

How to study/understand neutron stars in LMXBs... with mHz QPOs

(prediction of X-ray bursts, EoS and others)

Diego Altamirano
Universiteit van Amsterdam



November 5th, 2009

General message:

RXTE has discovered several phenomena which
are intimately related with the physics behind compact objects like
Black holes and Neutron stars

RXTE data allow us to study these phenomena individually
but also as a whole!

This is one of the RXTE strengths that we should not overlook!



How to study/understand neutron stars in LMXBs... with mHz QPOs

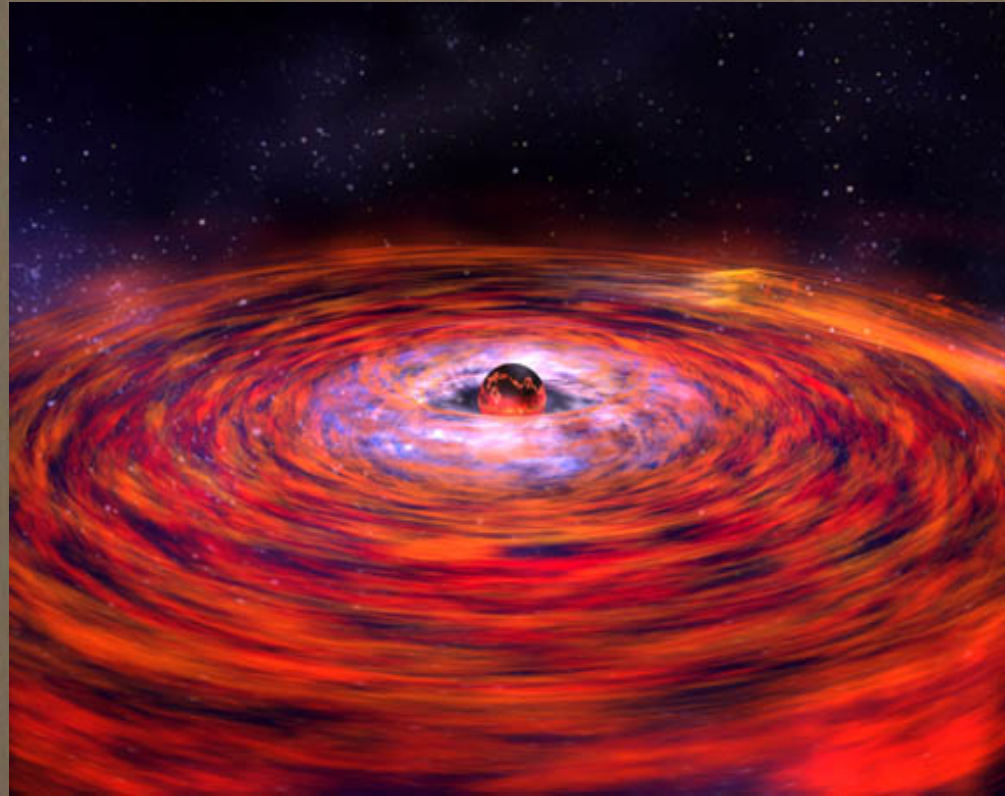
(prediction of X-ray bursts, EoS and others)

Diego Altamirano
Universiteit van Amsterdam

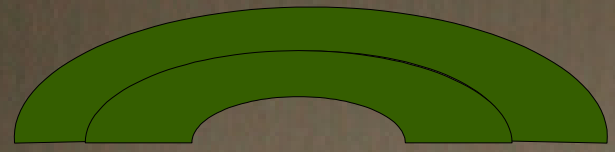


November 5th, 2009

I will concentrate in NS...



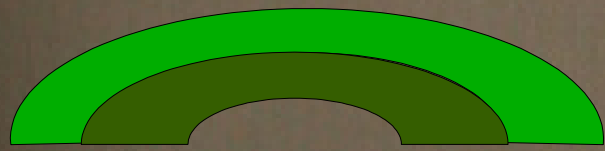
High Accretion rate



Stable Burning

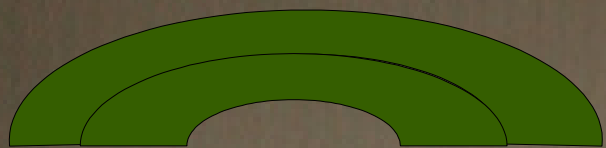


LOW Accretion rate



Unstable Burning





Stable Burning

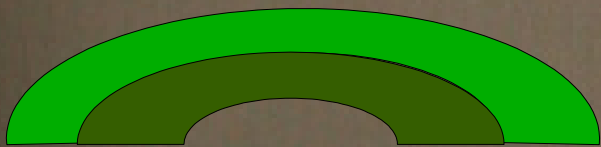


*Theory predicts
a transition
around here*



*Marginally
stable
burning*

Unstable Burning

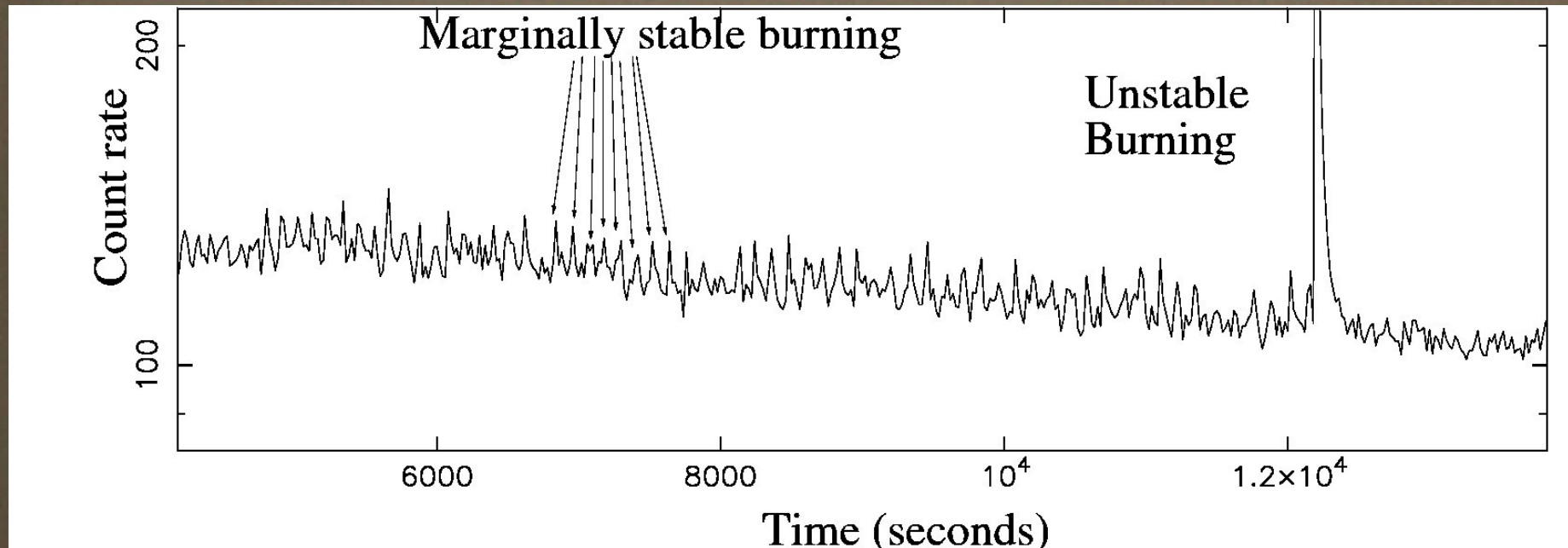


*But how do we see marginally
stable burning?*

→ *Time* →



A clear example....



Time



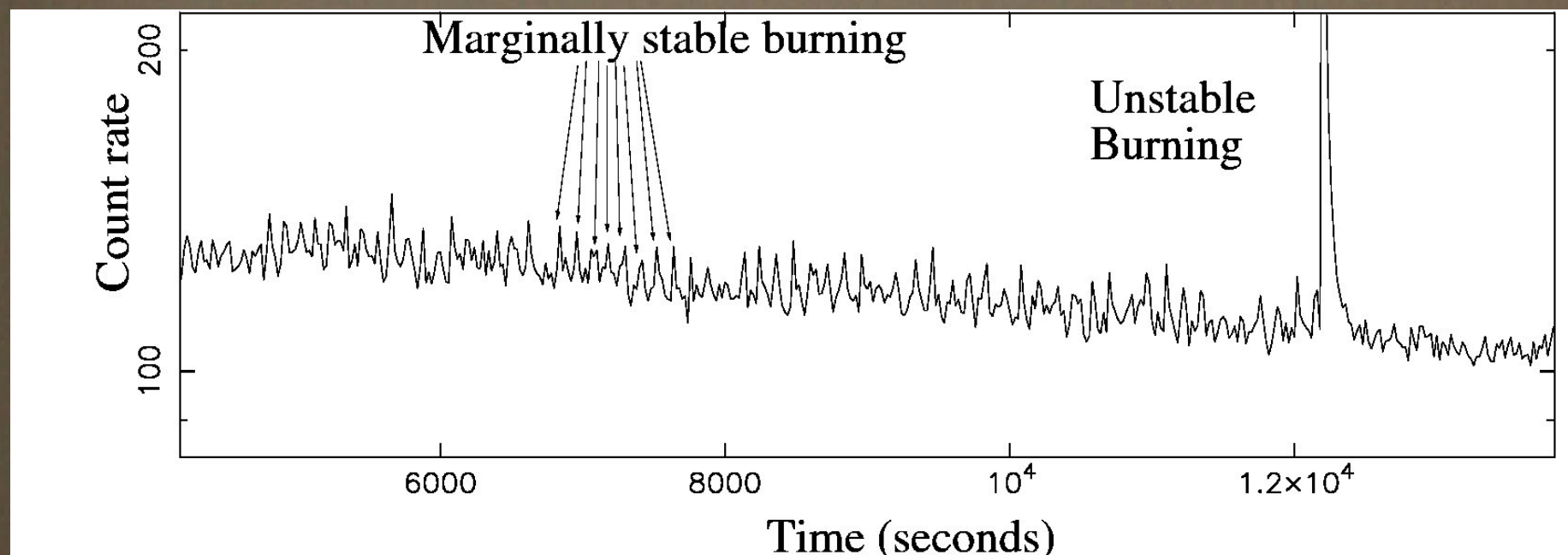
Unstable burning (X-ray burst)

Marginally stable burning

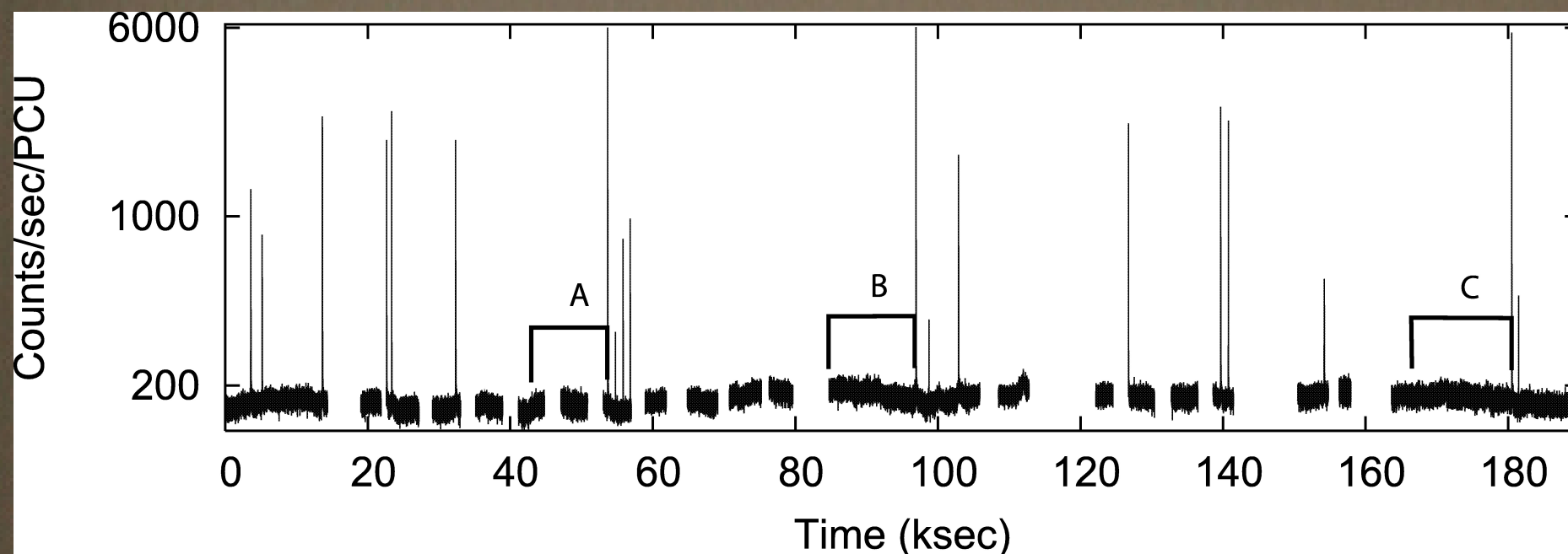


The mHz QPOs disappear just before an X-ray burst...

(of course... we lost all fuel!)



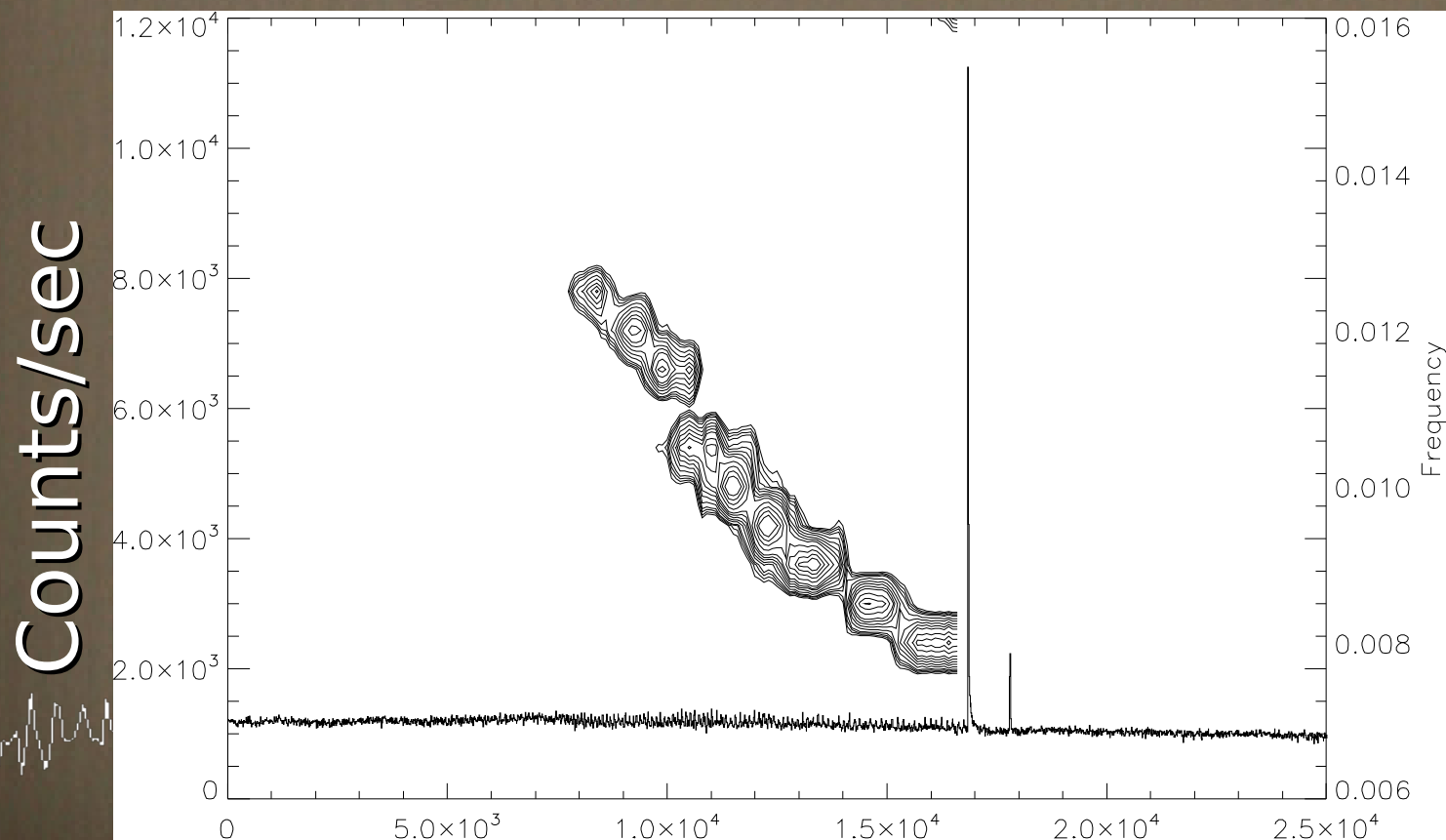
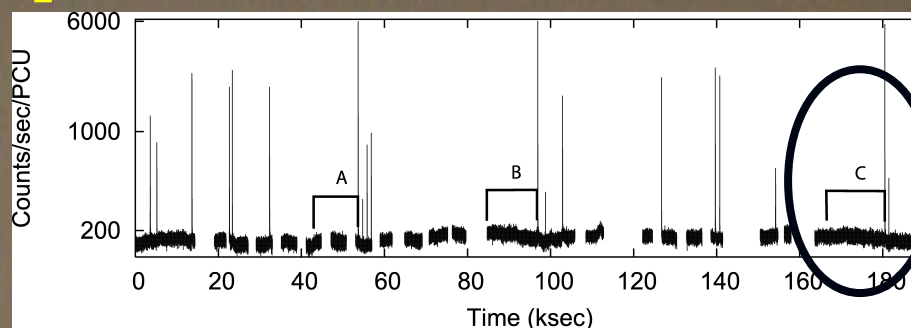
In the correct spectral state, the mHz QPOs appear systematically.. again and again...



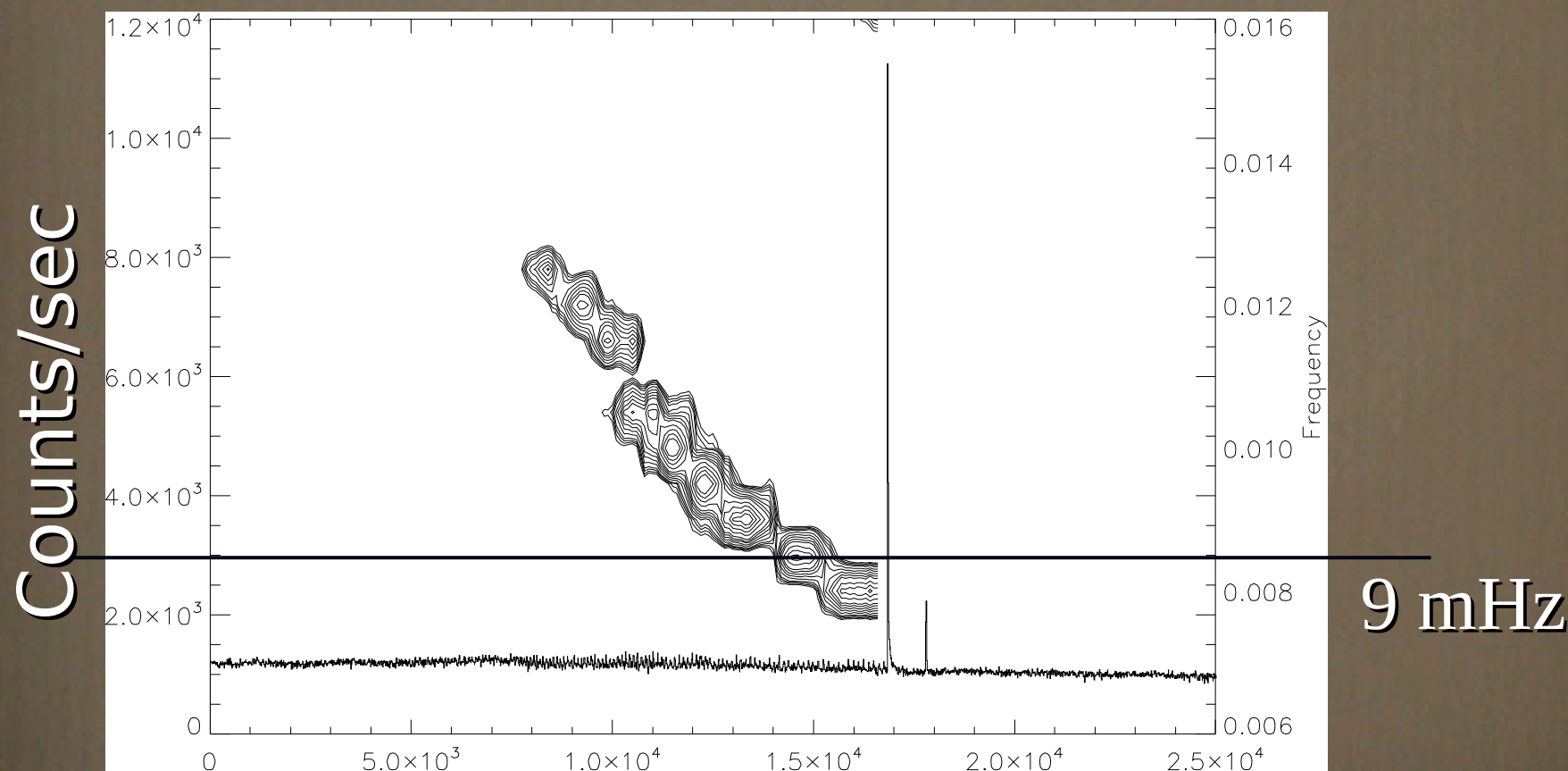
Altamirano et al. 2008a



The mHz QPO frequency can predict the occurrence of an X-ray burst:



The mHz QPO frequency can predict the occurrence of an X-ray burst:



Occurrence of mHz QPOs

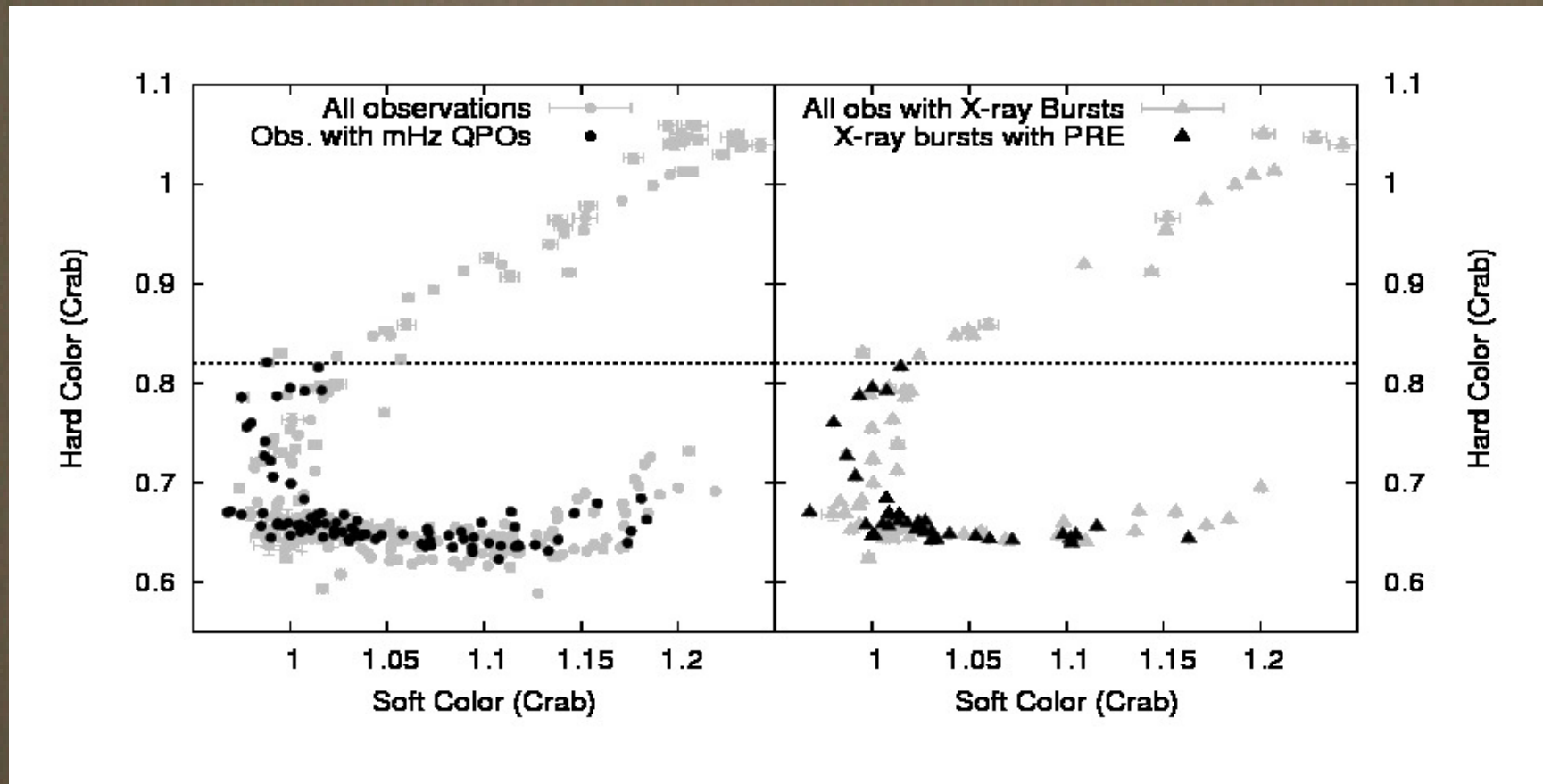
“the change” in burning behavior

“the change of spectra state”

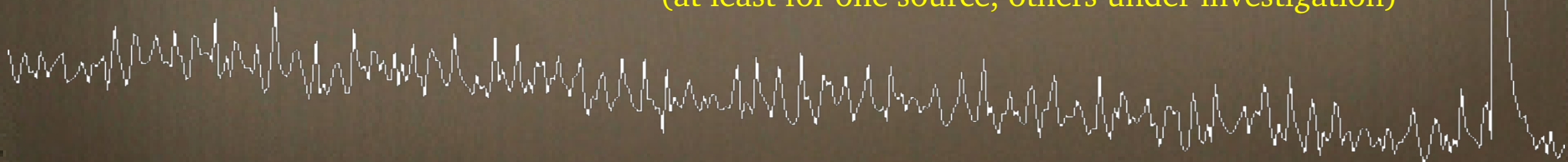
Change in disk geometry?



Very nice example: the atoll source 4U 1636-53

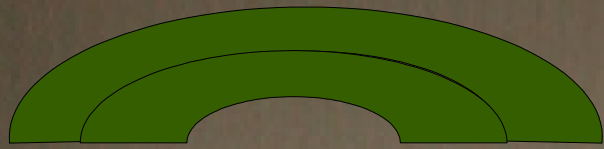


(at least for one source, others under investigation)



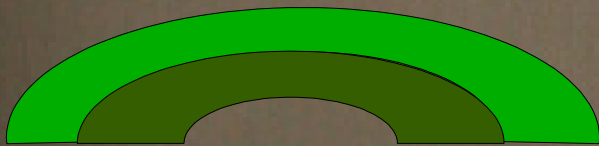
But is marginally stable burning...
interesting by itself?





Stable Burning

Unstable Burning



*Marginally
stable
burning*



*The frequency depends on the
surface gravity... i.e. on the
internal properties
of the Neutron Star (EoS)*

Heger et al. 2007

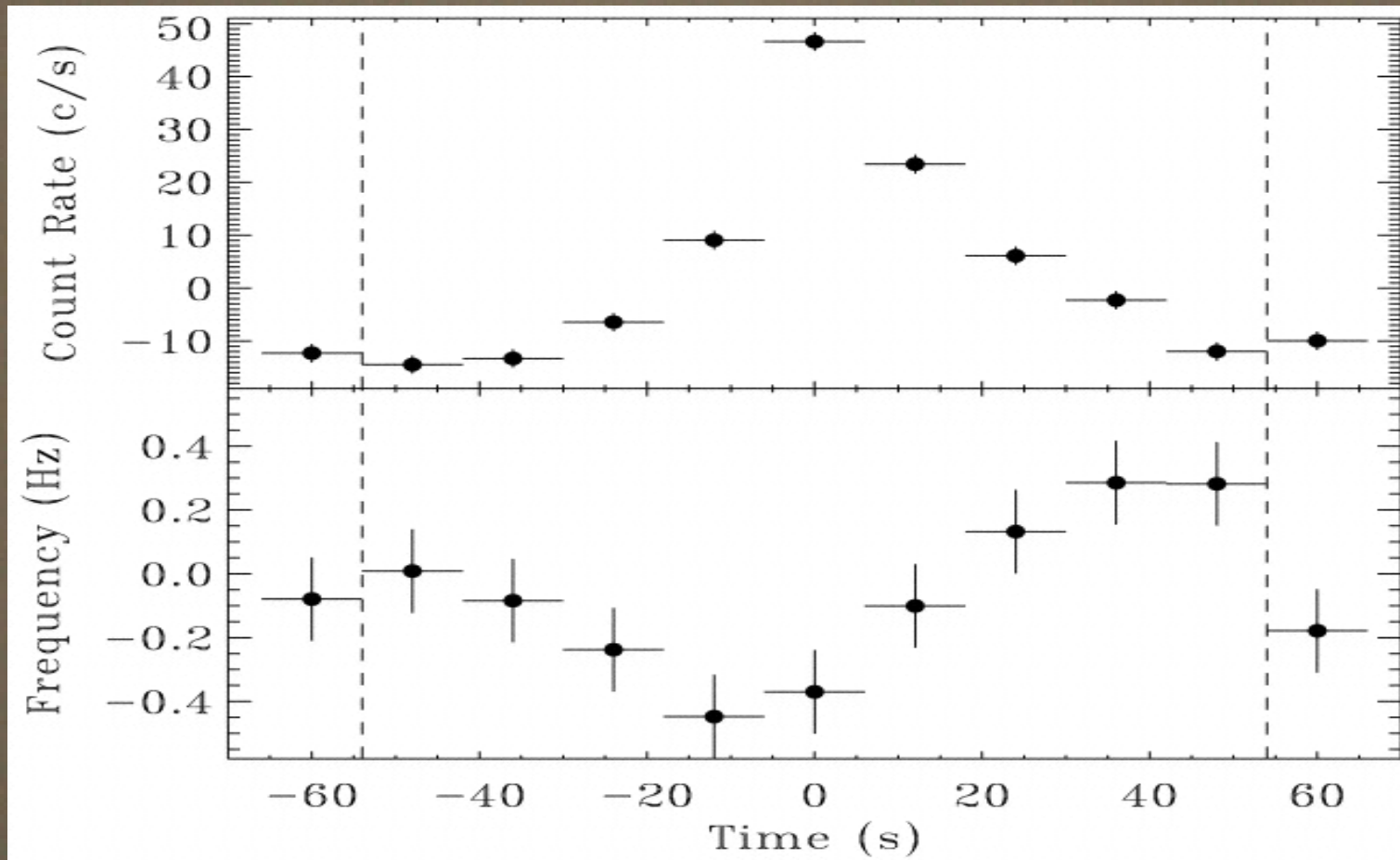




Is there any direct interaction between the marginally stable burning and the accretion disk?



MHz QPOs interact with accretion disk:



Yu & van der Klis (2002)



Conclusion:

Millihertz QPOs can help us understand more about accretion disk physics, high frequency QPOs, nuclear burning on the neutron star surface... and even help us constrain the neutron star EoS!



General message:

RXTE has discovered several phenomena which are intimately related with the physics behind compact objects like Black holes and Neutron stars

RXTE data allow us to study these phenomena individually but also as a whole!

This is one of the RXTE strengths that we should not forget!

