Black-Hole Binaries

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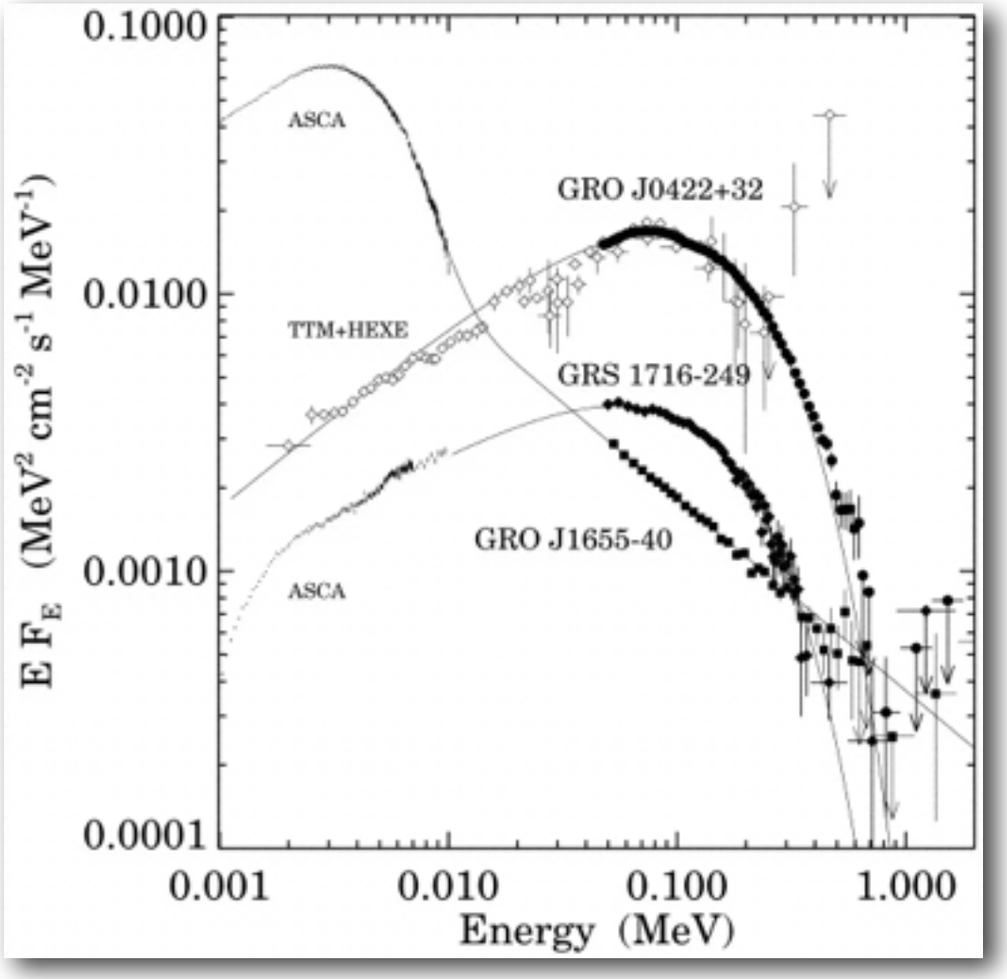
CNOC 2015

Accretion onto stellar-mass black holes

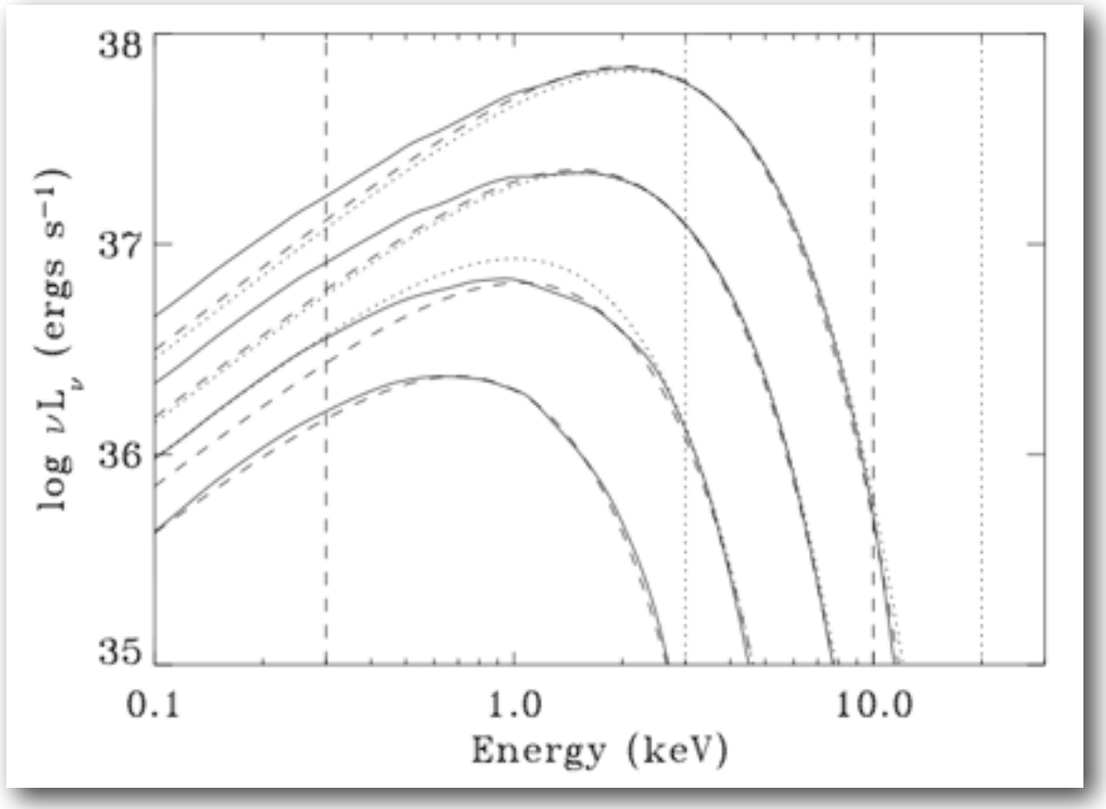
abcdefghijklmnop q rstuvwxyz

Soft state

- Thin disk model a spectacular success
- Still an additional component is present (always?)



Grove et al. (1998)

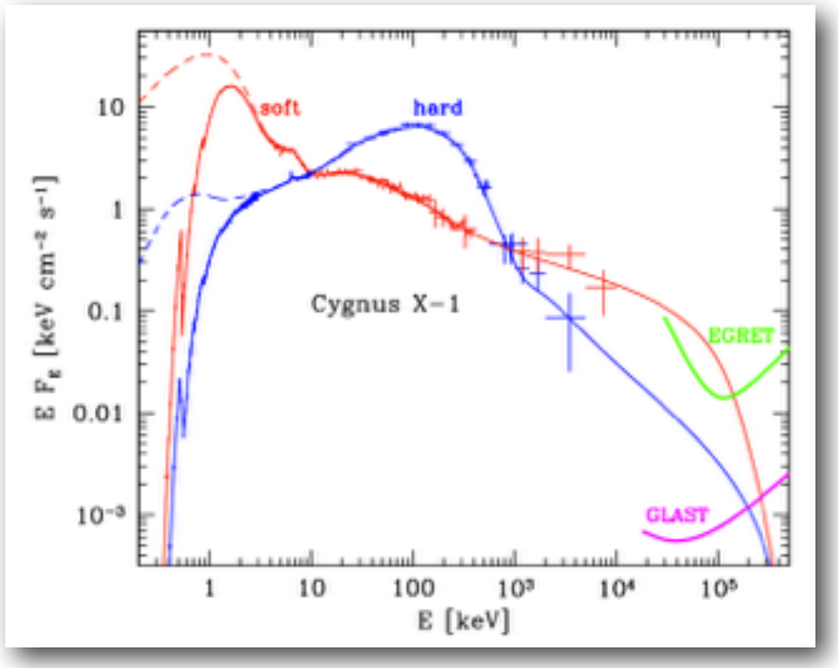


Davis et al. (2005)

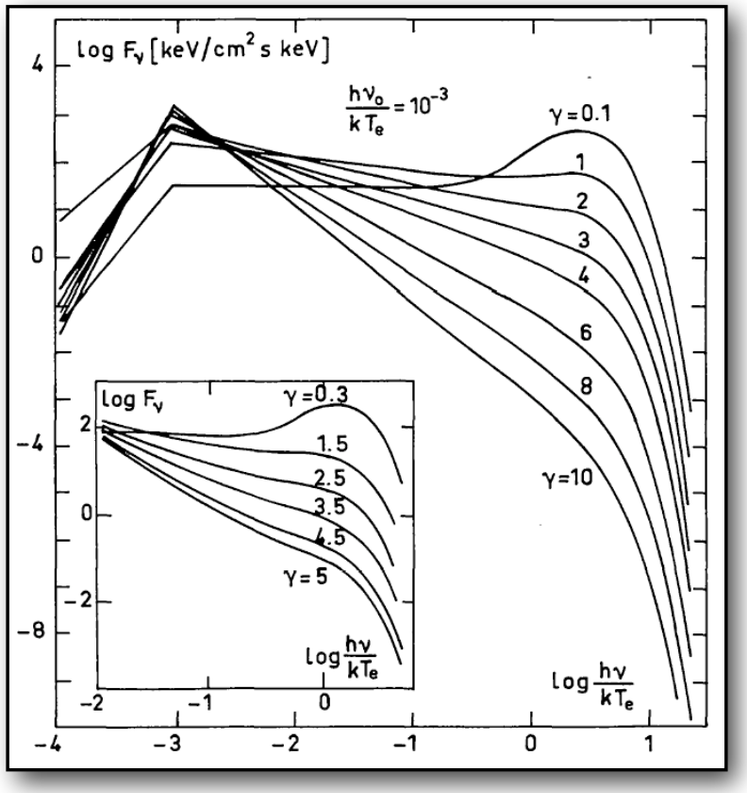
- A quiet disk

Hard state

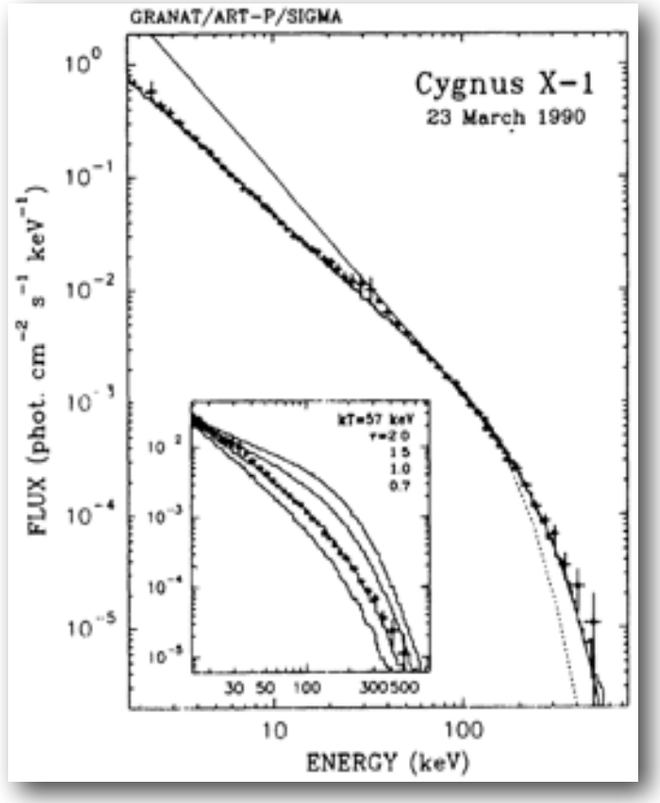
- Lots of complications
- Hybrid models
- Jet models



Zdziarski & Gierliński (2004)



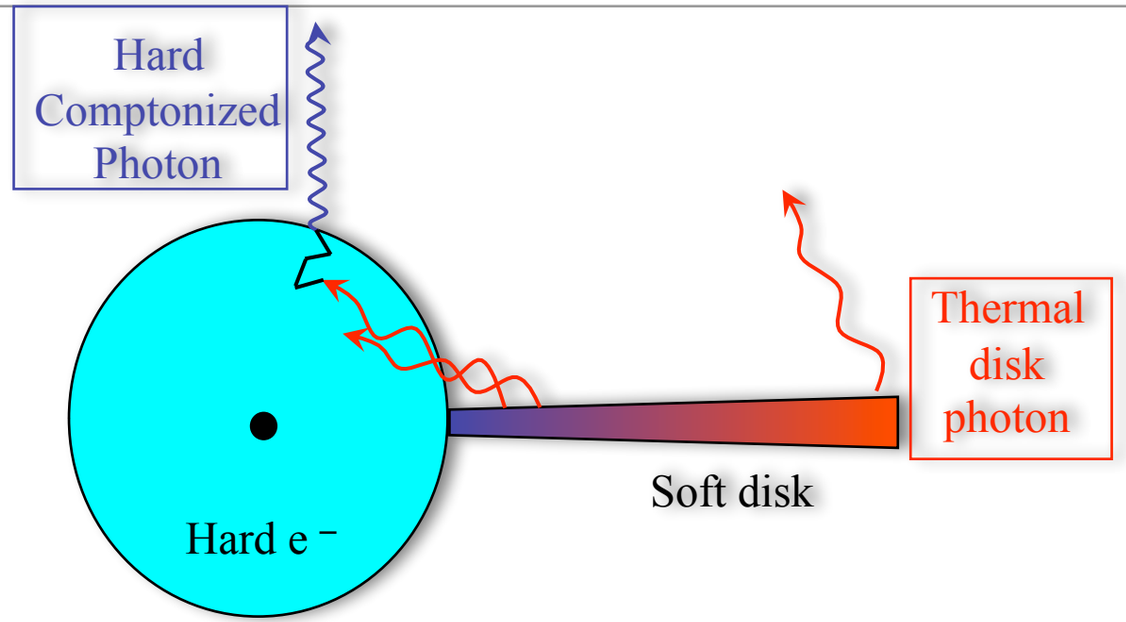
Sunyaev & Titarchuk (1980)

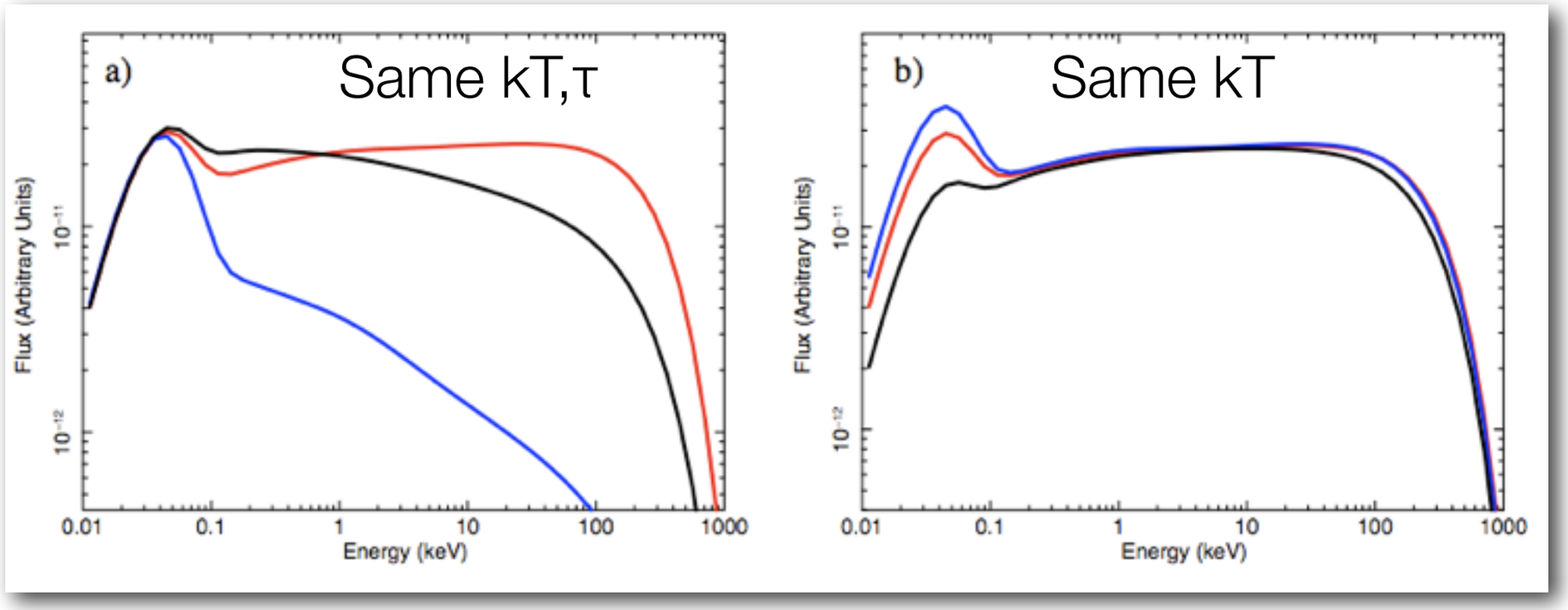


Sunyaev & Trümper (1979)

- A restless flow

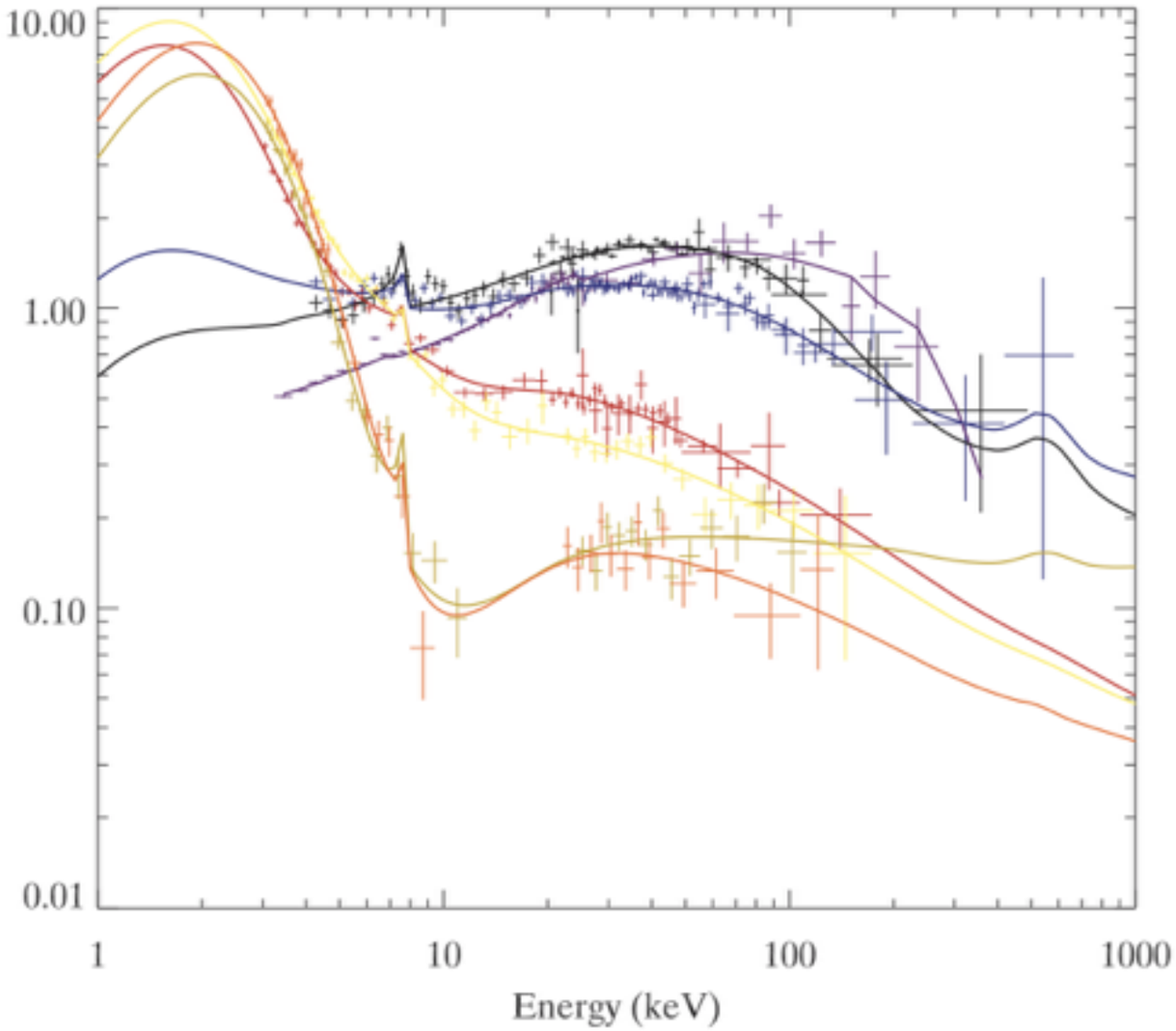
Geometry unclear





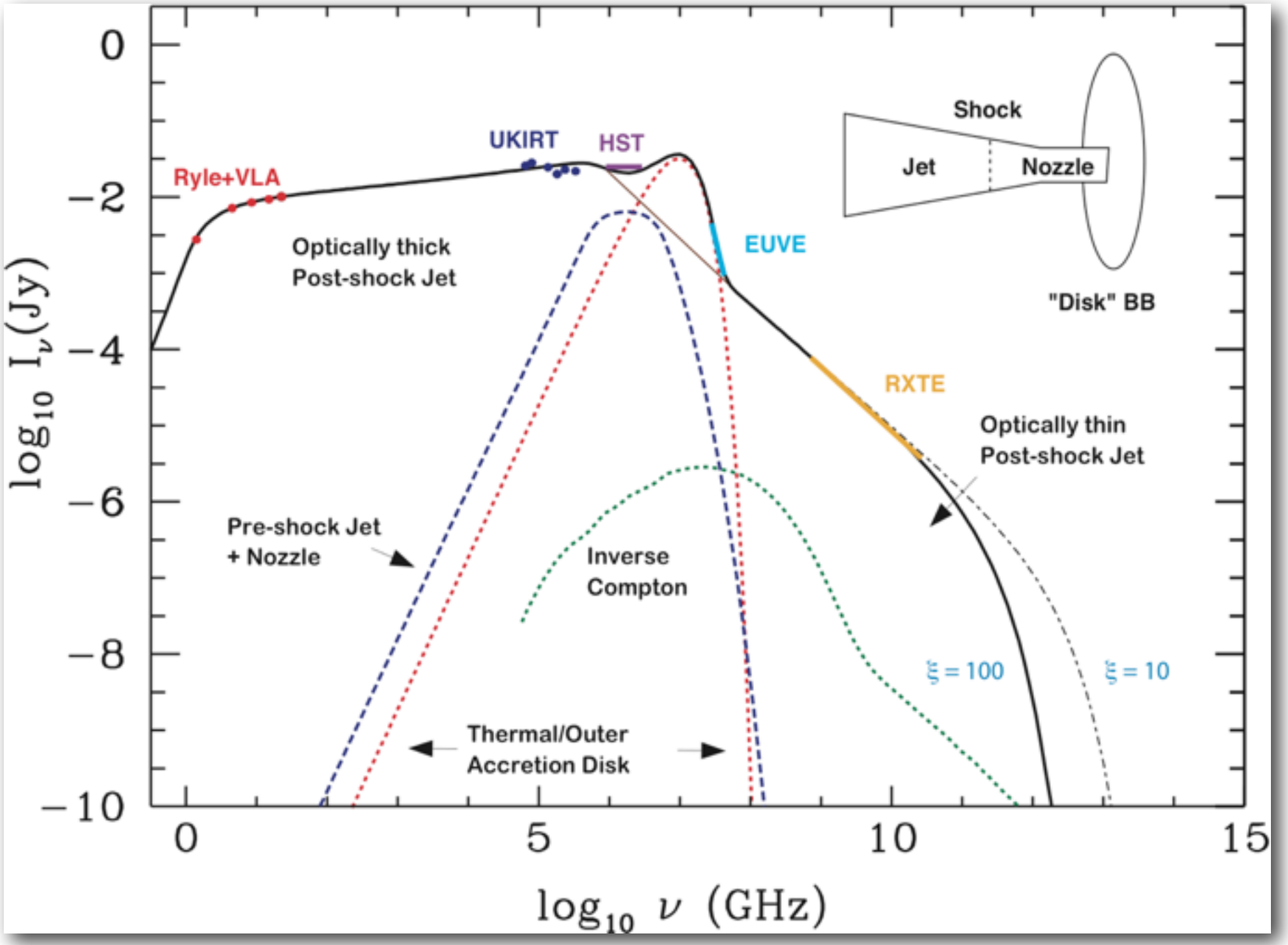
Petrucci (2009)

Hybrid plasma?



Del Santo (2008)

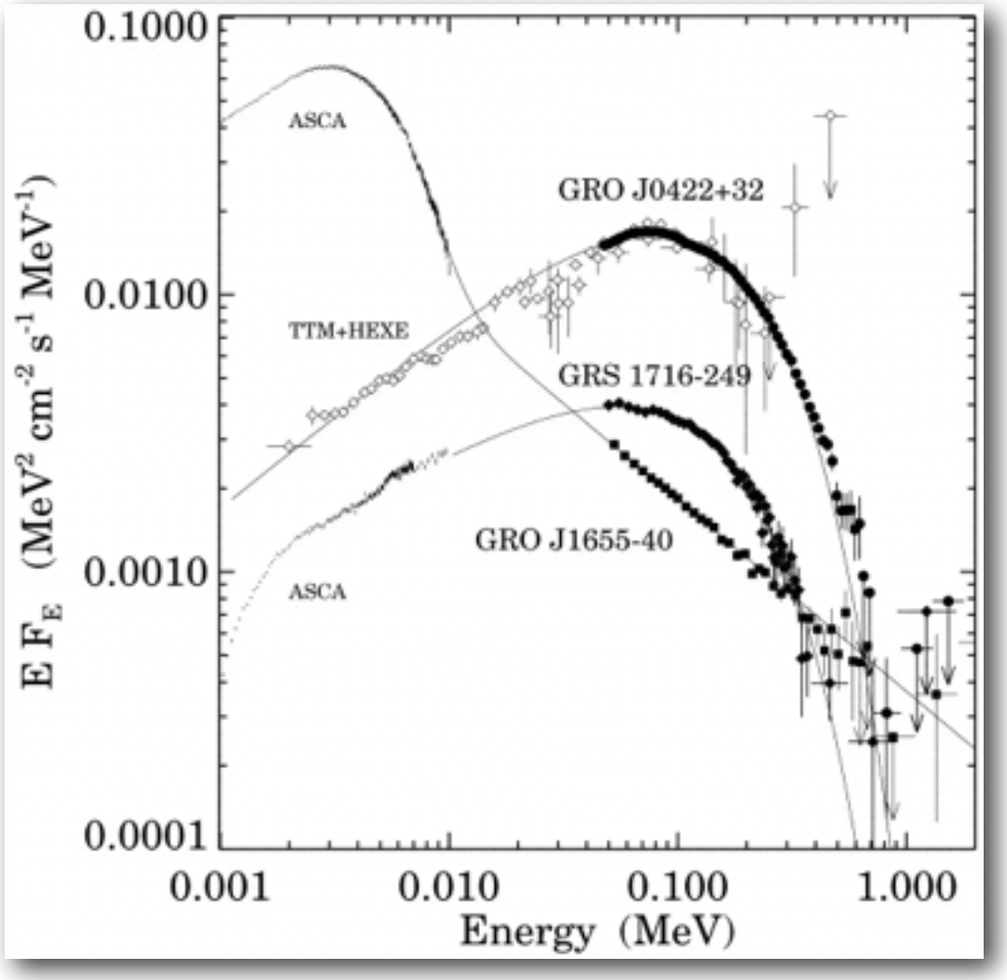
Jet contribution



Markoff (2009)

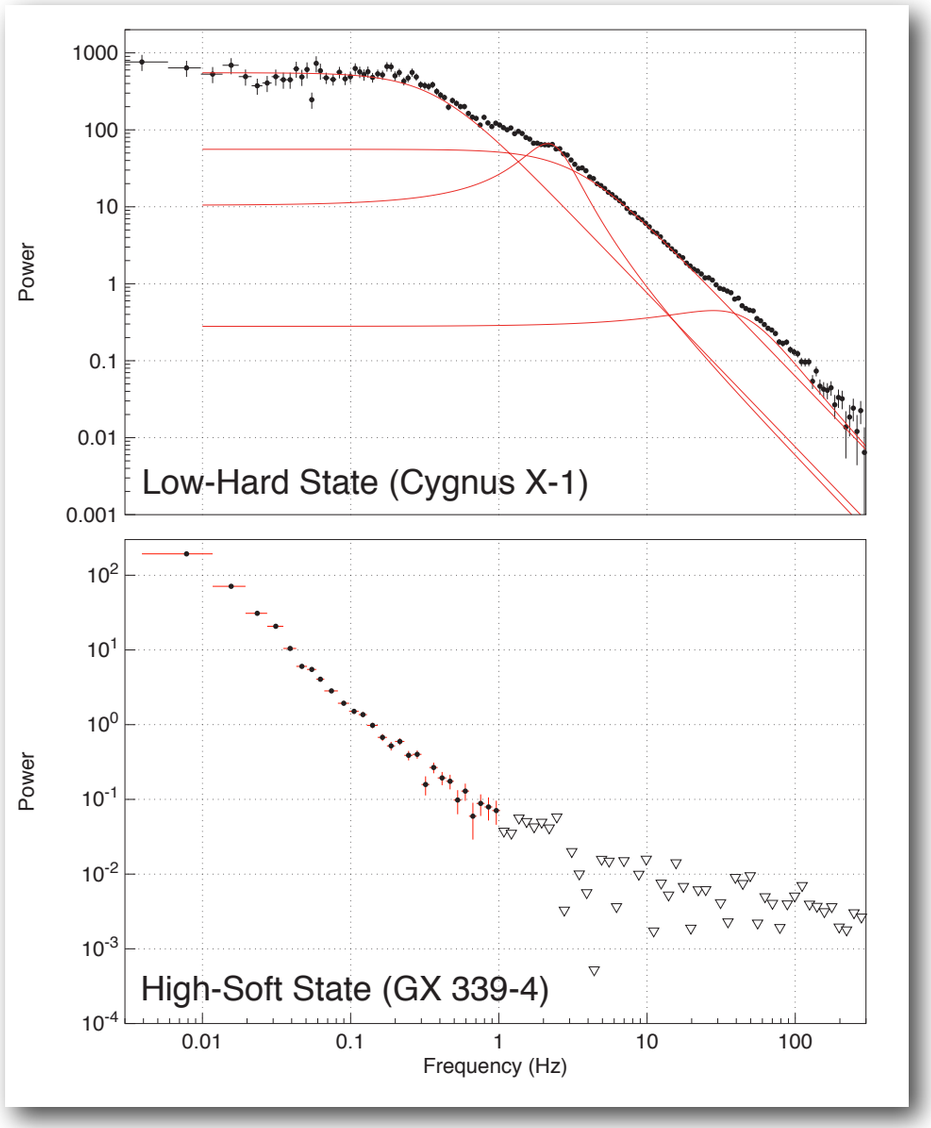
We need more information: timing

Spectra



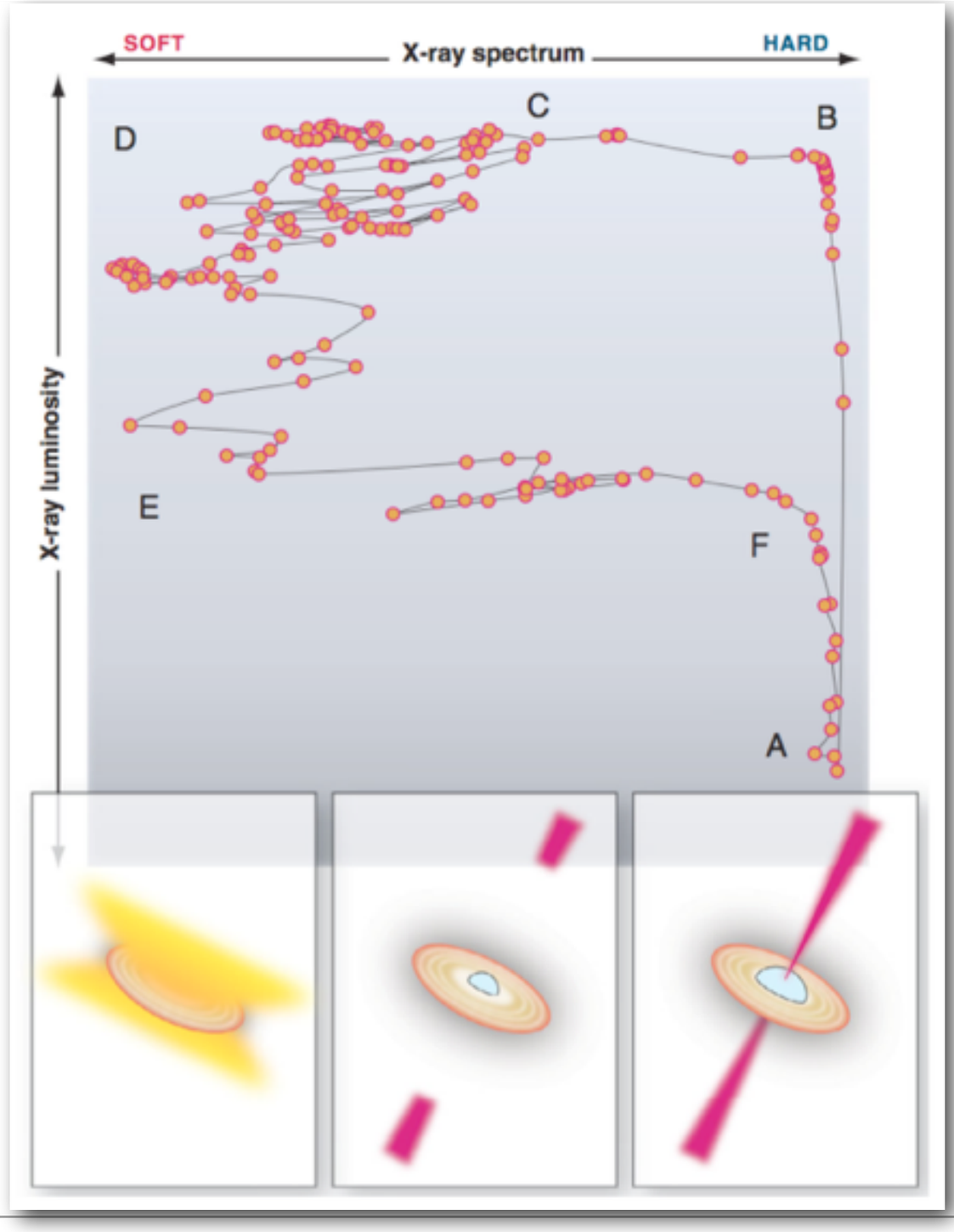
Grove et al. (1998)

Timing



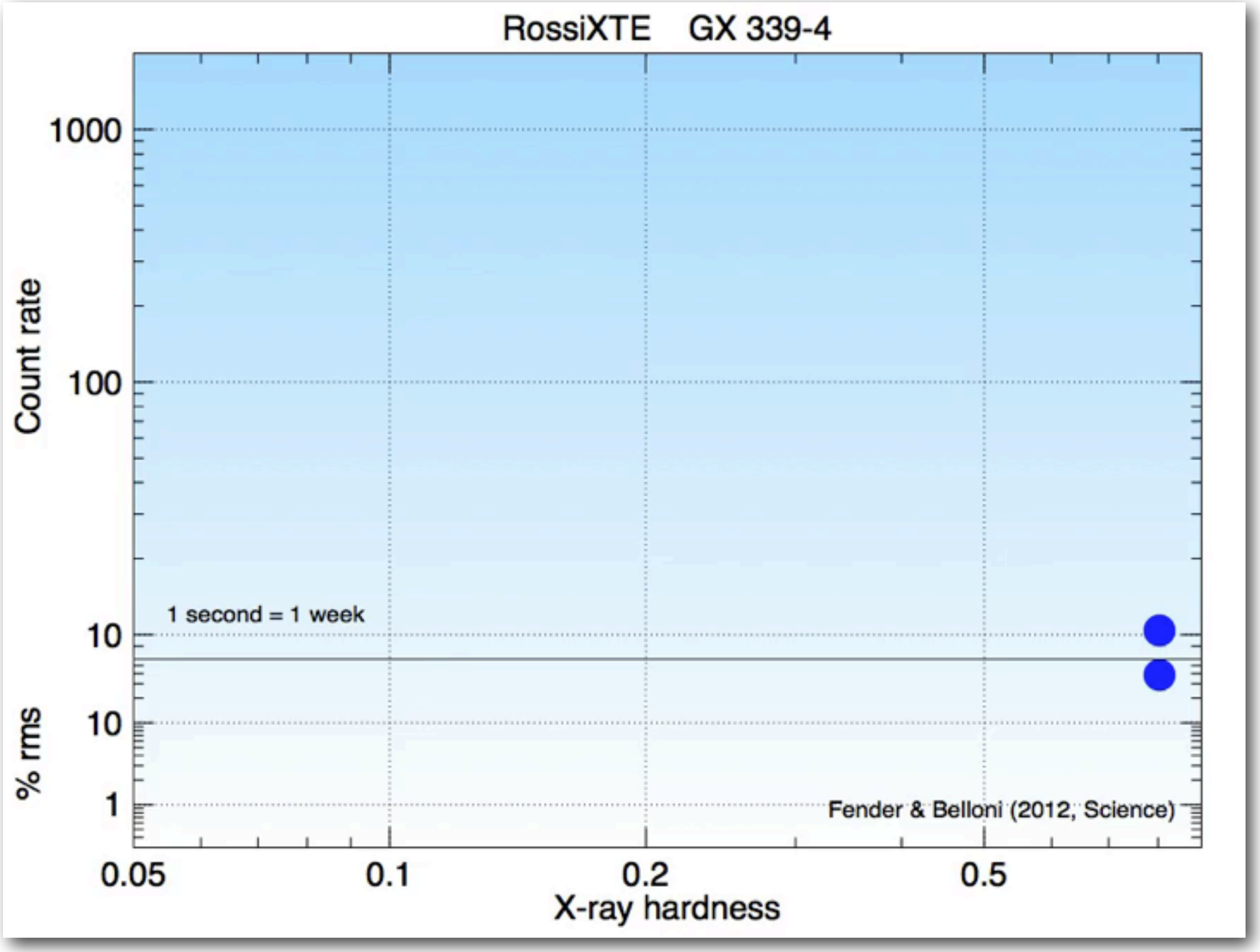
Belloni (2010)

THE RXTE BLACK-HOLE PARADIGM



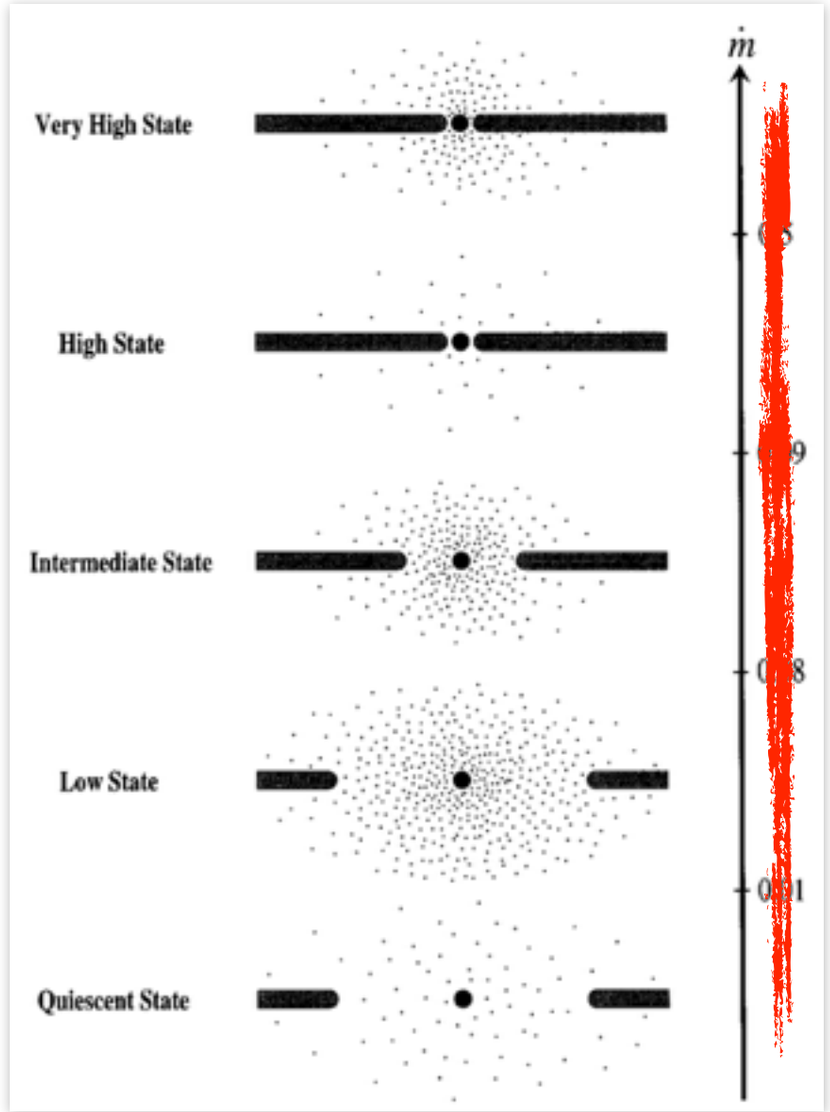
Fender & Belloni (2012)

A YEAR IN THE LIFE OF GX 339-4



SOME OPEN QUESTIONS

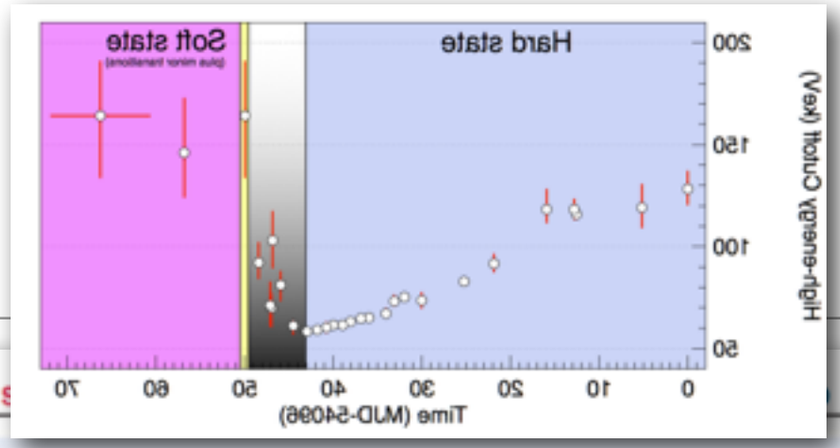
- Hysteresis: why and how?
- Why not clockwise?
- Nature of hard components
- Transitions
- Jet connection
- Wind connection

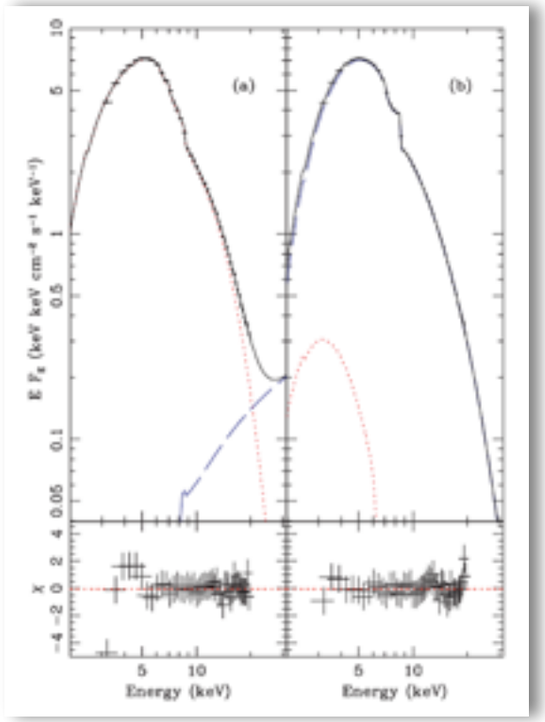


Esin et al. (1997)

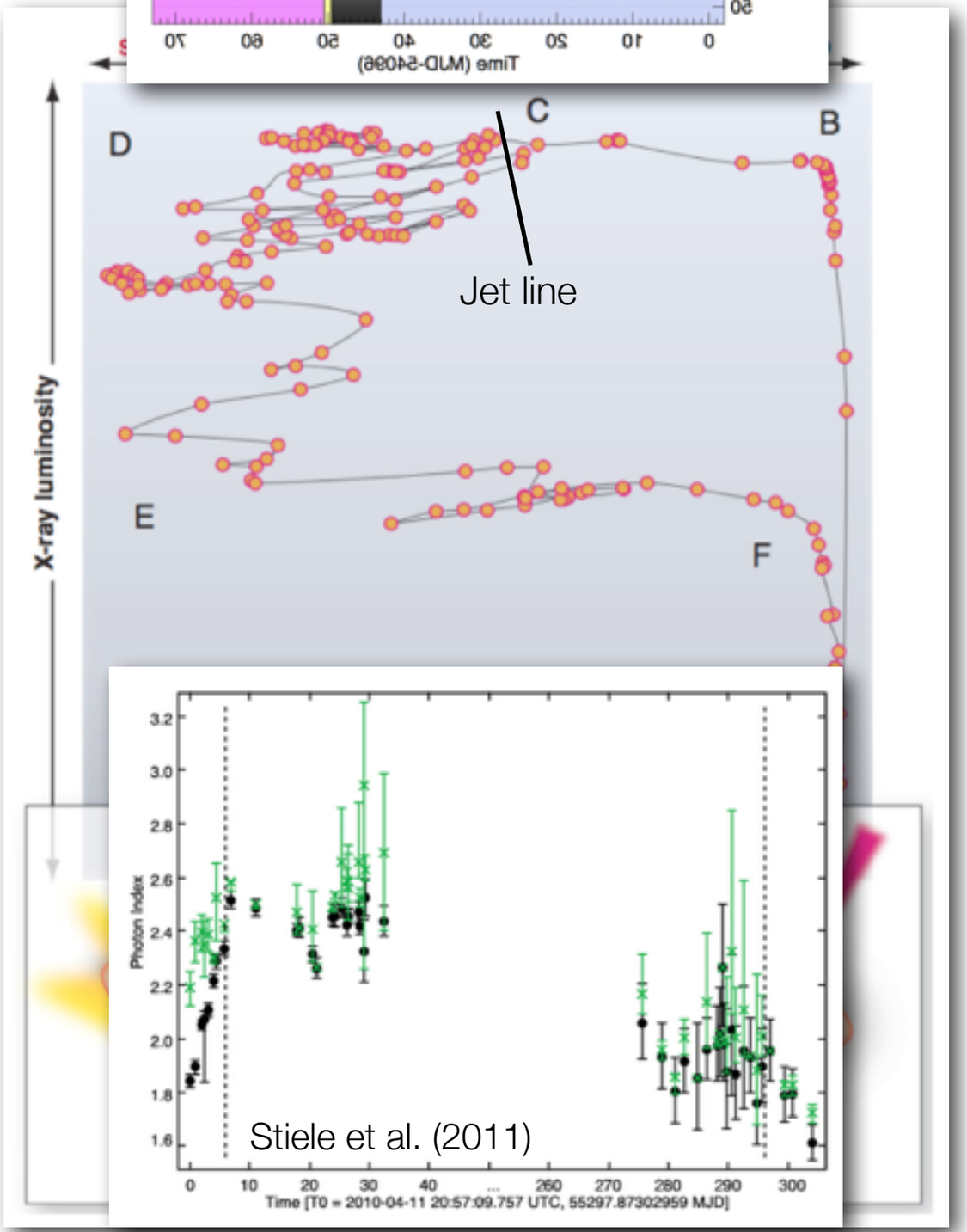
SPECTRA

Motta, TMB, Homan (2009)

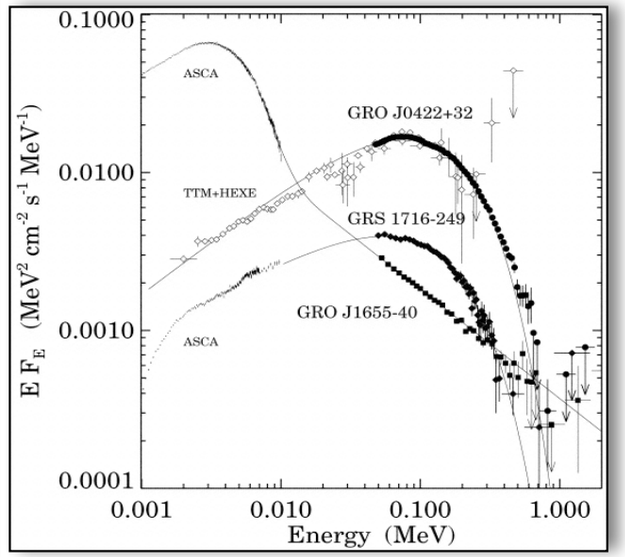




Middleton et al. (2006)

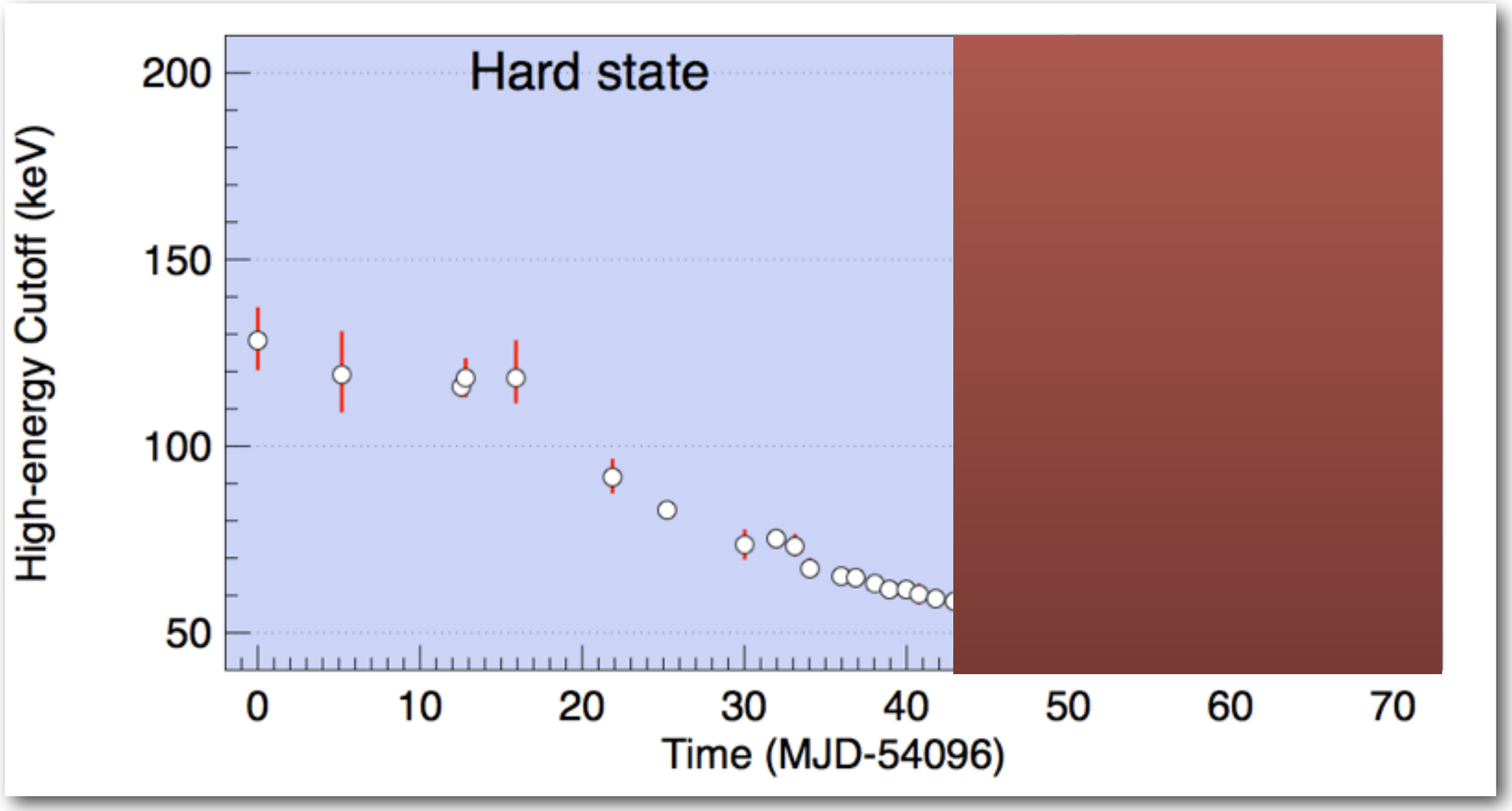


Stiele et al. (2011)



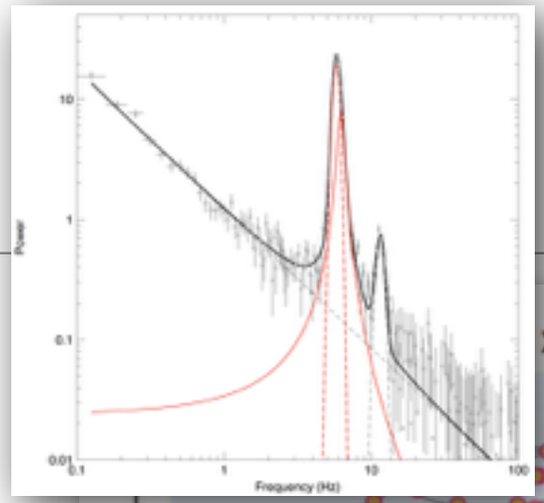
Grove et al. (1998)

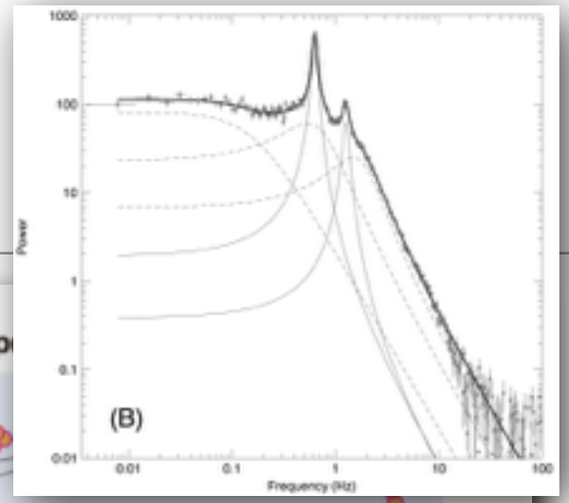
HIGH-ENERGY EVOLUTION

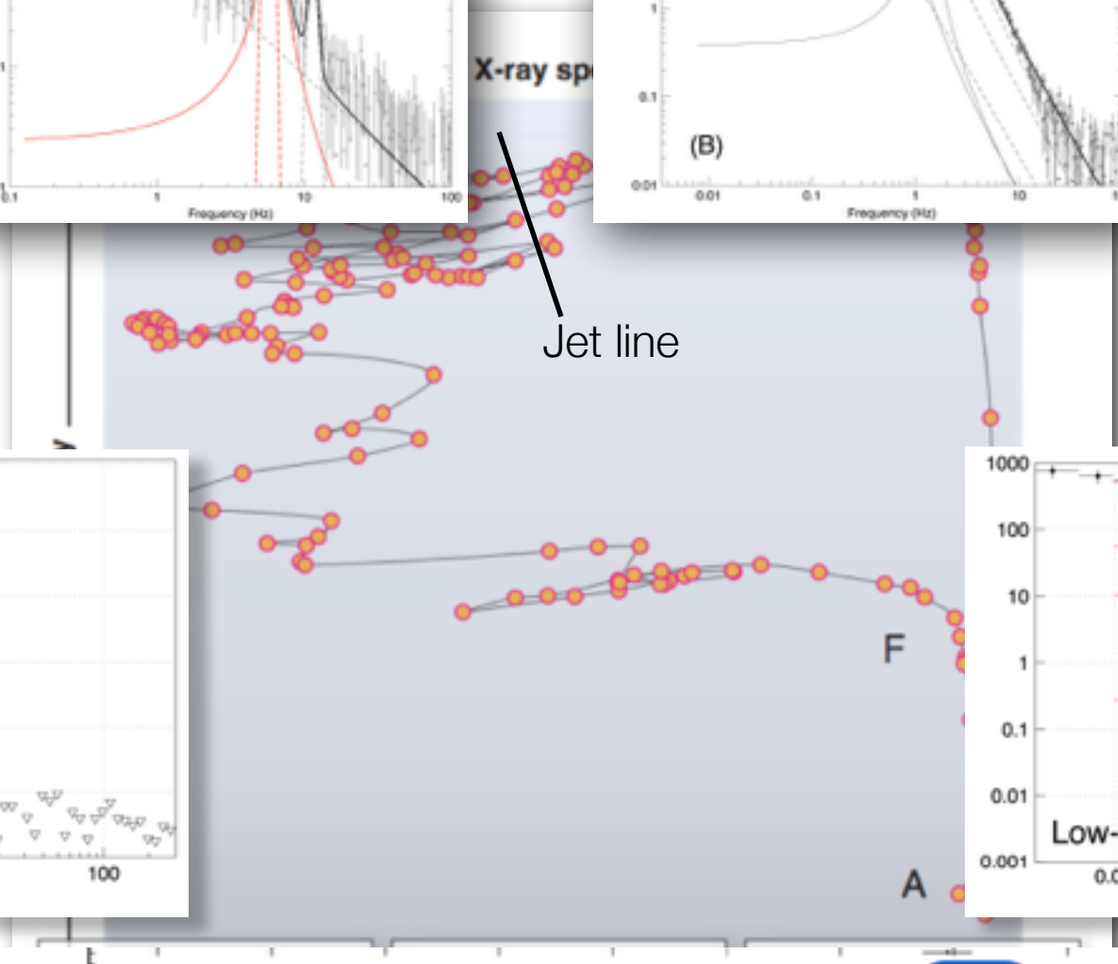


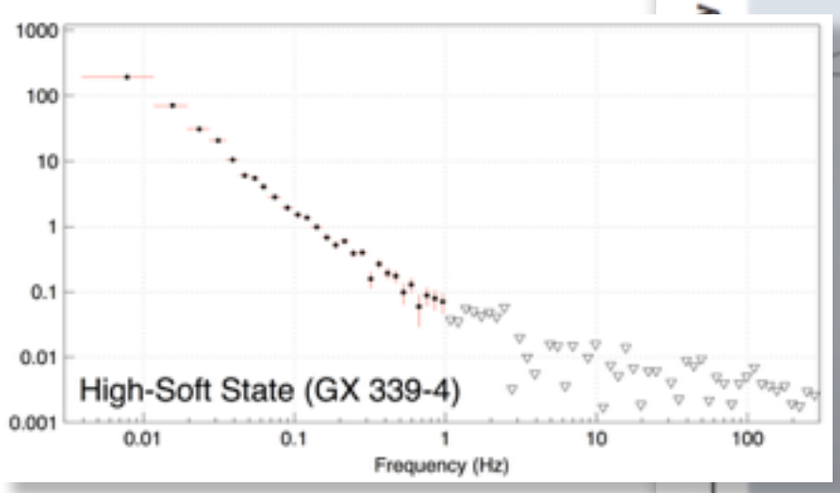
Motta et al. (2009)

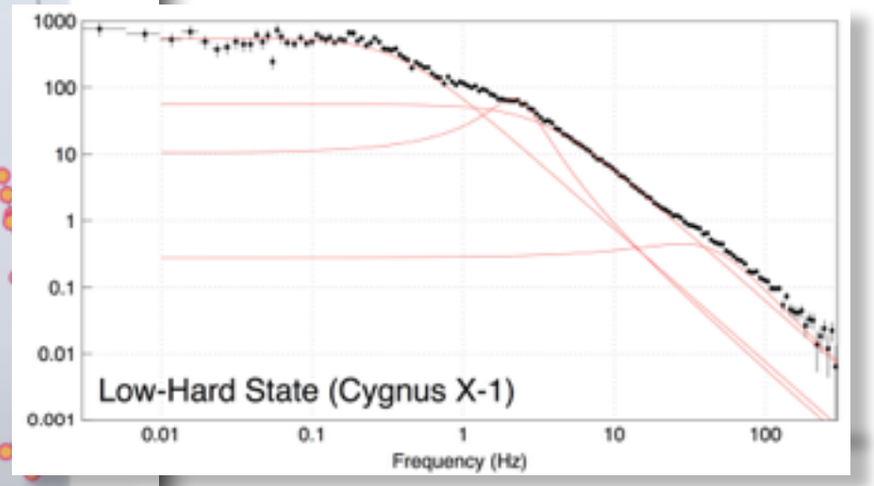
TIMING

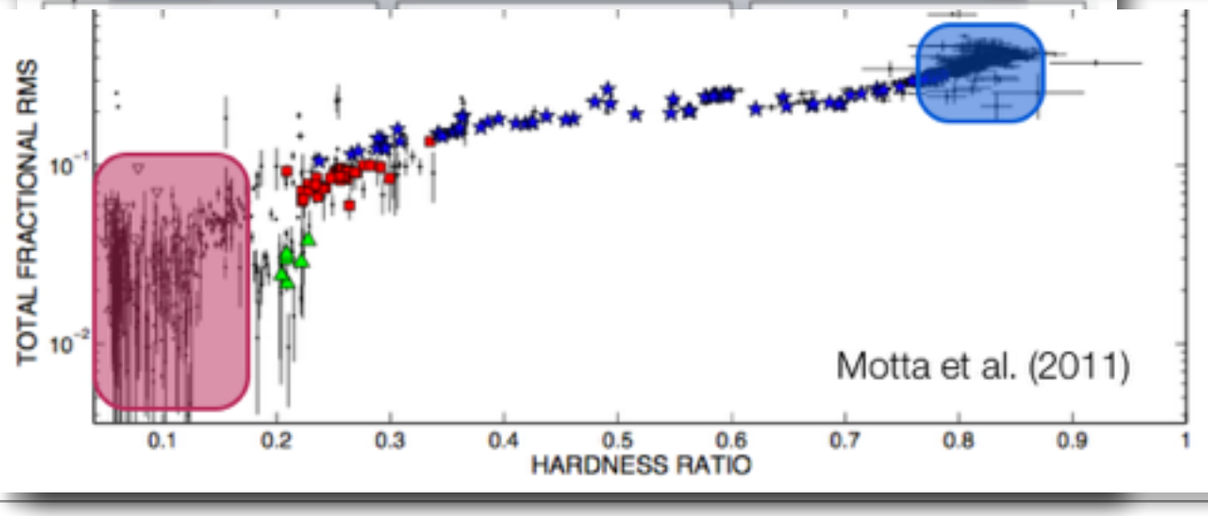

Power
Frequency (Hz)


(B)
Power
Frequency (Hz)


X-ray sp
Jet line
F
A

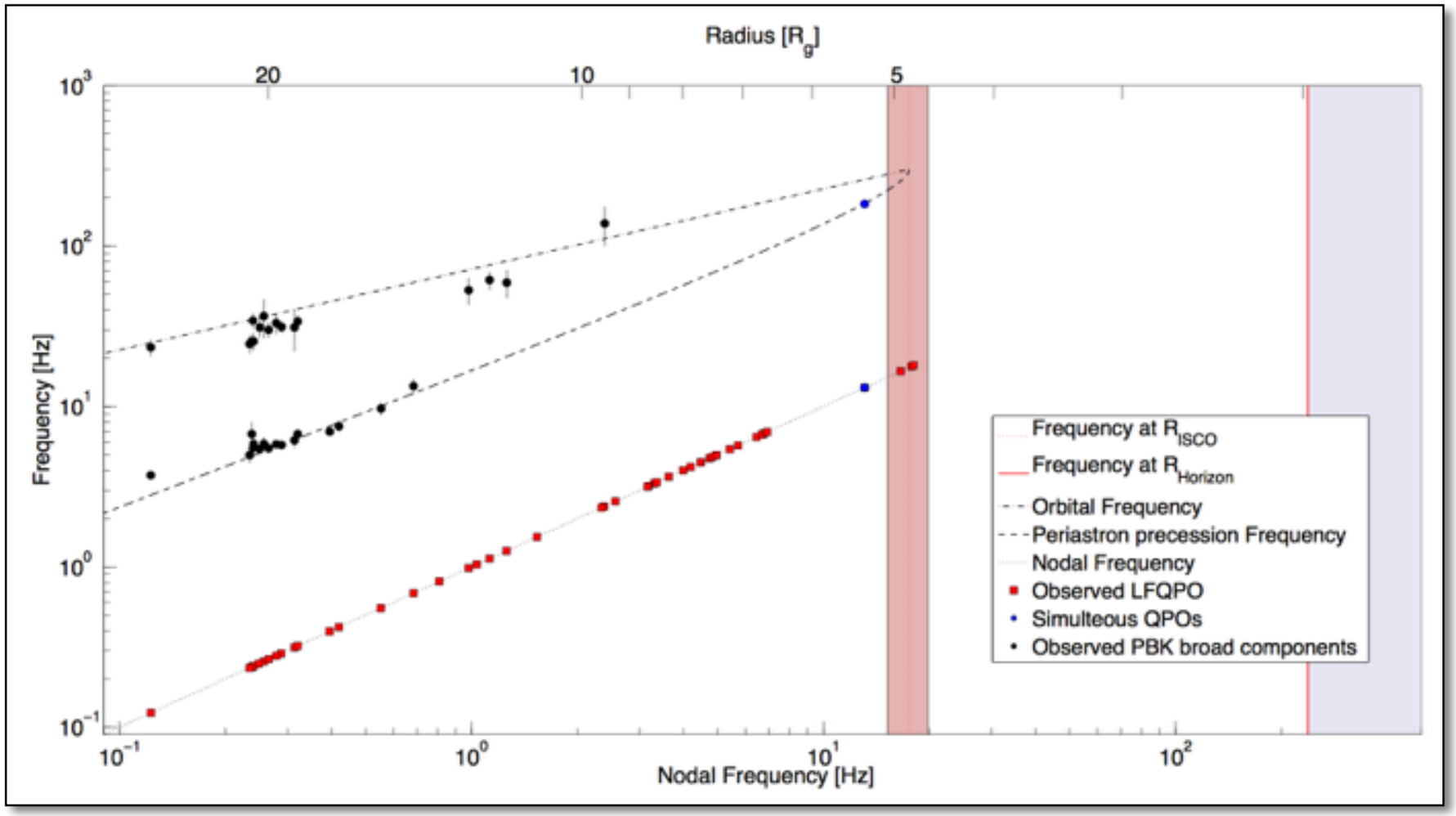

High-Soft State (GX 339-4)
Frequency (Hz)


Low-Hard State (Cygnus X-1)
Frequency (Hz)


TOTAL FRACTIONAL RMS
HARDNESS RATIO
Motta et al. (2011)

QPOs

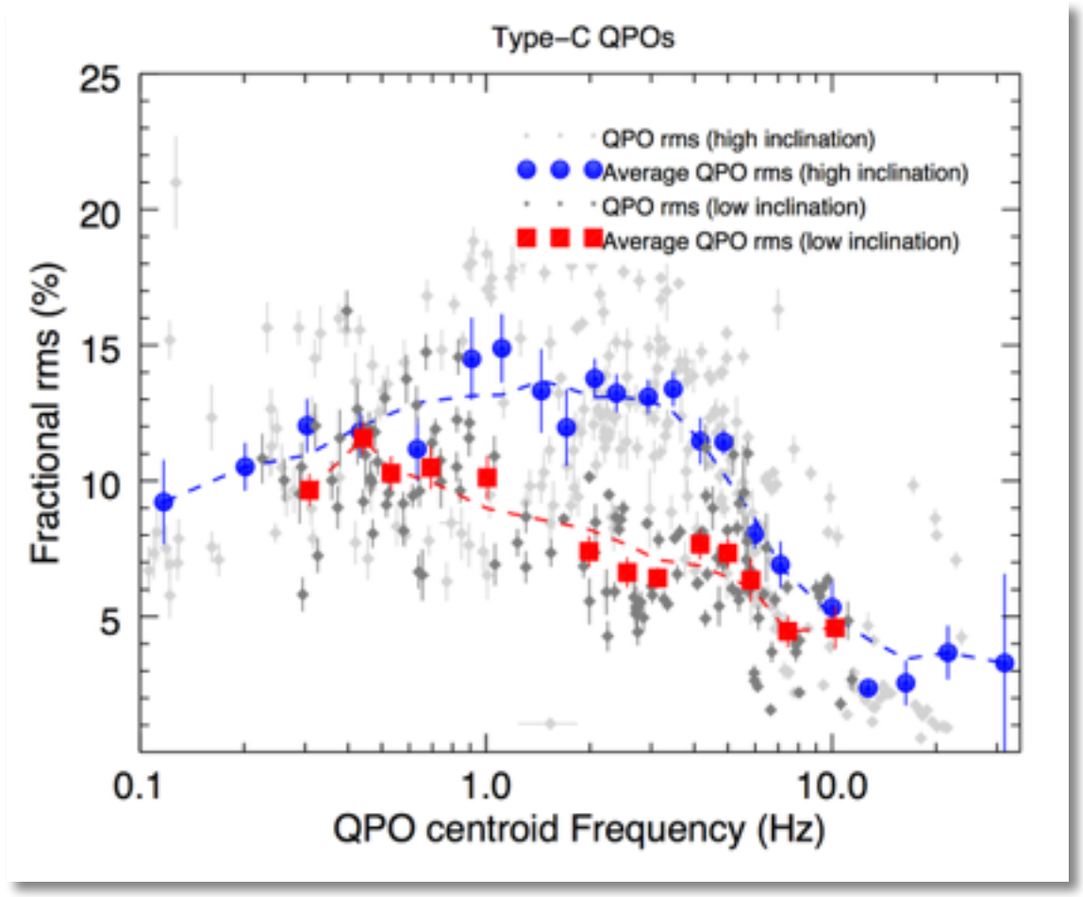
- Type-C: relativistic precessions
- Type-A: type-C

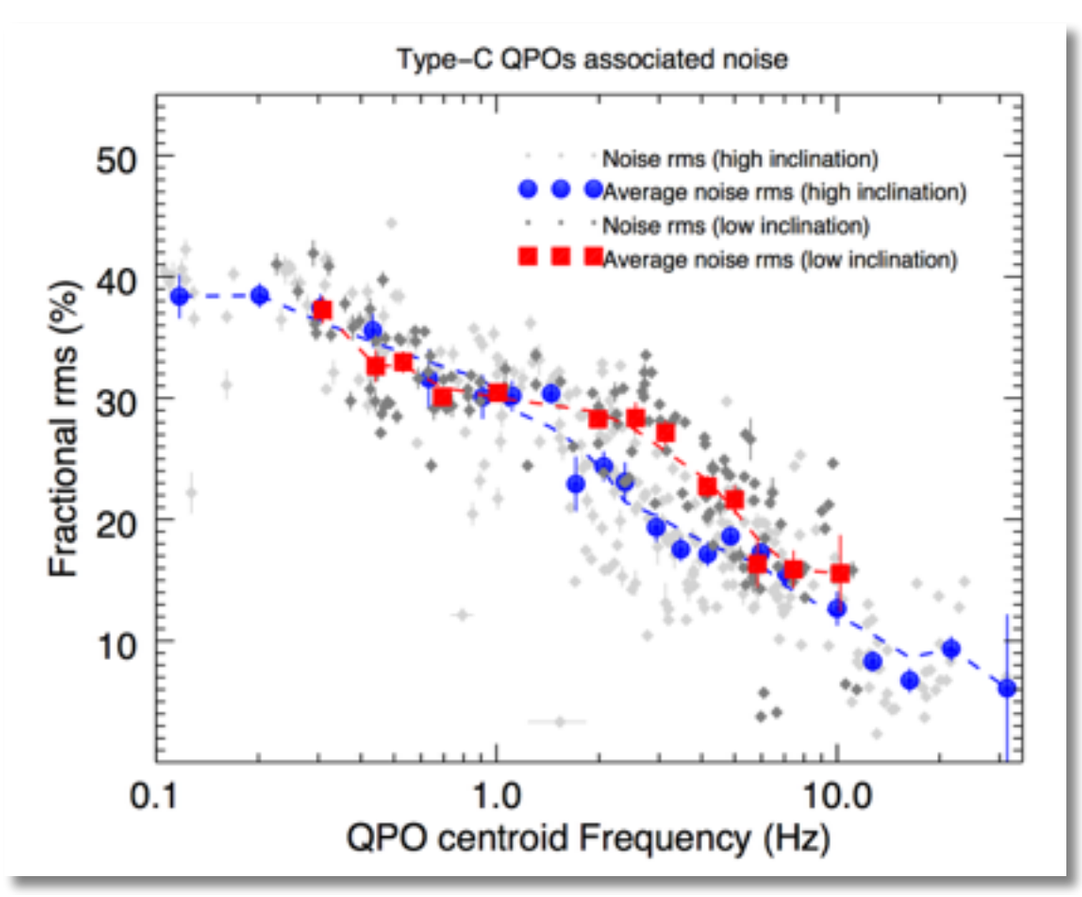


Motta et al. (2014)

QPOs

- Type-B: jets

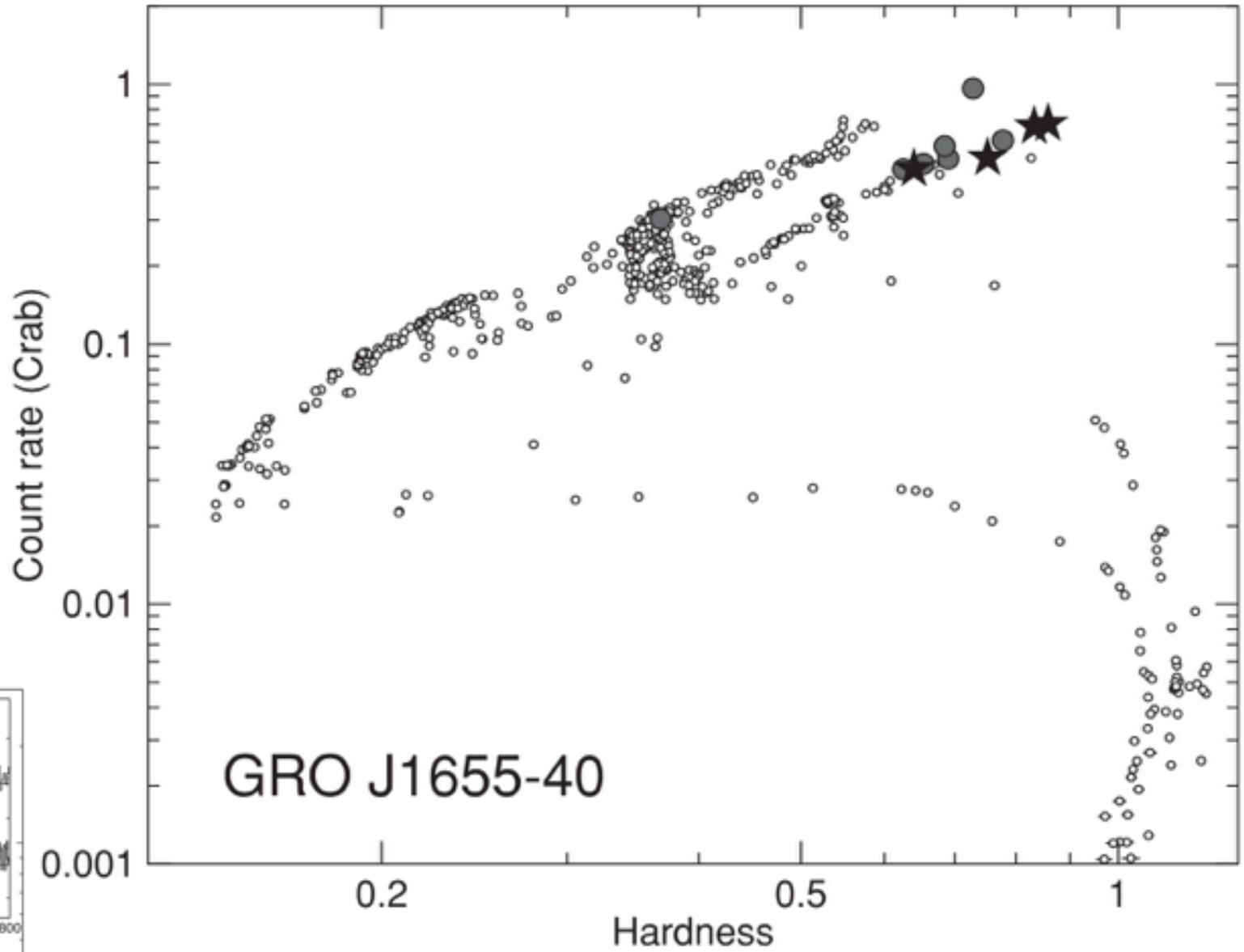


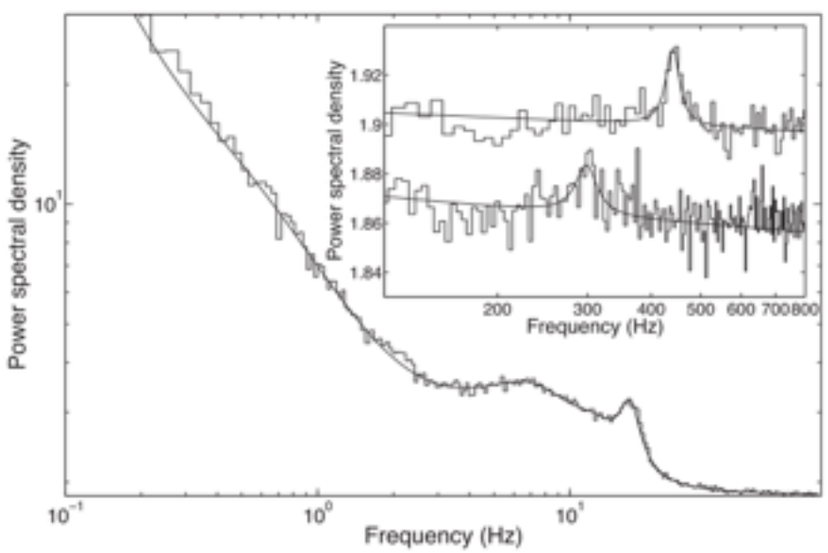


MOTTA ET AL. (2015)

ANOMALOUS STATE

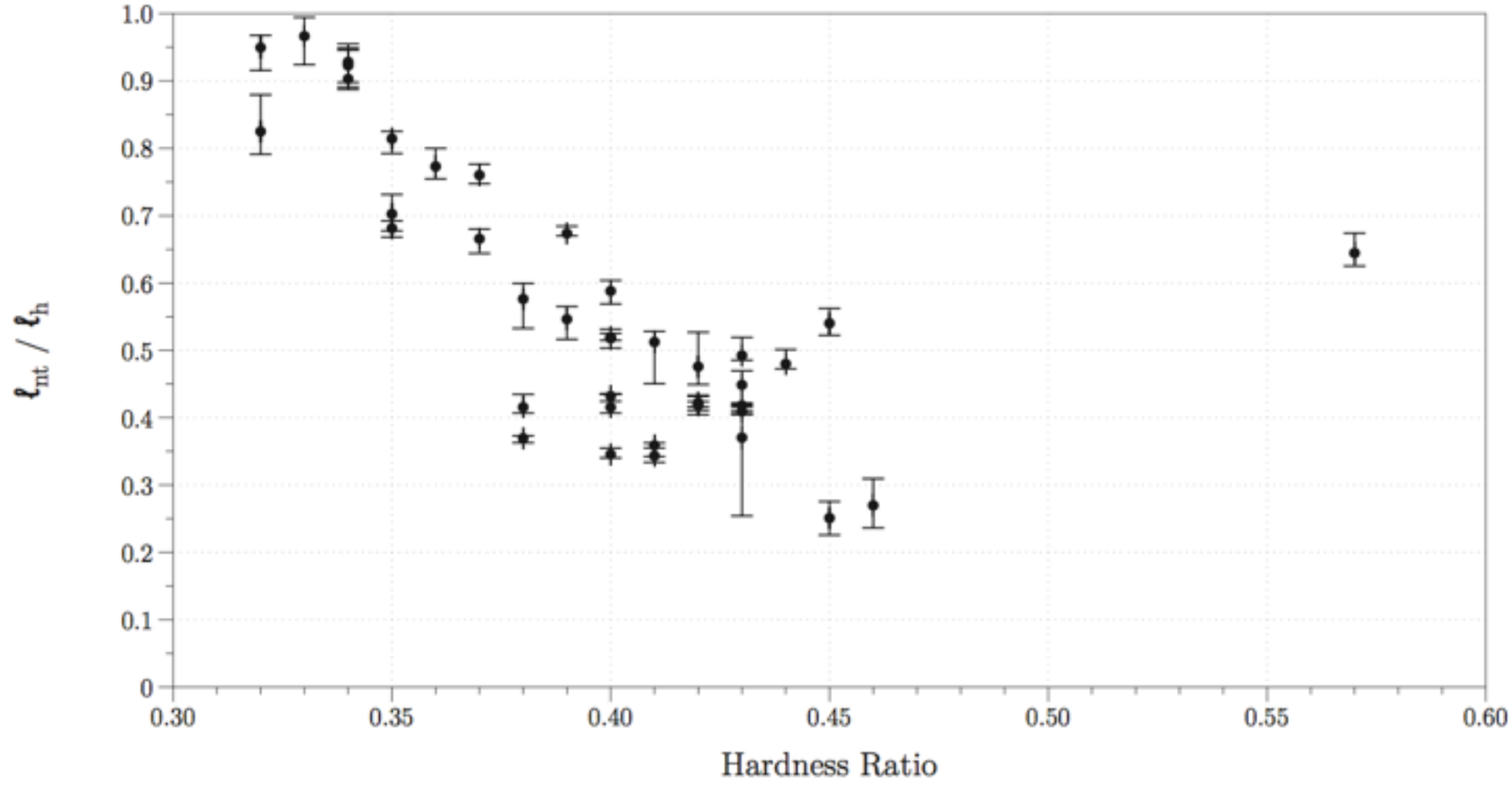
- If $\dot{M}$ does not stop
- Here HFQPO: no disk
- Energy spectrum is different
- Timing is different



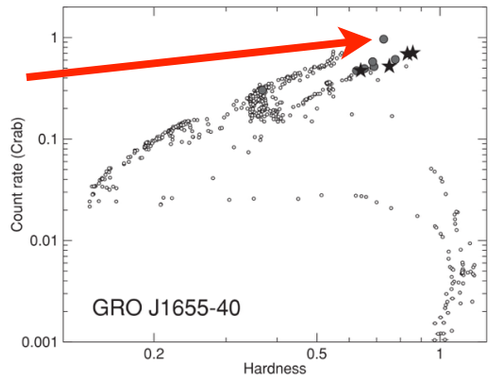


ANOMALOUS STATE: SPECTRUM

- Hybrid plasma



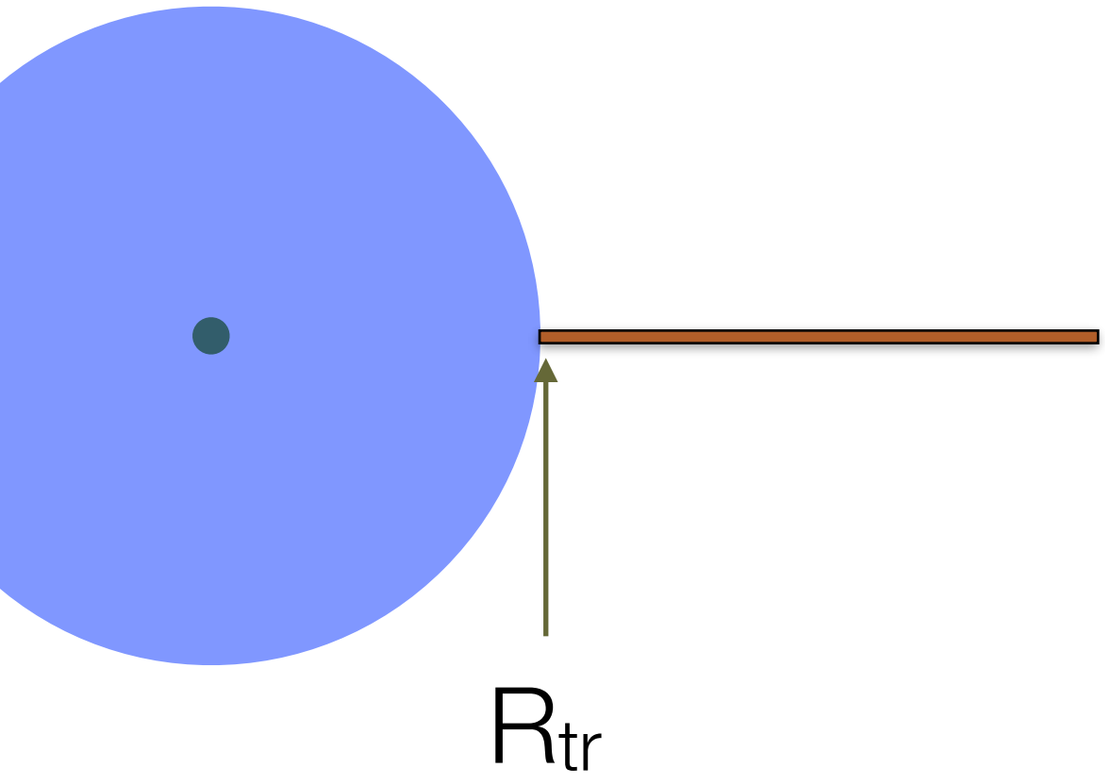
- At peak, slim disk model

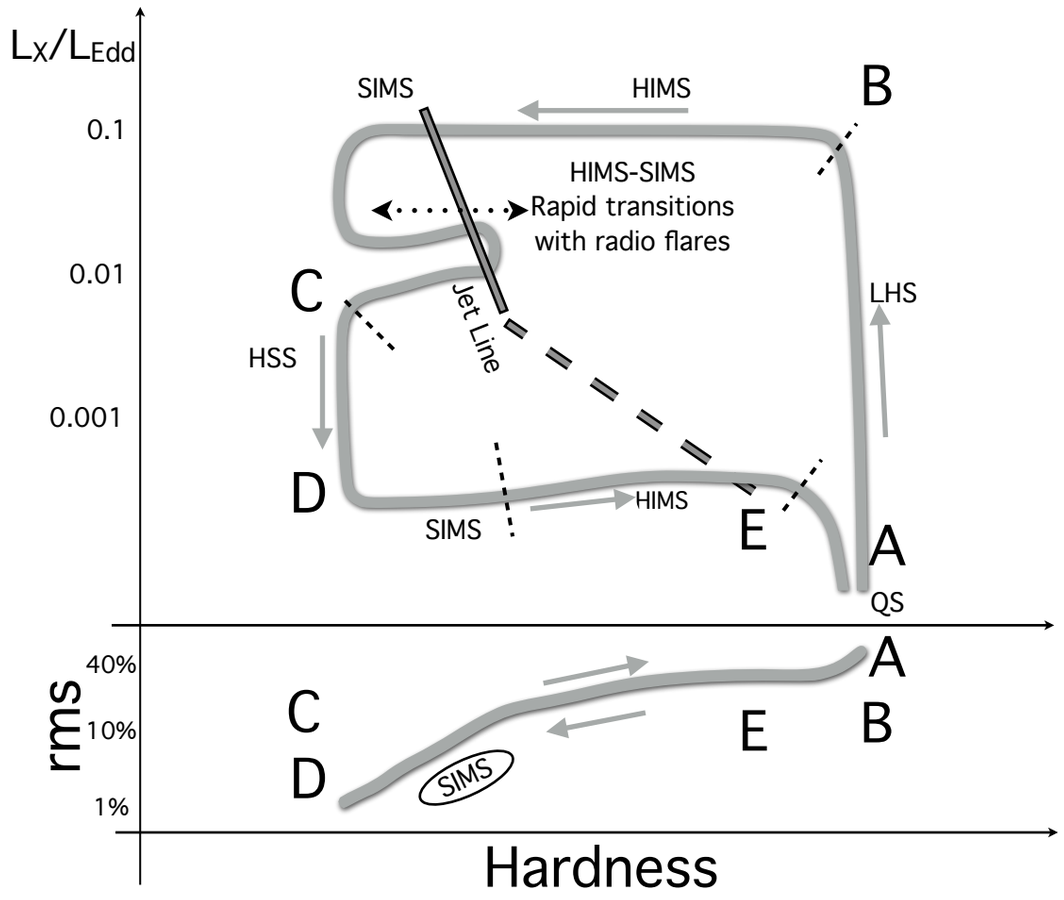


BELLODI ET AL. (2015)

A ZEROTH-LEVEL MODEL

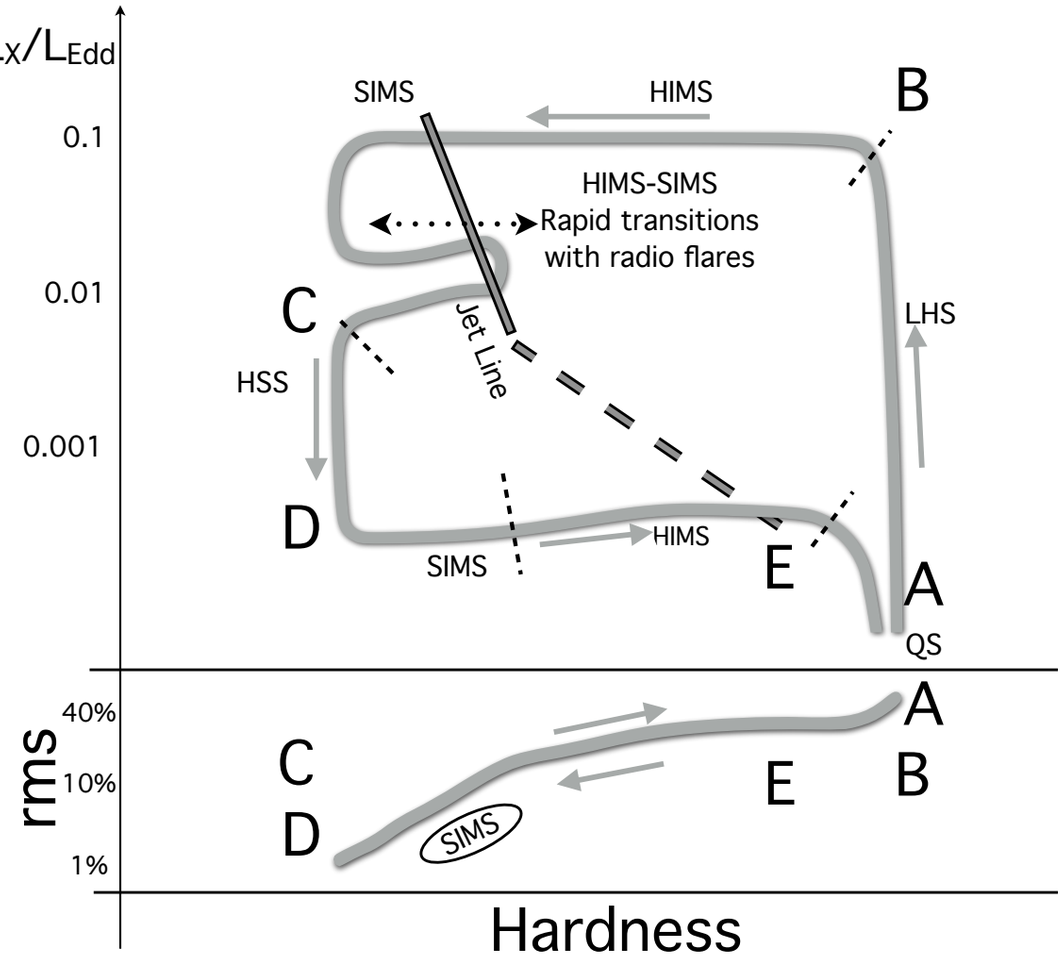
- Accretion rate vs. time: bell-shaped (up then down)
- High accretion rate: S&S disk
- Low-accretion rate: ADAF

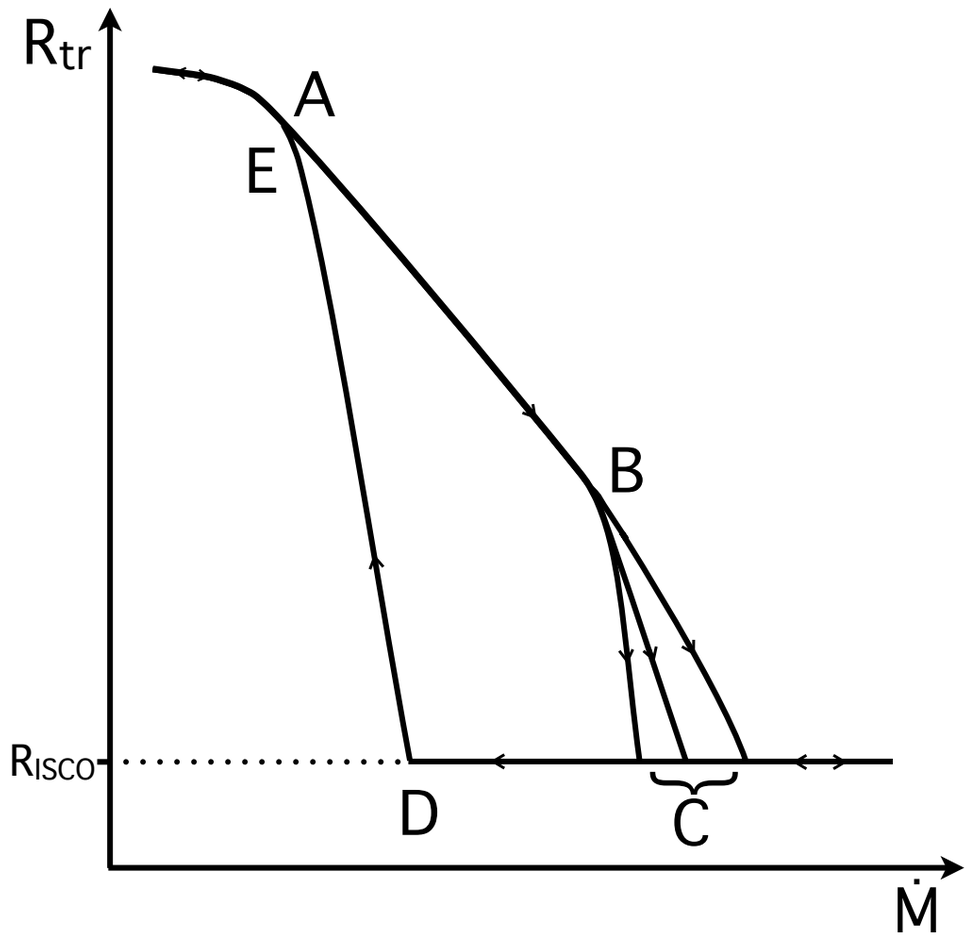




KYLAFIS & BELLONI (2015)

A ZEROTH-LEVEL MODEL

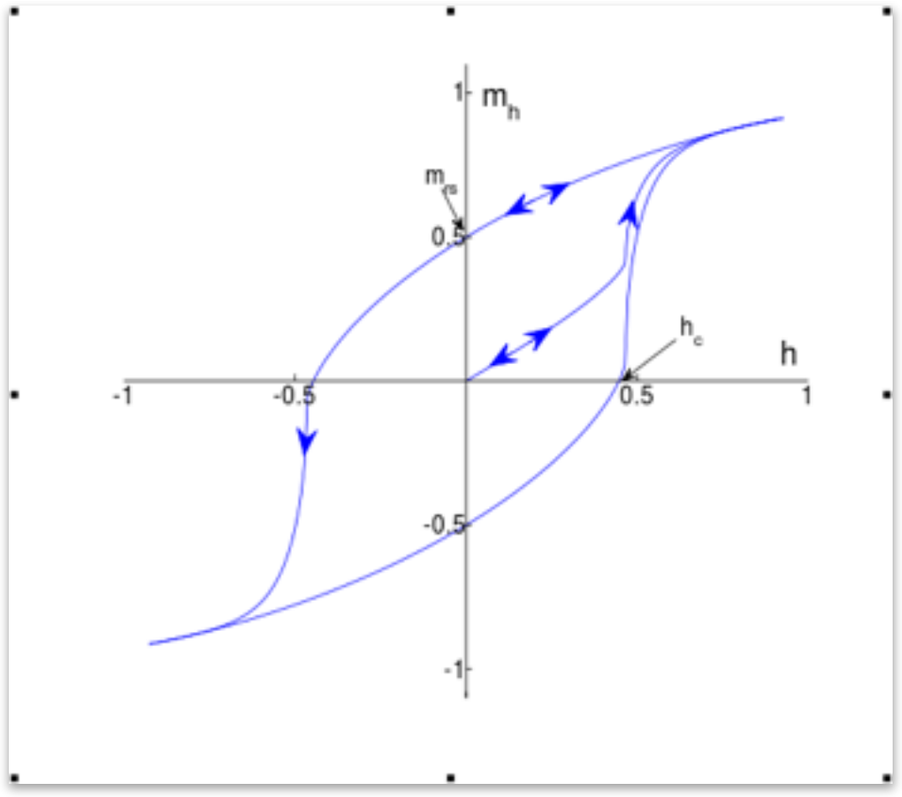


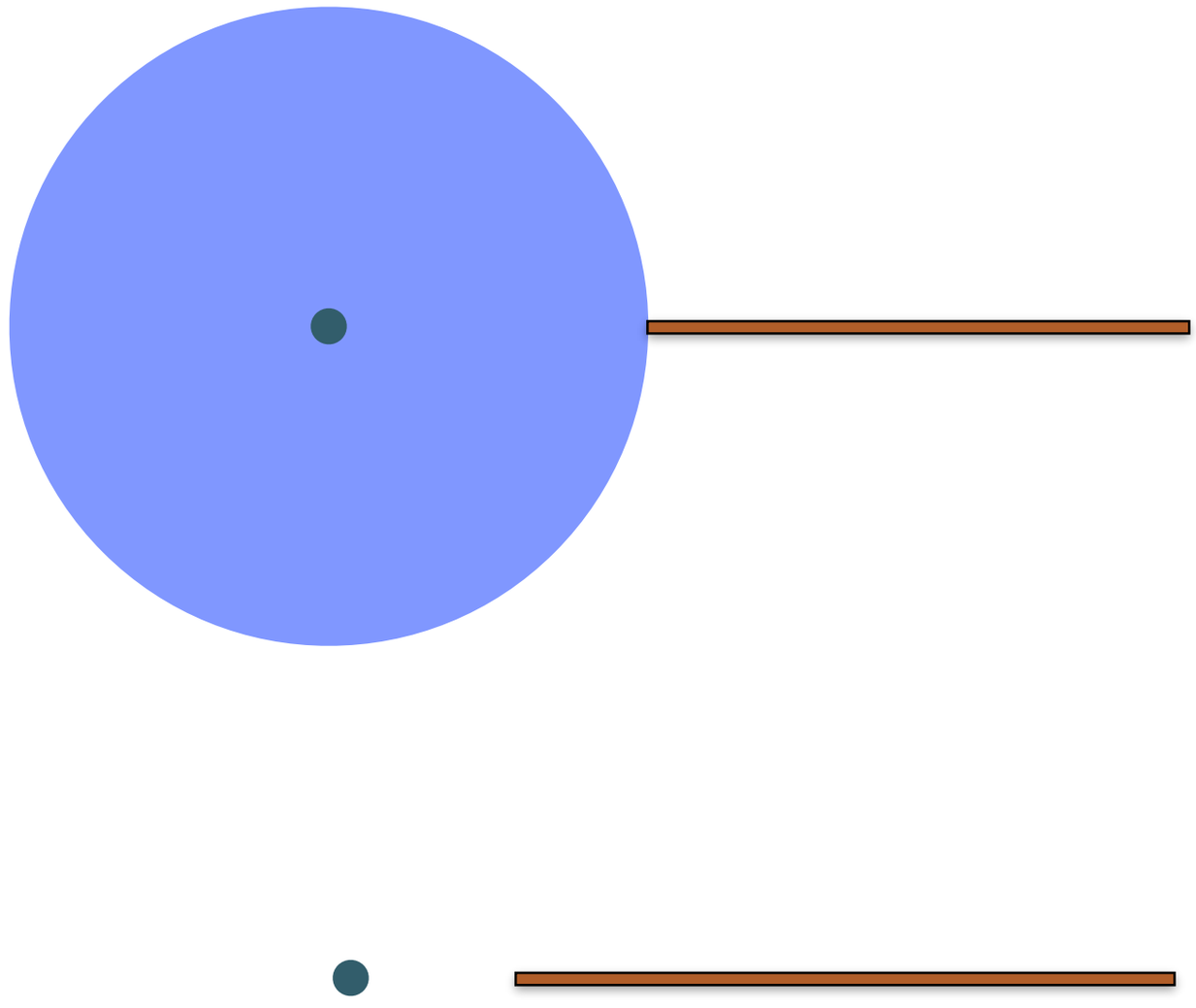


KYLAFIS & BELLONI (2015)

JETS AND HYSTERESIS

- Cosmic Battery mechanism
- System memory





KYLAFIS & BELLONI (2015)

SOME QUESTIONS

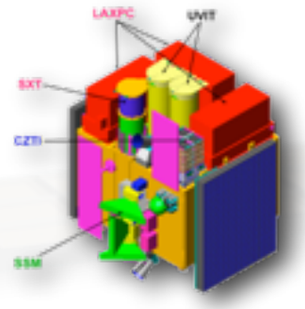
- How is the transition between thermal and non-thermal?
- What is the geometry?
- What is the jet contribution?
- Where does the variability come from and who makes it?
- What is the soft-state variability?

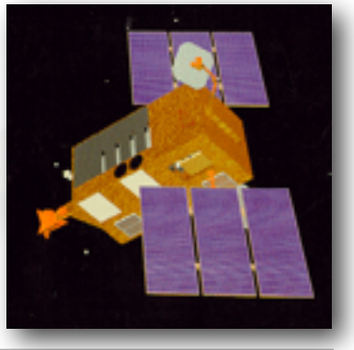
- How can we answer these questions?

CORONAE AND ACCRETION STRUCTURE

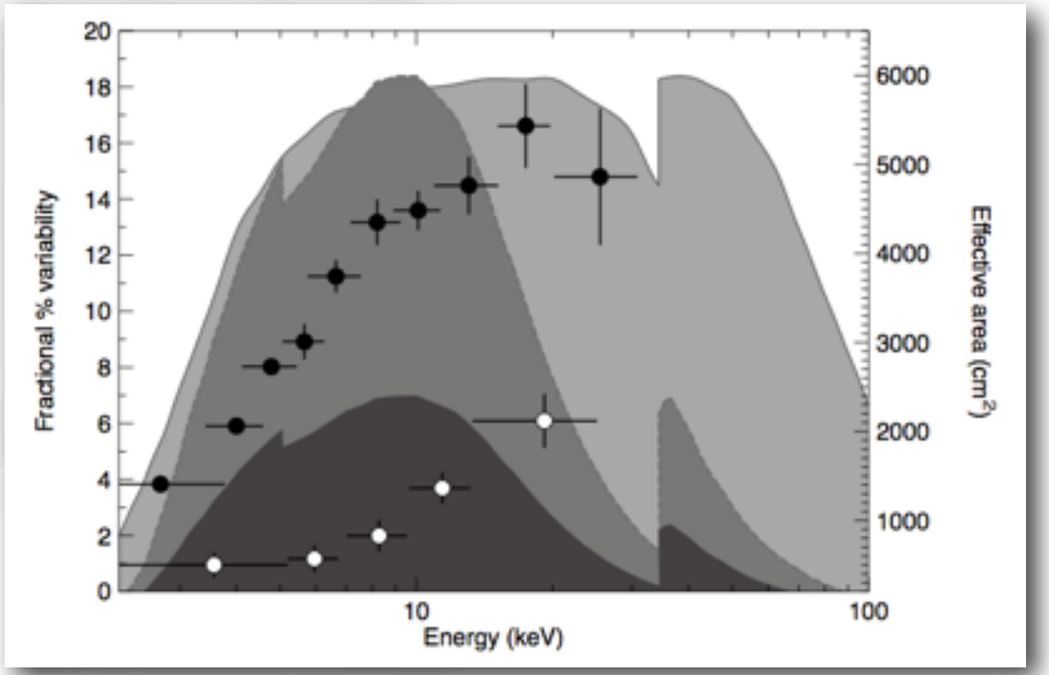
- Disk
- Wobbling & precessing disk
- Where is the corona? Dynamics?
- What is the interaction between disk and corona?
- Accretion structure as a whole

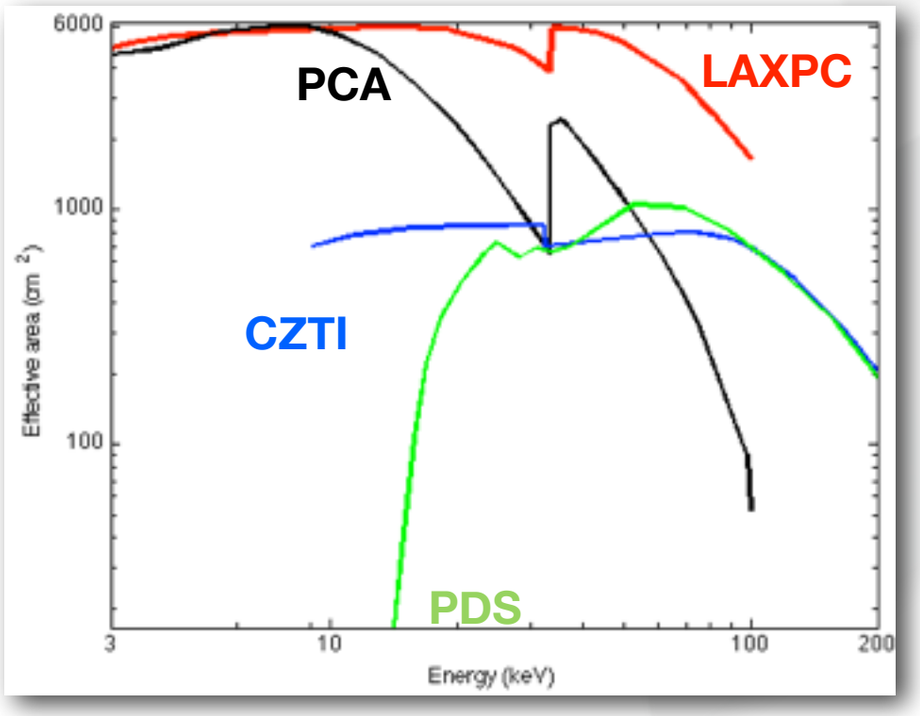
RXTE and THE FUTURE



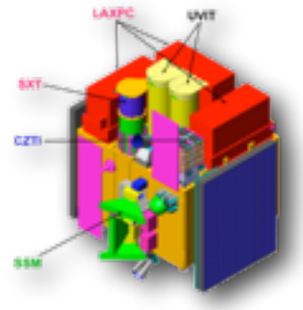


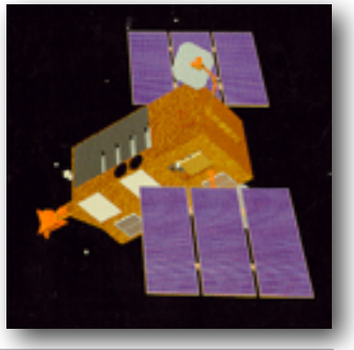
- The near future: **ASTROSAT**
- Better than RXTE above > 20 keV
- Coverage?

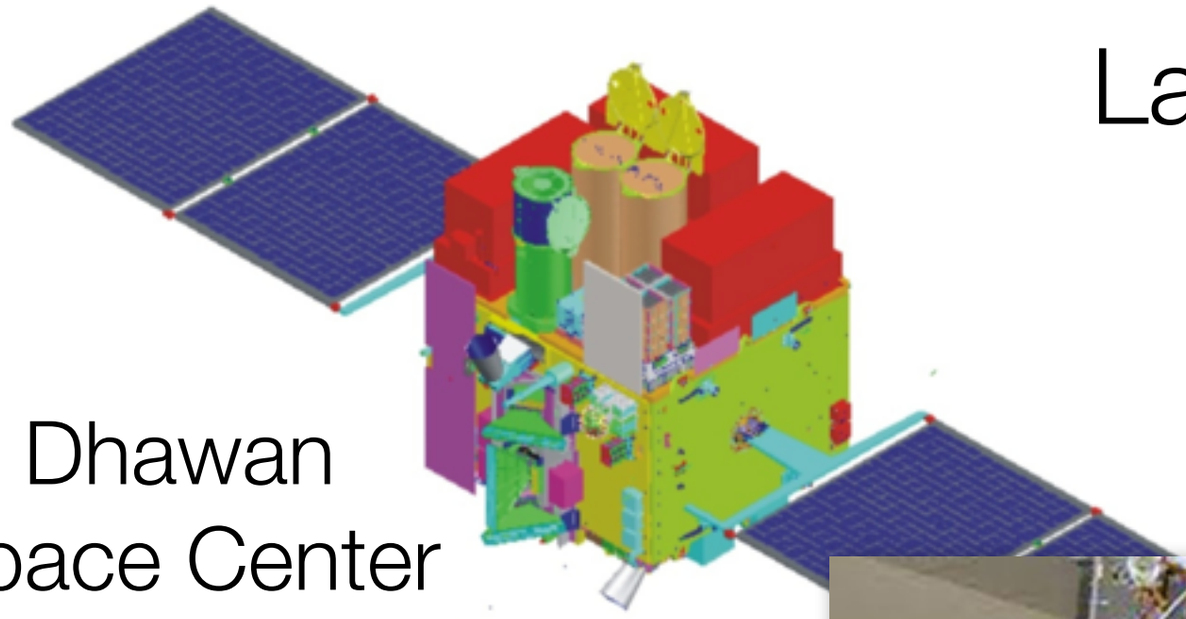




ASTROSAT







Launch will be next….

MONDAY!

Dhawan
Space Center
Sriharikota