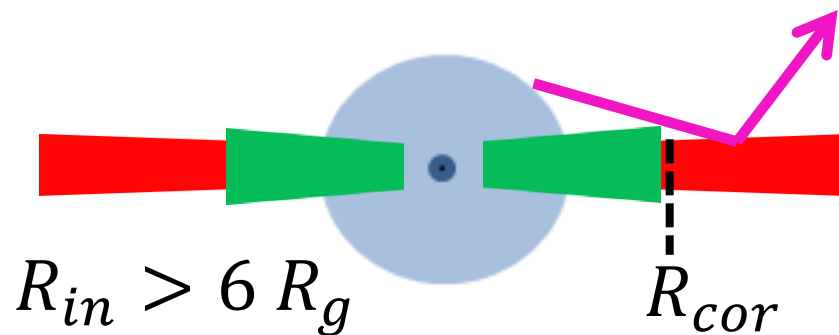
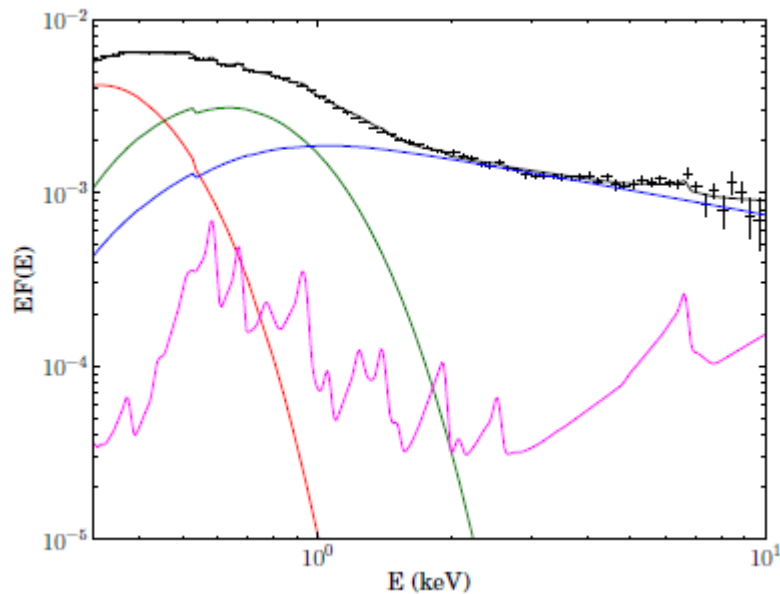


**Soft
X-ray
Excess**



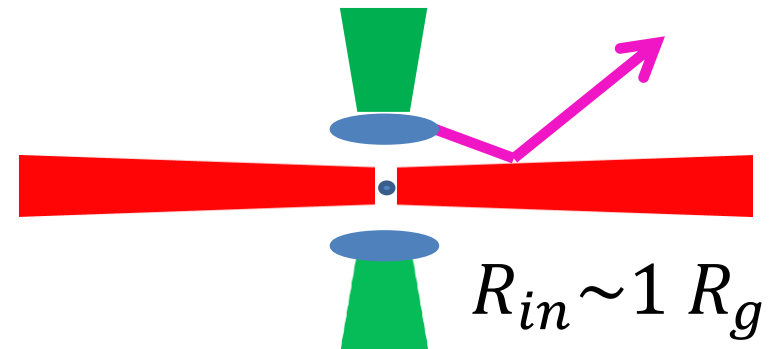
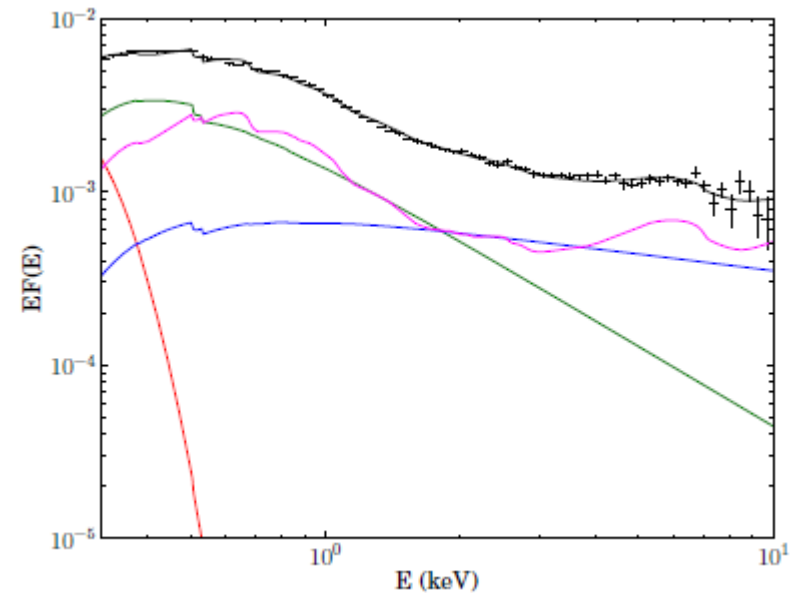
Soft Excess Model

eg. Jin et al 2013



Reflection Model

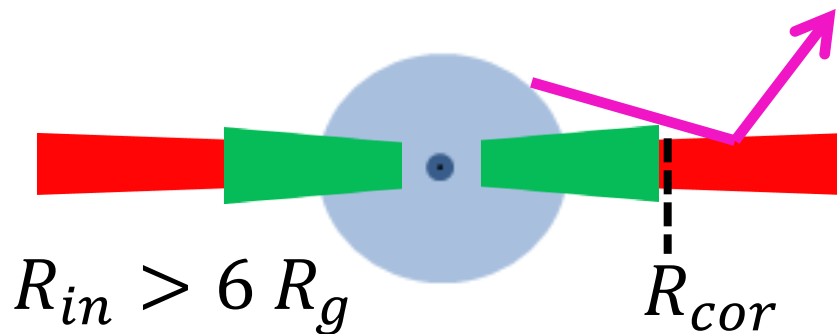
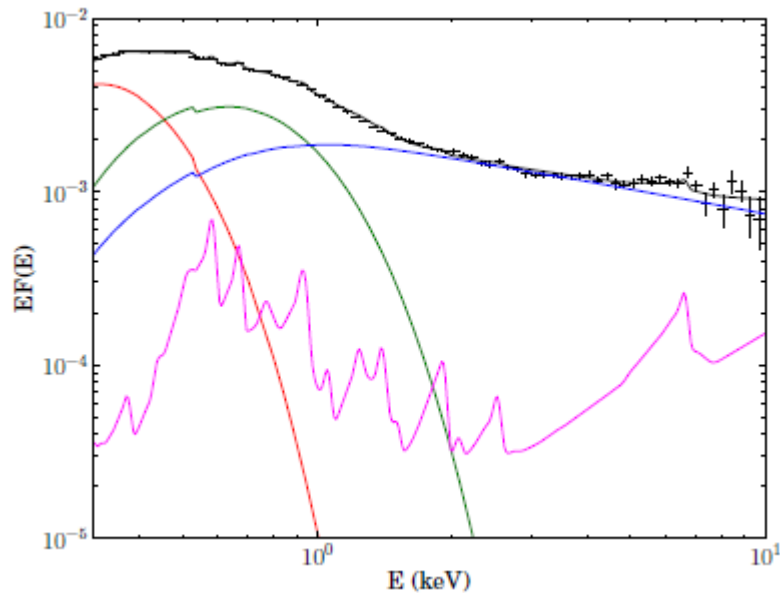
eg. Kara et al 2014



Spectra are degenerate – use timing to distinguish

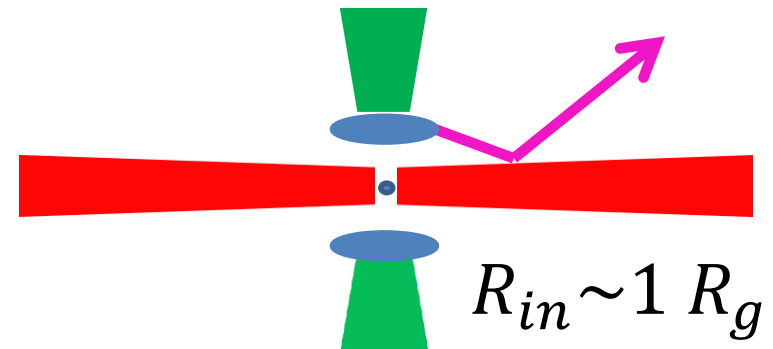
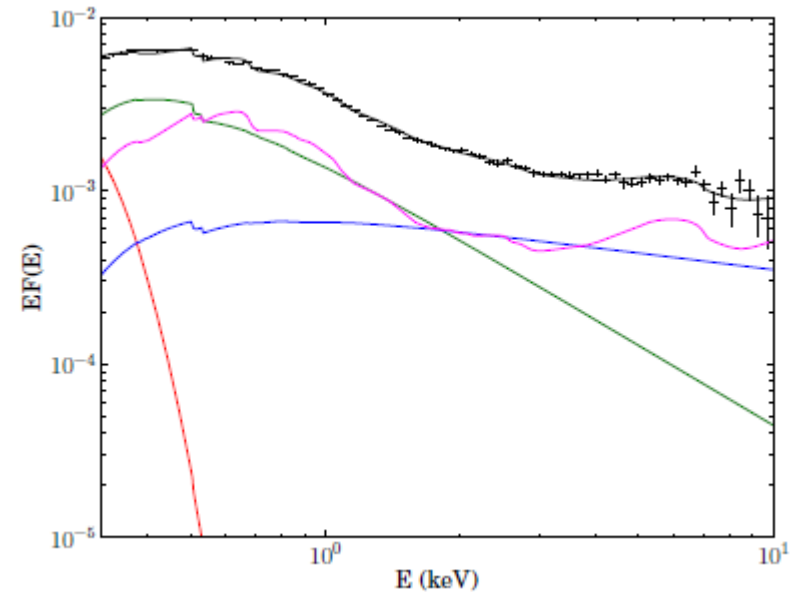
Soft Excess Model

eg. Jin et al 2013



Reflection Model

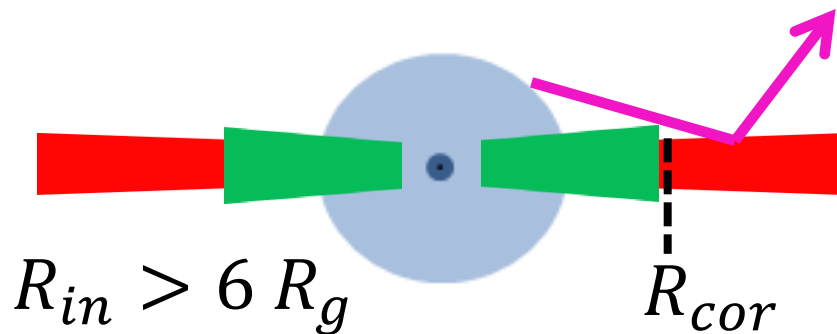
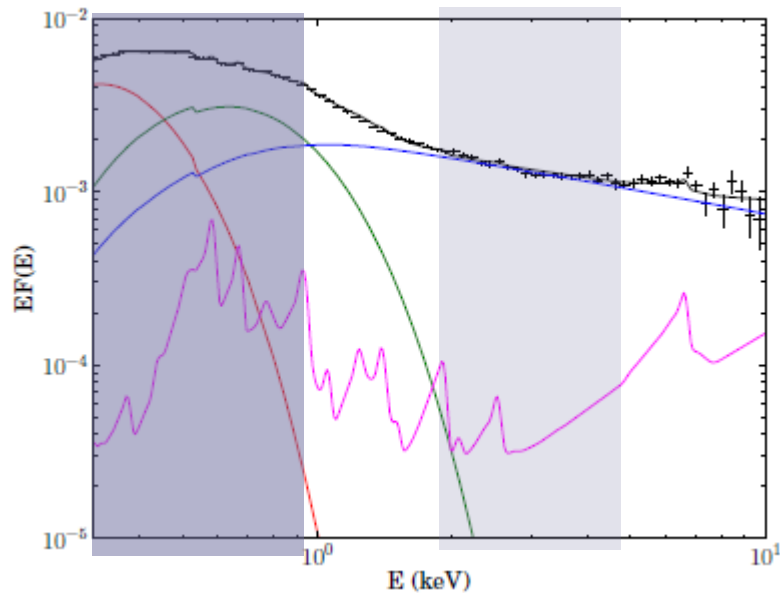
eg. Kara et al 2014



Spectra are degenerate – use timing to distinguish

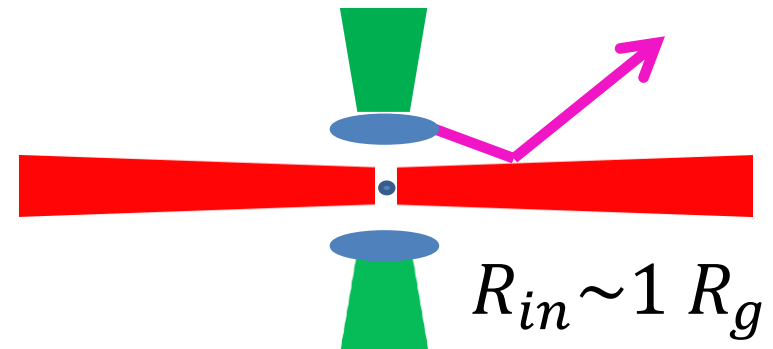
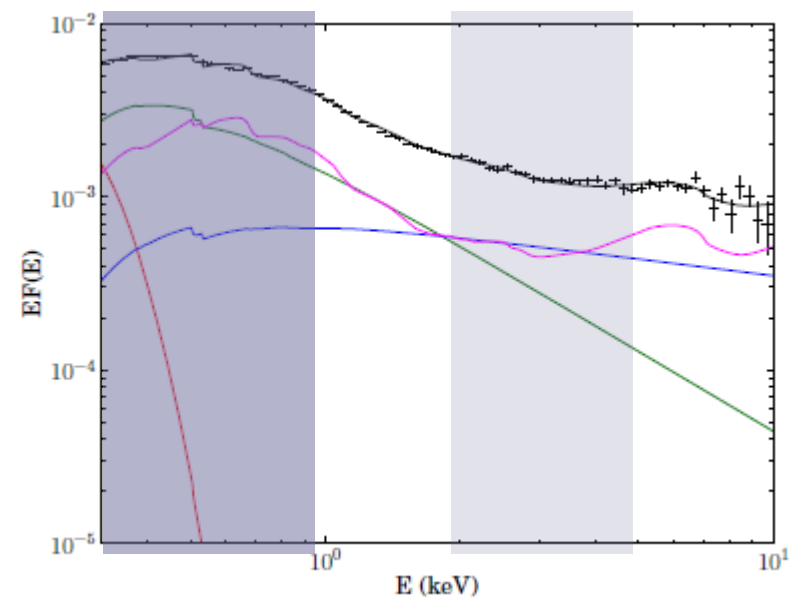
Soft Excess Model

eg. Jin et al 2013

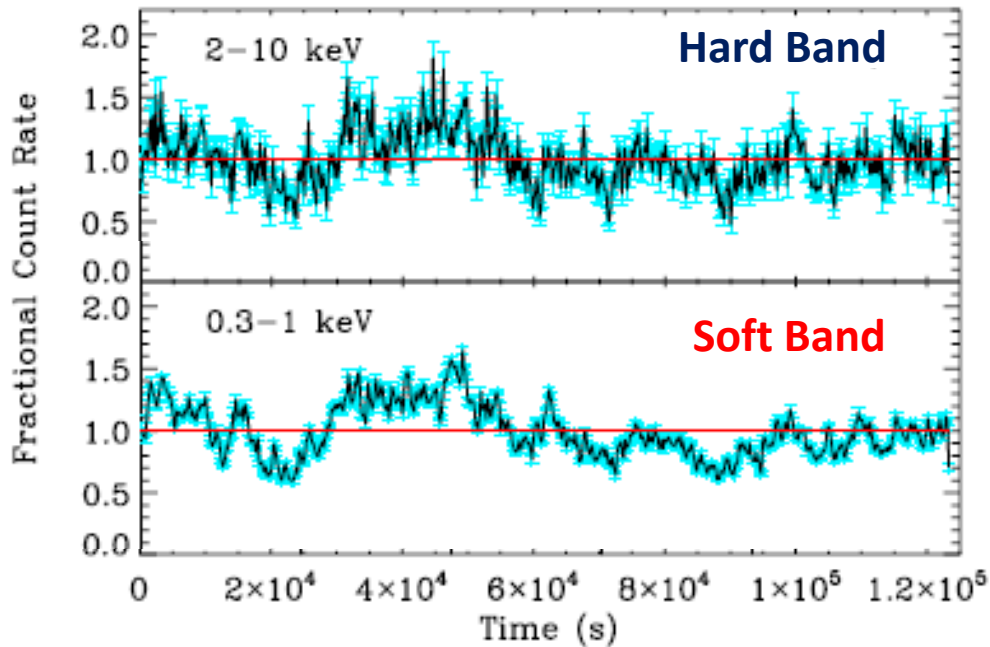


Reflection Model

eg. Kara et al 2014

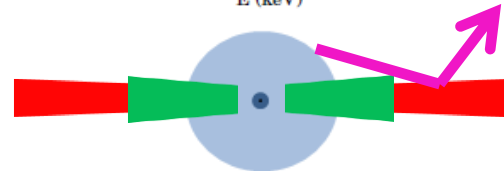
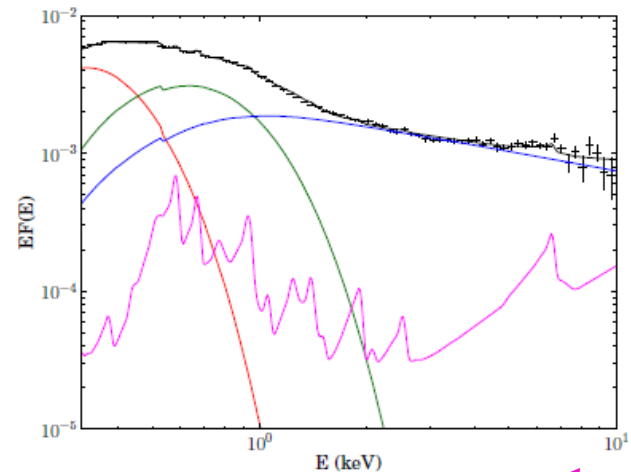


Variability in PG1244

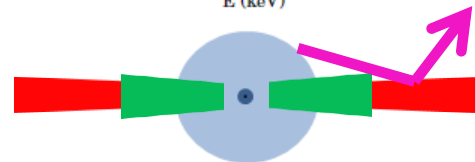
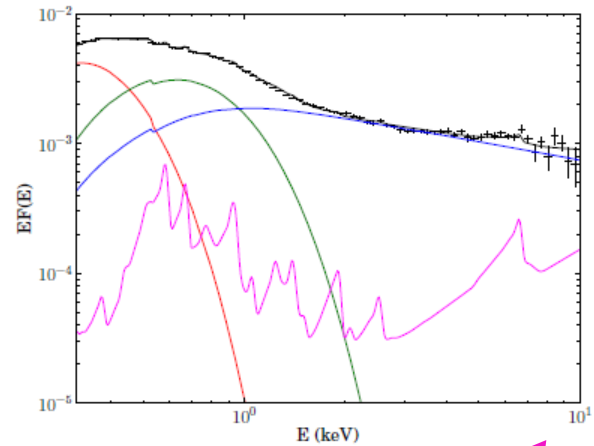
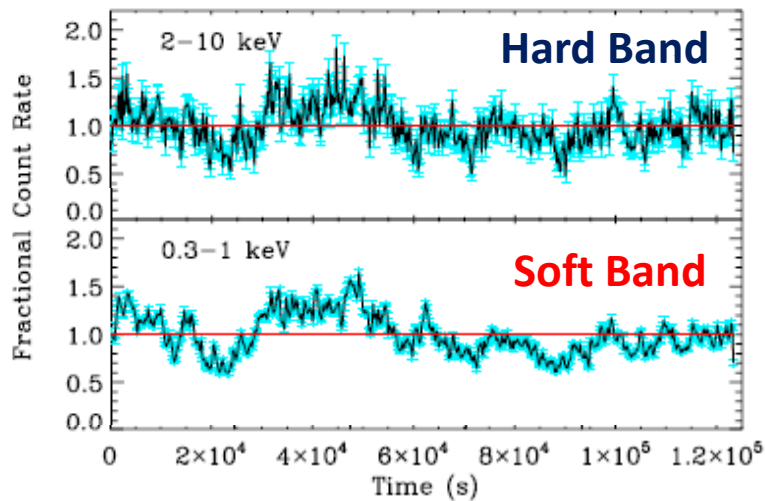
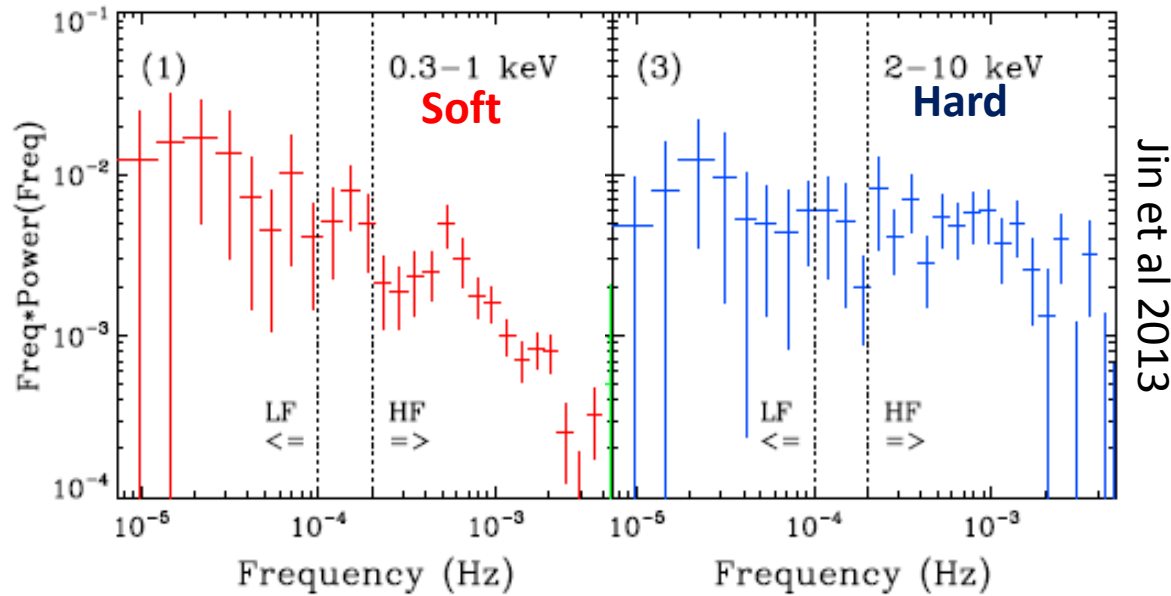


Jin et al 2013

- **Soft energies:** long timescale variability i.e. **low frequencies**.
- **Hard energies:** short timescale variability i.e. **high frequencies**

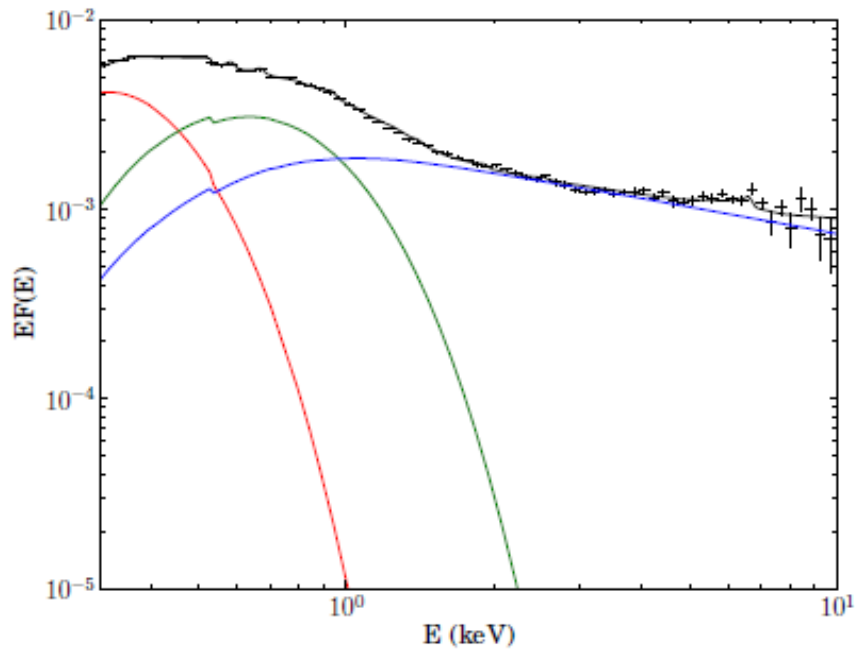


Power Spectra

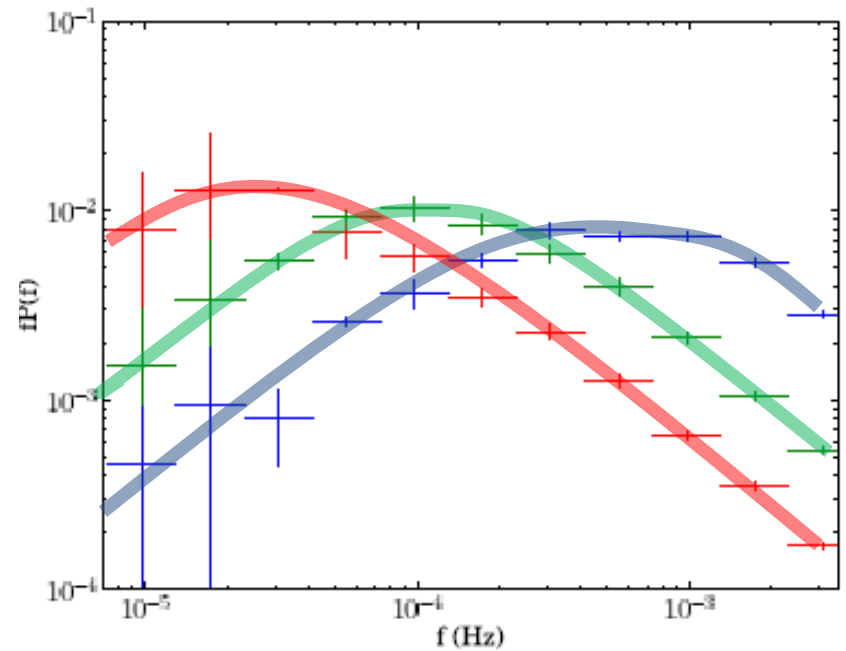


Generating Fluctuations

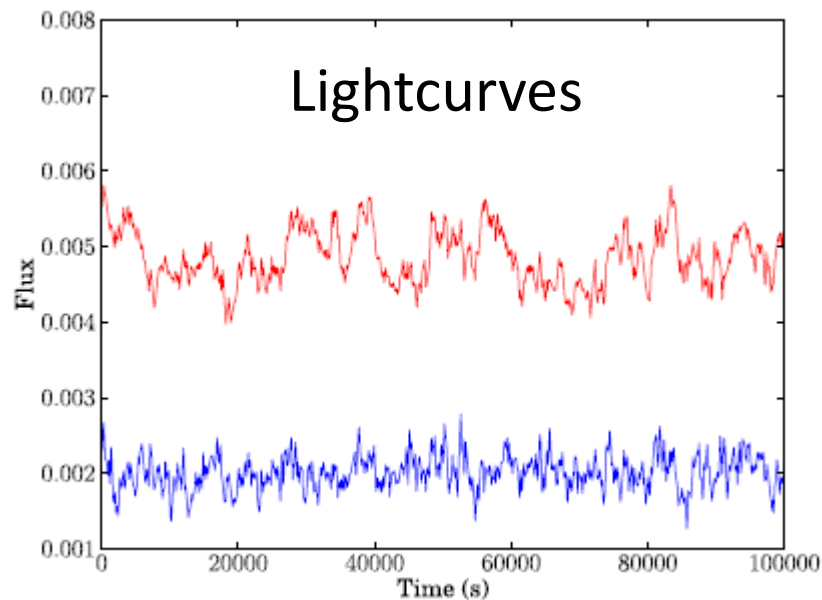
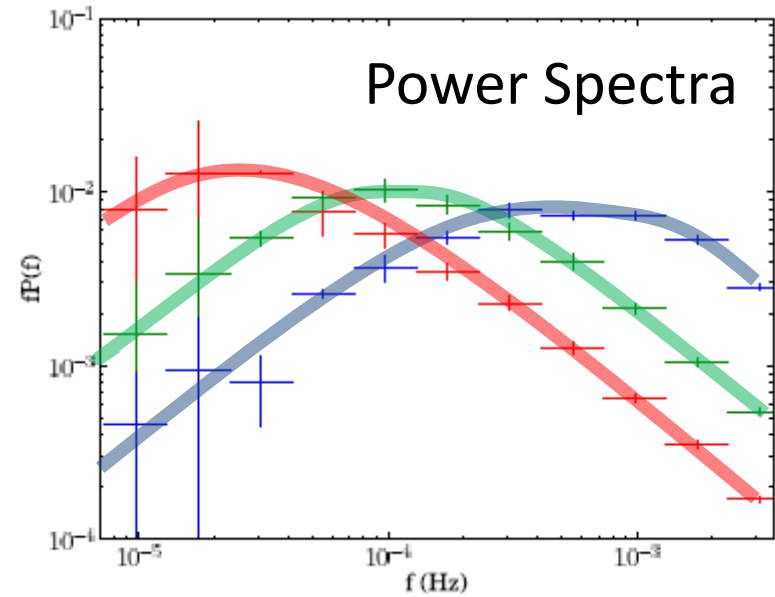
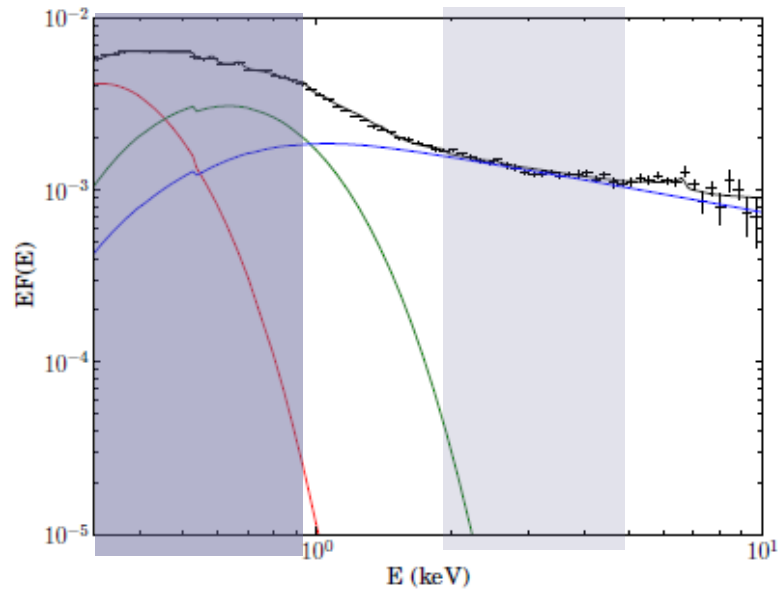
Spectral Components



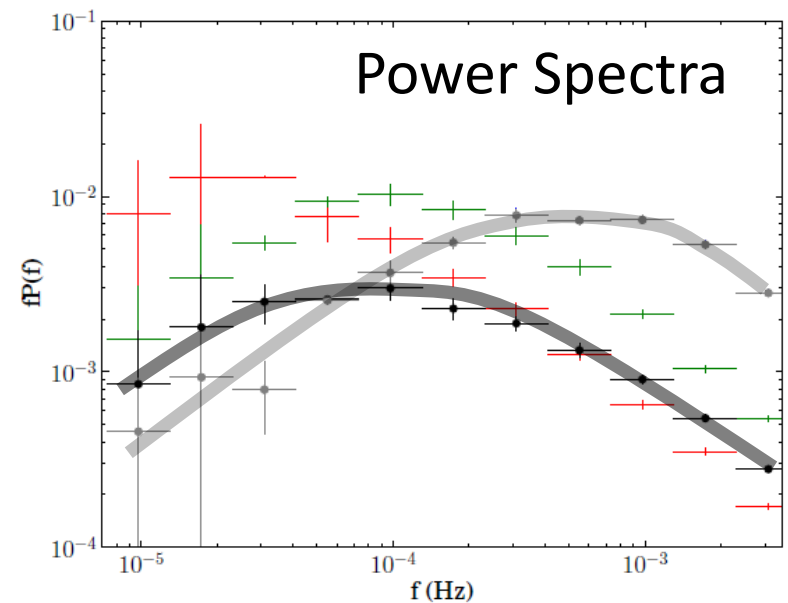
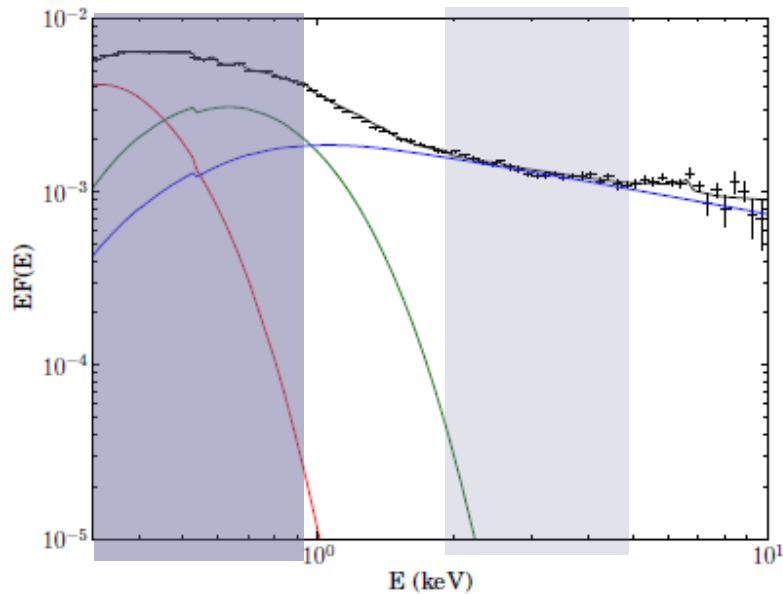
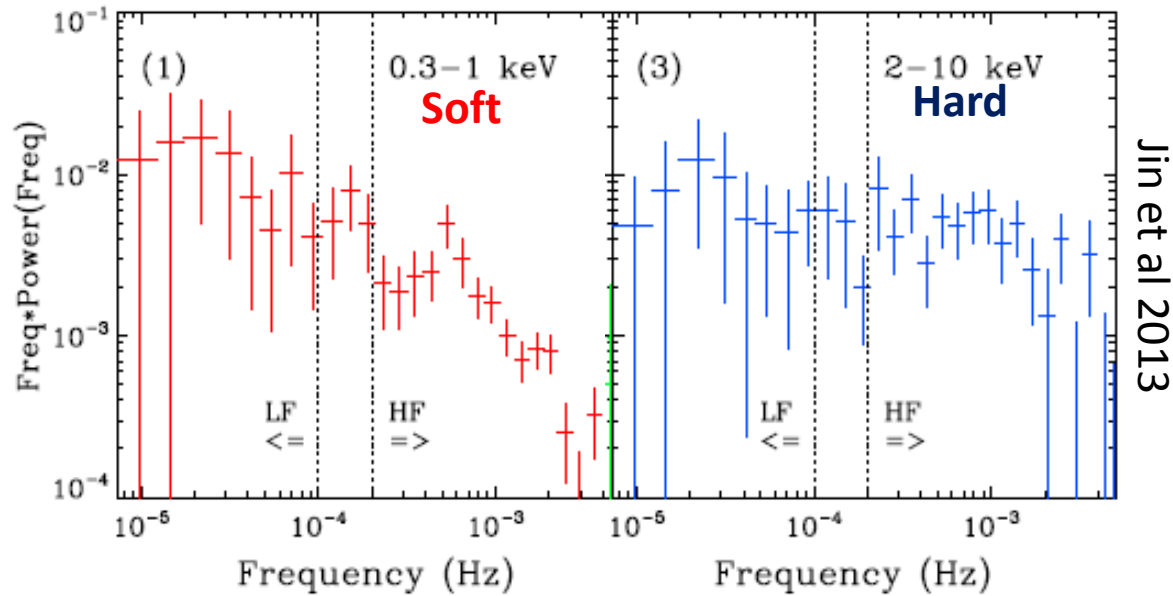
Component Power Spectra



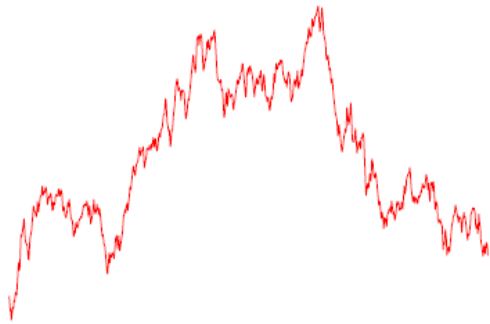
Generating Fluctuations



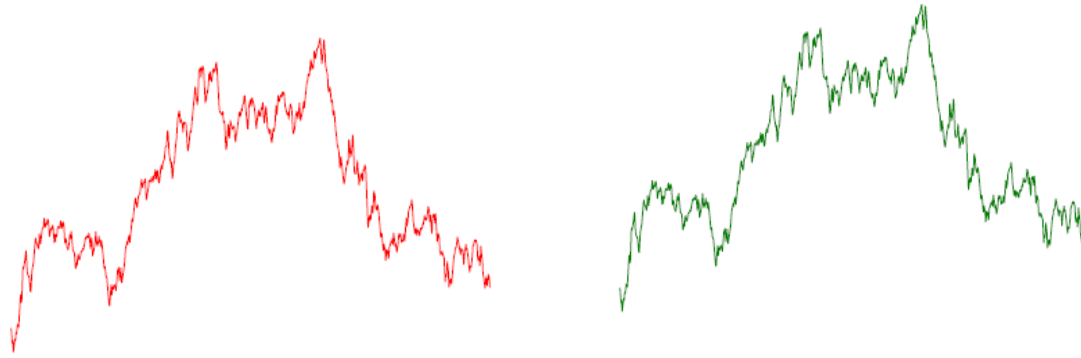
Compare Power Spectra



Propagating Fluctuations



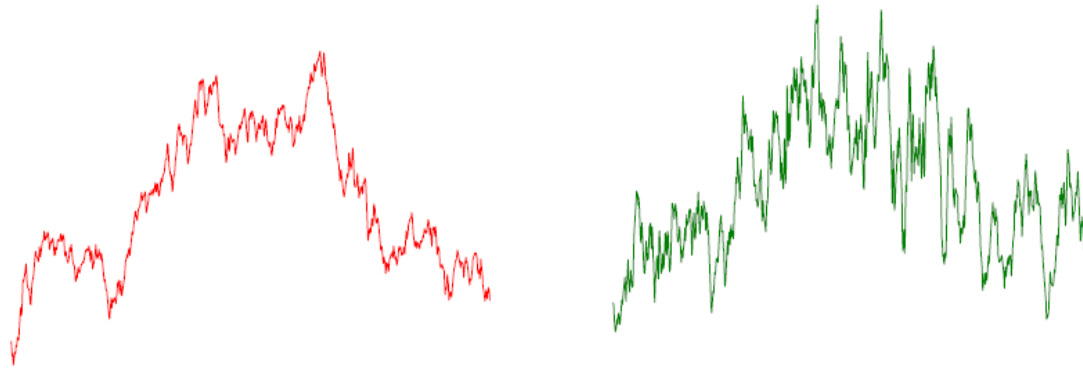
Propagating Fluctuations



$$t_{lag,d \rightarrow s} = 1000s$$



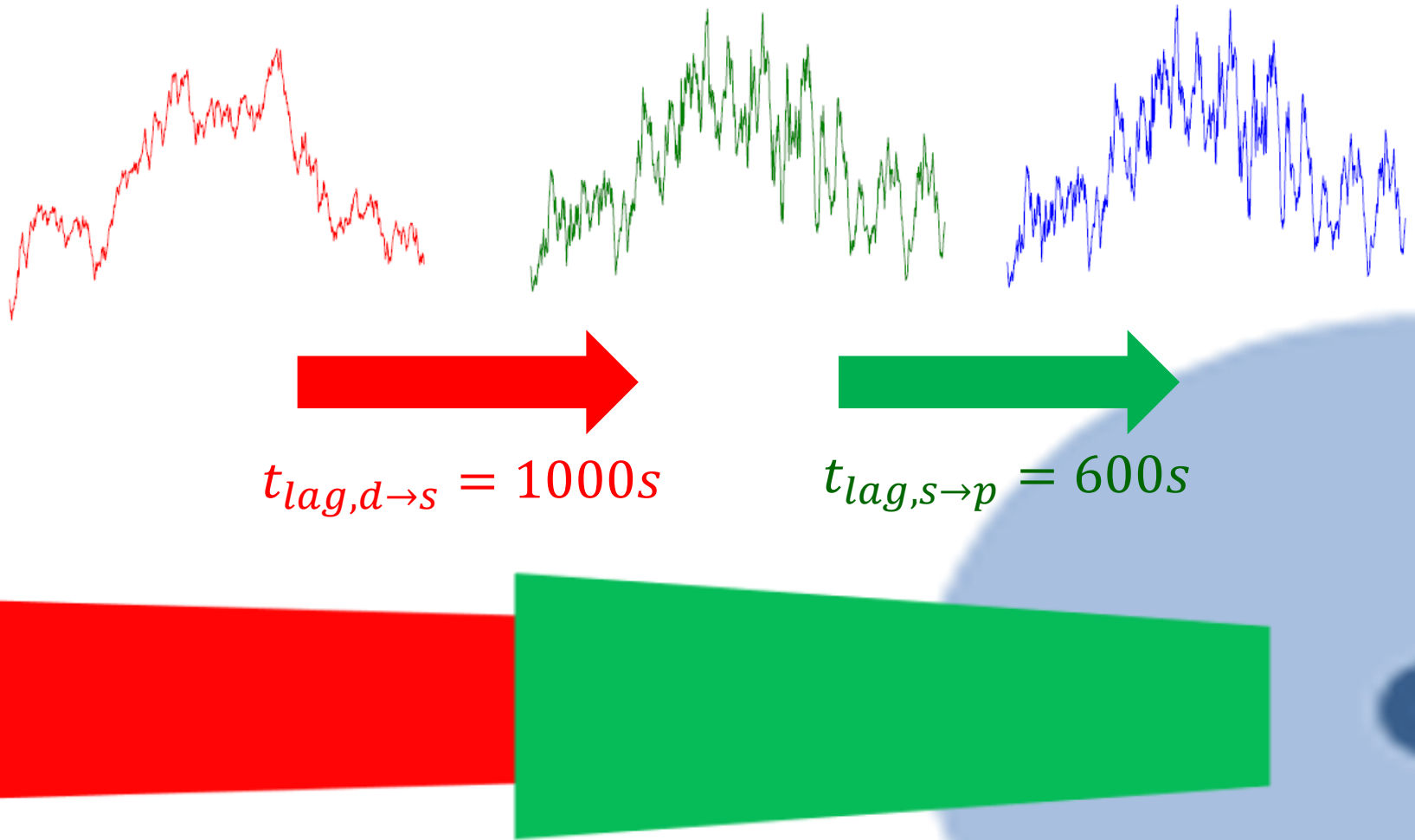
Propagating Fluctuations



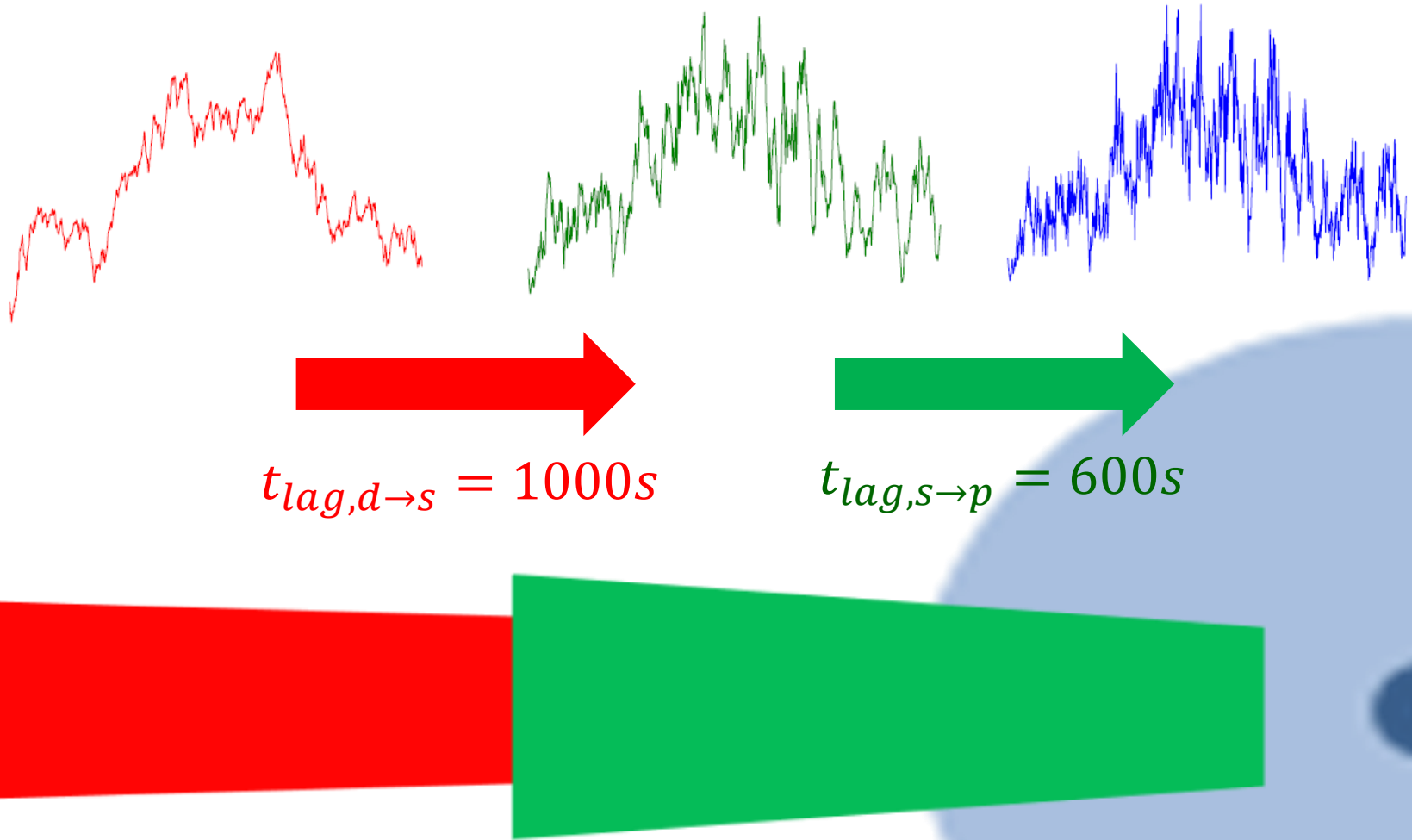
$$t_{lag,d \rightarrow s} = 1000s$$



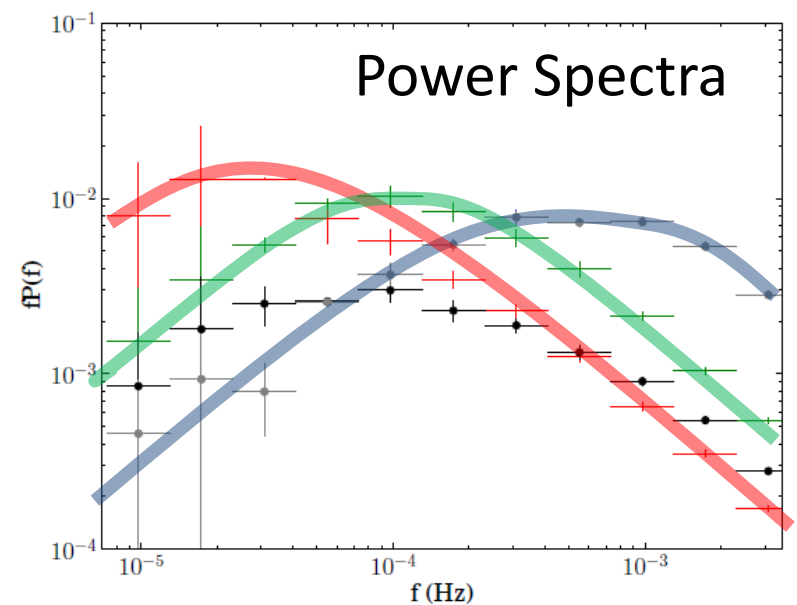
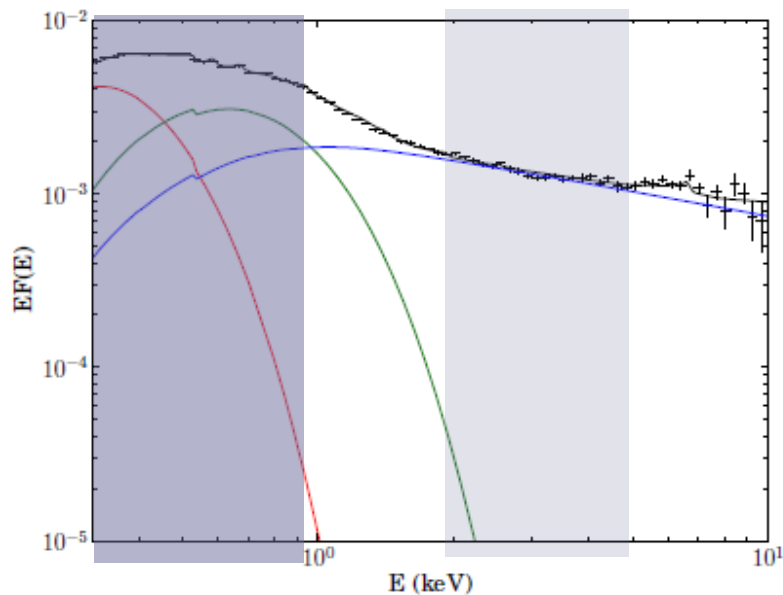
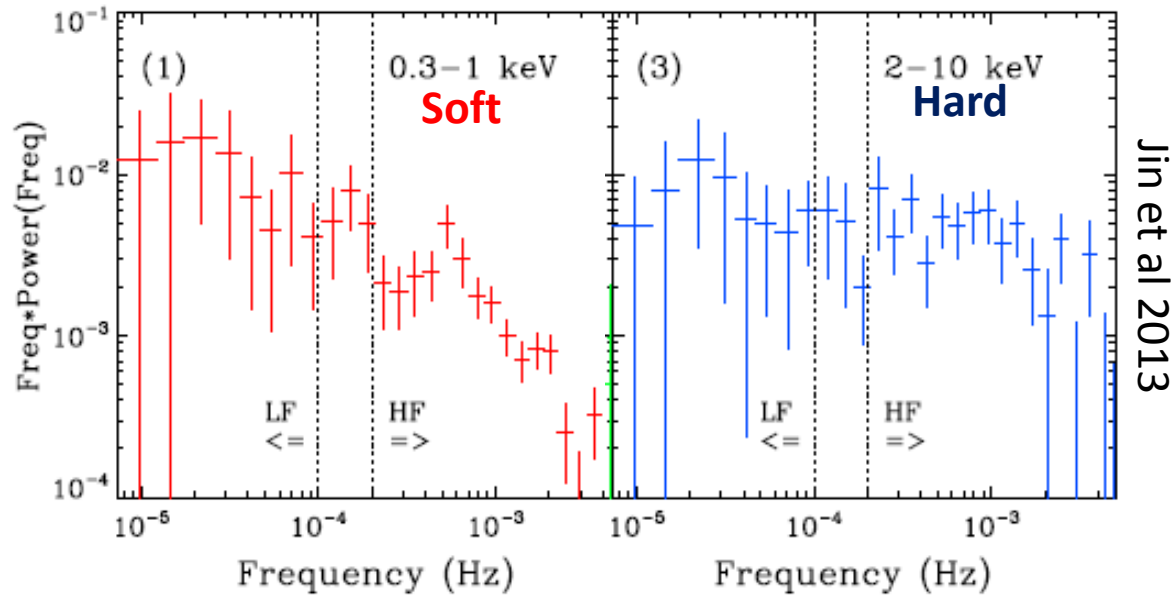
Propagating Fluctuations



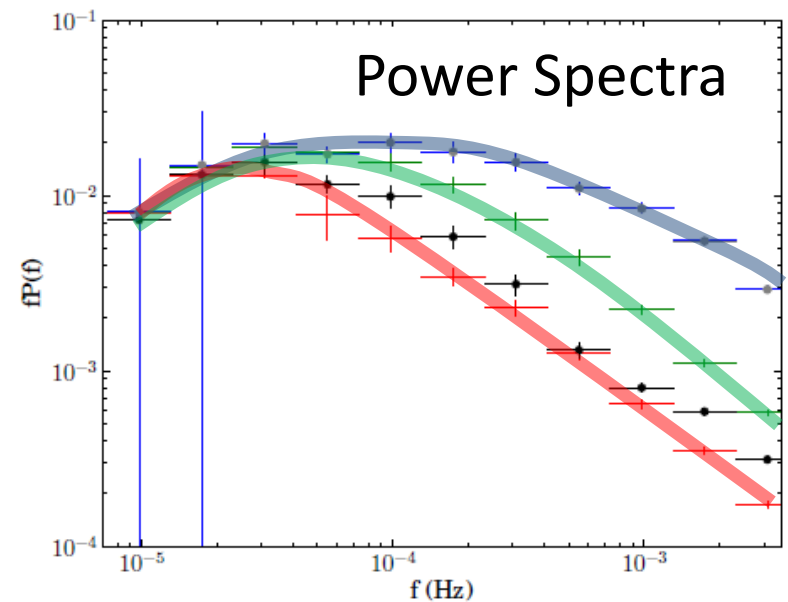
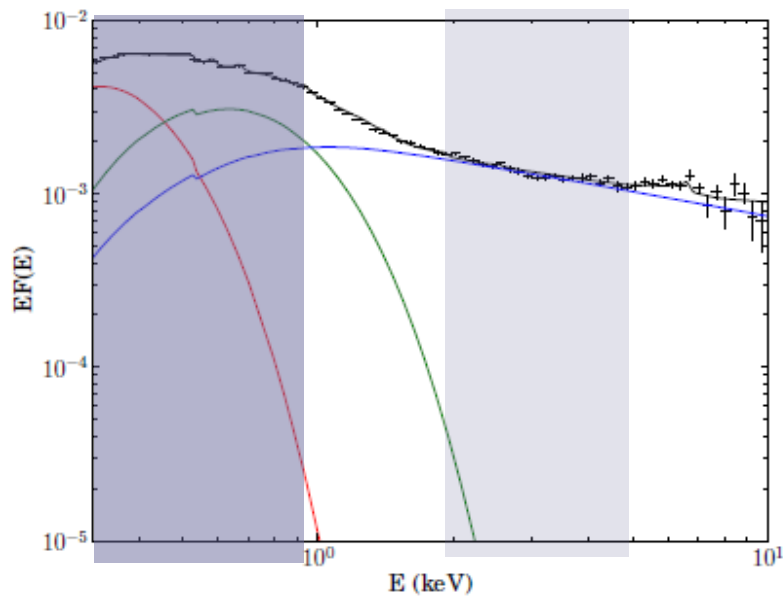
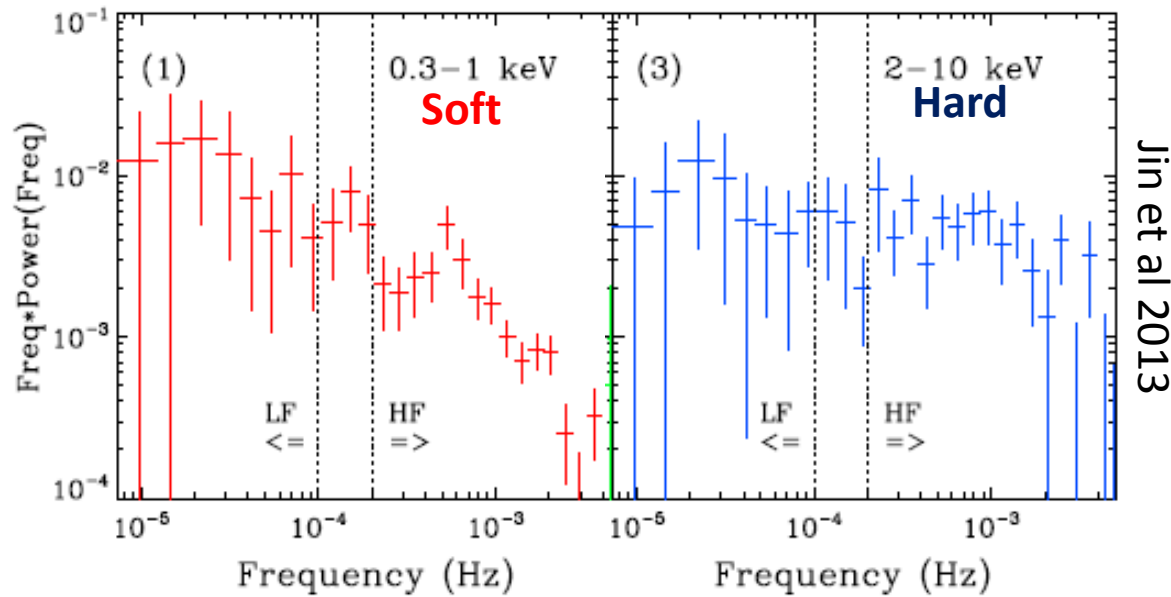
Propagating Fluctuations



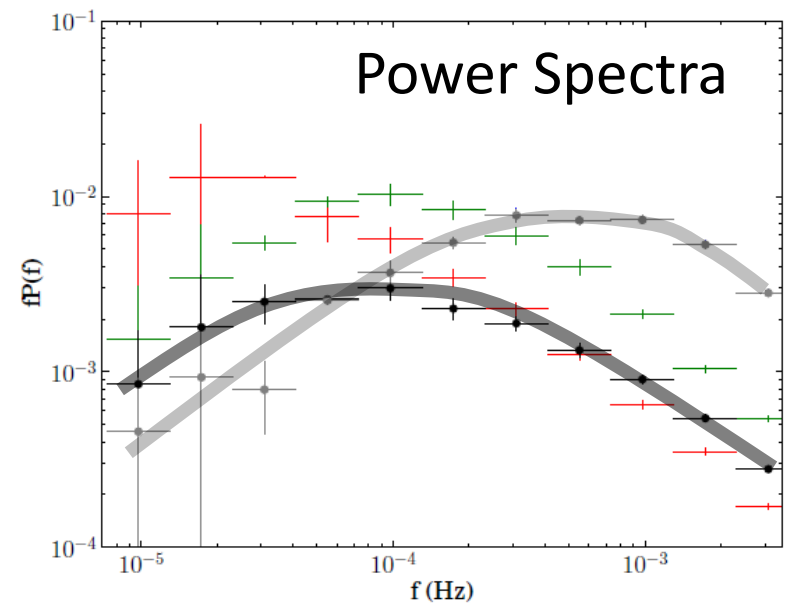
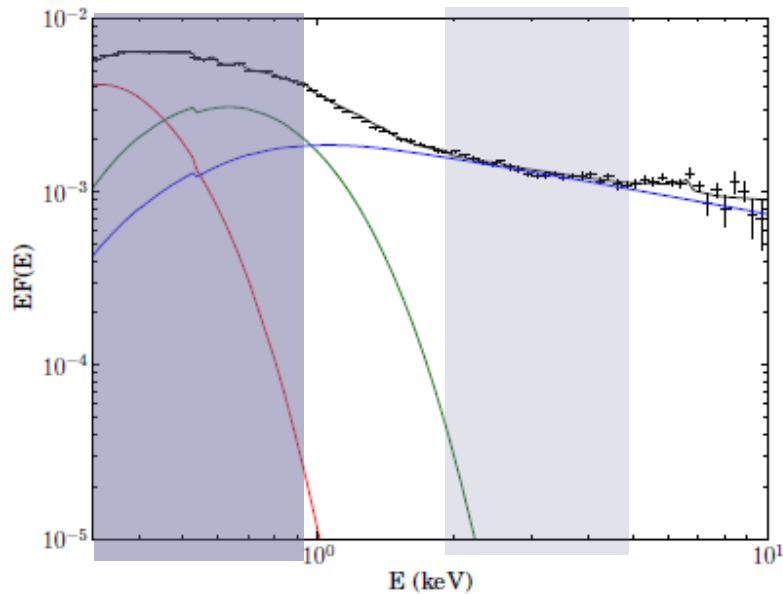
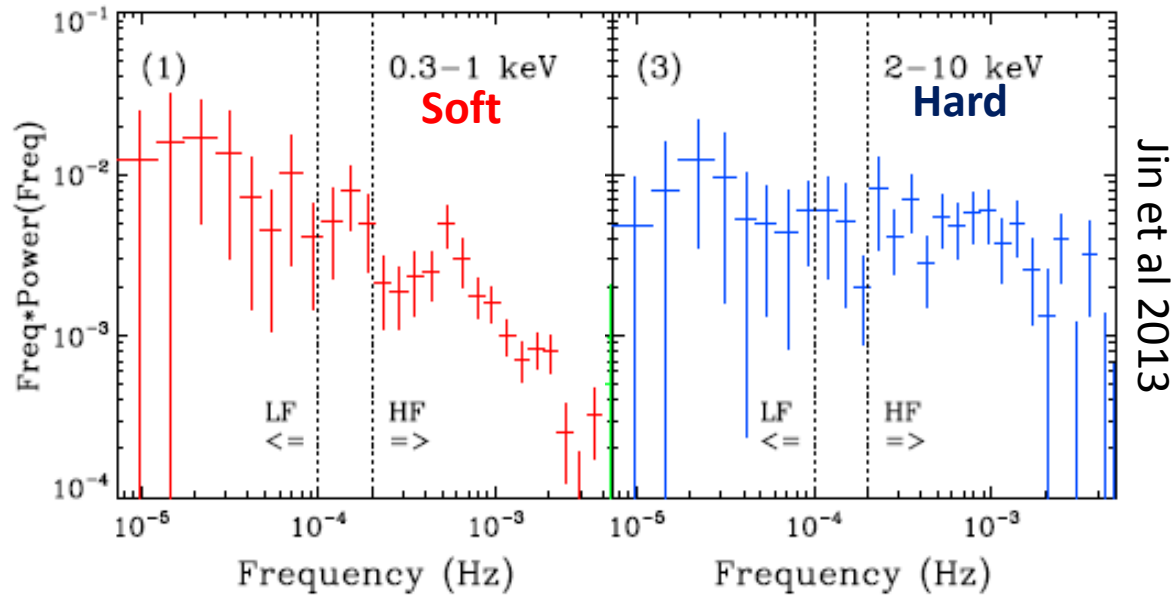
No Propagation



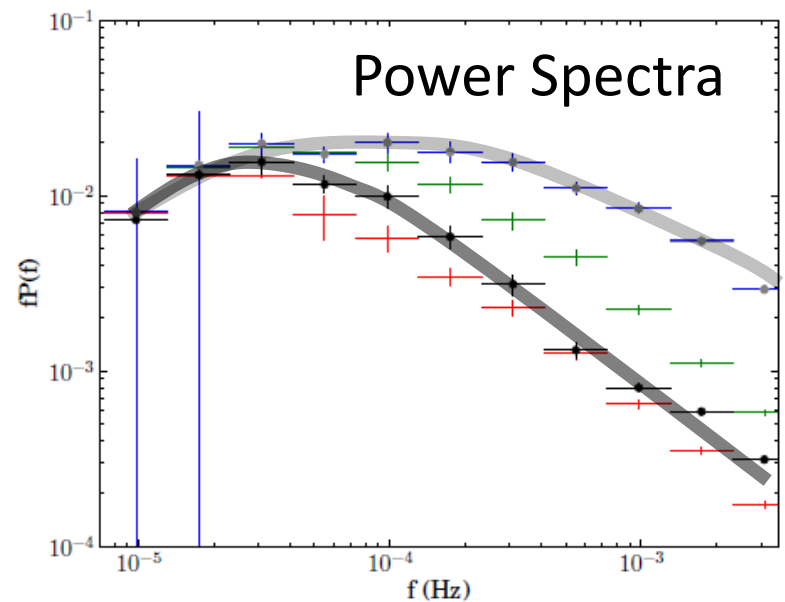
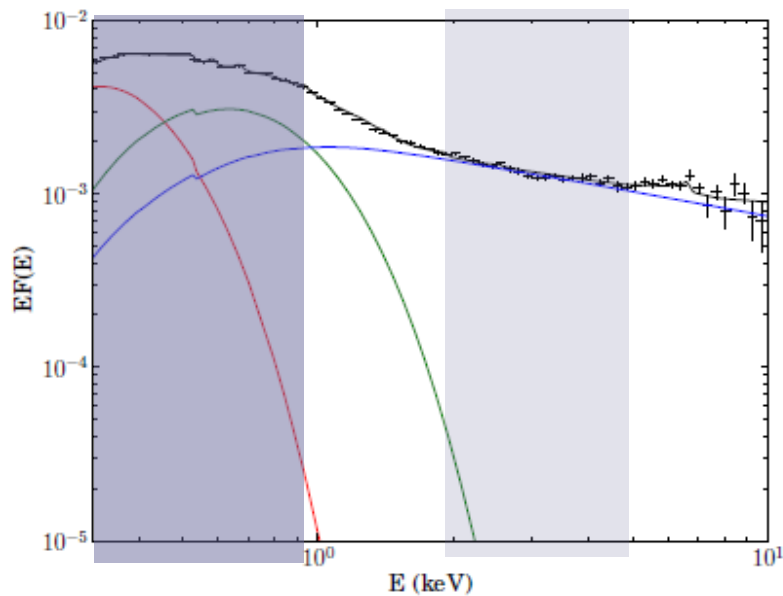
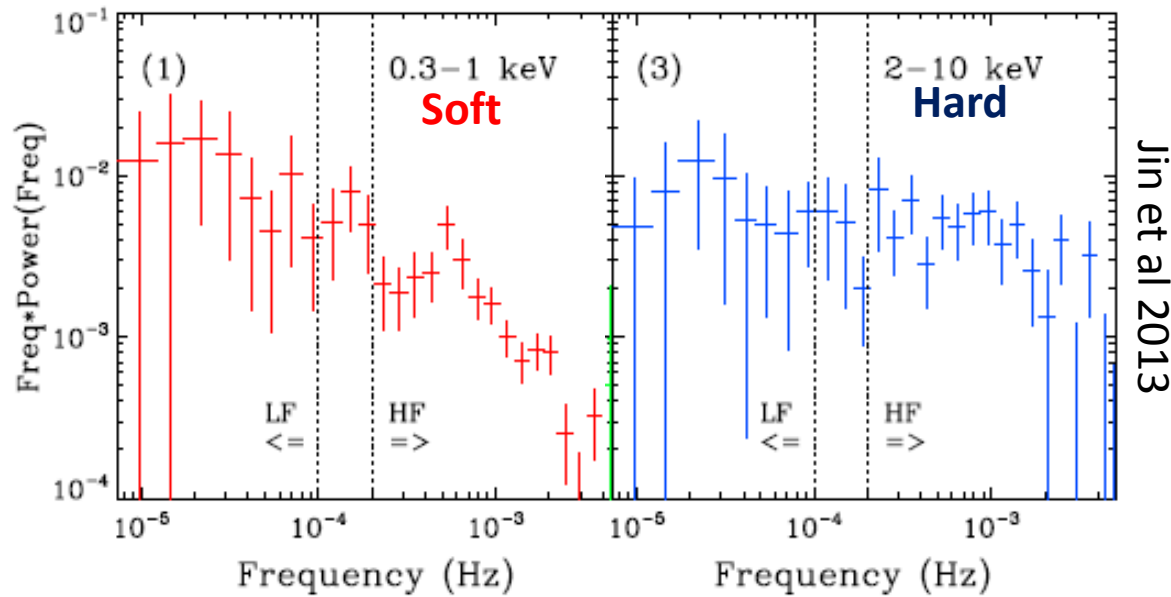
Propagation



No Propagation



Propagation

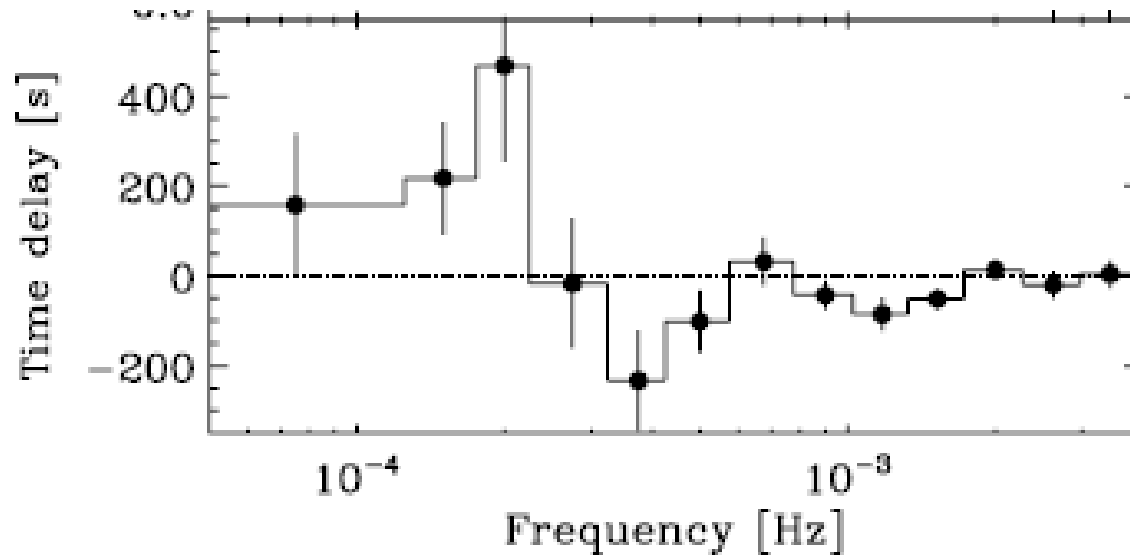


Time Lags between Hard and Soft Bands

Alston et al 2014

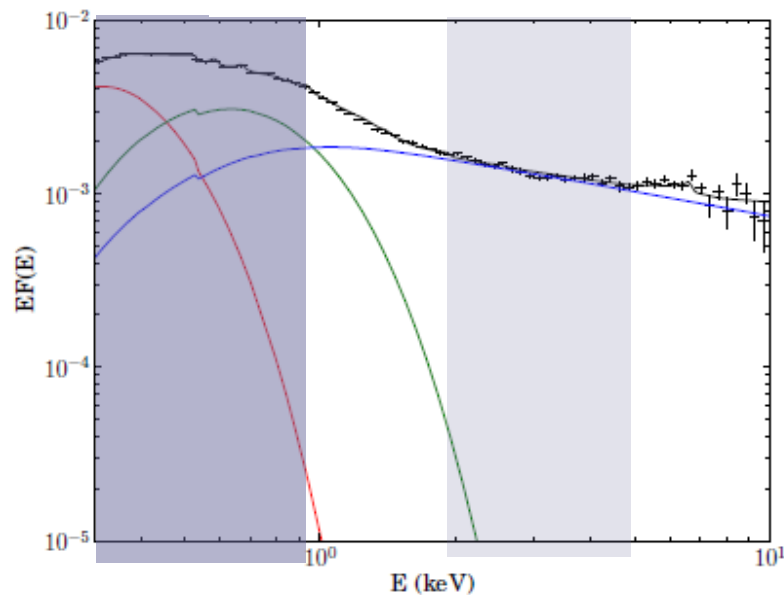
'Hard Lags'

'Soft Lags'



Soft before
Hard

Hard before
Soft



At Low
Frequencies
Hard Lags
Soft

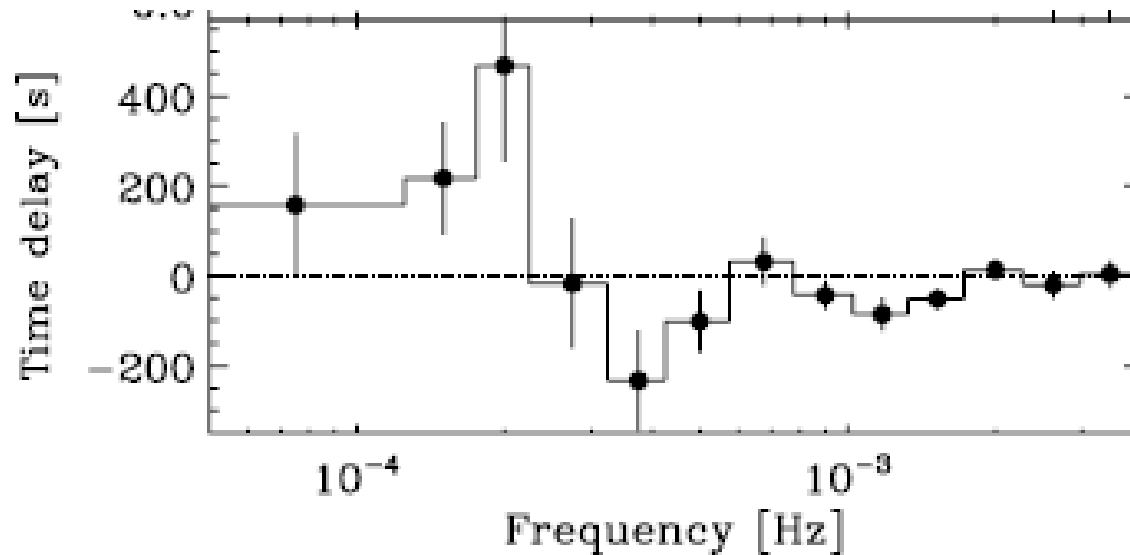


Time Lags between Hard and Soft Bands

Alston et al 2014

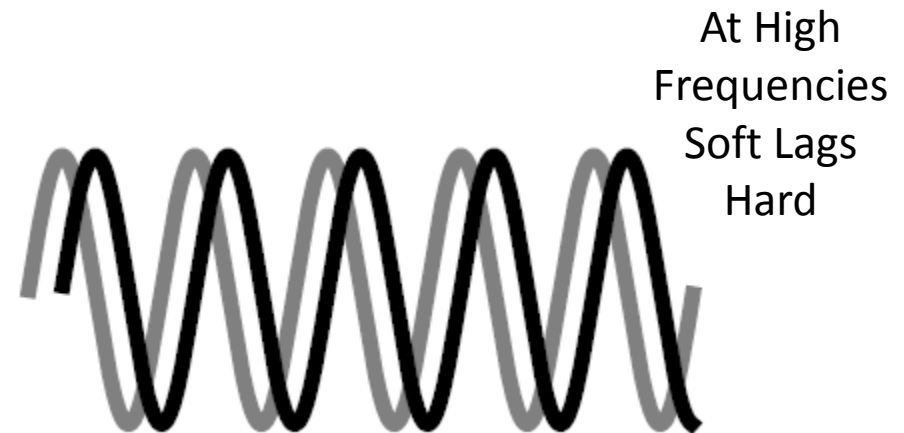
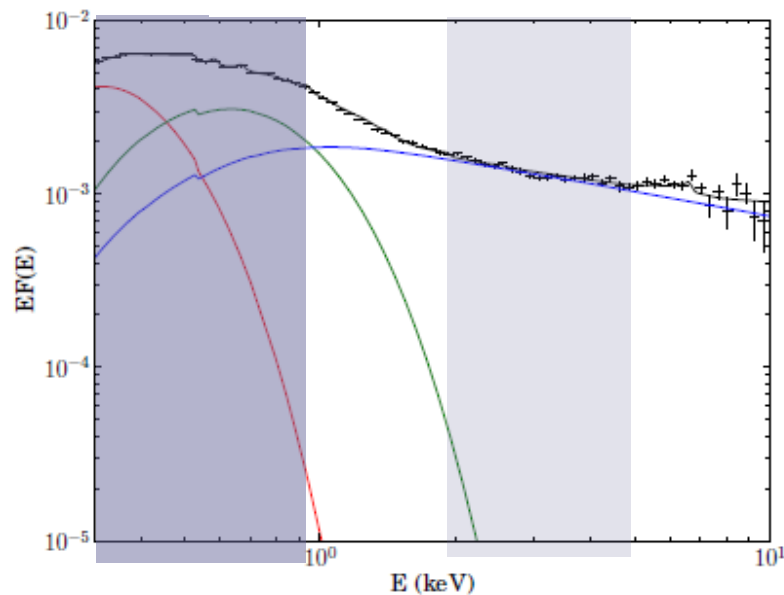
'Hard Lags'

'Soft Lags'



Soft before
Hard

Hard before
Soft

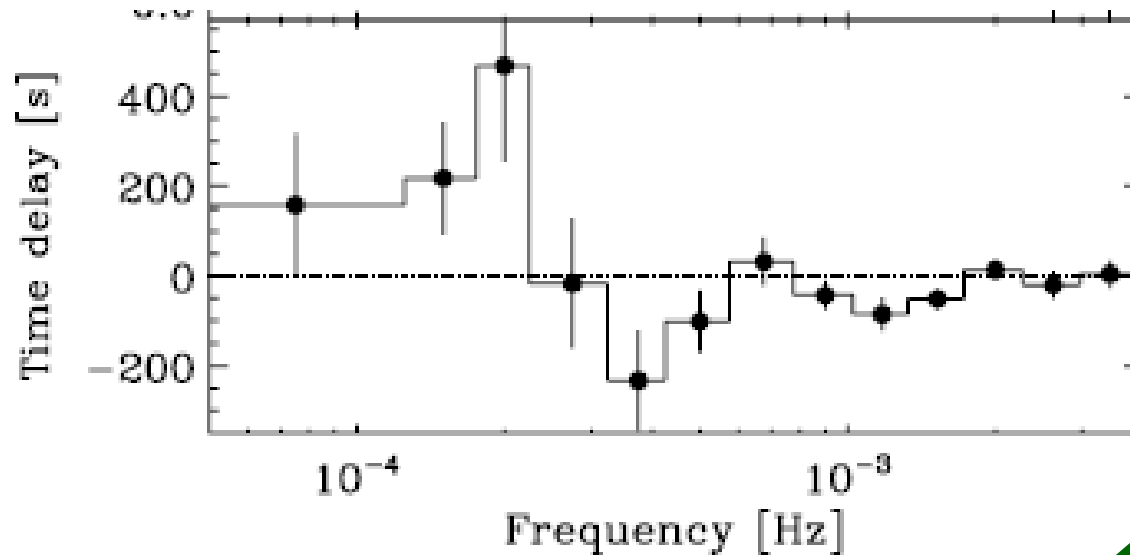


Time Lags between Hard and Soft Bands

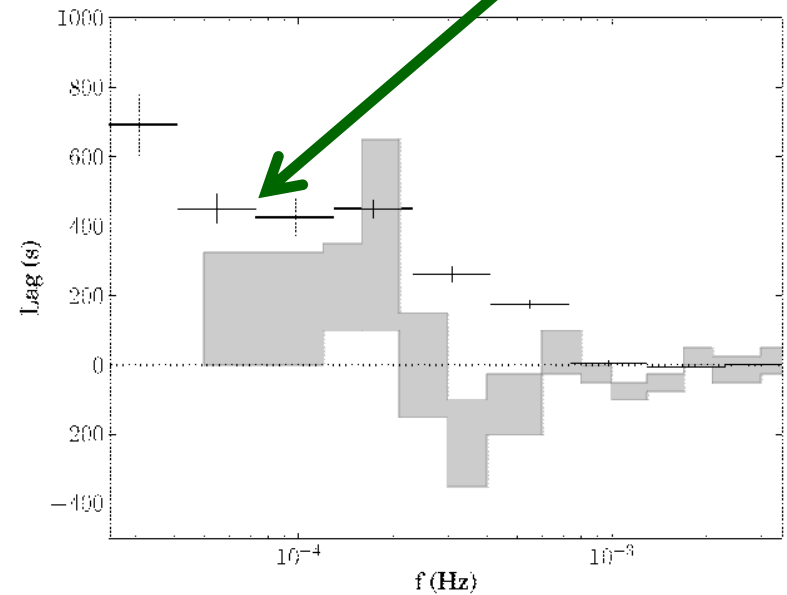
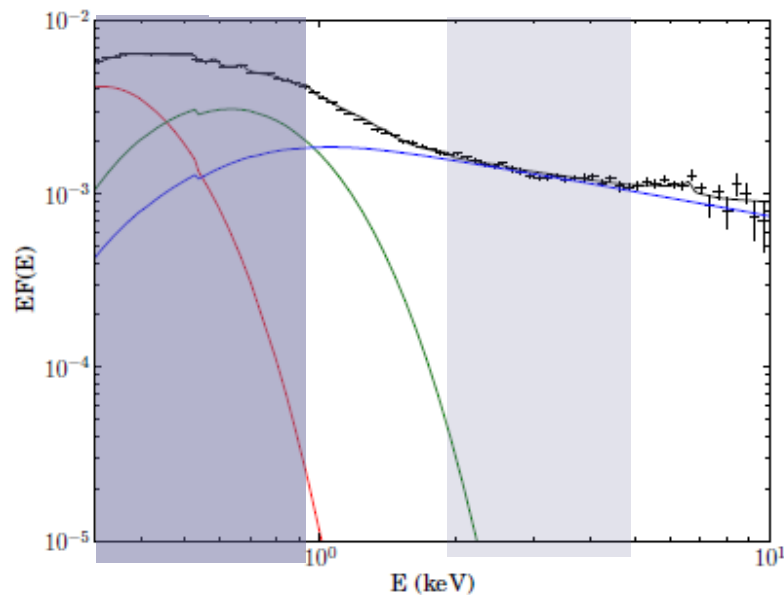
Alston et al 2014

'Hard Lags'

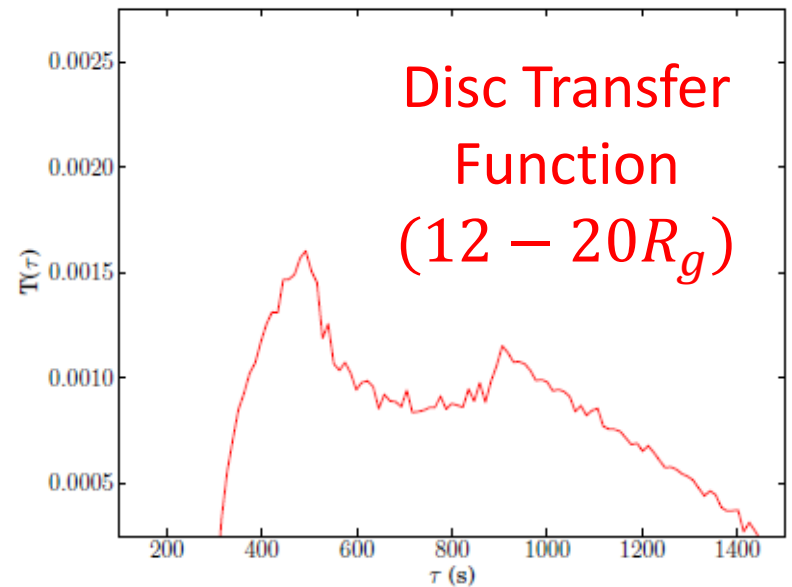
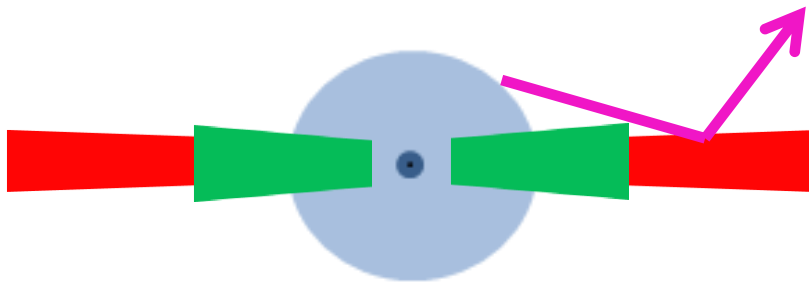
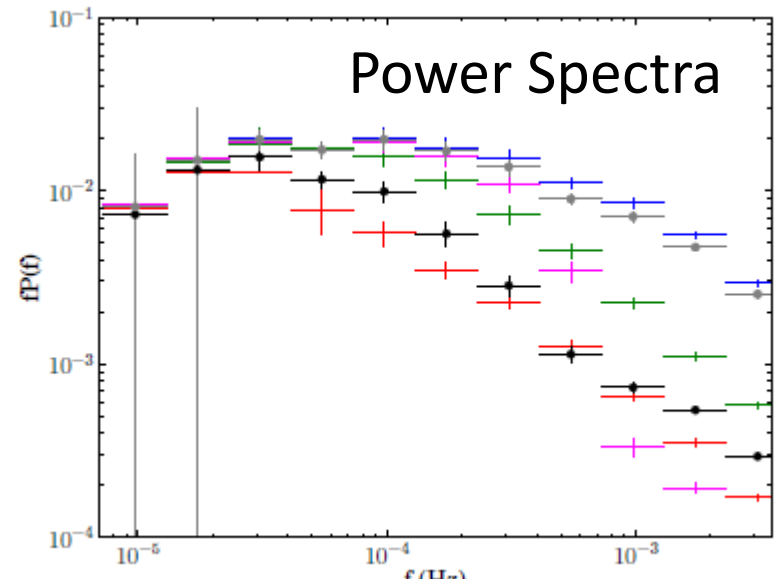
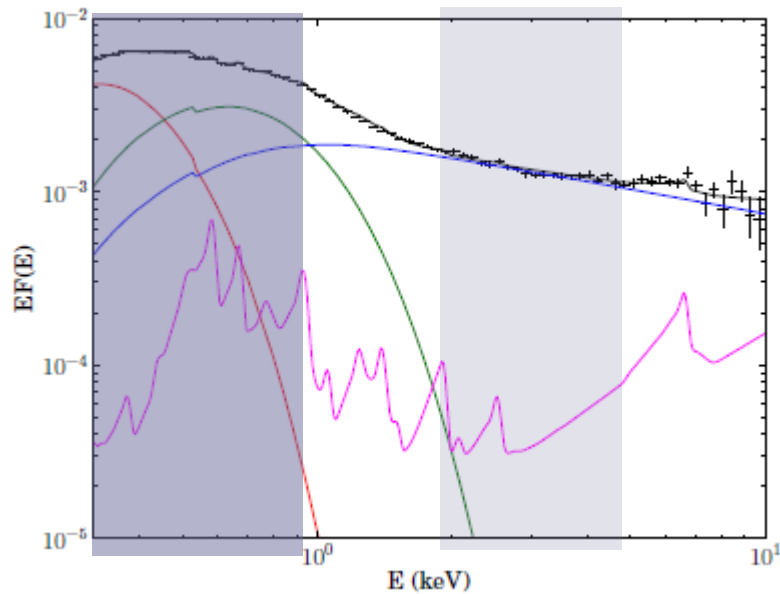
'Soft Lags'



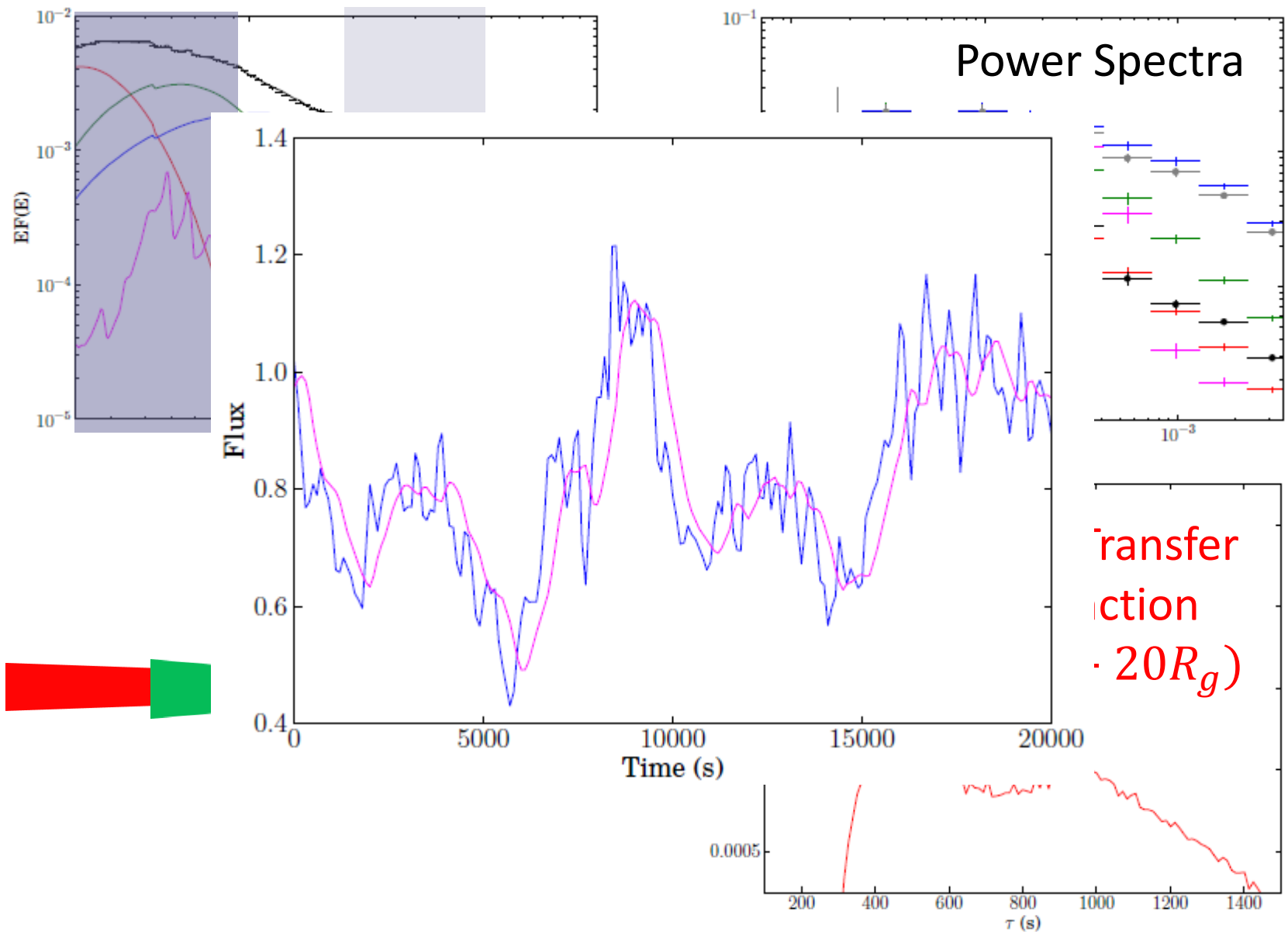
Propagation gives Hard Lags



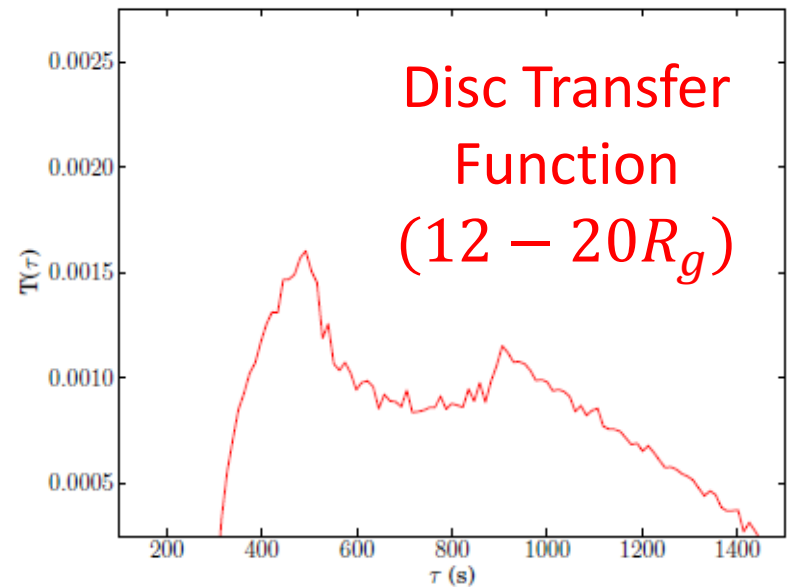
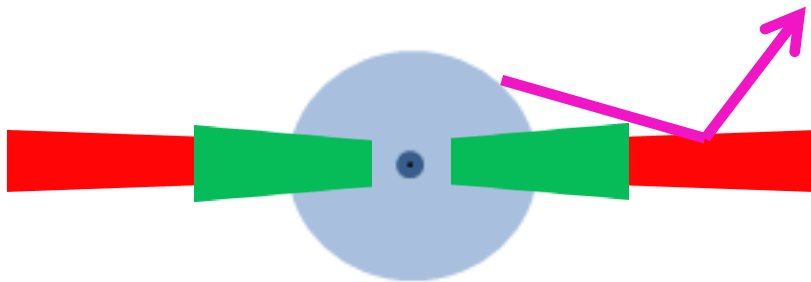
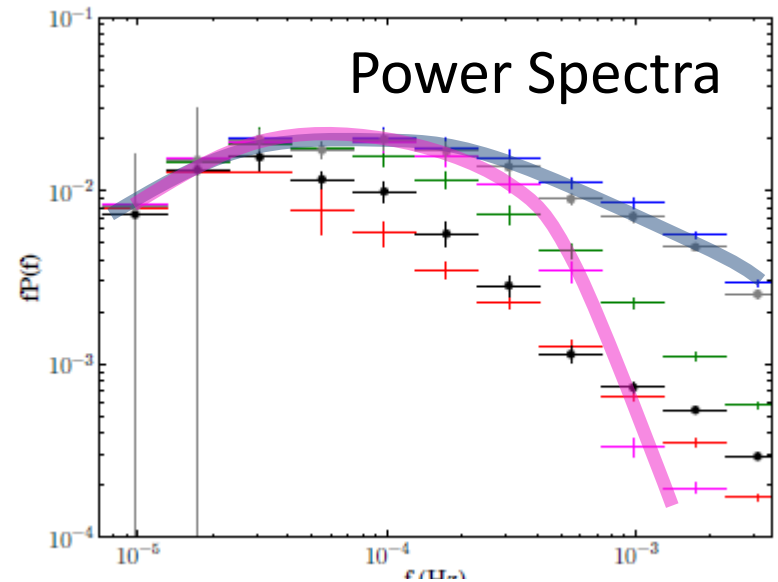
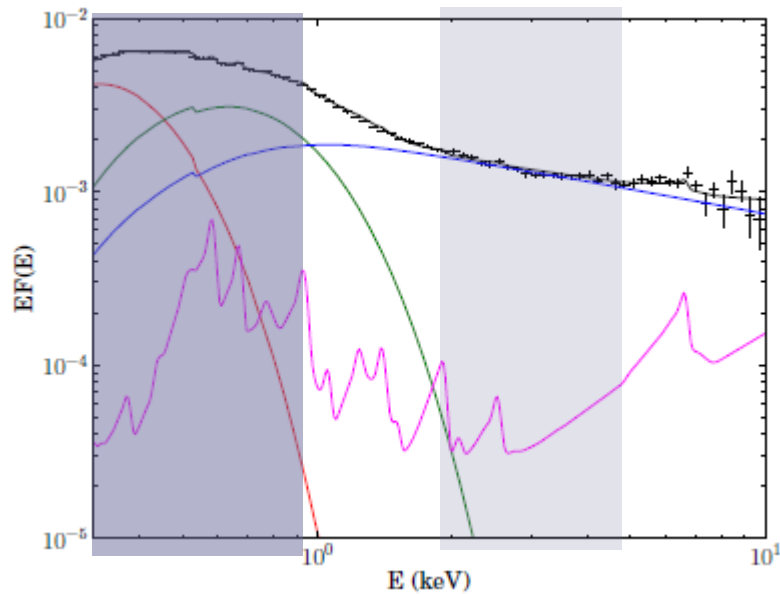
Producing Soft Lags by Reflection?



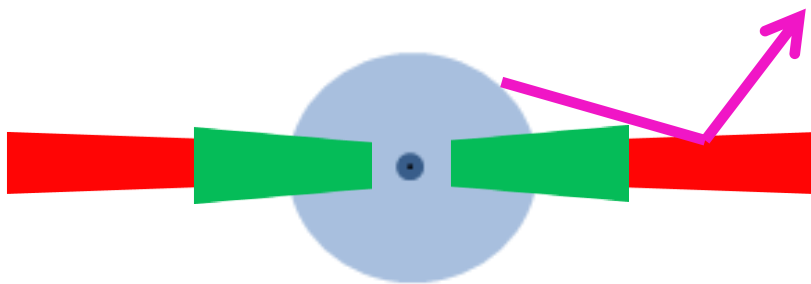
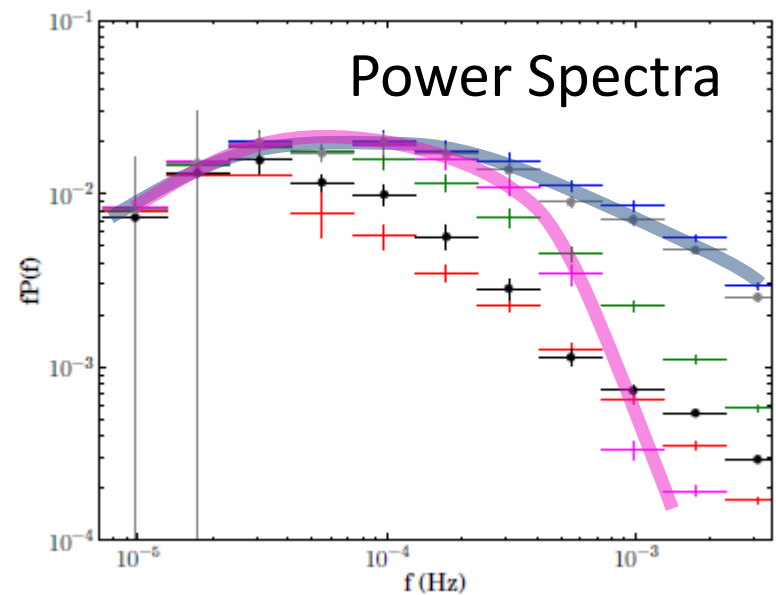
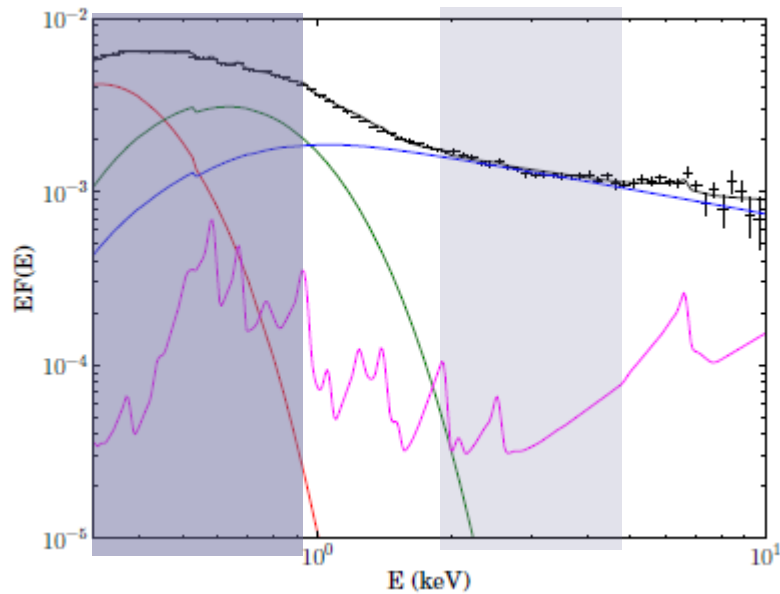
Producing Soft Lags by Reflection?



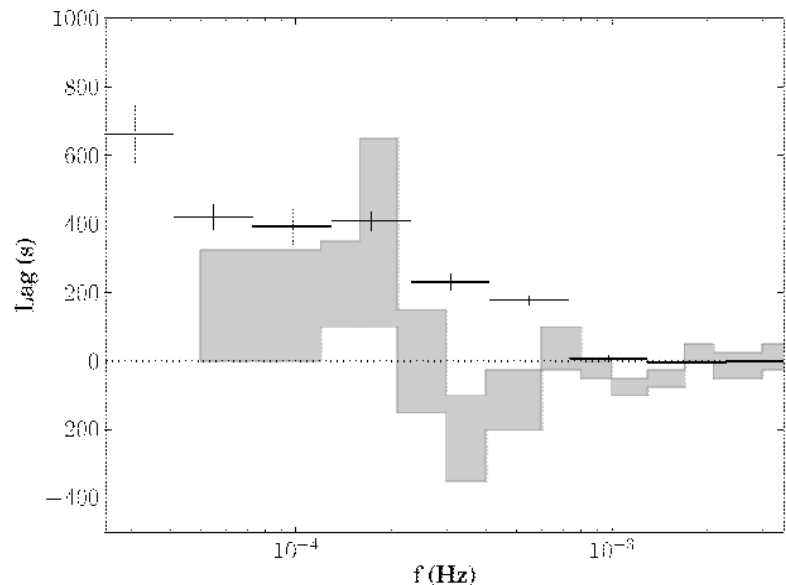
Producing Soft Lags by Reflection?



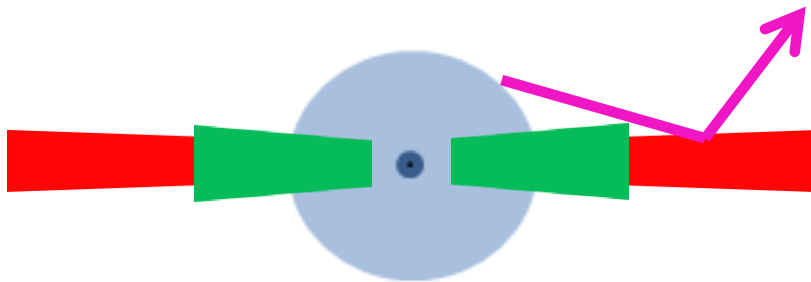
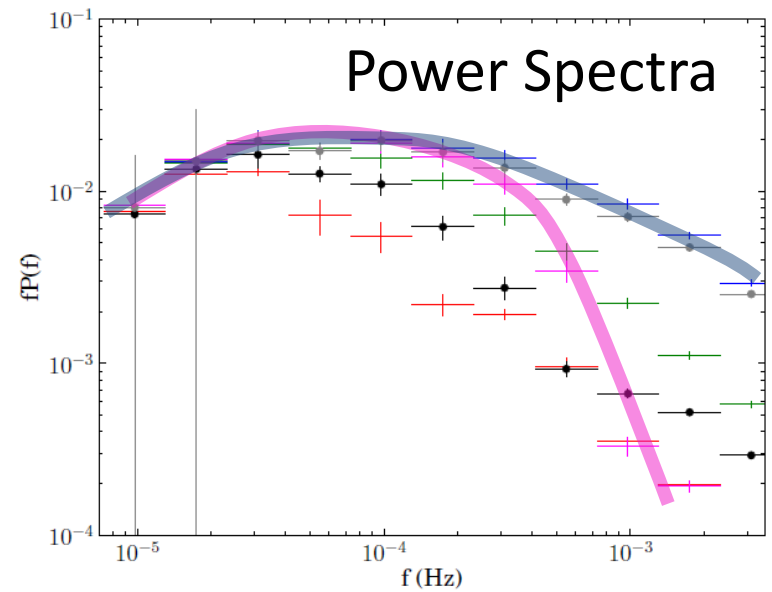
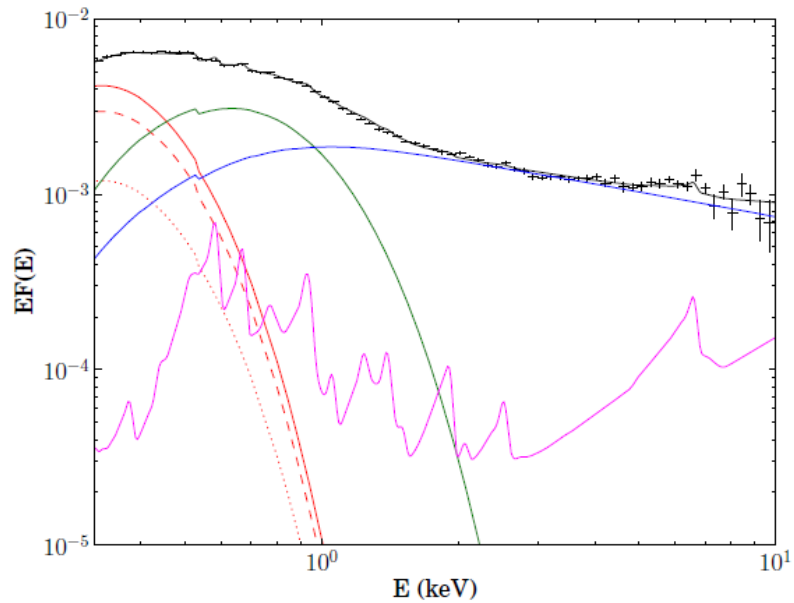
Producing Soft Lags by Reflection?



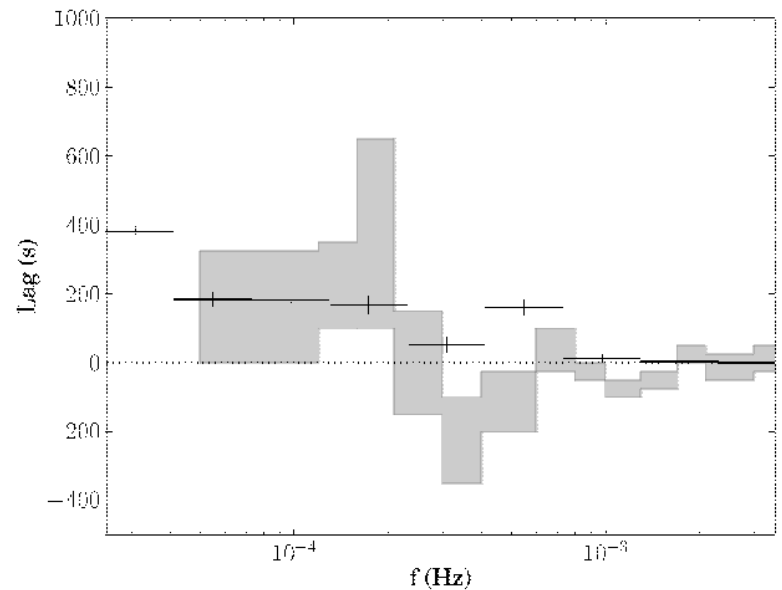
Contribution from reflected flux
too small to produce soft lags



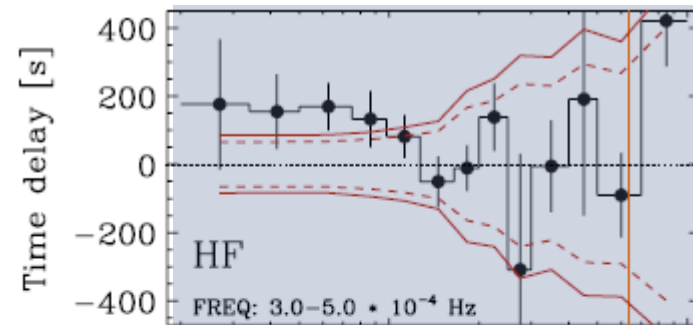
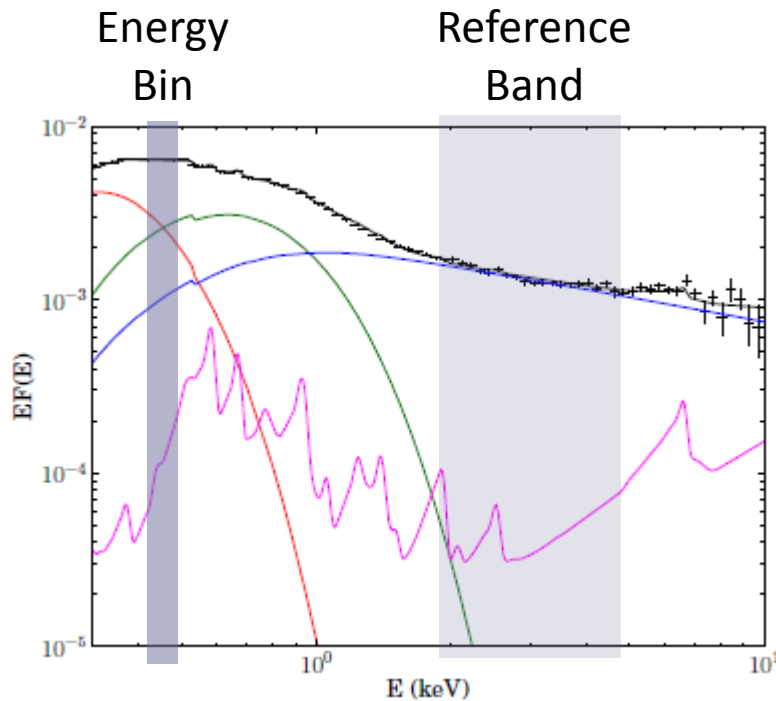
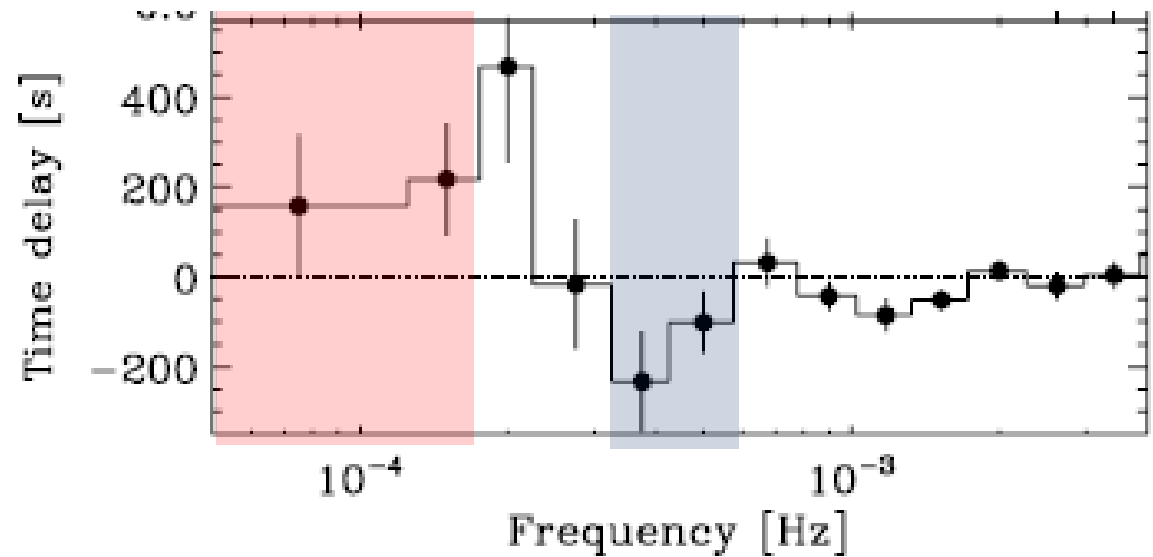
Reprocessing on Disc



Flux not reflected by the disc is
absorbed and **reradiated**

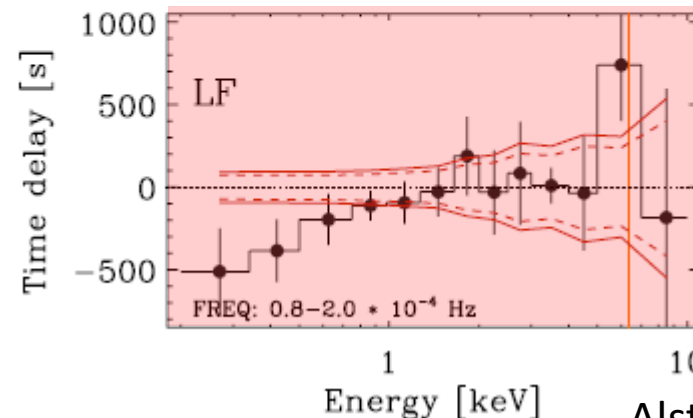


Making Lag-Energy Spectra



Bin Lags

Ref. Lags

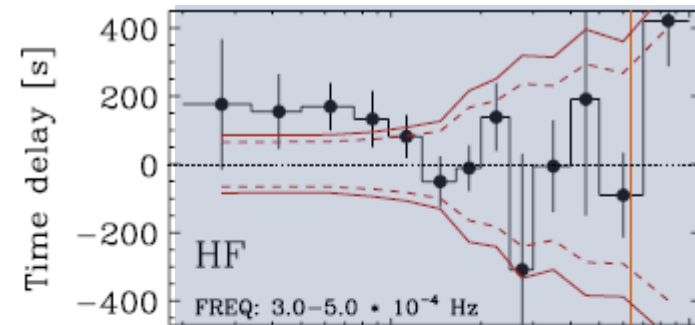
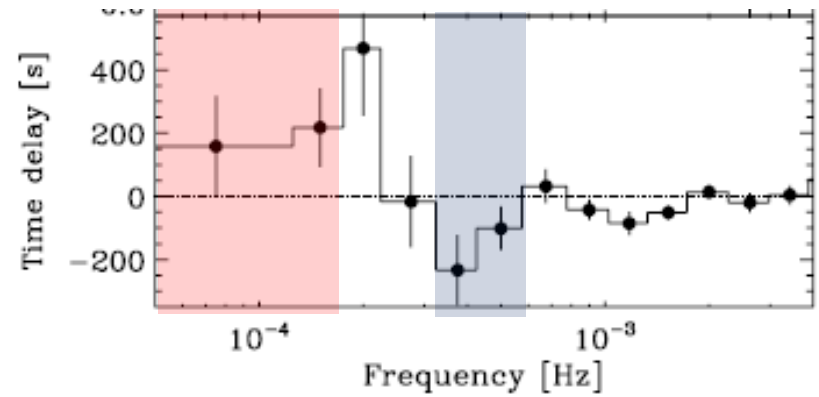
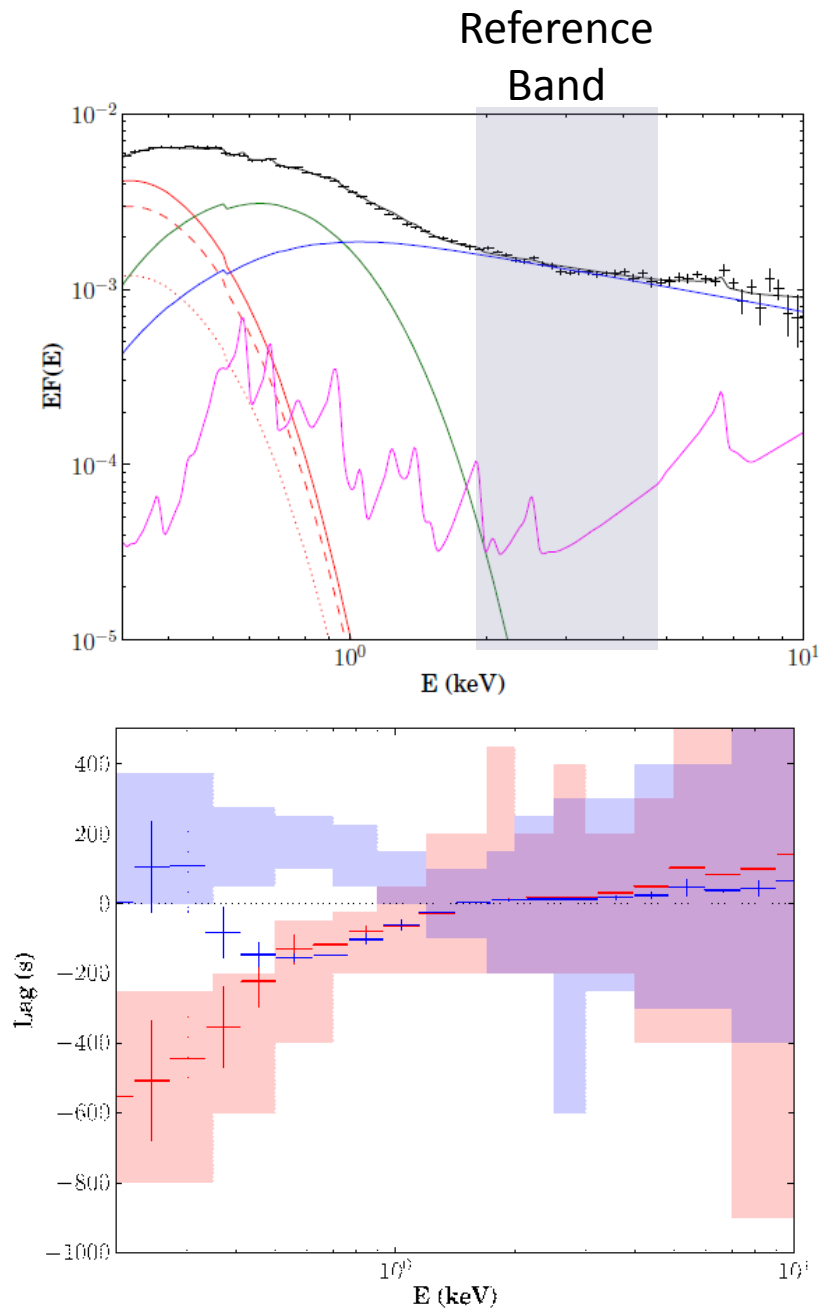


Bin Lags

Ref. Lags

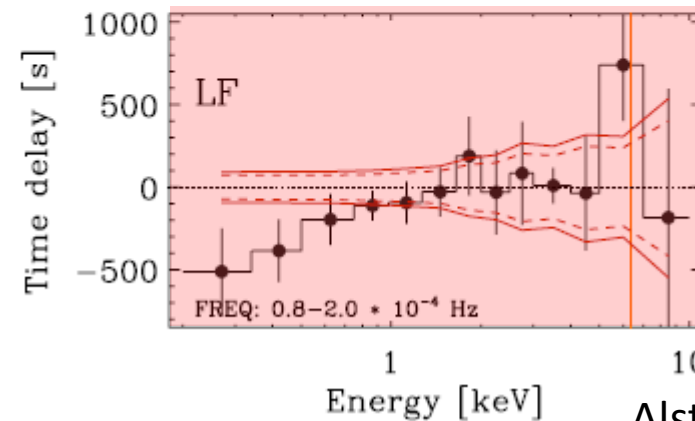
Alston et al 2014

Reprocessing on Disc



Bin Lags

Ref. Lags

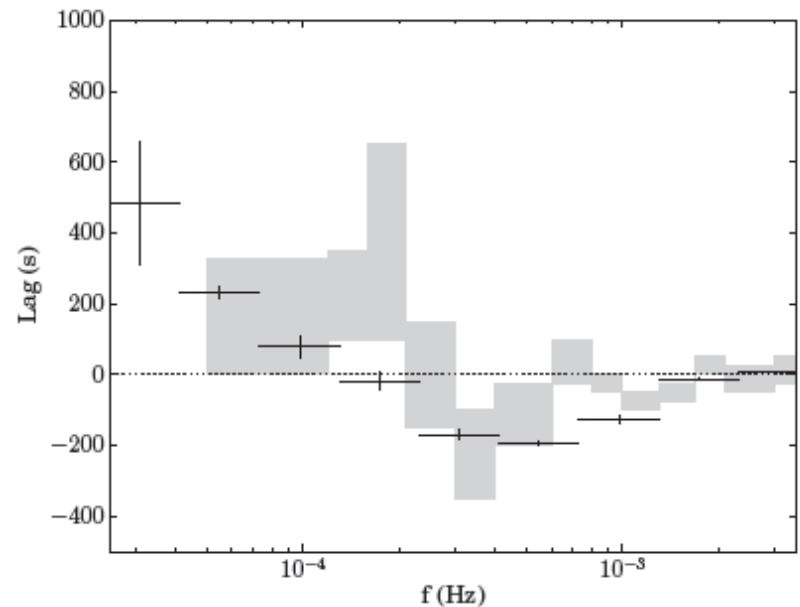
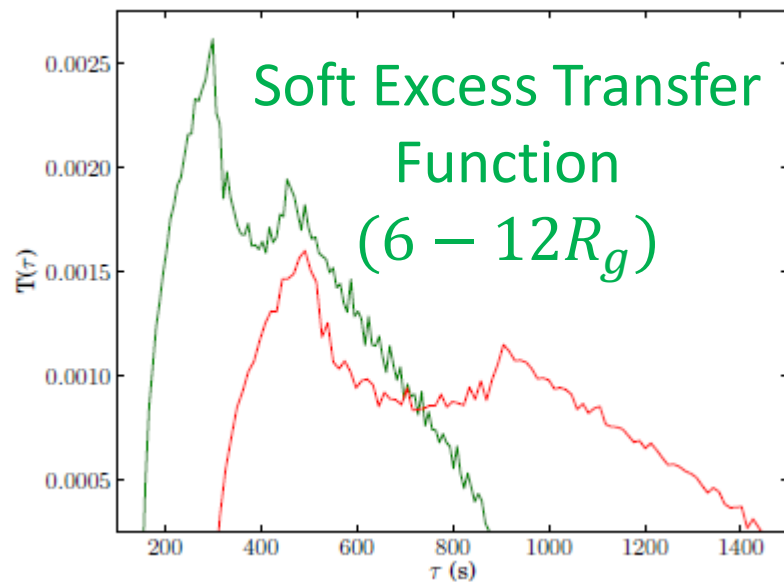
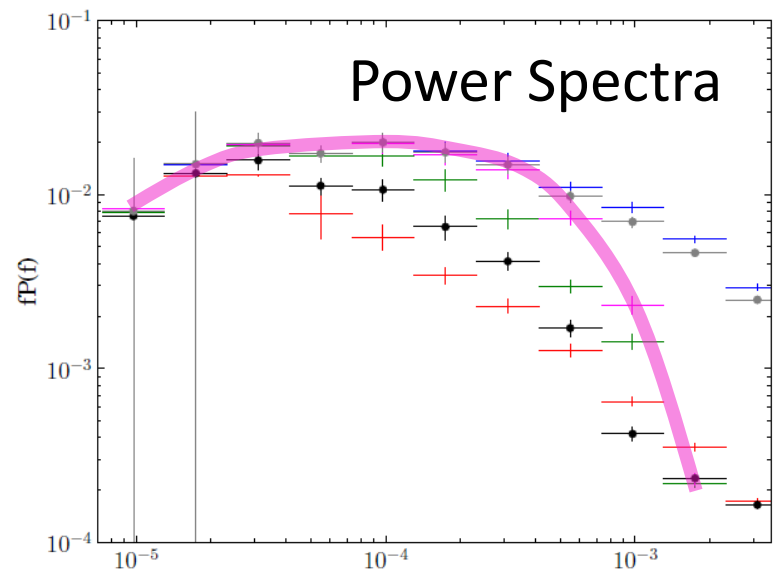
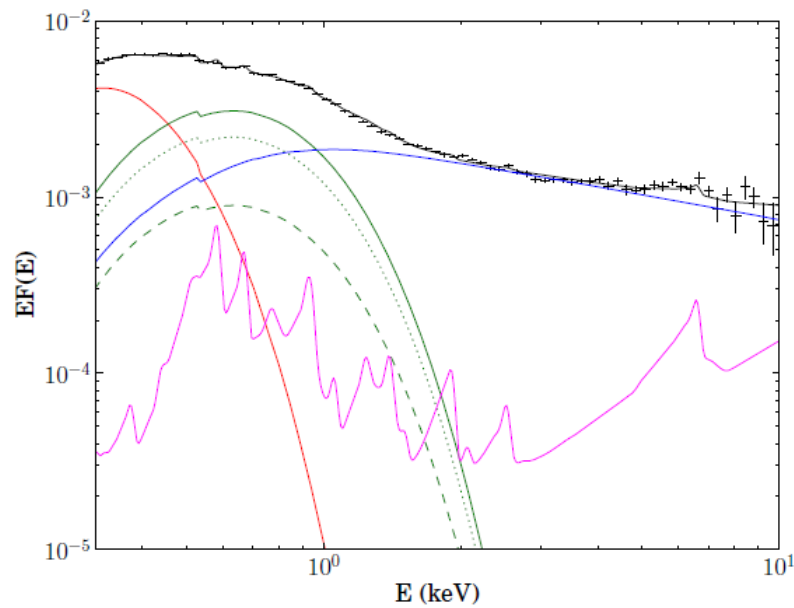


Bin Lags

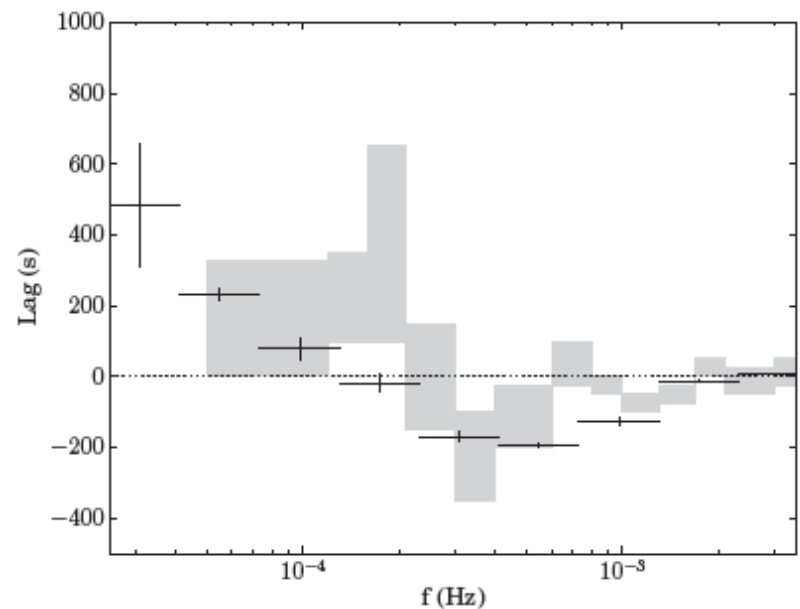
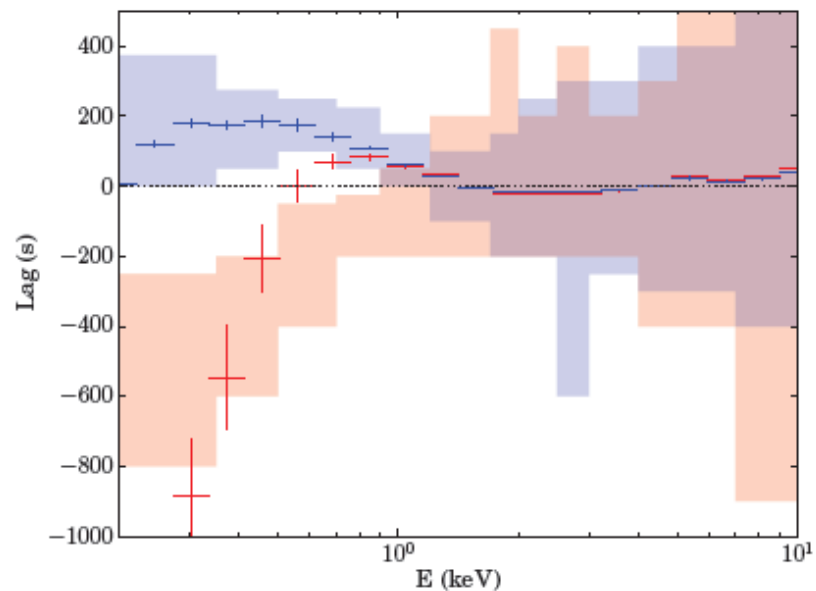
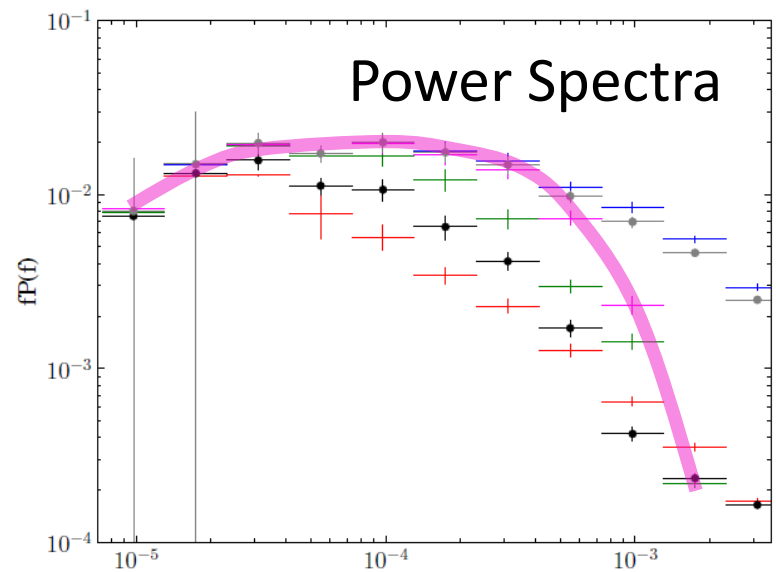
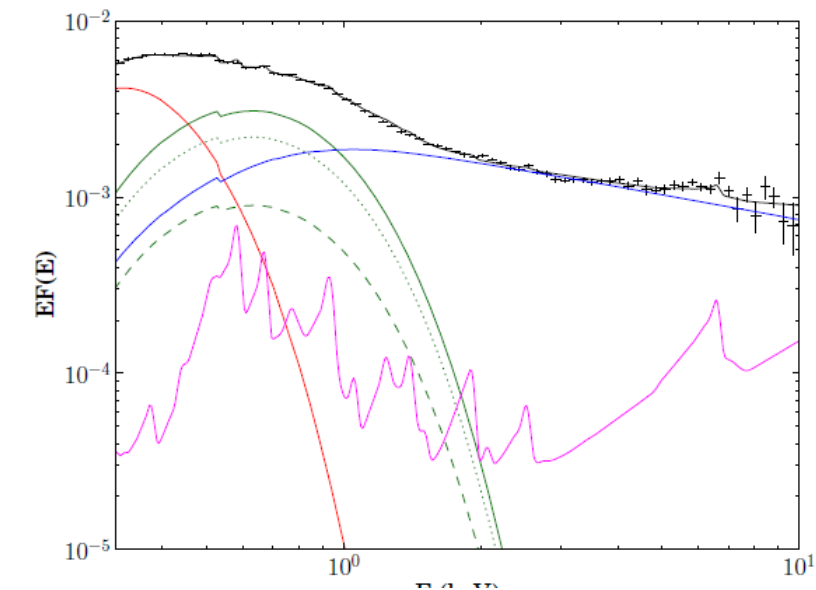
Ref. Lags

Alston et al 2014

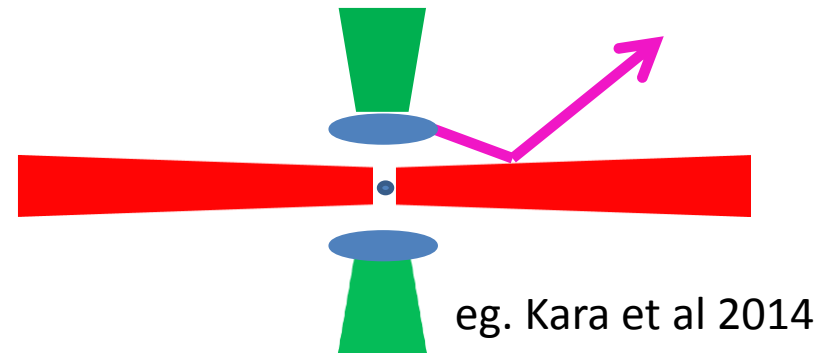
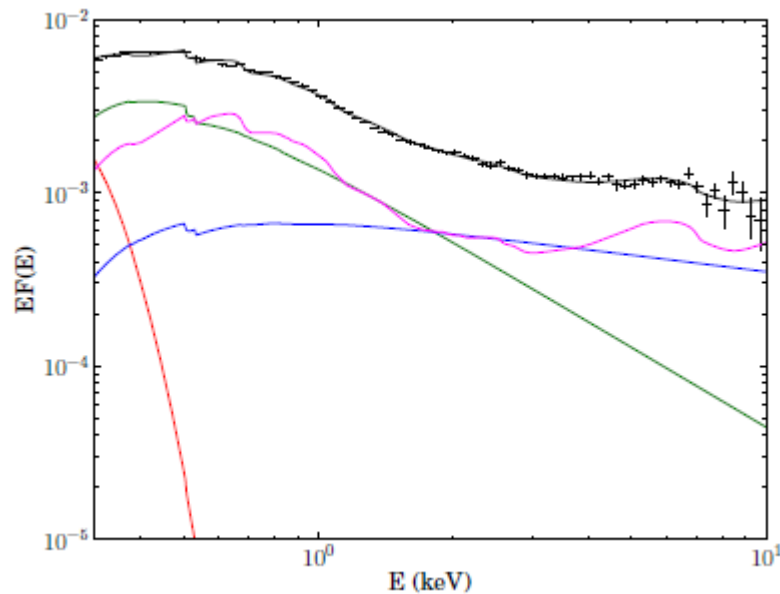
Reprocessing on Soft Excess

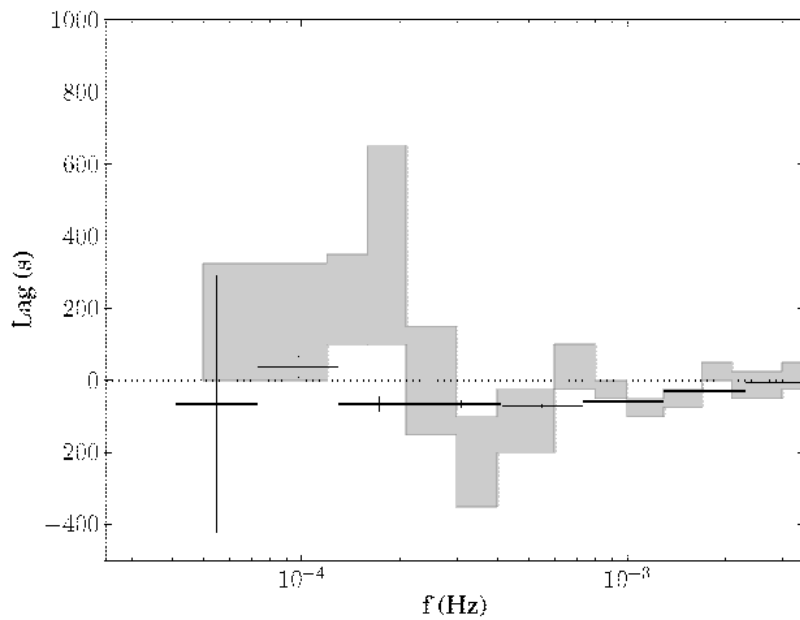
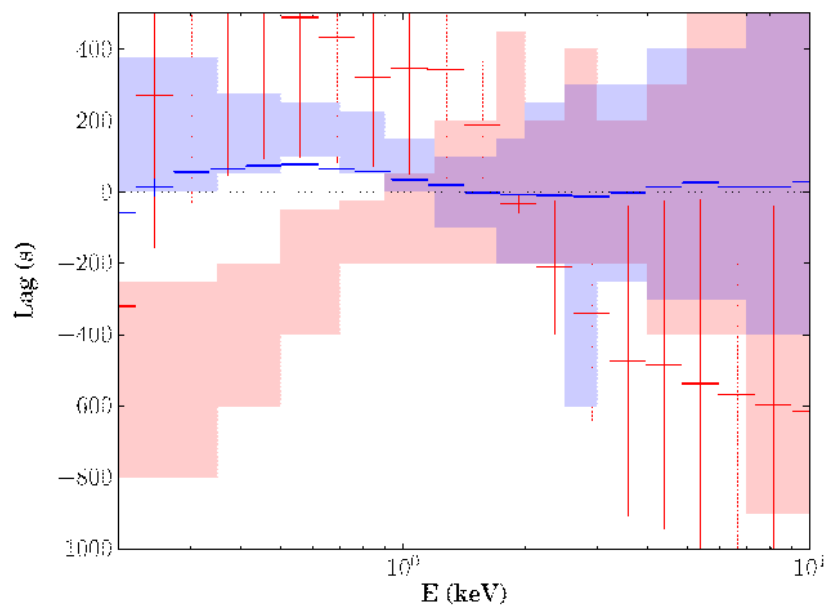
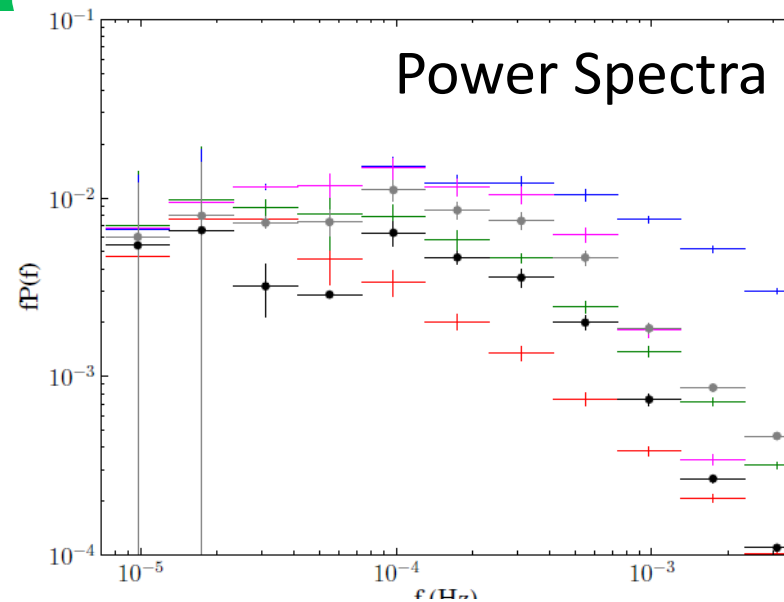
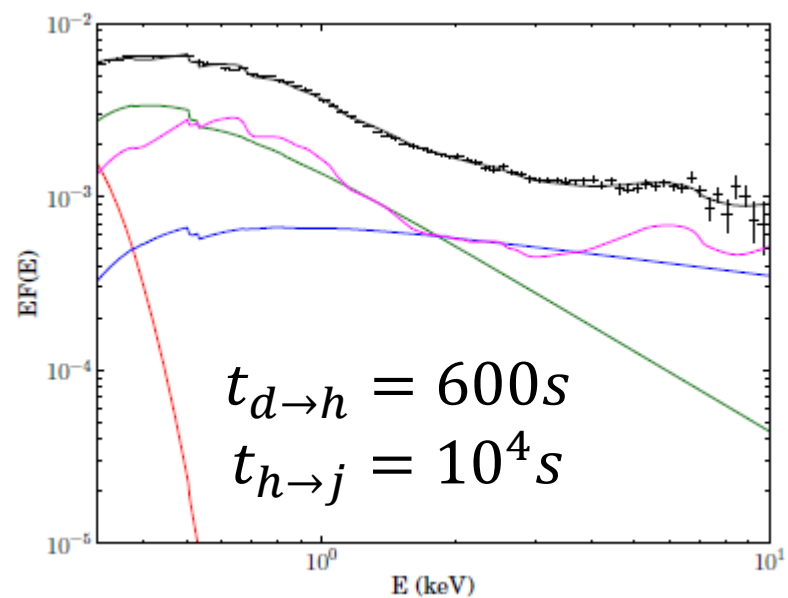
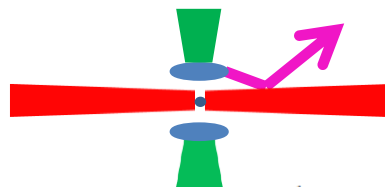


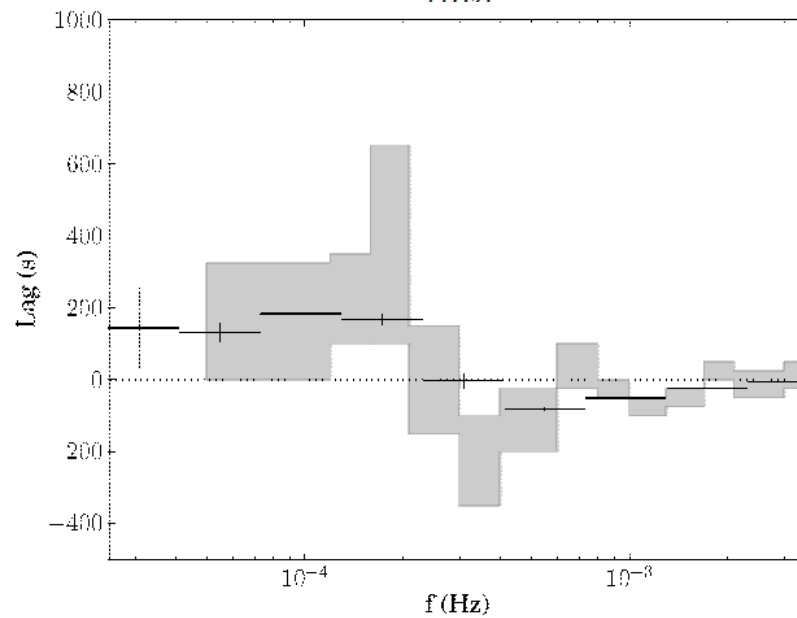
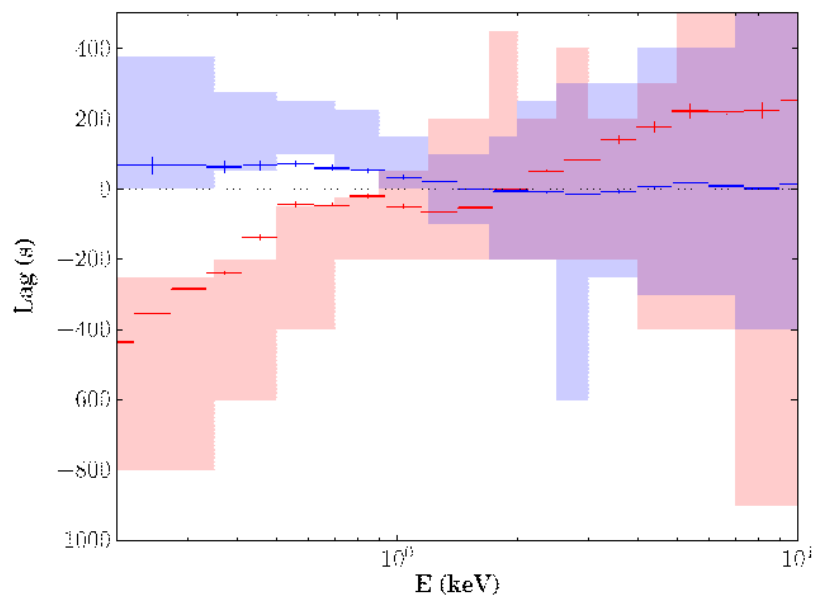
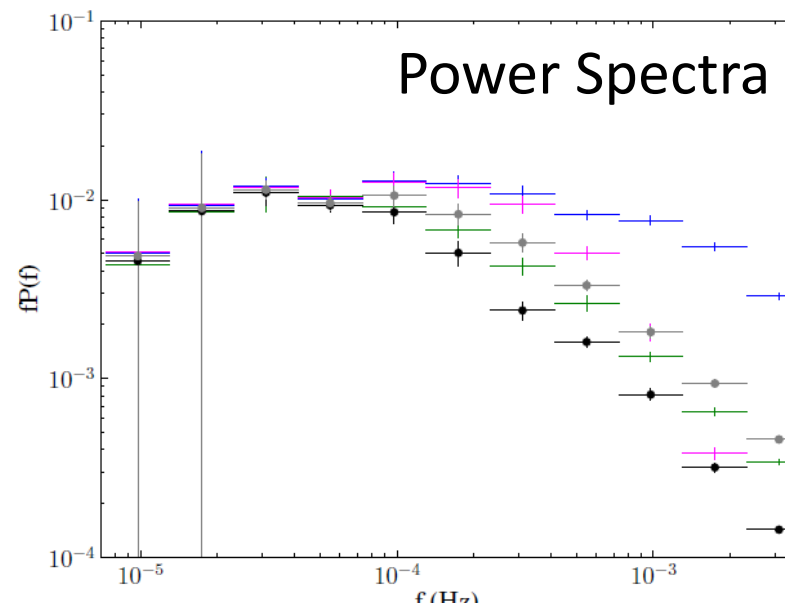
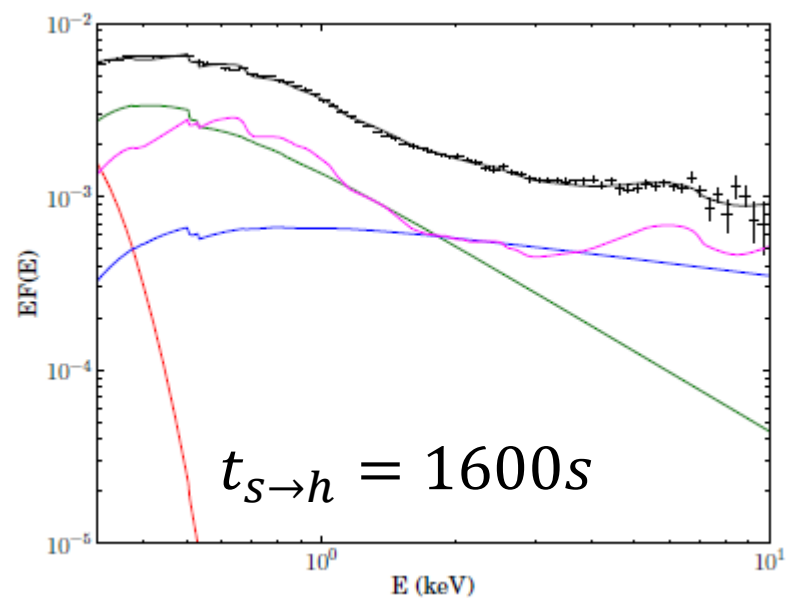
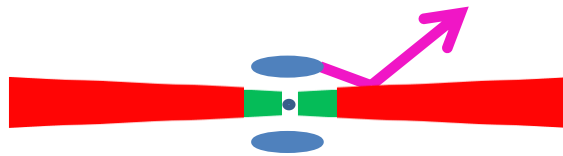
Reprocessing on Soft Excess

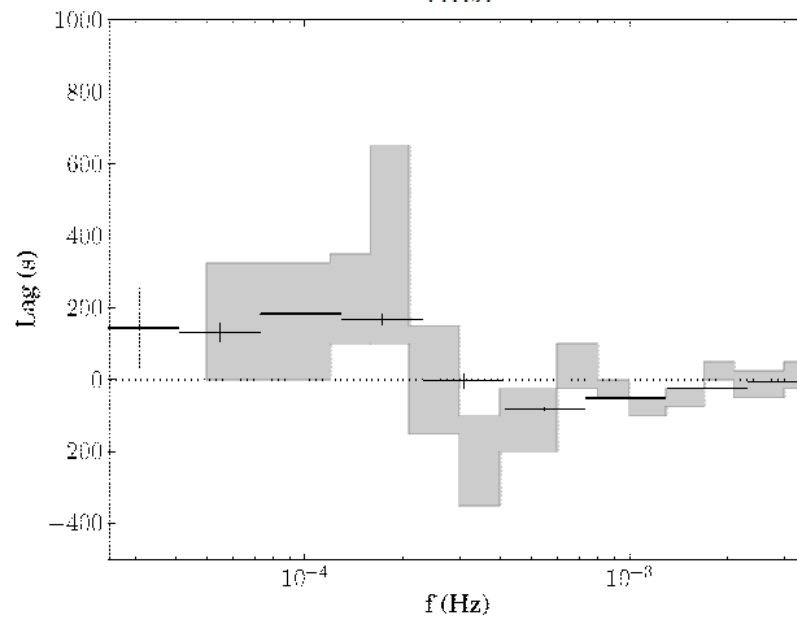
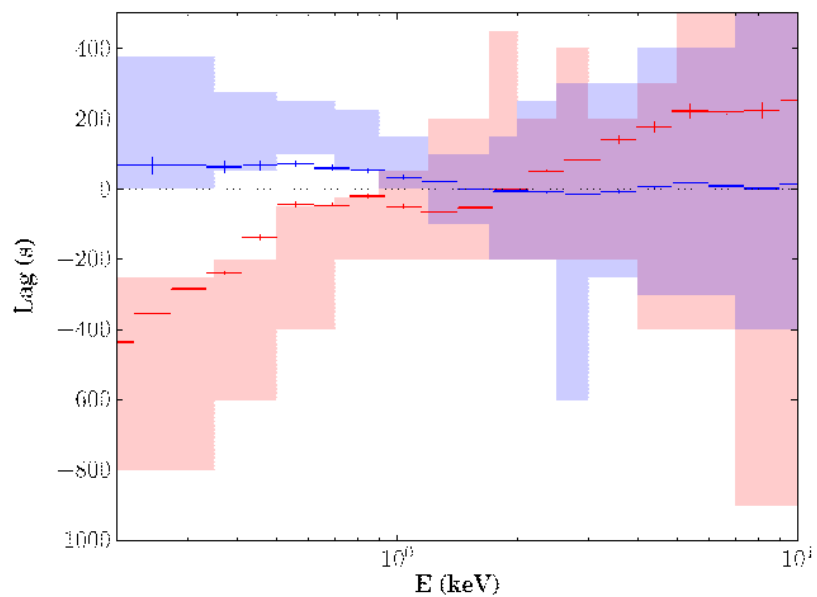
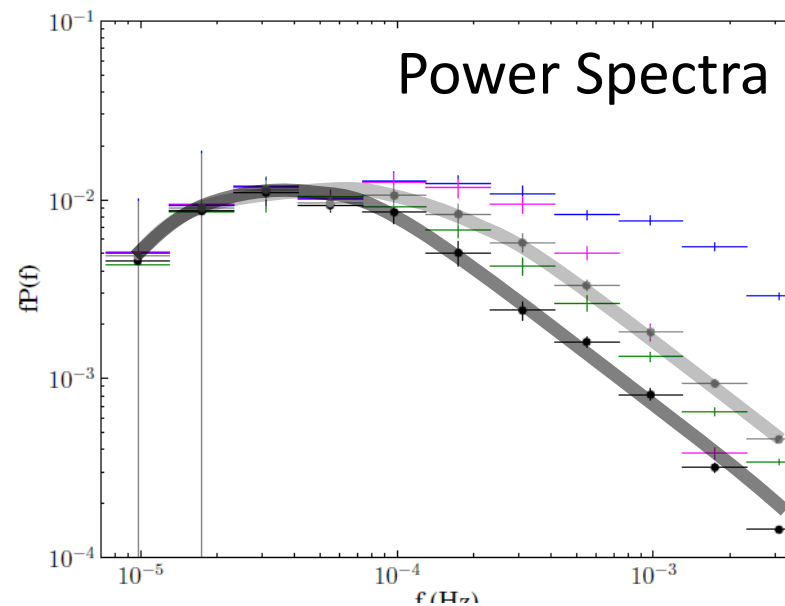
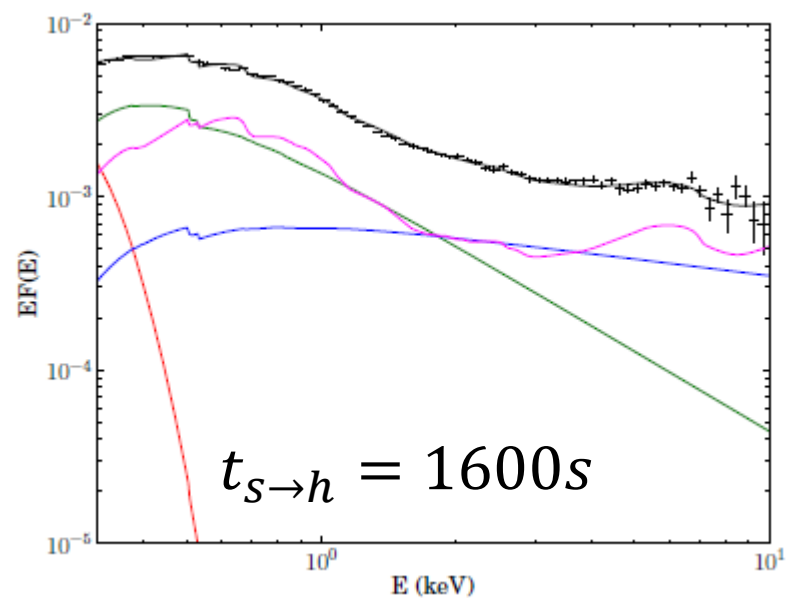
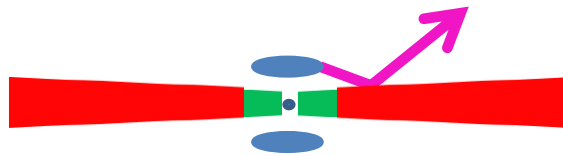


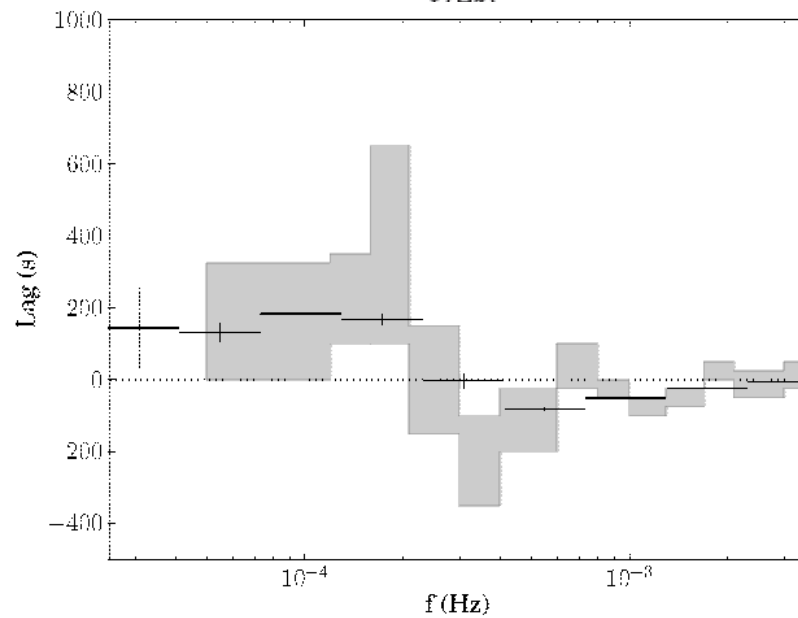
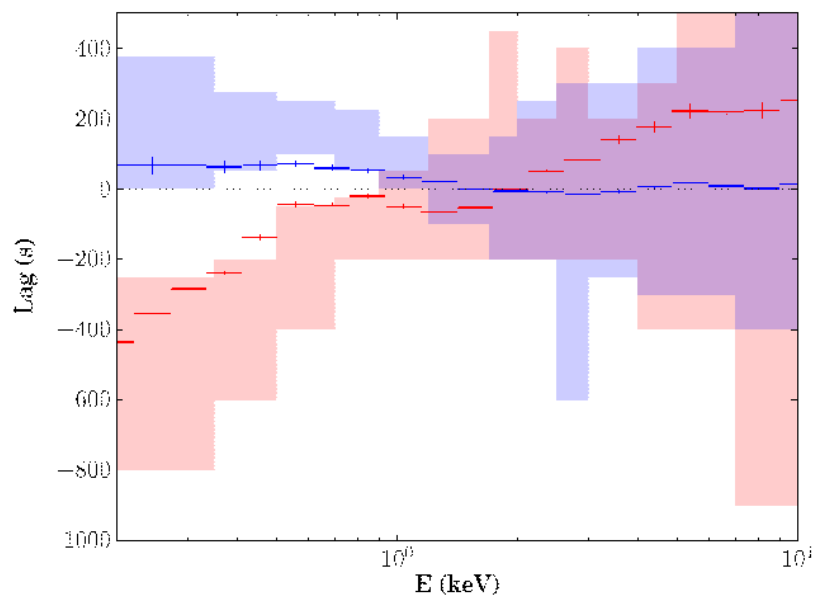
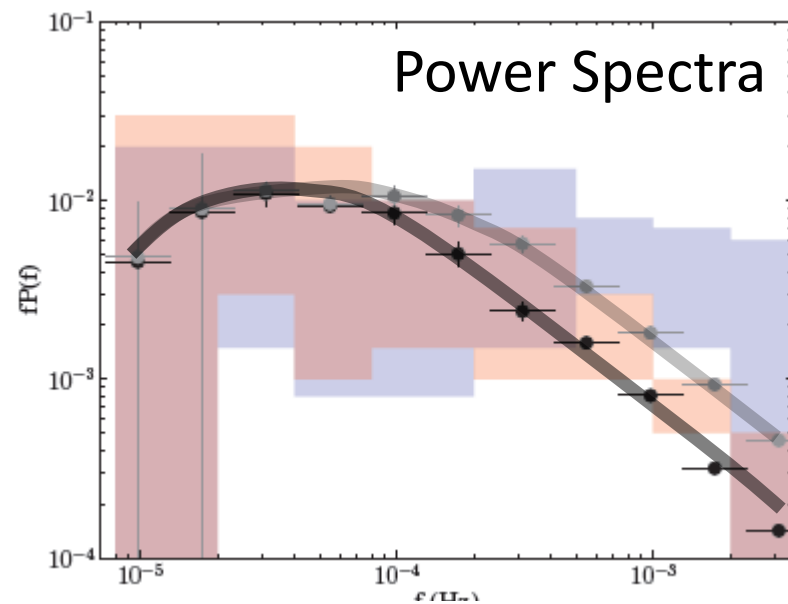
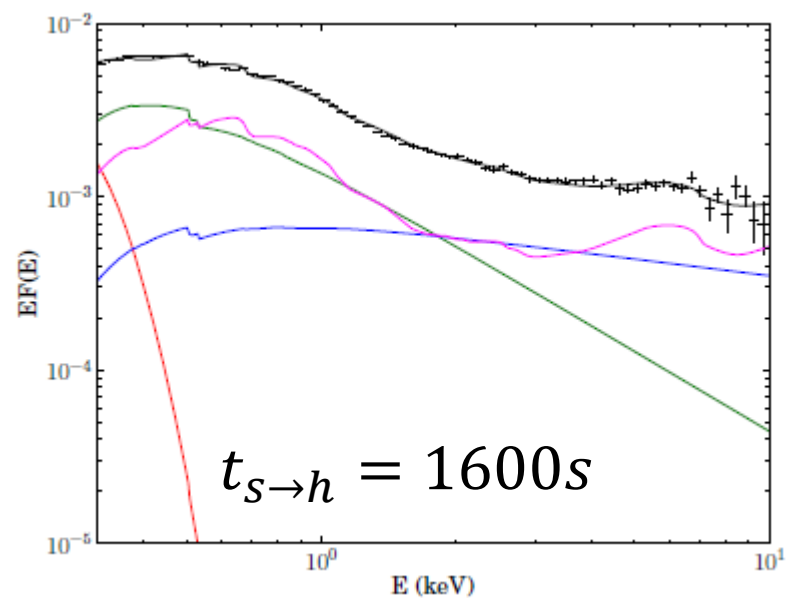
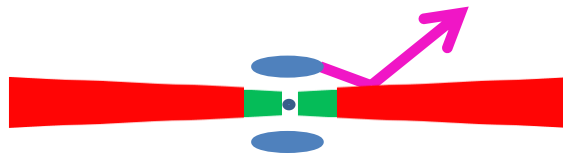
Comparison with a Reflection Dominated Model

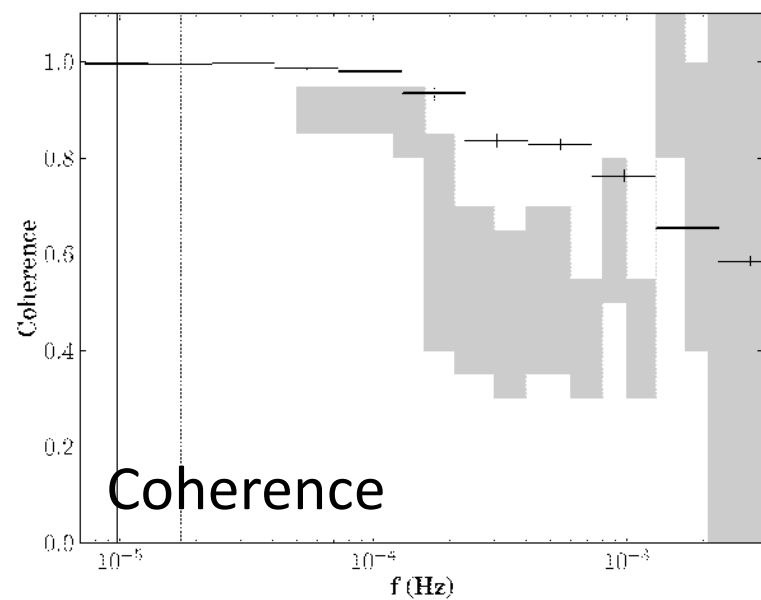
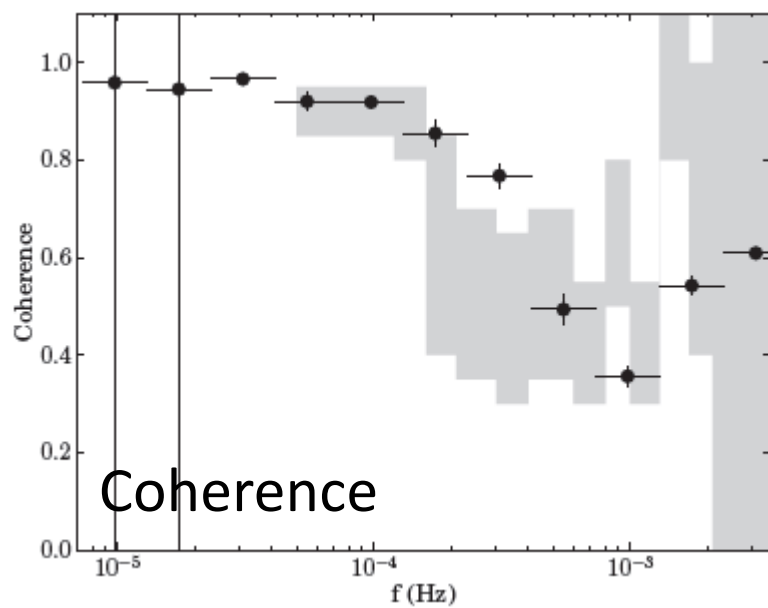
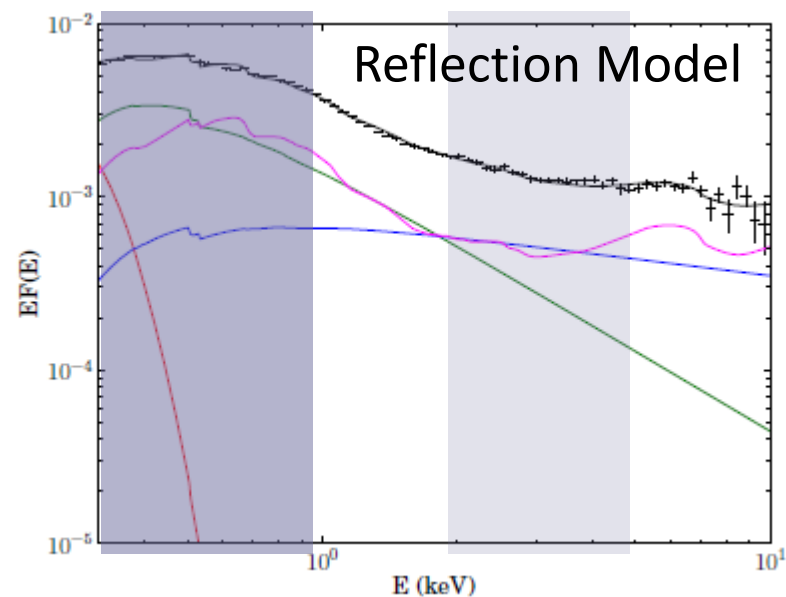
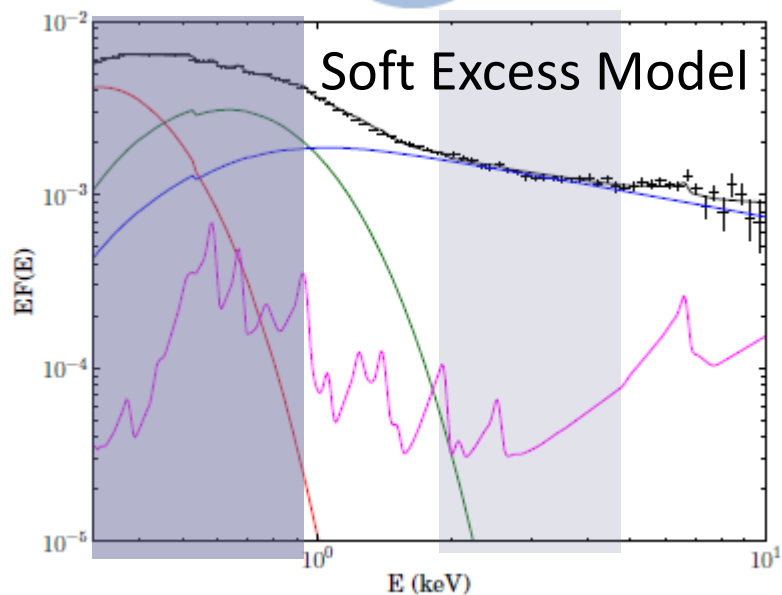
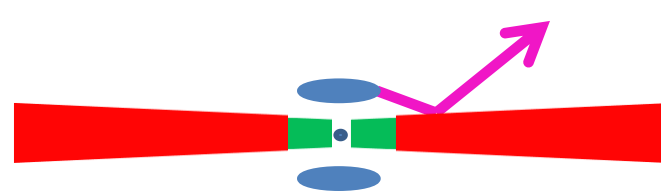
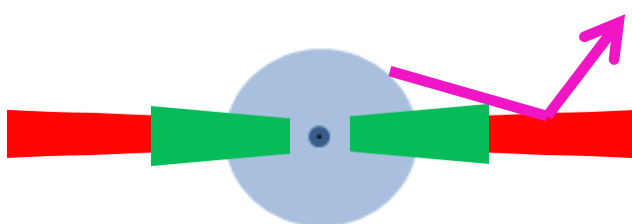












data from Alston et al 2014

Conclusions

Separate Soft Excess Model

- No constraints on spin
 - $R_{in} \geq 6R_g$
- Can match **all observed timing features** of PG1244+026

Reflection Dominated Model

- Requires high spin
 - $R_{in} \sim 1R_g$
- Only matches **high frequency soft lags**
- **Cannot** match power spectra/coherence/low freq. lags

The data for PG1244 require the component generating the propagating fluctuations (and reverberating) to be **confined to the soft band**.