Fast variability in the black-hole candidate Swift J1753.5-0127: the tracer of different accretion regimes

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Outburst evolution of black holes: the spectral states

Spectral states are probably associated with different accretion regimes and jet properties

- Hard state: power-law shaped energy spectrum and high level of aperiodic variability (rms ≥30%). Compact jet on.
- Soft state: energy spectrum dominated by a soft thermal component, almost no variability (rms<5%). Compact jet highly quenched.

In between (e.g. Homan & Belloni 2005):

- Hard-intermediate state (HIMS): Softer spectrum, lower level of variability. Different disc/jet coupling than in the hard state.
- Soft-intermediate state (SIMS): drop in variability, radically different timing properties. Possible relativistic ejections, followed by a quenching of the compact jet.

Outburst evolution of black holes

"Normal" outburst:

- q-shape pattern drawn anticlockwise in a X-ray hardness-intensity diagram (HID)
- the source is observed in all the 4 states during the outburst

However, several sources do not soften and spend the whole outburst in the hard states (e.g. XTE J1118+480, Brocksopp et al. 2004).

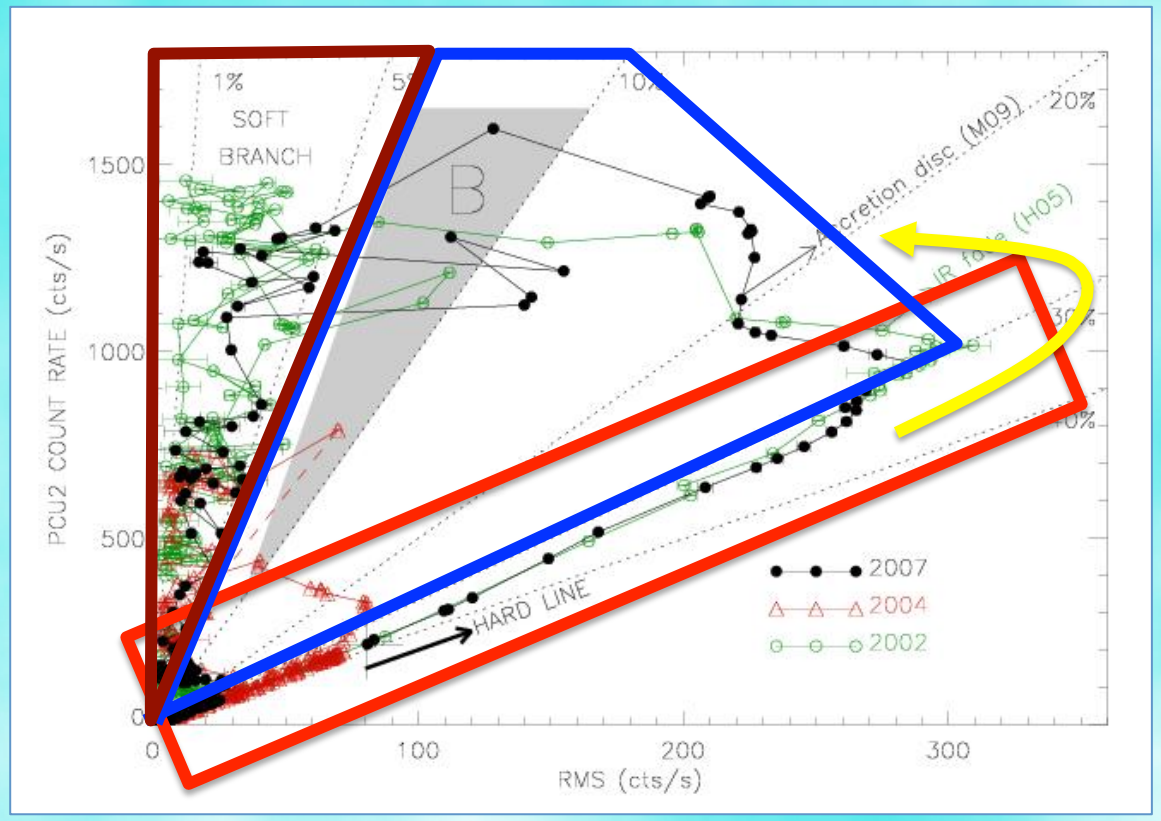
Some sources featured both "normal" and "hard" outbursts (e.g. H1743-322, Capitanio et al. 2009)

The HID is not enough for detailed studies, for example to establish when spectral transitions occur.

Complementary tools: e.g. multiwavelength observations, power spectra, rms-intensity diagram (RID)

Outburst evolution: the RID

3 outbursts of GX 339-4



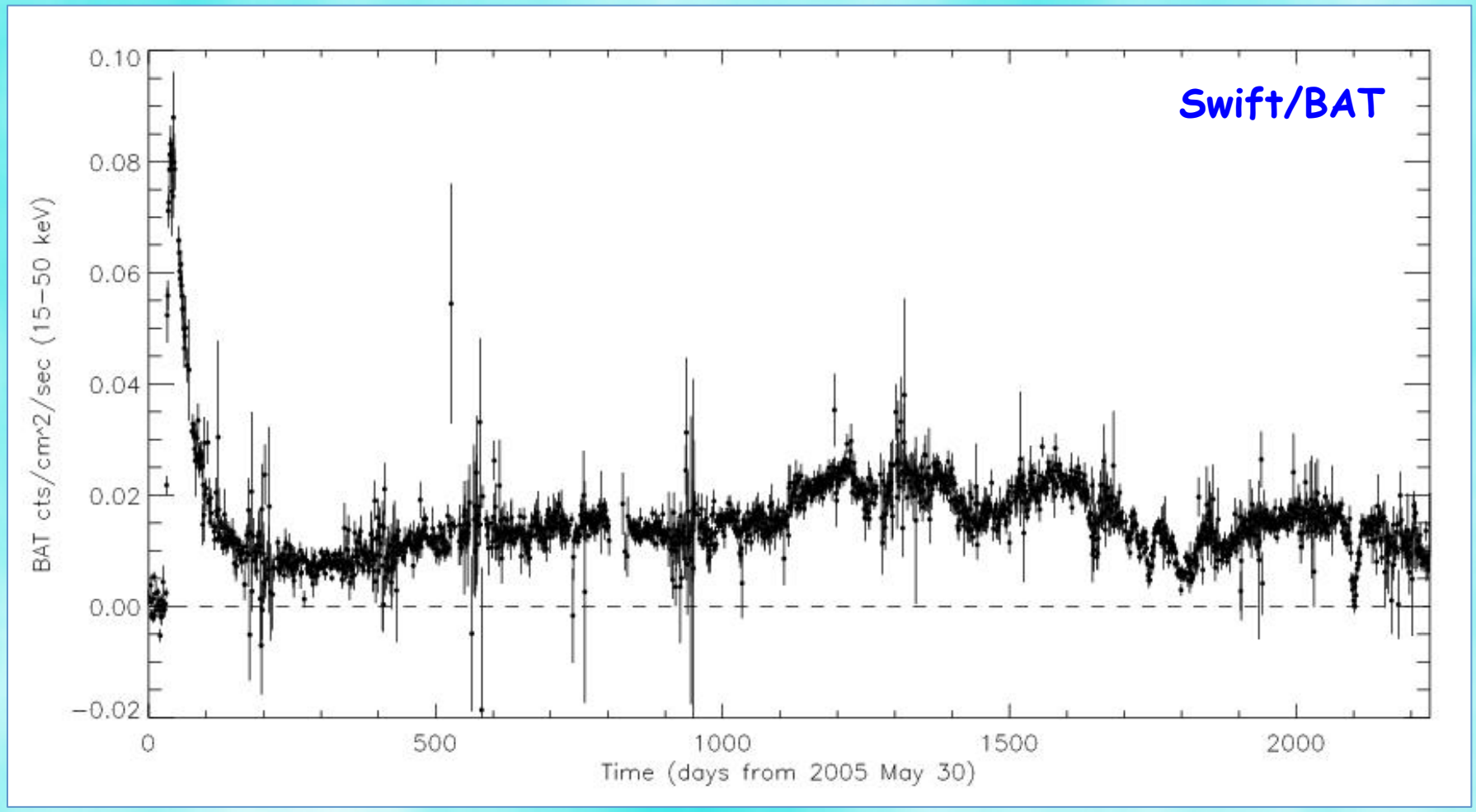
Muñoz-Darias et al. (2011)

- Hard state well defined by the "hard line"
- Sharp transition to the intermediate states
- A soft branch is also well defined

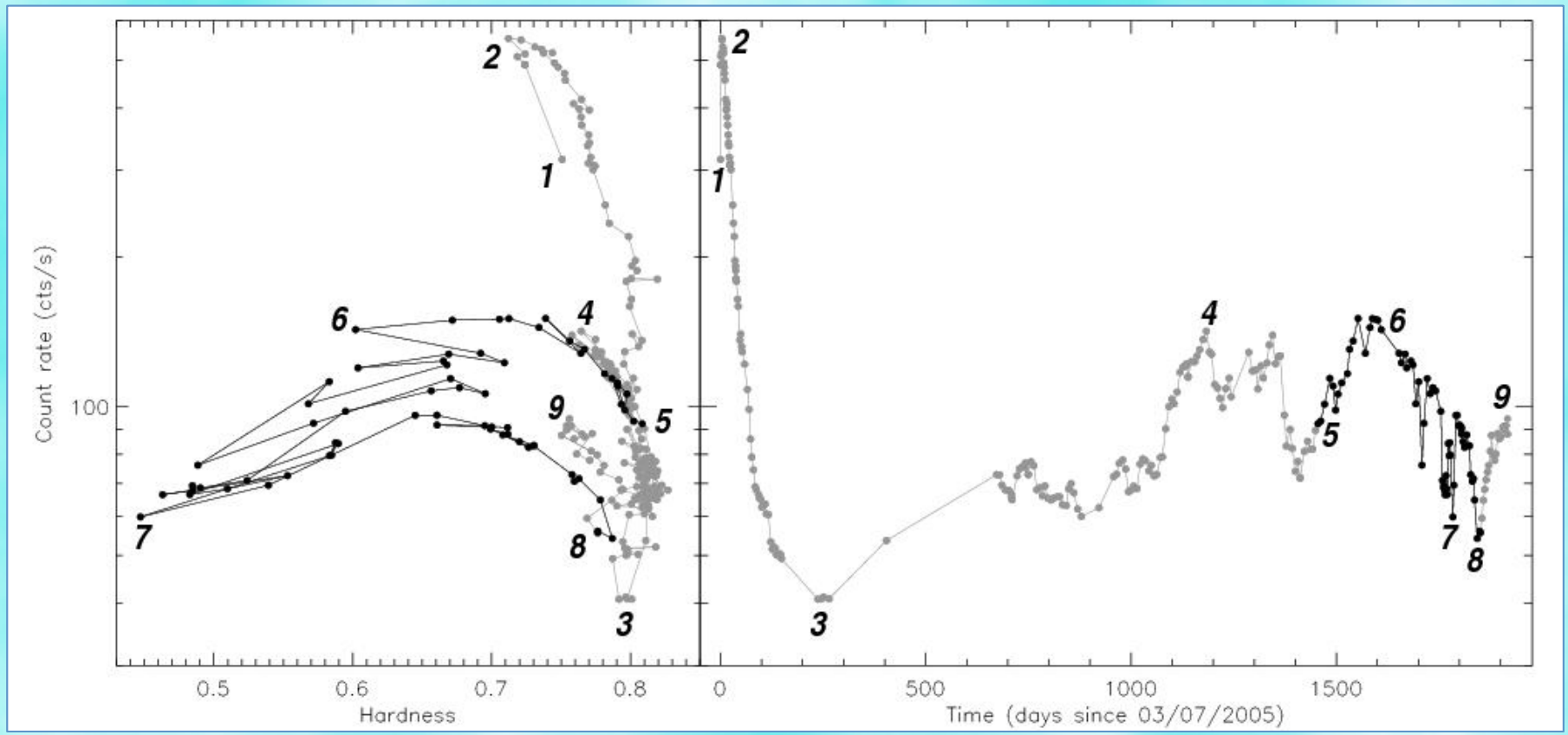
Swift J1753.5-0127

- Black-hole candidate (strong hints from its X-ray spectral and timing properties but no final prove, e.g. Cadolle Bel et al. 2007)
- It started its outburst in 2005, active since then!
- It is possibly the black hole with the second shortest orbital period (P_{orb}~3.2 hours, Zurita et al. 2008)
- It is a "radio quiet" source: its jet is fainter than expected from the X-ray/radio correlation (Soleri et al. 2010)
- It has been in the hard spectral state during most of its outburst (e.g. Zhang et al. 2007)

Swift J1753: the outburst



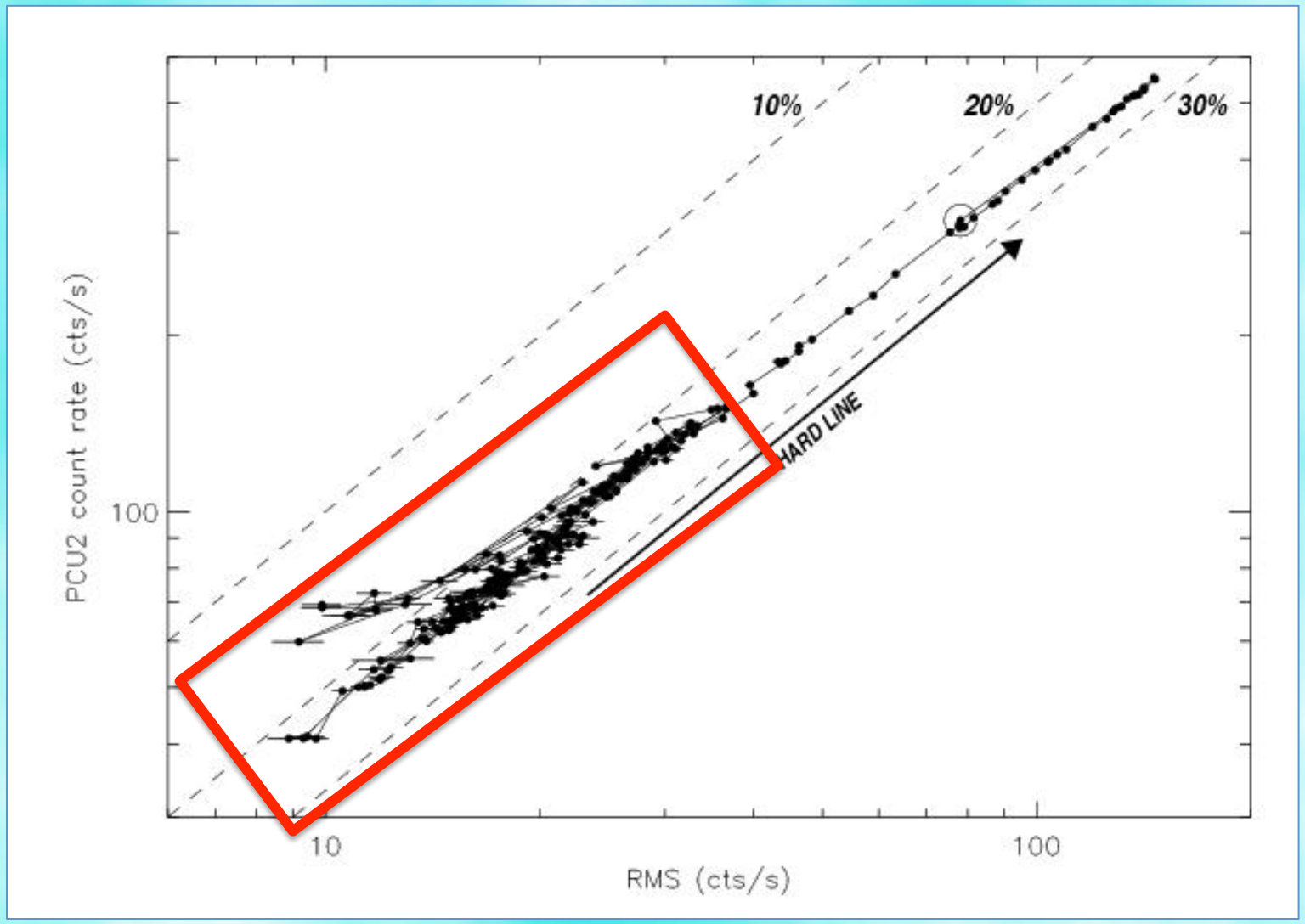
Swift J1753: the outburst



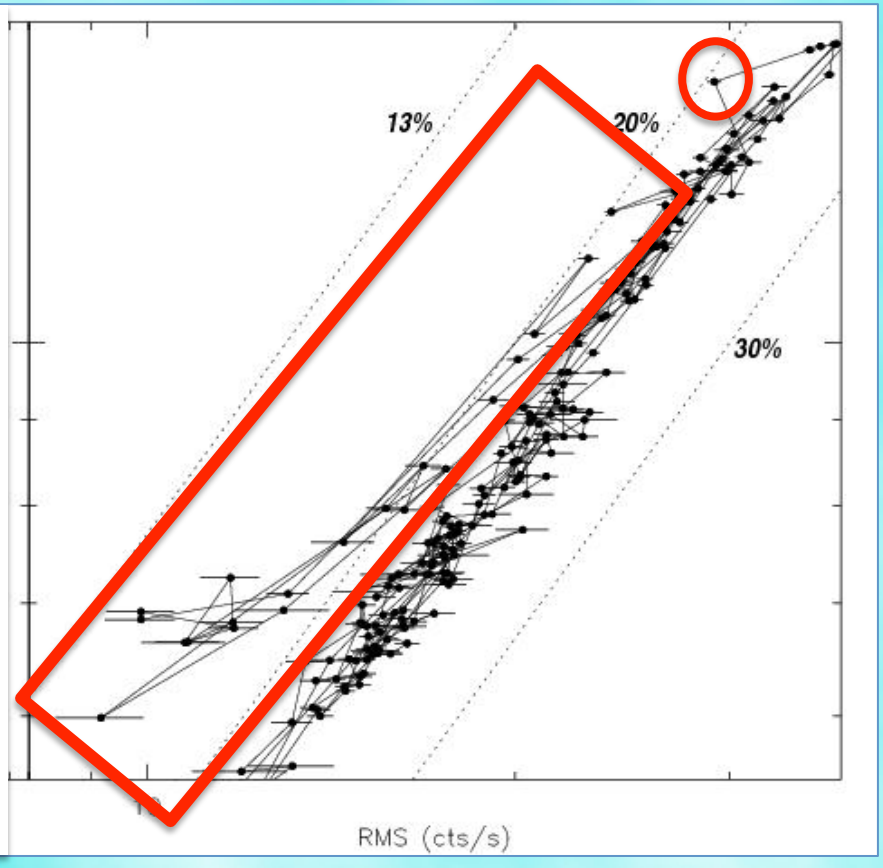
Outburst well monitored by RXTE

We focus in particular on the "failed" transition

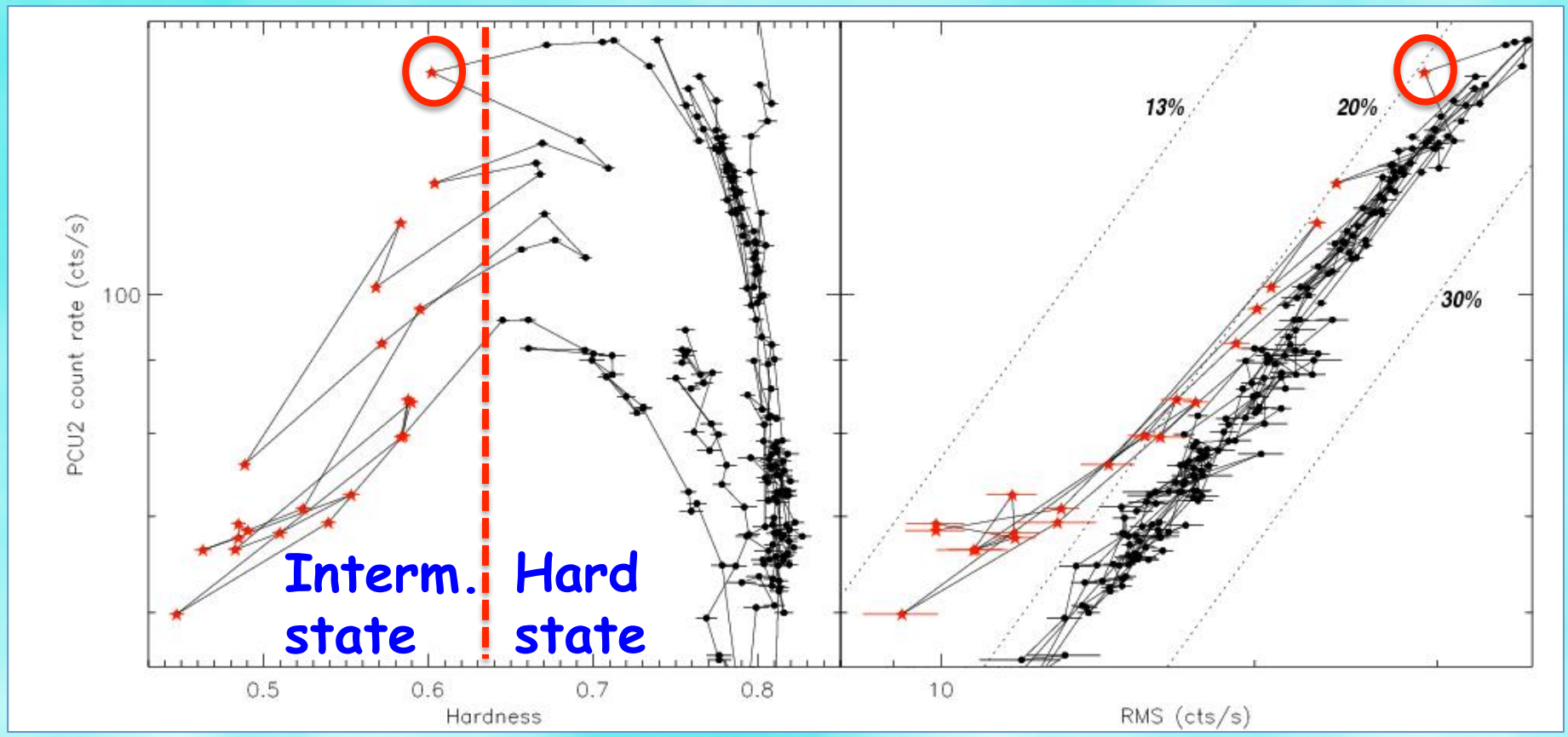
Swift J1753: the RID



Swift J1753: transition to the hard-intermediate state



Swift J1753: transition to the hard-intermediate state



We can precisely mark the transitions to the hard-intermediate state (until now possible only with multiwavelength observations)

Swift J1753 in the intermediate states

The transition to the hard-intermediate state has been associated with a sudden change in X-ray/IR correlation: different disc-jet coupling (at least in GX 339-4; Homan et al. 2005).

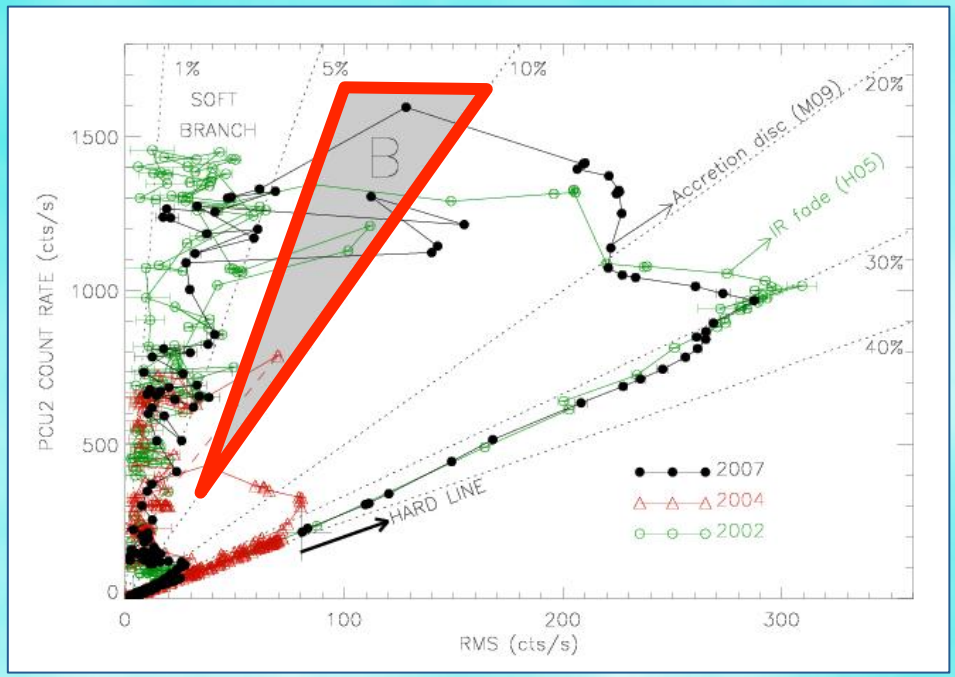
Did Swift J1753 go to the soft-intermediate state?

- The transition to the soft-intermediate state is possibly related to emission of major ejections and followed by a quenching of the jet

- Marked differences also in the X-ray timing domain: drop of variability; specific signatures in the power density spectra

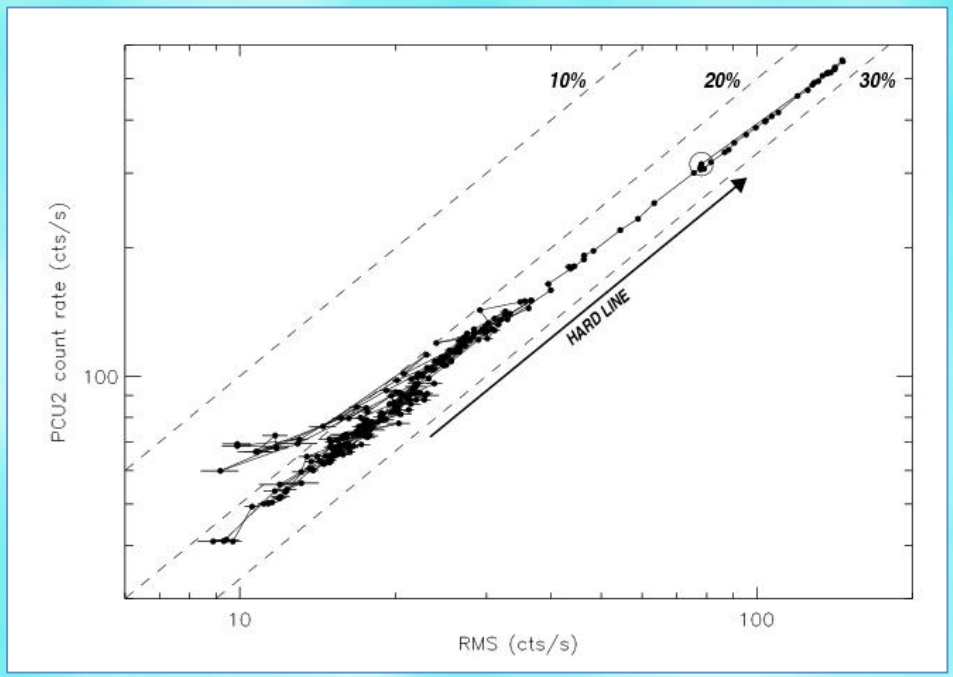
Swift J1753 in the intermediate states: the RID

GX 339-4



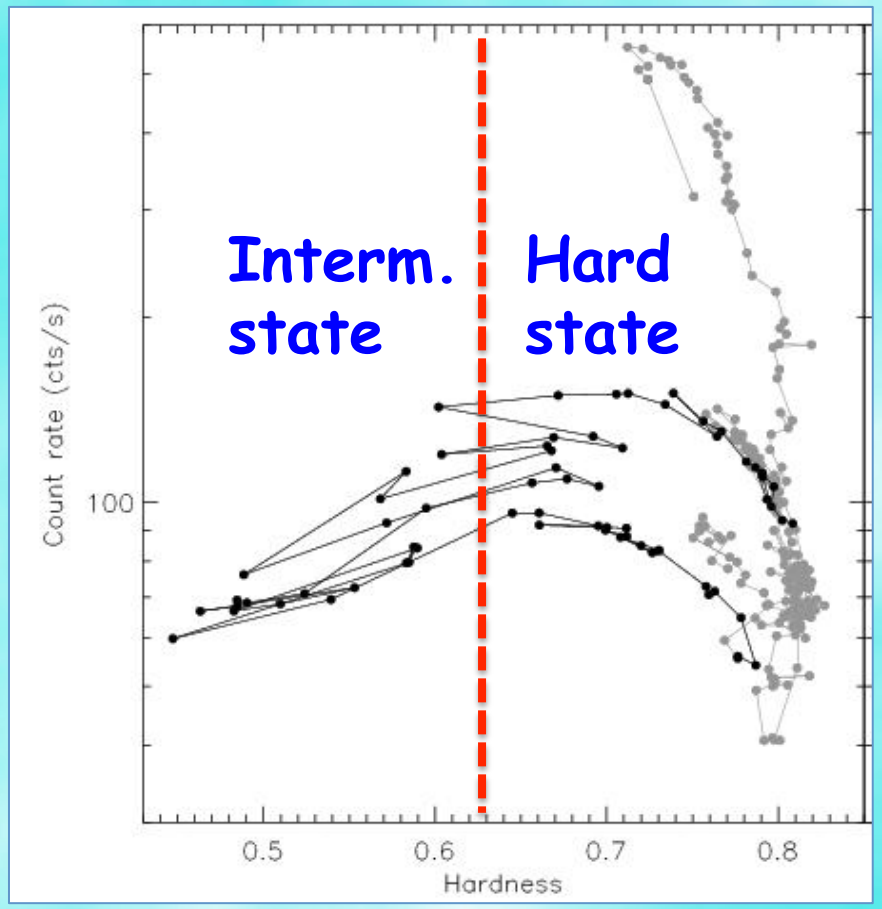
- SIMS in a well defined area of the RID
- fractional rms in the range ~7-10%

Swift J1753

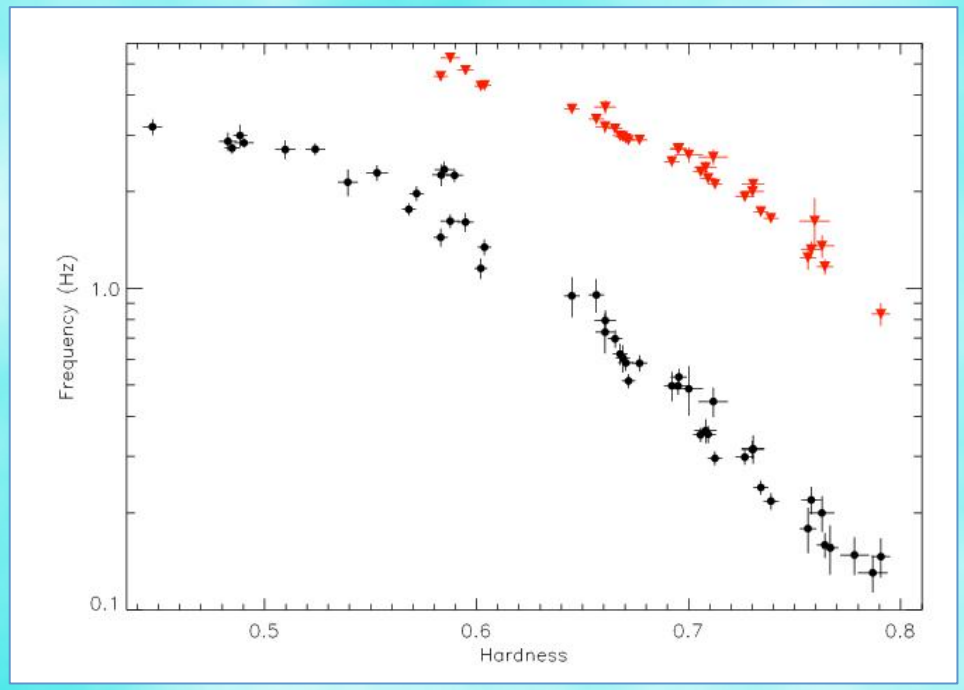


- fractional rms well above 10%
- the RID suggests no transition to the SIMS

Swift J1753 in the intermediate states



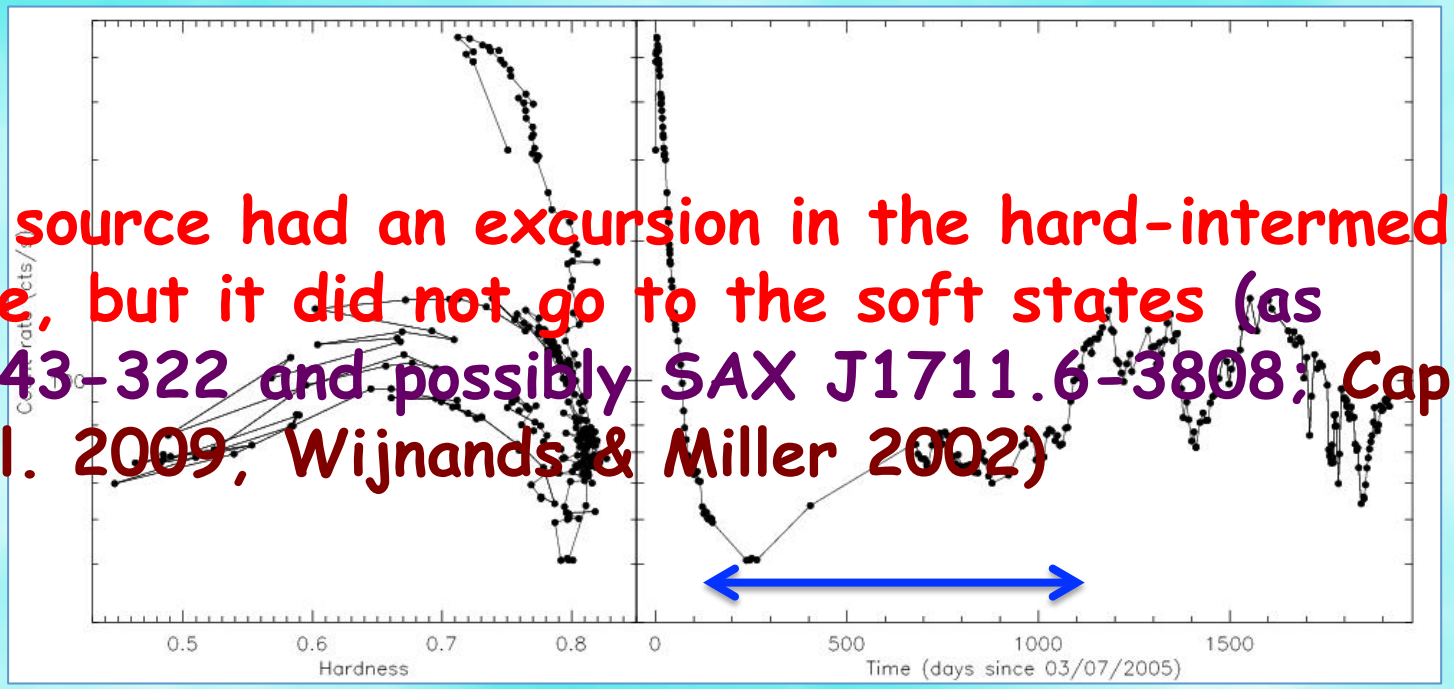
The power spectra in the marked area are fitted with one or two Lorentzians



No change in the power density spectra: the source never went to the soft-intermediate state

Swift J1753: a peculiar object

- Exceptionally long outburst (more than 6 years, not over yet!)
- It spent ~3 years in the hard state at low X-ray flux. Similar behaviour to the neutron star 4U 1608-52
- The source had an excursion in the hard-intermediate state, but it did not go to the soft states (as H1743-322 and possibly SAX J1711.6-3808; Capitanio et al. 2009, Wijnands & Miller 2002)



Swift J1753: a peculiar object

- It is a "radio quiet" source:

1. other "radio quiet" sources had "normal" outbursts (e.g. XTE J1720-318, Brocksopp et al. 2005)
2. hard outbursts do not seem to be prerogative of "radio quiet" sources (Soleri & Fender 2011)

- It is probably the source with the 2nd shortest orbital period (~3.2 hours):

1. 3 out of 4 sources with the shortest orbital period had hard outbursts only (exception is MAXI J1659-322, e.g. Muñoz-Darias et al. 2011, Kalamkar et al. 2011)
2. hard outbursts are not a prerogative of short period systems (e.g. XTE J1550-564, Belloni et al. 2002)

Conclusions

- We followed the black-hole candidate Swift J1753 during its long outburst
- We described the outburst by making use of two fundamental diagrams: the HID and the RID
- The source had an excursion in the hard-intermediate state. We can fairly precisely catch the moment of the transition
- The source has several peculiar features but none of them seem to be sufficient to explain the uncommon outburst