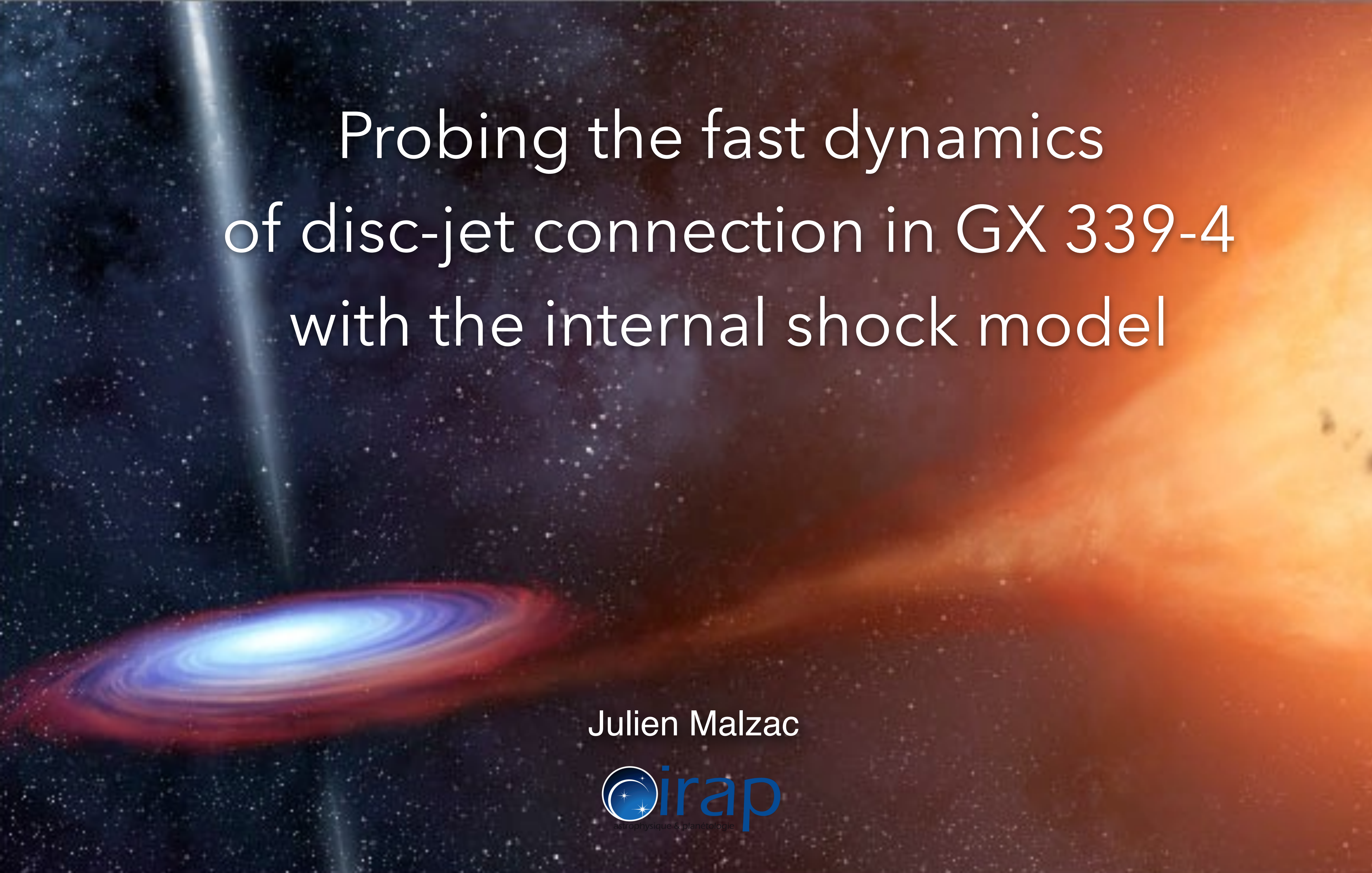

Probing the fast dynamics of disc-jet connection in GX 339-4 with the internal shock model

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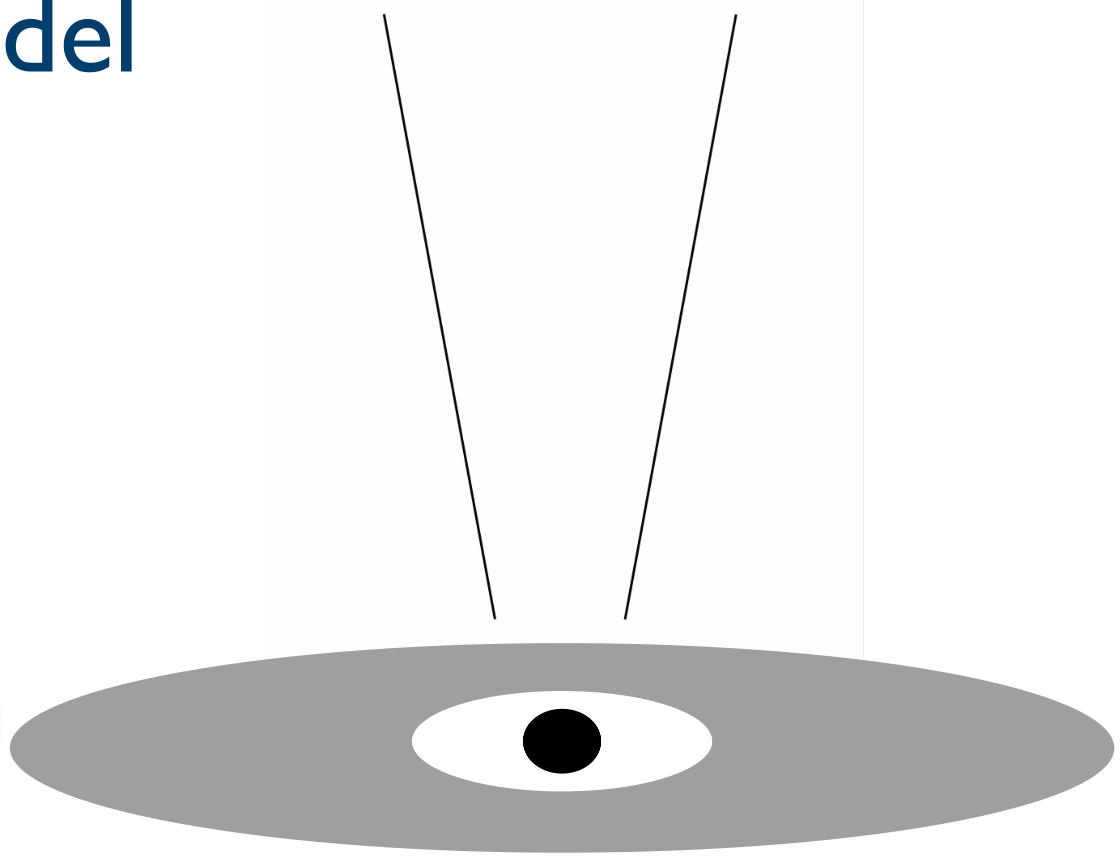
Internal shock model

- Dissipation through shocks driven by rapid fluctuations of jet ejection Lorentz Factor.

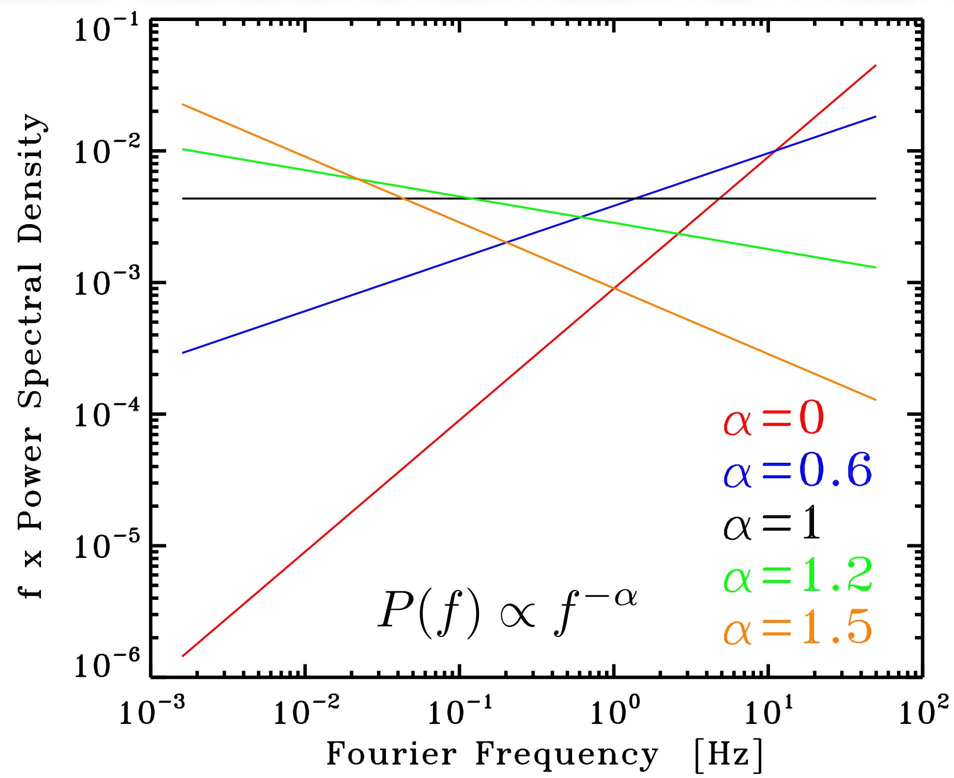
  Jamil et al. 2010, Malzac 2013

- ISHEM code: simulate SEDs and light curves

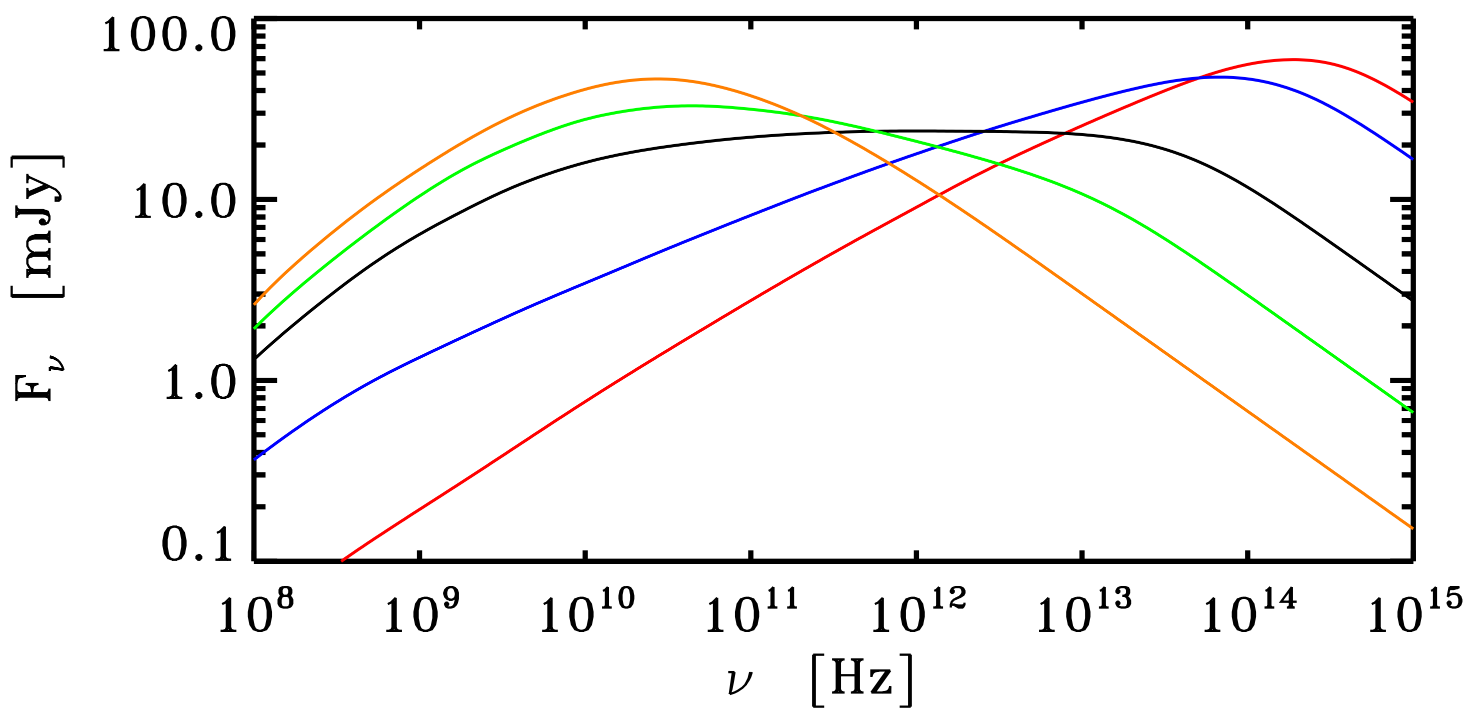
  Malzac 2014



- SED sensitive to Fourrier PSD of input Lorentz factor fluctuations



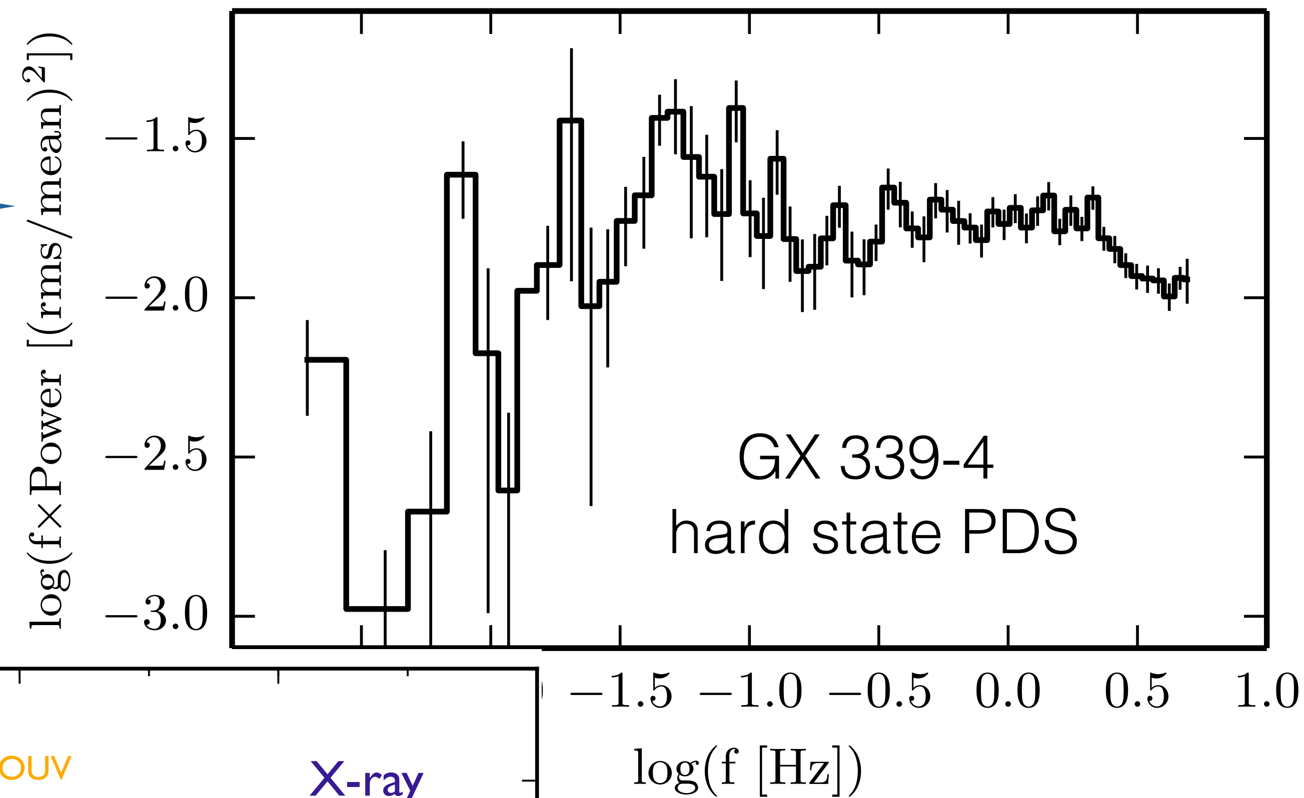
PSD of Lorentz factor

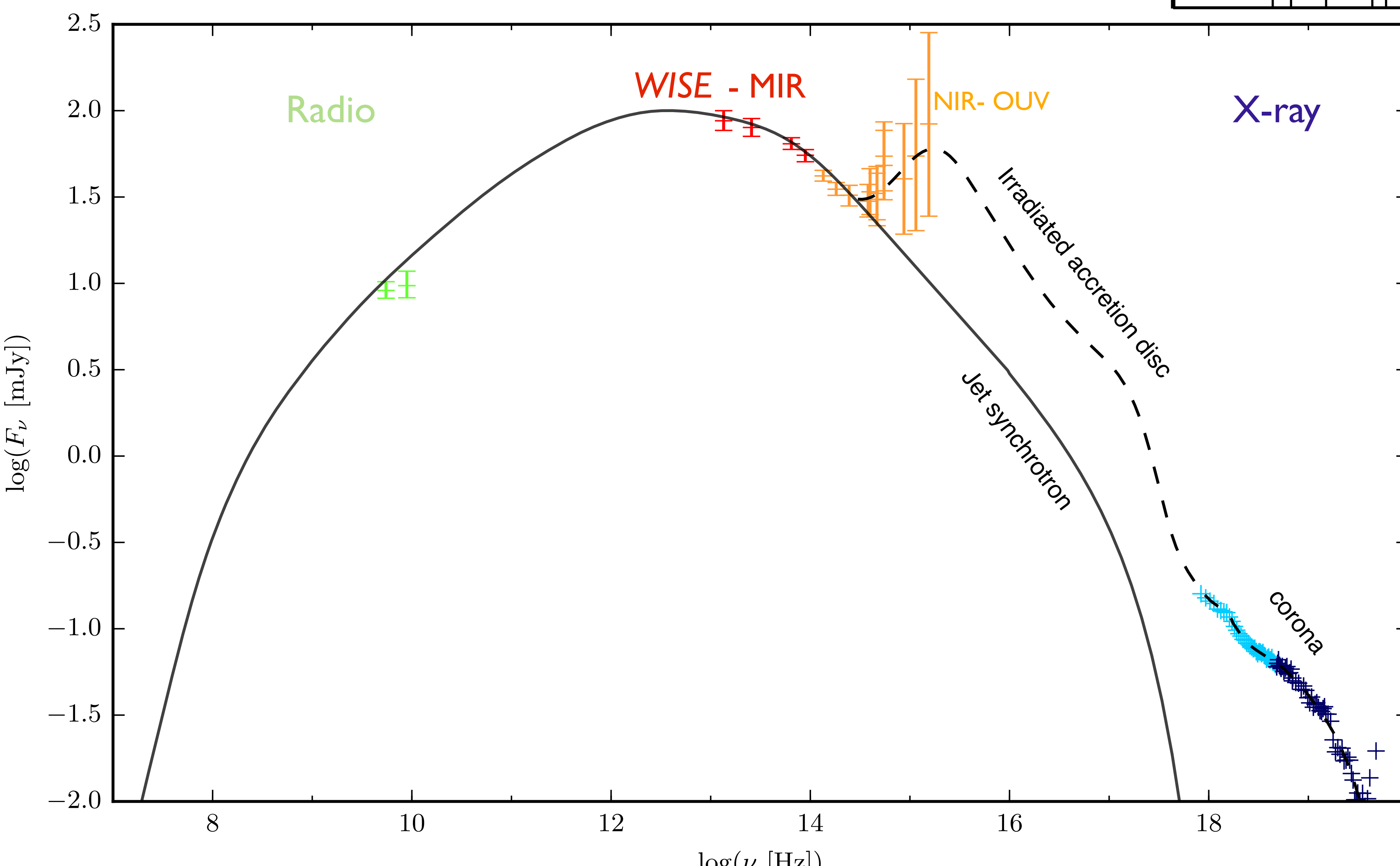


Spectral energy distribution

- Jet Lorentz factor fluctuations driven by accretion flow variability which is best traced by X-ray light curves

Fourier PDS of X-ray light curve
=
Power spectrum of Lorentz factor fluctuations

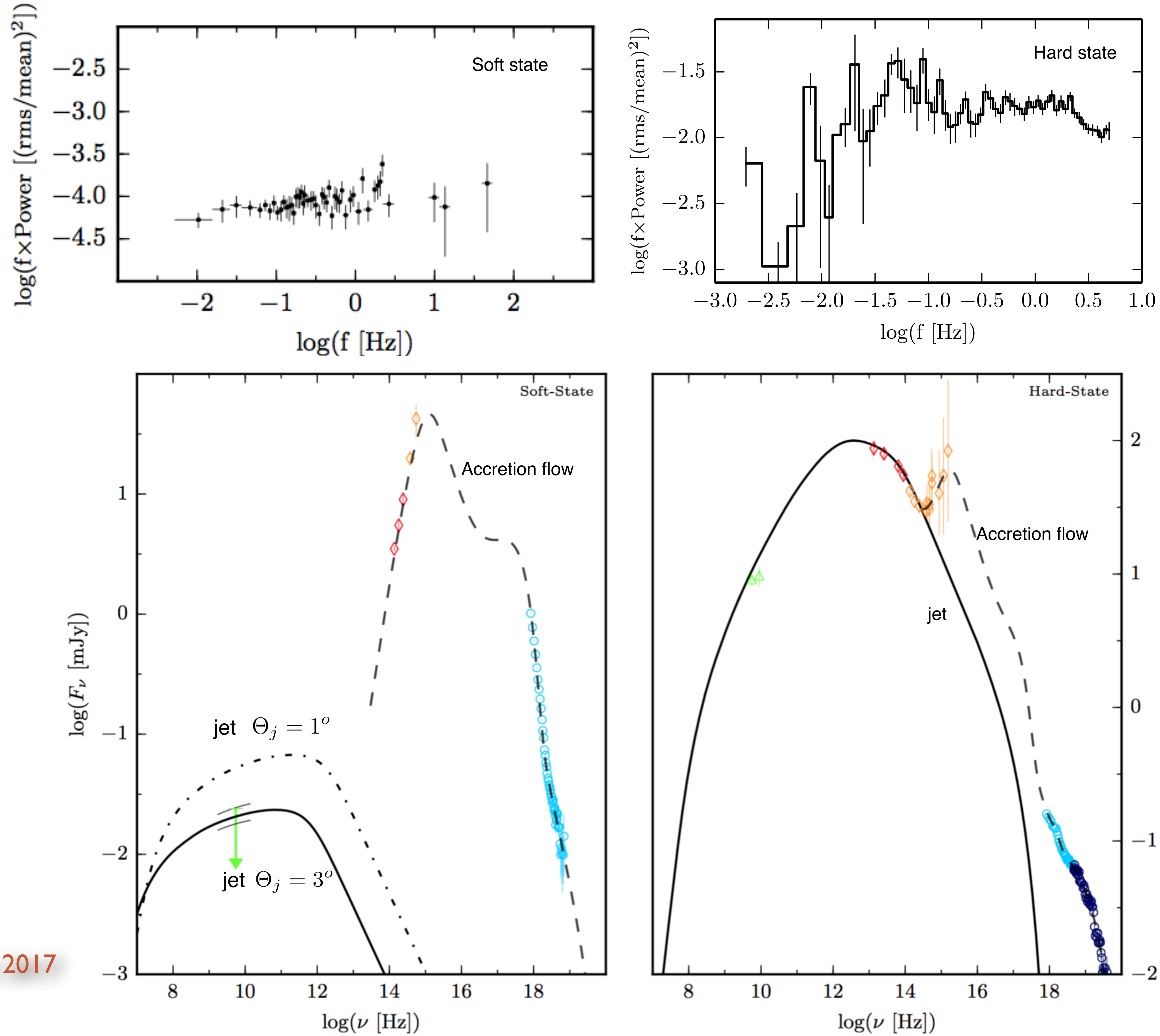




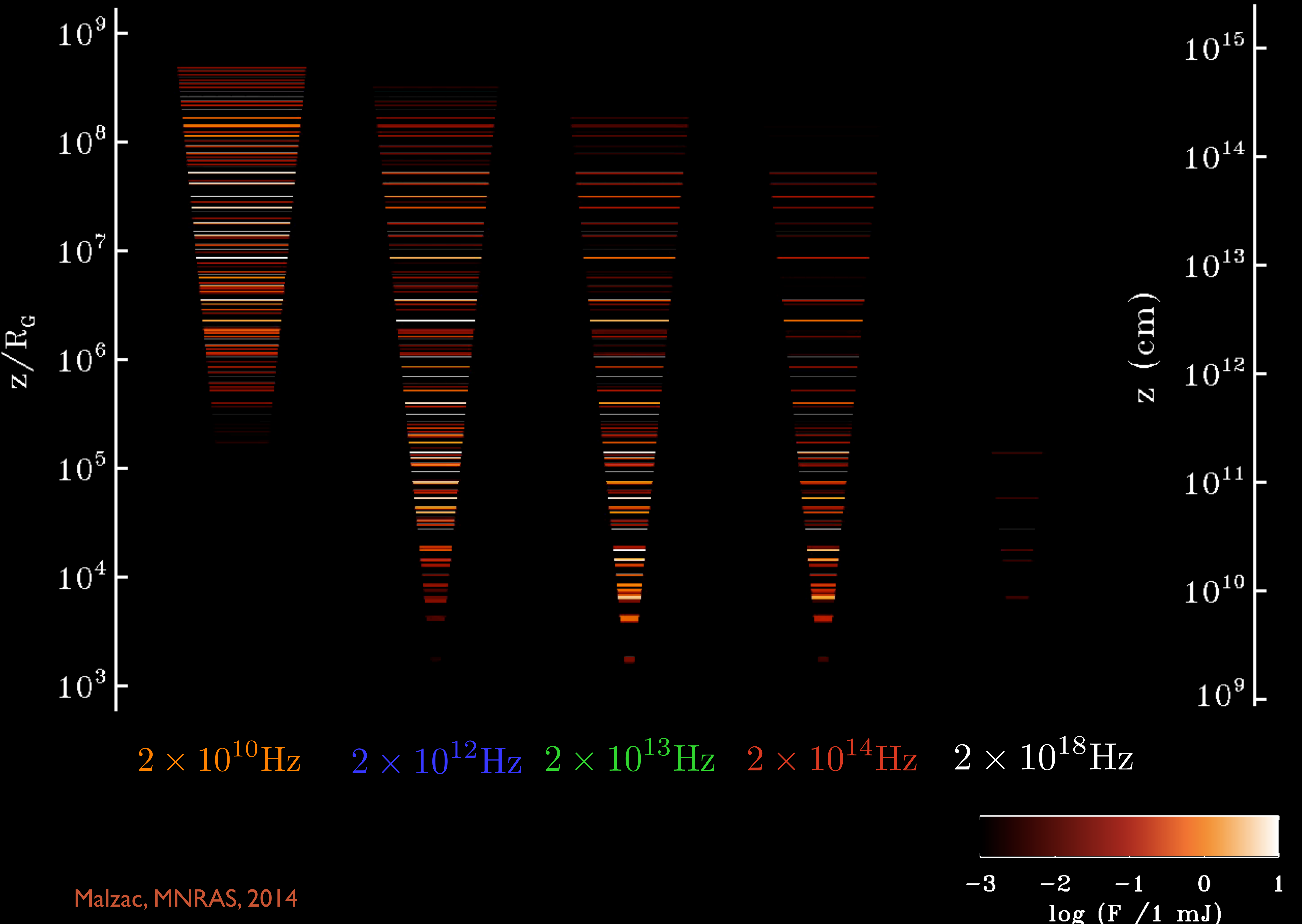
Jet SED

Drappeau, et al. MNRAS, 2015

A dark jet in the soft state ?

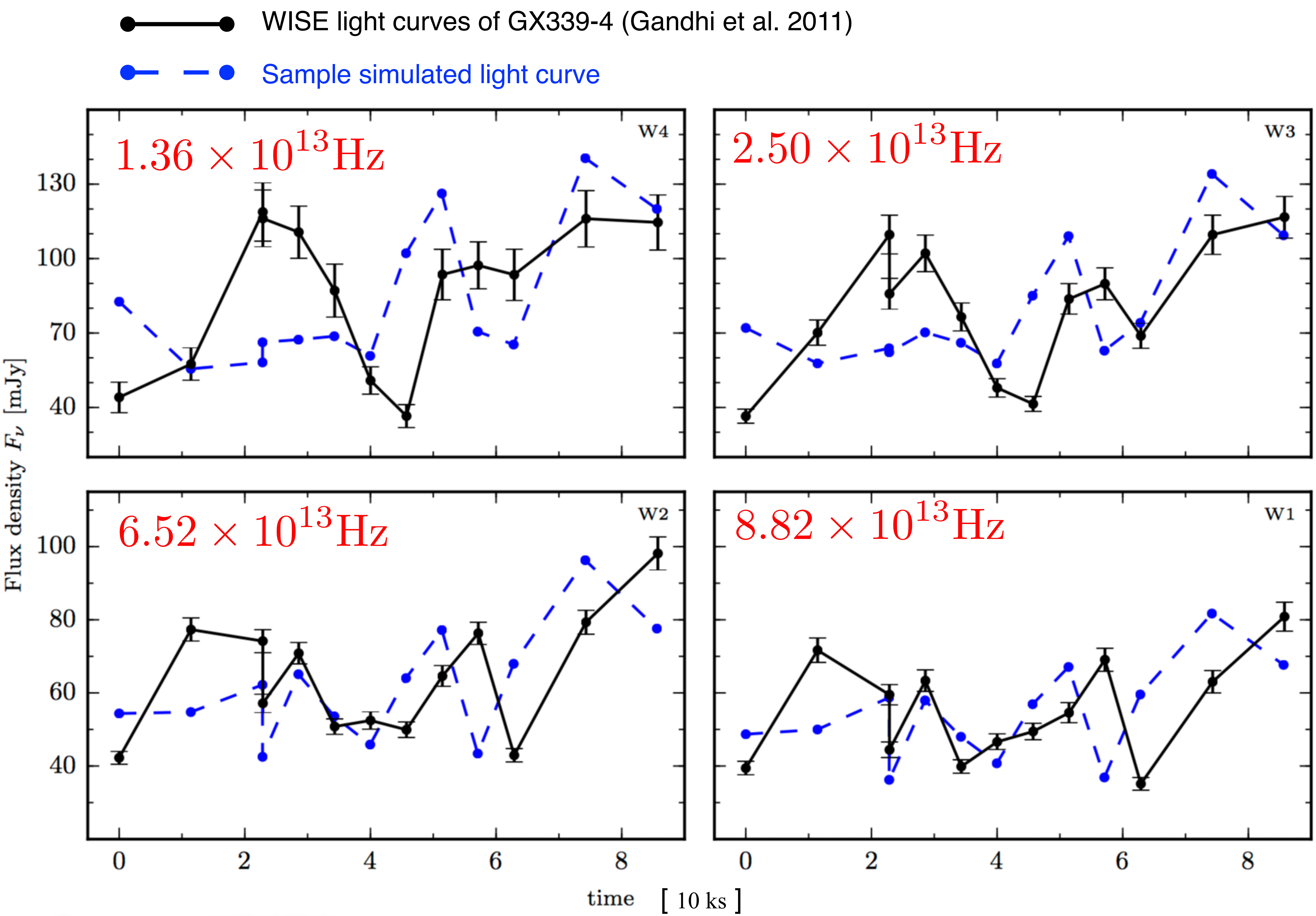


Drappeau et al. 2017



Malzac, MNRAS, 2014

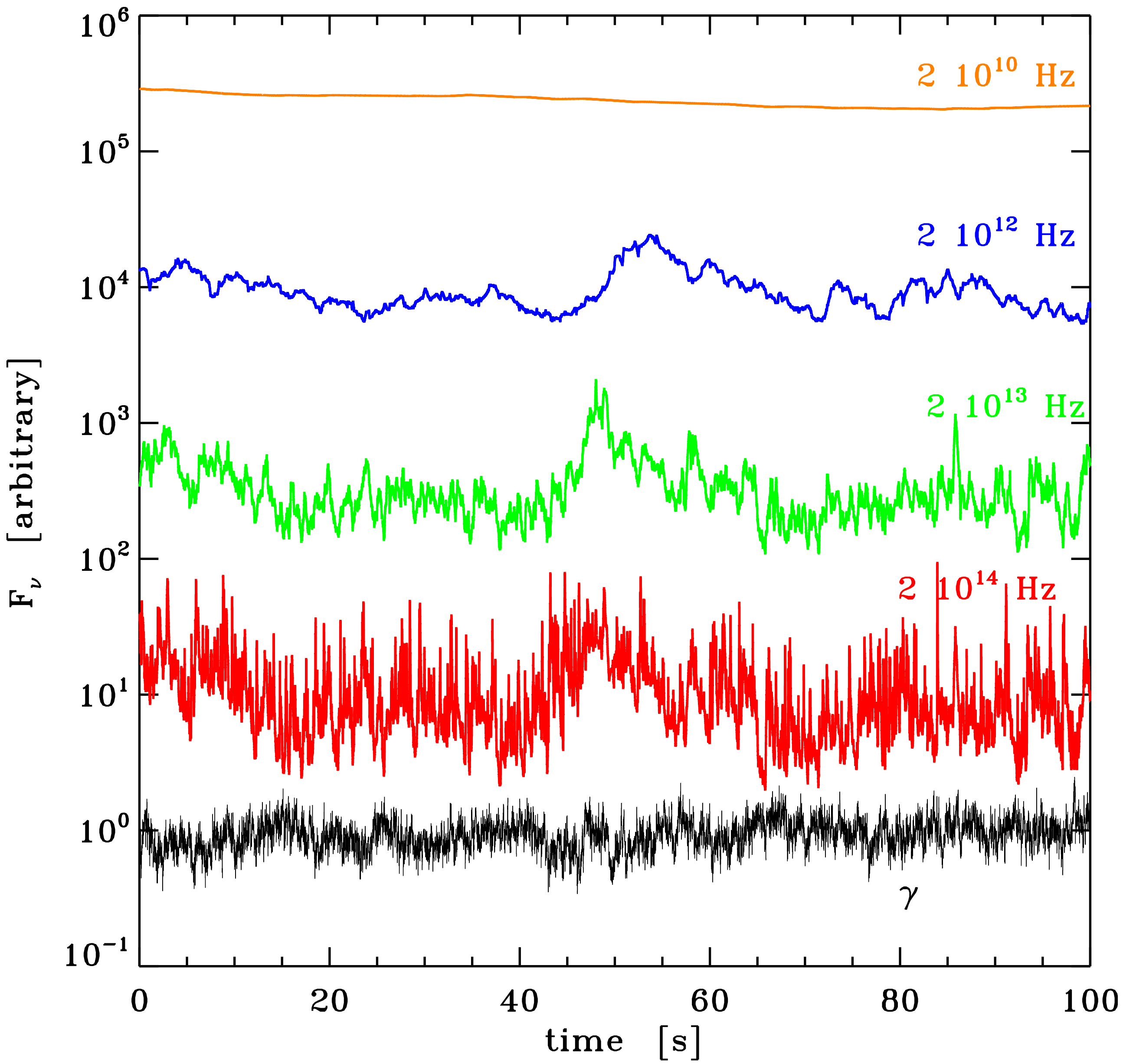
NIR Variability in Hard state



Drappeau et al., MNRAS 2015

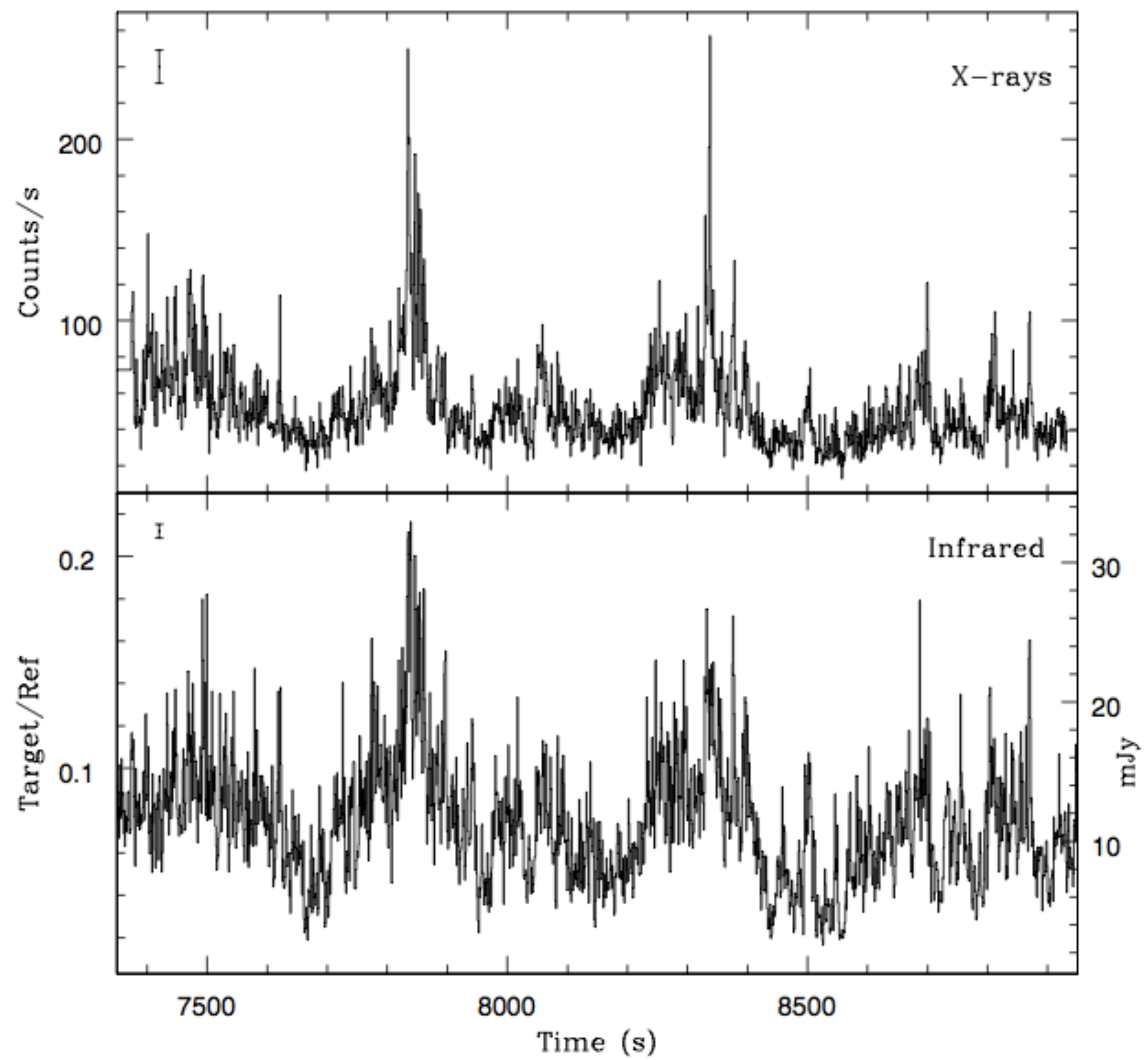
Fast variability from jets

Simulation



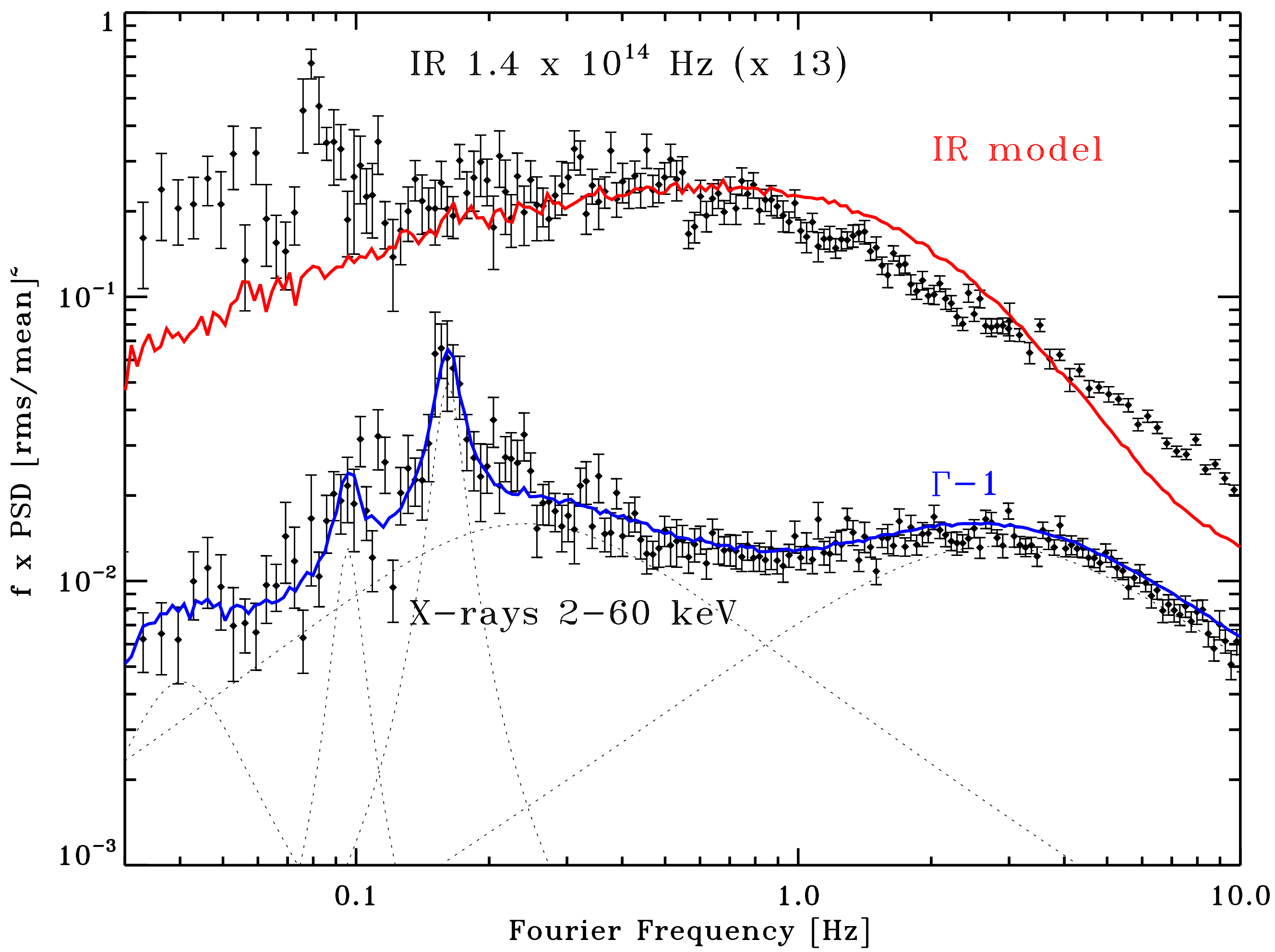
Malzac, MNRAS, 2014

Observation



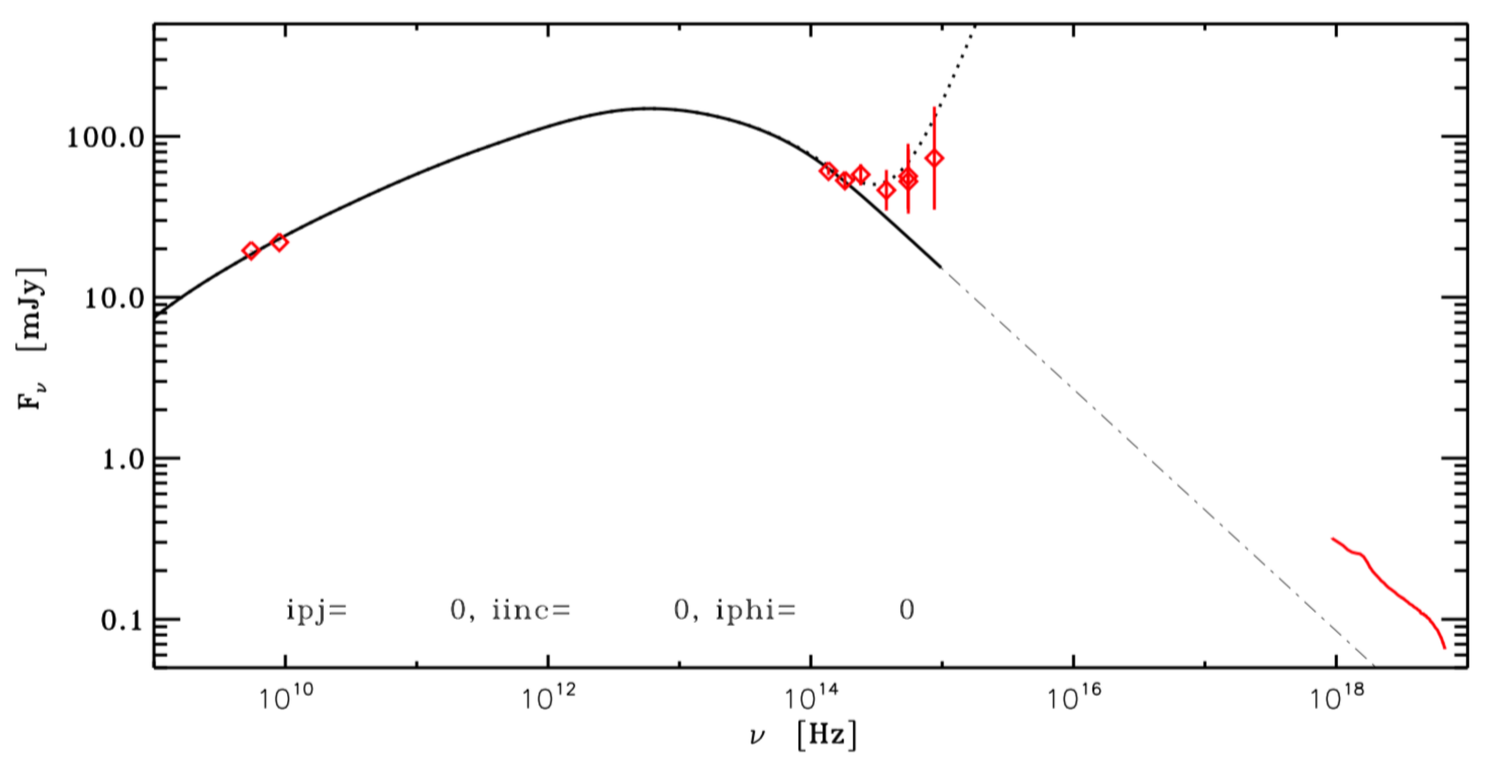
Casella et al. 2010

IR timing data of GX 339-4: First QPO detected in Infrared

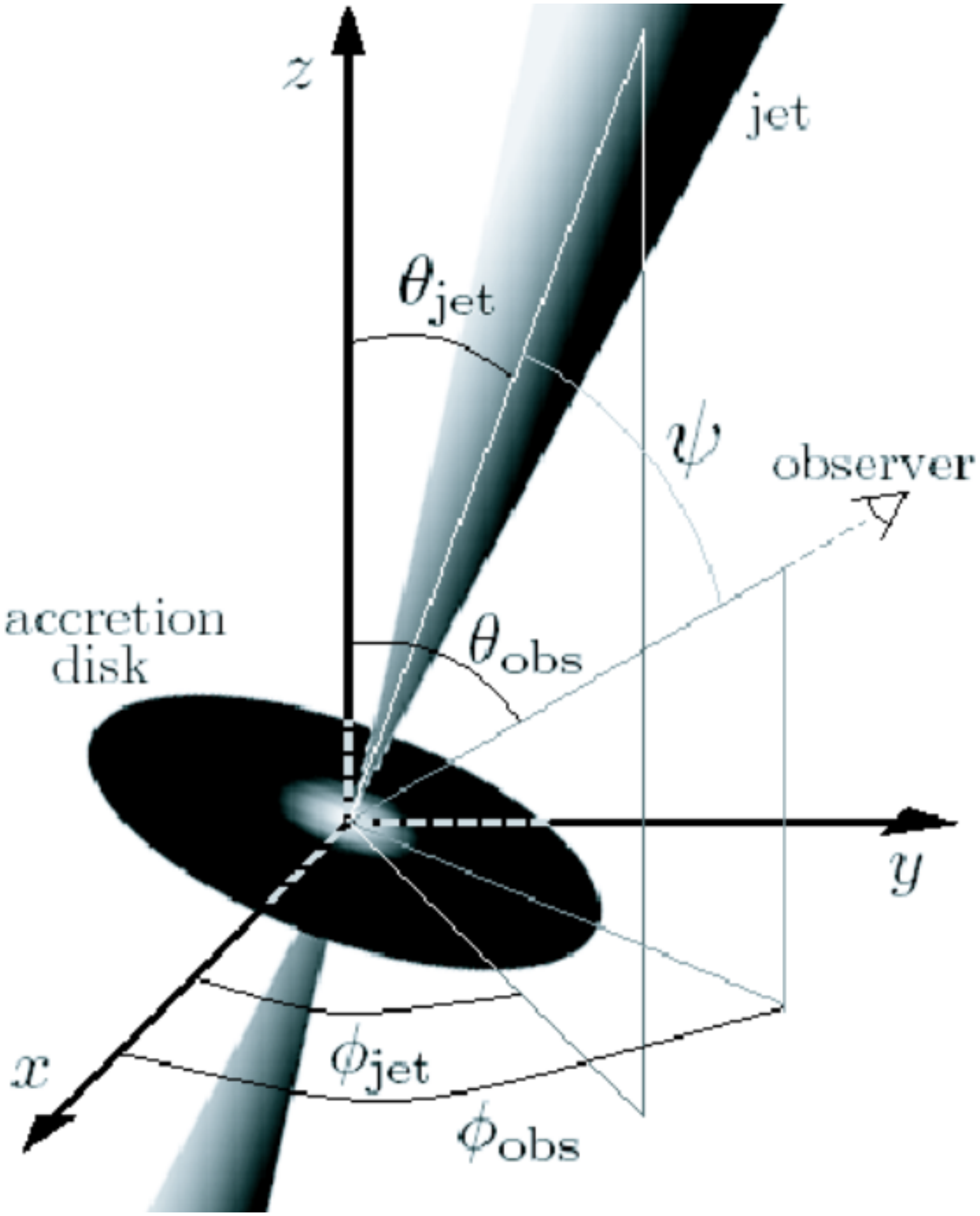


- Simultaneous IR / X timing data with VLT/ISAAC and RXTE (Kalamkar et al. 2016)
- IR rms ~ X-ray rms ~ 20 %
- IR QPO @ ~0.08 Hz
  X-ray QPO @ ~0.16 Hz

- Internal shock model predicts similar shape of IR PSD but model rms amplitude larger by factor of ~4. Additional constant component from disc or jet ?
- Model lacks IR QPO.



IR QPO from jet precession



- X-ray low frequency QPO caused by Lense-Thirring precession of the hot accretion flow ?

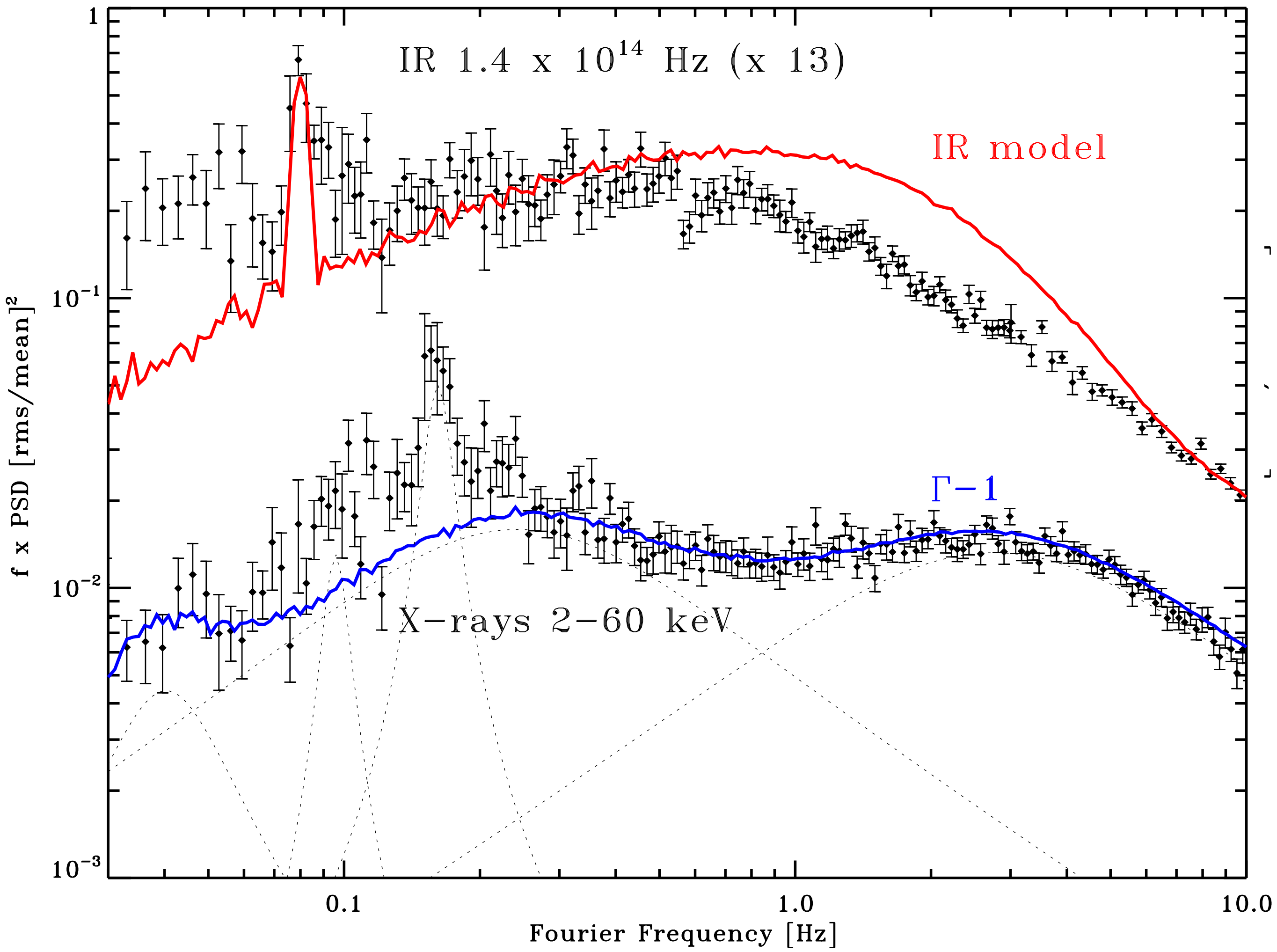
Ingram, Done & Fragile 2009; Ingram et al. 2015

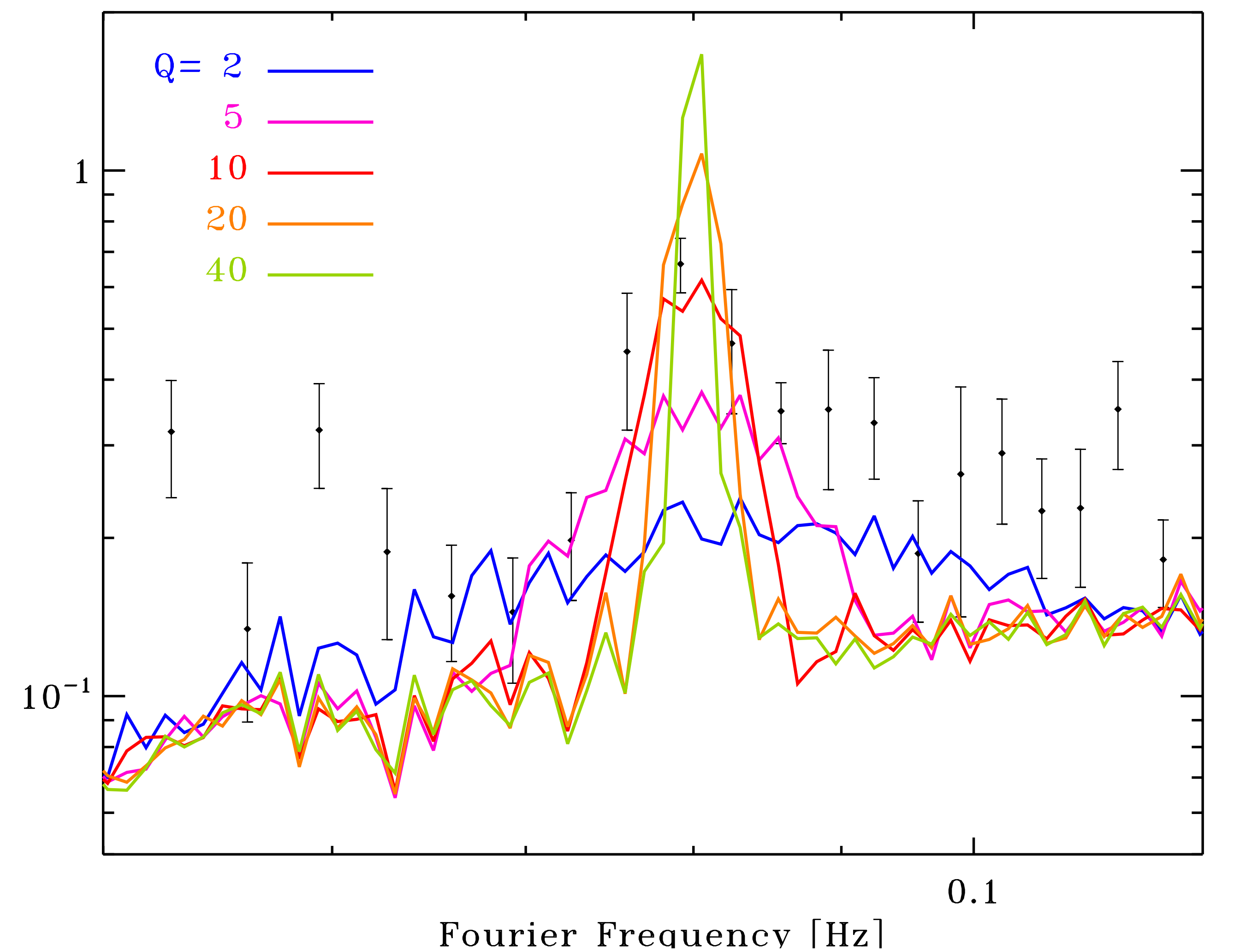
- If jet launched by accretion flow, jet precesses with the hot flow

➡ modulation of synchrotron emission

ISHEM simulation with jet precession

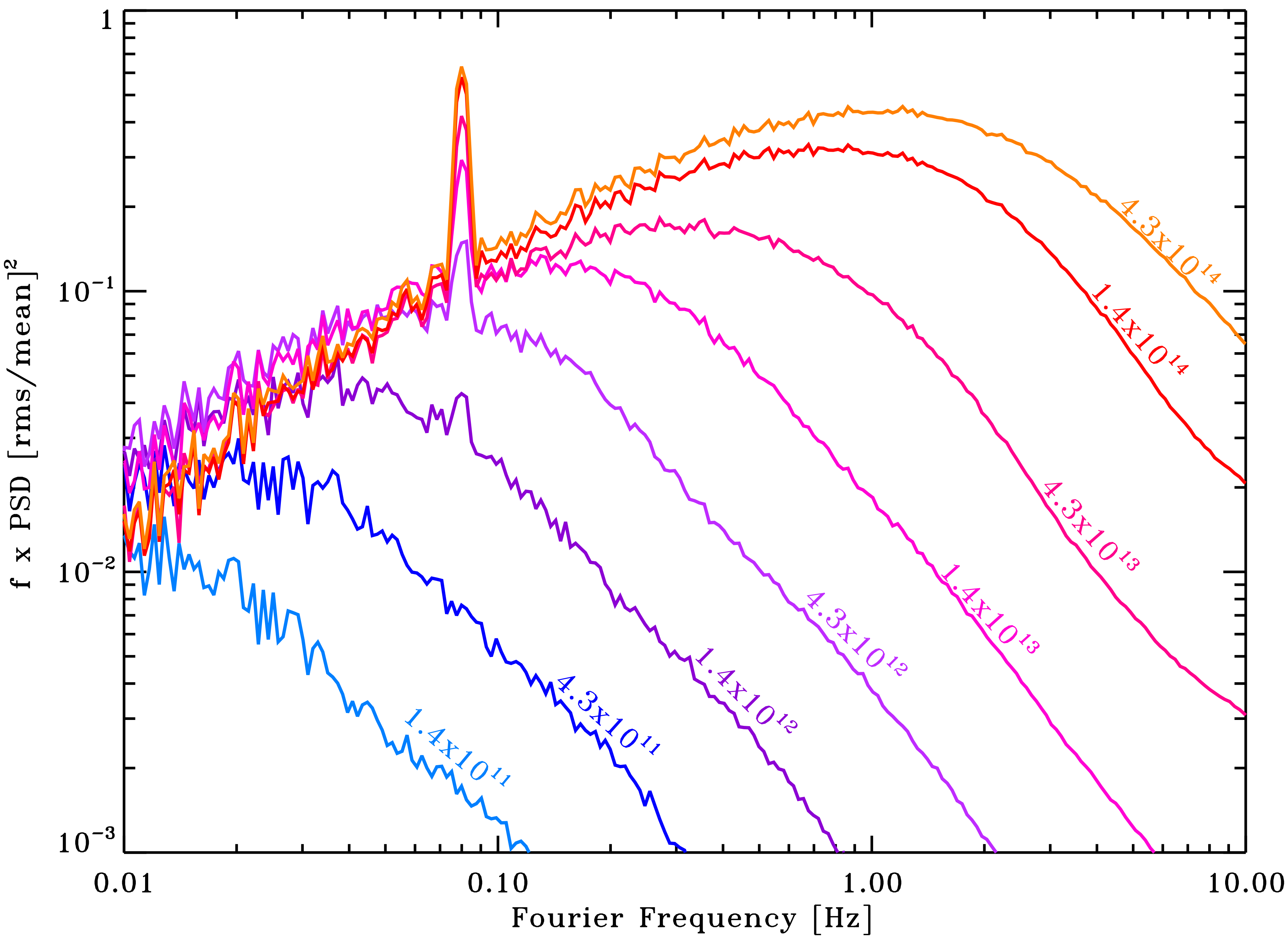
- Jet precession at observed IR QPO frequency, precession angle: 5 deg.
- X-ray QPO subtracted from input jet Lorentz factor fluctuations
- QPO width: precession phase randomised every Q~10 cycles.



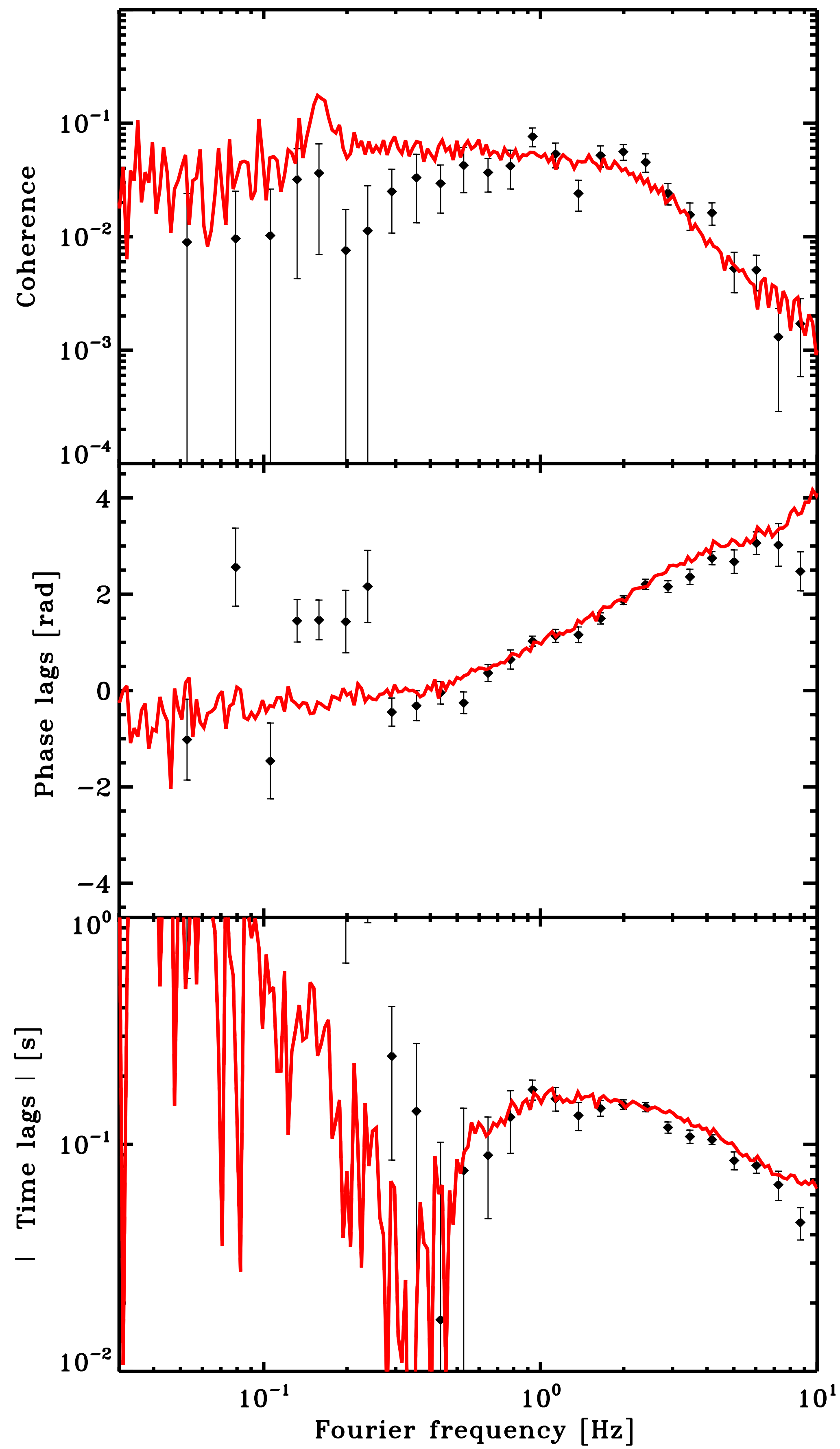


- Depending on hot flow geometry and inclination and precession angle, X-ray QPO can be dominated by first harmonic (see Veledina et al. 2013).

Wavelength dependence of synthetic IR Fourrier power spectrum



Fast IR /X-ray correlations in GX339-4



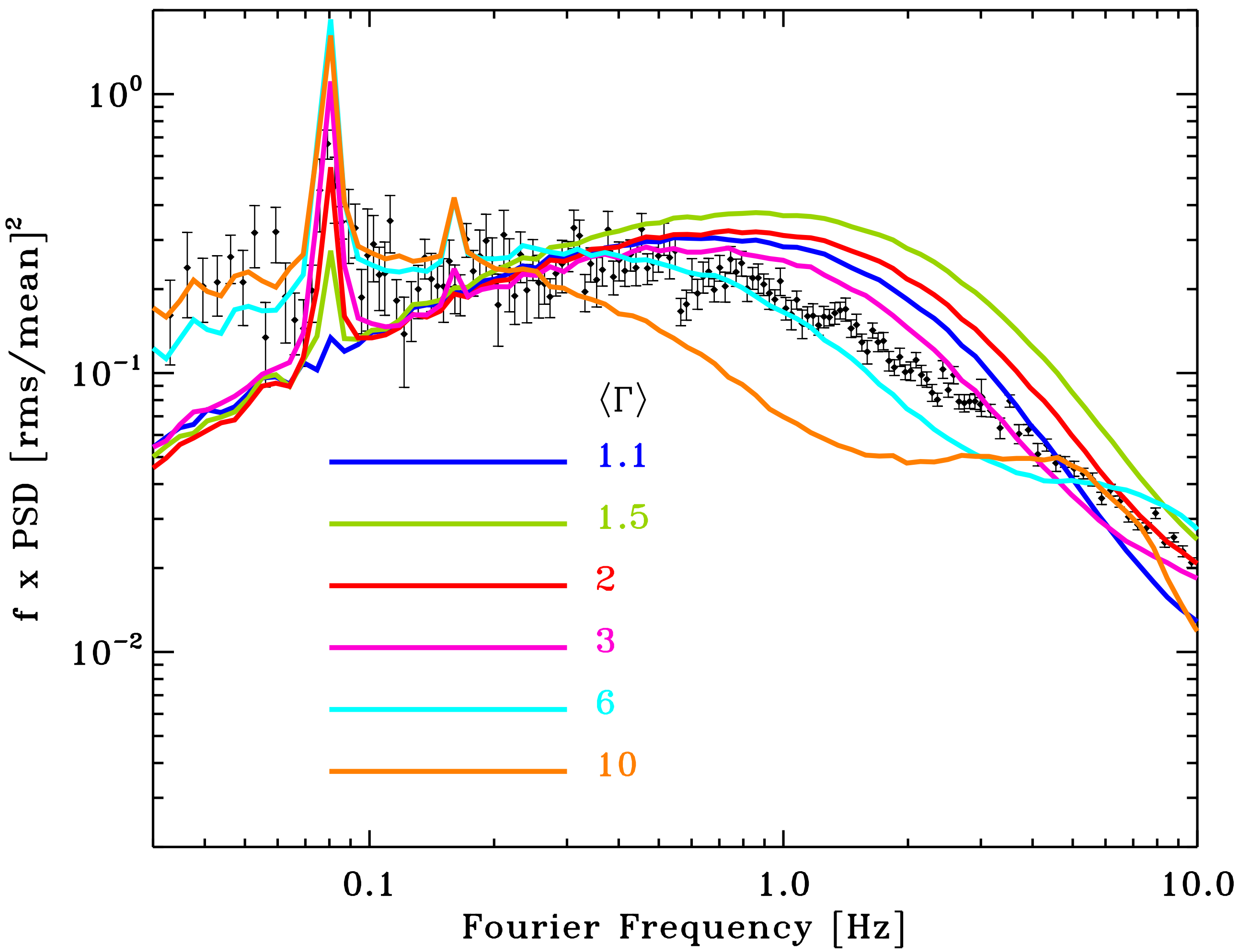
- IR vs X-ray Fourier coherence, and lags from Kalamkar et al. (2016) data

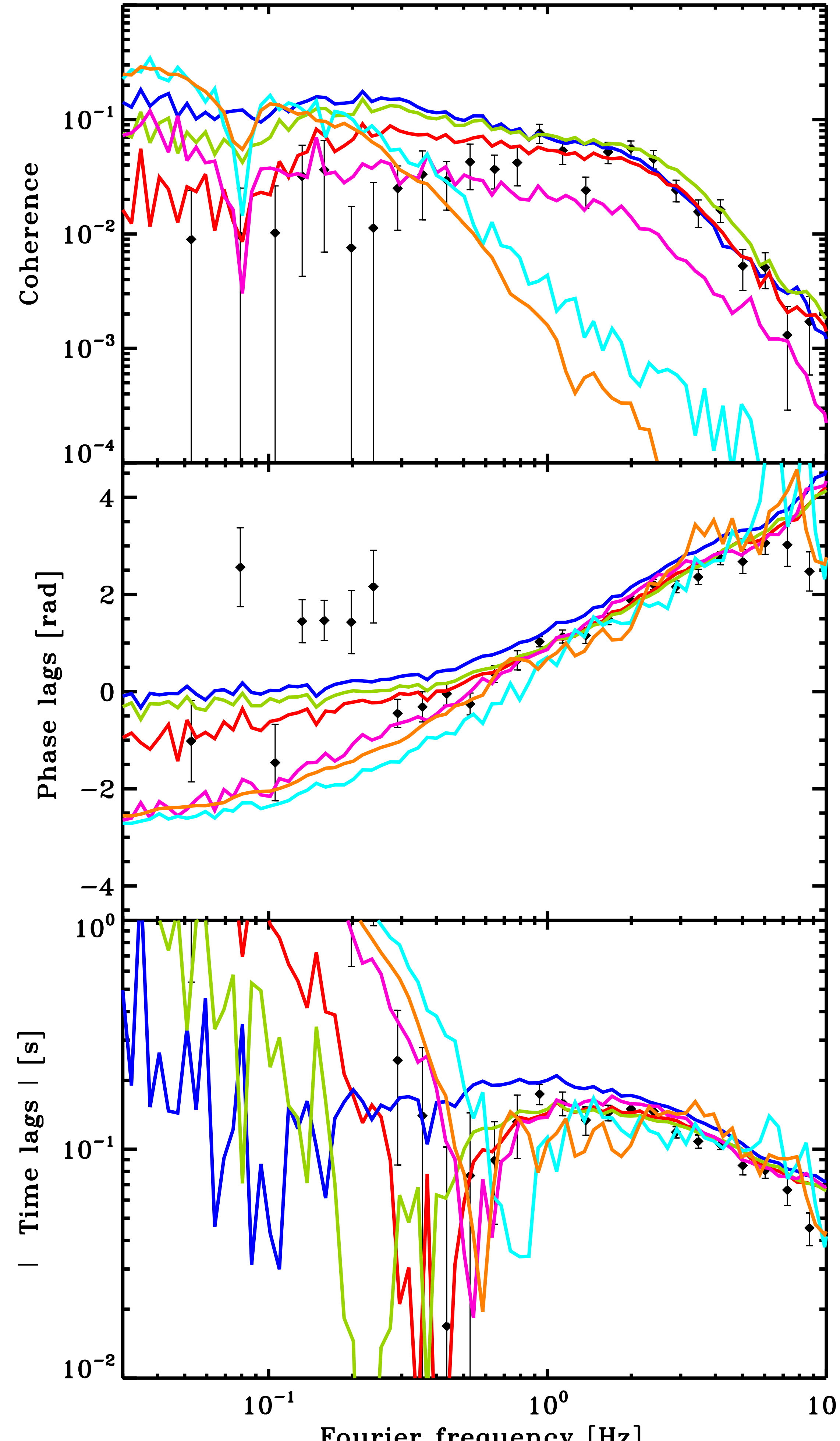
- Model:

- IR light curve from same model used for SED and IR PSD.

- X-ray light curve: $L_X(t) \propto \Gamma(t) - 1$

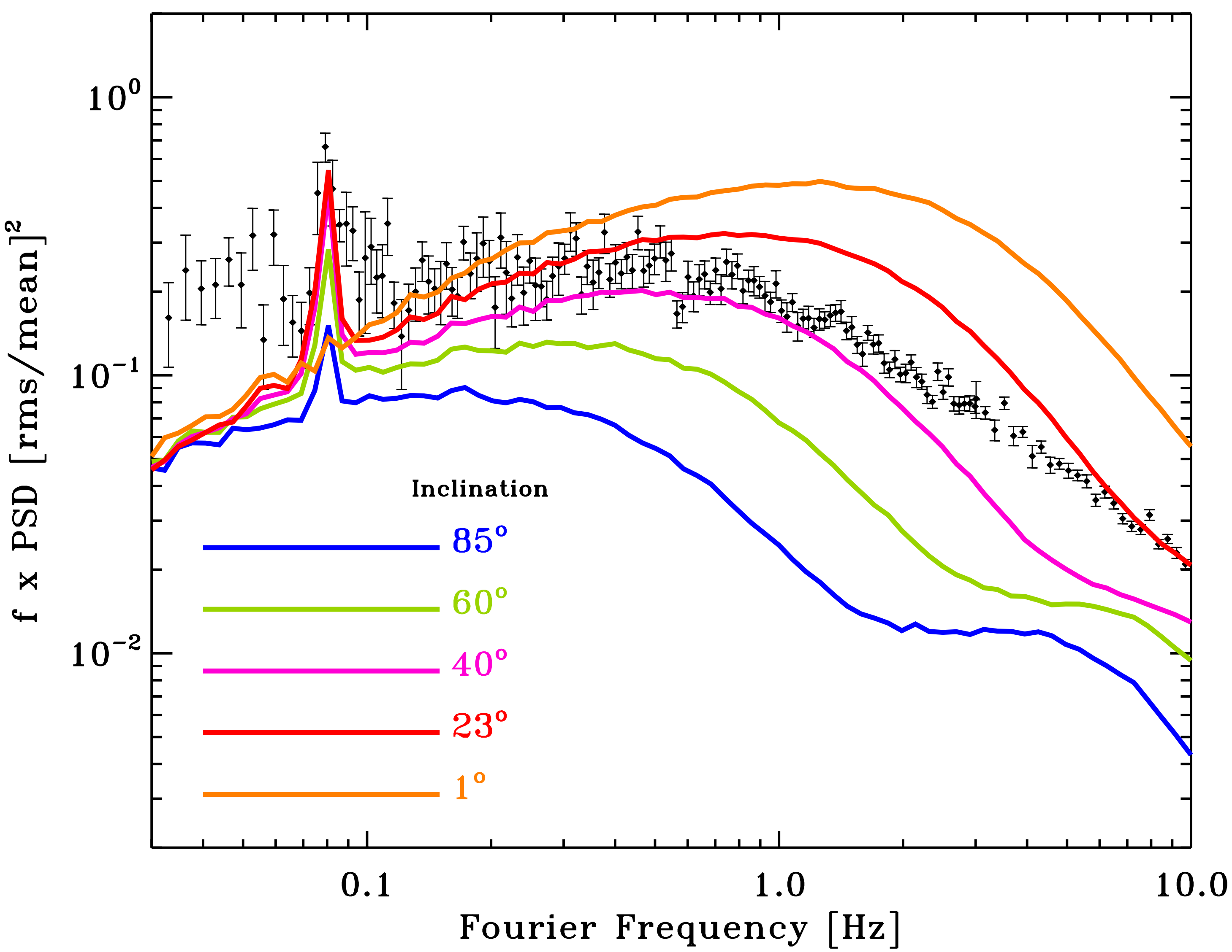
Effect of jet Lorentz factor

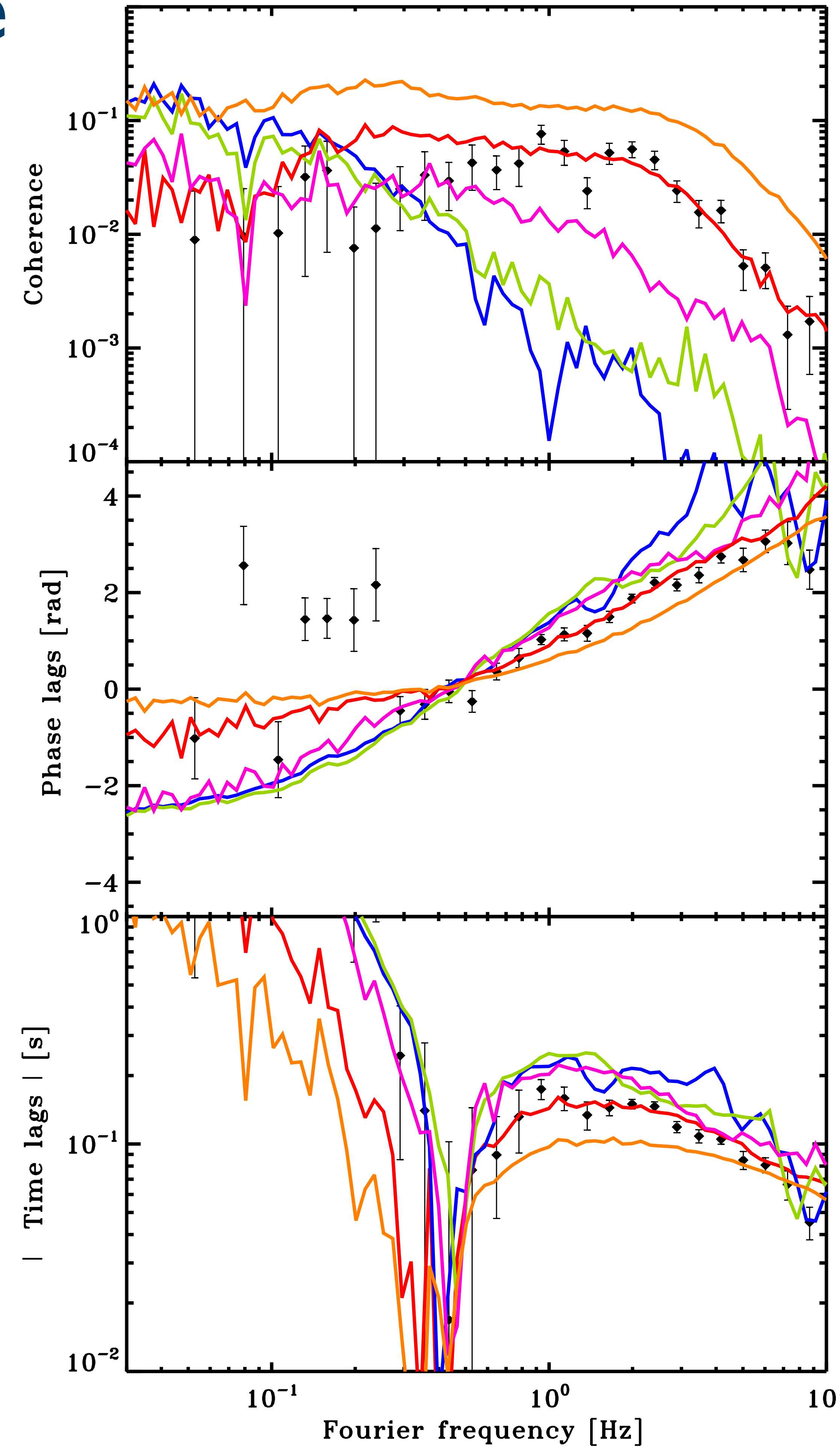




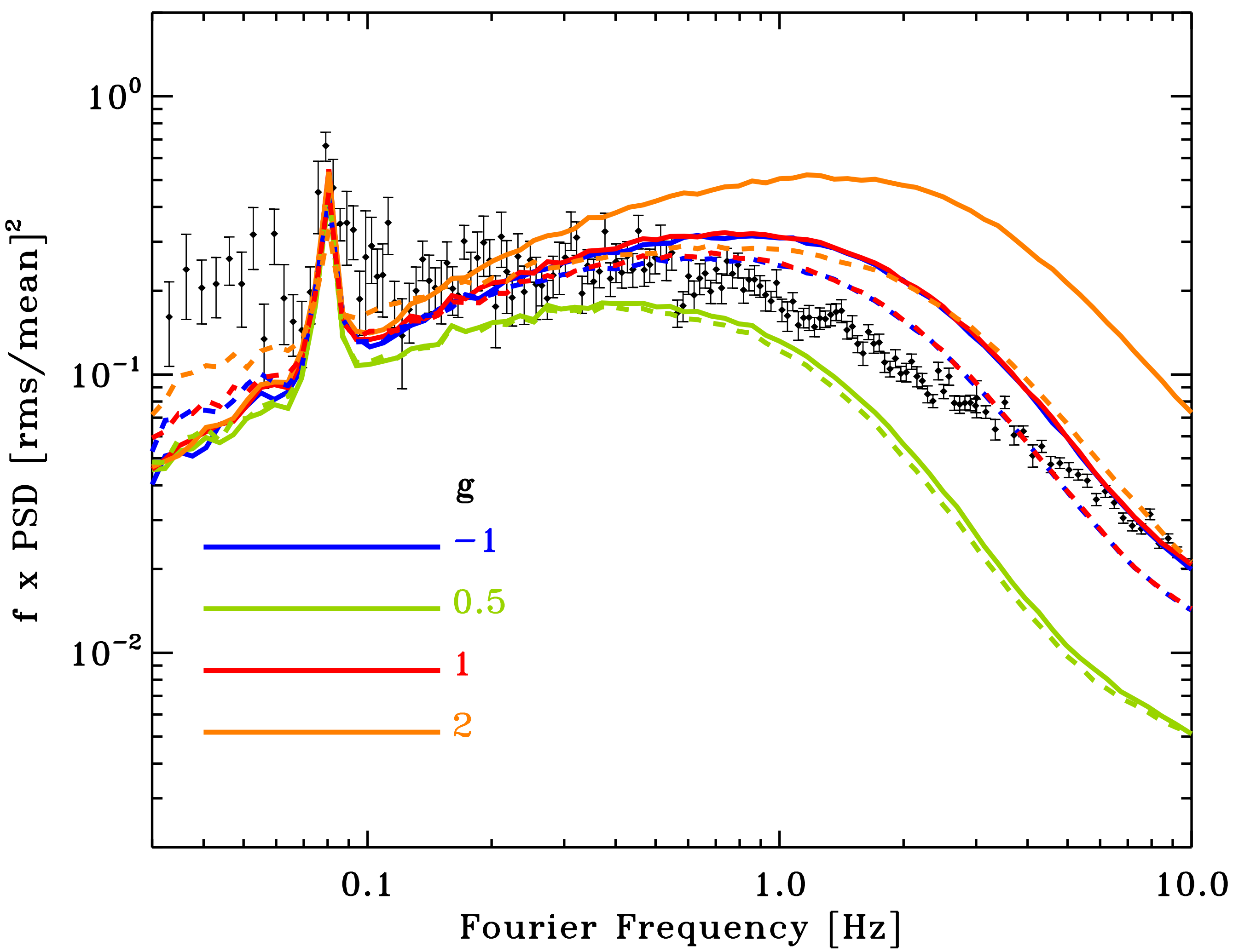
$\langle\Gamma\rangle < 3$ favoured

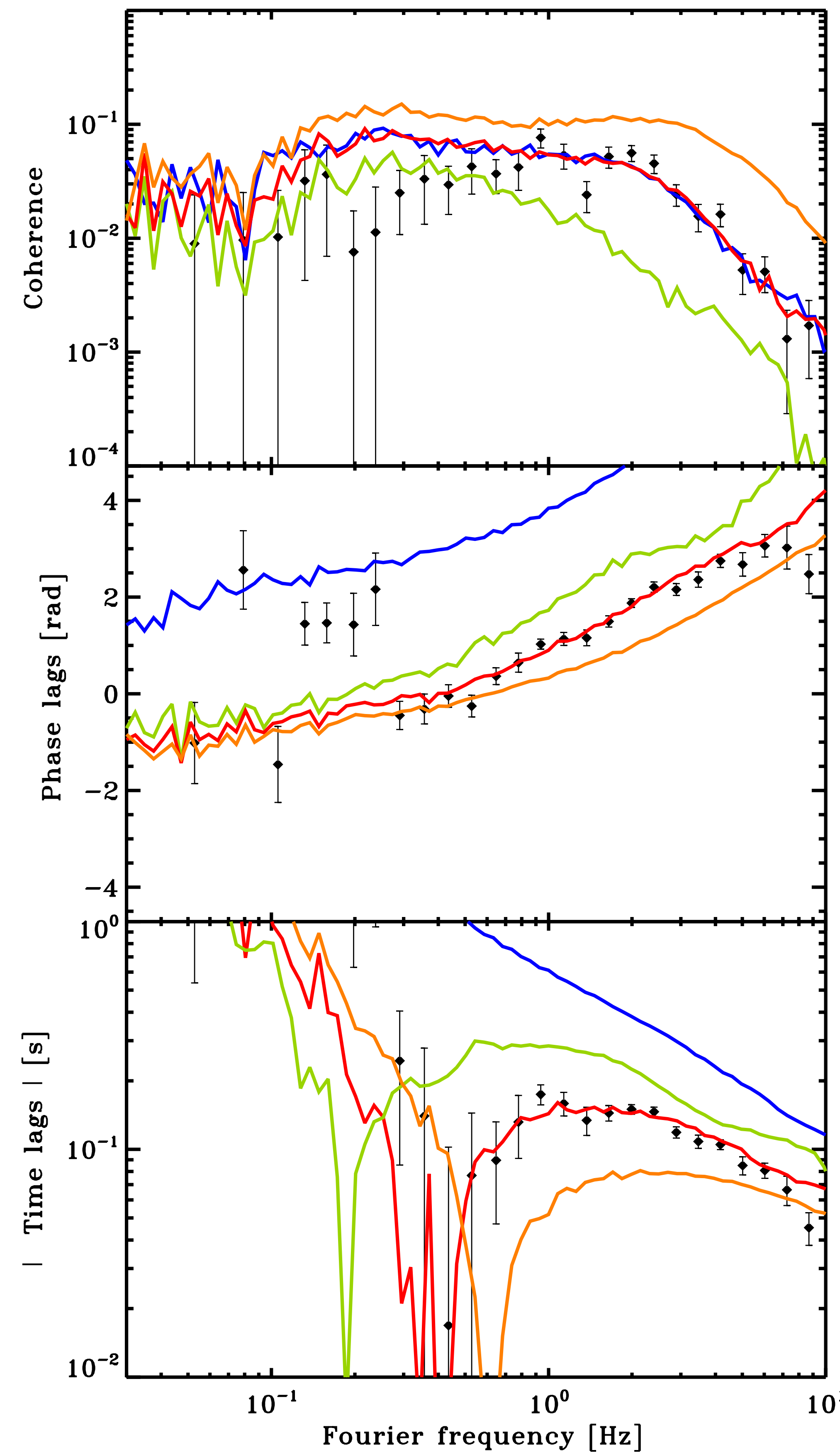
Effect of viewing angle





Jet disc coupling



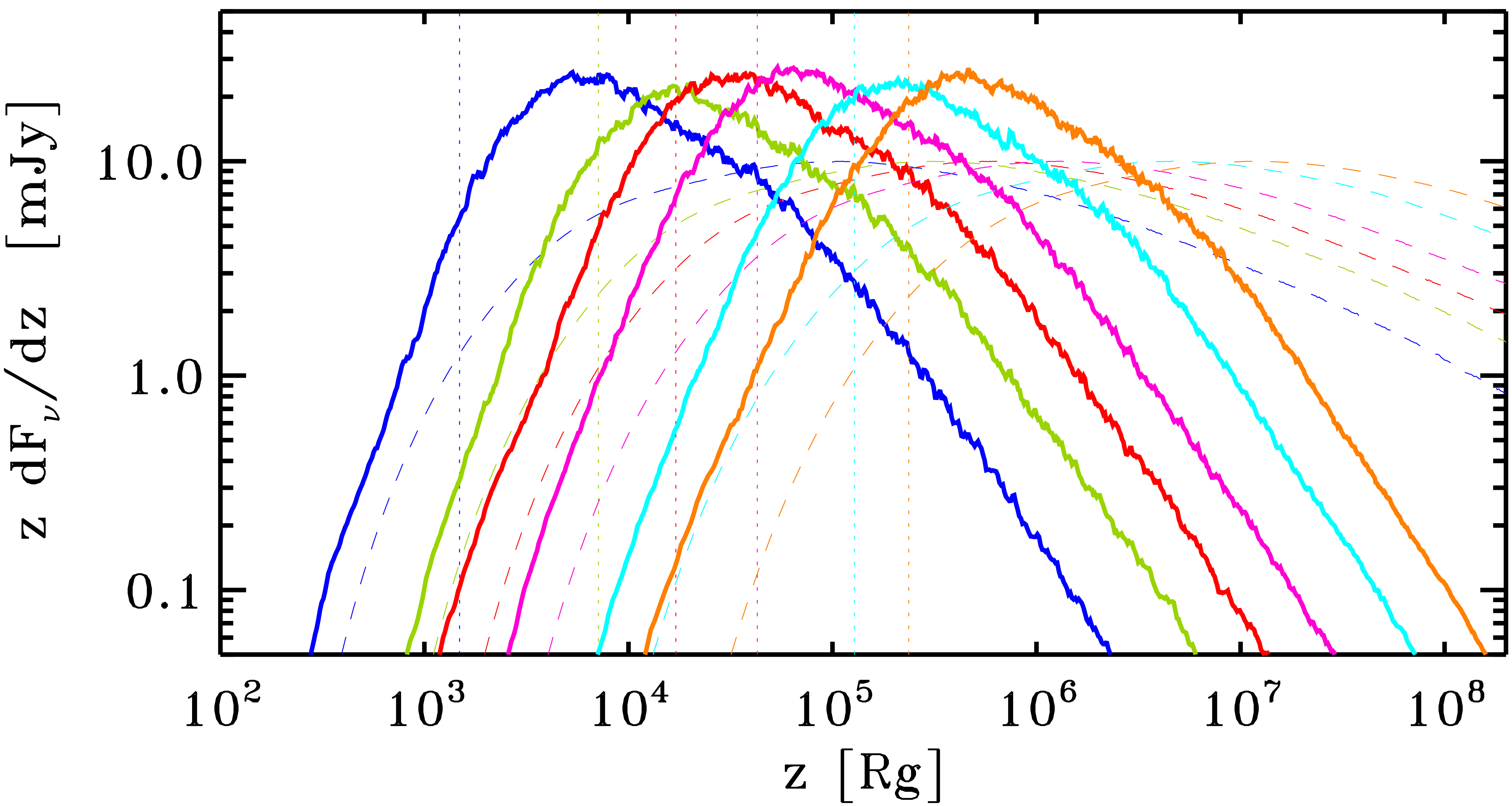


$$\Gamma(t) - 1 \propto L_X^g(t)$$

g=1 favoured

Summary

- There might be powerful radiatively inefficient jets in soft states.
- Internal shock model predicts strong variability and IR/X-ray correlations similar to that observed in GX339-4.
- IR QPO may be caused by jet precession.
- Opt/IR/X-ray correlations could be used to constrain the jet parameters, unveil the dynamics of accretion and ejection physics, and also constrain the hot flow geometry (X-ray vs IR QPOs).
- Need to combine accretion flow and jet models.



z dF$_\nu$/dz [mJy]
10.0
1.0
0.1
10^2
10^3
10^4
10^5
10^6
10^7
10^8
z [Rg]