High-frequency QPOs from Black Hole Binaries: the RossiXTE Legacy

Tomaso Belloni
(INAF - Osservatorio Astronomico di Brera)
Leverhulme Visiting Professor, University of Southampton

with Andrea Sanna & Mariano Méndez (Univ. Groningen)

Black Hole Universe

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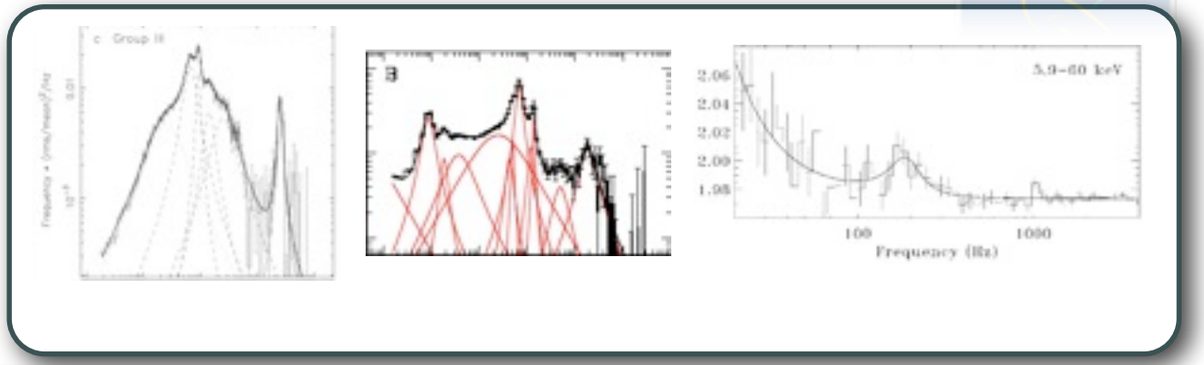
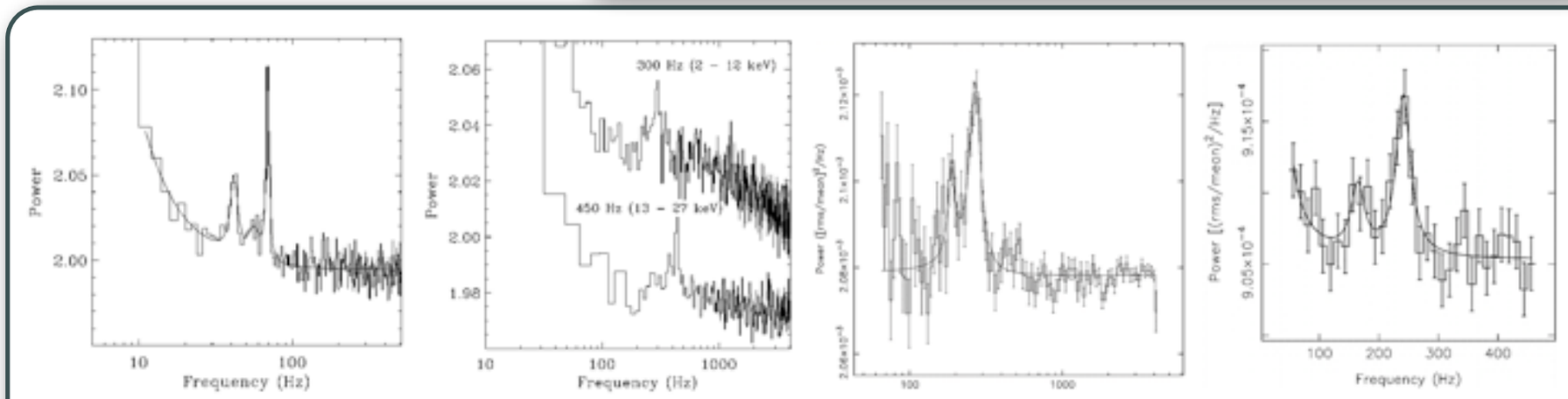
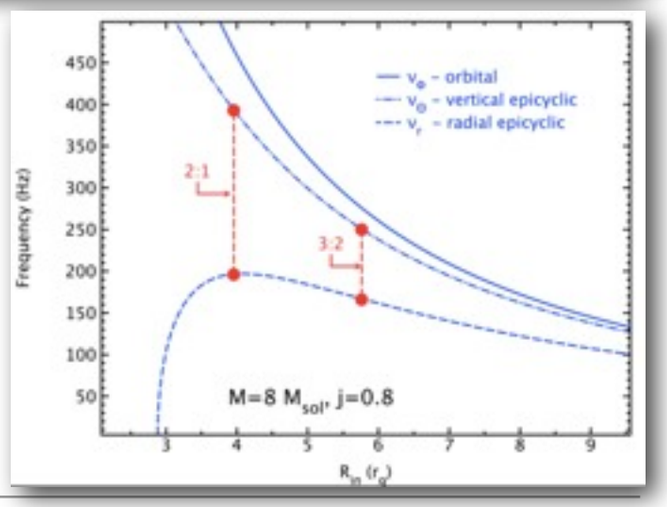
High-Frequency oscillations in BHT

- 30-450 Hz
- Very few detections
- Ratios?
- BH mass?
- Resonance model
- Too few points... some of them not even real

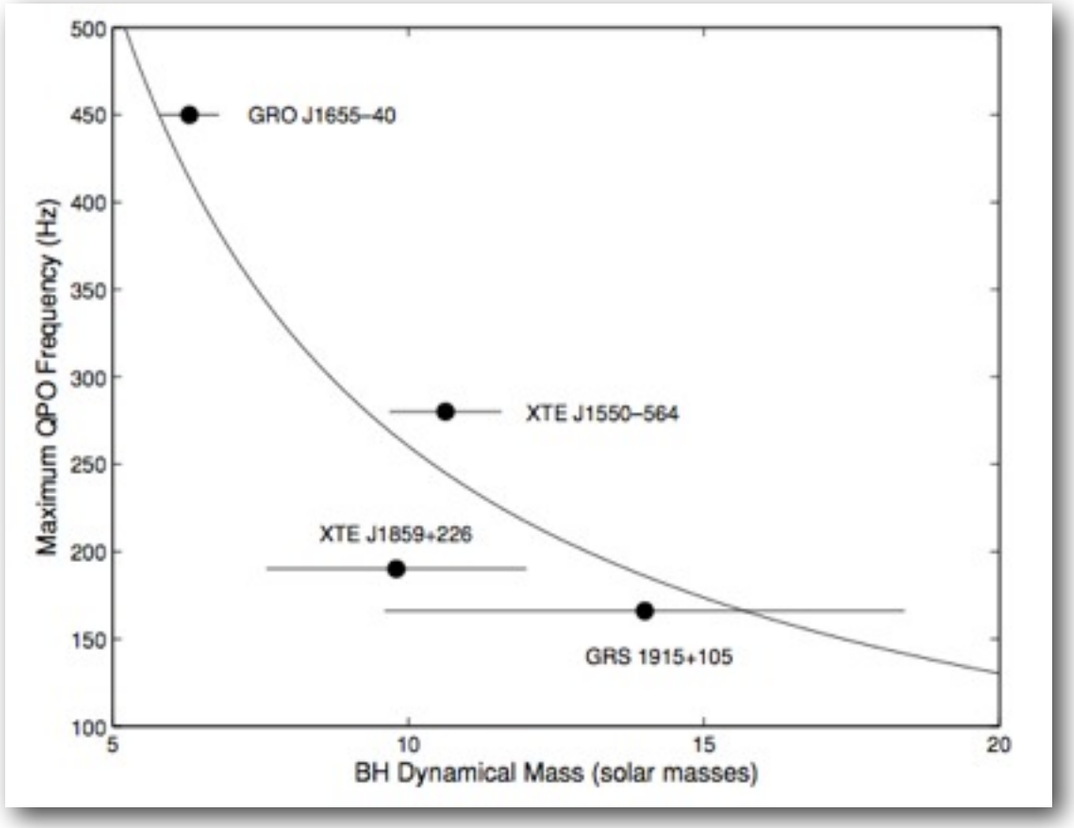


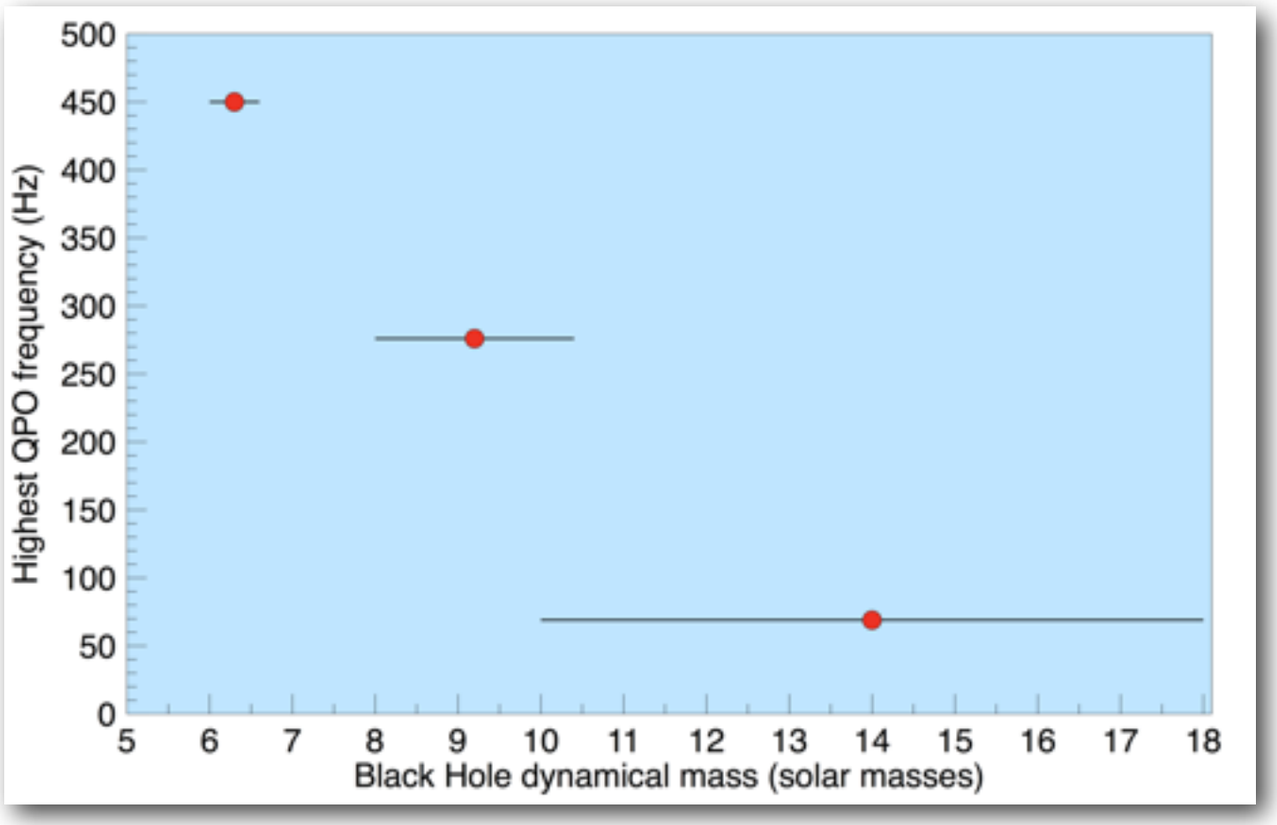


41/69 300/450 184/276 165/241



Mass correlation?

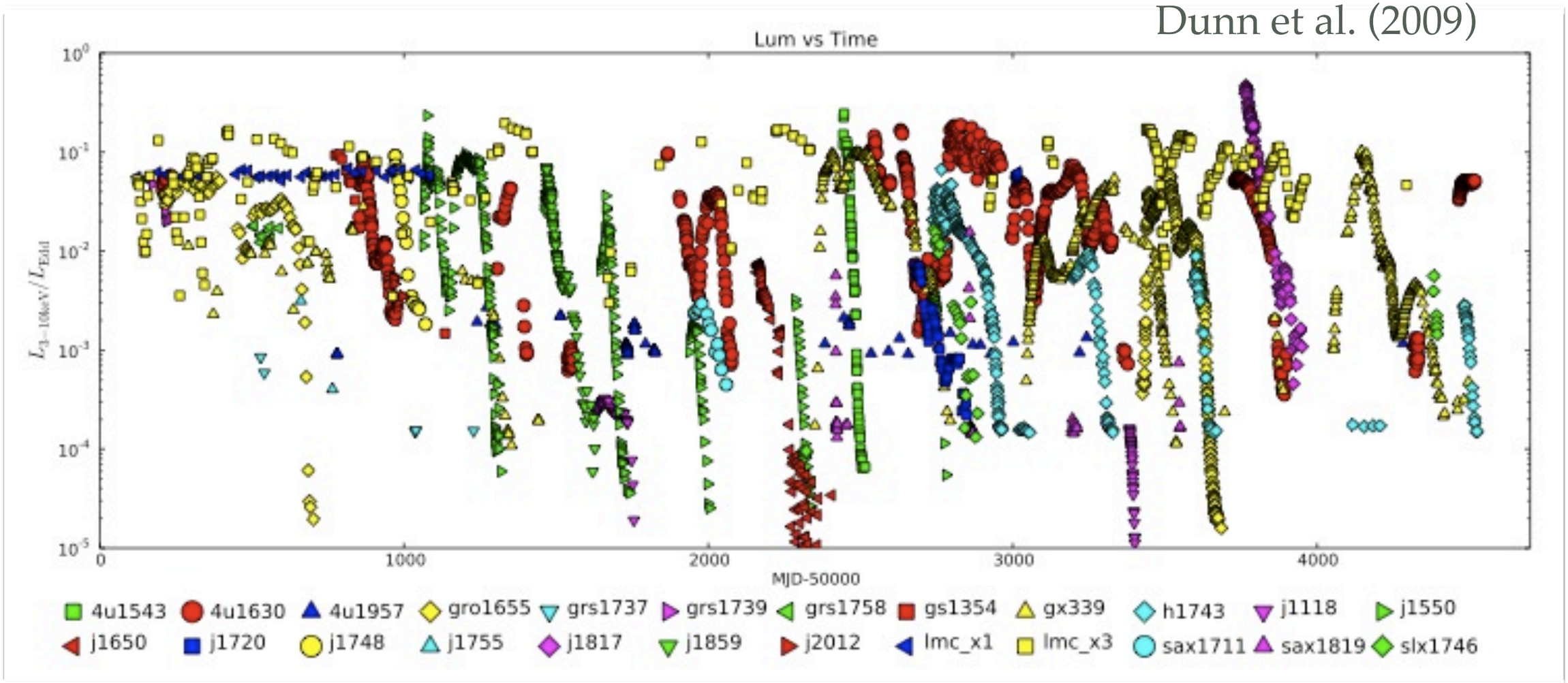




Last RXTE one from IGR J17091-3624 (Altamirano's talk)

RXTE observed many BHT many times

Dunn et al. (2009)



Need for a systematic analysis

Source name	N. obs.	Valid T.	Valid H.	Exp. T (ks)	Exp. H (ks)	$> 3\sigma$ T	$> 3\sigma$ H	Good T	Good H	Final
GX 339-4	1353	893	517	2190	1657	31	34	4	11	4
4U 1630-47	1002	846	701	1934	1672	31	27	11	7	4
GRO J1655-40	596	516	491	2295	2214	18	24	7	8	11
H 1743-322	504	386	300	1153	941	19	20	6	8	4
XTE J1550-564	409	319	280	860	790	46	31	15	14	16
Swift J1753.5-0127	278	240	172	671	527	14	8	3	3	0
XTE J1752-223	208	138	79	343	250	6	6	0	4	2
XTE J1650-500	182	101	69	219	155	17	5	4	2	0
Swift J1539.2-6227	156	61	42	153	122	1	3	1	1	0
XTE J1817-330	155	112	79	372	256	3	2	1	1	0
XTE J1859+226	131	115	102	314	281	6	4	2	2	1
4U 1543-47	104	53	38	161	125	6	3	0	1	0
XTE J1720-318	100	75	19	233	101	1	1	0	1	0
4U 1957+115	100	97	46	529	334	1	0	0	0	0
XTE J1118+480	94	62	50	174	154	0	3	0	1	0
MAXI J1659-152	66	63	54	148	135	1	1	0	1	0
SLX J1746-331	65	47	23	125	72	2	2	0	0	0
XTE J1652-453	57	30	1	67	2	1	0	0	0	0
XTE J1748-288	24	23	21	103	99	0	1	0	0	0
SAX J1711.6-3808	17	17	12	43	30	0	0	0	0	0
GS 1354-644	8	7	7	52	52	0	1	0	0	0
GRS 1737-31	5	4	3	40	28	0	0	0	0	0
Total	7108	4205	3106	12177	9996	204	176	54	65	42

Belloni, Sanna & Méndez (2012)

Strict procedure

- ☐ Exclusion of hopeless observations
- ☐ Automatic detection procedure
- ☐ Look for one significant peak (> 3σ 1 trial)
- ☐ Check all by hand
- ☐ Re-fit manually

- ☐ Found 42 detections (> 3σ 1 trial)
- ☐ 7 sources (no GRS 1915+105 & XTE J17091)

Belloni, Sanna & Méndez (2012)

Number of trials

- Very important issue
- For each source:
  - Number of soft+hard observations
  - Number of independent frequencies

- Select only detections with P<1%

- Left with 11 detections
- No double peaks

Belloni, Sanna & Méndez (2012)

The final detections

- Very important issue
- For each source:
  - Number of soft+hard observations
  - Number of independent frequencies

- Select only detections with P<1%

- Left with 11 detections
- Two sources: XTE J1550-564 & GRO J1655-40

Belloni, Sanna & Méndez (2012)

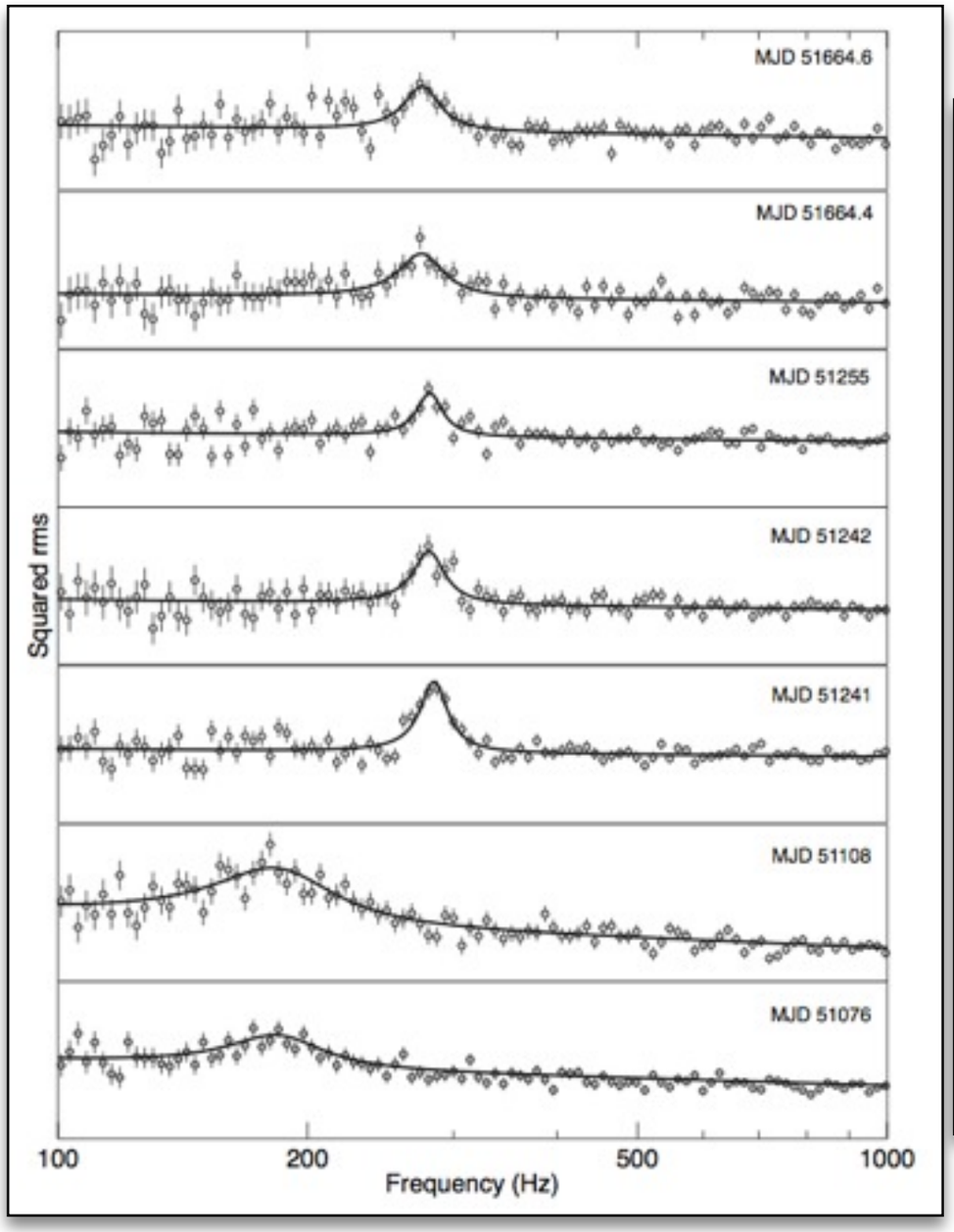
The final detections

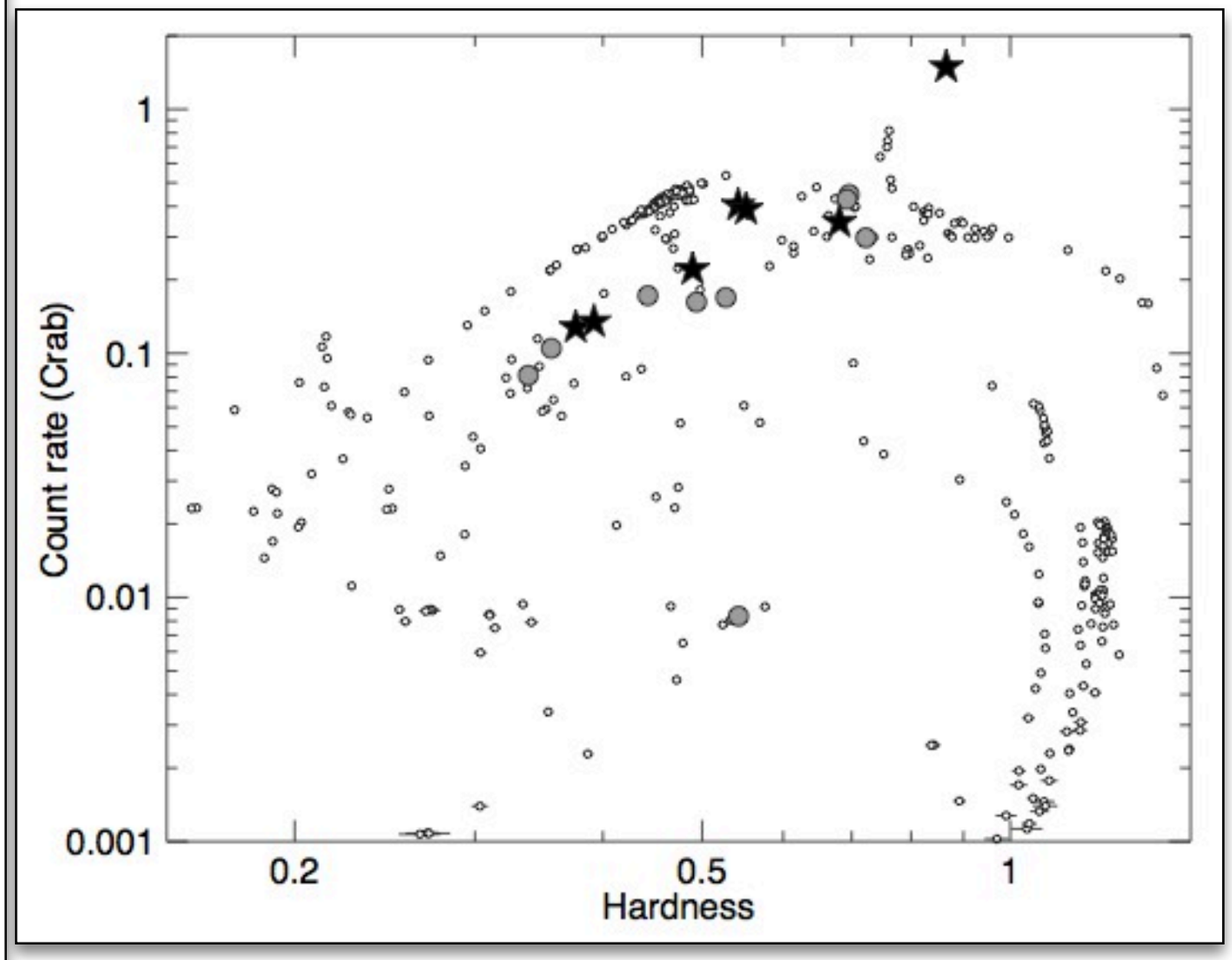
Belloni, Sanna & Méndez (2012)

MJD	Exp. (s)	B	ν_0 (Hz)	FWHM (Hz)	%rms	P_0	P_F	Rate	HR
			XTE J1550-564						
51076.000	2960	T	**180.76** $^{+3.92}_{-4.37}$	95.12 $^{+16.12}_{-22.00}$	1.15 $^{+0.14}_{-0.12}$	2.87E-07	1.62E-03	15700	0.68
51101.607	1584	T	140.70 $^{+1.71}_{-1.92}$	16.51 $^{+19.85}_{-4.84}$	1.12 $^{+0.59}_{-0.17}$	6.64E-04	1.00E+00	3135	0.57
51108.076	9872	T	**182.27** $^{+3.25}_{-3.20}$	77.88 $^{+11.65}_{-9.77}$	1.74 $^{+0.20}_{-0.16}$	1.90E-08	1.31E-04	3636	0.53
51115.281	2048	H	272.43 $^{+3.42}_{-4.09}$	30.59 $^{+16.30}_{-8.95}$	4.02 $^{+0.78}_{-0.47}$	7.80E-06	1.28E-01	1785	0.41
51241.802	3104	H	**284.07** $^{+1.35}_{-1.36}$	26.86 $^{+3.88}_{-3.12}$	3.66 $^{+0.21}_{-0.17}$	8.77E-29	0.00E+00	4258	0.42
51242.507	1504	H	**280.00** $^{+2.87}_{-2.49}$	30.00 $^{+9.80}_{-6.85}$	3.78 $^{+0.46}_{-0.32}$	2.05E-09	3.69E-05	4107	0.43
51245.354	2752	T	180.75 $^{+2.02}_{-2.54}$	16.76 $^{+8.71}_{-6.21}$	1.08 $^{+0.25}_{-0.13}$	8.54E-06	2.40E-01	4718	0.54
51247.979	2816	T	185.20 $^{+6.73}_{-4.93}$	46.04 $^{+15.69}_{-12.13}$	1.32 $^{+0.30}_{-0.17}$	3.30E-05	3.21E-01	4509	0.54
51255.158	4080	H	**280.84** $^{+2.00}_{-1.92}$	24.37 $^{+8.53}_{-6.28}$	4.35 $^{+0.50}_{-0.41}$	7.20E-08	1.59E-03	2329	0.38
51258.497	1104	H	276.02 $^{+6.64}_{-6.20}$	36.77 $^{+23.00}_{-12.36}$	5.22 $^{+0.01}_{-0.76}$	2.91E-04	9.86E-01	1816	0.35
51259.253	880	H	274.87 $^{+4.30}_{-3.61}$	26.00 $^{+14.57}_{-8.68}$	5.09 $^{+1.00}_{-0.67}$	7.53E-05	7.90E-01	1710	0.39
51291.184	1536	T	134.75 $^{+1.76}_{-1.45}$	7.81 $^{+5.16}_{-3.25}$	6.84 $^{+1.28}_{-1.09}$	8.45E-04	1.00E+00	88	0.42
51664.409	2240	H	**274.40** $^{+3.43}_{-3.47}$	41.96 $^{+19.88}_{-10.66}$	6.66 $^{+1.23}_{-0.64}$	1.11E-07	1.42E-03	1347	0.29
51664.637	2864	H	**274.97** $^{+2.90}_{-3.21}$	33.51 $^{+13.97}_{-8.16}$	5.42 $^{+0.87}_{-0.51}$	4.65E-08	7.47E-04	1419	0.31
51665.406	2144	H	264.66 $^{+7.09}_{-3.19}$	42.87 $^{+22.01}_{-15.43}$	6.50 $^{+1.35}_{-1.02}$	6.87E-04	1.00E+00	1105	0.28
51668.829	2976	H	263.29 $^{+9.41}_{-9.96}$	53.90 $^{+30.55}_{-17.58}$	5.50 $^{+1.56}_{-0.75}$	1.36E-04	7.44E-01	856	0.26
			GRO J1655-40						
50296.311	9056	T	**273.72** $^{+3.97}_{-3.96}$	70.33 $^{+19.40}_{-10.92}$	1.15 $^{+0.15}_{-0.08}$	1.15E-13	1.483E-9	7443	0.67
50301.665	6464	T	307.16 $^{+8.17}_{-6.77}$	68.46 $^{+0.00}_{-38.07}$	0.88 $^{+0.21}_{-0.11}$	3.91E-05	4.04E-01	6414	0.61
50311.391	1856	T	285.56 $^{+8.91}_{-11.19}$	63.78 $^{+42.48}_{-17.38}$	1.14 $^{+0.36}_{-0.16}$	1.93E-04	9.35E-01	5450	0.54
50317.441	6176	H	443.16 $^{+4.12}_{-3.79}$	41.44 $^{+20.27}_{-13.66}$	5.39 $^{+0.81}_{-0.64}$	1.28E-05	2.44E-01	5210	0.51
50324.380	4896	T	**289.67** $^{+6.26}_{-6.03}$	98.78 $^{+40.67}_{-17.67}$	1.41 $^{+0.30}_{-0.11}$	1.59E-10	1.46E-06	7267	0.65
50330.254	6144	H	453.72 $^{+6.29}_{-5.32}$	37.69 $^{+16.46}_{-12.16}$	5.69 $^{+0.89}_{-0.71}$	2.91E-05	5.03E-01	4964	0.49
50335.913	8160	H	**446.35** $^{+4.10}_{-4.15}$	38.74 $^{+9.80}_{-8.00}$	6.03 $^{+0.59}_{-0.54}$	9.01E-09	2.11E-04	4983	0.50
50383.565	6192	H	442.34 $^{+4.71}_{-4.28}$	31.50 $^{+15.62}_{-10.61}$	4.55 $^{+0.70}_{-0.62}$	1.31E-04	9.77E-01	6092	0.54
50394.884	5792	T	**313.45** $^{+9.38}_{-9.81}$	98.11 $^{+38.42}_{-19.10}$	1.17 $^{+0.25}_{-0.11}$	3.72E-08	3.44E-04	5497	0.59
53498.415	13968	T	125.81 $^{+1.10}_{-1.20}$	7.49 $^{+3.86}_{-2.91}$	0.65 $^{+0.11}_{-0.09}$	2.16E-04	1.00E+00	3190	0.29
53508.507	7504	T	266.63 $^{+7.96}_{-7.80}$	61.76 $^{+30.61}_{-13.60}$	0.76 $^{+0.19}_{-0.09}$	2.67E-05	3.24E-01	10164	0.57

XTE J1550+564

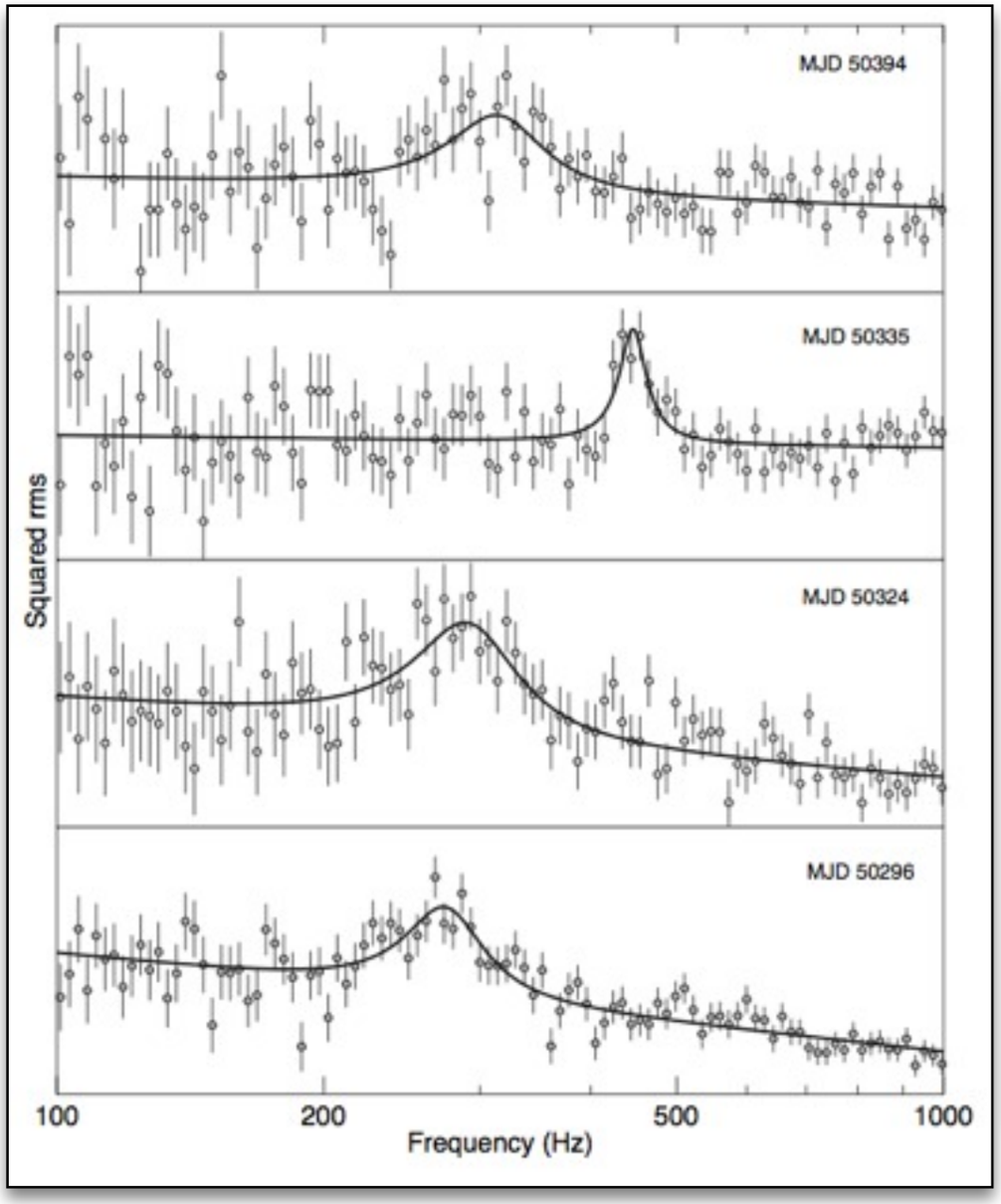
Belloni, Sanna & Méndez (2012)

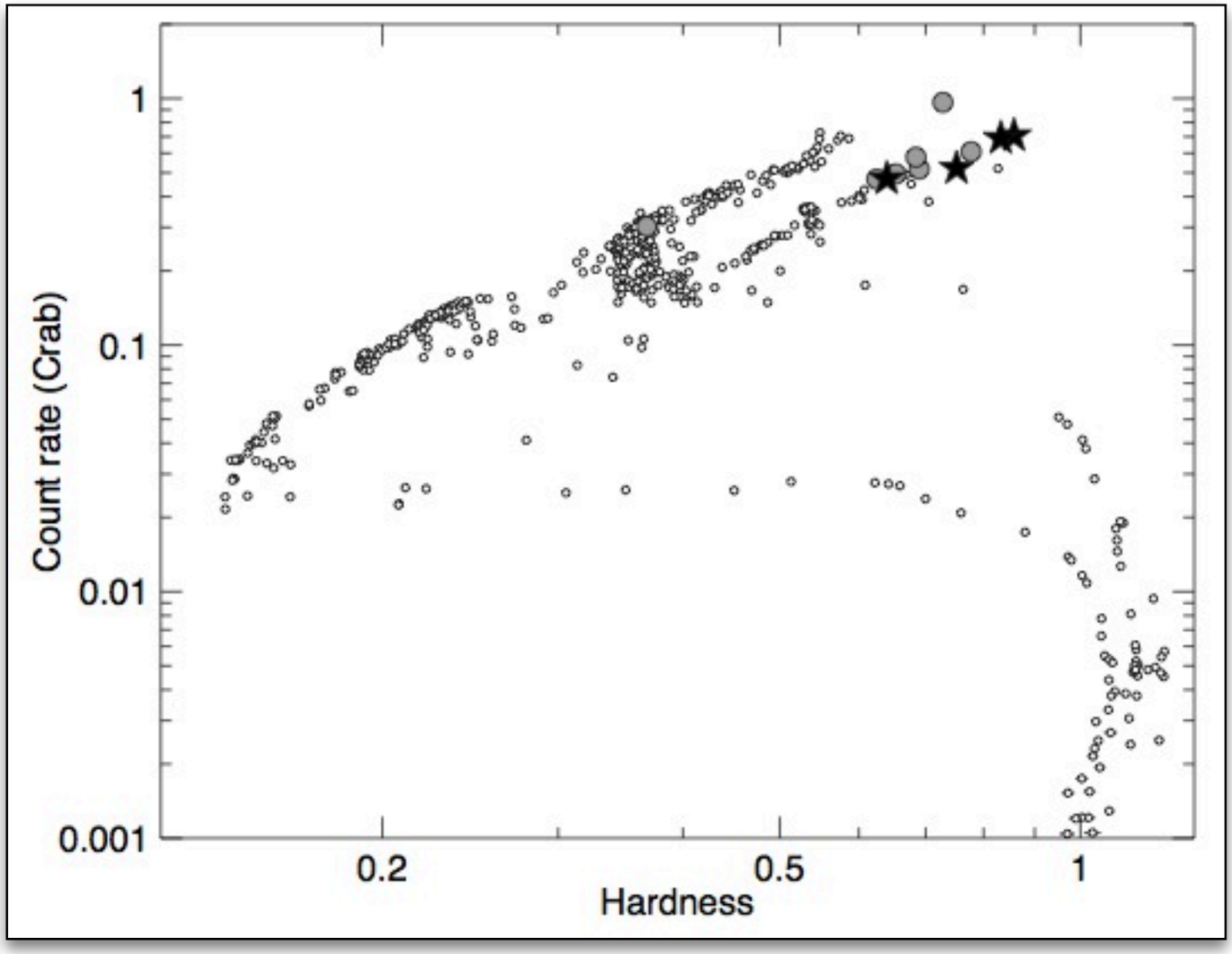




GRO J1655-40

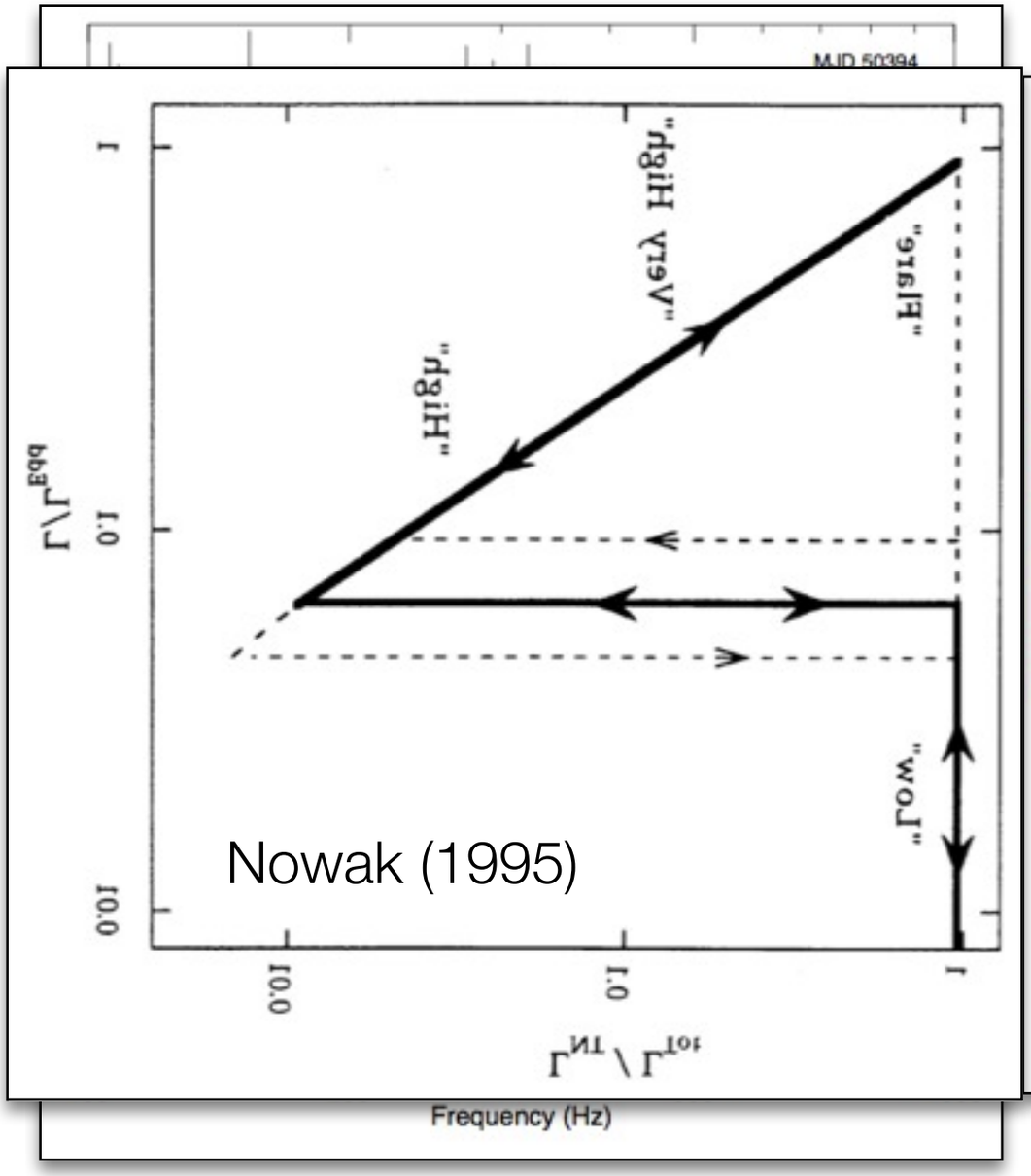
Belloni, Sanna & Méndez (2012)



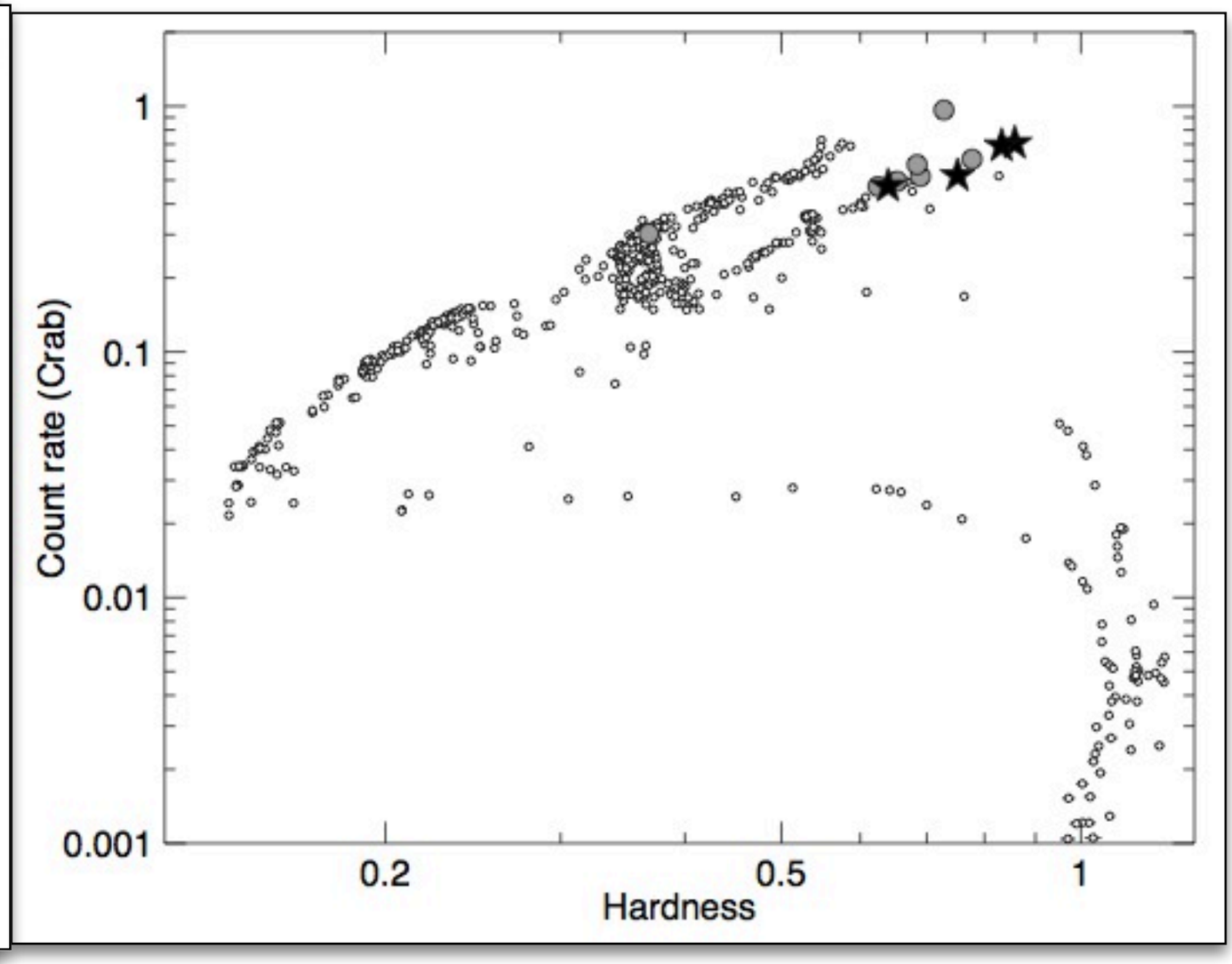


GRO J1655-40

Belloni, Sanna & Méndez (2012)



Nowak (1995)

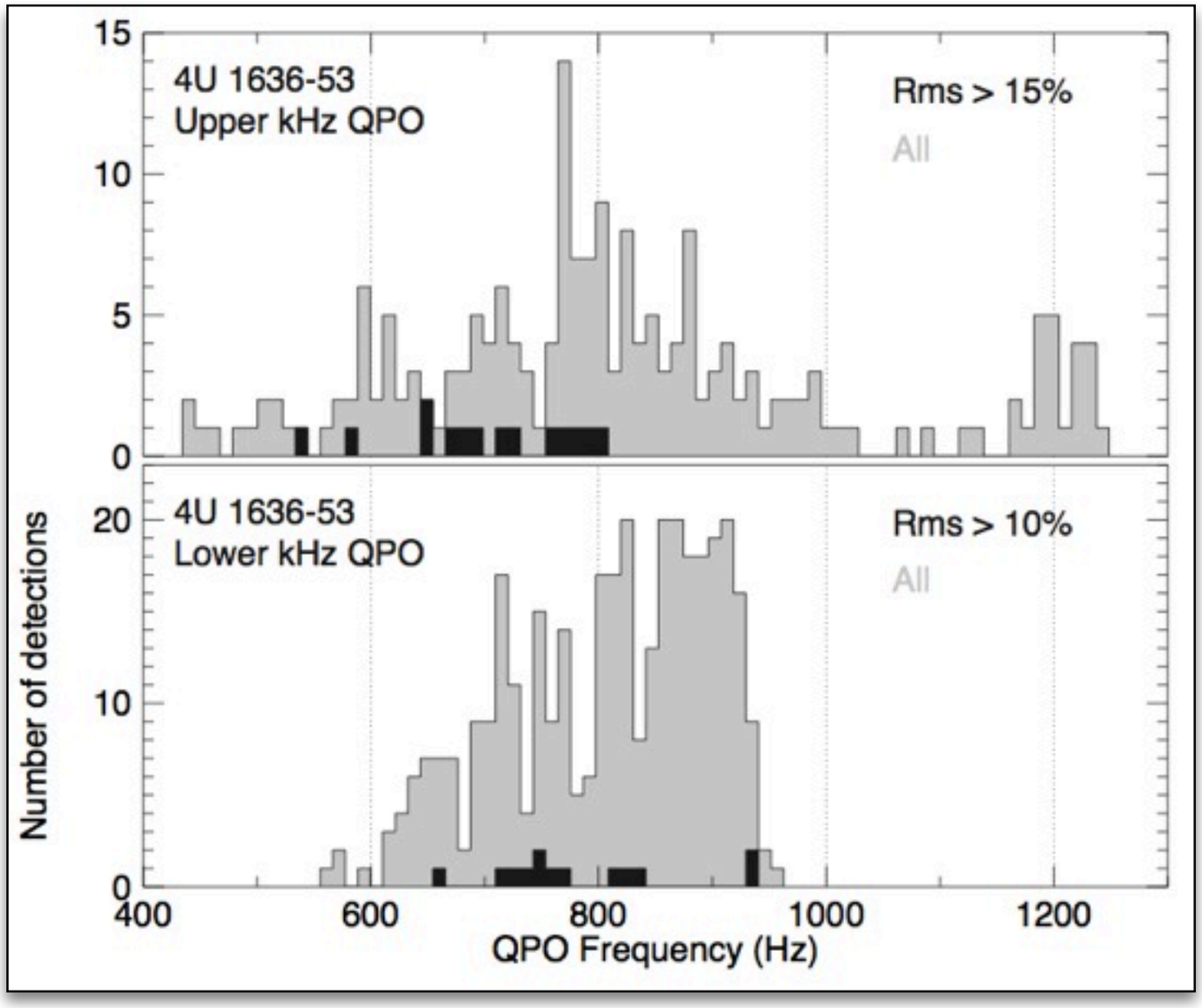


What we have

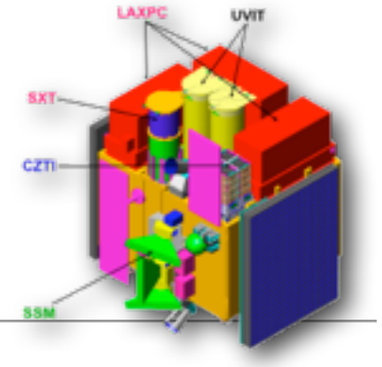
Belloni, Sanna & Méndez (2012)

- ☐ Few detections (others)
- ☐ Special ratios?
- ☐ **NO** type-C QPO
- ☐ Only intermediate states

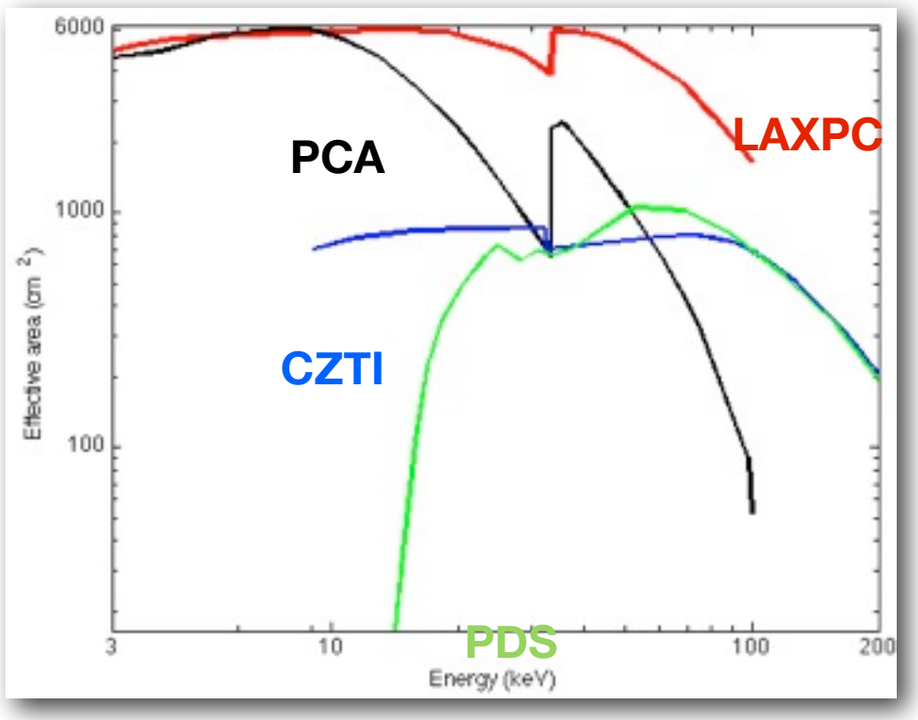
- ☐ Higher ν:
  - ☐ Narrower peak
  - ☐ Harder spectrum
- ☐ Same as kHz QPOs in NS?
- ☐ Boundary layer effects?

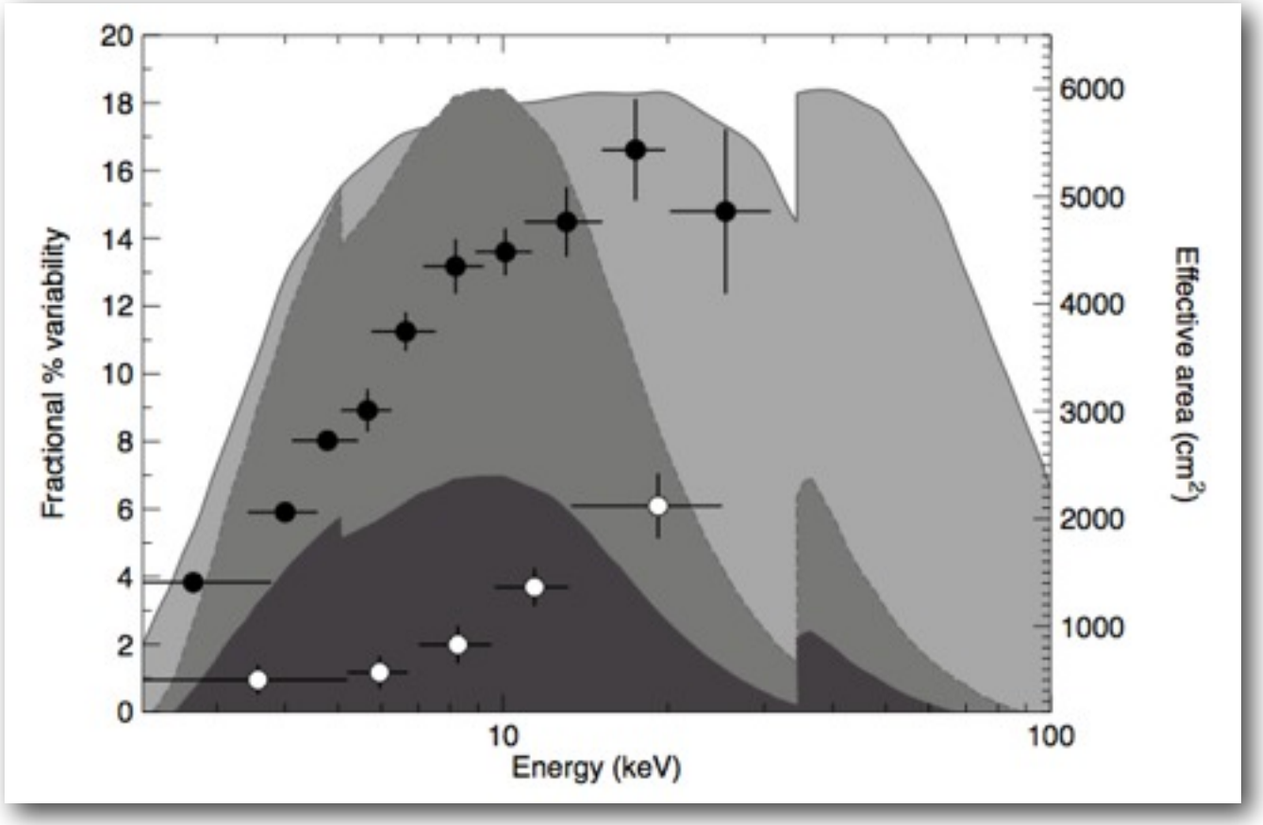


RXTE and THE FUTURE



- The near future: **ASTROSAT** (2013?)
- Better than RXTE above > 20 keV
- Coverage?





LOFT

- Selected for assessment by ESA
- Launched in 2020+ ?
- 12 m^2 effective area