Observational Evidence against the Association of Episodic Jet Power with the BH spin

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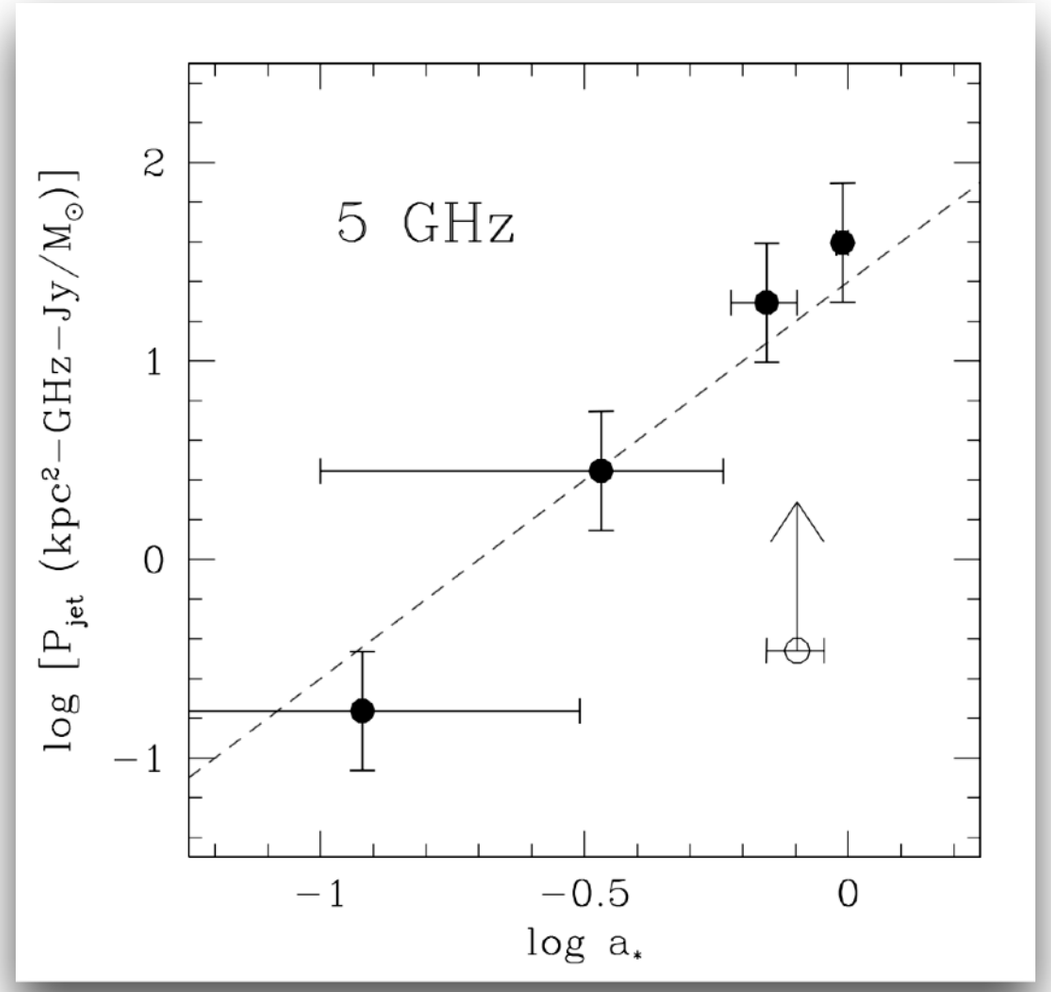
Thanks to the SOC and LOC for organizing the workshop, and the workshop will be very successful.

Unfortunately due to new regulation rules for international traveling by CAS starting in September, I can not attend the workshop by convenient transportation while the total extension of the travel is fixed by CAS.

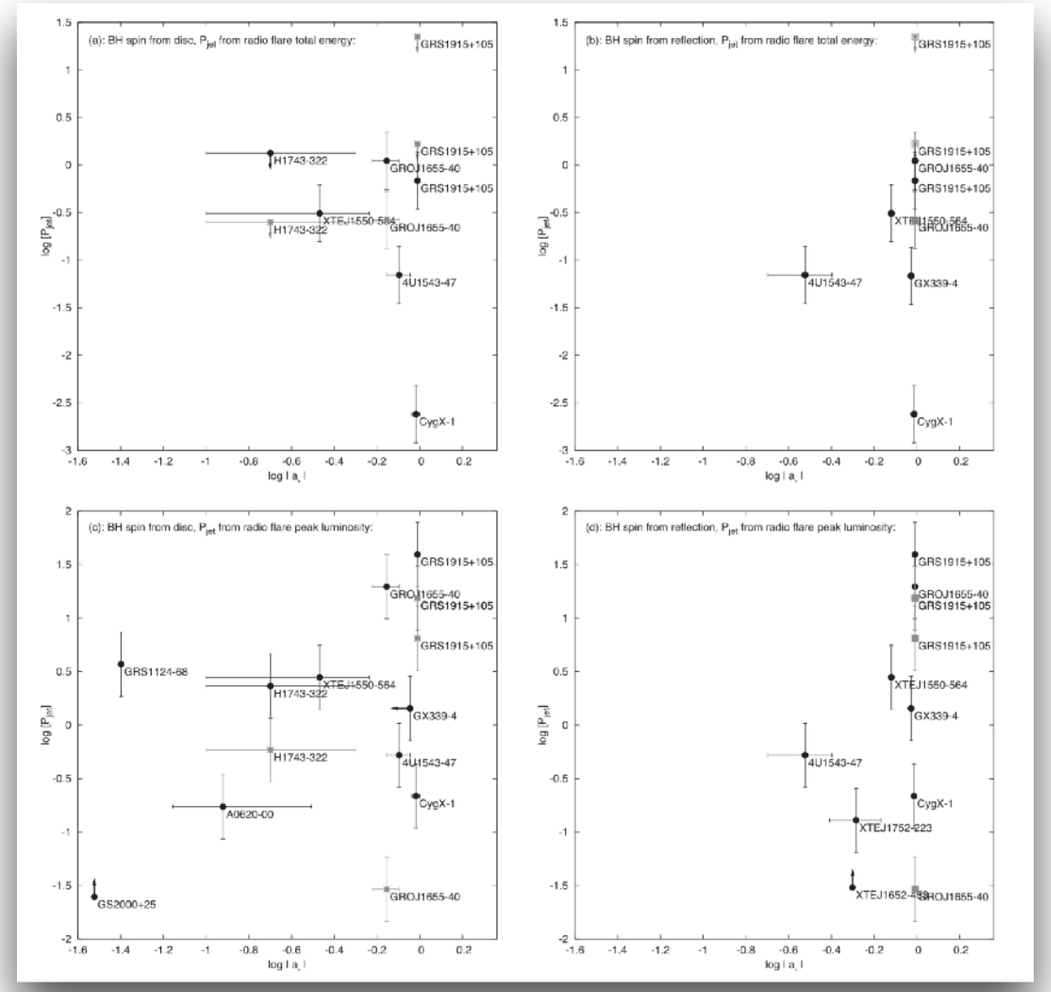
The Issue: Episodic jet Power and BH spin

The "on-going" debate



Jet power vs. BH spin (Narayan & McClintock 2012)

- **use maximum radio flux detected in ballistic jets of individual sources as the probe**
- spin measurements from X-ray observations
- sample: GRS1915, A0620-00, GROJ1655, 4U 1543
- maximum radio flux taken in sources in which radio measurements were made in ONLY one outburst !!

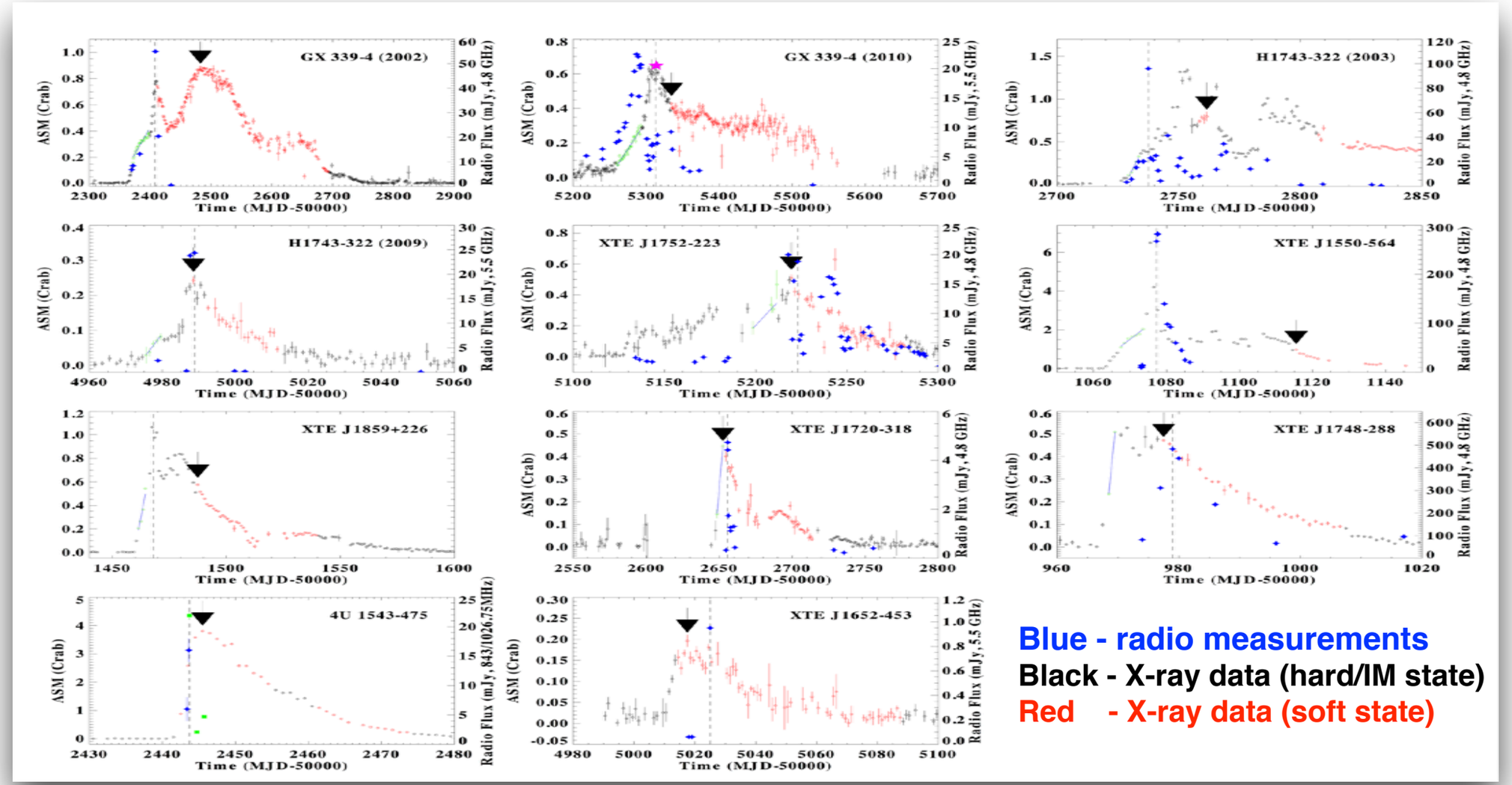


Jet power vs. BH spin (Russel, Gallo & Fender 2013)

- considering different BH spin measurements, etc.

Episodic jets in the Outbursts of BH transients

- the rather complete sample in the literature (Zhang & Yu 2015)



Radio flux vs. X-ray intensity in BH transients (Zhang & Yu 2015, MNRAS)

- coverage of individual jet flares might have been sparse
- but statistical results are valuable
- multiple events from single sources tell more about underlying driving mechanism

sources include: GX 339-4, H1743-322, etc.

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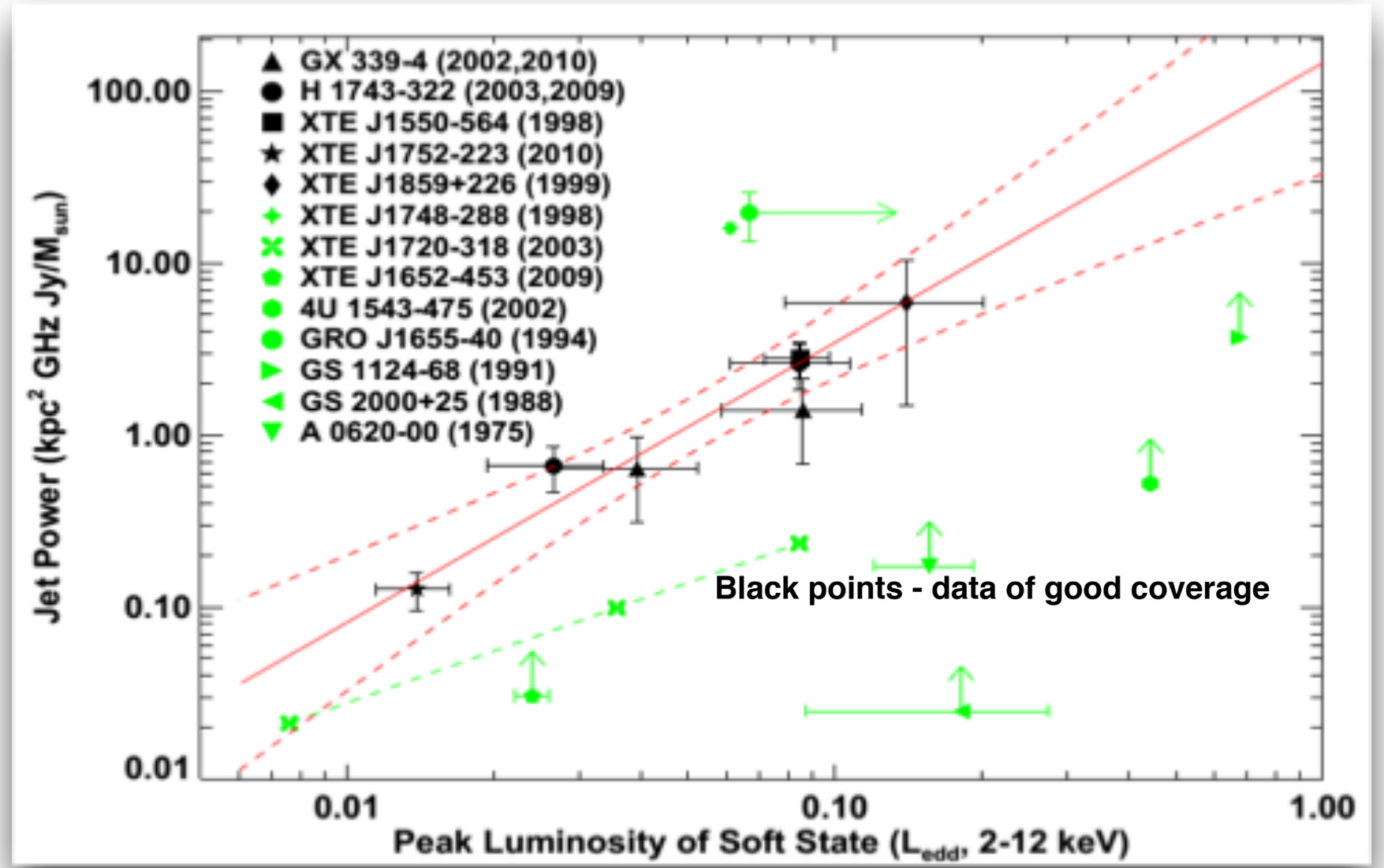

Maximum Radio flux vs. X-ray intensity in BH transients (Zhang & Yu 2015, MNRAS)

- correlation between jet power and peak Luminosity of soft state
- multiple events from single sources: same correlation holds (GX 339-4 and H1743)

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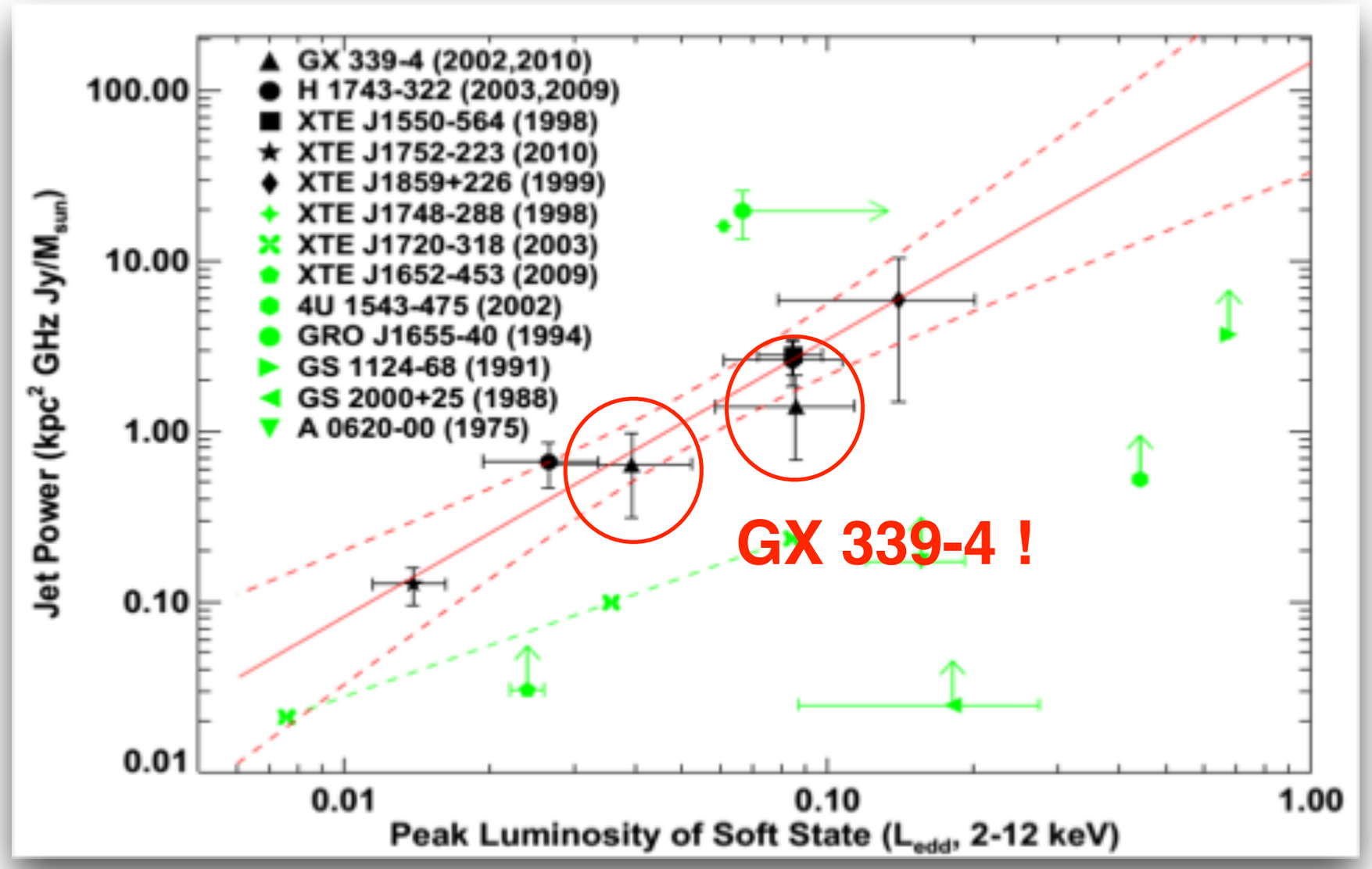

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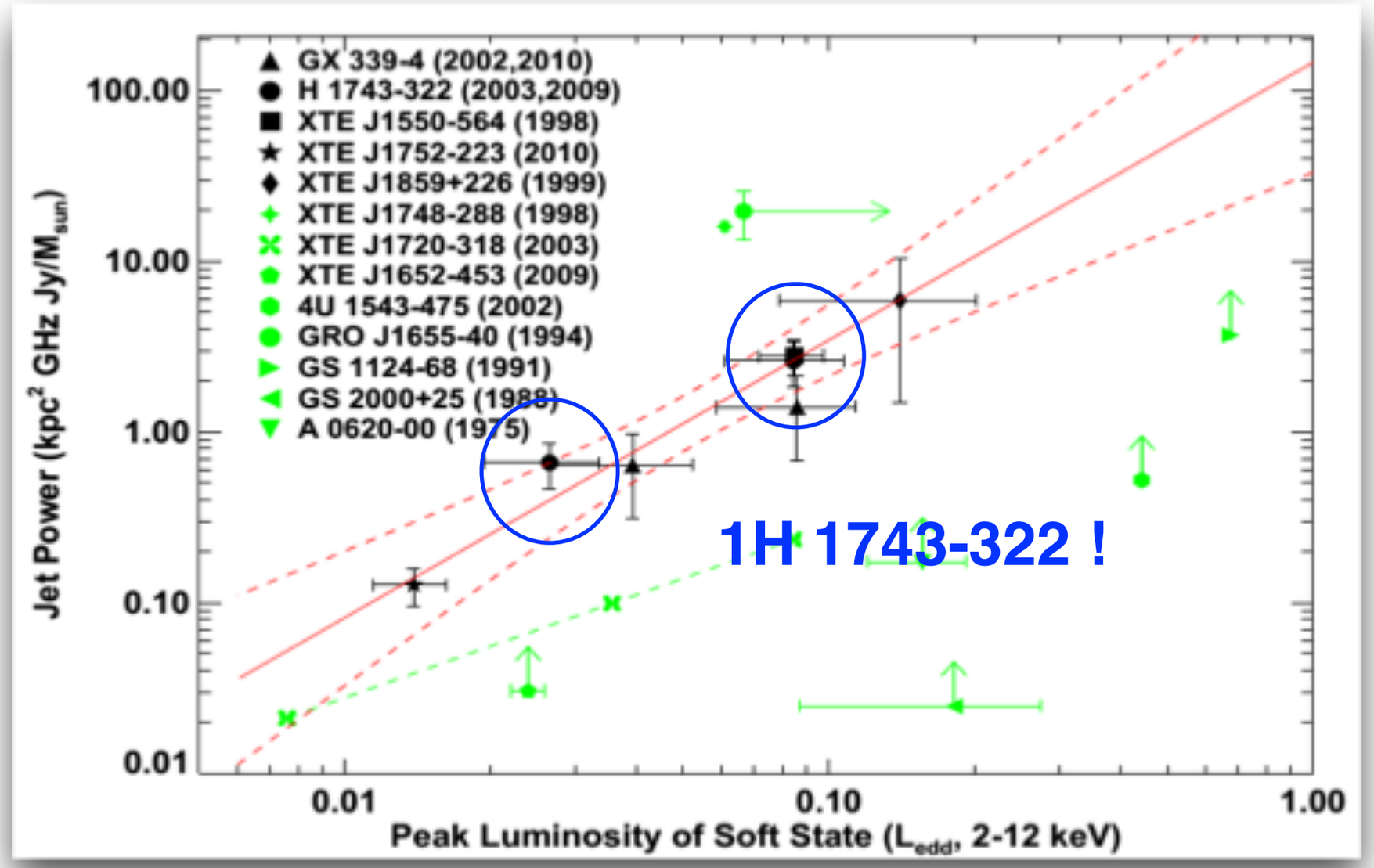

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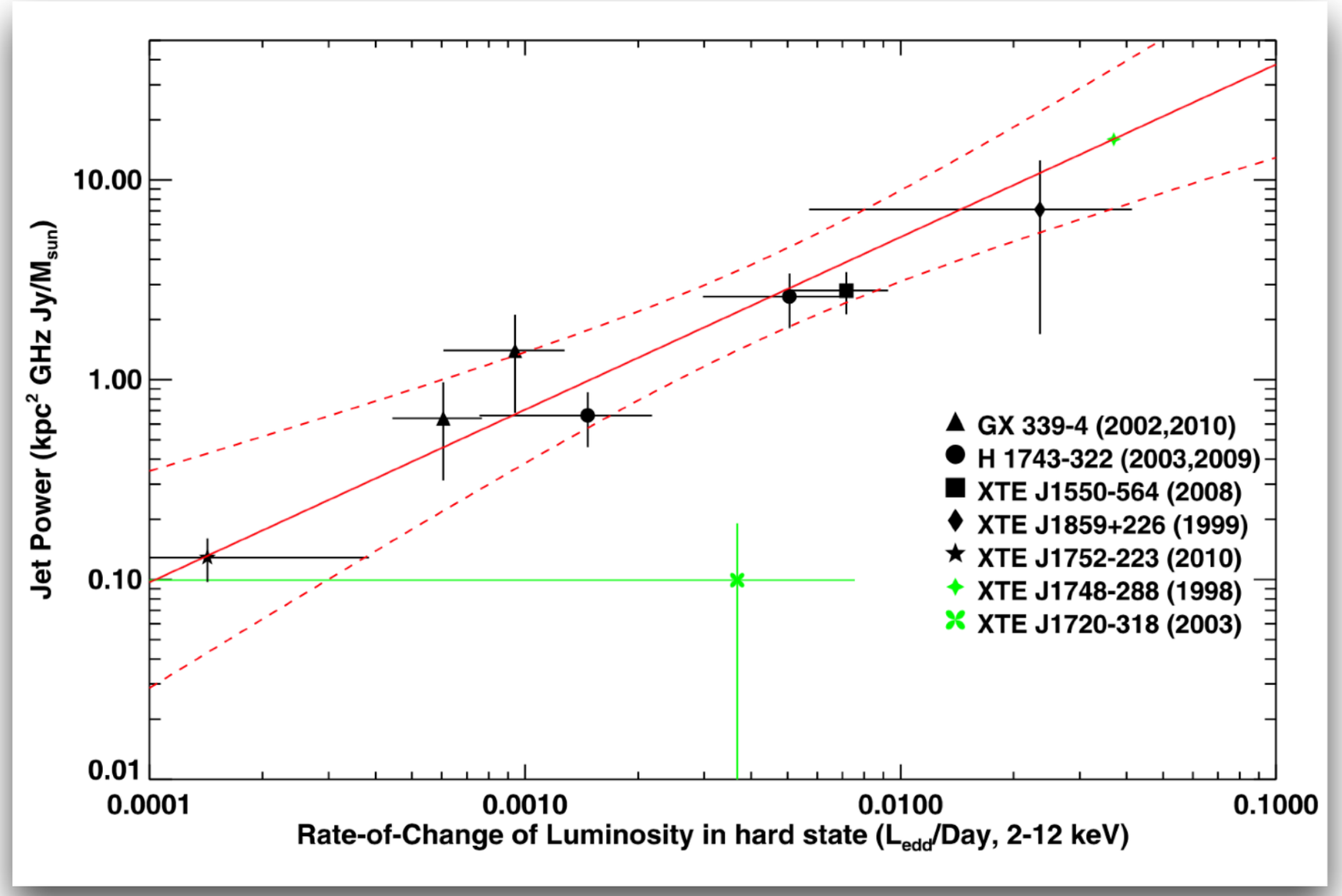

Radio flux vs. rate-of-increase of Lx in BH transients (Zhang & Yu 2015, MNRAS)

- correlation between Jet Power and rate-of-increase of Lx
- multiple events from single sources: same correlation holds (GX 339-4 and H1743)

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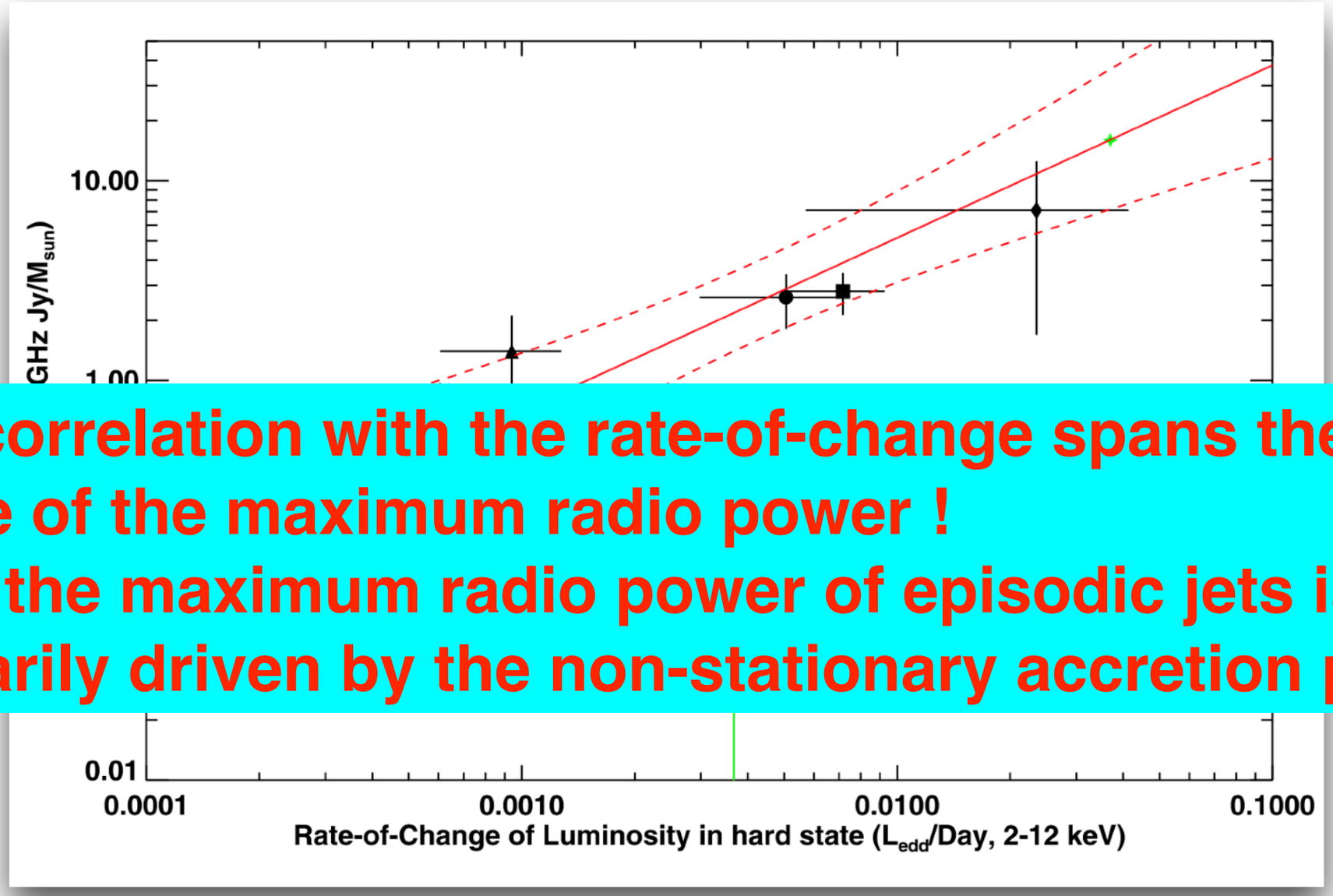

The correlation with the rate-of-change spans the entire range of the maximum radio power !

=>> the maximum radio power of episodic jets is primarily driven by the non-stationary accretion process !

Radio flux vs. rate-of-increase of Lx in BH transients (Zhang & Yu 2015, MNRAS)

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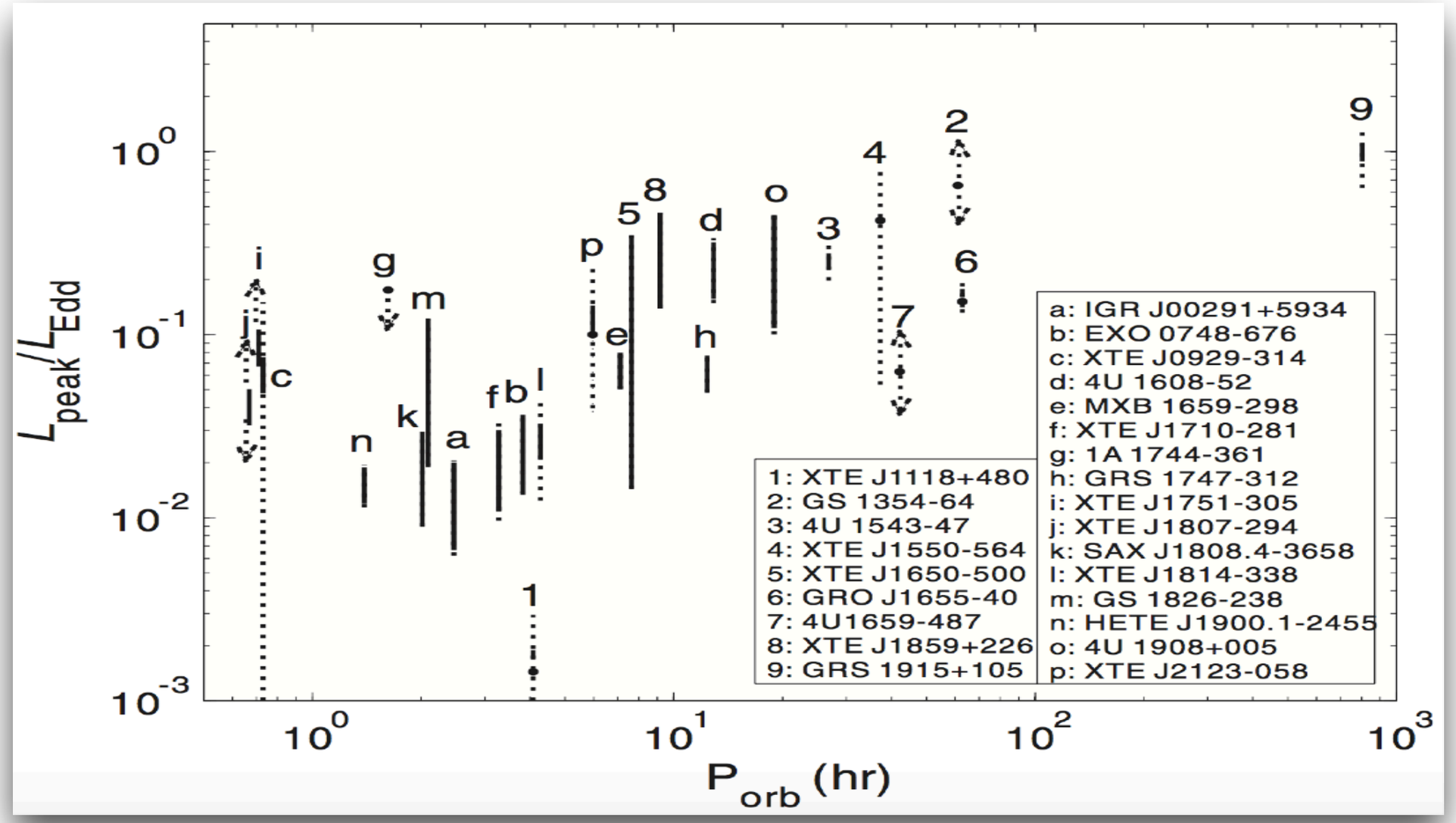
Problem 1:

Maximum radio flux in transients which had only one or a few outbursts

- what is the chance to get the actual maximum radio flux permitted by physics ?



Maximum X-ray flux (range) vs. orbital period in BH transients (Wu et al. 2010, ApJ)

- the data are based on X-ray measurements in about two decades
- the Lpeak range generally spans by a factor of a few
- most BH transients have had only one outburst, and at most 10+ outbursts

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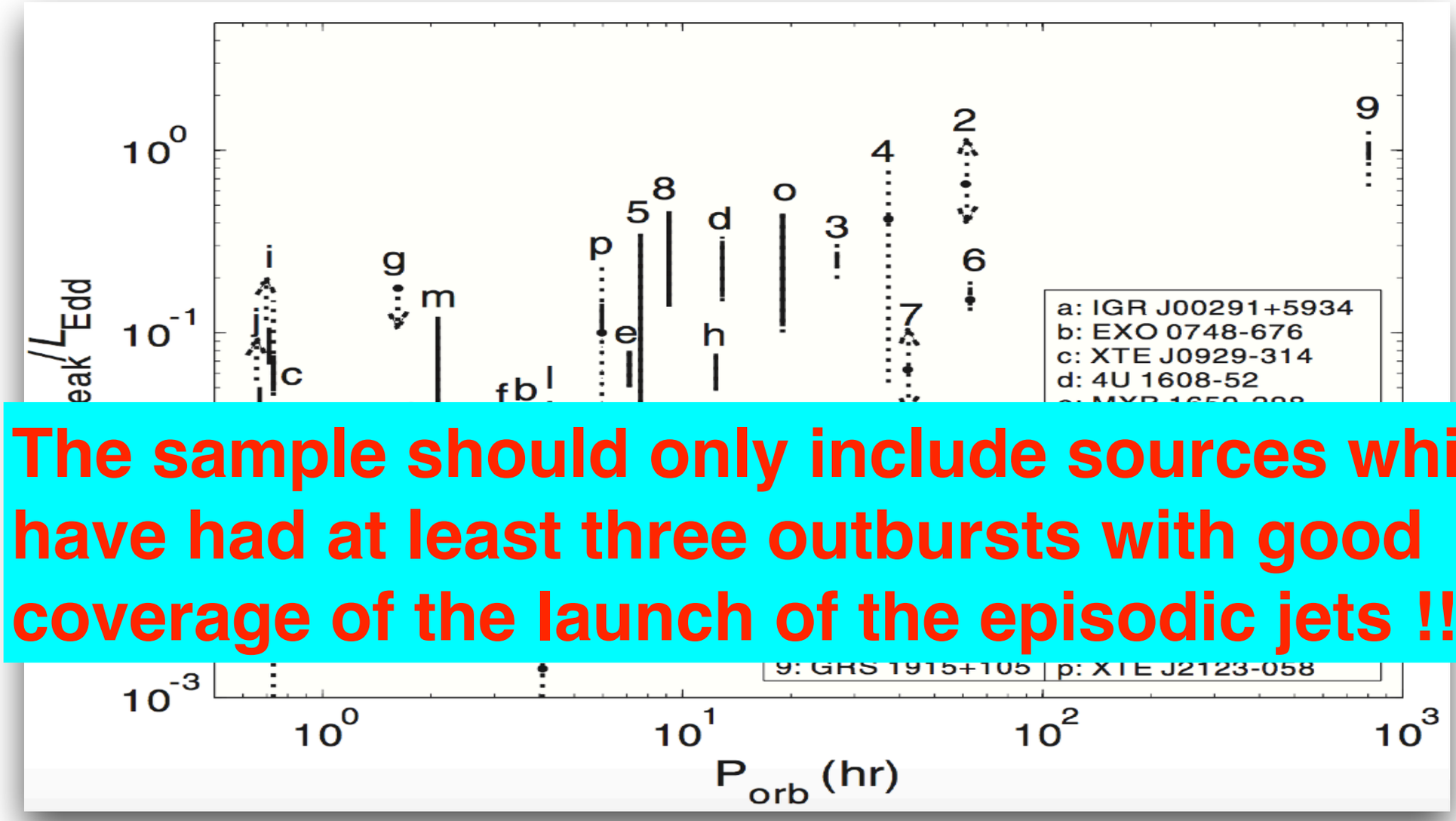

The sample should only include sources which have had at least three outbursts with good coverage of the launch of the episodic jets !!!

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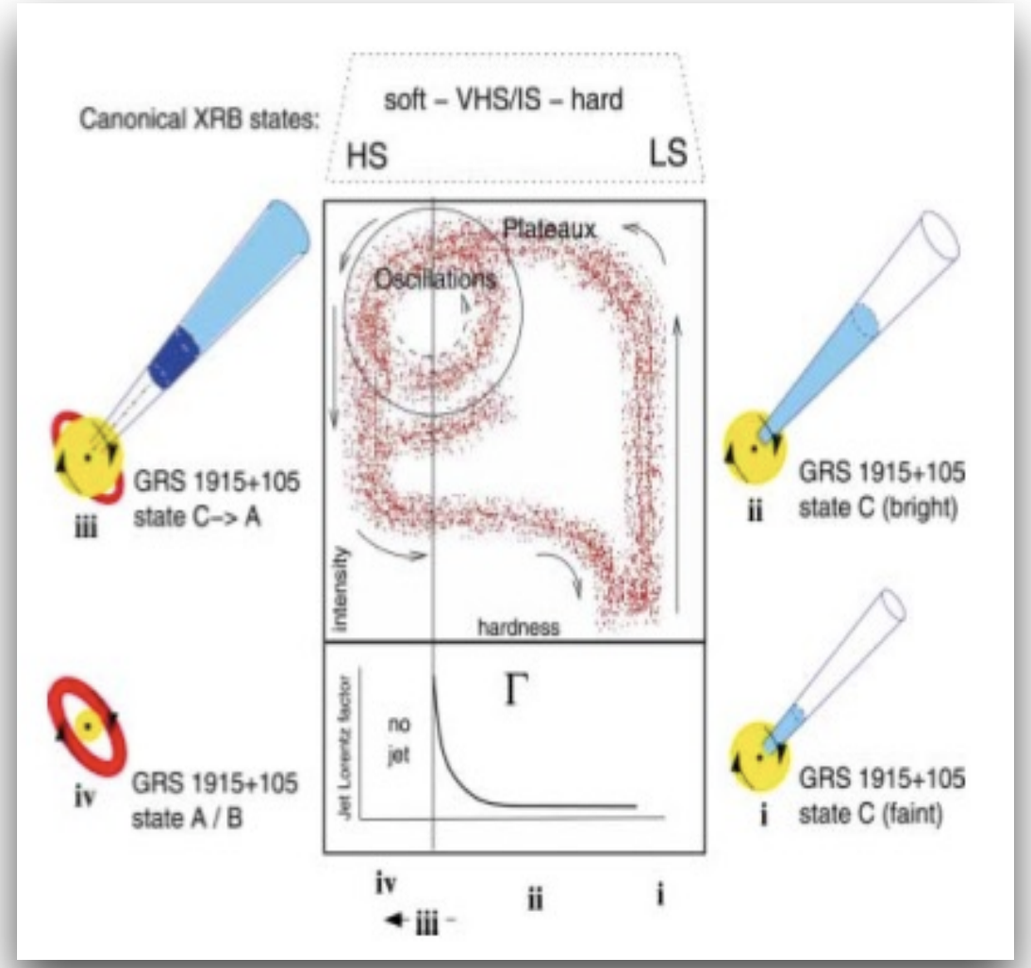
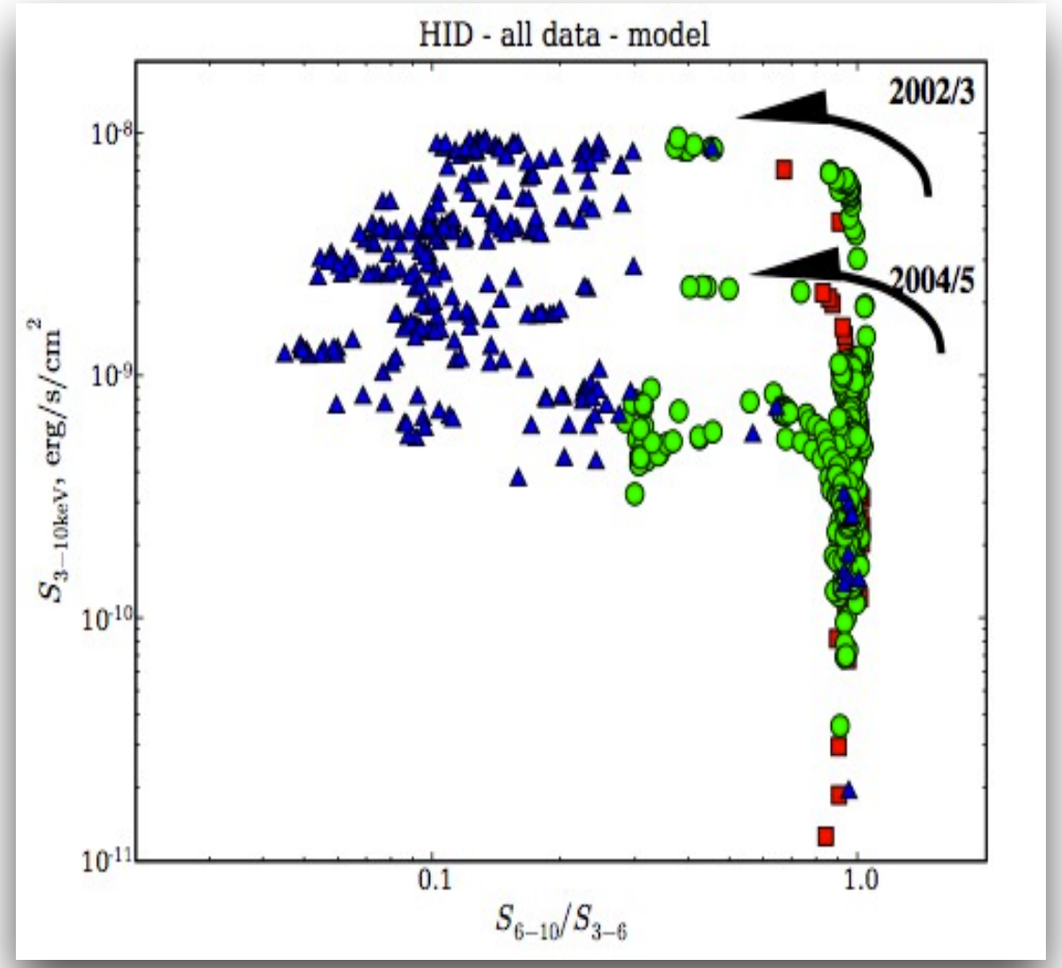
Problem 2:

The maximum Lx and rate-of-change in BH transients with multiple outbursts

- the effects of the second parameter other than the mass accretion rate itself





What is underlying in the Q-diagram (see Fender & Belloni 2004 for the review)

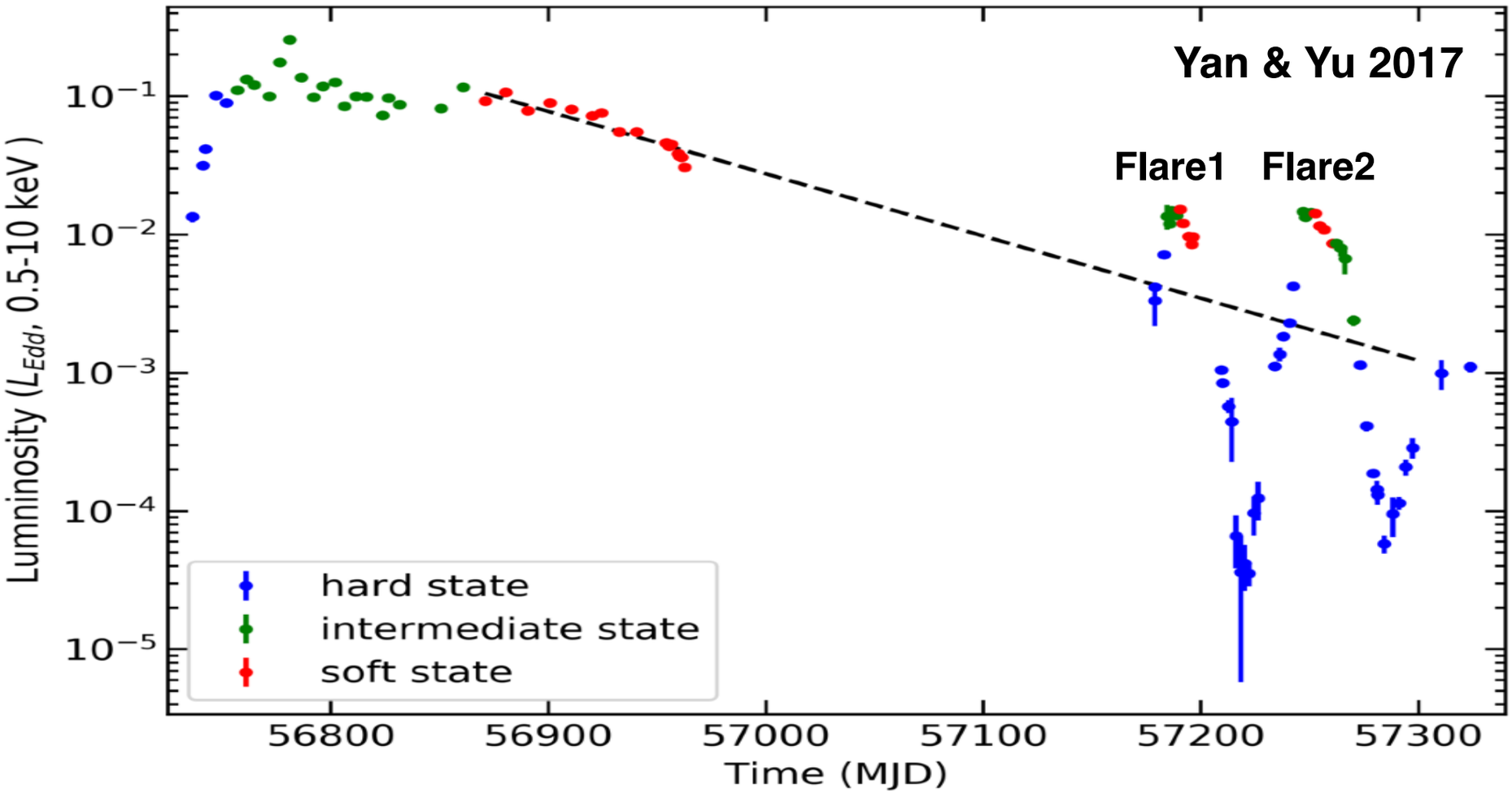
- Theorists please do not misunderstand: actually no single Q at all !!!
- In general, multiple Qs are traced in different outbursts
- What Zhang & Yu (2015) says:

maximum episodic jet power varies with outburst peak Lx and rate-of-increase of Lx !!!

BH spin does not vary significantly between the outbursts, right ?

Swift Monitoring Observations of Black Hole Transients

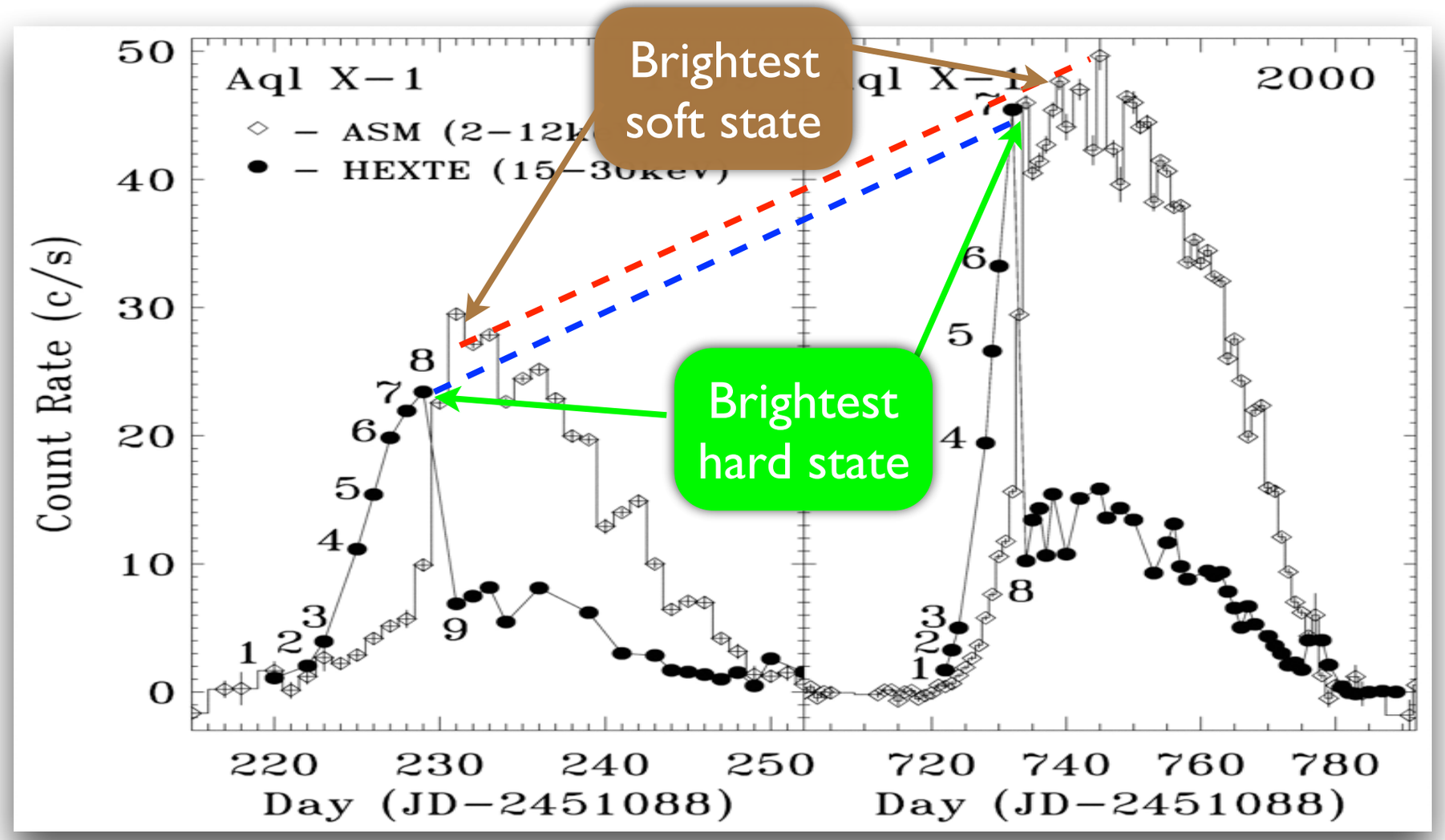
Detection of Black Hole Classical State Transitions in Mini-Flares (2017)



X-ray novae are black hole or neutron star transients undergoing outbursts. Two X-ray mini-flares were found at the end of the most recent outburst of the X-ray Nova GRS 1739-278.

X-ray state transitions to High/Soft states were discovered in such mini-flares in a BH transient (Yan & Yu 2017, MNRAS)

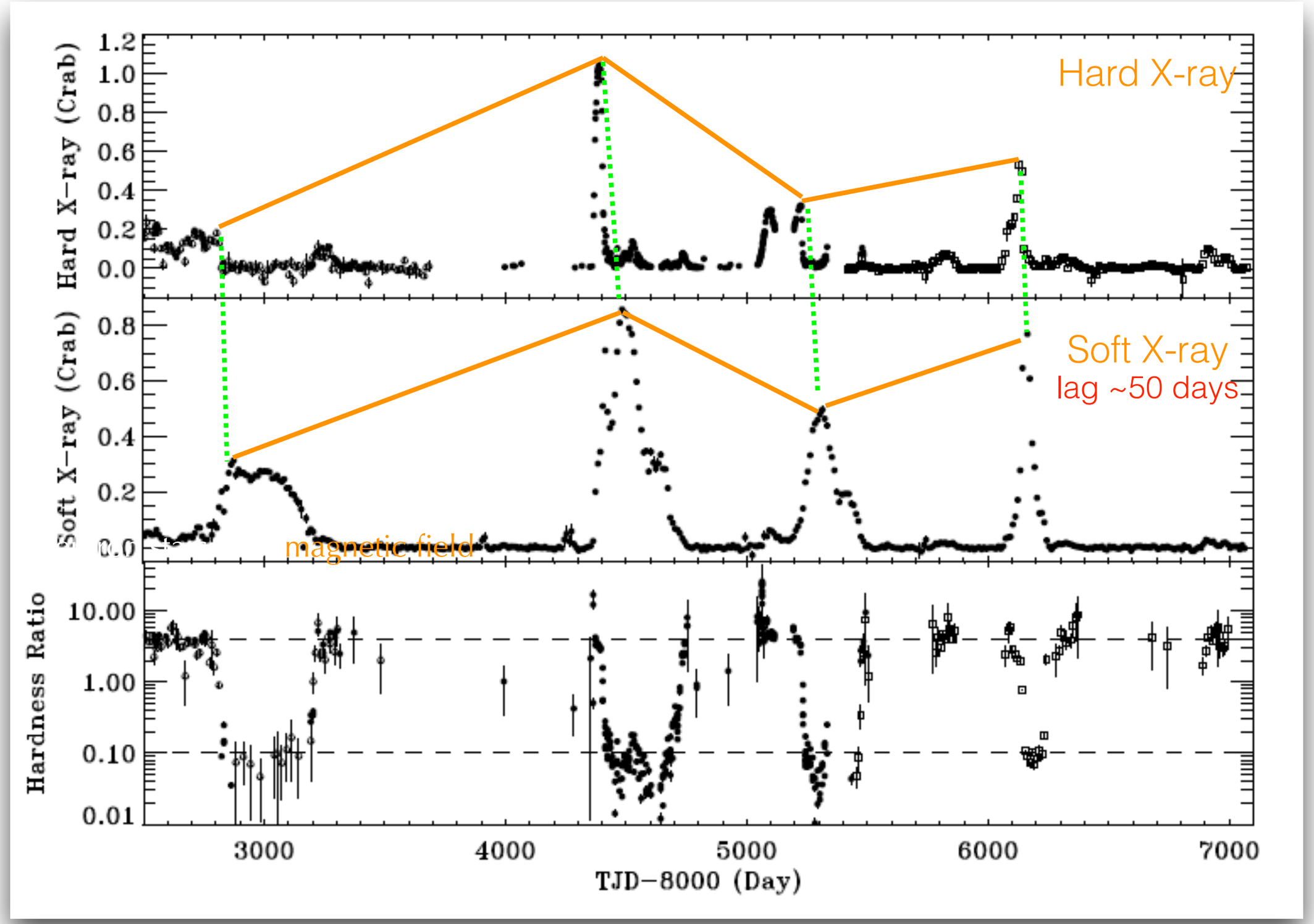
Transition luminosity vs. peak luminosity during outbursts



Yu et al. 2003, ApJ, 589, L33

The luminosities of the hard-to-soft transitions were not arbitrarily chosen !
The transition luminosity and the outburst peak luminosity correlates.

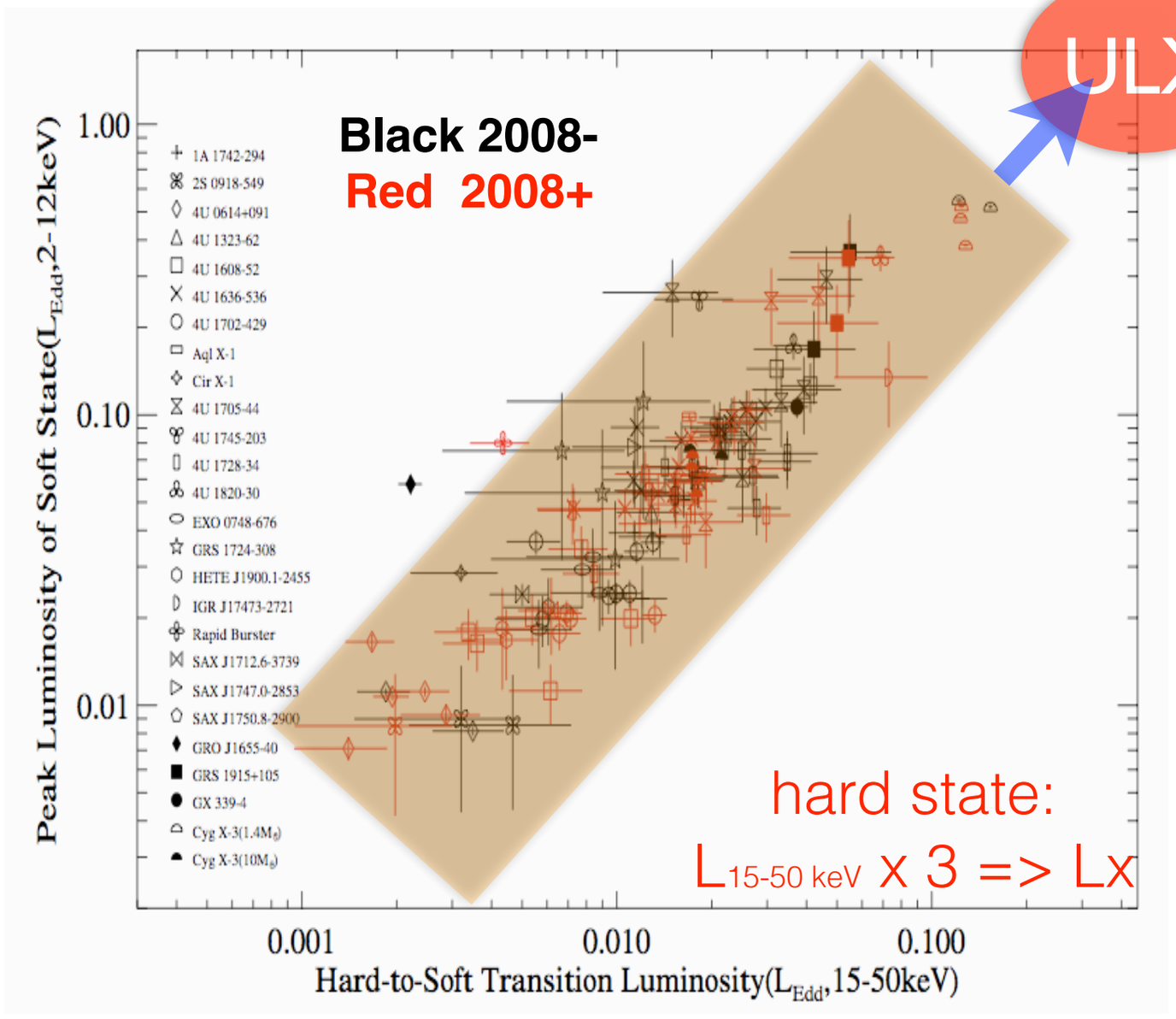
Proportionality in BH LMXB transient GX 339-4



Yu, Lamb, van der Klis & Fender 2007

Correlation holds for all bright Galactic XRBs with transitions

Yu & Yan 2009 and update in Tang et al. 2011, RAA: 120+ transitions



- holds over a luminosity range of two orders of magnitude

- holds for both mini-flares and bright outbursts

- holds for both transients and persistent sources

- holds for both BHs and NSs

- no luminosity saturation

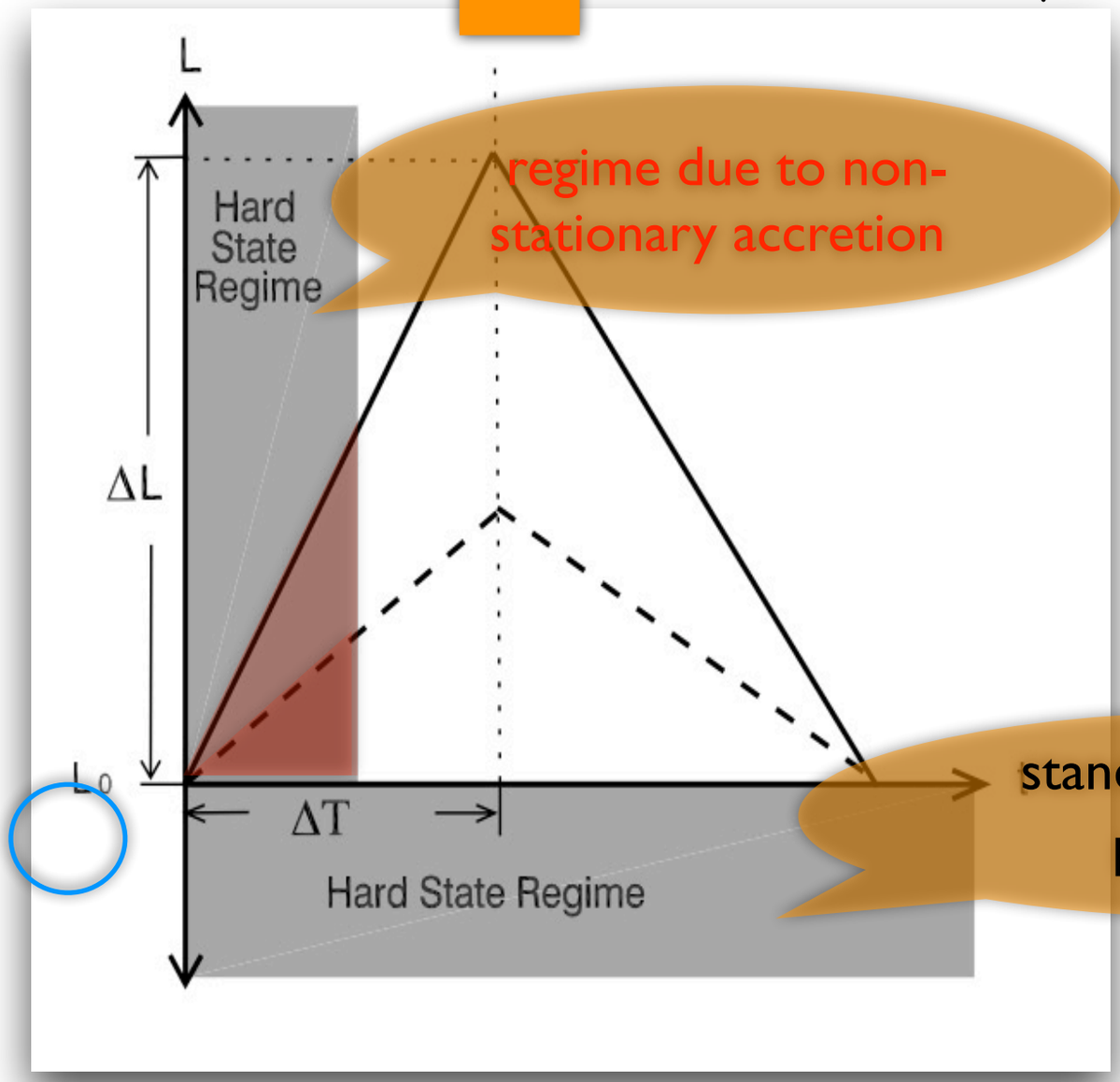
Brighter hard state/outburst is allowed by physics

Hard state regime brighter than model predictions - can be brighter than 30% LE
ADAF model predicts transition luminosity ~ a few percent LE (e.g., Esin et al. 1997)
while in NS sysems transition luminosity should be ~ 10 times lower(Yi,Narayan et al. 1996)

The schematic picture of the hard-to-soft transition

ULXs

Yu & Yan 2009 ApJ



Two assumed outbursts/flares of different peak luminosities of the same source:

assume outbursts/flares have similar rise time ΔT, then ΔL/ΔT is approximately proportional to Lpeak

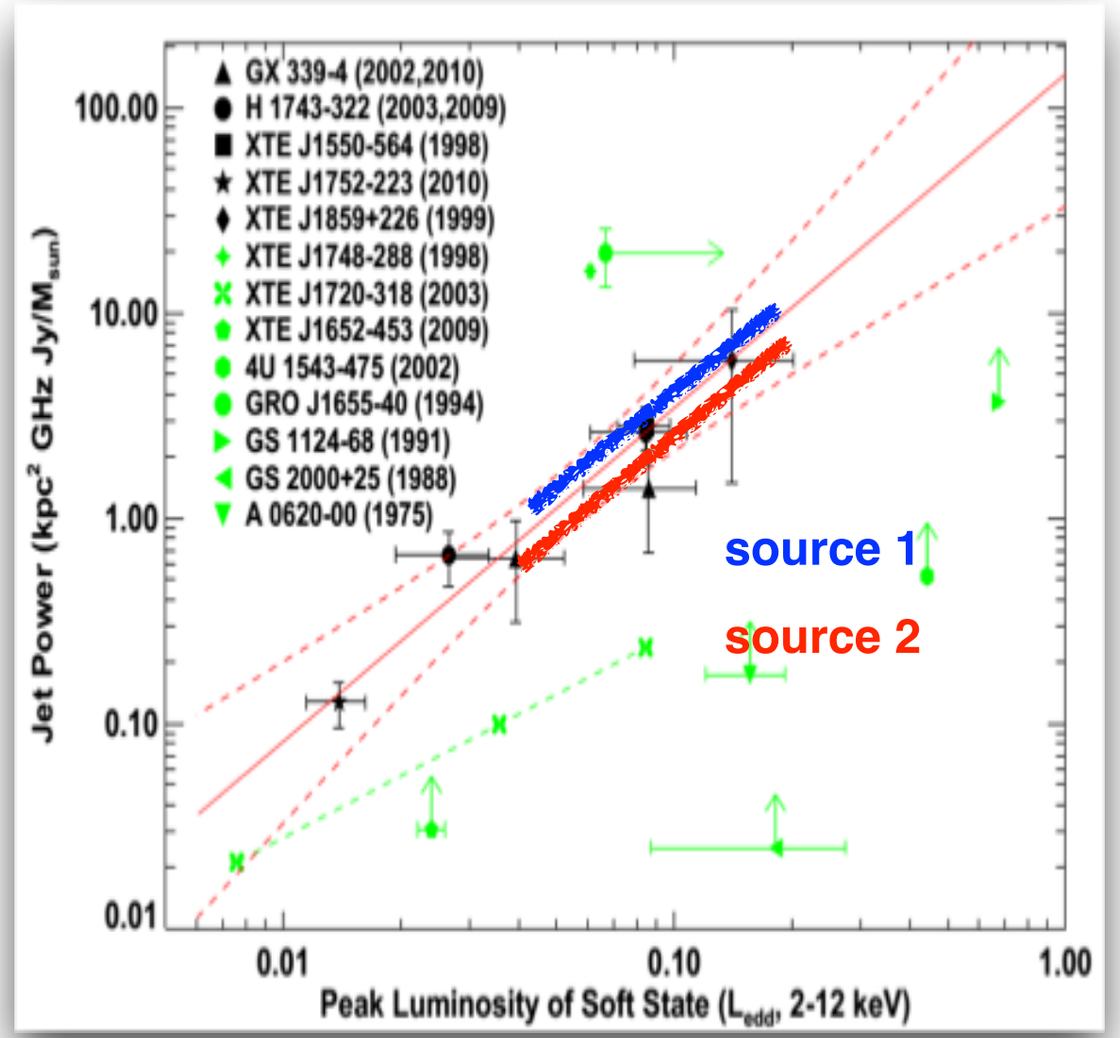
For an infinitsimal flare, transition luminosity ~ L0

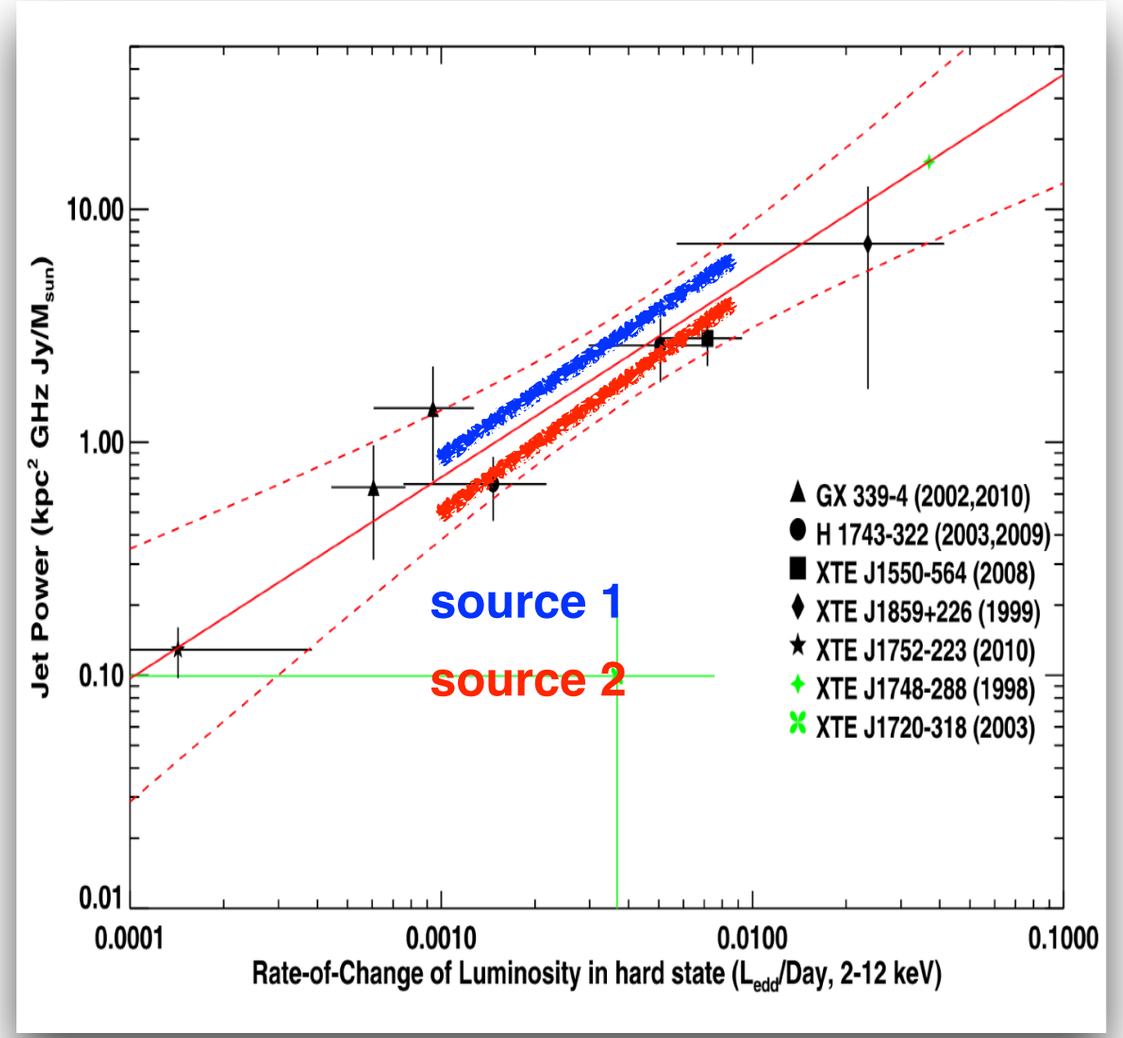
All about the second parameter other than the mass accretion rate:

- the rate-of-change of the mass accretion rate !!!

Episodic jets in the Outbursts of BH transients

- the room left for the BH spin's role





Peak radio power vs. X-ray intensity (or rate-of-change) in BH transients (Zhang & Yu 2015, MNRAS)

- only possibility is that BH spin induces possible distinct vertical offsets among sources with distinct spin (overlaps with the effect of jet-disk inclination/geometry)
- the room left for the role of BH spin is very tiny as shown in the above plot !!!

Conclusion

- The correlation between the peak episodic jet power and the outburst peak luminosity in the soft state suggests a major role of accretion in the non-stationary regimes, rather than the possible role of black hole spin, i.e., black hole spin can not be the second parameter we seen in black hole transients showing significant hysteresis !!!

- The effect of non-stationary accretion drives the entire range of the maximum episodic jet power seen in black hole transients, which suggests that there is only a little room, if not at all, left for the possible effect of role of black hole spin in episodic jet power.