Black-hole binaries in the AstroSat era

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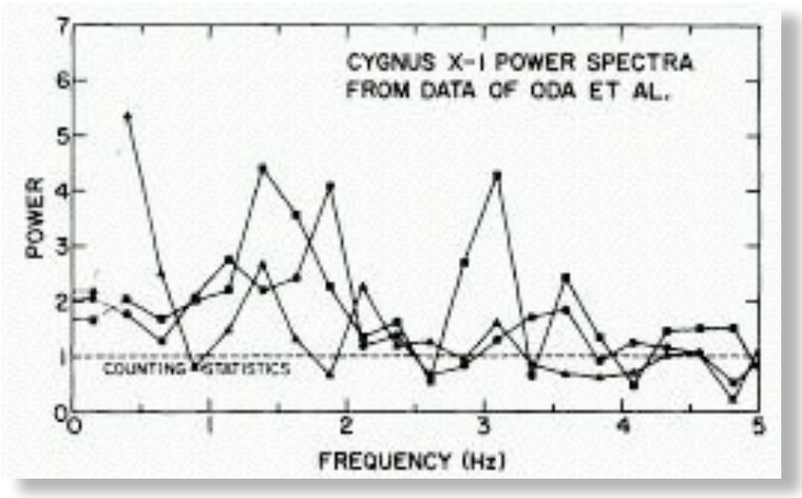
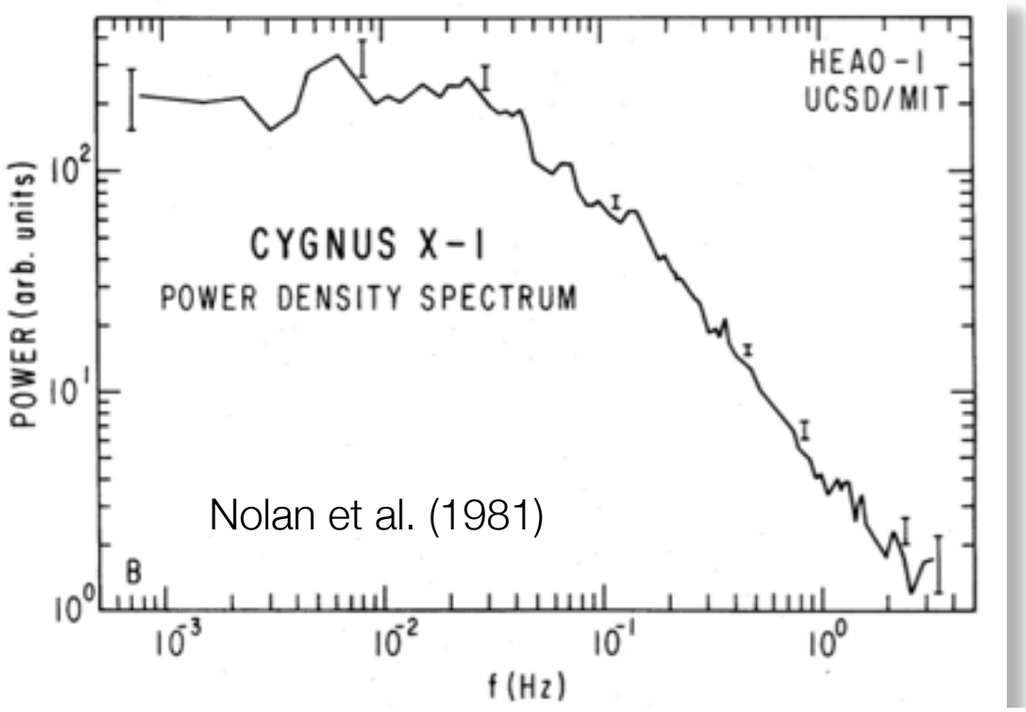
TIFR - Mumbai

A BIT OF HISTORY: NOISE

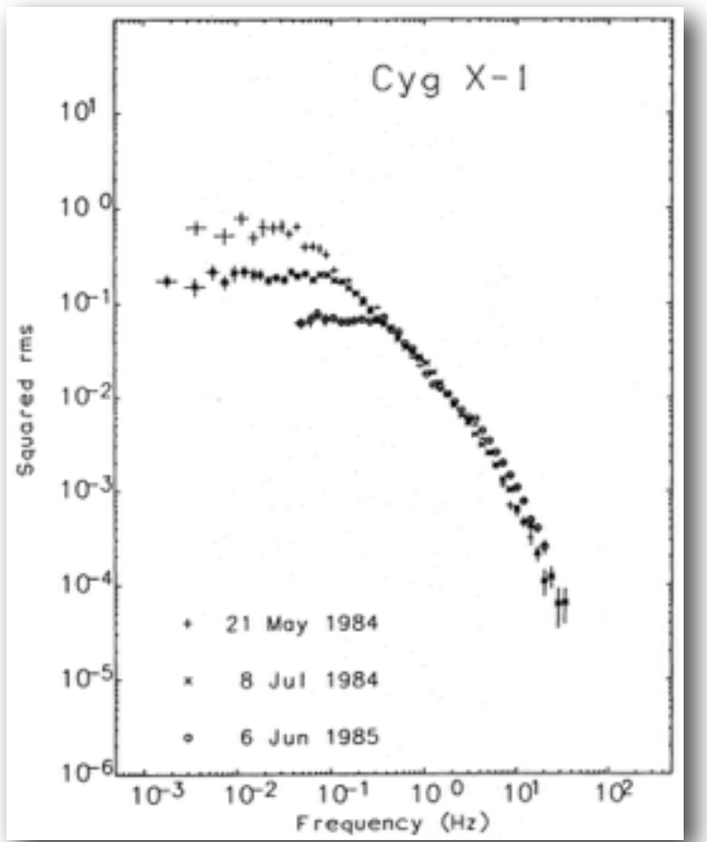
Terrell (1972)

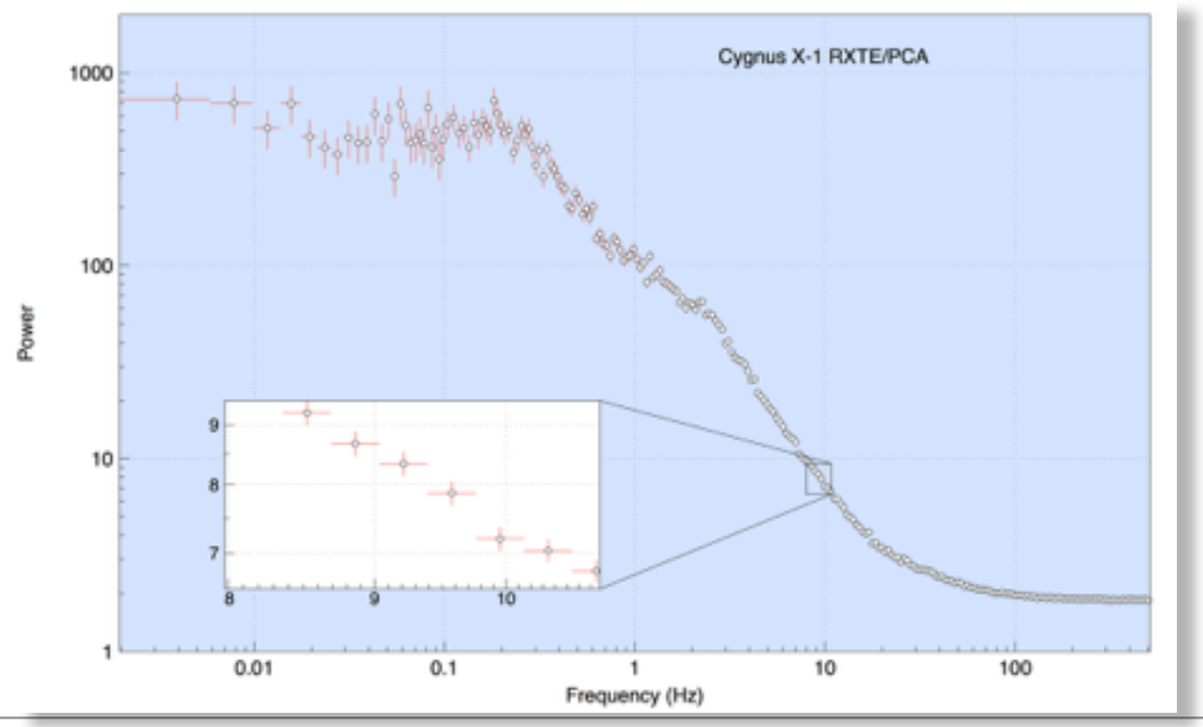


Nolan et al. (1981)

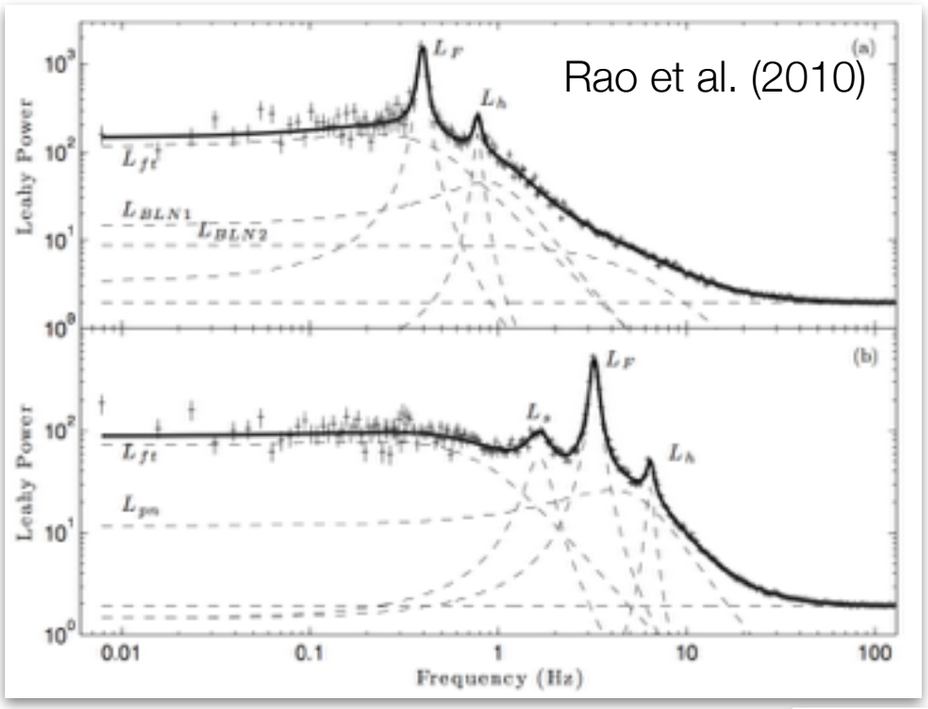


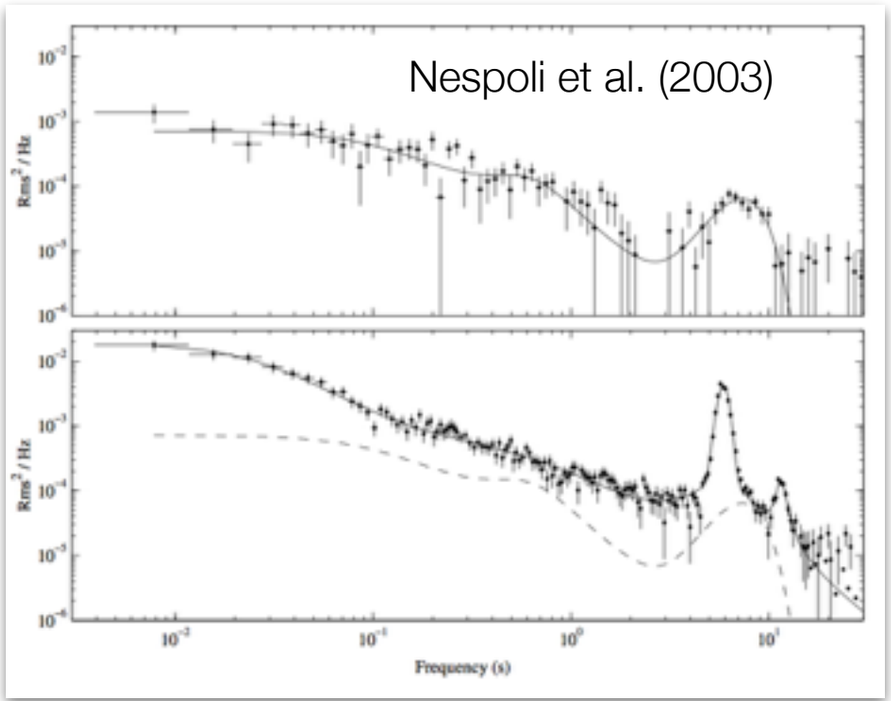
Belloni & Hasinger (1990)

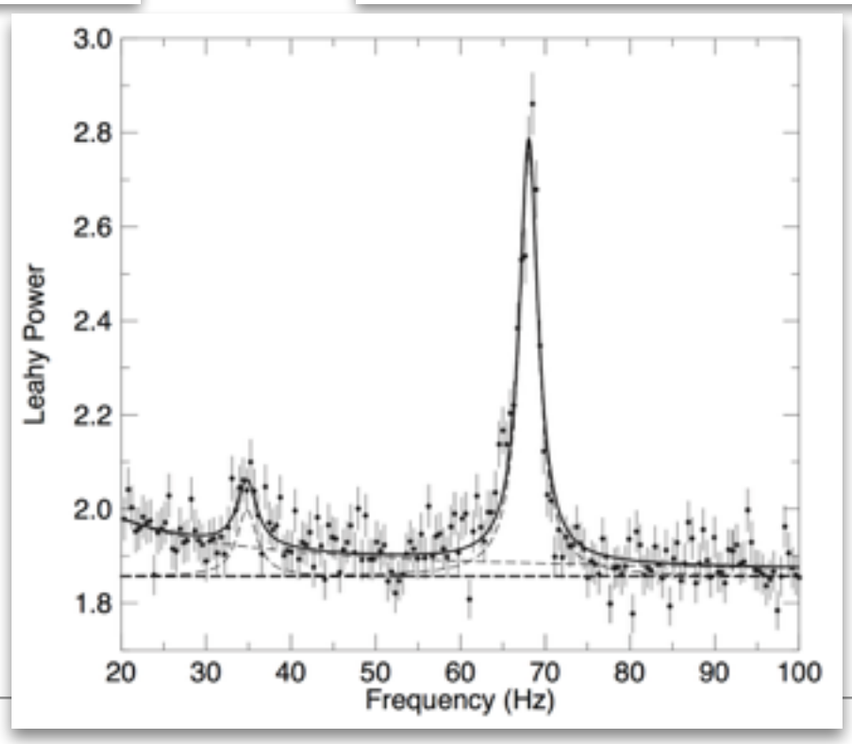




A BIT OF HISTORY: QPO

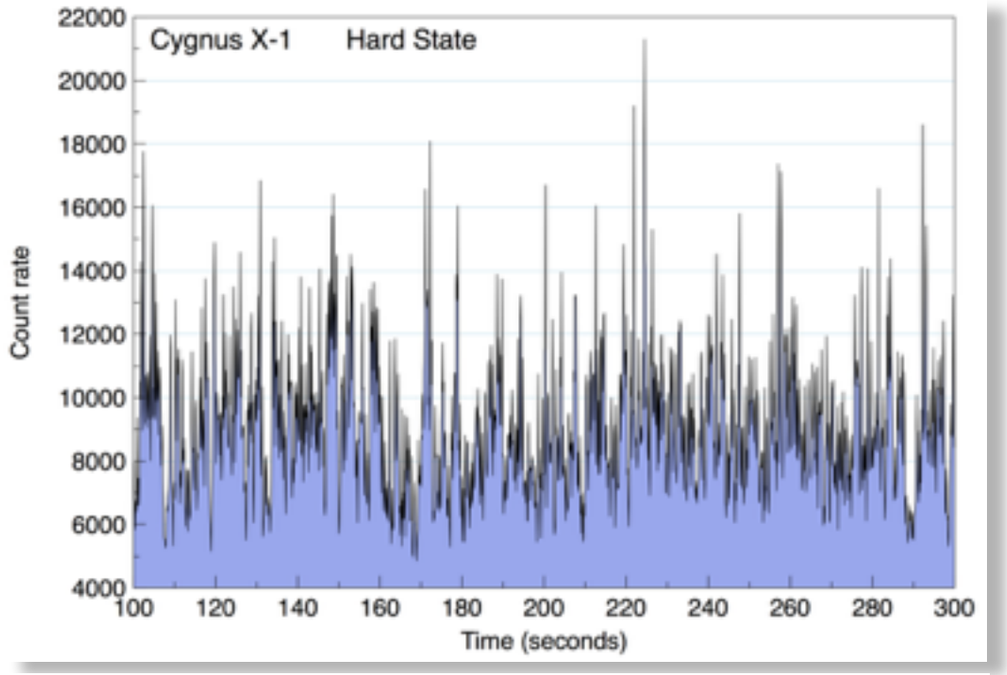


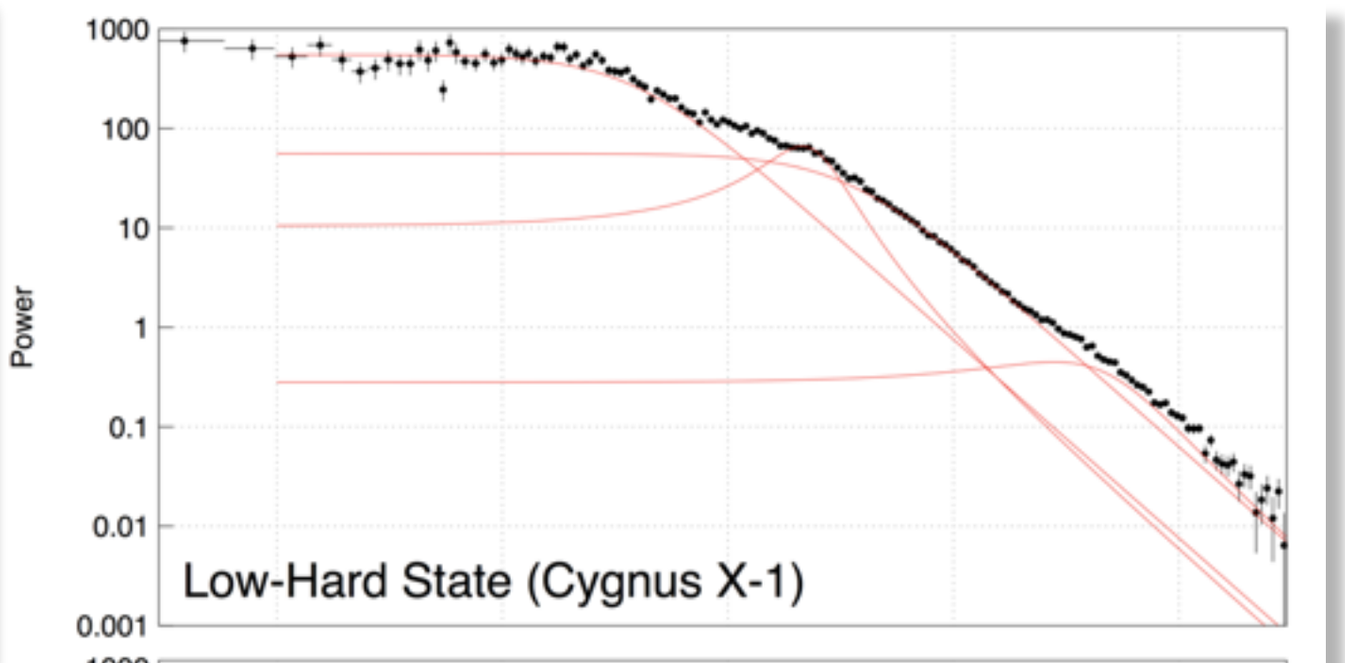


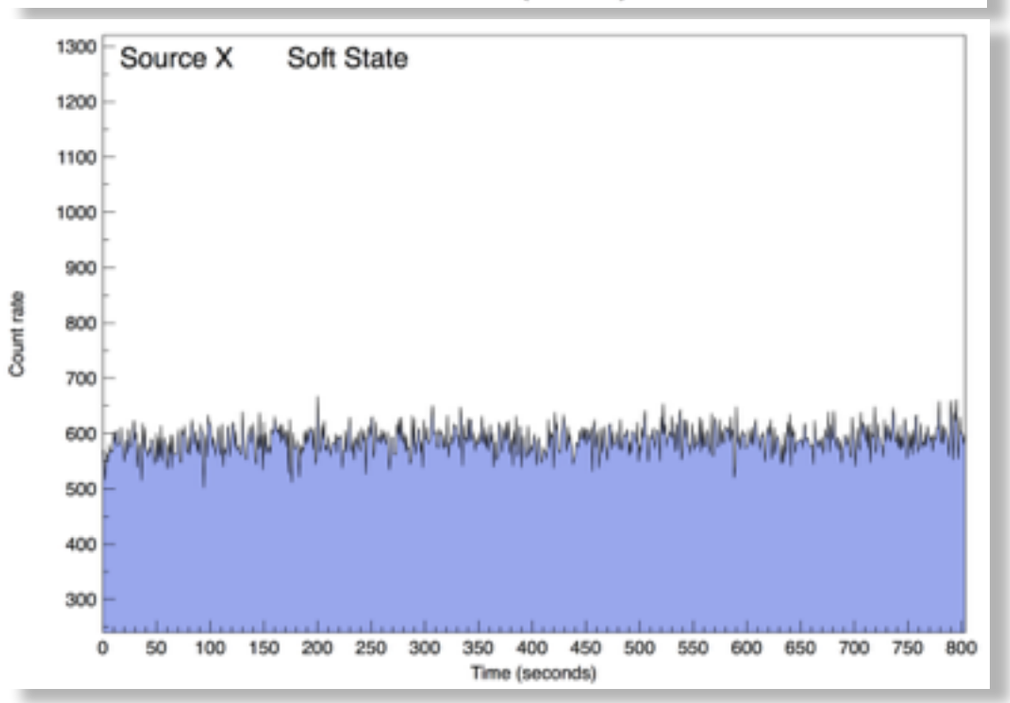


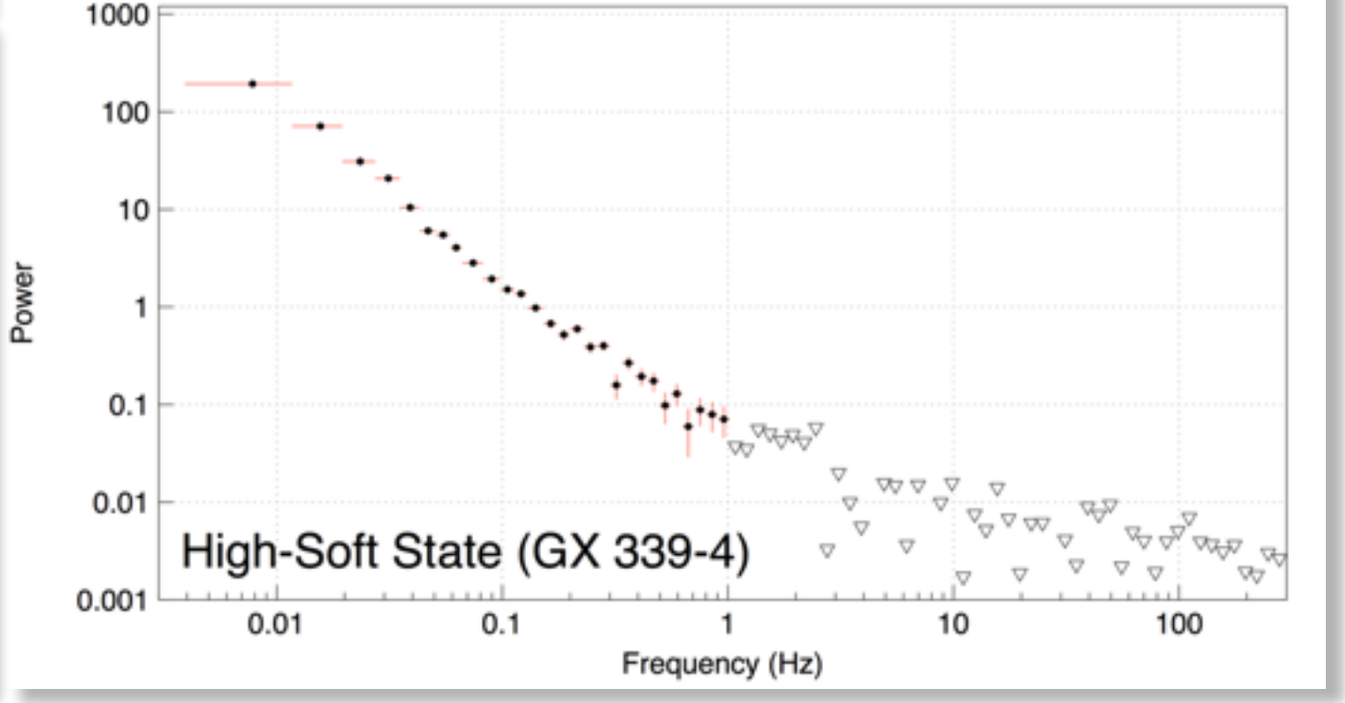
Belloni & Altamirano (2013)

VARIABLE OR QUIET?



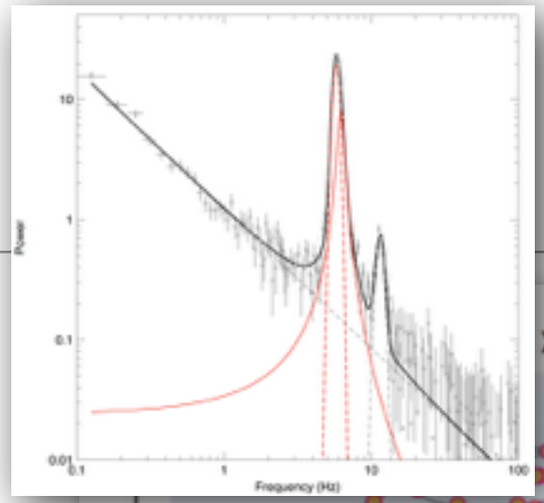


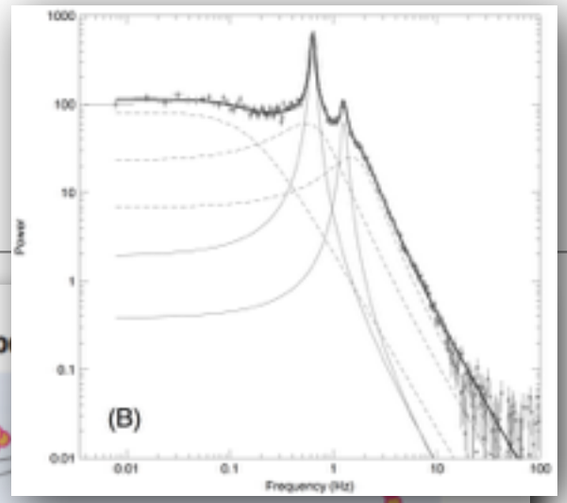


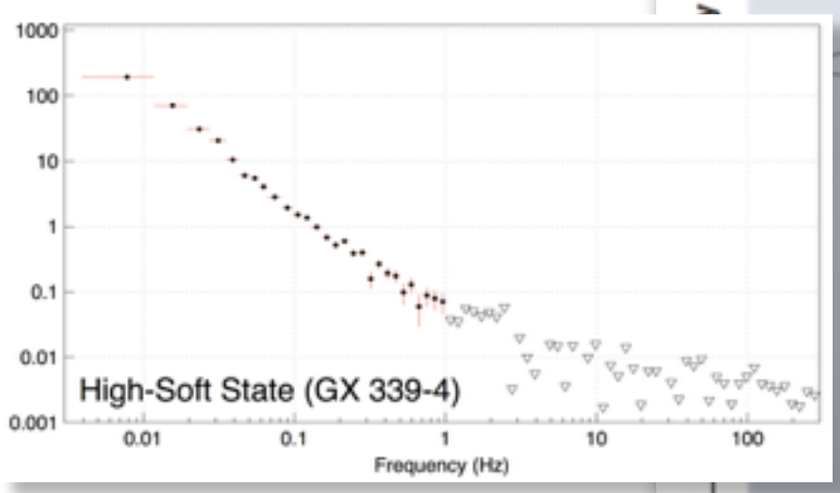


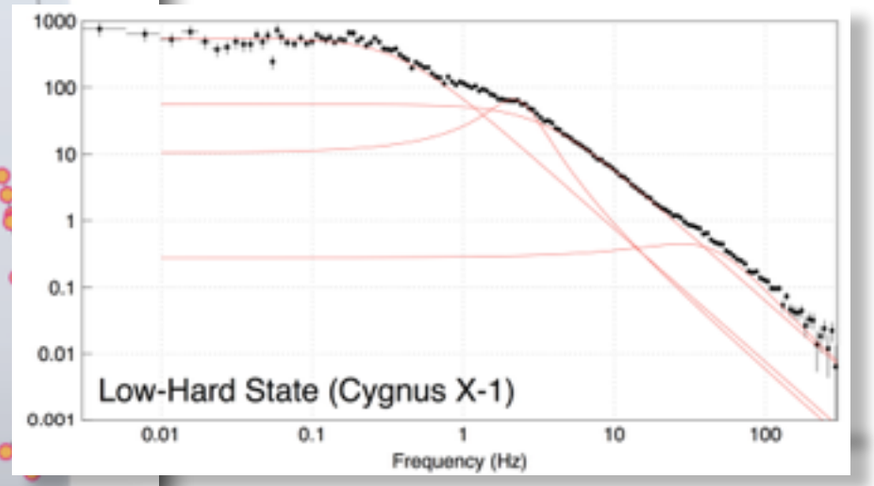
STATES

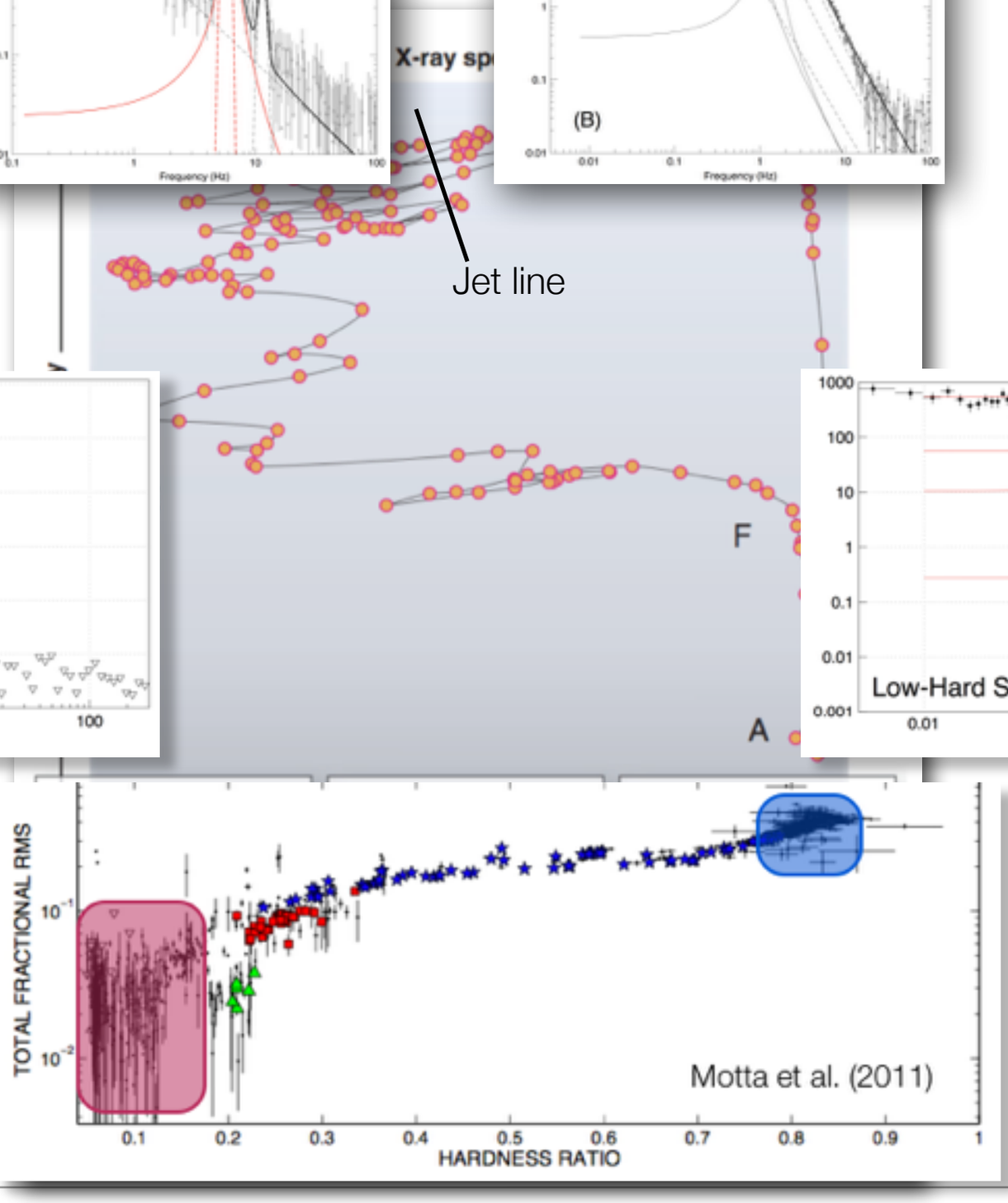
see Kylafis & Belloni (2015)









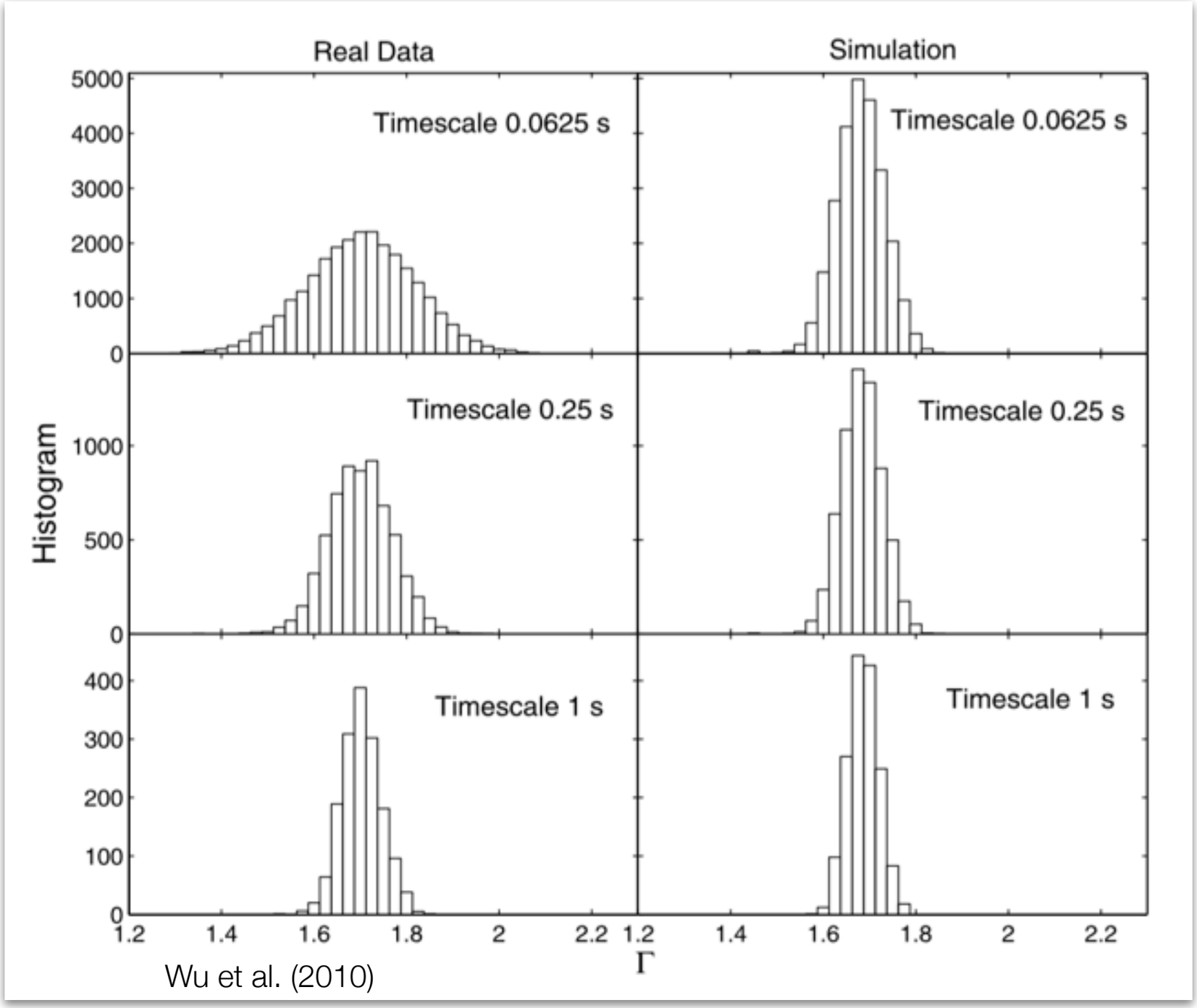


FAST TIME VARIABILITY

- *Dependence on source state —> related to physics*
- *Energy dependence —> spectrum changes fast*
- *Broad-band noise components —> lots of noise*
- *Low-Frequency Quasi-Periodic Oscillations —> Common*
- *High-Frequency Quasi-Periodic Oscillations —> Rare*
- *Accretion and General Relativity —> Which is which?*
- *Fast variability at other wavelengths*

ENERGY DEPENDENCE

Cyg X-1

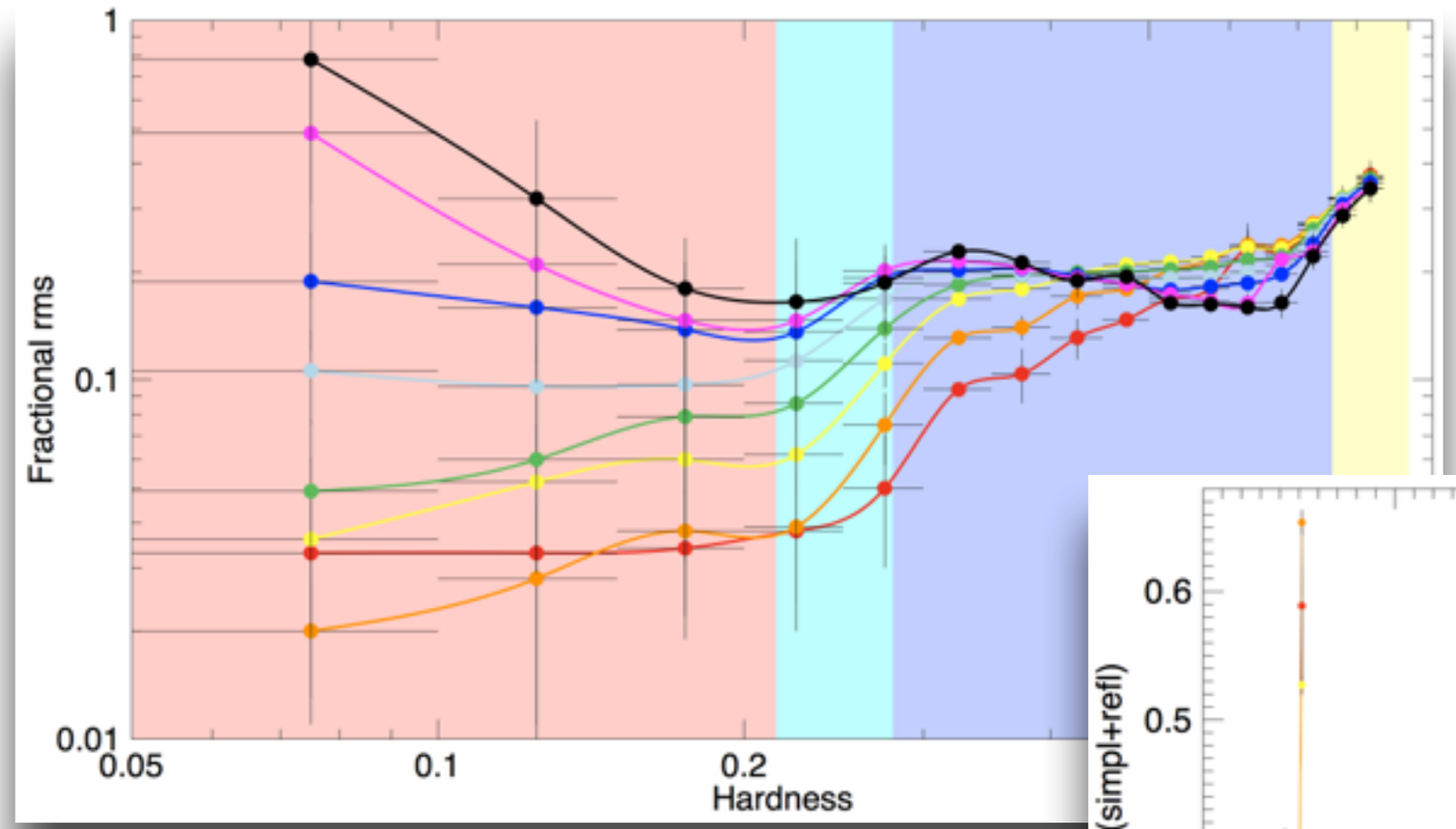


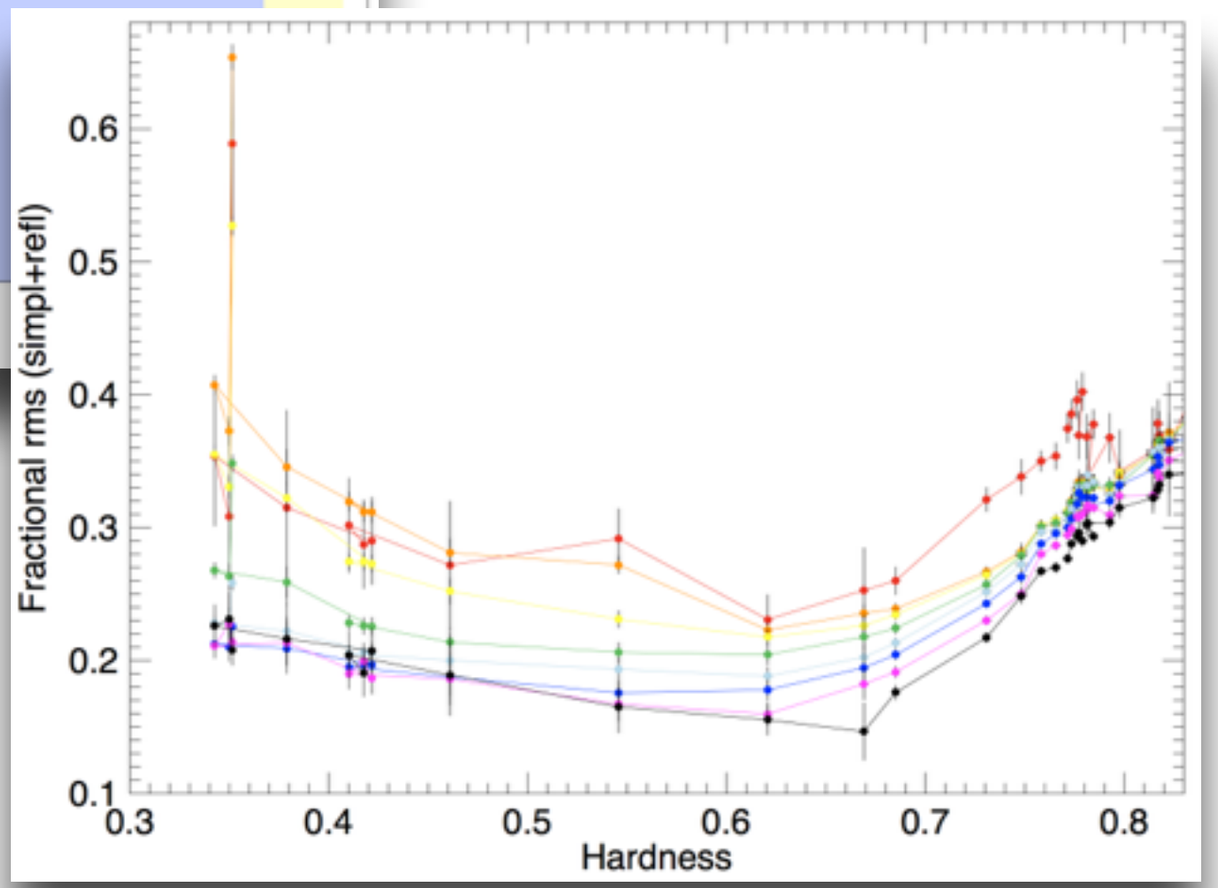
Wu et al. (2010)

ENERGY DEPENDENCE

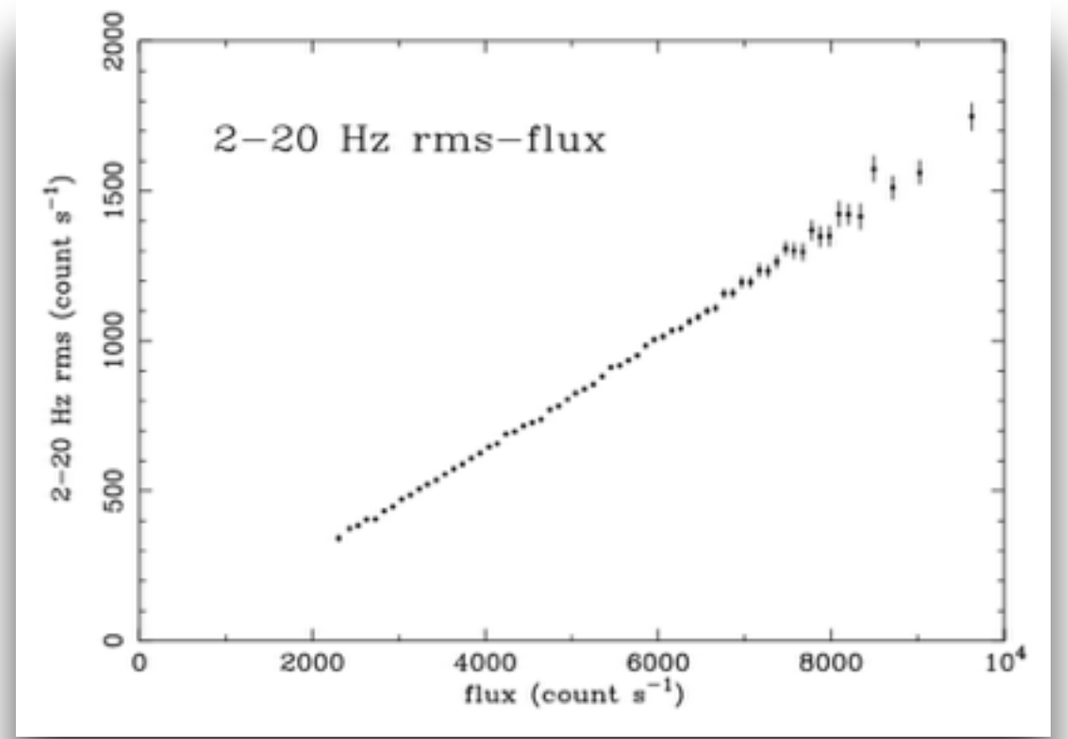
Belloni, Motta (in prep.)

GX 339-4

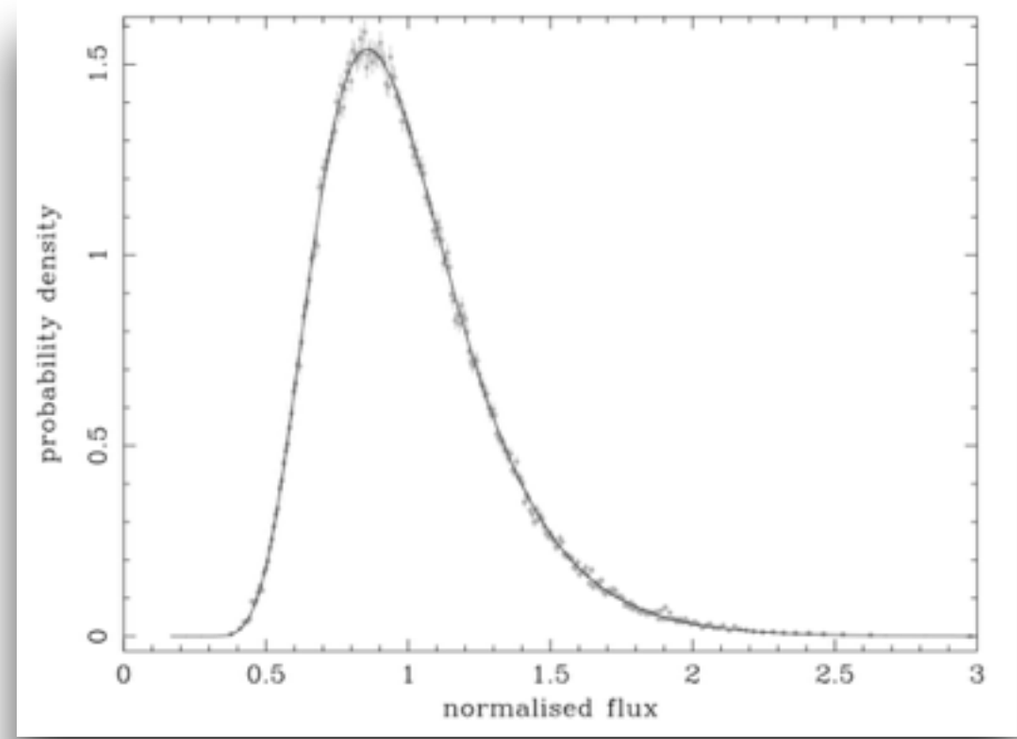




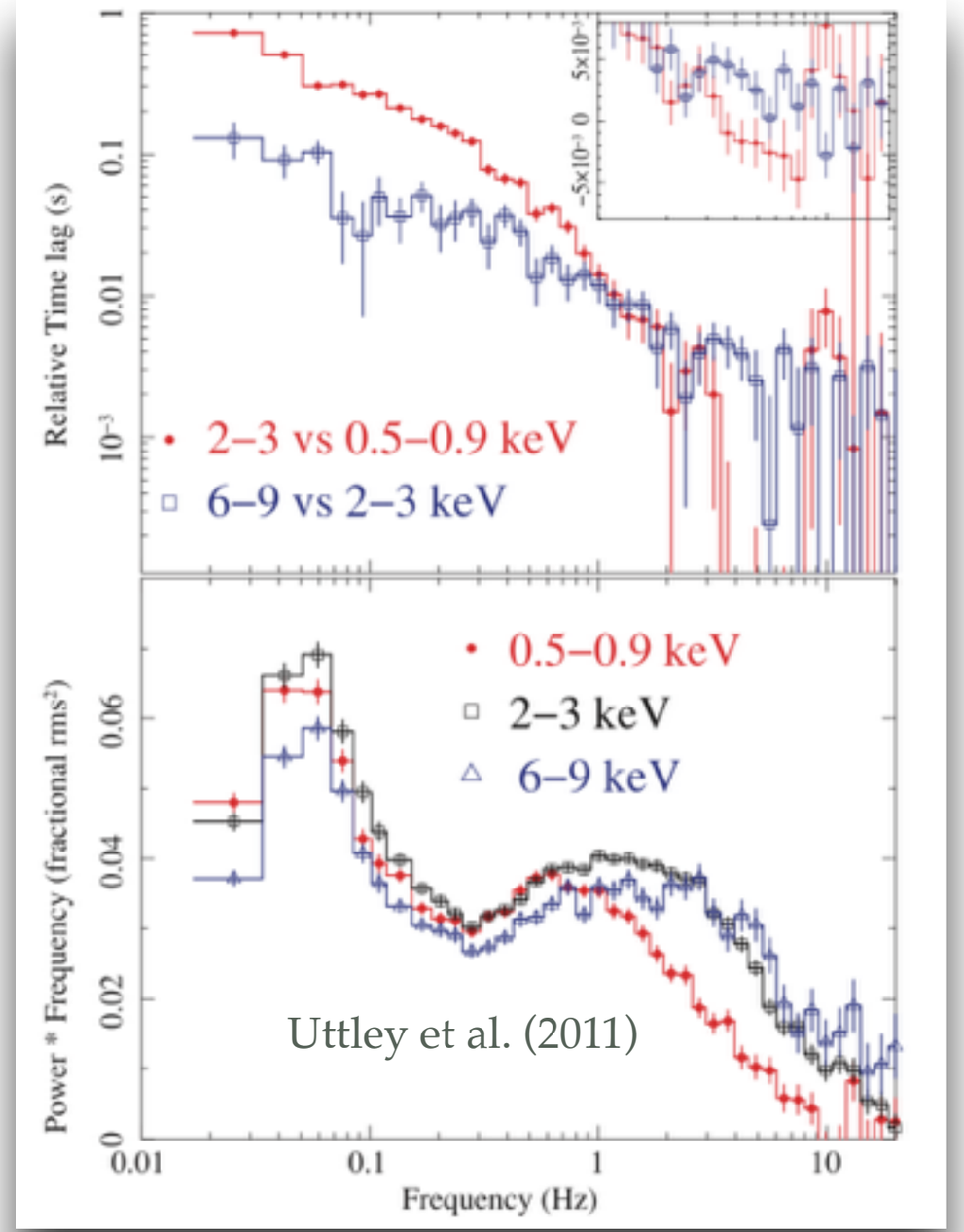
BROAD-BAND NOISE: FLUCTUATIONS



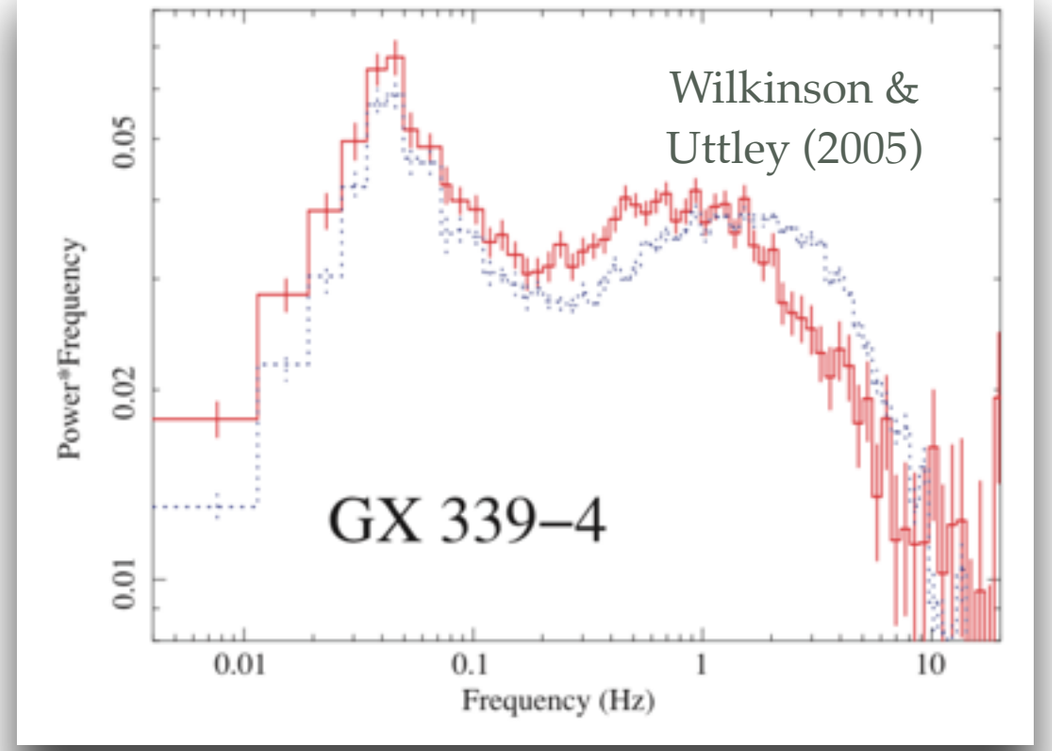
Uttley et al. (2005)



TO VARY OR NOT TO VARY



Uttley et al. (2011)



Disk varies more and leads at low frequencies

Disk varies only when not seen

LOW-FREQUENCY QPO: LENSE-THIRRING

Lense-Thirring precession & MRI

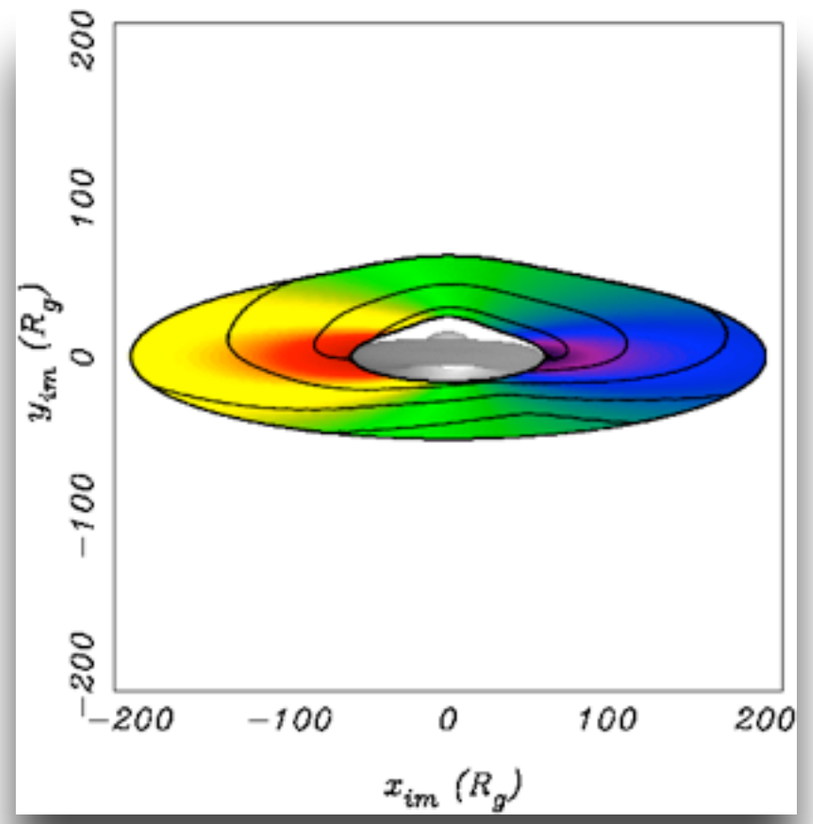
Stella & Vietri 1998a,b, 1999

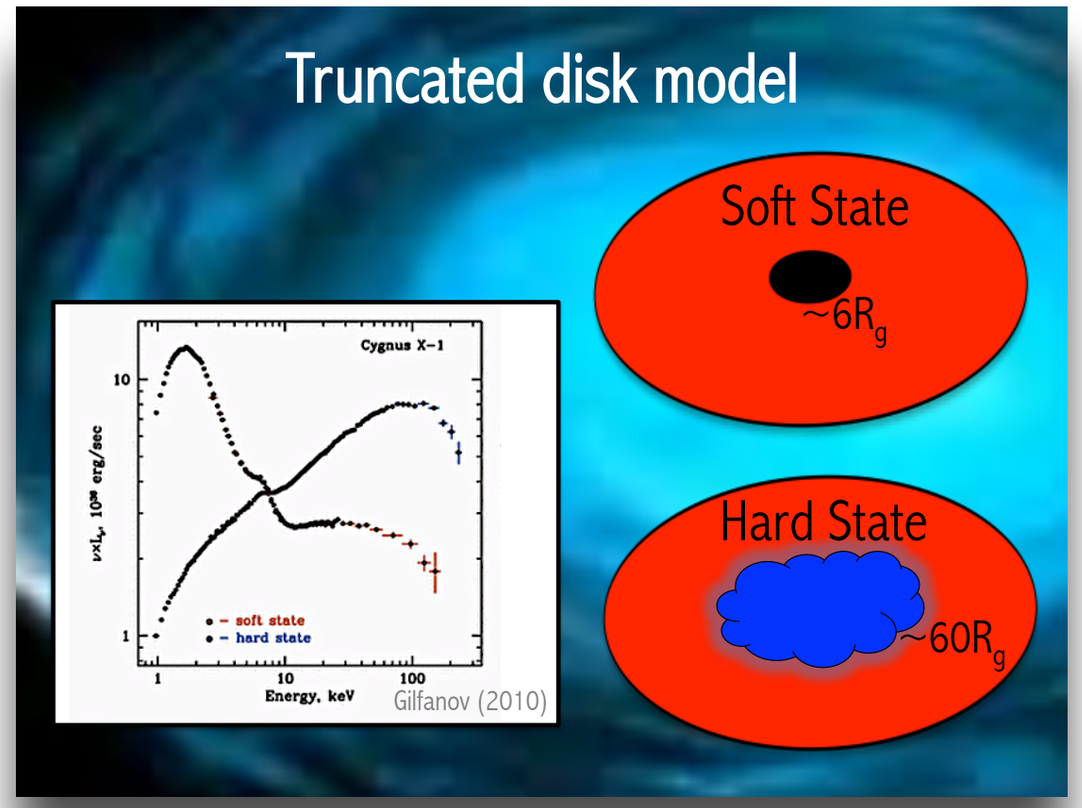
Ingram et al 2009, Ingram & Done 2010, Ingram & Done 2011

+

Truncated disk model

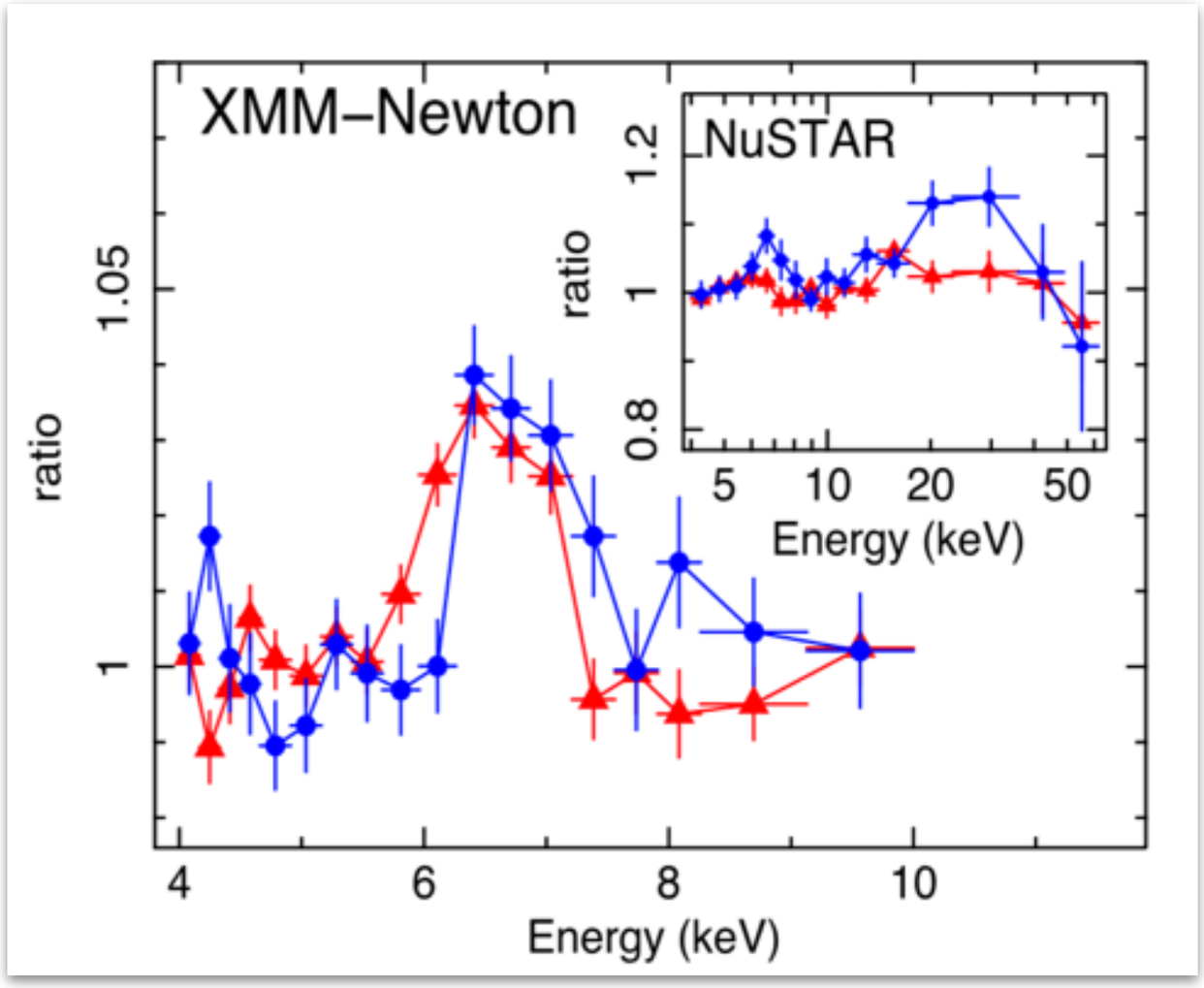
Done, Gierliński, Kubota 2007

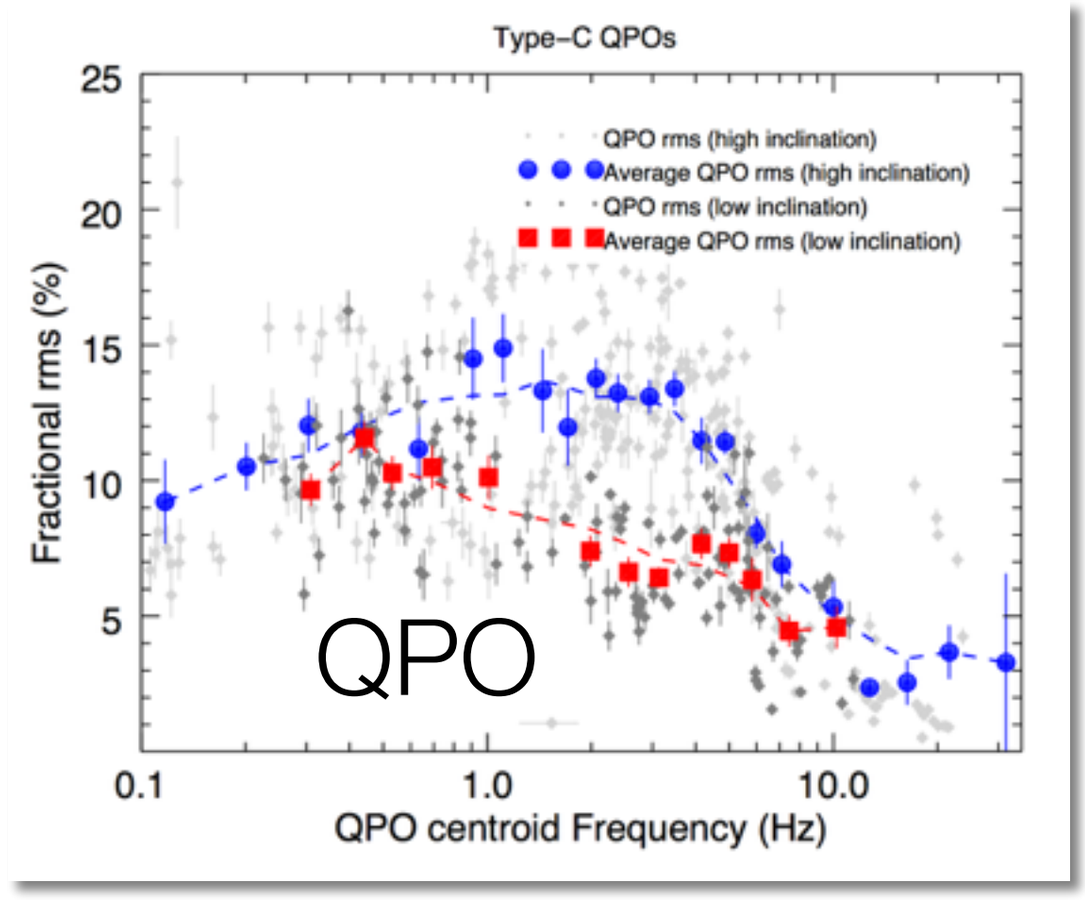




LOW-FREQUENCY QPO: LENSE-THIRRING

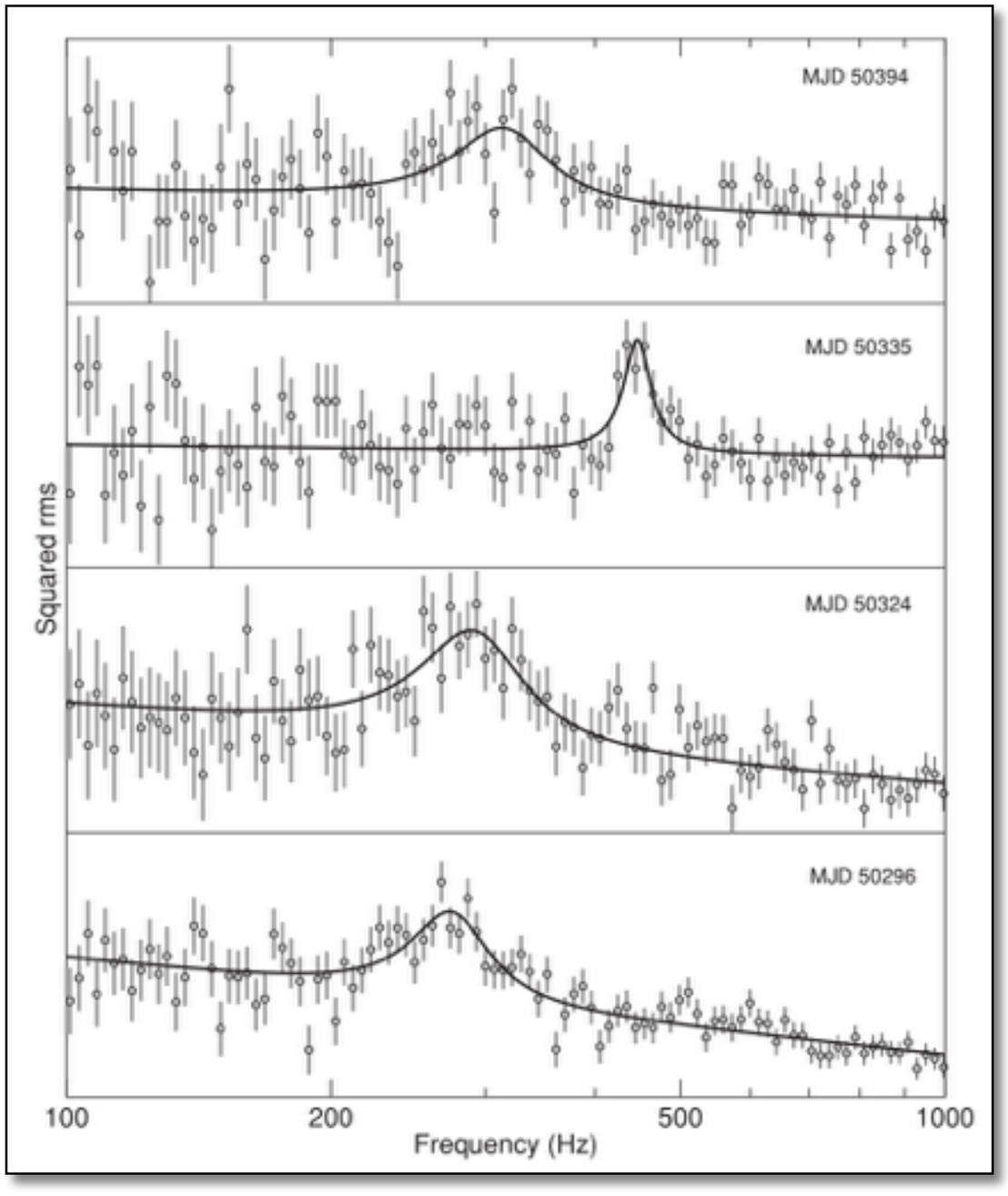
Ingram et al.
(2016)

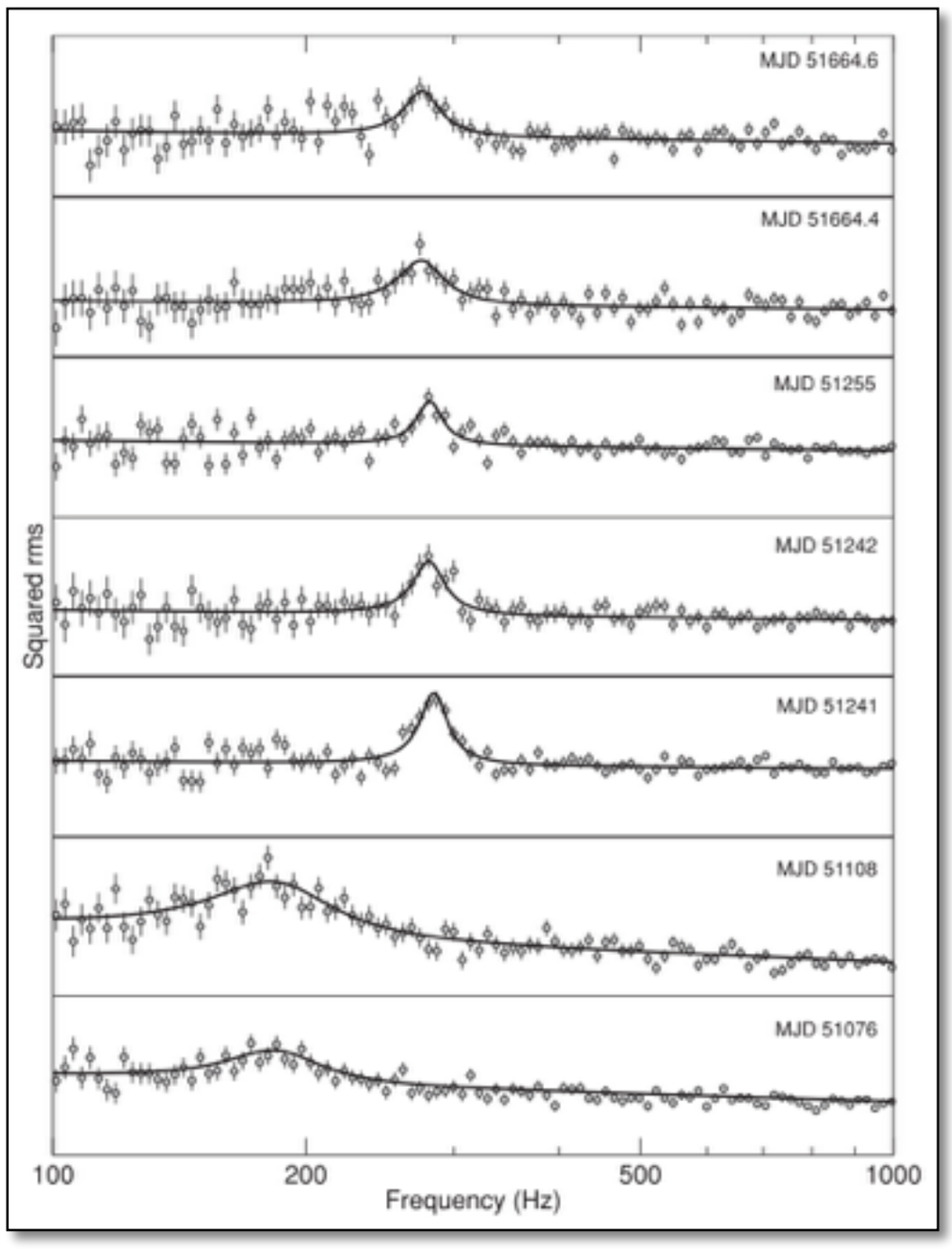




Motta et al.
(2015)

HIGH-FREQUENCY QPO: GR





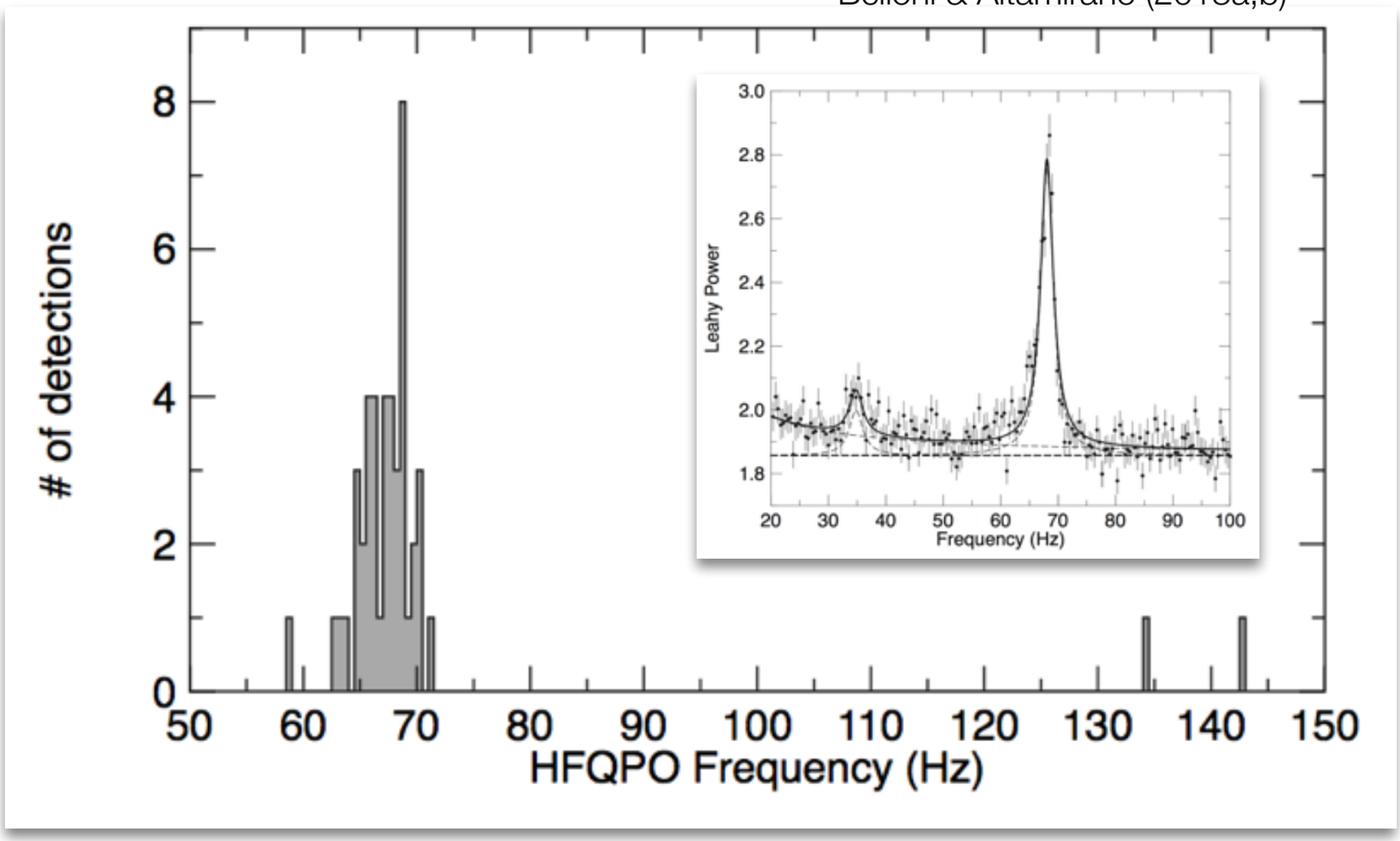
Belloni, Sanna & Méndez (2012)

HIGH-FREQUENCY QPO: GRS1915+105

Almost all at the same frequency

ISCO?

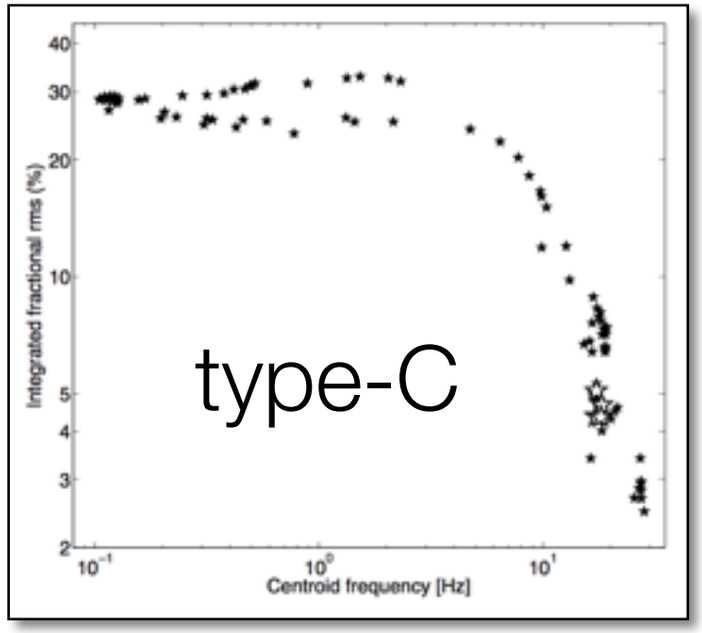
Belloni & Altamirano (2013a,b)

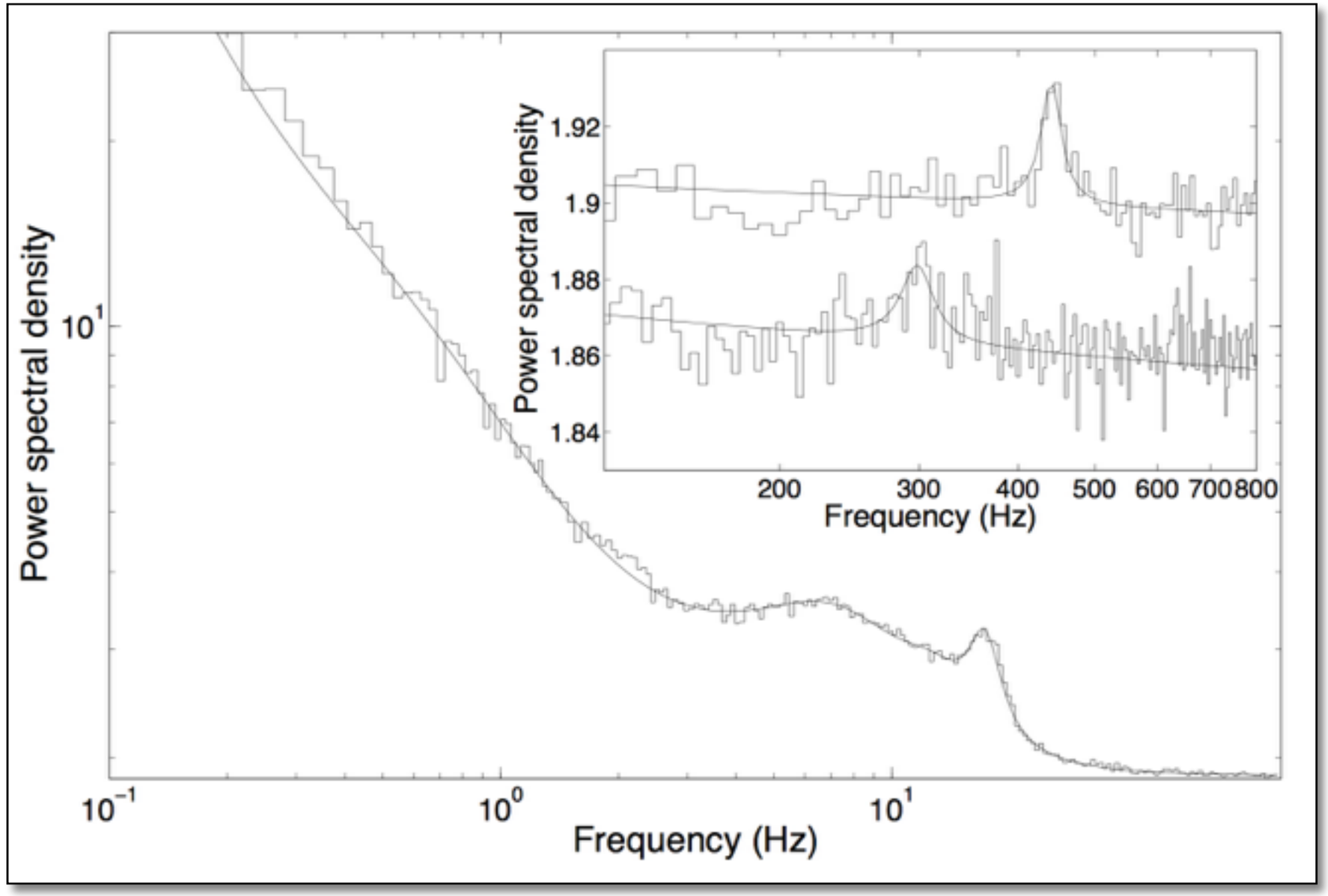


Caveat: @ISCO, Keplerian and precession are the same

GRO J1655-40: UNIQUE SOURCE

Only source which shows simultaneous type-C and 2xHFQPO





MOTTA ET AL. (2015)

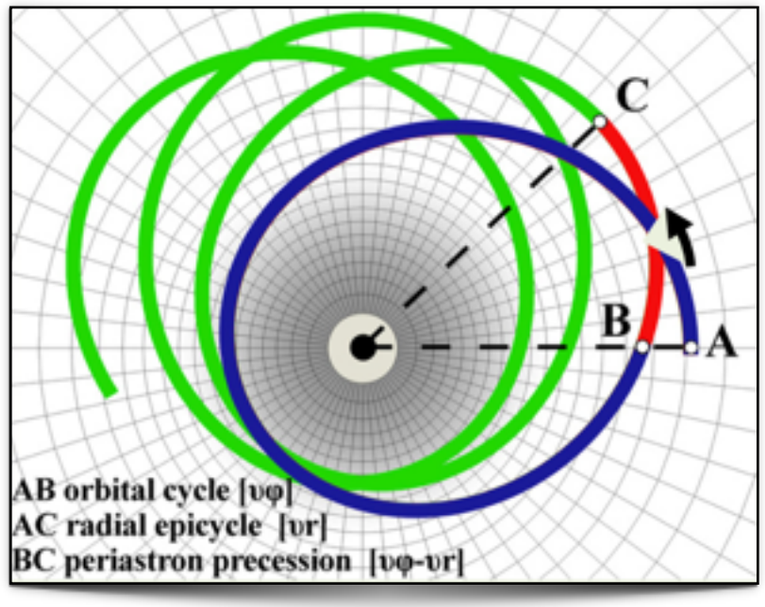
MODEL CAN BE TESTED

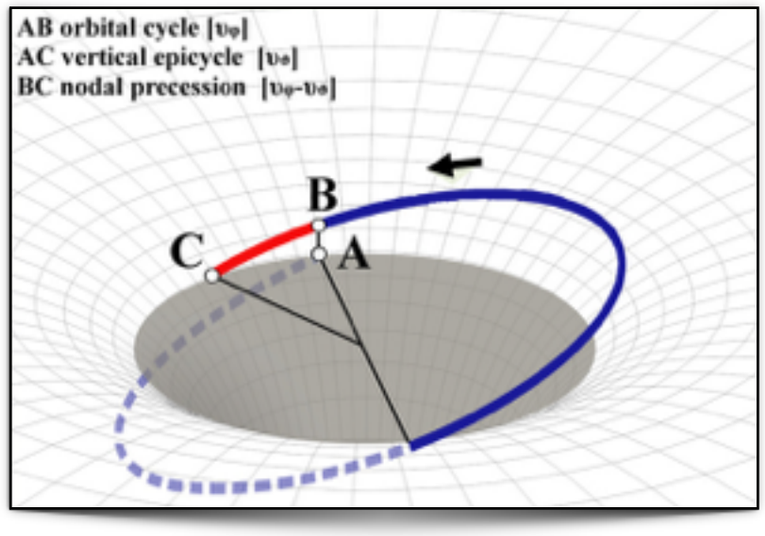
- The Relativistic Precession Model (RPM) predicts three frequencies

- Relativistic frequencies: keplerian, nodal, Lense-Thirring

- We have three frequencies

typeC = 17.3 +/- 0.1 Hz
lower = 298 +/- 4 Hz
upper = 441 +/- 2 Hz





STELLA & VIETRI 1998; STELLA, VIETRI & MORSINK 1999

THREE EQUATIONS

Solution for

$a = 0.29 +/- 0.01$

$M = 5.31 +/- 0.07\ M_{\odot}$

$R = 5.68 +/- 0.04\ R_g$

Dynamical mass:

$M = 5.4 +/- 0.3\ M_{\odot}$

MOTTA (2015)

XTE J1550-564: THE NEXT BEST

It shows simultaneous type-C and 1xHFQPO

typeC = 13.08 +- 0.08 Hz
HFQPO = 183 +/- 5 Hz

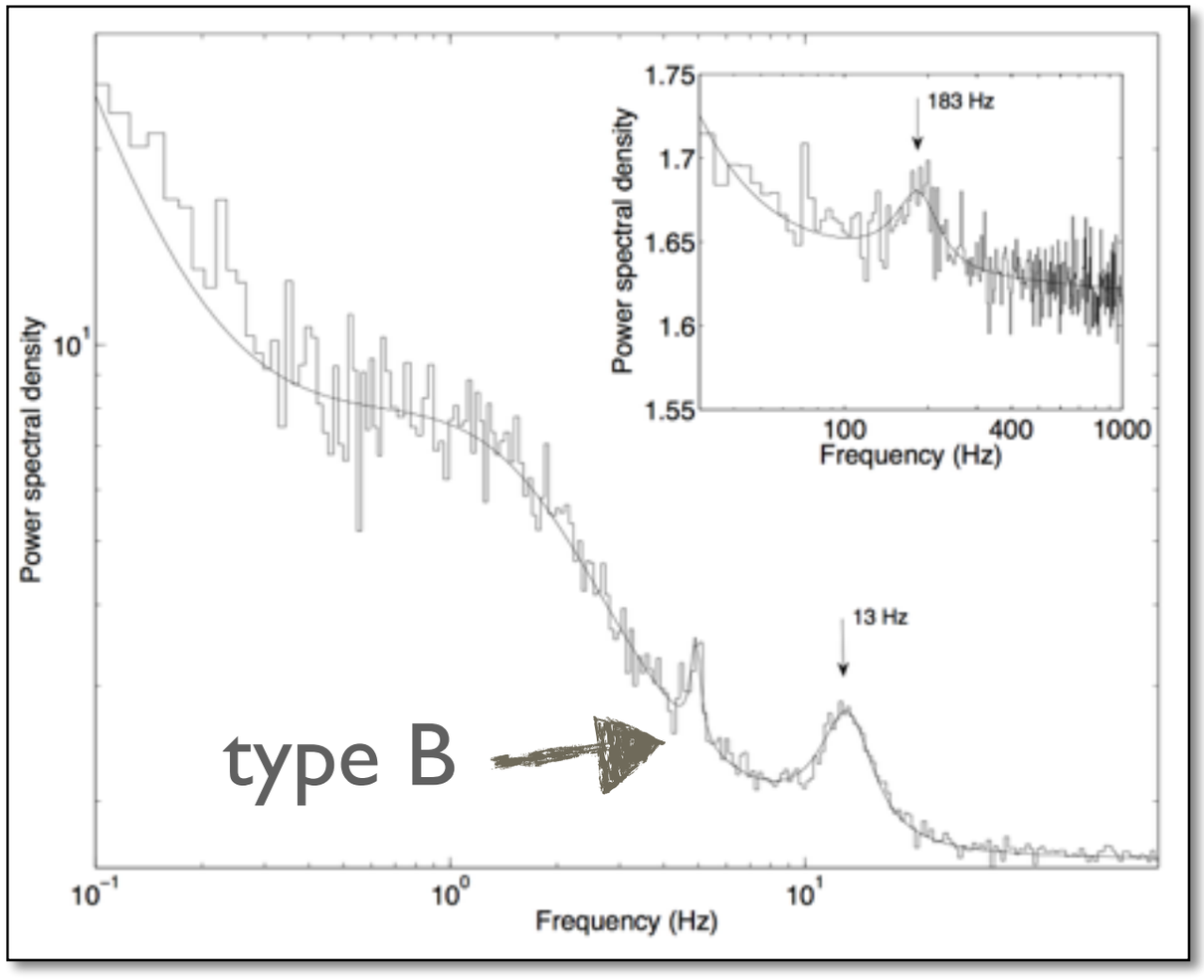
Solution for

$a = 0.34 +/- 0.01$

$R = 5.47 +/- 0.12\ R_g$

Dynamical mass:

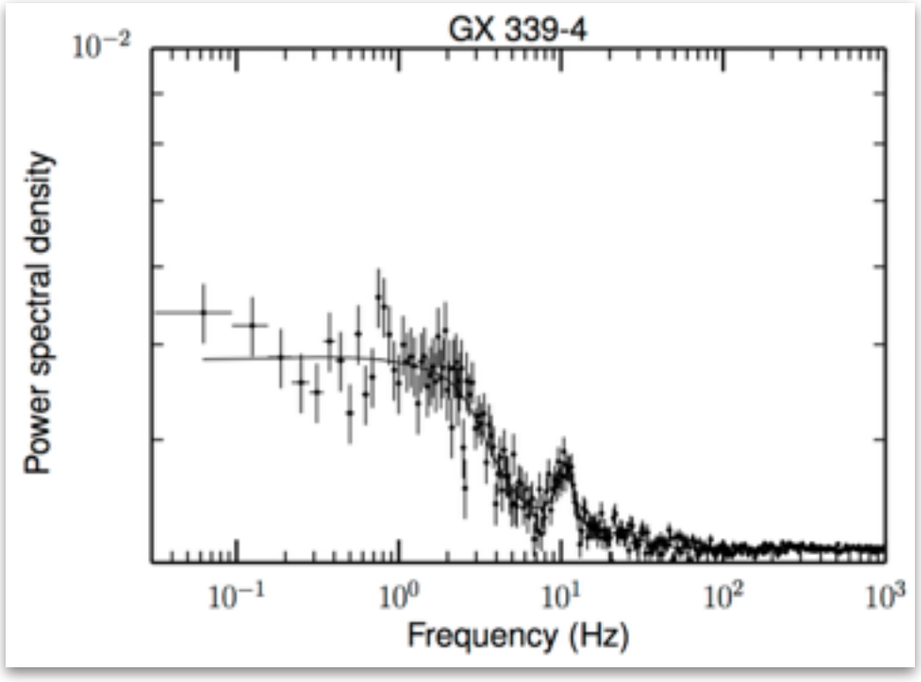
$M = 9.1 +/- 0.6\ M_\odot$



MOTTA ET AL. (2015)

QPOs in HSS

Target	Obs-ID	ν_{max} (Hz)	Q	rms	New ?	state	spin limits
GX 339-4	92085-01-02-03	10.59 ± 0.18	3.46 ± 0.50	5.05 ± 0.03	yes	HSS	0.16 - 0.38
4U 1630-47	80117-01-07-01	14.80 ± 0.28	2.17 ± 0.27	9.5 ± 0.4	no	ULS	0.12
4U 1543-47	70133-01-01-00	15.37 ± 0.18	2.57 ± 0.27	4.2 ± 0.03	yes	HSS	0.13 - 0.47
XTE J1859+226	40124-01-14-00	8.56 ± 0.06	2.76 ± 0.18	12.4 ± 0.4	no	HIMS	>0.07
XTE J1650-500	60113-01-13-02	6.84 ± 0.05	8.05 ± 1.23	20.8 ± 0.3	no	HIMS	>0.06
XTE J1817-330	91110-02-32-00	9.6 ± 0.5	2.93 ± 0.82	5.7 ± 0.1	yes	HSS	0.08 - 0.36
XTE J1748-288	30171-02-01-00	31.55 ± 0.13	6.00 ± 0.42	10.2 ± 0.5	no	HIMS	>0.23
XTE J1752-223	95360-01-11-00	6.46 ± 0.13	3.6 ± 1.1	23.4 ± 1.2	no	HIMS	>0.06
XTE J1550-564	40401-01-48-00	18.10 ± 0.06	19 ± 4	6.2 ± 0.1	no	HSS	0.31 - 0.34
MAXI J1543-564	96371-02-02-01	5.72 ± 0.04	10.2 ± 1.4	27.3 ± 1.2	no	HIMS	>0.05
H1743-322	80135-02-03-00	14.6 ± 0.2	12.6 ± 6.3	4.4 ± 0.2	no	ULS	0.12
GRO J1655-40	91702-01-17-01	27.51 ± 0.13	44 ± 21	2.7 ± 0.1	no	HSS	0.29 - 0.31



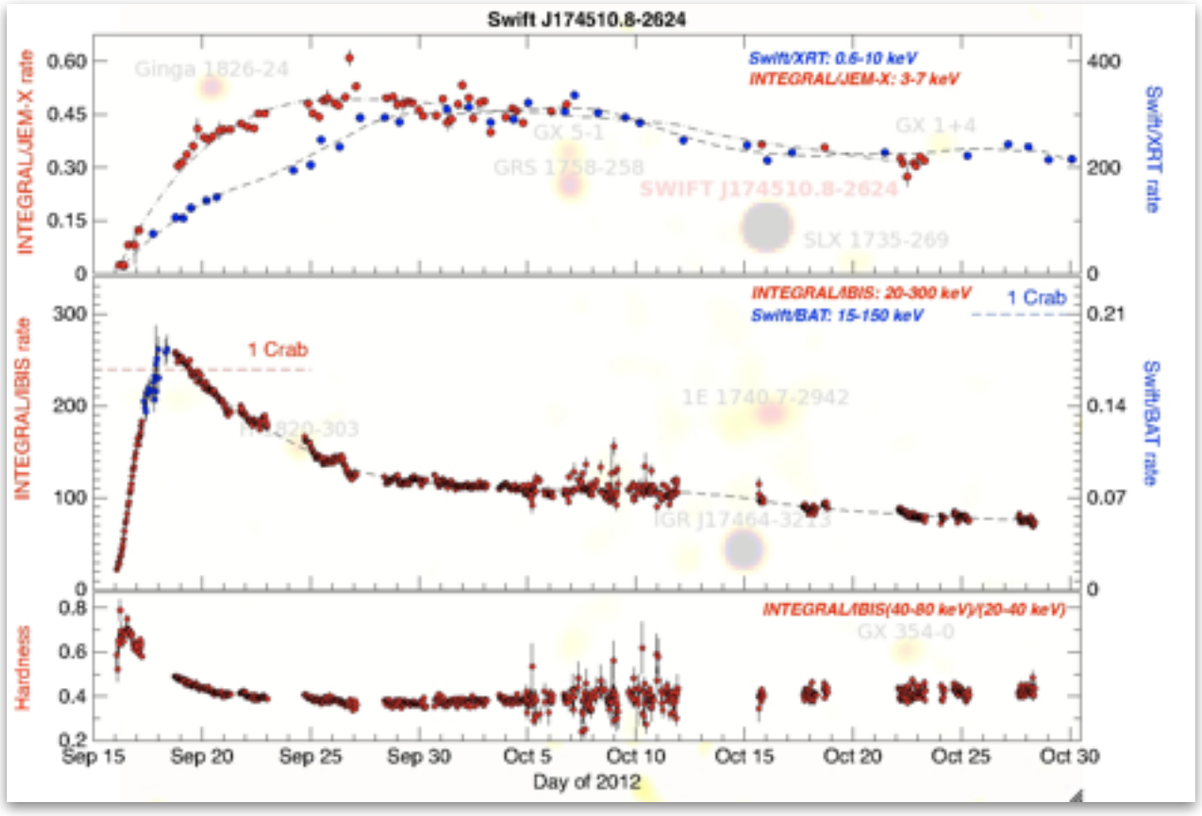
FRANCHINI, MOTTA & LODATO (2017)

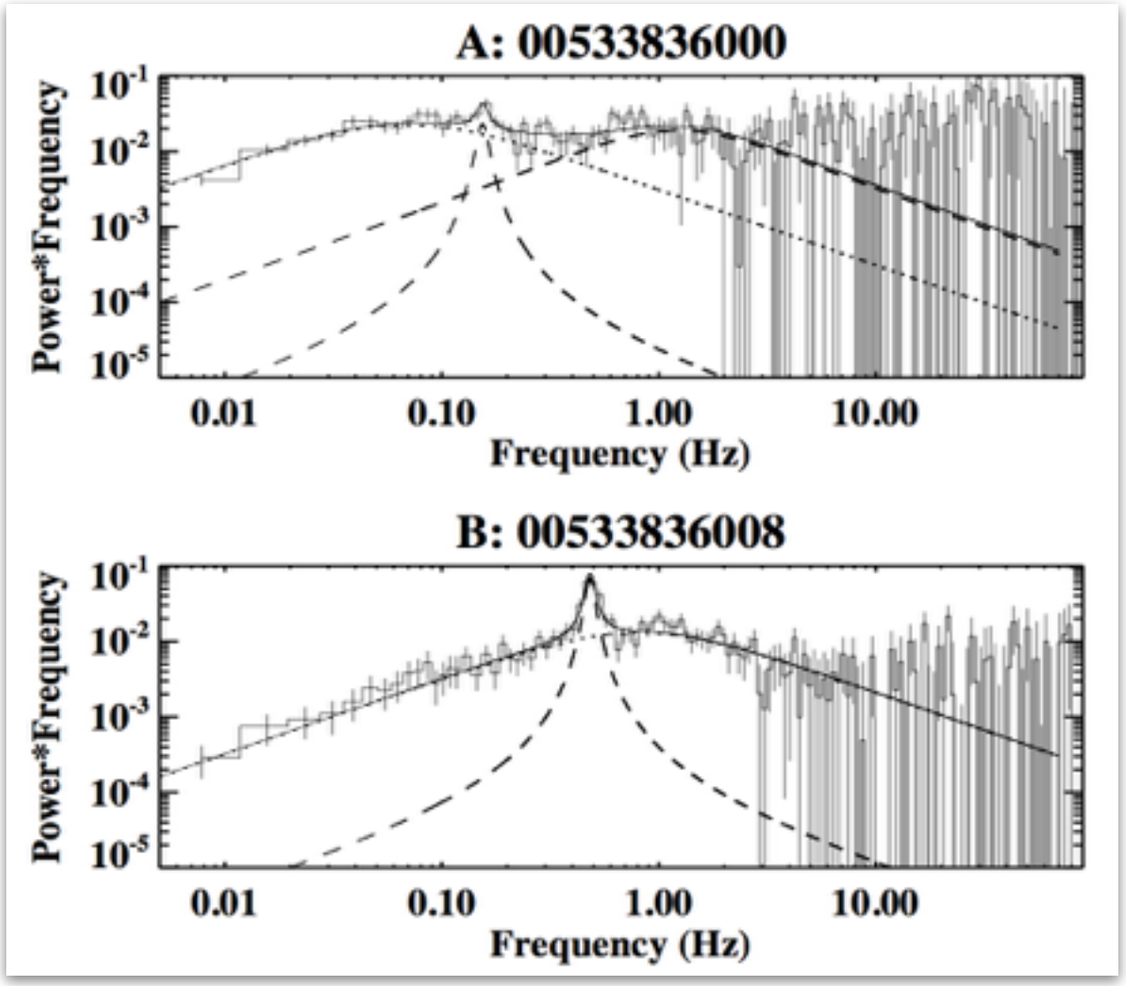
OPEN ISSUES

- *Additional evidence (HFQPOs are few)*
  - *GR, BH spin, ISCO, BH signature*
- *Modulation mechanism (QPOs not from disk)*
- *Other types of QPOs*
- *Connection to MW observations (radio, IR)*
- *Unified model for NS LMXB*

THE PRESENT

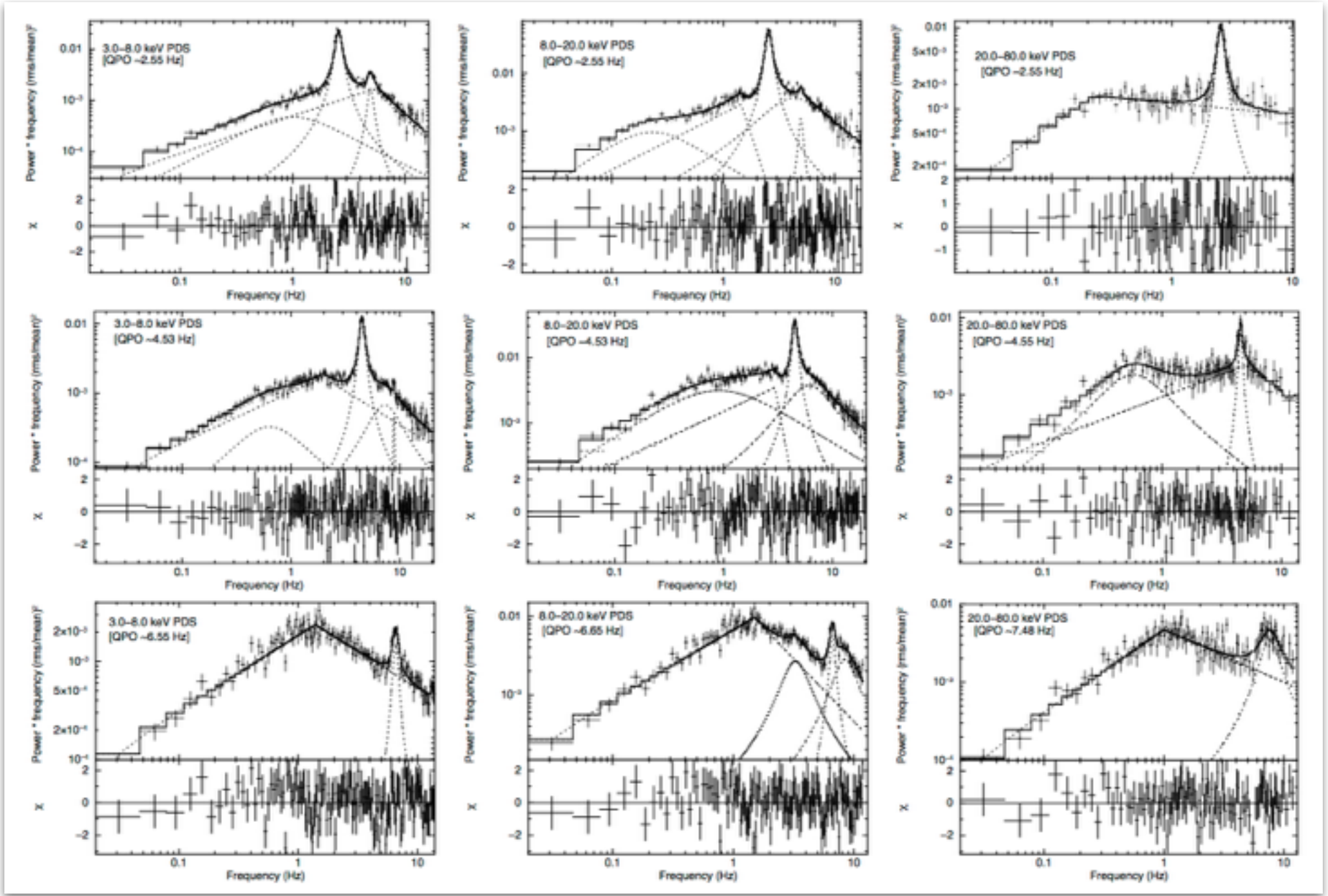
- Swift J174510.8–262411
- INTEGRAL/Swift campaign





DEL SANTO ET AL. (2016)

THE PRESENT

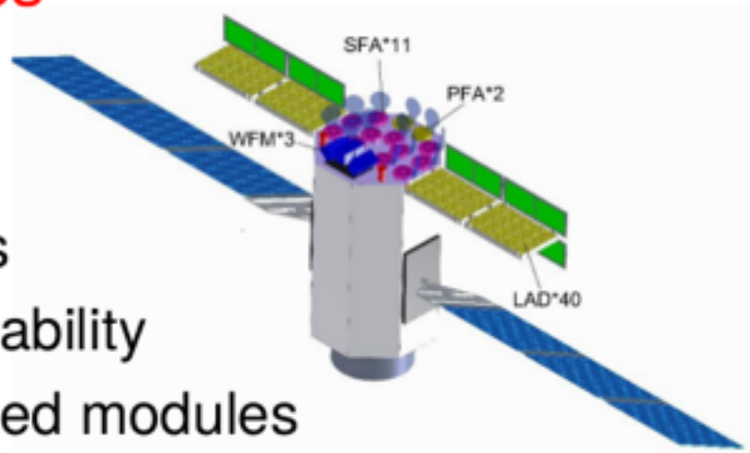


Yadav et al. (2016)

THE FUTURE

eXTP satellite

A satellite with the largest focusing and collimated telescopes



- Payload characteristics
  - Short FL for multiple modules
  - Polarimeter with imaging capability
  - Deployable panel for collimated modules