RADIATIVELY EFFICIENT ACCRETING BLACK HOLES IN THE HARD STATE: THE CASE STUDY OF H1743−322

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MNRAS early view

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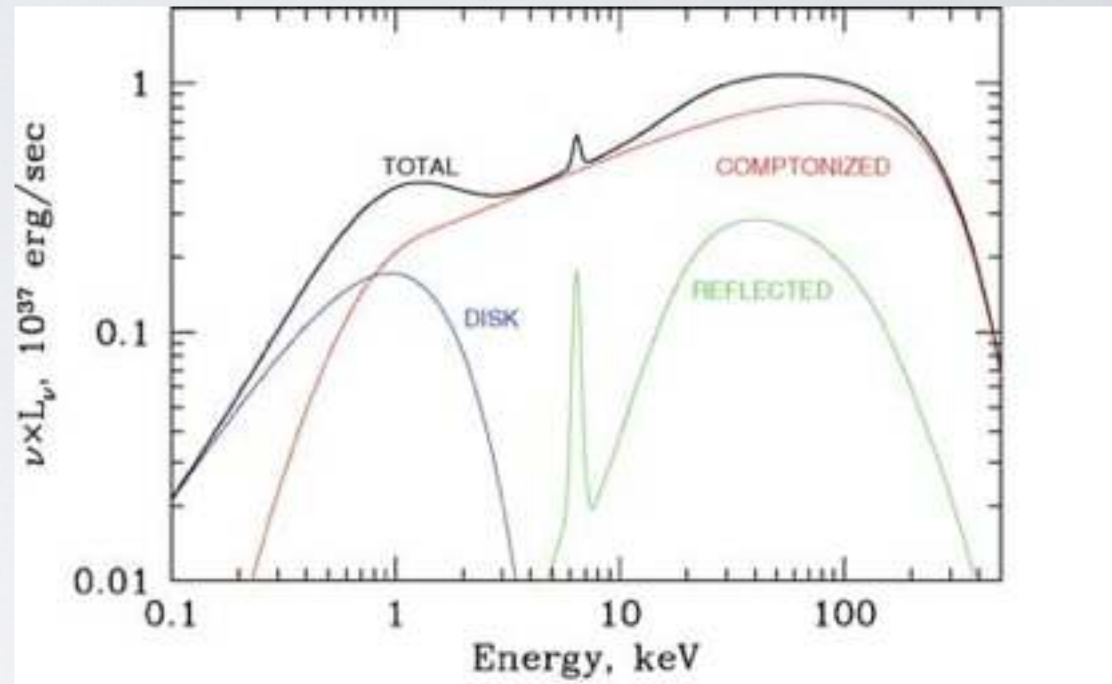
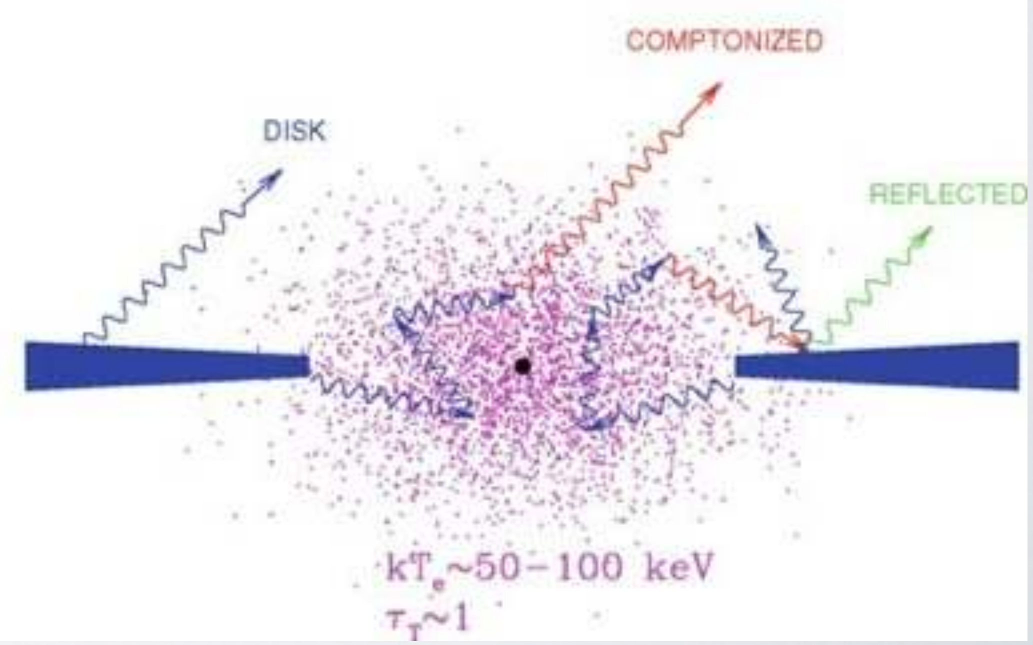
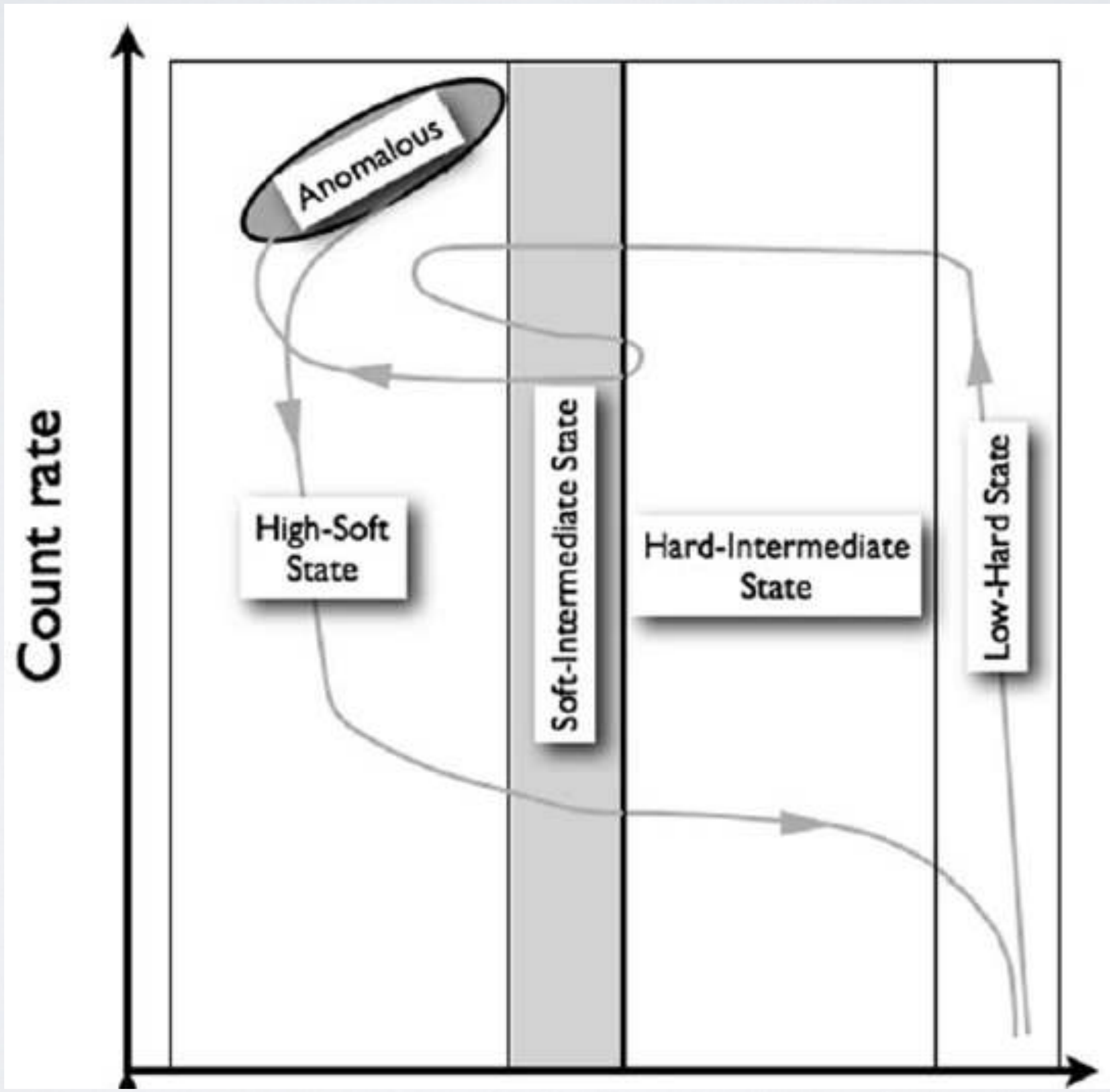
BLACK HOLE X-RAY BINARY

- Components: black hole + less evolved companion star
- Accretion Disk -- Soft X-ray (black body)
- Corona (inner accretion flow)-- Hard X-ray (Inverse Compton Scat.)
- Compact Jet -- Radio (Synchrotron); flat spectrum

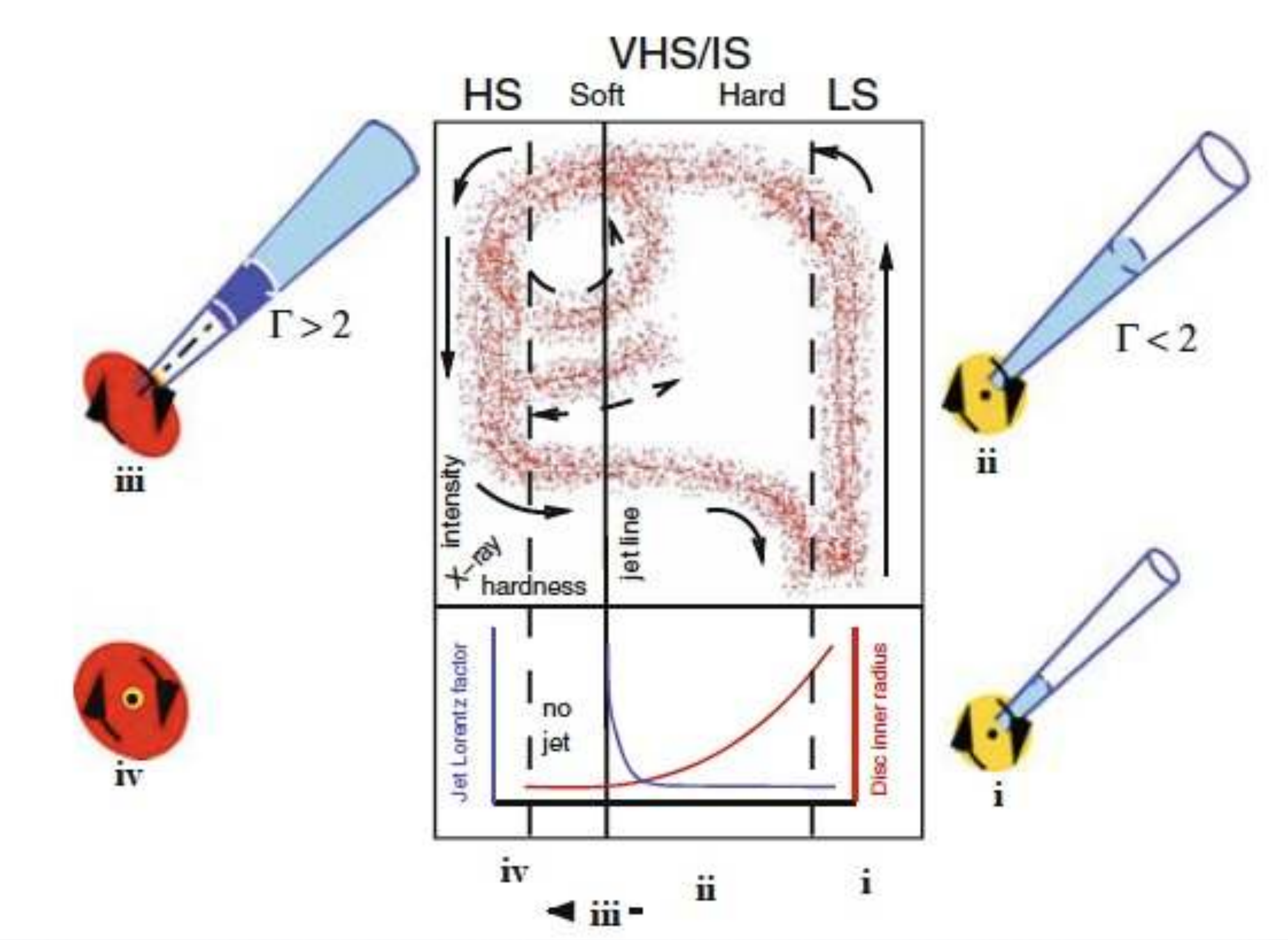




HARDNESS-INTENSITY DIAGRAM (HID)



OUTBURST & JET



- optically thin jet (out flow/knot) & optically thick jet (compact jet).

RADIO/X-RAY RELATION

- Radio and X-ray emission during the hard state:
  $F_{Rad} \propto F_X{}^b$

- b=0.6~0.8 for black hole;
  b=1.4 for neutron star (fainter radio emission).

- Connections between the corona/accretion disk and the jet.

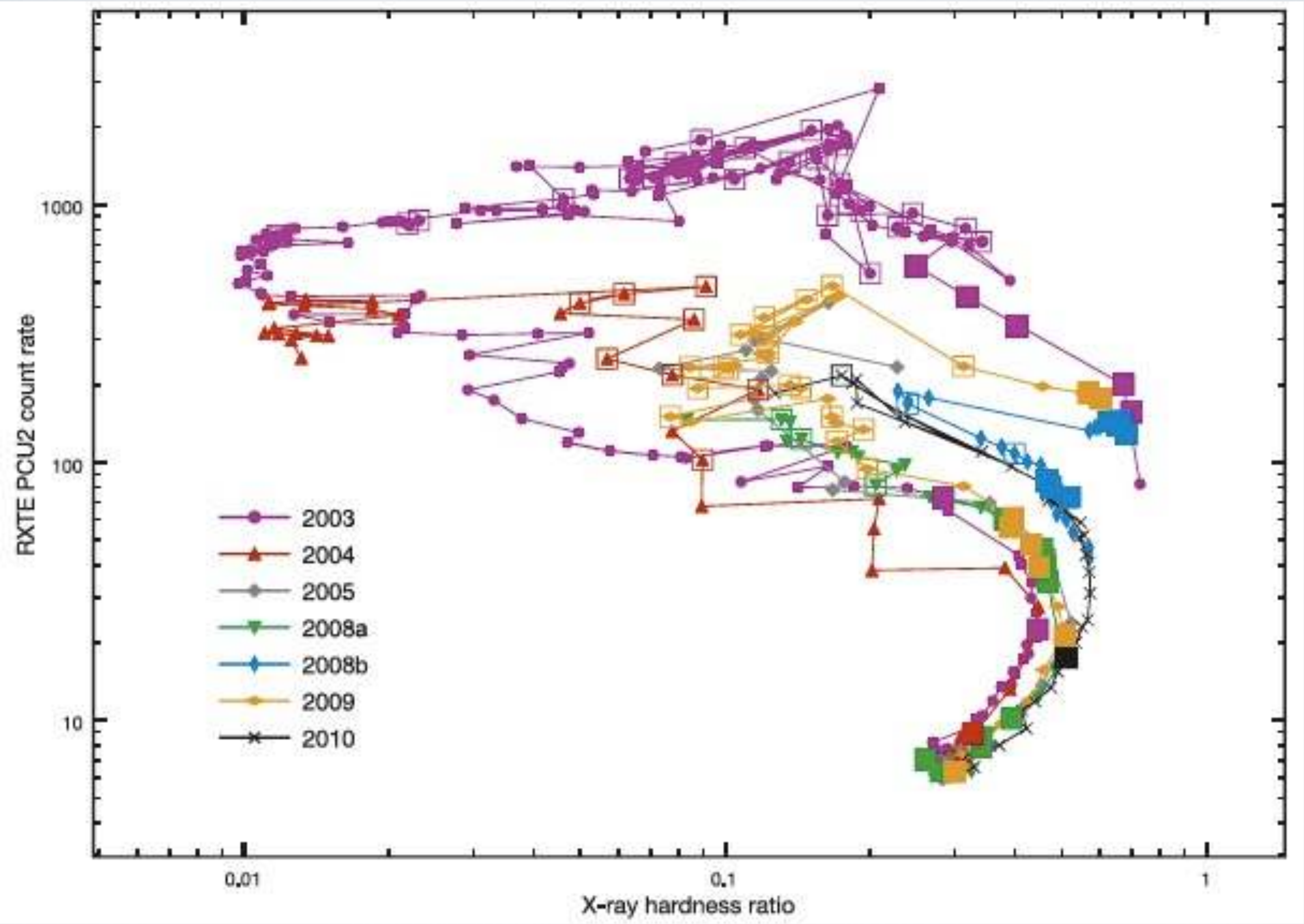
H1743-322

- Outlier of the standard BHXB radio/X-ray relation.
- No dynamically confirmed compact object mass.
- Show similar behaviors of X-ray spectral and timing features to those of dynamically BHXB.
- First precise measurements of the slope of the radio/X-ray correlation among the outliers.

OBSERVATIONS

- 2003 ~ 2010 RXTE, Chandra, ATCA, VLA observations.
- Mainly interested in phases where the compact jets are present and where the X-ray emission in the 3–9 keV band is dominated by the power-law emitting component.
- Selected observations in the hard state for which the radio spectral index whose lower limit is ≥ -0.3.
  Discarded observations that took place following the first radio flare of an outburst, since the compact jets might be disrupted when discrete ejection events take place.

HID OF H1743-322



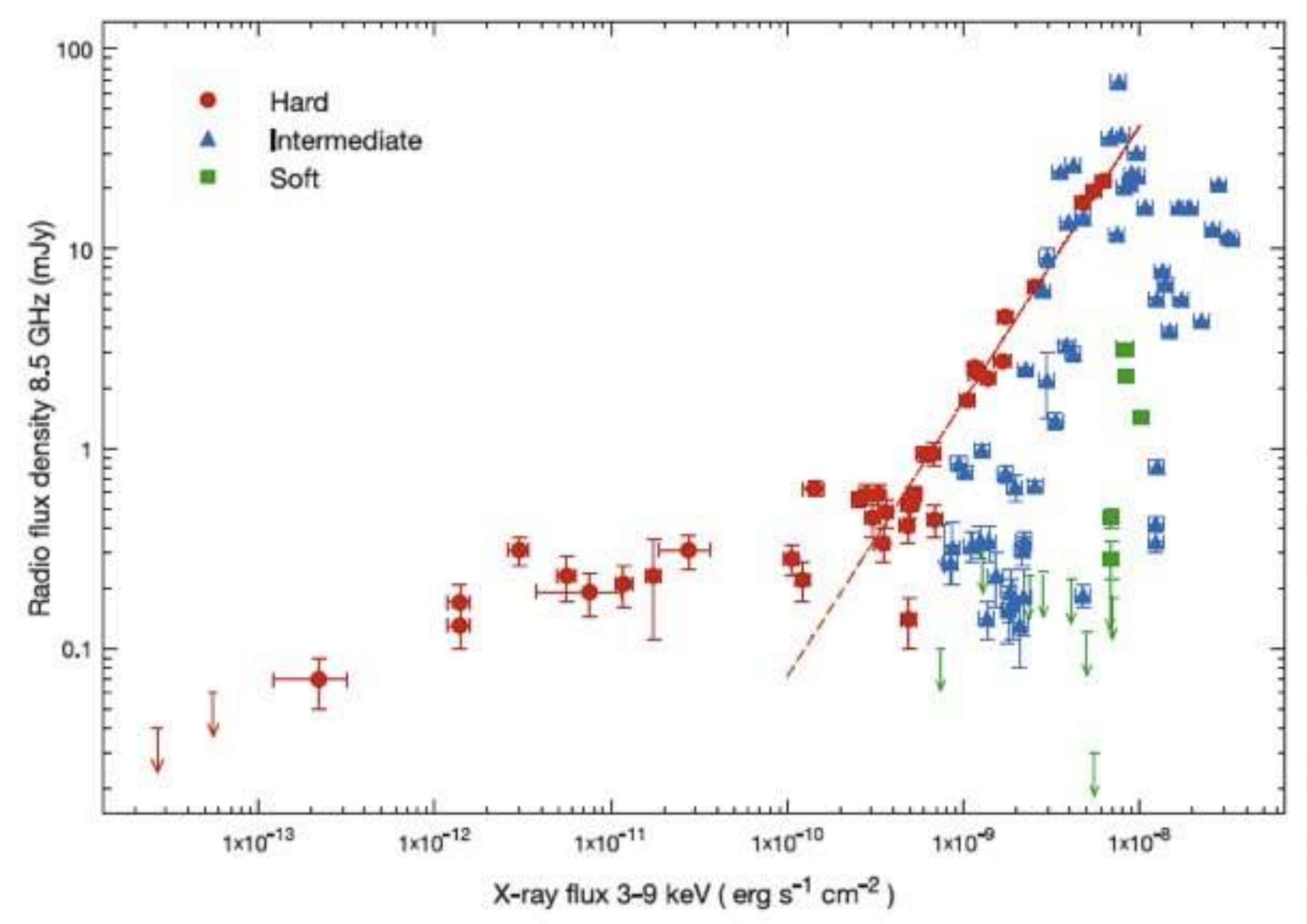
- Squares (open and filled) indicate the radio detections, plotted on top of the HIDs at the location of the nearest RXTE observation. Filled squares indicate the data selected for the radio/X-ray diagram.

STATES OF H1743-322

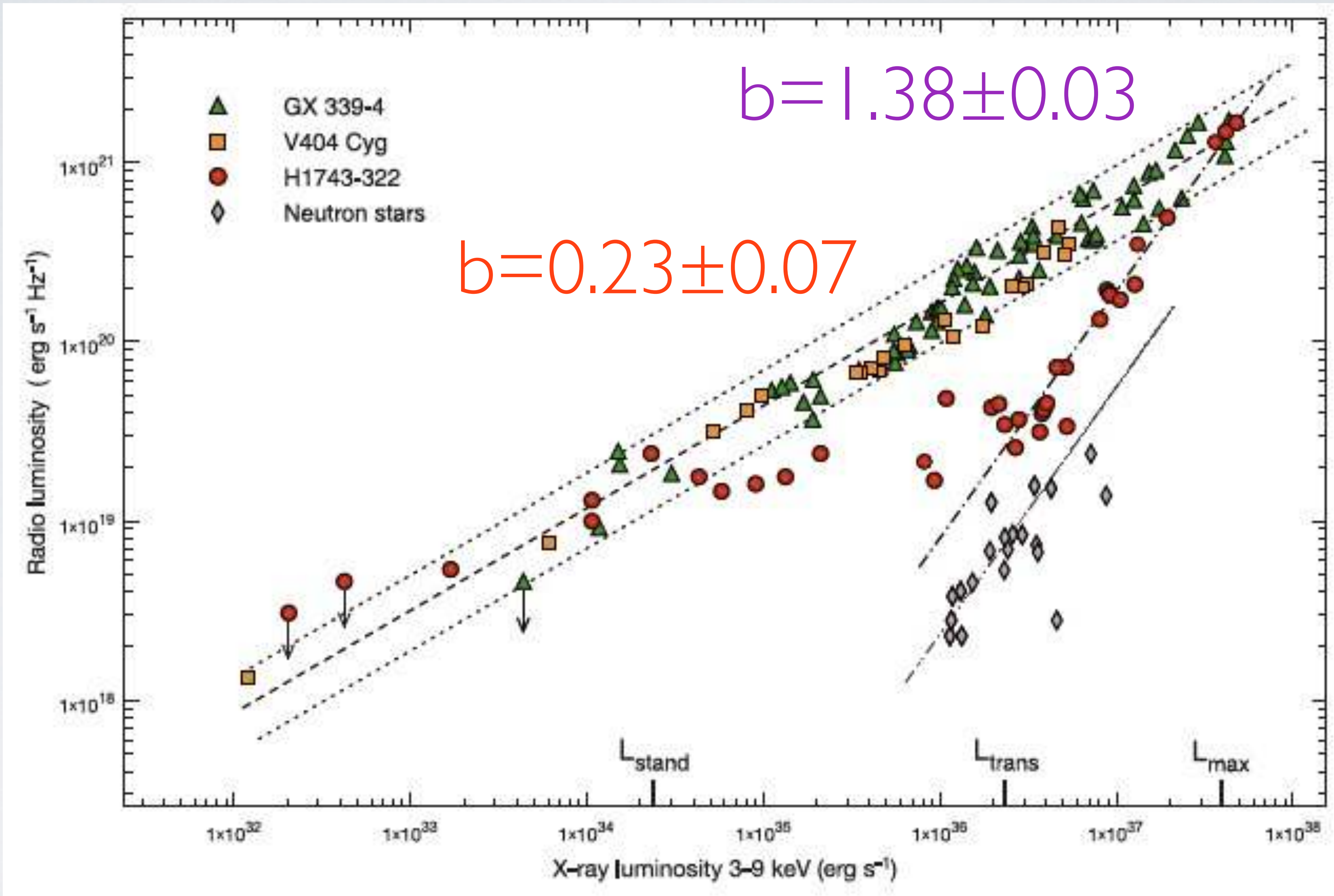
- Hard:
  the power-law component dominates the X-ray spectrum and a power-law photon index Γ<2

- Soft:
  a power-law photon index Γ>2 and a disc flux comprising > 75% of the 3-9 keV flux.

- Intermediate:
  all observations that do not correspond to either of these criteria.



RADIO/X-RAY BEHAVIOR



- 8.5 GHz radio luminosity against 3–9 keV X-ray luminosity. Transition at $L_X \sim 5\times10^{-3} L_{EDD}$ (2×10^{36} erg s^{-1}).

MODELS

- Radiatively efficient flow: $L_X \propto \dot{M}$
- Radiatively inefficient flow: $L_X \propto \dot{M}^{2\text{-}3}$ (dominated by advection)
- radio quiet or X-ray loud hypothesis?

X-RAY LOUD HYPOTHESIS

- Standard jet emission model:
  $Q_{acc} = \dot{M}c^2$; $Q_{jet} = f_j\, Q_{acc}$
  Assuming Synchrotron emission:
  $L_{jet} \propto Q_{jet}^{\xi}$
  $\xi = [2p-(p+6)a+13] / 2(p+4)$
  α is the spectral index of the jet spectrum,
  an initial energy distribution of relativistic electrons in the form of a power law with index p.

- $L_{radio} \propto \dot{M}^{\xi}$ if f_j is a constant and assuming $L_X \propto \dot{M}^q$
  $L_{radio} \propto L_X^{\xi/q}$
  fiducial value: p=2~3, α=-0.2~2 => ξ~1.4

- 1) $L_{radio} \propto L_X^{0.6}$ => q~2-3 => $L_X \propto \dot{M}^{2-3}$(radiatively efficient)
  2) $L_{radio} \propto L_X^{1.4}$ => q~1 => $L_X \propto \dot{M}$ (radiatively inefficient)

RADIATIVE EFFICIENT AT LHS

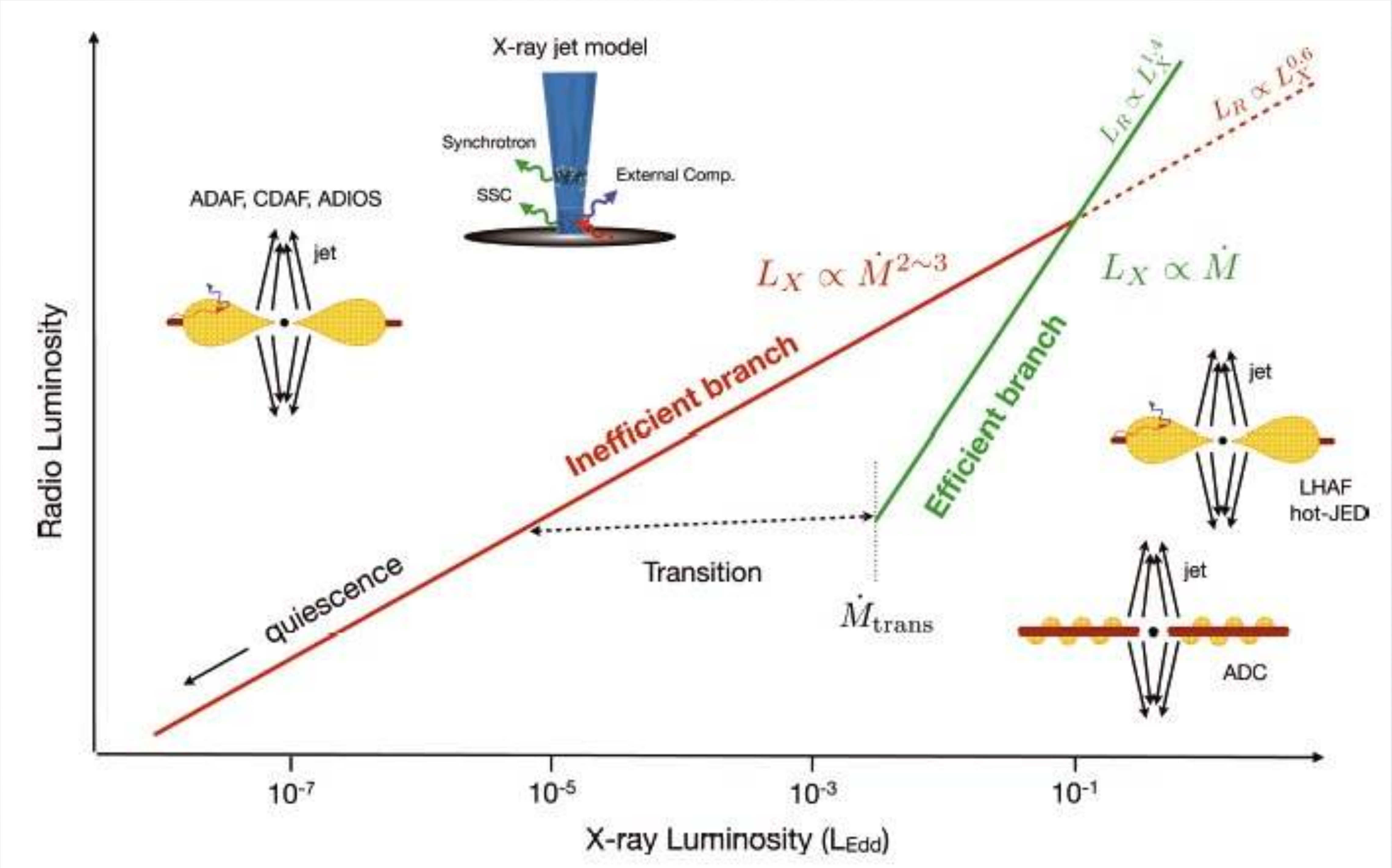
- Where is the X-ray come from?
- Extended ADAF in the high accretion rate regime: Luminous hot accretion flow
- Accretion disk corona
- Geometry of the corona/accretion flow?

RADIO QUIET HYPOTHESIS

- $Q_{jet} = f_j \, Q_{acc}$
  f_j depends on accretion rate:
  $f_j \propto \dot{M}$ => $L_{radio} \propto L_X^{2\xi/q}$ => q~1 (radiatively inefficient)

- Jet launching mechanism, magnetic field strength in the jet, ...

GENERAL PICTURE



THANK YOU!