High Throughput X-ray Astronomy in the eXTP Era

QPO simulations with eXTP

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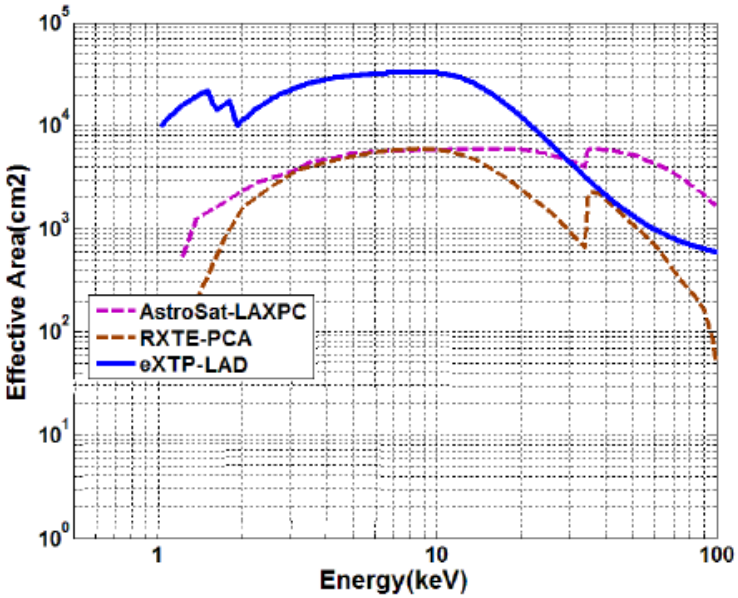
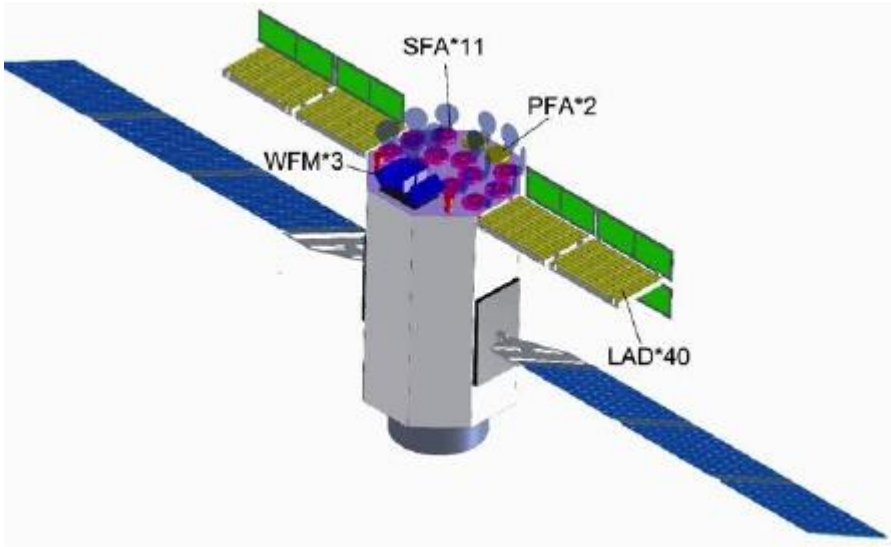
Outline

- **QPOs in Astronomy**
- **Simulation process**
- **Simulation results**
- **Summary**

eXTP

- **Science goals:**
  - Dense matter
  - Physics and Astrophysics of Strong Magnetic fields
  - Accretion in strong field gravity
  - **Observatory science**

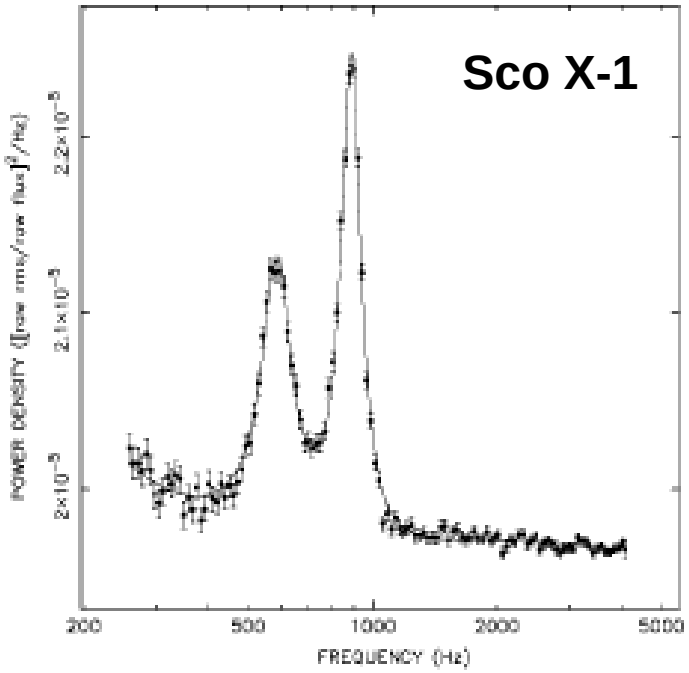




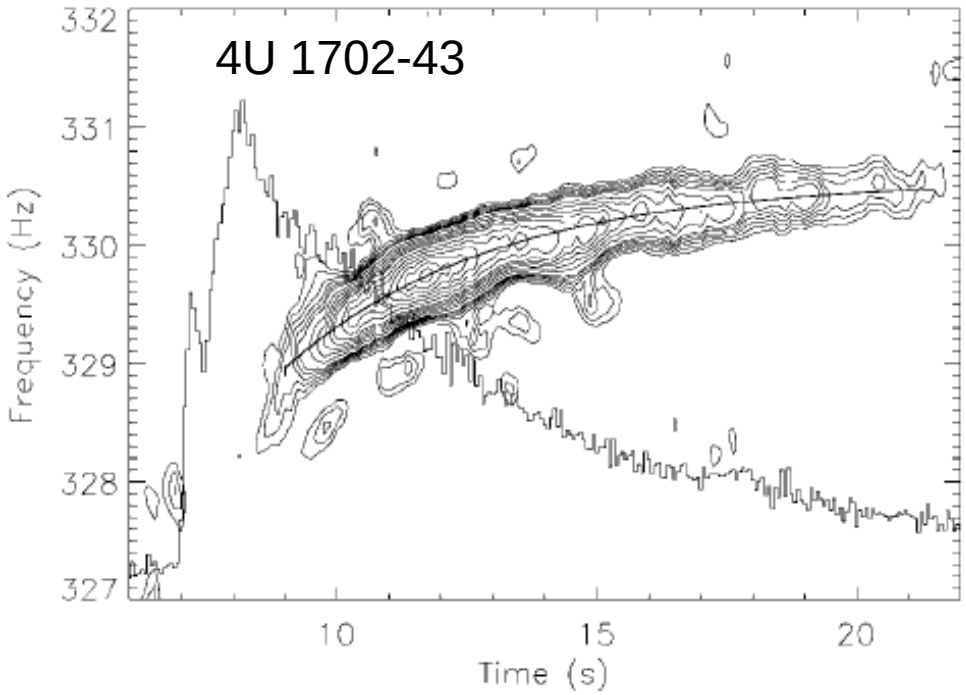
LAD and SFA

QPO

LMXB



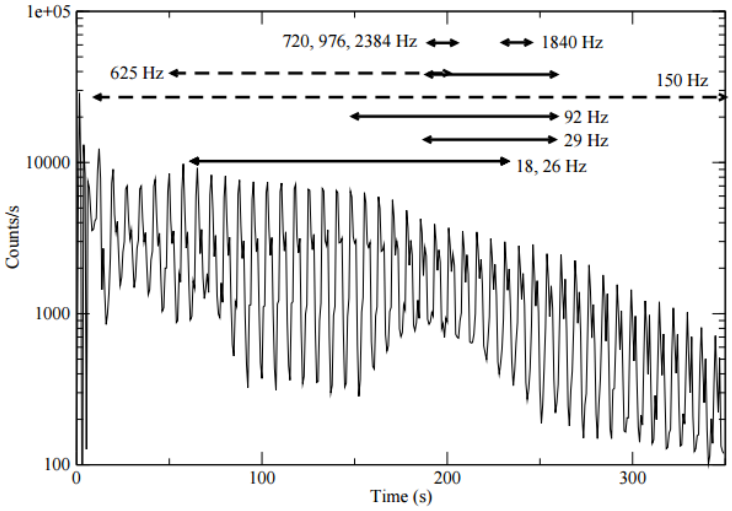
van der Klis et al. 1997

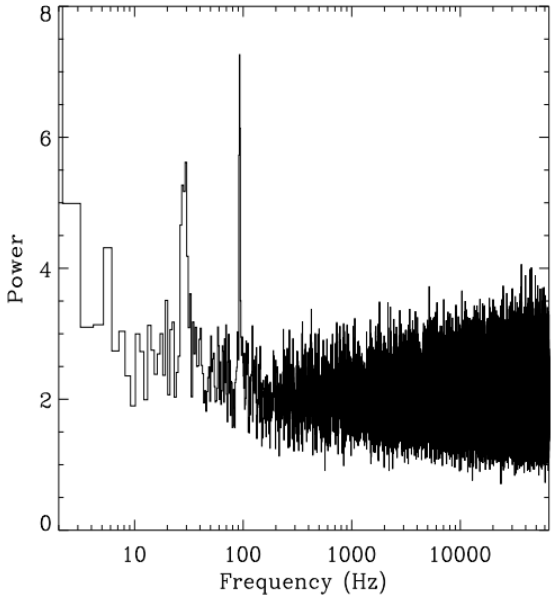


Strohmayer et al. 1999

QPO

Magnetar：SGR 1806-20

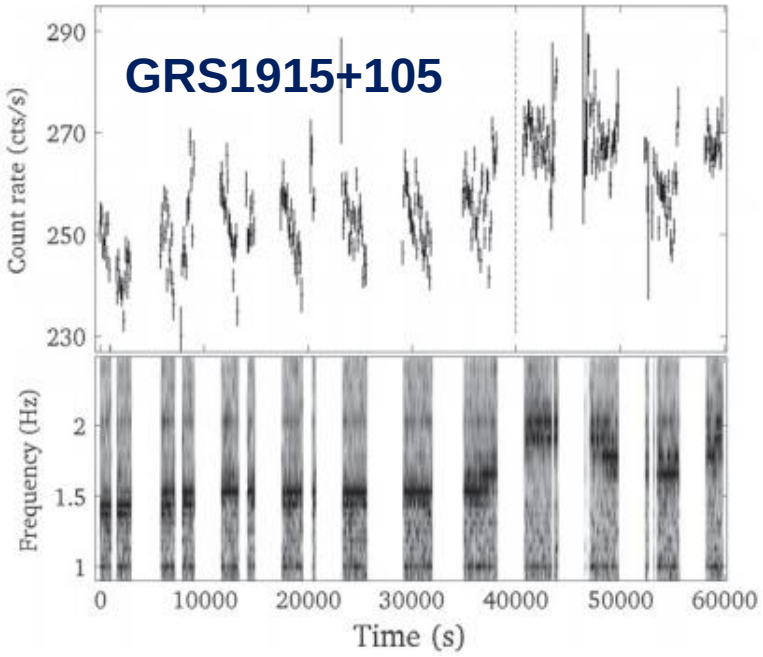




Strohmayer and Watts 2006

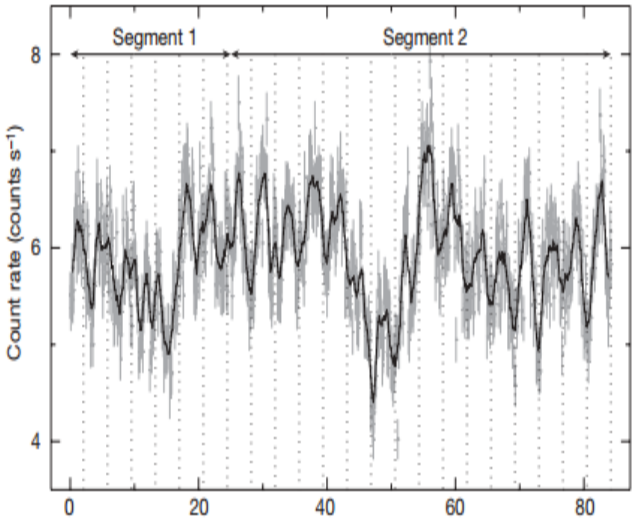
QPO

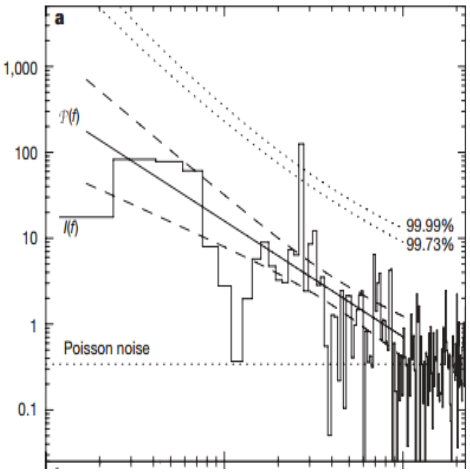
BHs



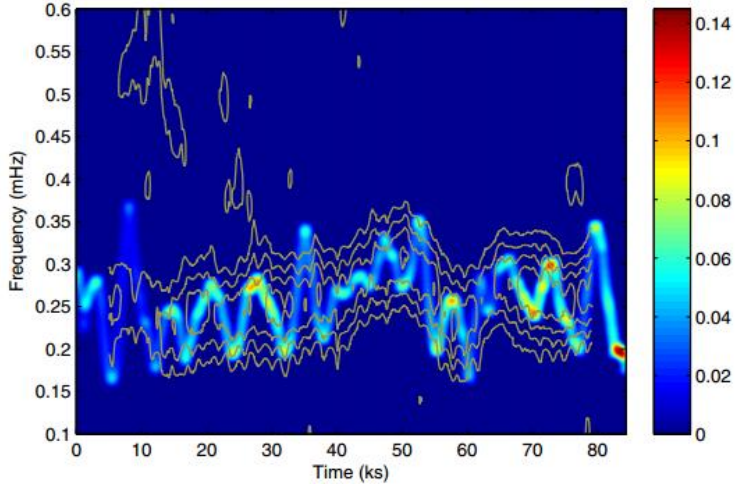
Zhang et al. 2015

J1034+396





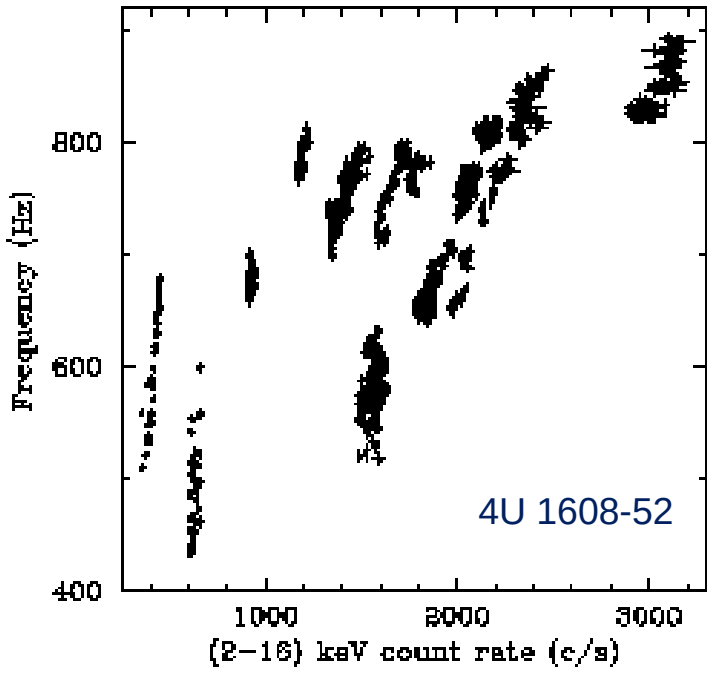
Gierlinski et al. 2008



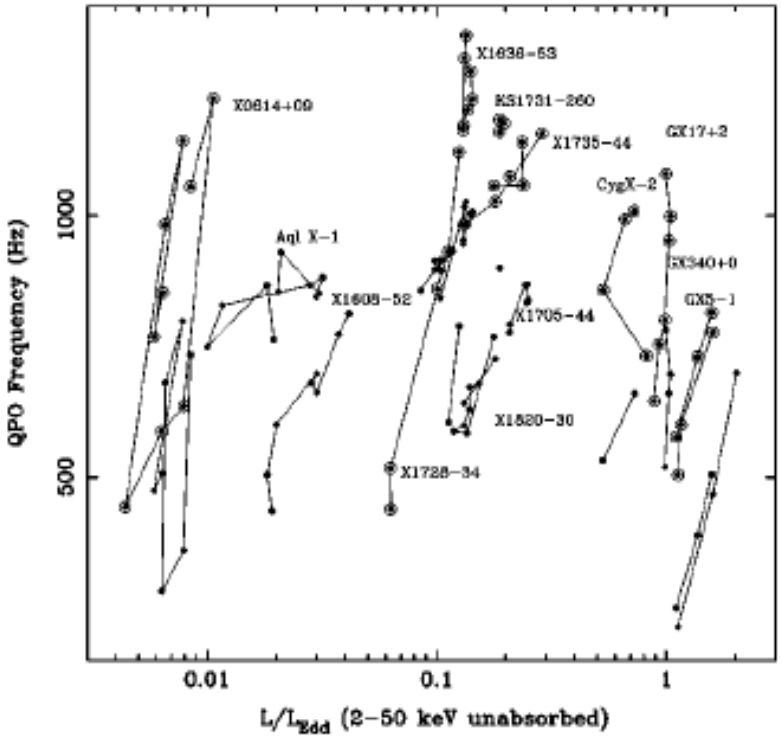
Hu et al. 2014

QPO

- **Parallel lines phenomenon**



Mendez et al. 1999

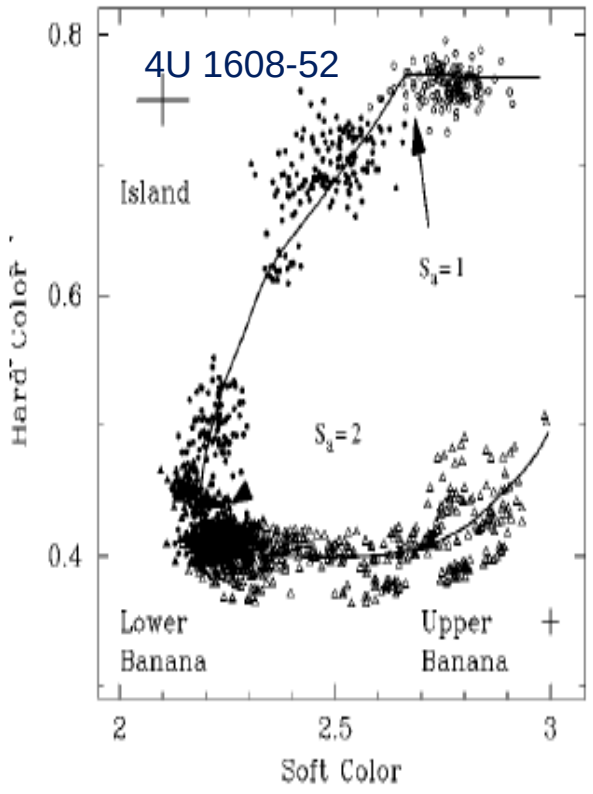


Ford et al. 2000

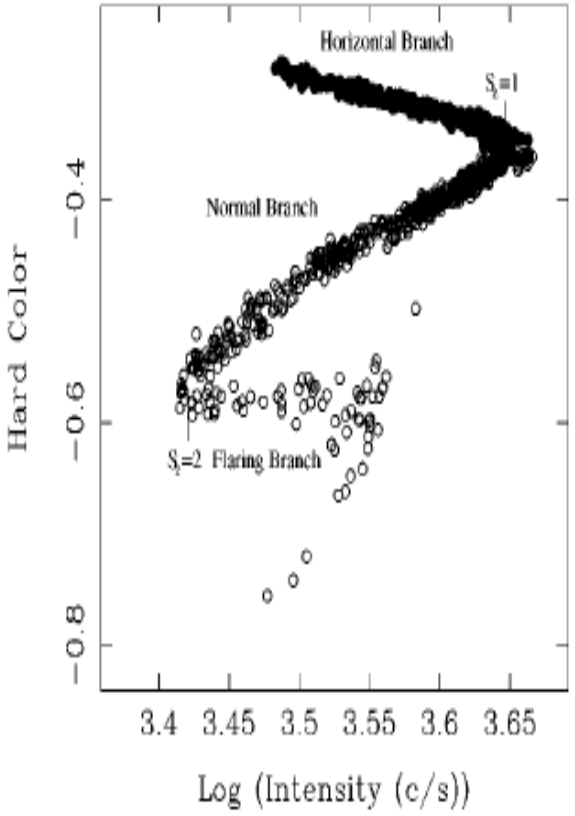
Also See Yu's talk

QPO

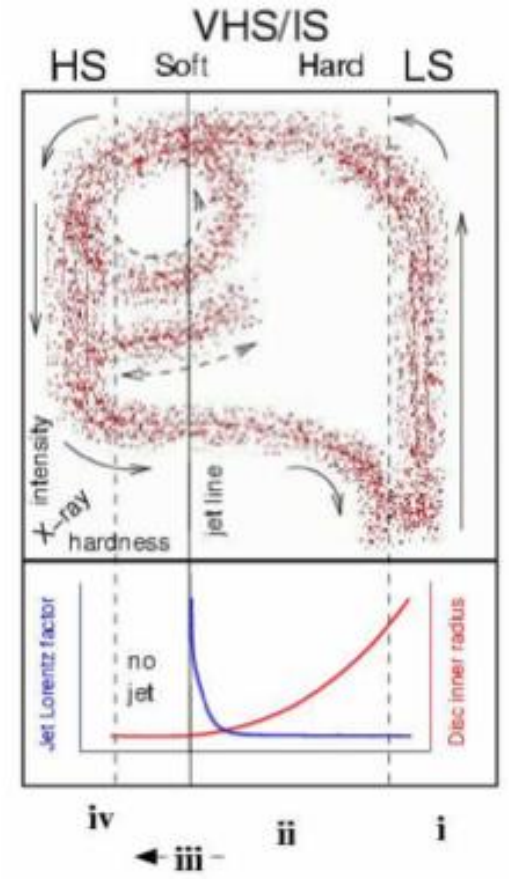
- **CCDs and HIDs**



Mendez et al. 1999



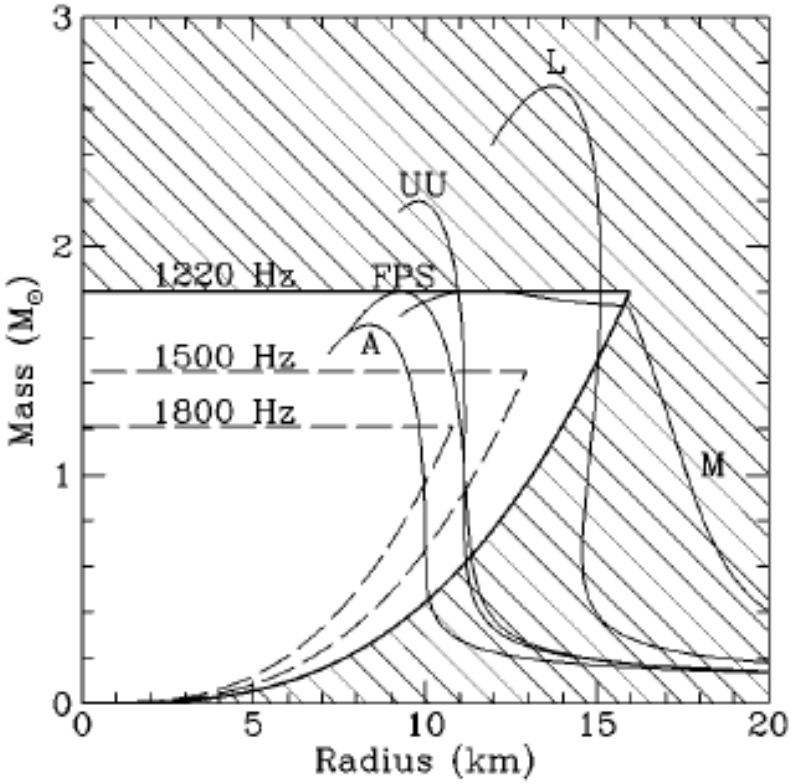
Jonker et al. 2000

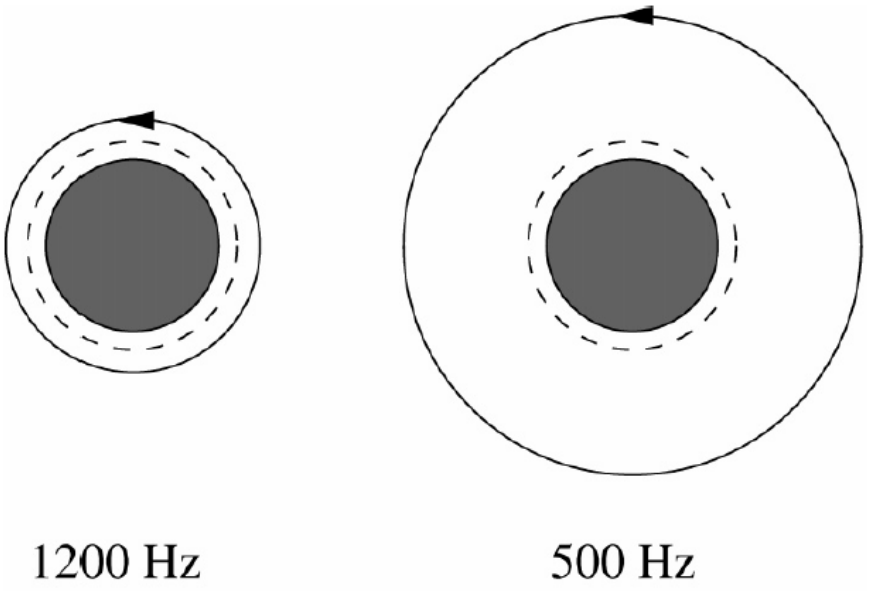


Fender et al. 2004

QPO

- **EoS: M-R**





M. Van der Klis 2000

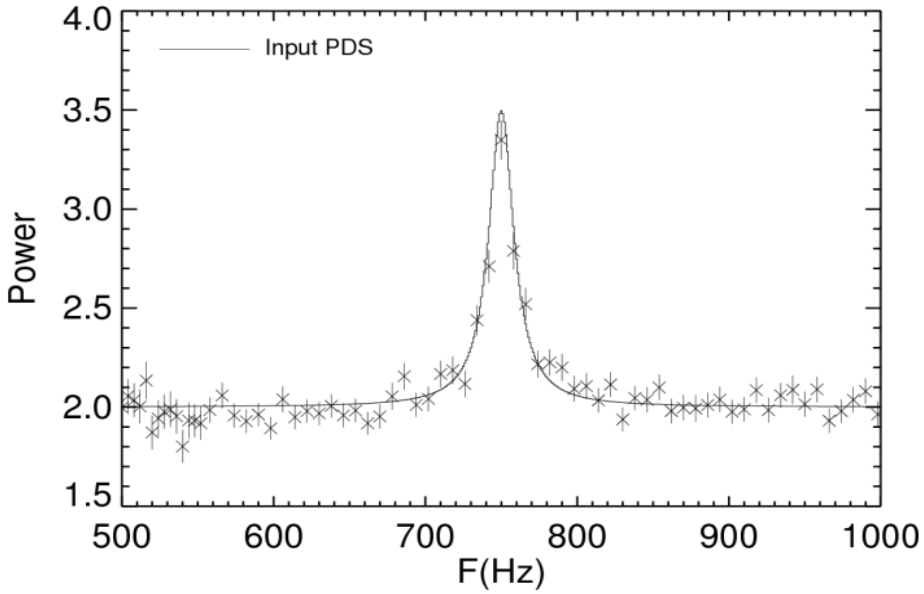
QPO

- **QPO**
  - Many systems: XRB(WD,NS,BH), Magnetar, AGN
  - Multi-time scale
  - Many types

- **Mechanism**
  - Need more knowledge to understand QPO

QPO simulation

- **Light curve generation**
  - From PDS （Timmer 1995）



$$rms = \{\int_{f_1}^{f_2} \overline{P(f)} df\}^{\frac{1}{2}}$$

$$rms_{QPO} = (0.5\pi * LN * LW)^{\frac{1}{2}}$$

http://astro.uni-tuebingen.de/software/idl/aitlib/timing/timmerlc.pro

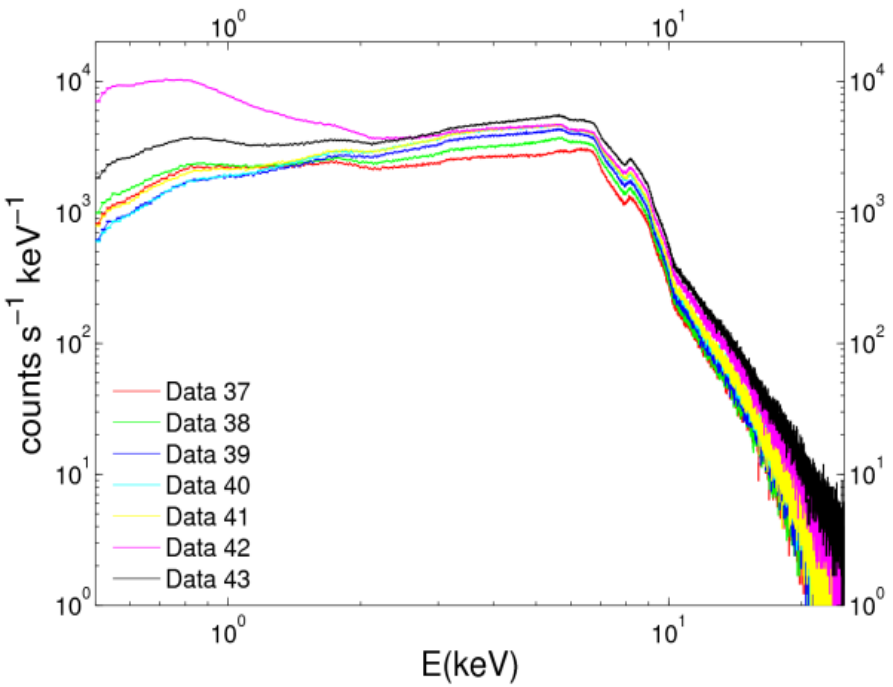
Simulation results for eXTP

- QPO Frequency vs. accretion disk feature
- QPO Frequency vs. Energy or Time
- QPO RMS vs. Energy
- QPO RMS sensitivity

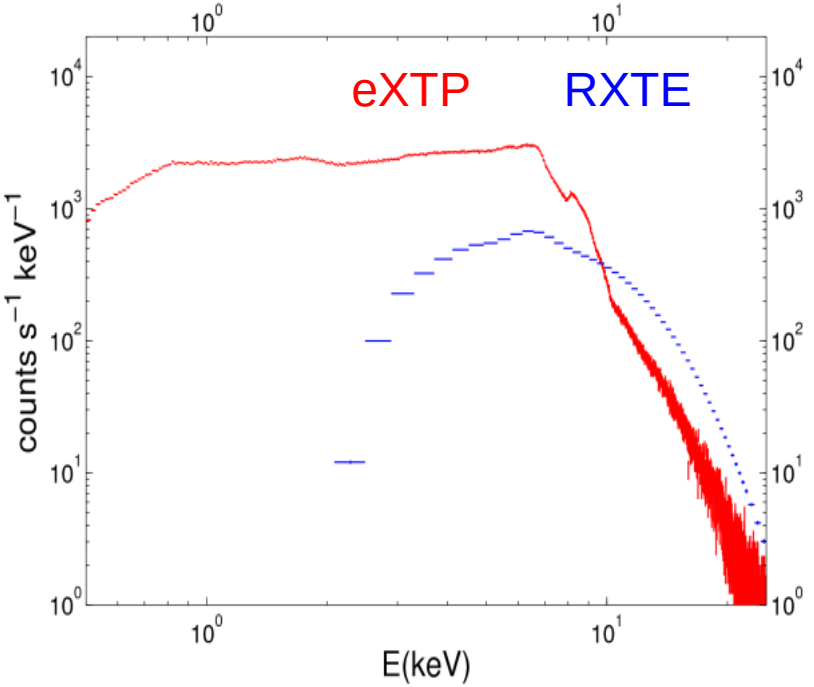
Simulation results for eXTP

Spectra:

Sco X-1 From D'Ai et al. 2007



Spectra for sequence 37-43 for **eXTP SFA**

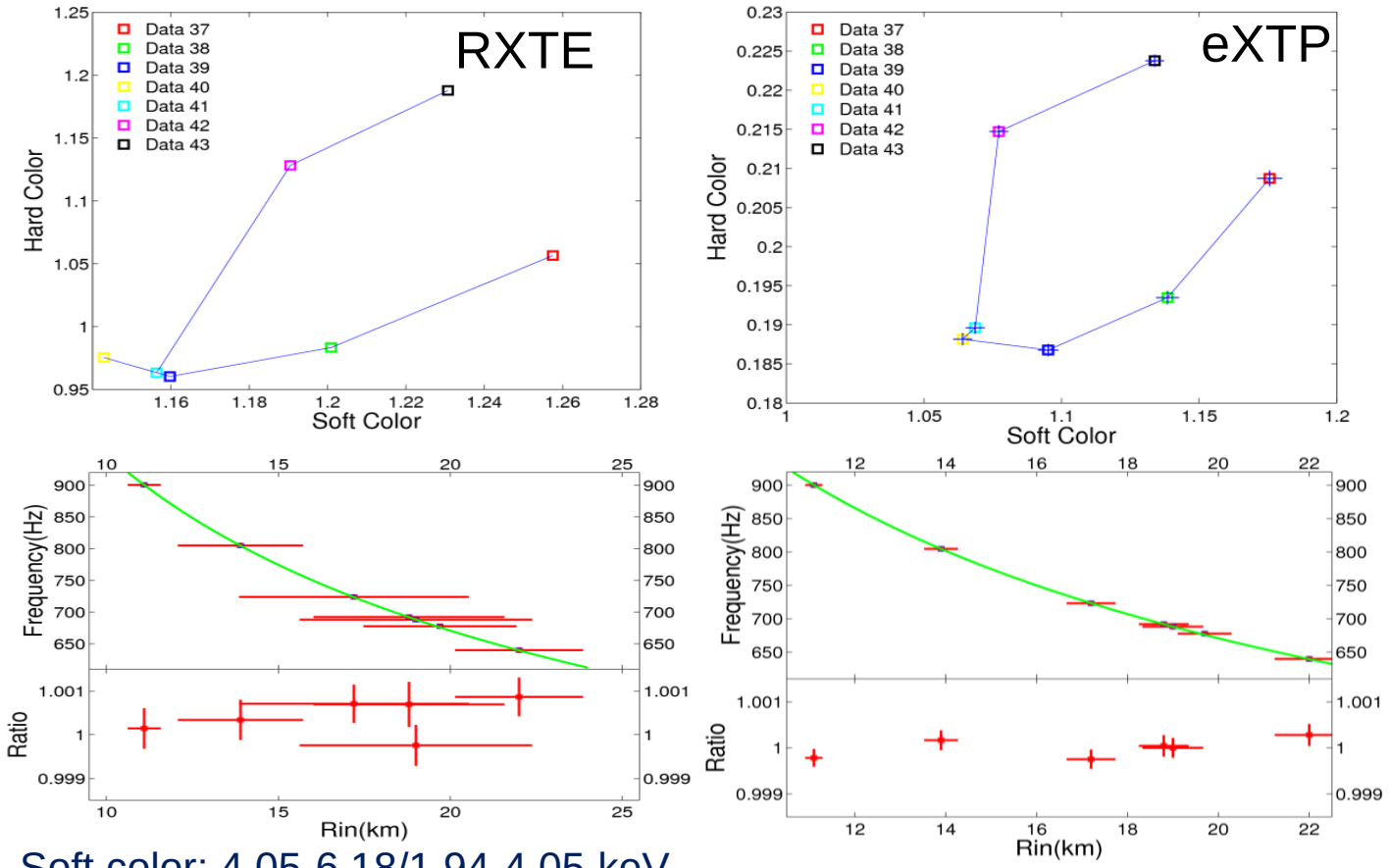


Spectra of **eXTP SFA** and RXTE PCU2

Assumption : QPO frequency ~ $R_{in}^{-1.5}$

Simulation results for eXTP

Assumption : QPO frequency ~ $R_{in}^{-1.5}$

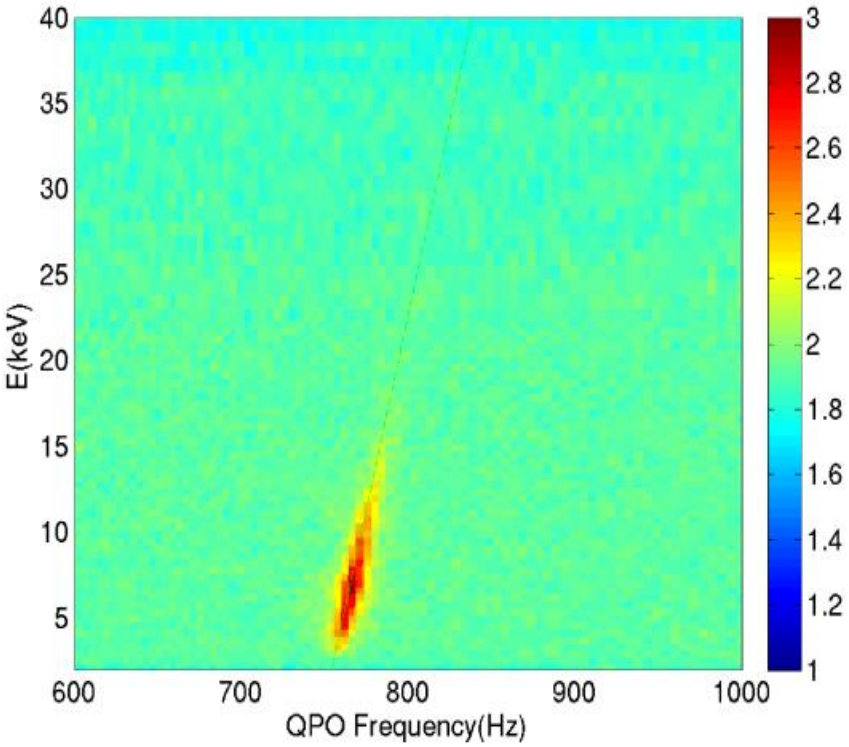


Soft color: 4.05-6.18/1.94-4.05 keV

Hard color: 8.32-16.26/6.18-8.32 keV

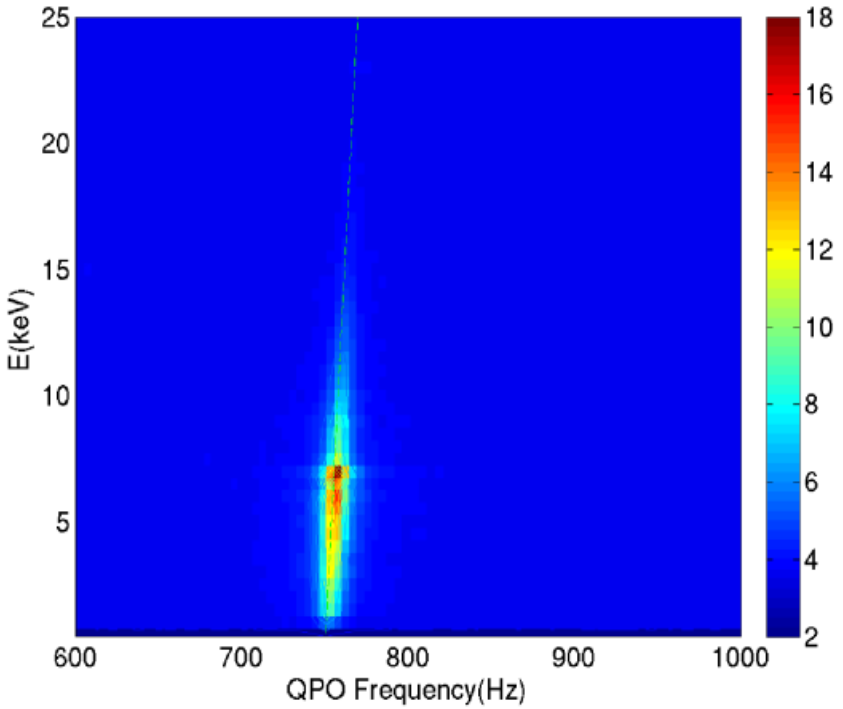
Simulation results for eXTP

QPO vs. energy



RXTE

0.1 Crab



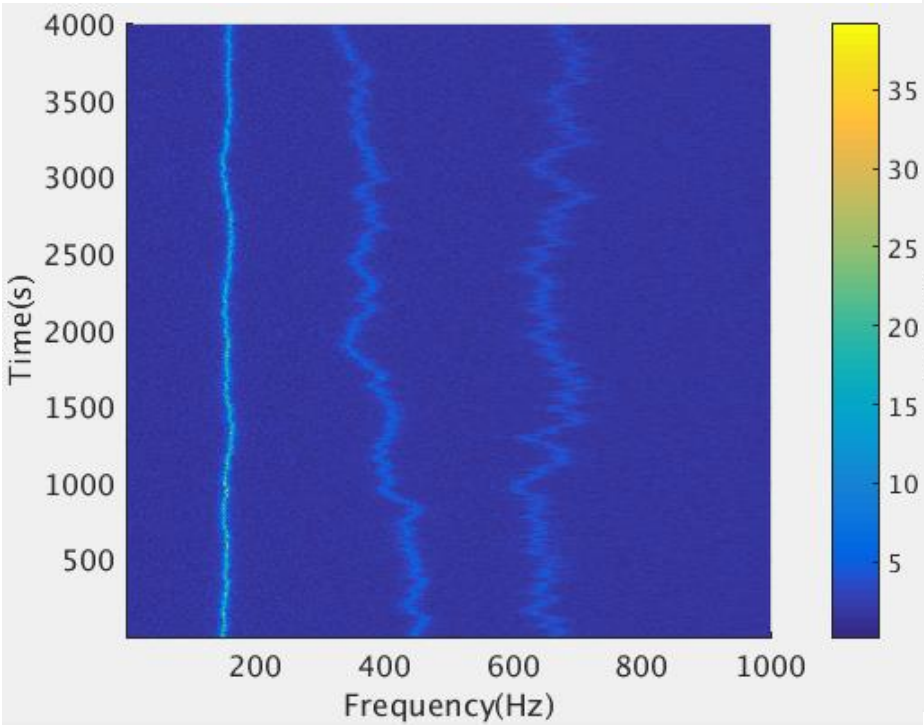
eXTP LAD + SFA

QPO RMS=20%，Exp time: 512s

Δf=50Hz

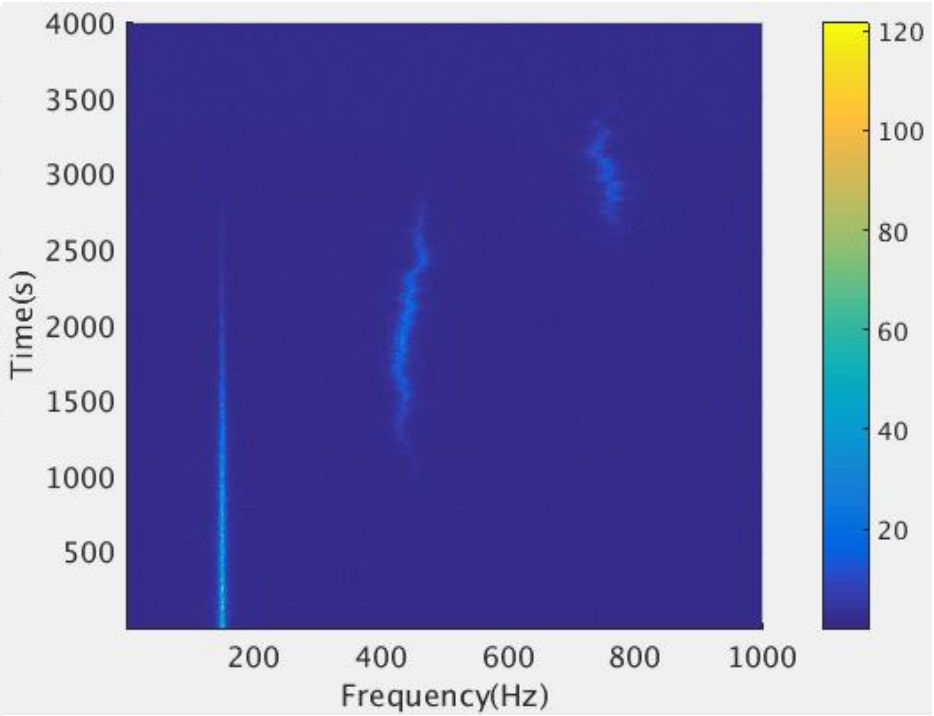
Simulation results for eXTP

QPO vs. time



FWHM = 5, 15, 21.5Hz, RMS<20%

0.1 Crab

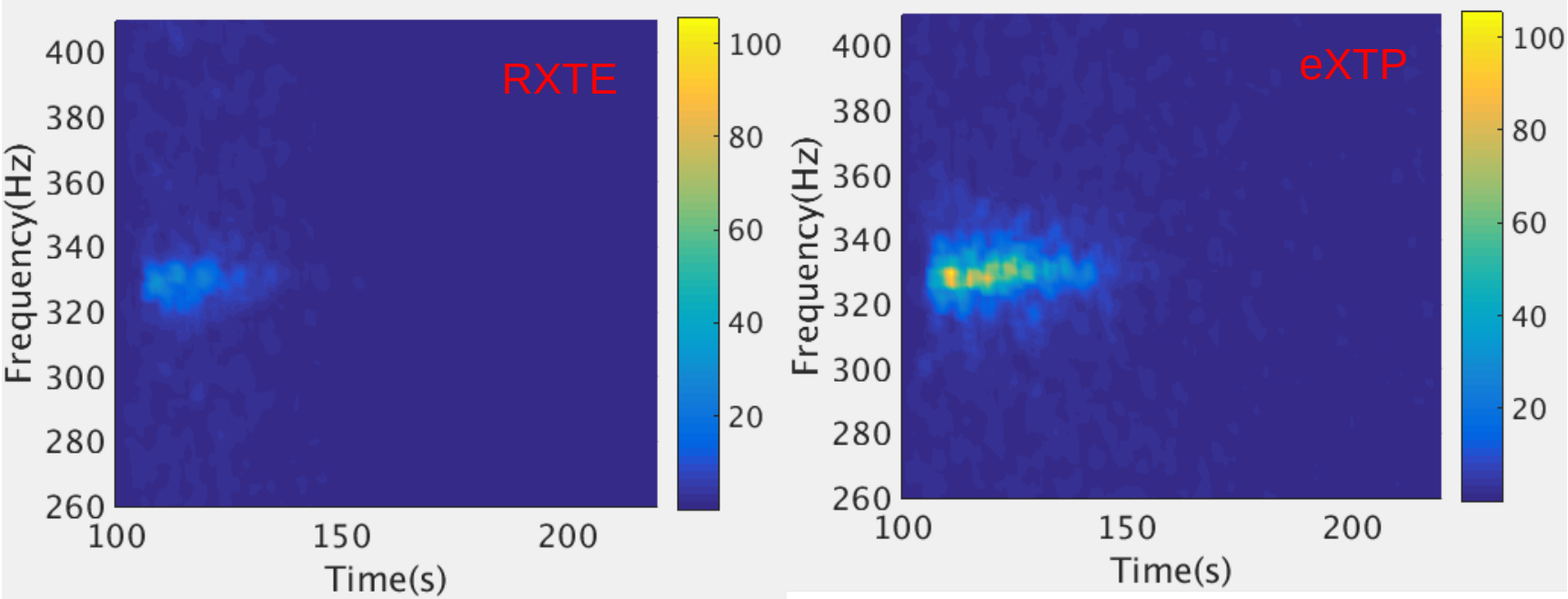


FWHM = 5, 15, 21.5Hz, RMS<20%
2000,1000,500 seconds

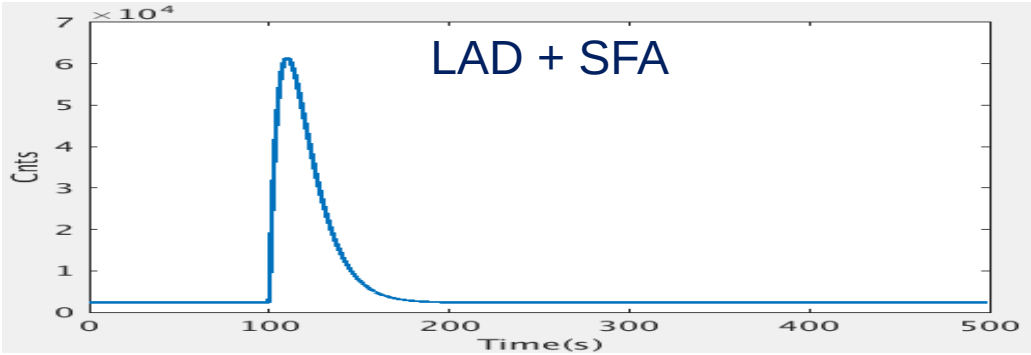
LAD + SFA

Simulation results for eXTP

Type I burst

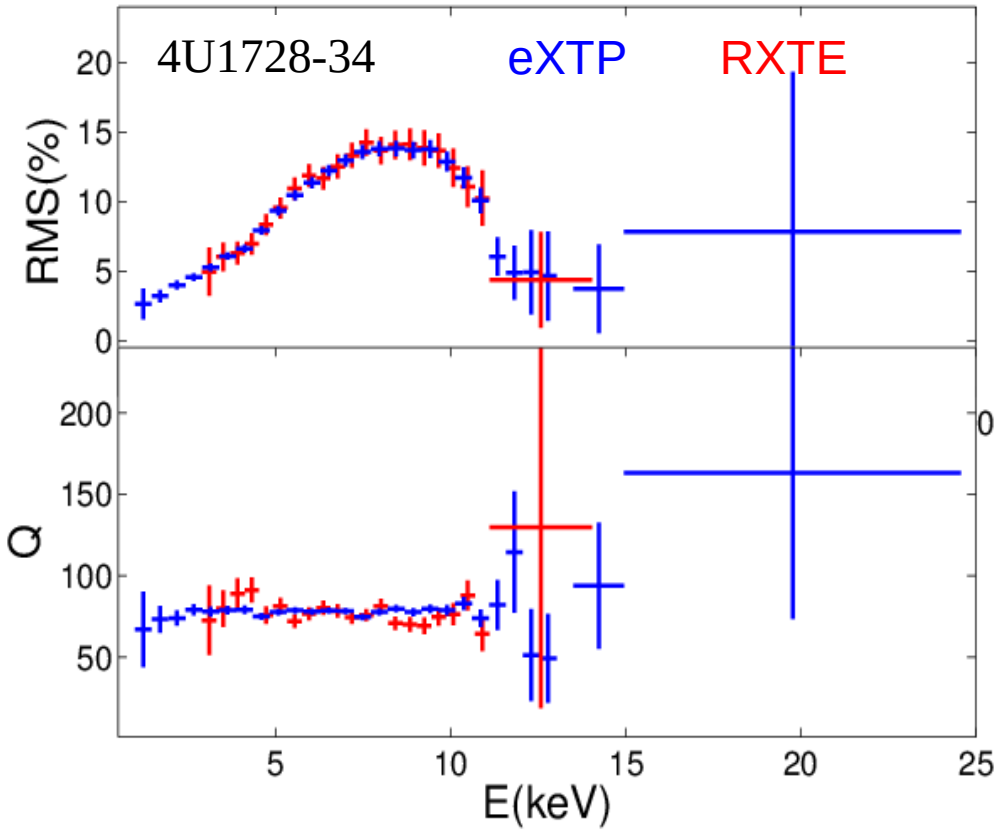


FWHM =10Hz, RMS<20%



Simulation results for eXTP

QPO RMS



RMS from Arunava Mukherjee et al. 2012

Exposure time: 10ks

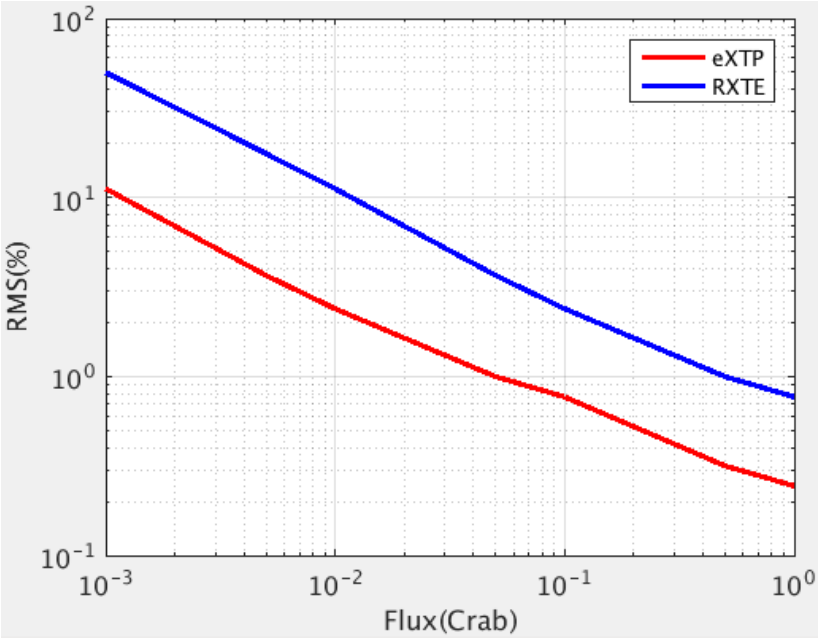
Broader energy band

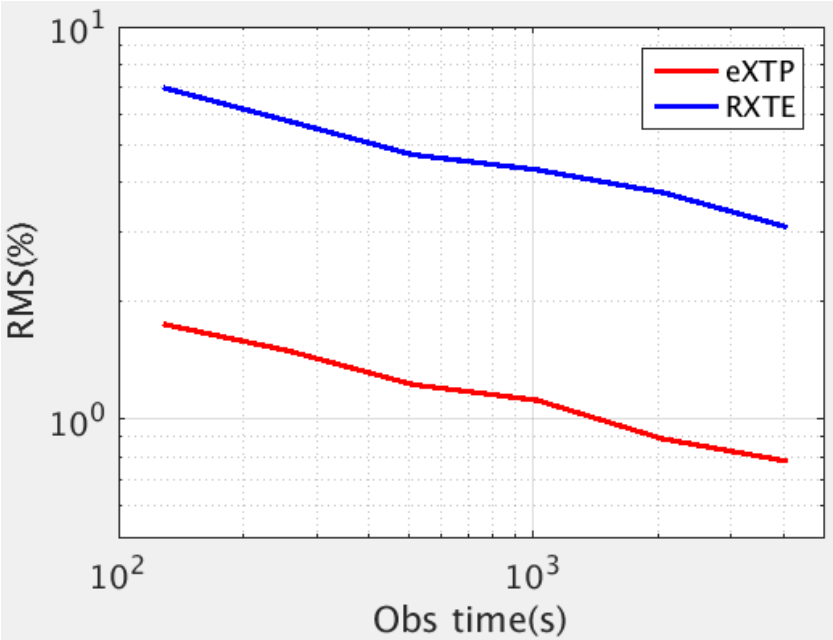
High sensitivity

Simulation results for eXTP

QPO RMS sensitivity:

FWHM=5Hz





Exposure time：4096s

0.1Crab

Similar results with Zhang et al. 2016

LAD + SFA

Summary

- **Good ability to study the phenomenon of QPOs：**
  - Time evolution
  - Energy evolution

- **Good ability to study the nature of QPOs：**
  - Accretion Disk
  - Generation and Evolution
  - PRE
  - …

Thank you for your attention！