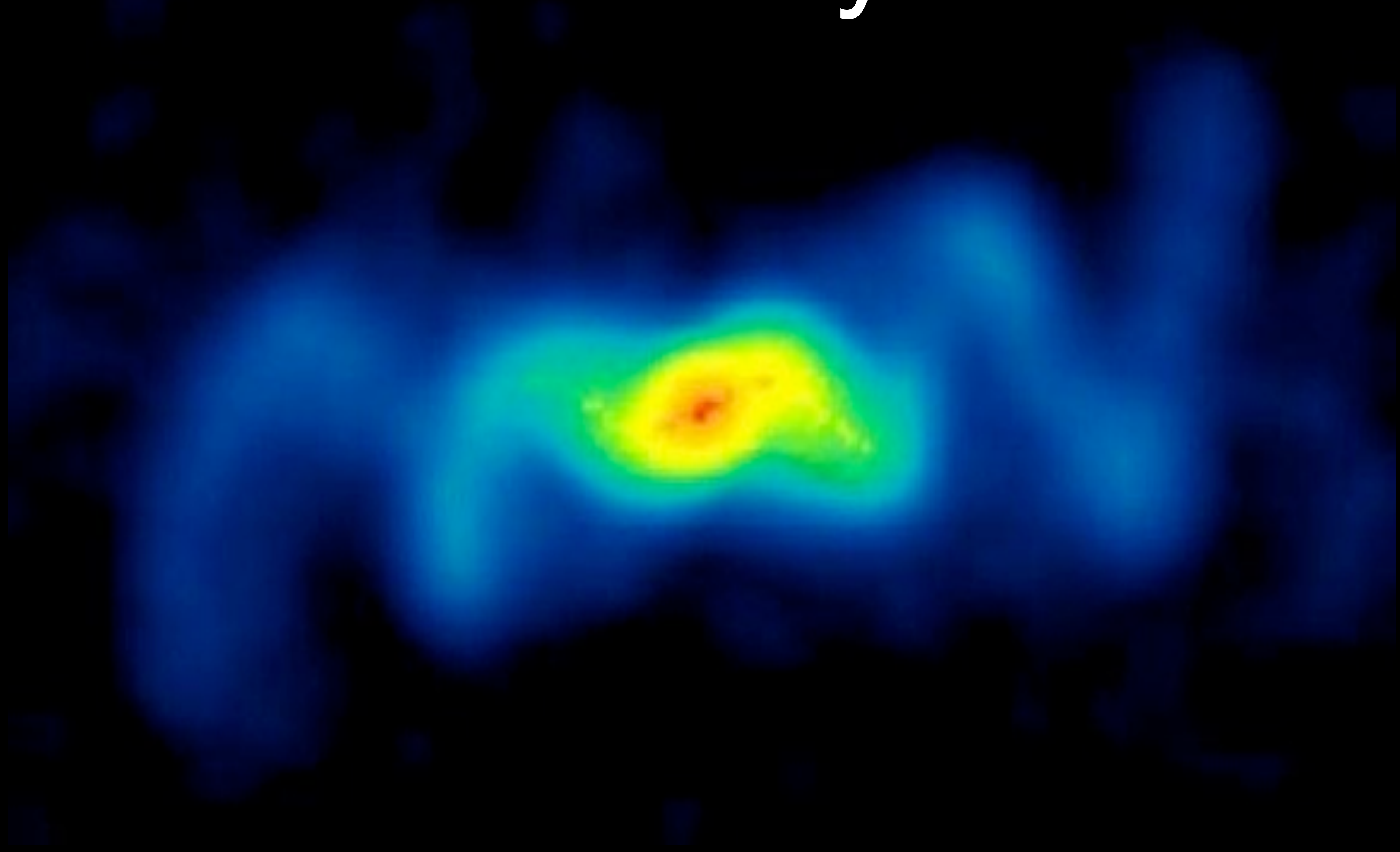
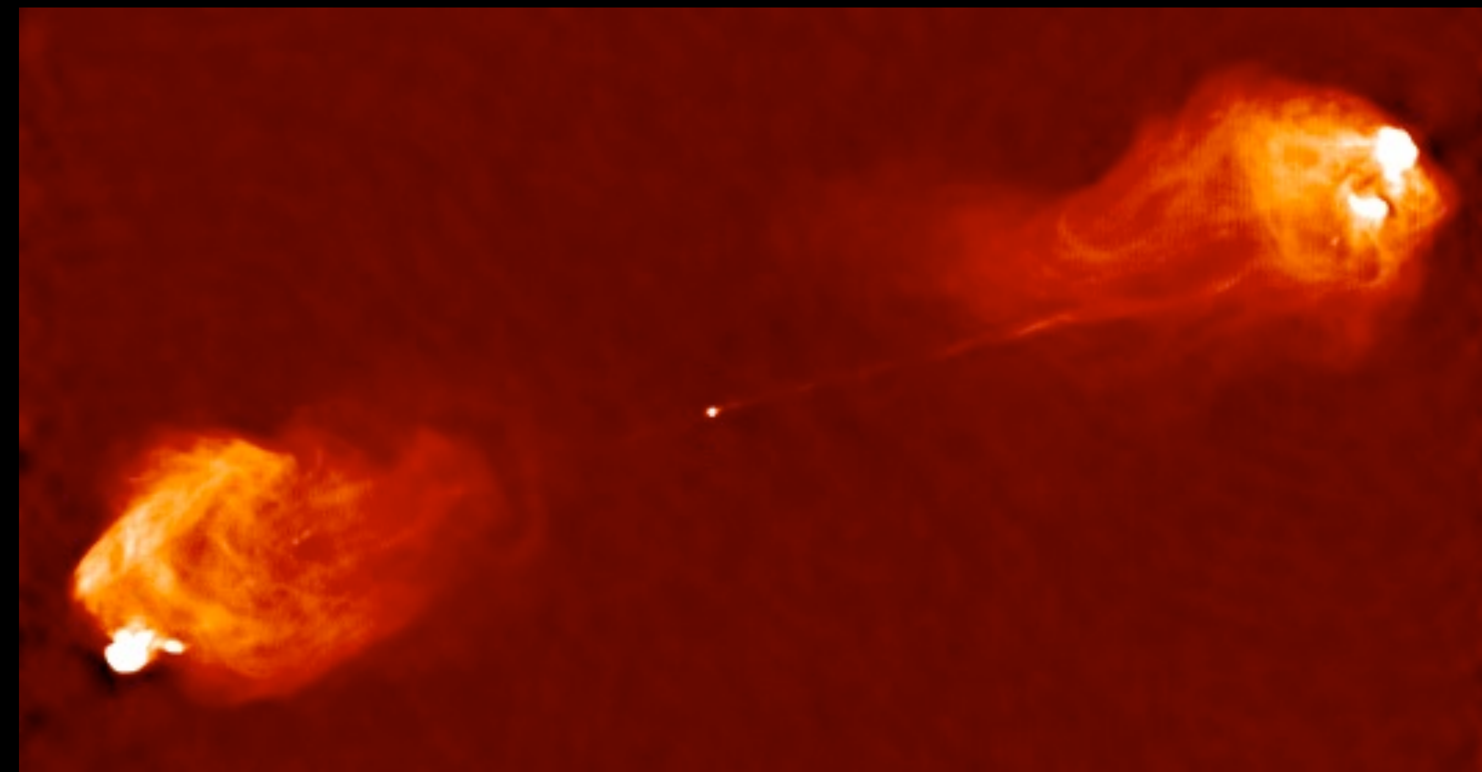
Jets from X-ray binaries



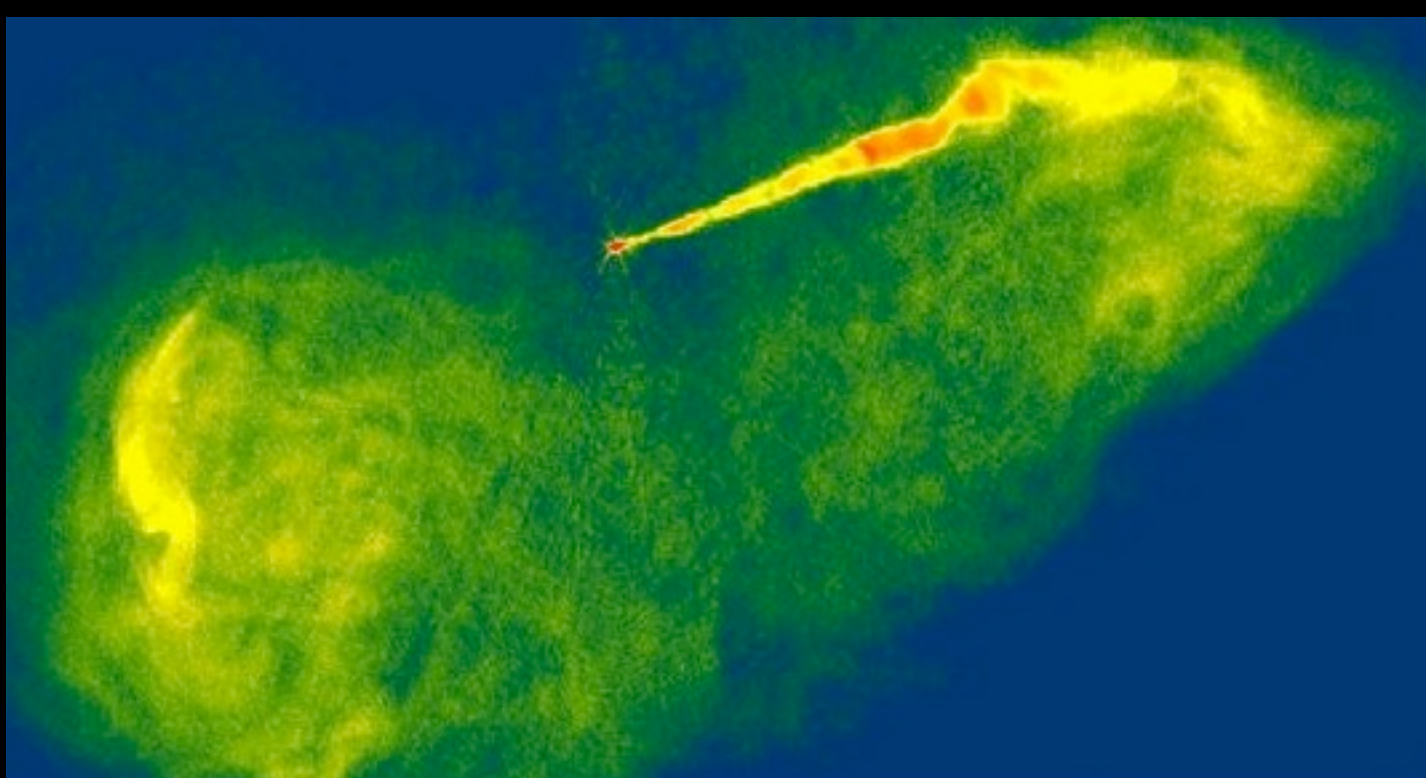
Simone Migliari
ESAC

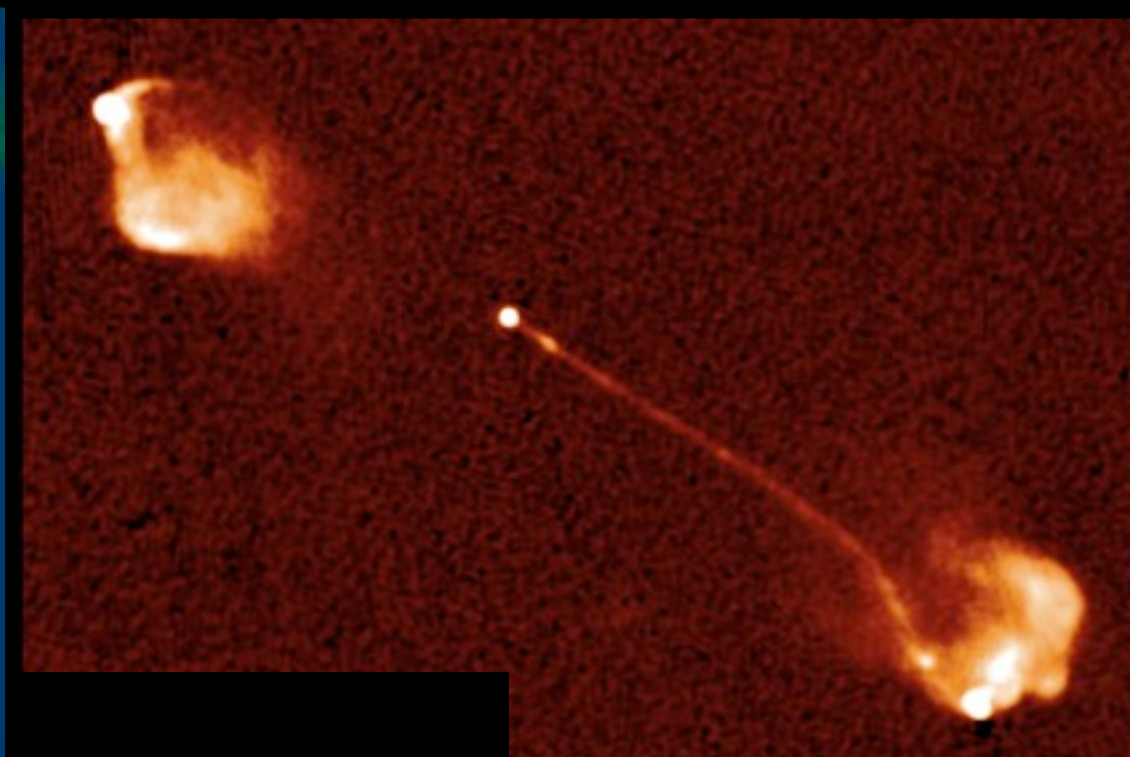
“Jets are possibly the most spectacular and powerful phenomena in astrophysics; they are ubiquitous in the universe, common to a number of different accreting systems”

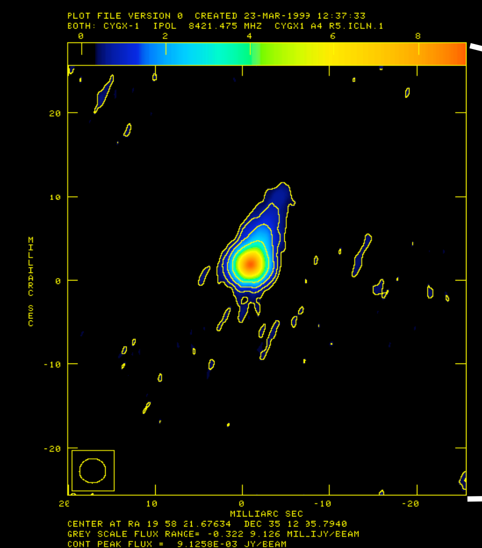
“Jets are possibly the most spectacular and powerful phenomena in astrophysics; they are ubiquitous in the universe, common to a number of different accreting systems”



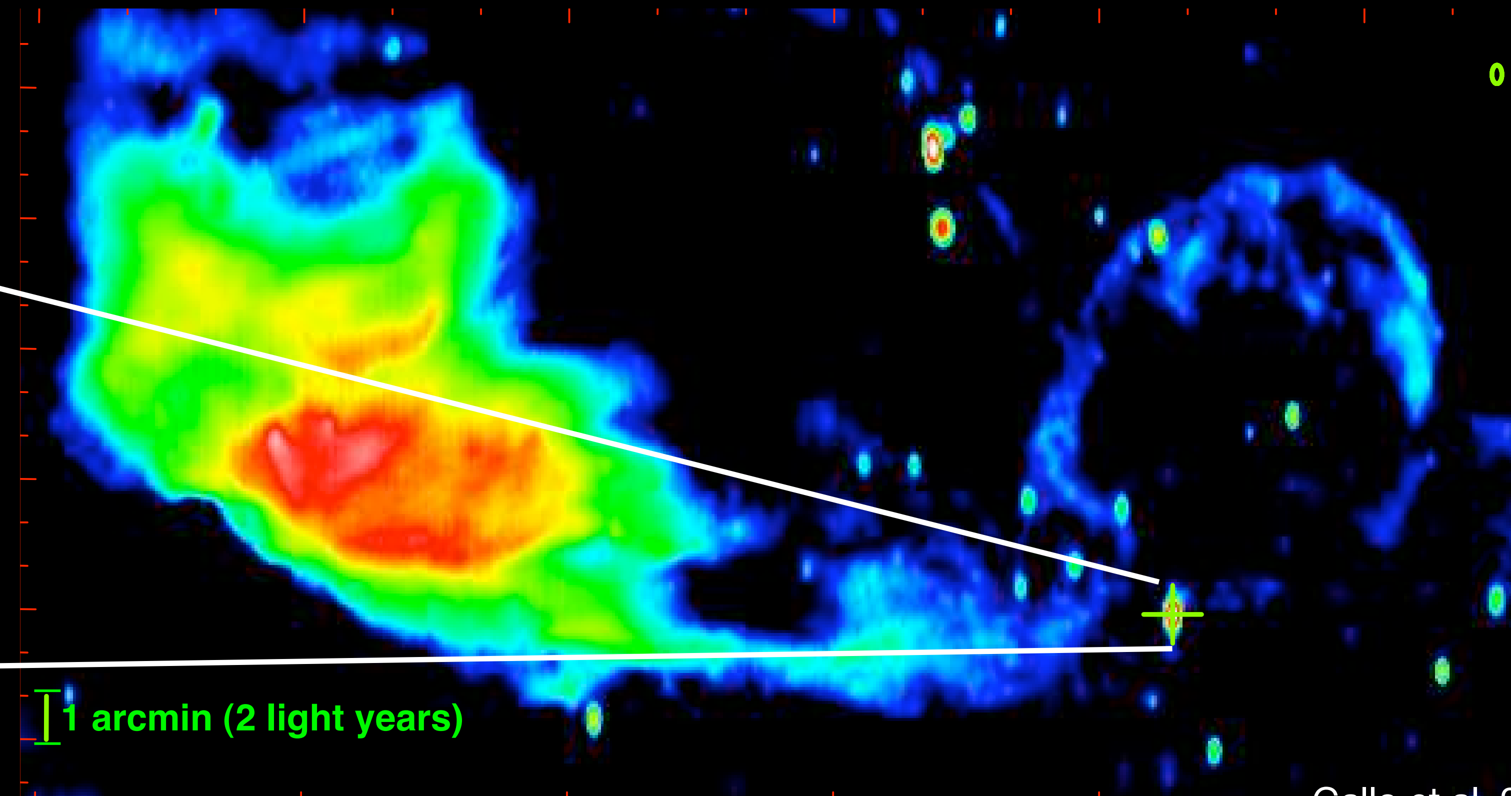
spectacular





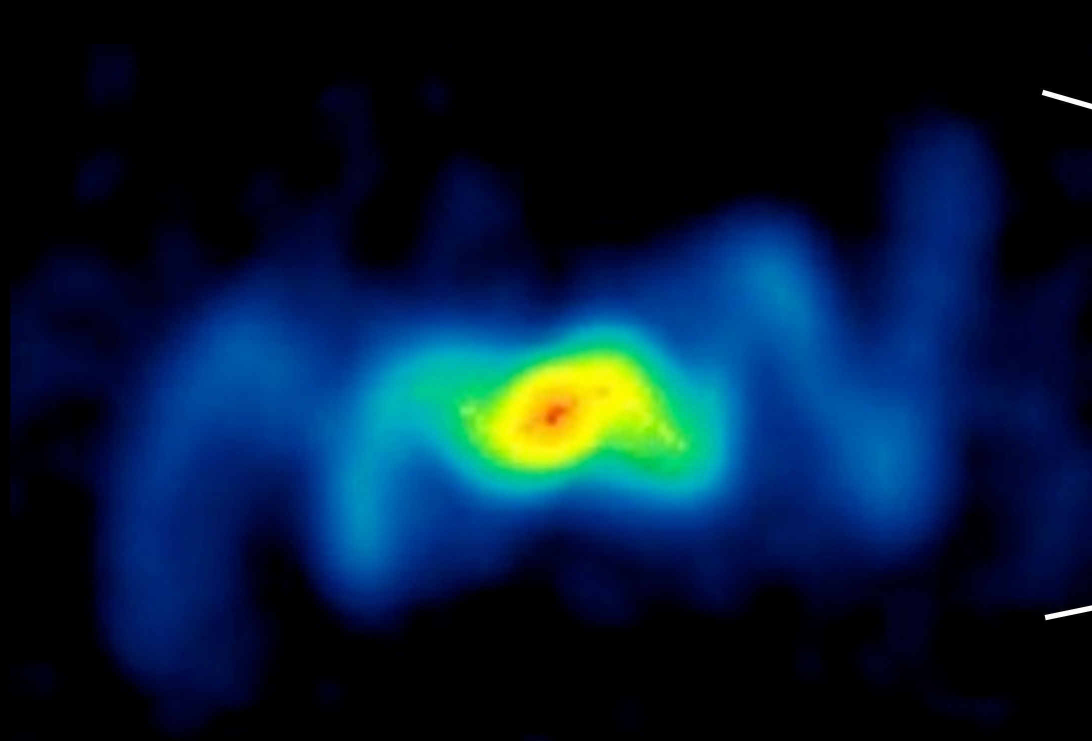


Stirling et al 2001

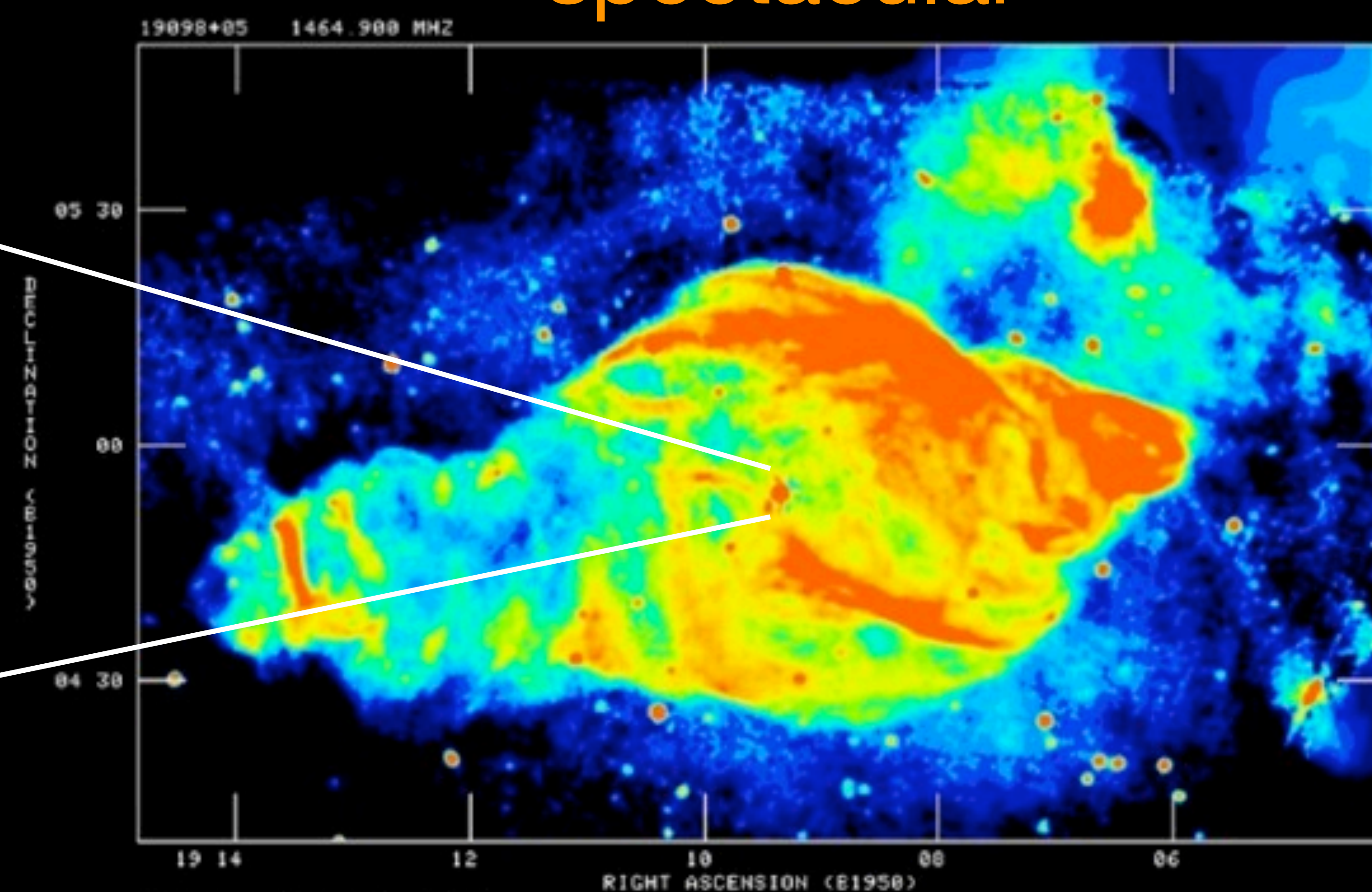


Gallo et al. 2005

spectacular

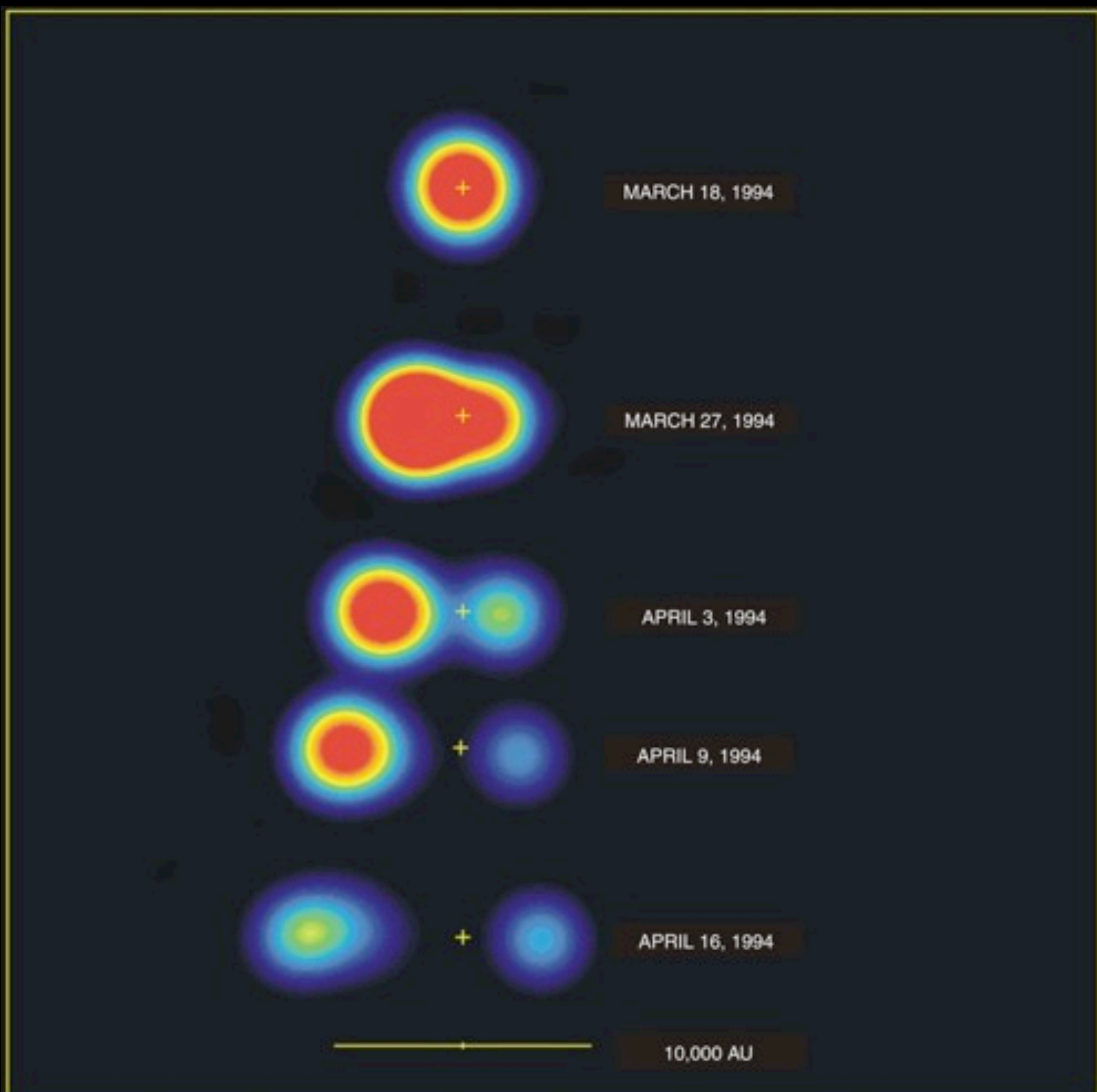


Miller-Jones, Migliari et al. 2007

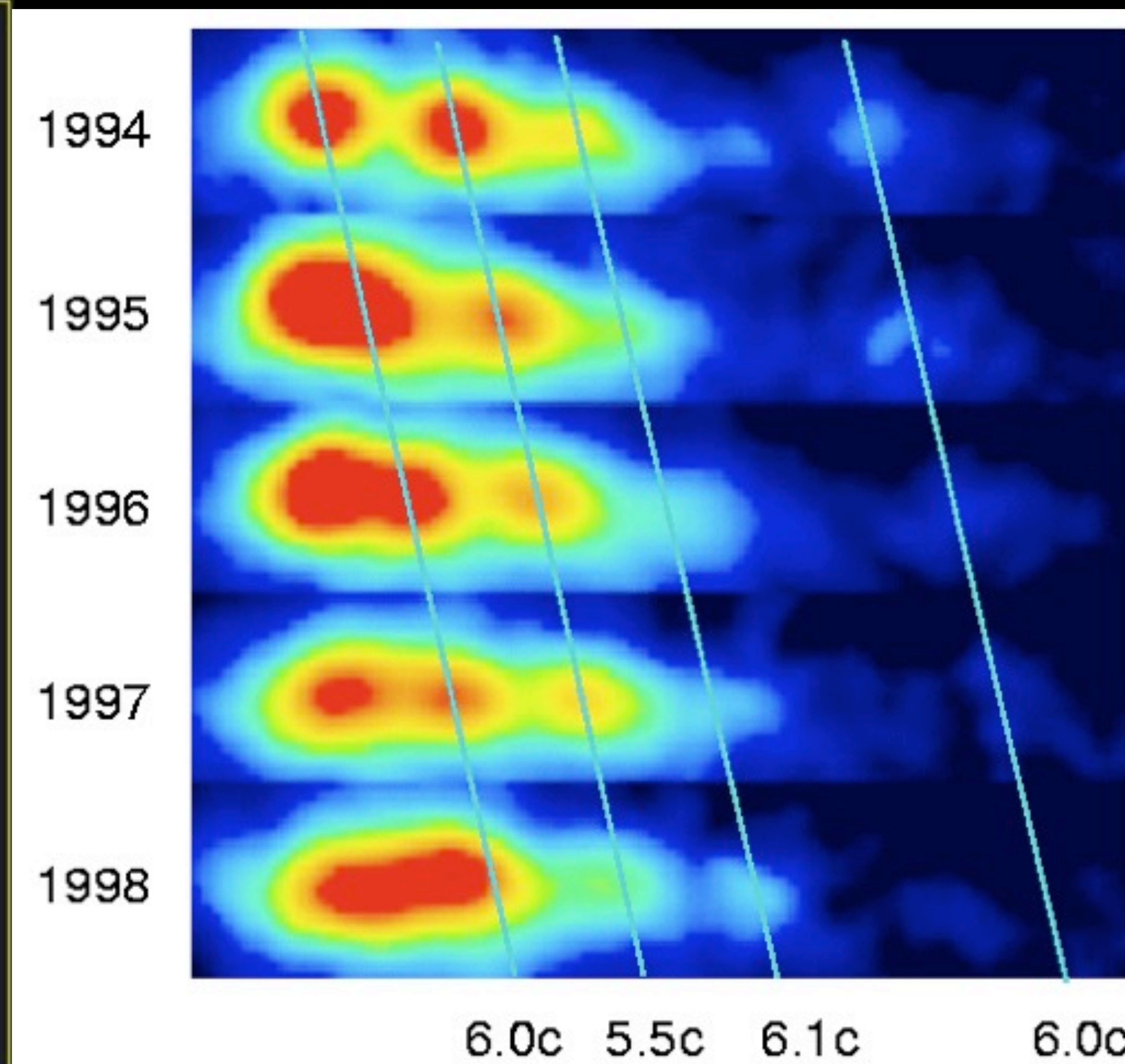


Powerful

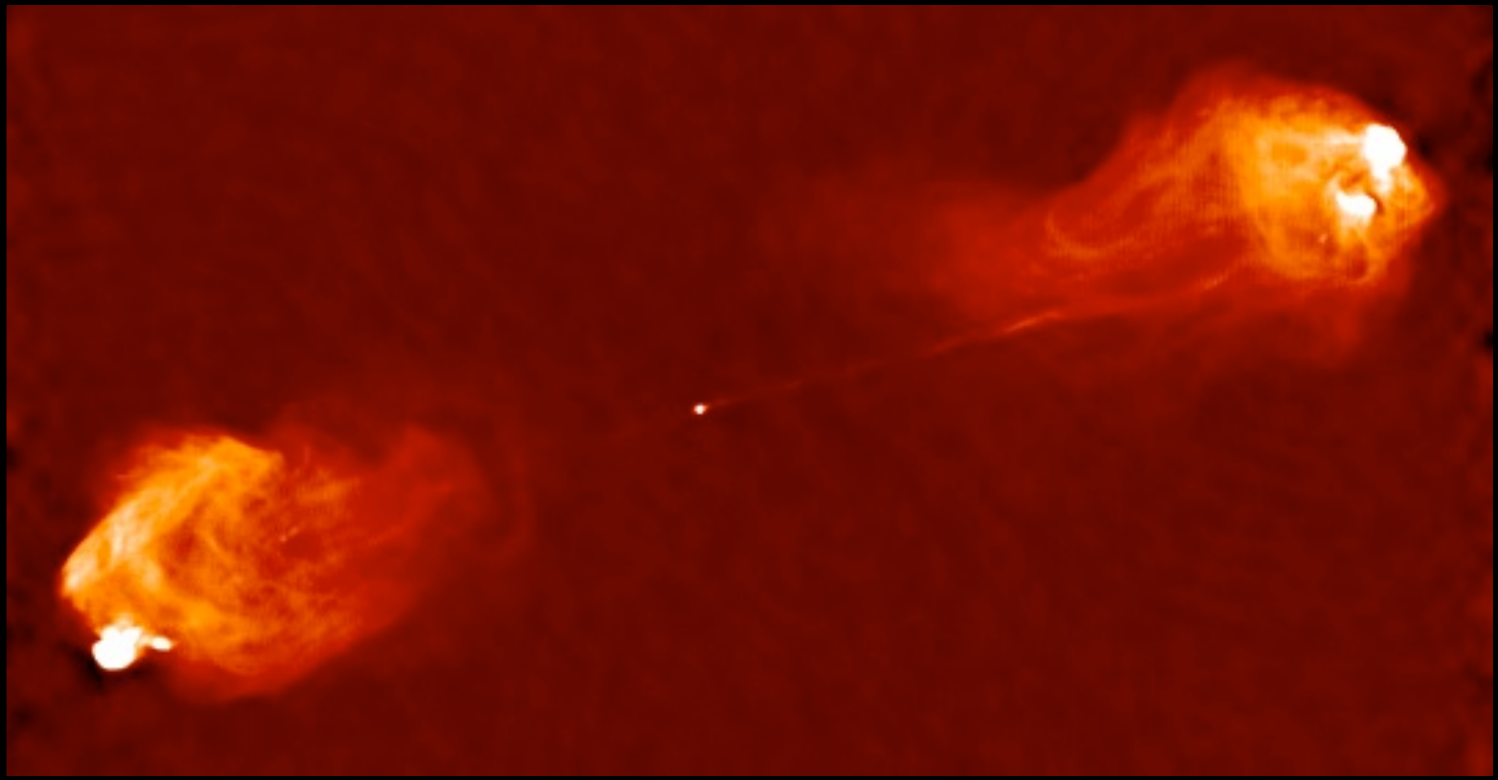
Special relativity in action



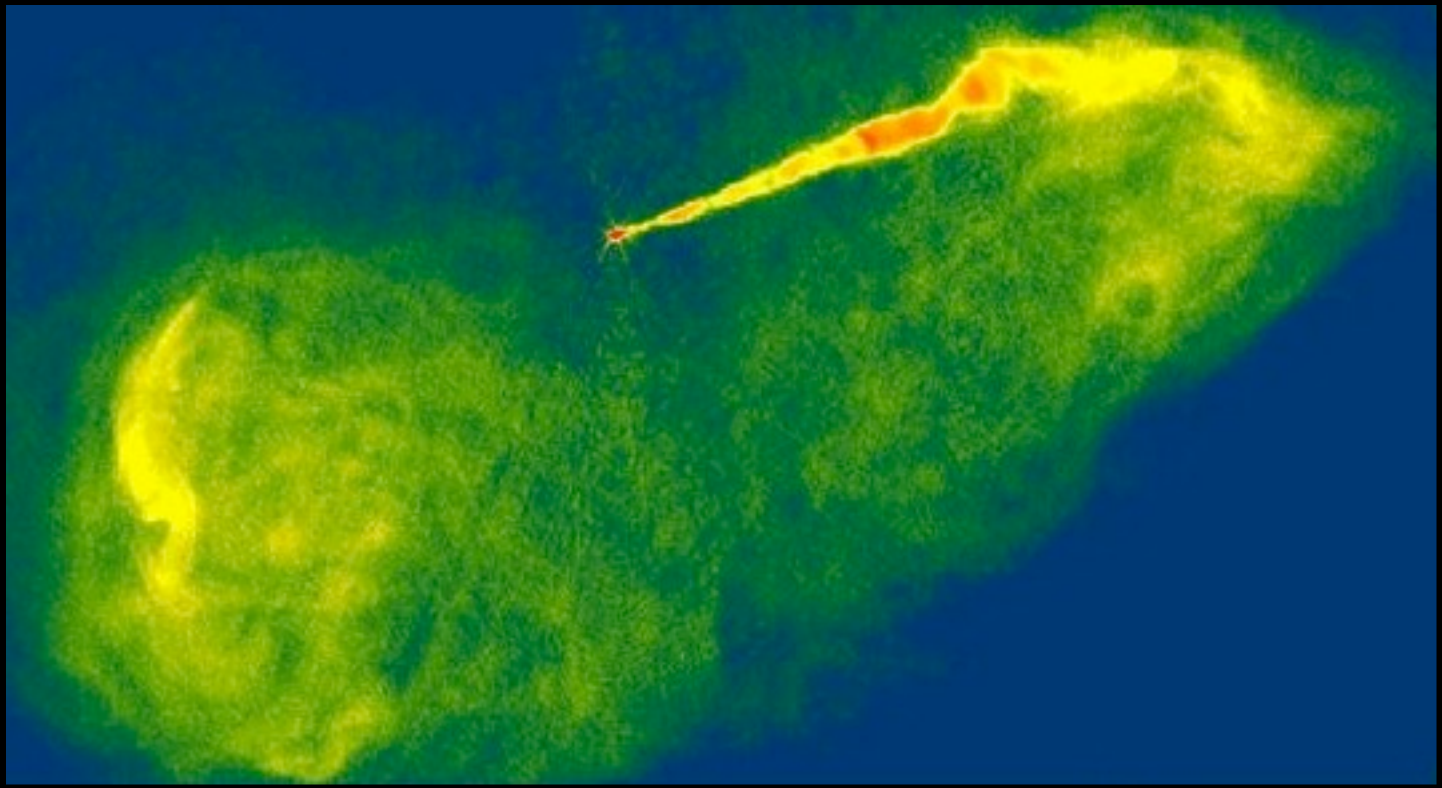
Mirabel & Rodriguez 1992



Biretta et al. 1999

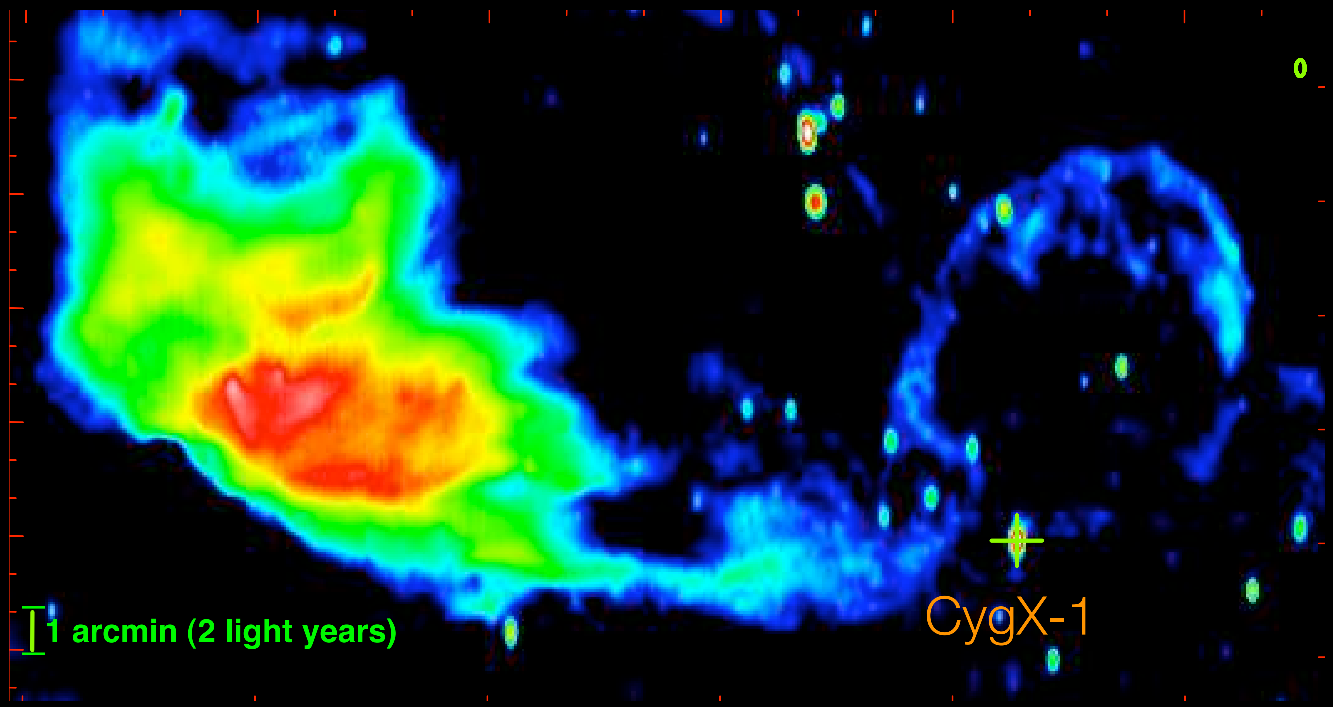


powerful

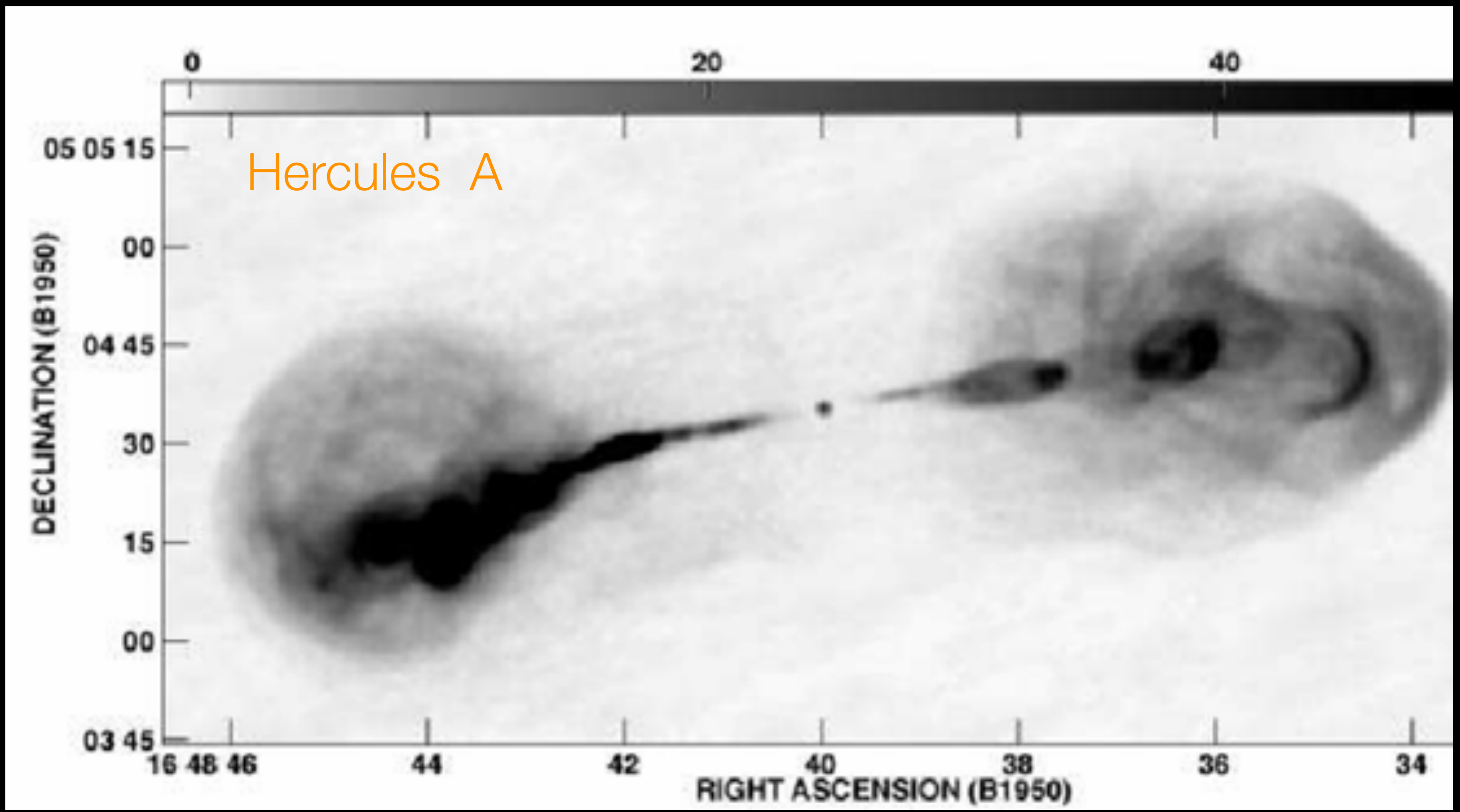


Powerful

Gallo et al. 2005

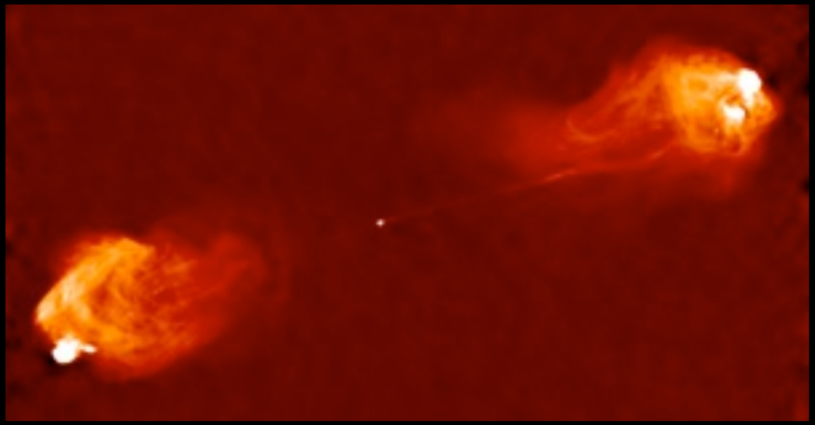


>20% Accreting Power

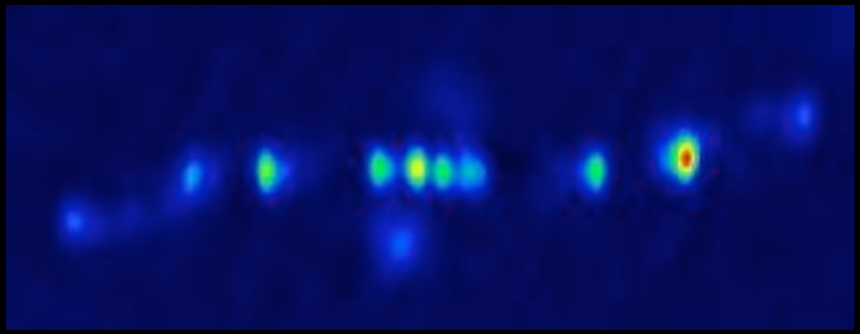


Gizani et al. 2002

AGN



X-ray binaries



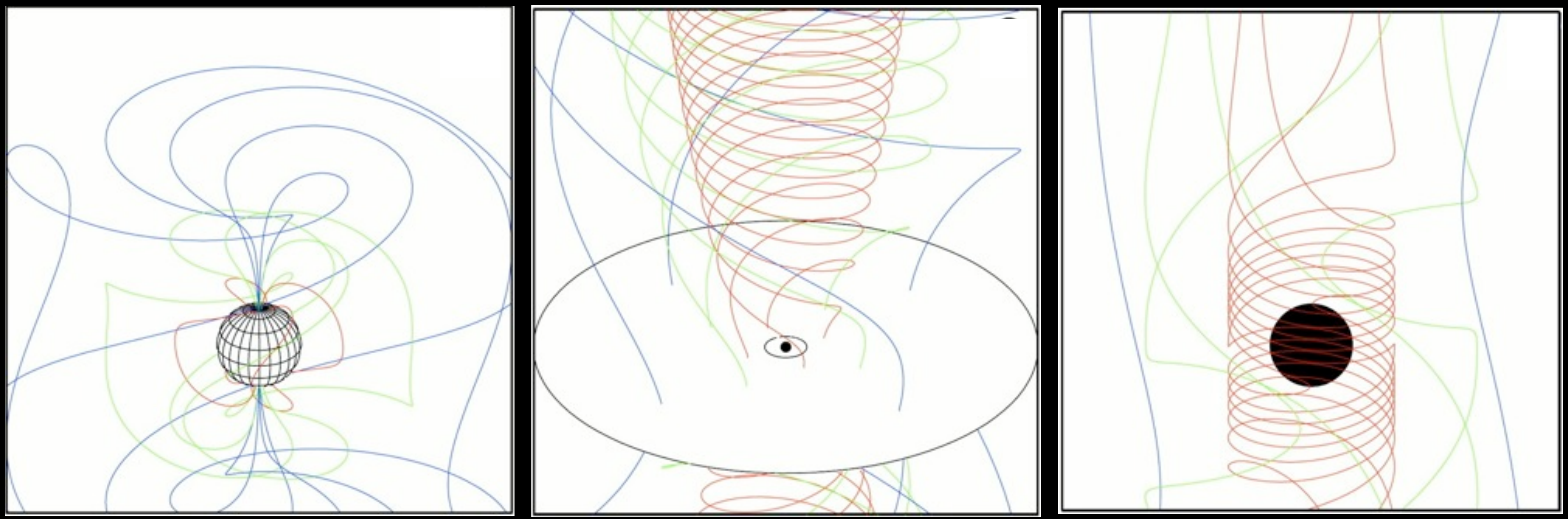
WD binaries

YSOs

Ubiquitous

“Jets are possibly the most spectacular and powerful phenomena in astrophysics; they are ubiquitous in the universe, common to a number of different accreting systems”

“However, the mechanism(s) of jet production is still poorly understood”



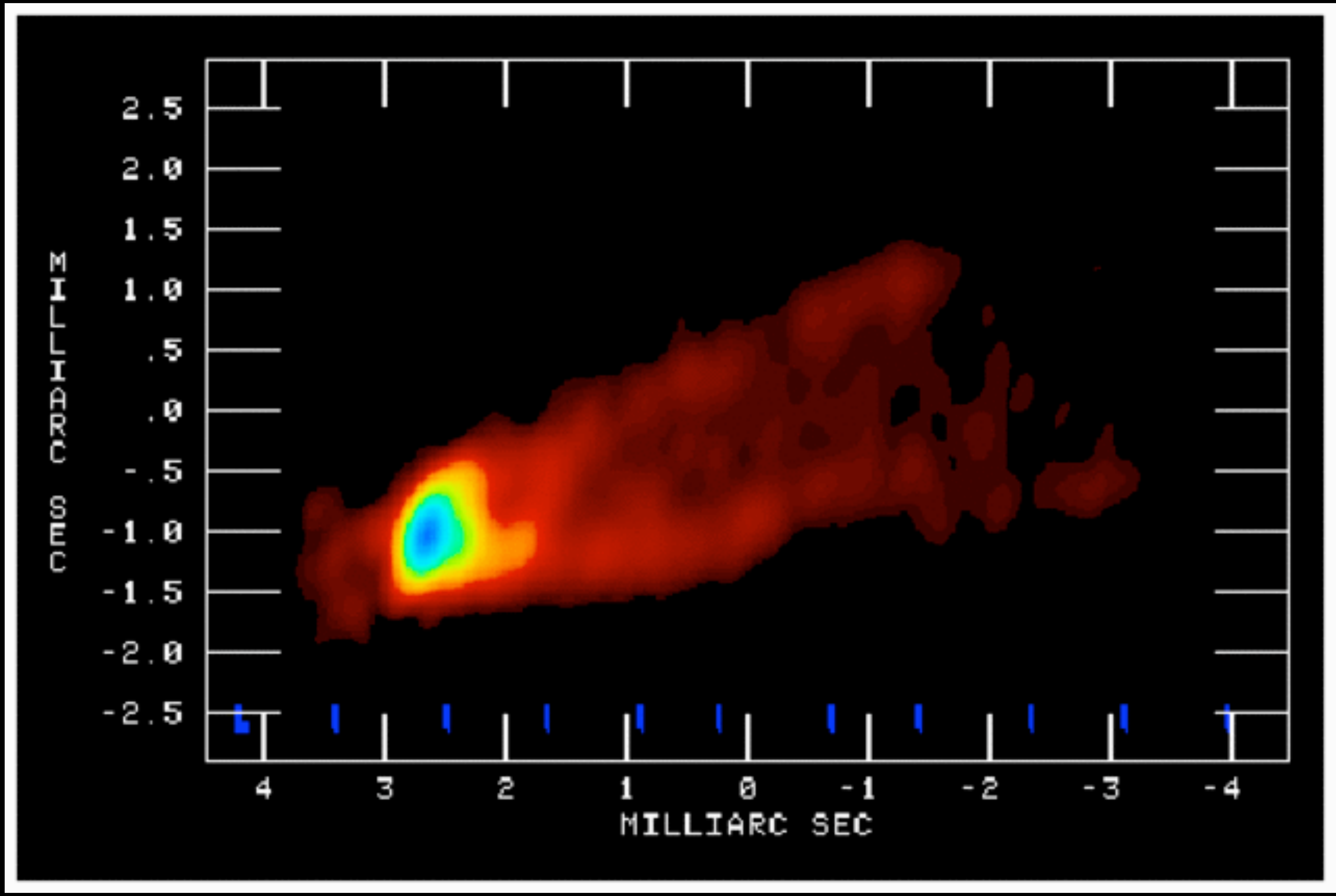
Meier et al. 2001

Which parameters are involved in jet formation?

$\dot{M}$

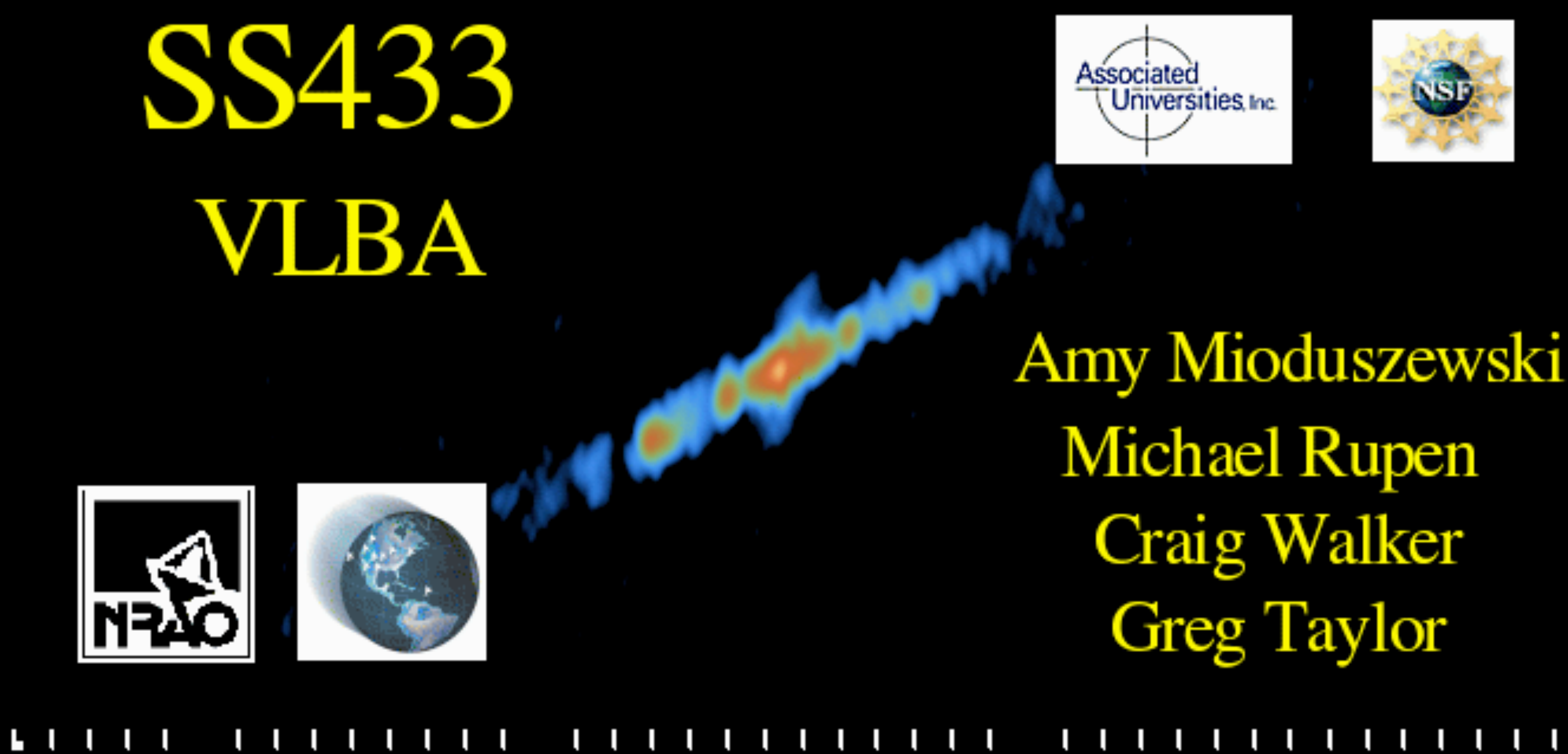
Accreting Object

M87: 1 yr

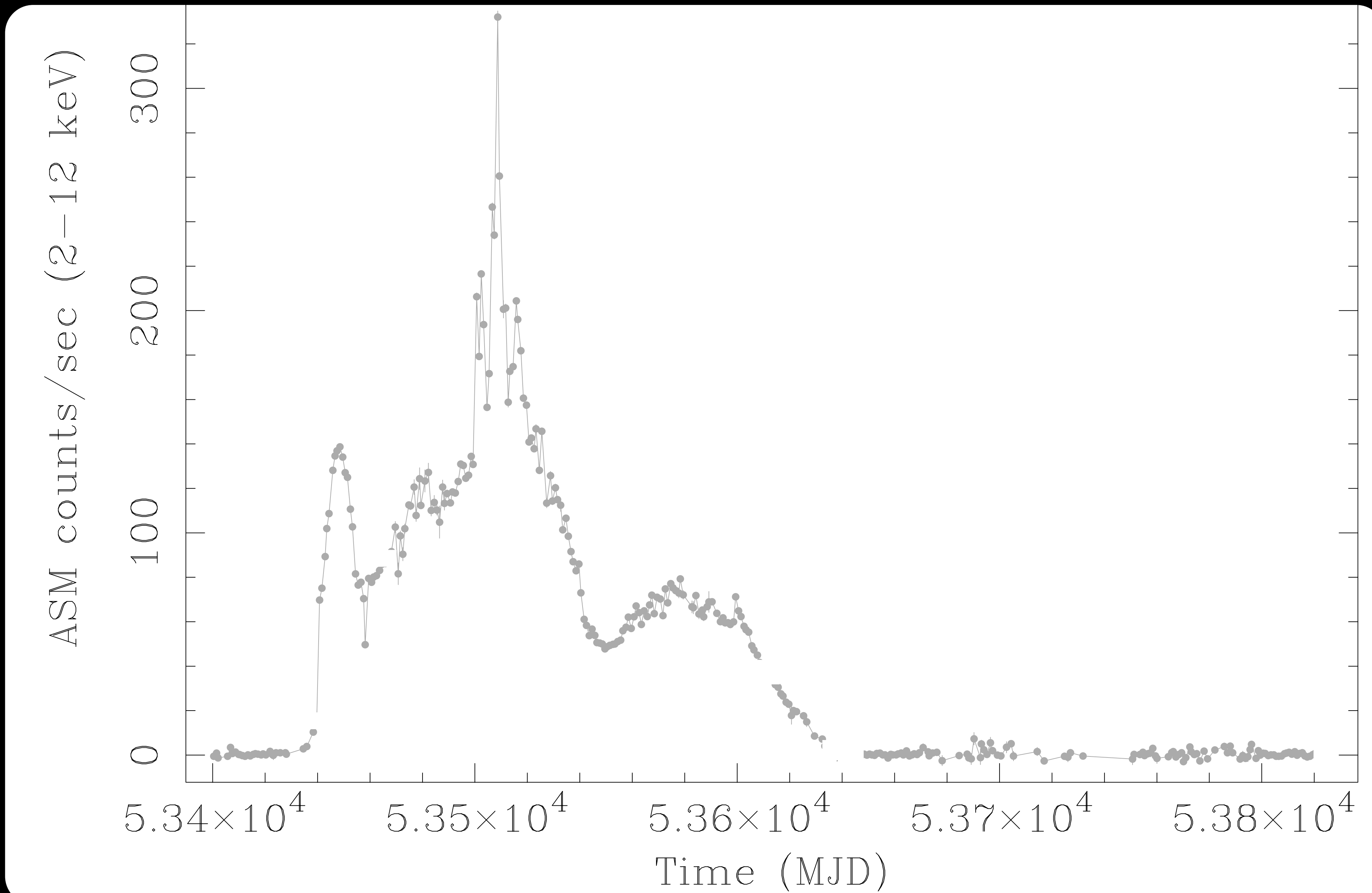


Walker et al.

X-ray binary: 42 days

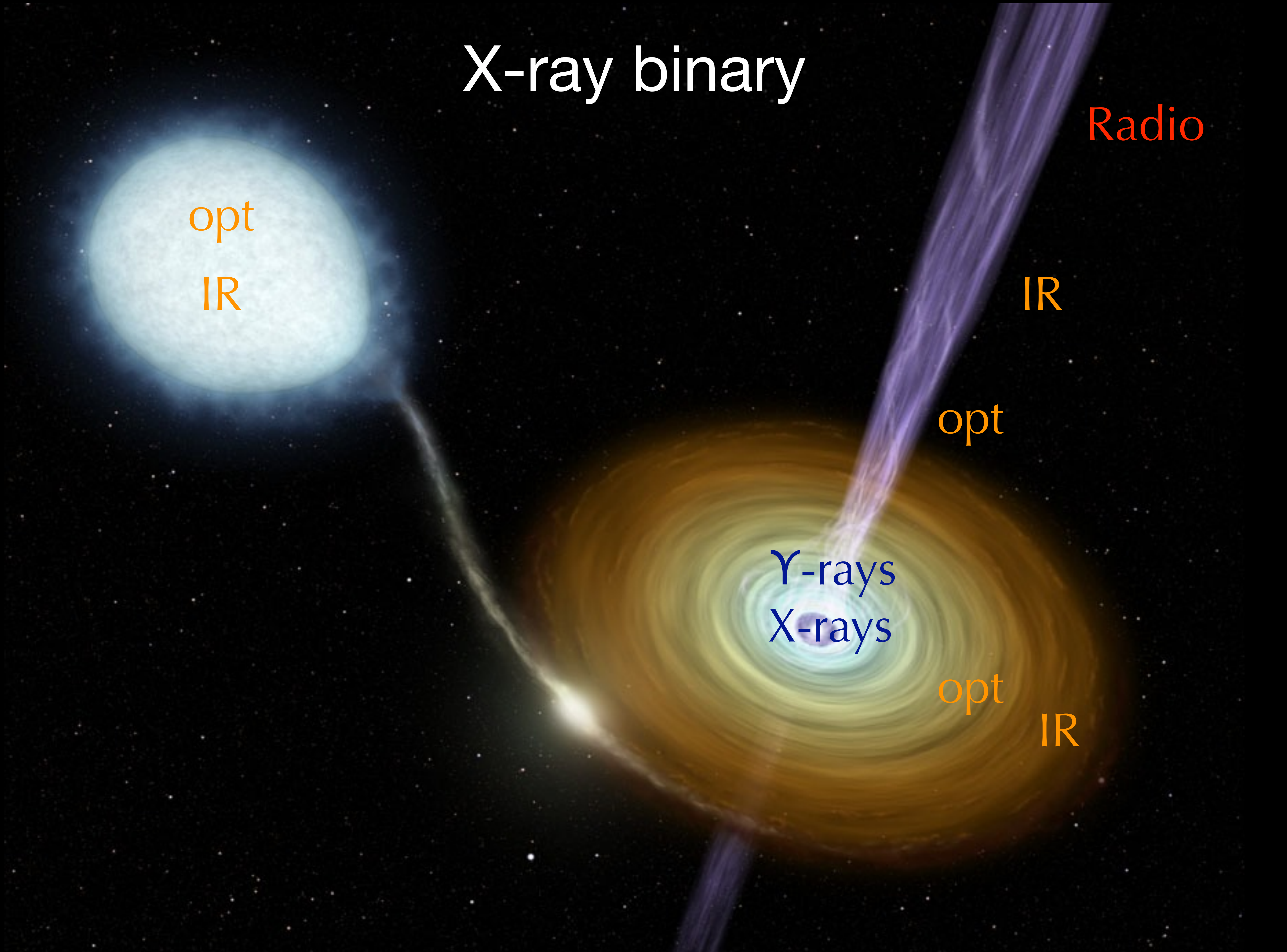


outburst: accretion disc variability



Migliari et al. 2007

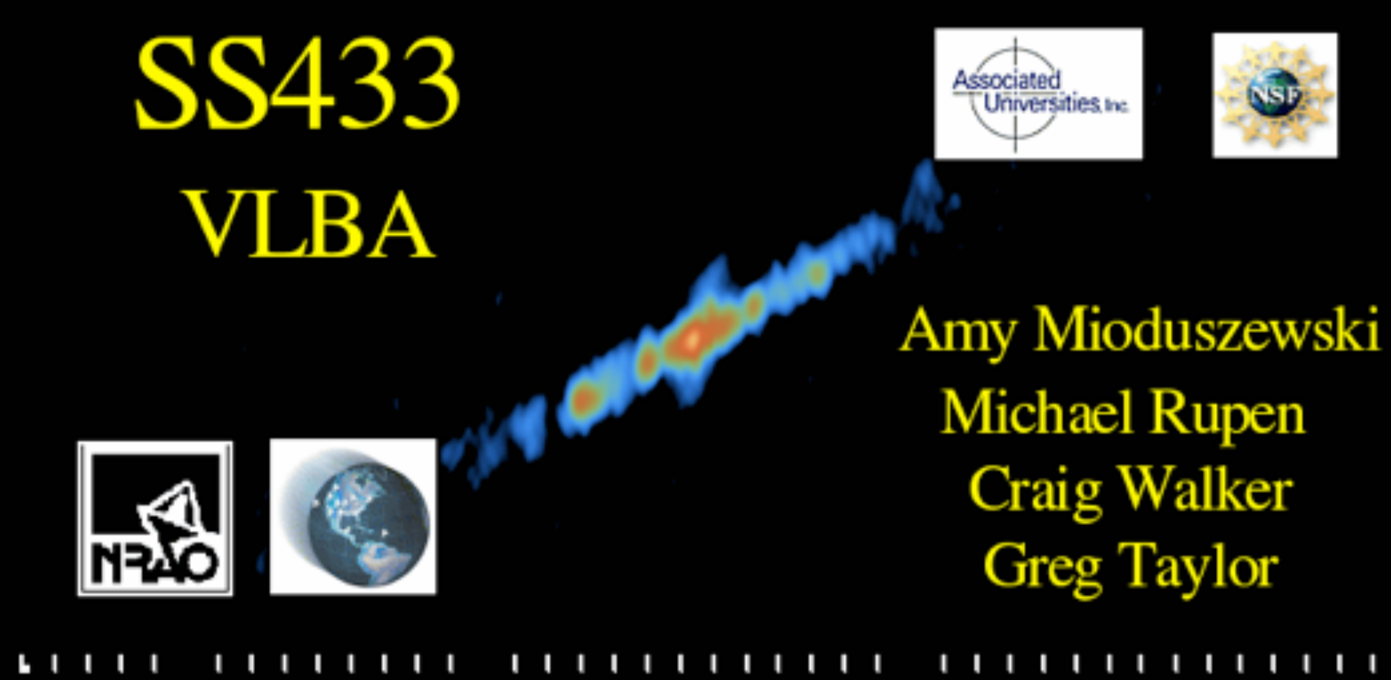
X-ray binary

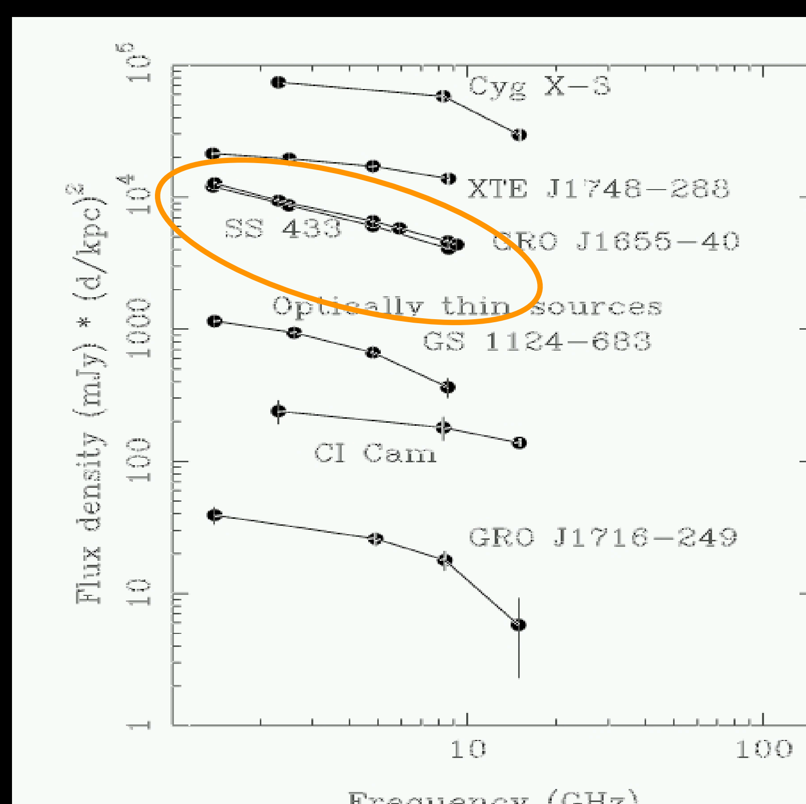


BH X-ray binaries

Two types of jets

transient

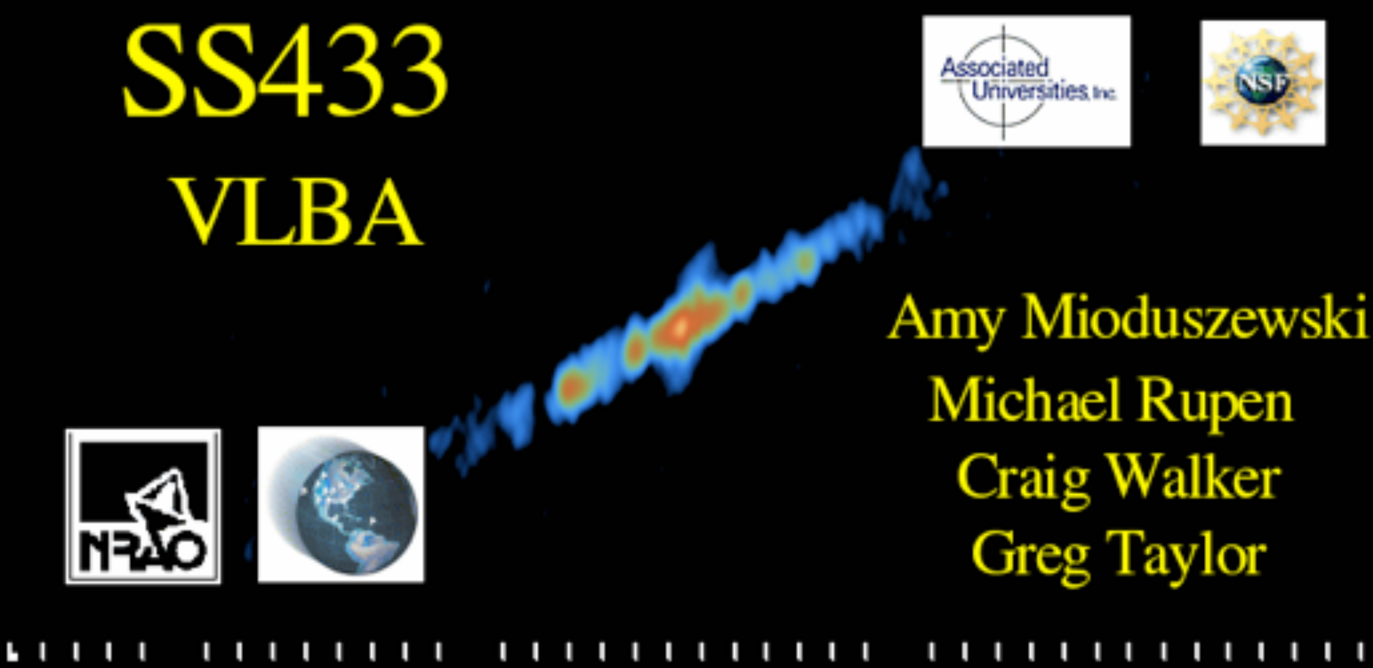




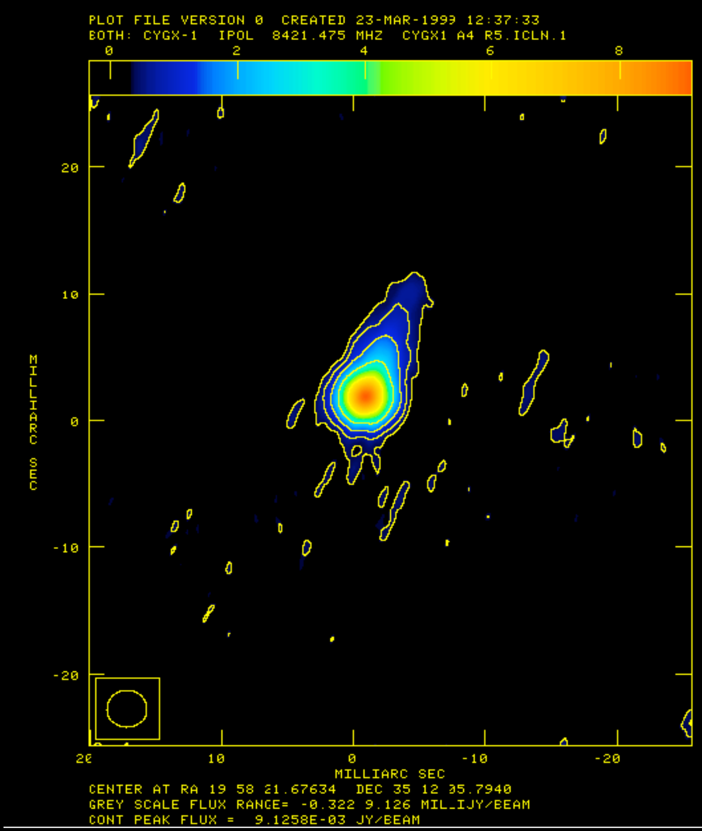
Fender 2000

Two types of jets

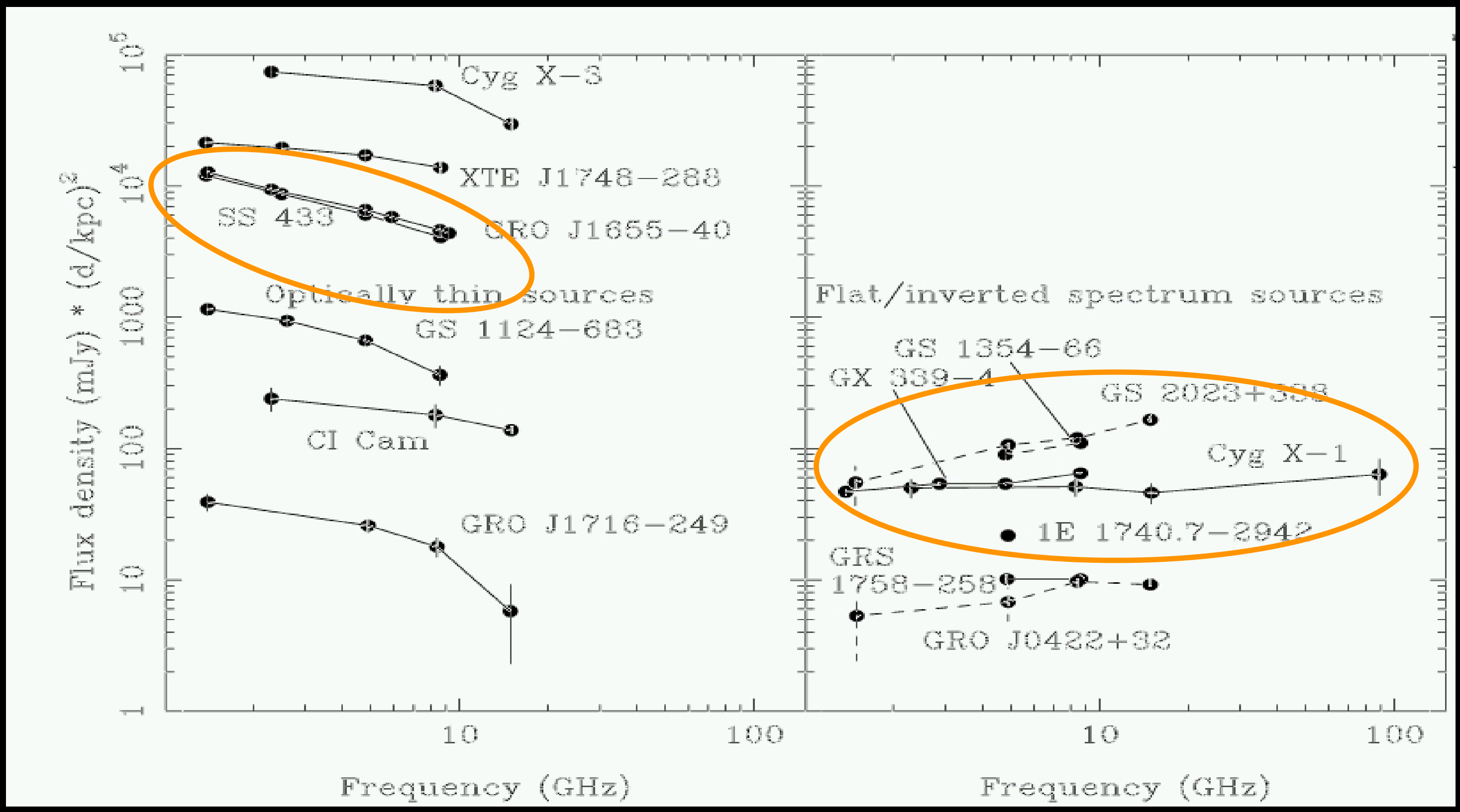
transient



compact



Starling et al. '01



Fender 2000

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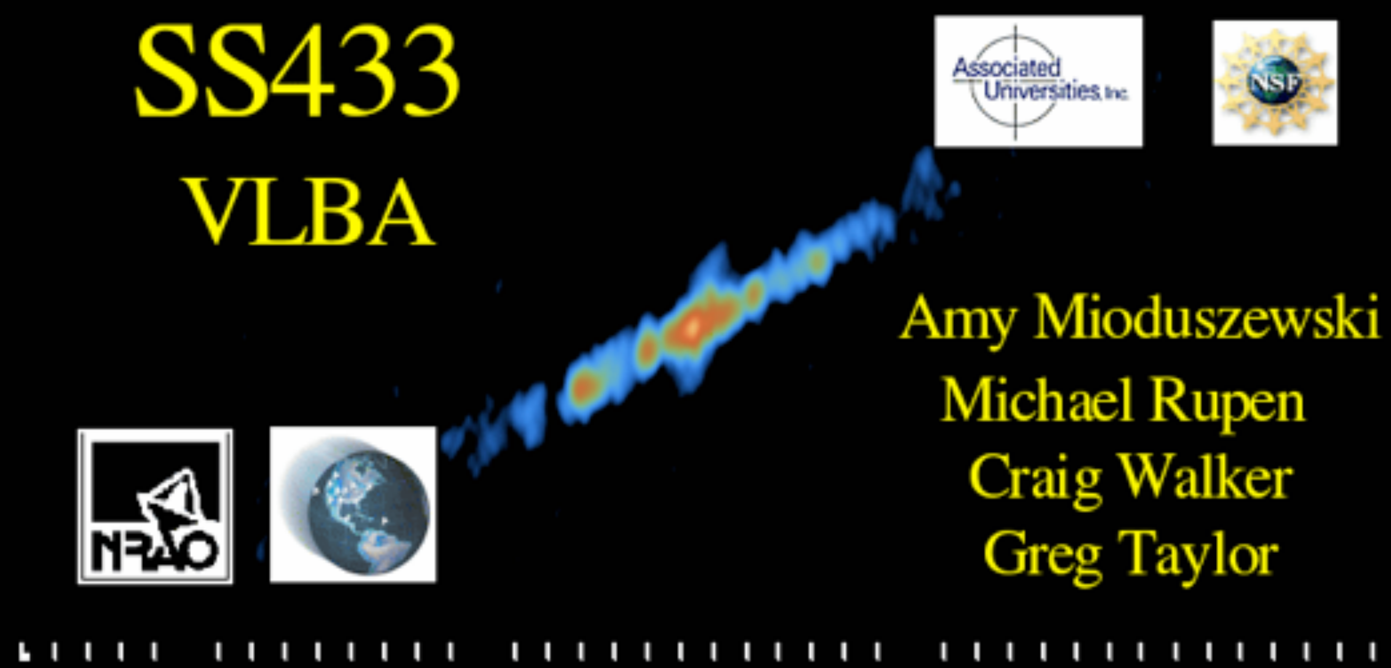

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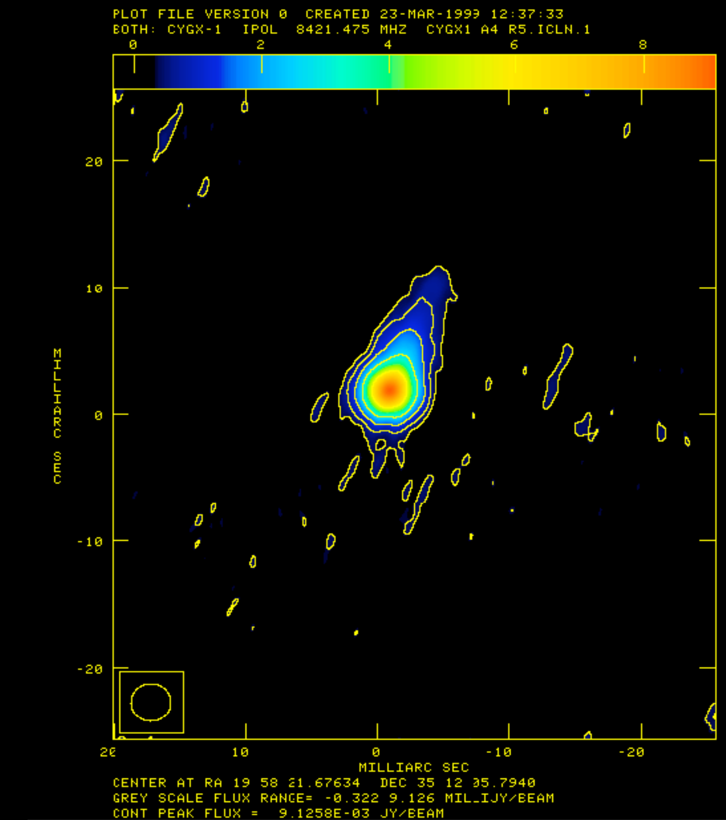
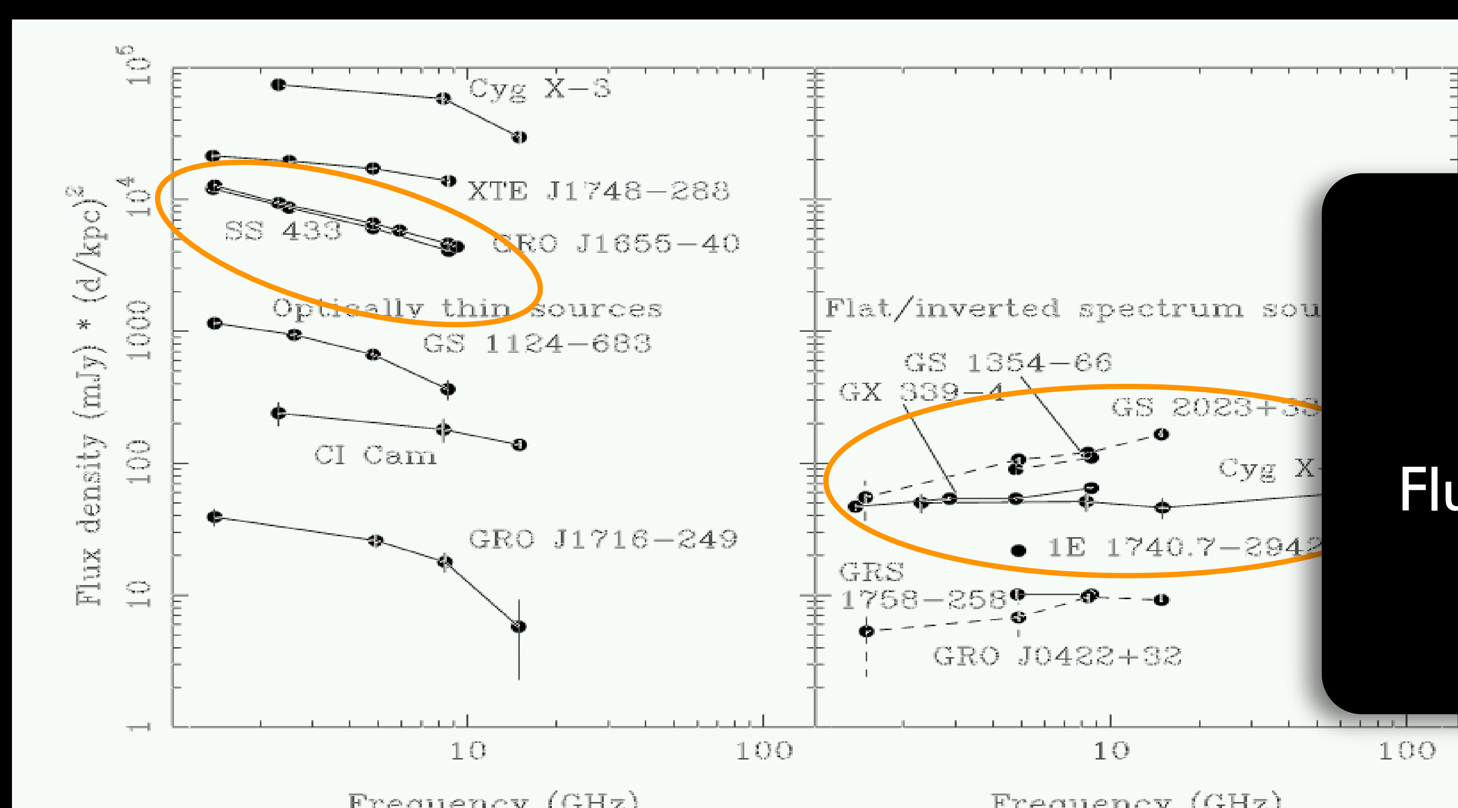
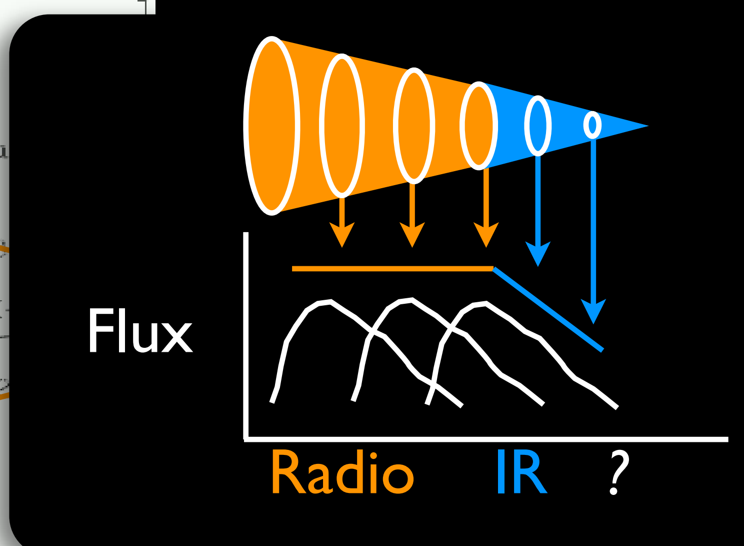
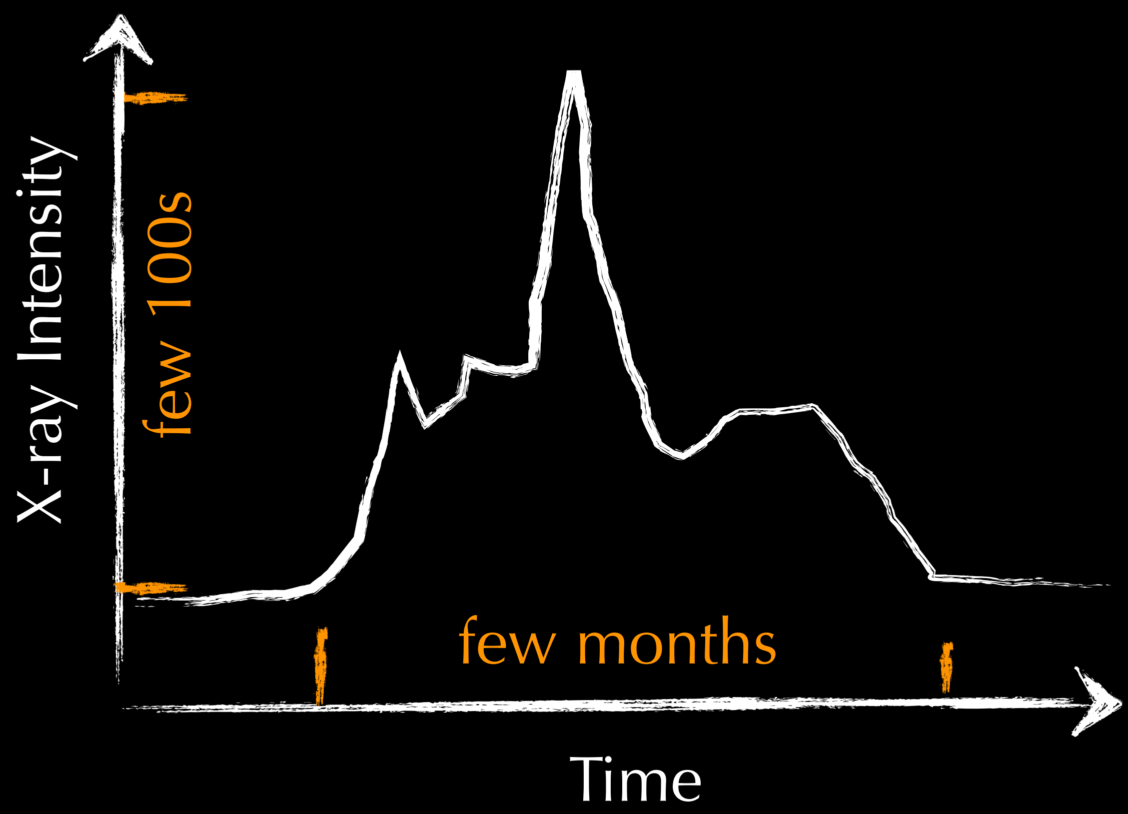


Starling et al. '01

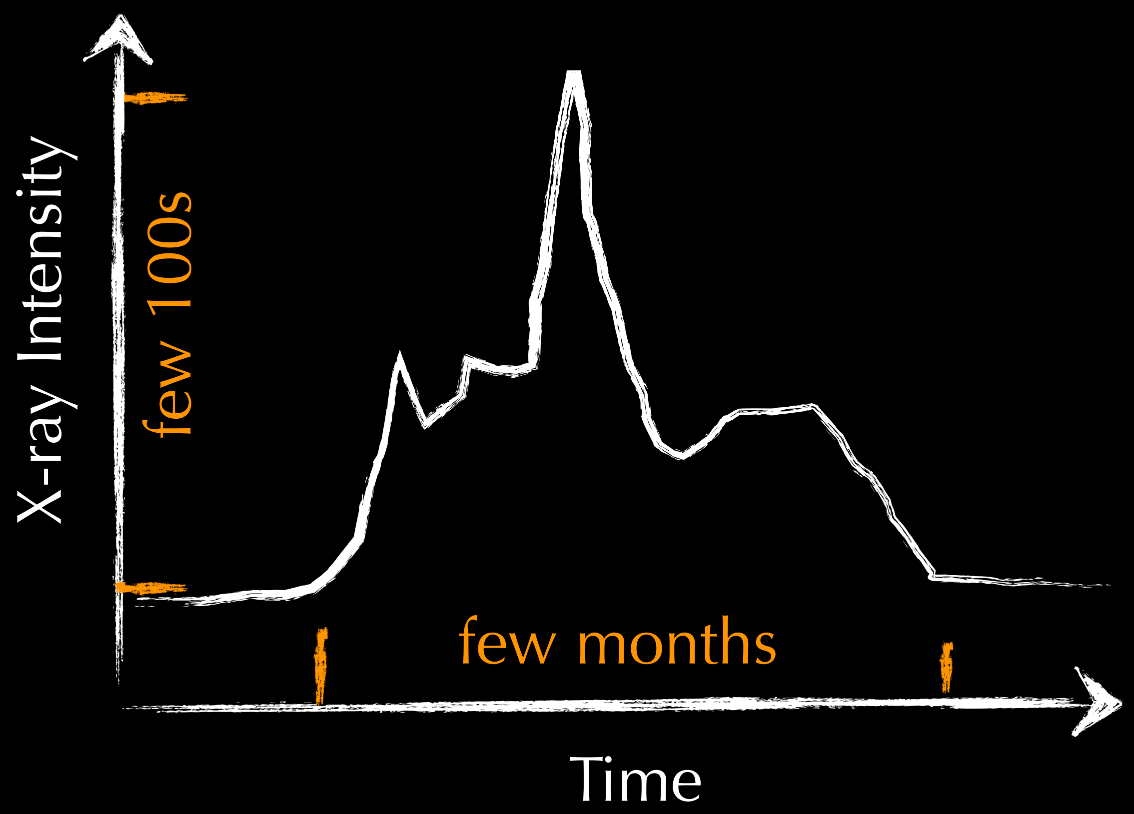




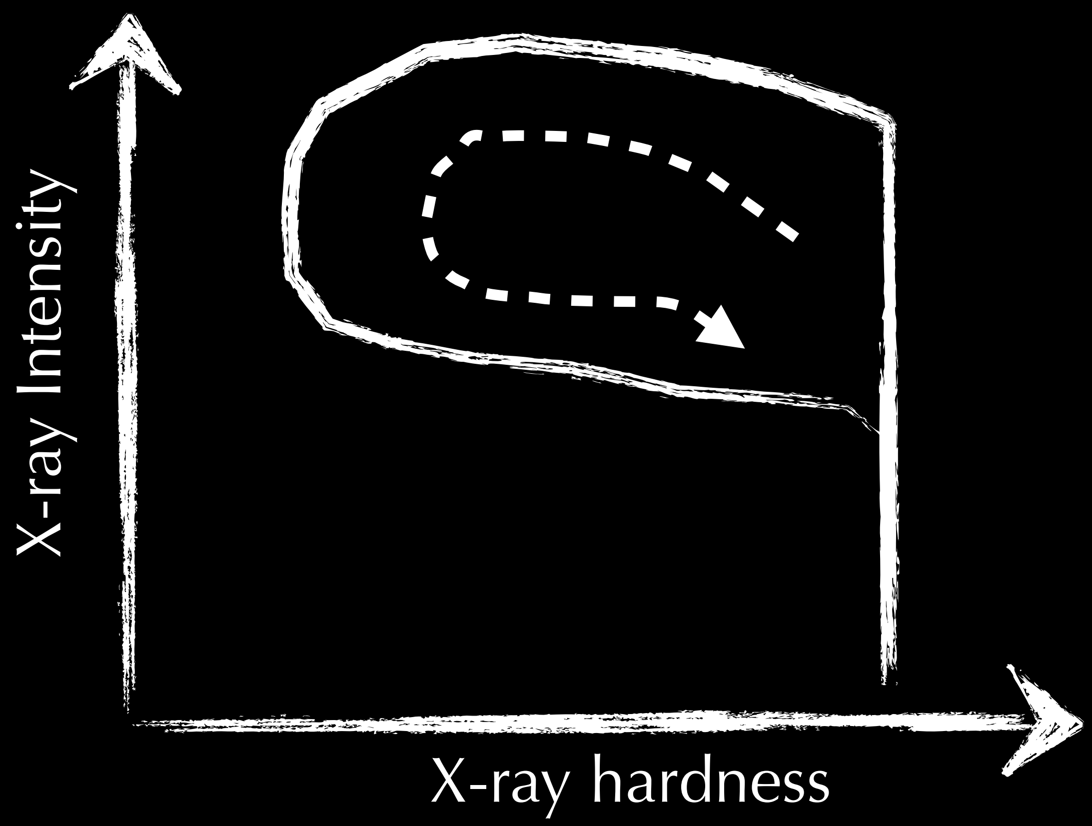
Fender 2000



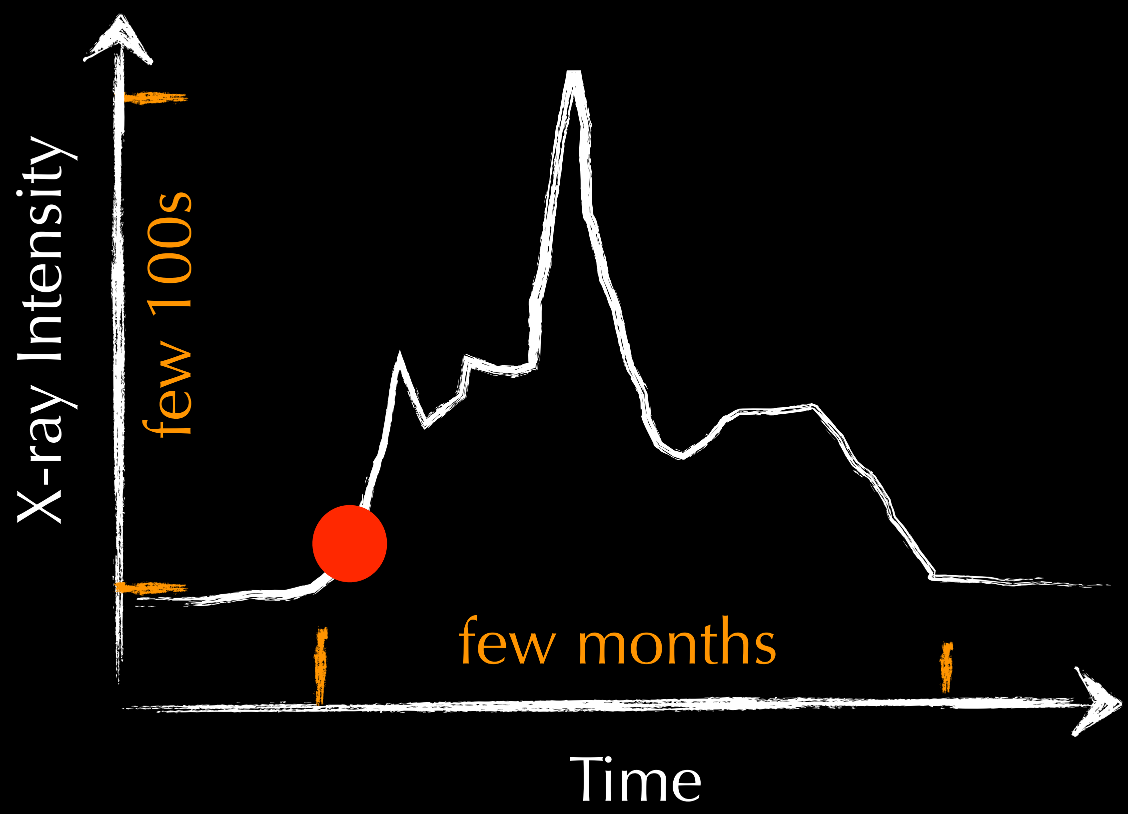
accretion disc variability



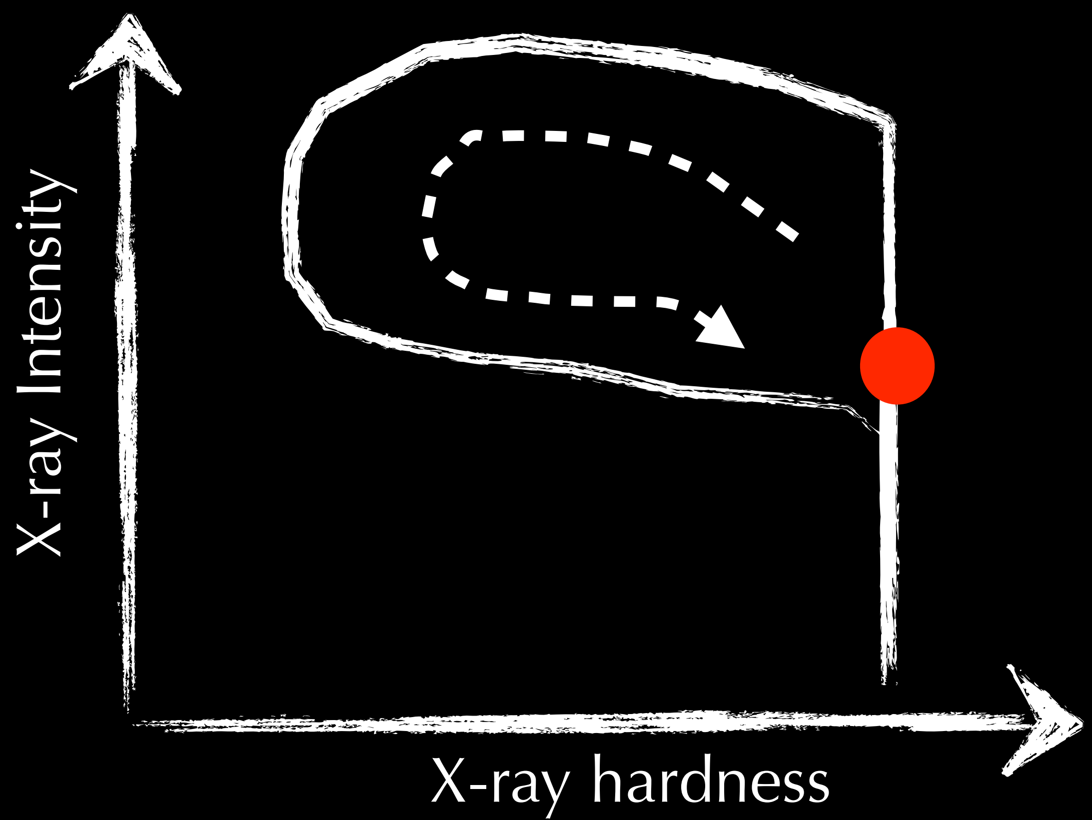
accretion disc variability



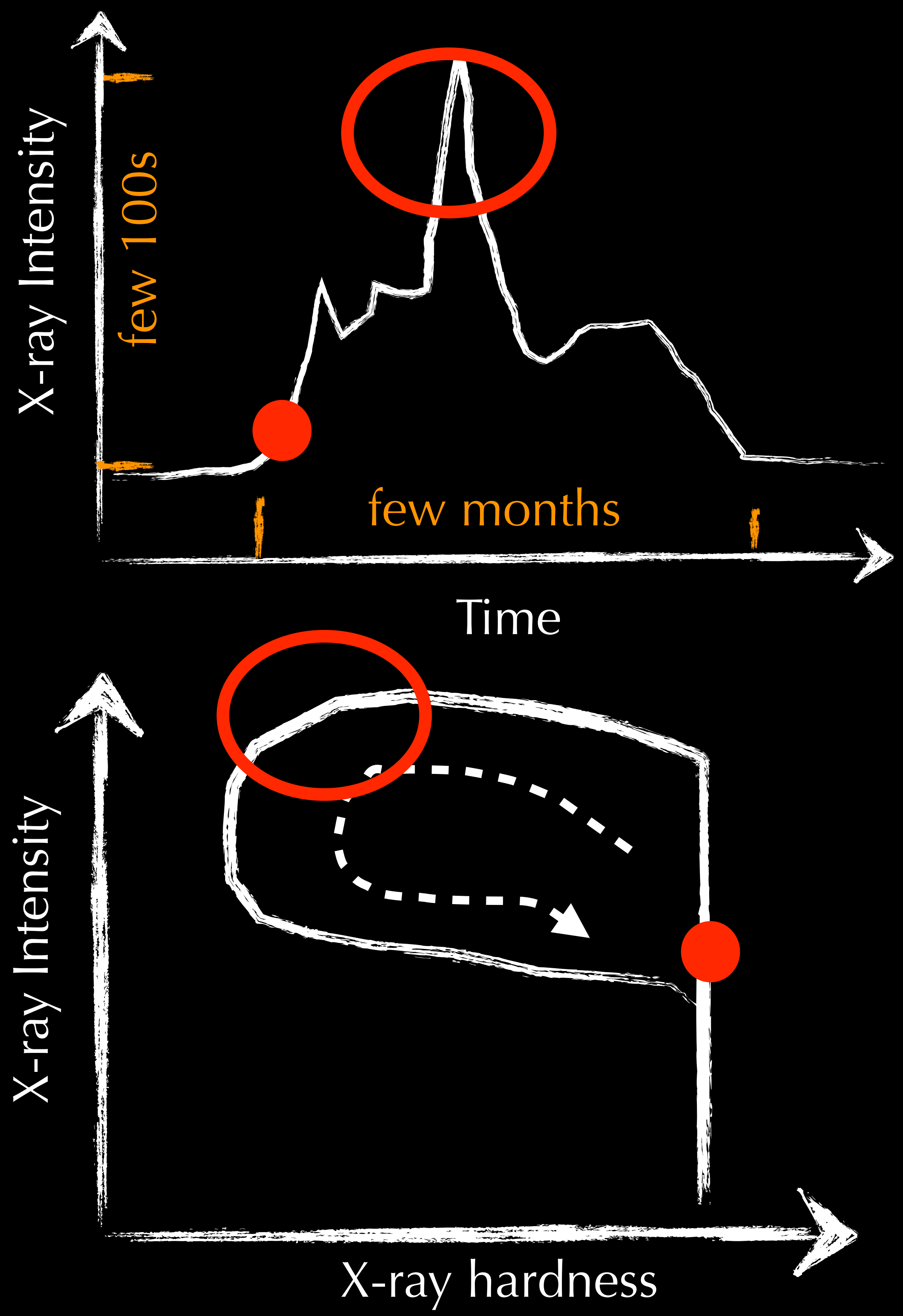
full cycle of an outburst



accretion disc variability

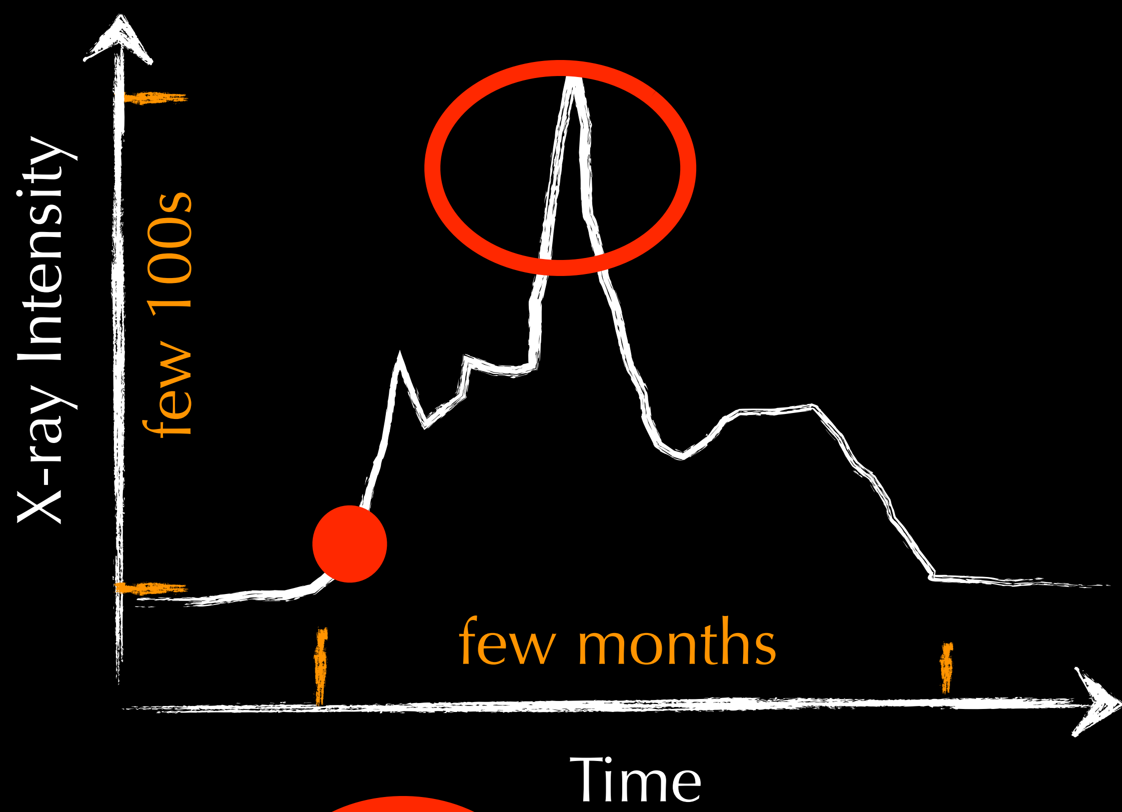


full cycle of an outburst

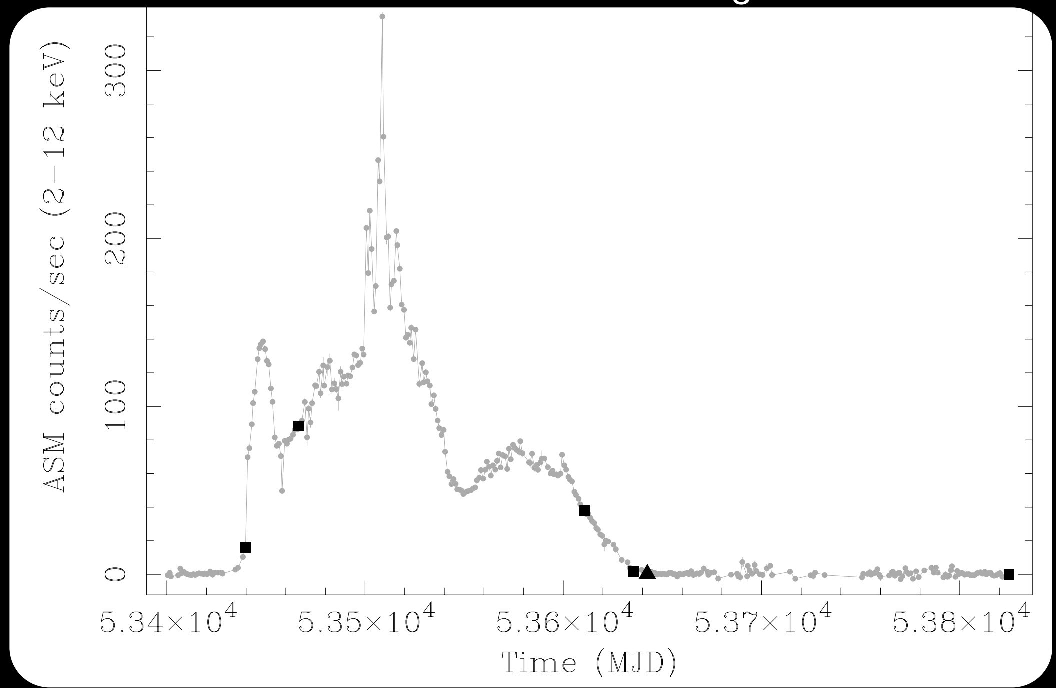


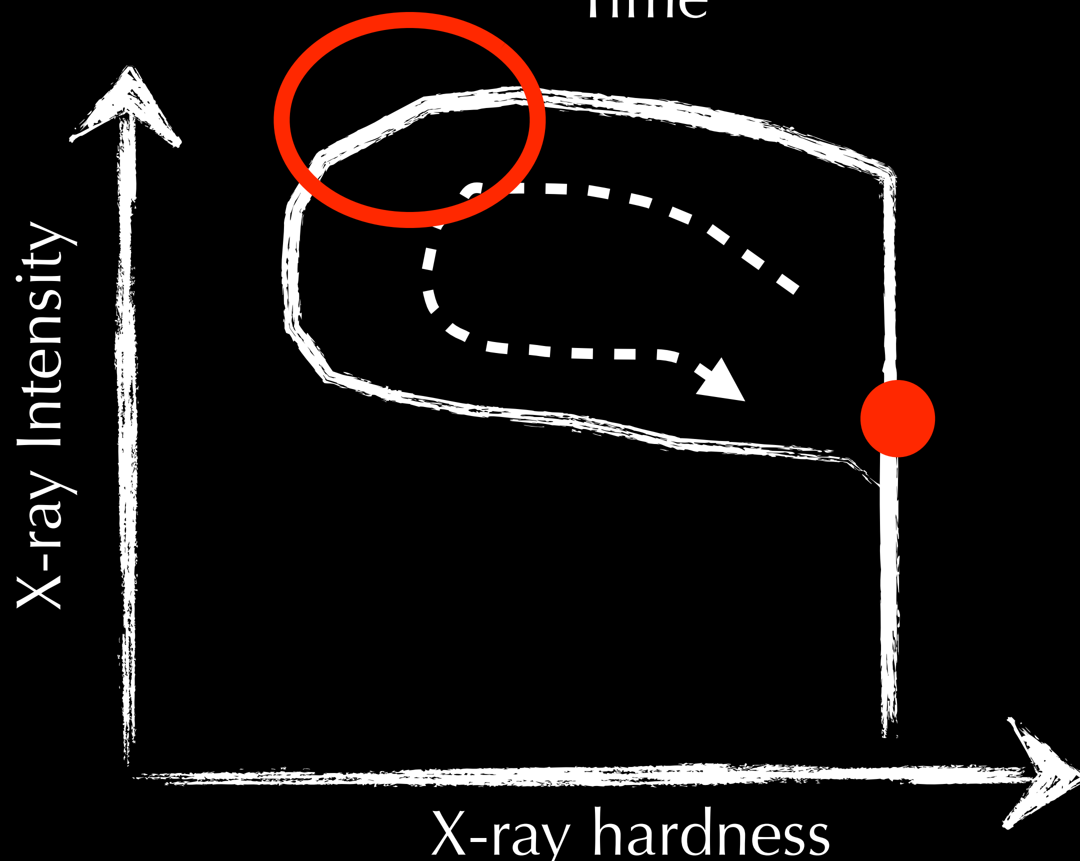
accretion disc variability

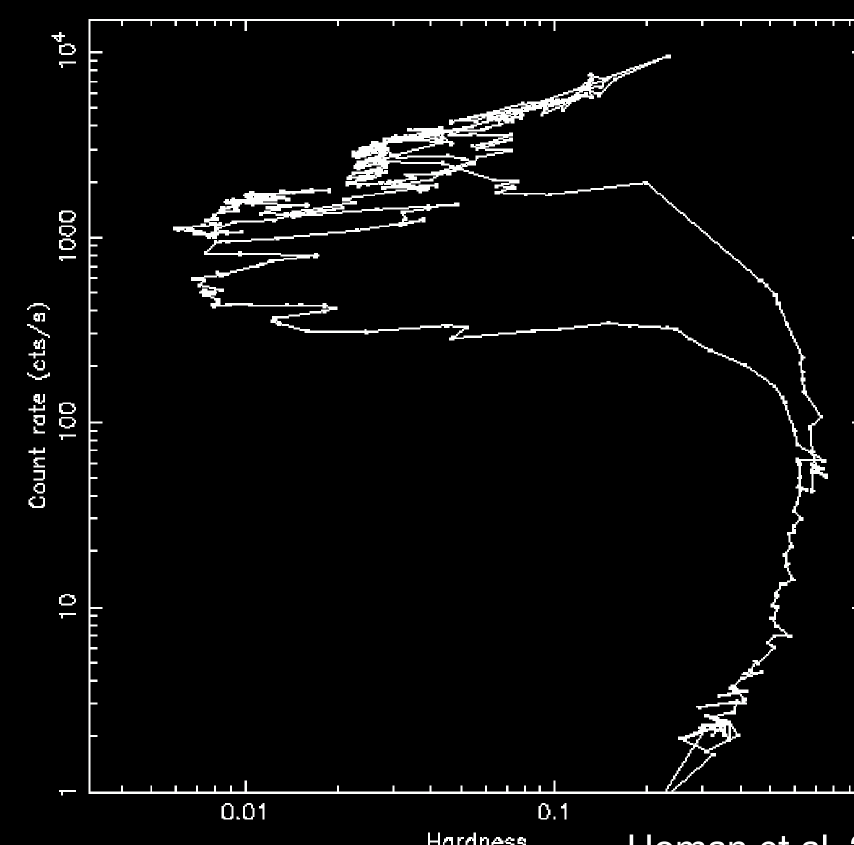
full cycle of an outburst



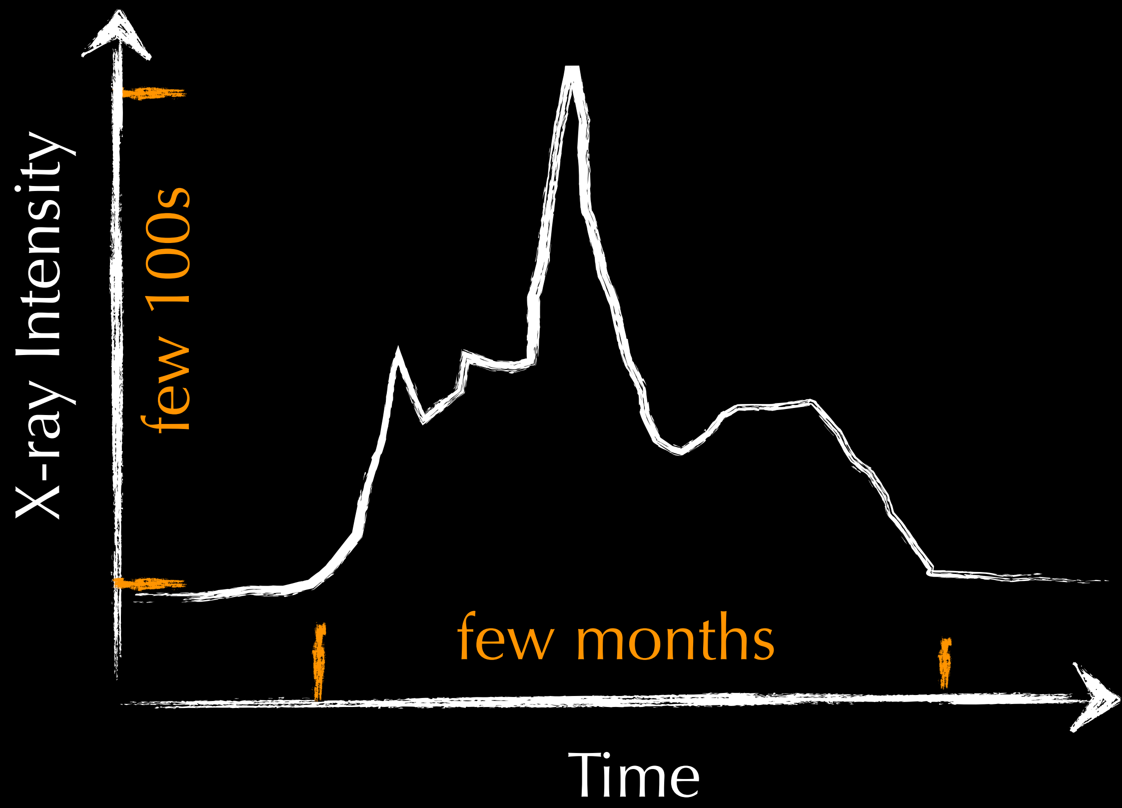
Migliari et al. 2007

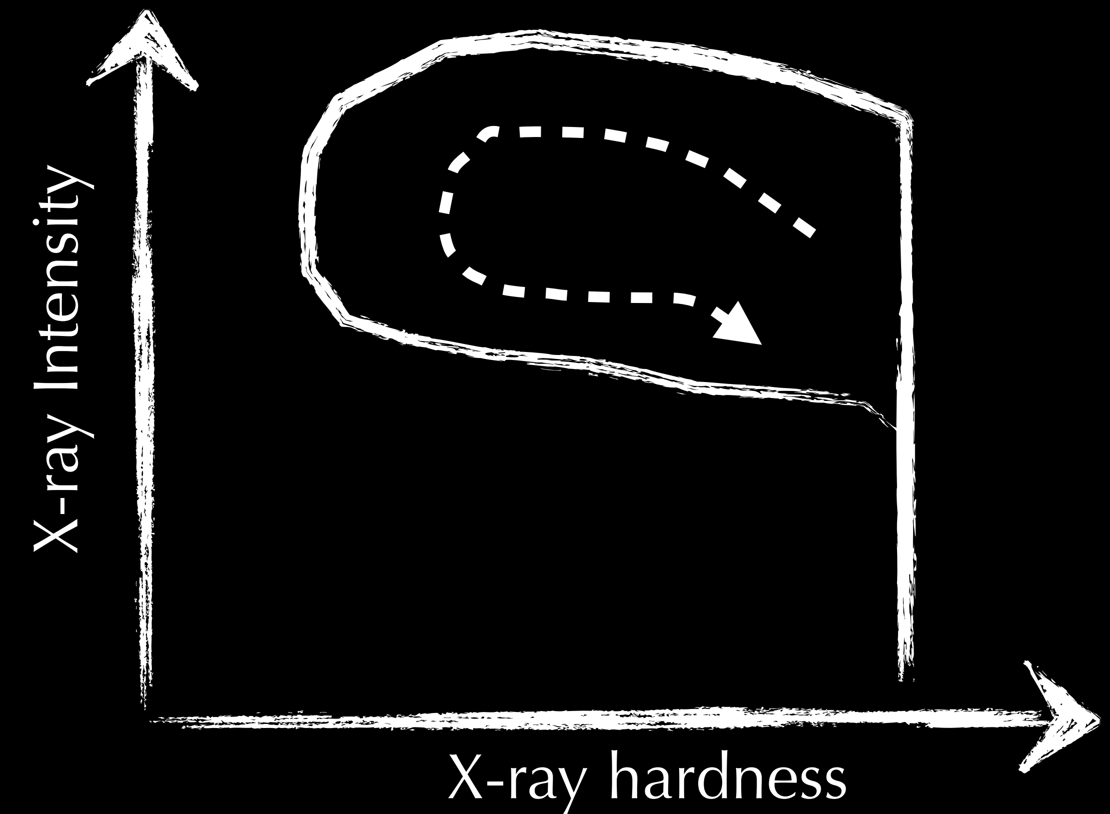




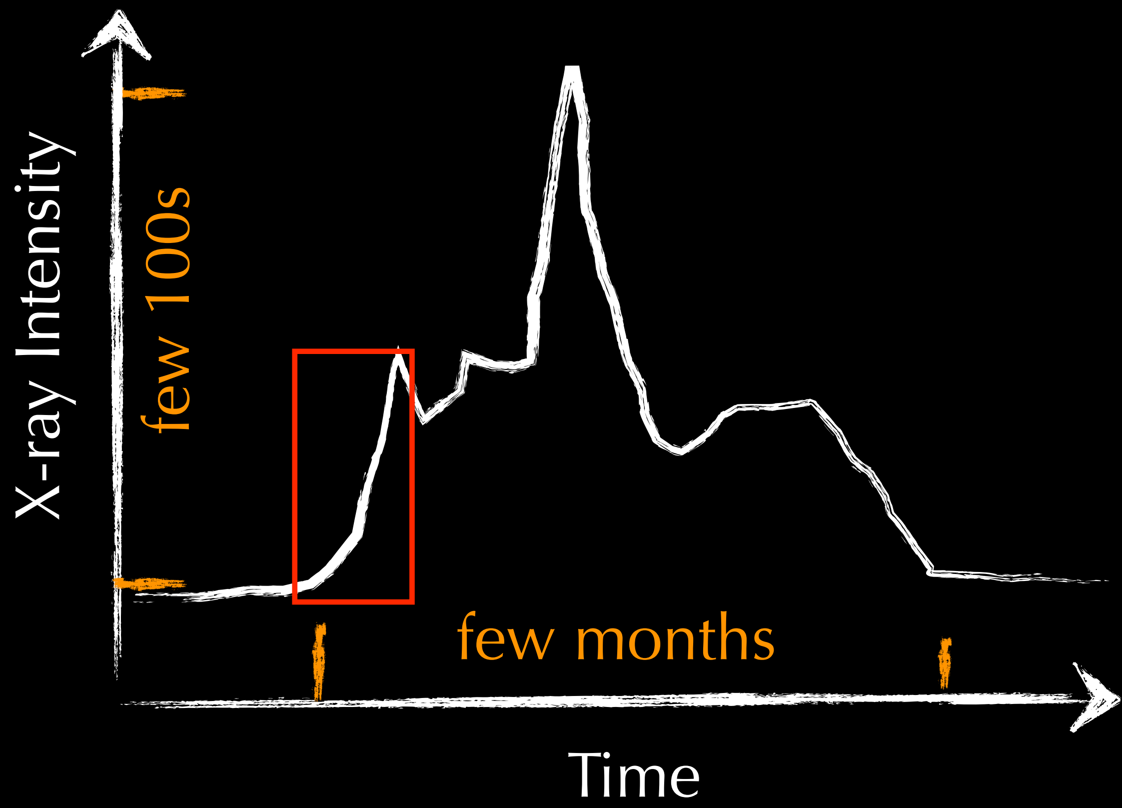


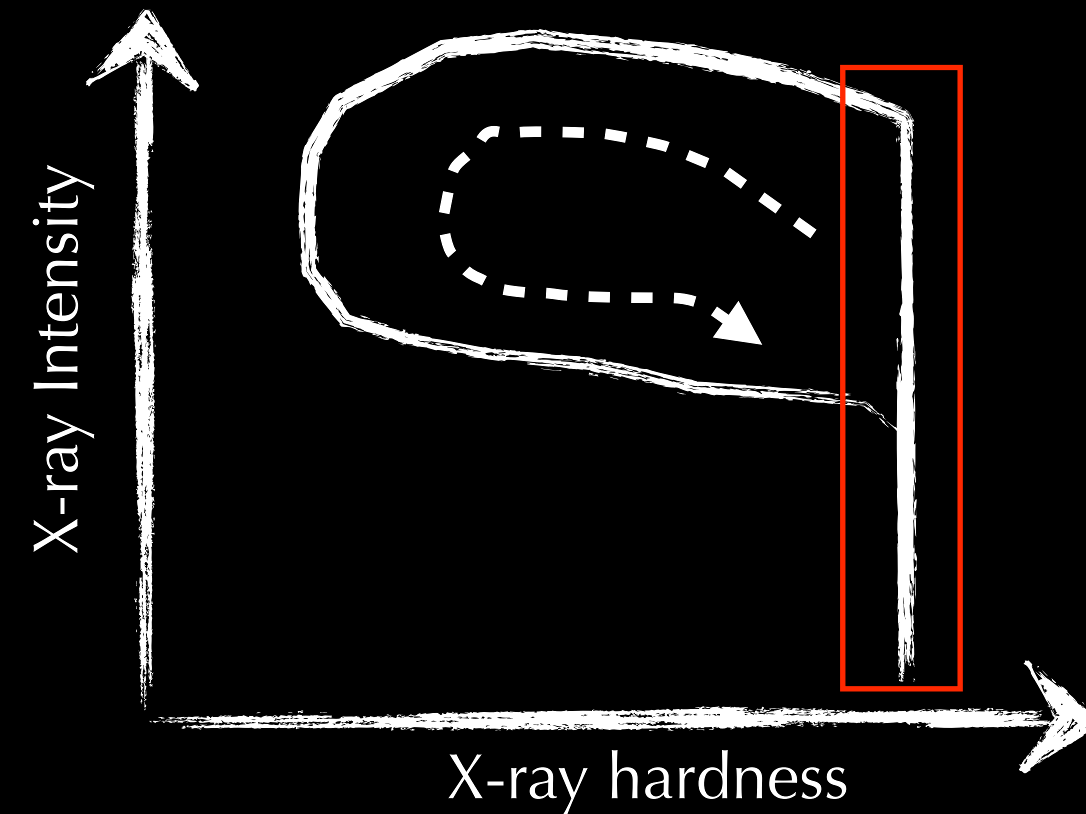
Homan et al. 200



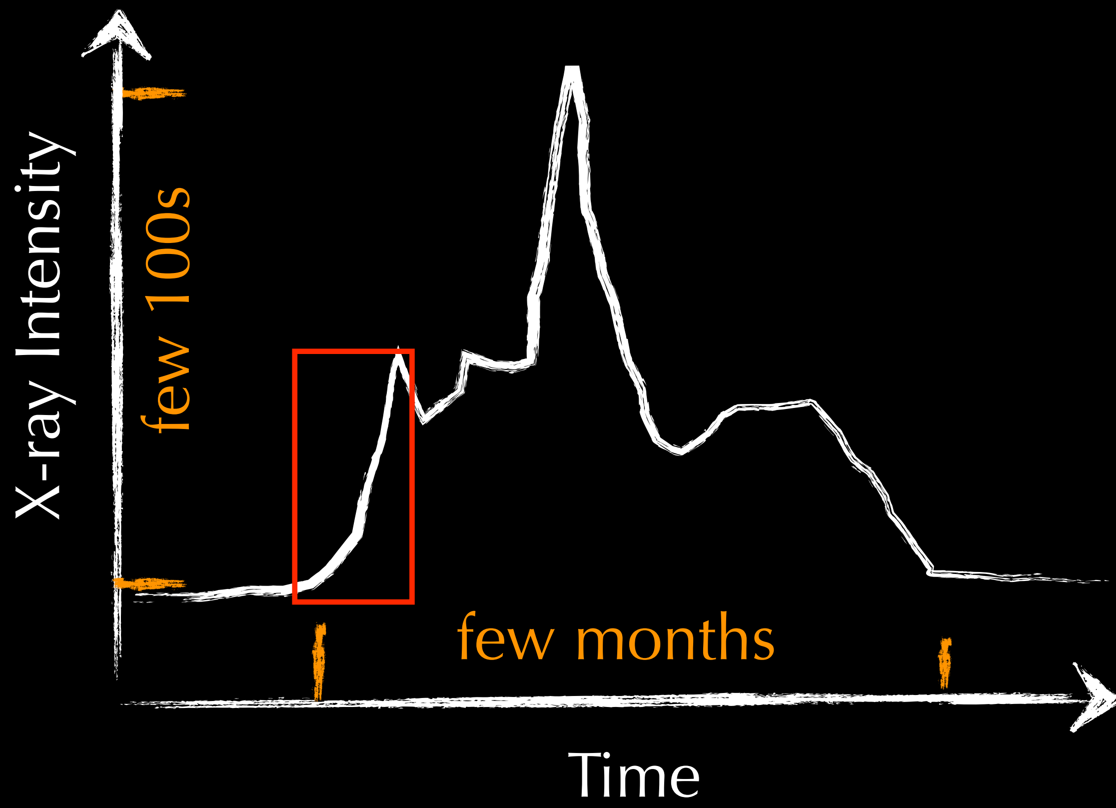


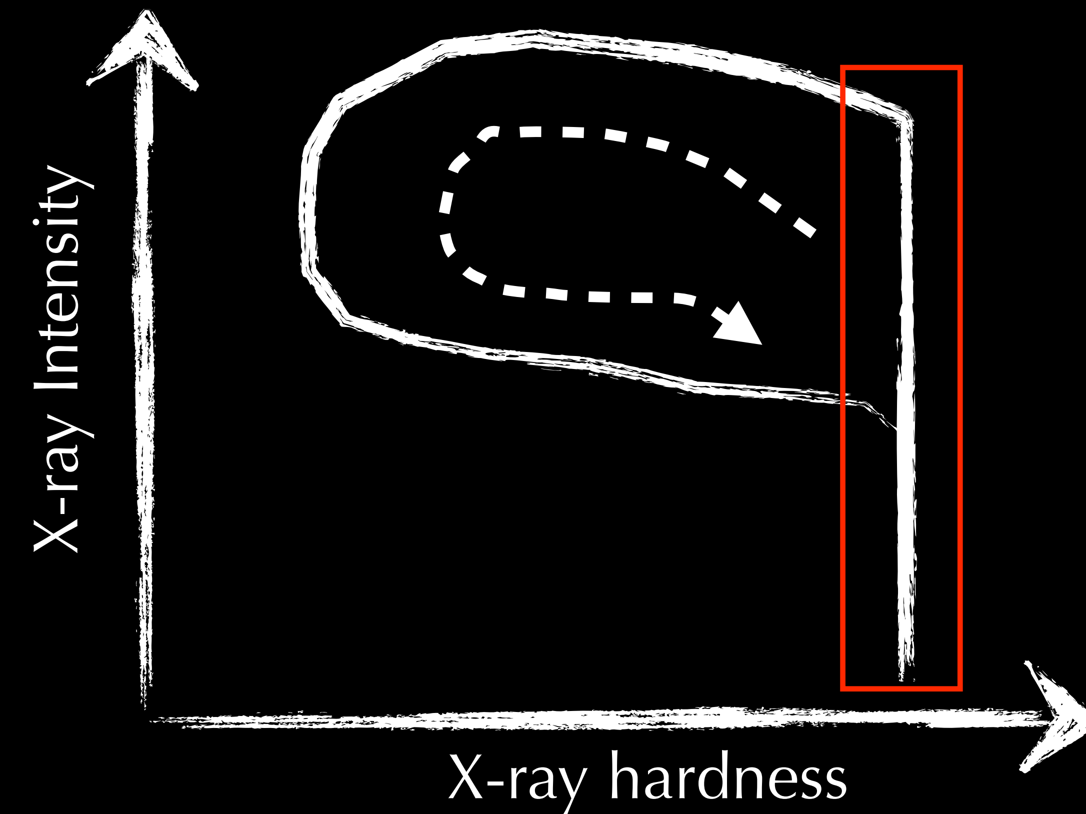
Gallo et al. 2002

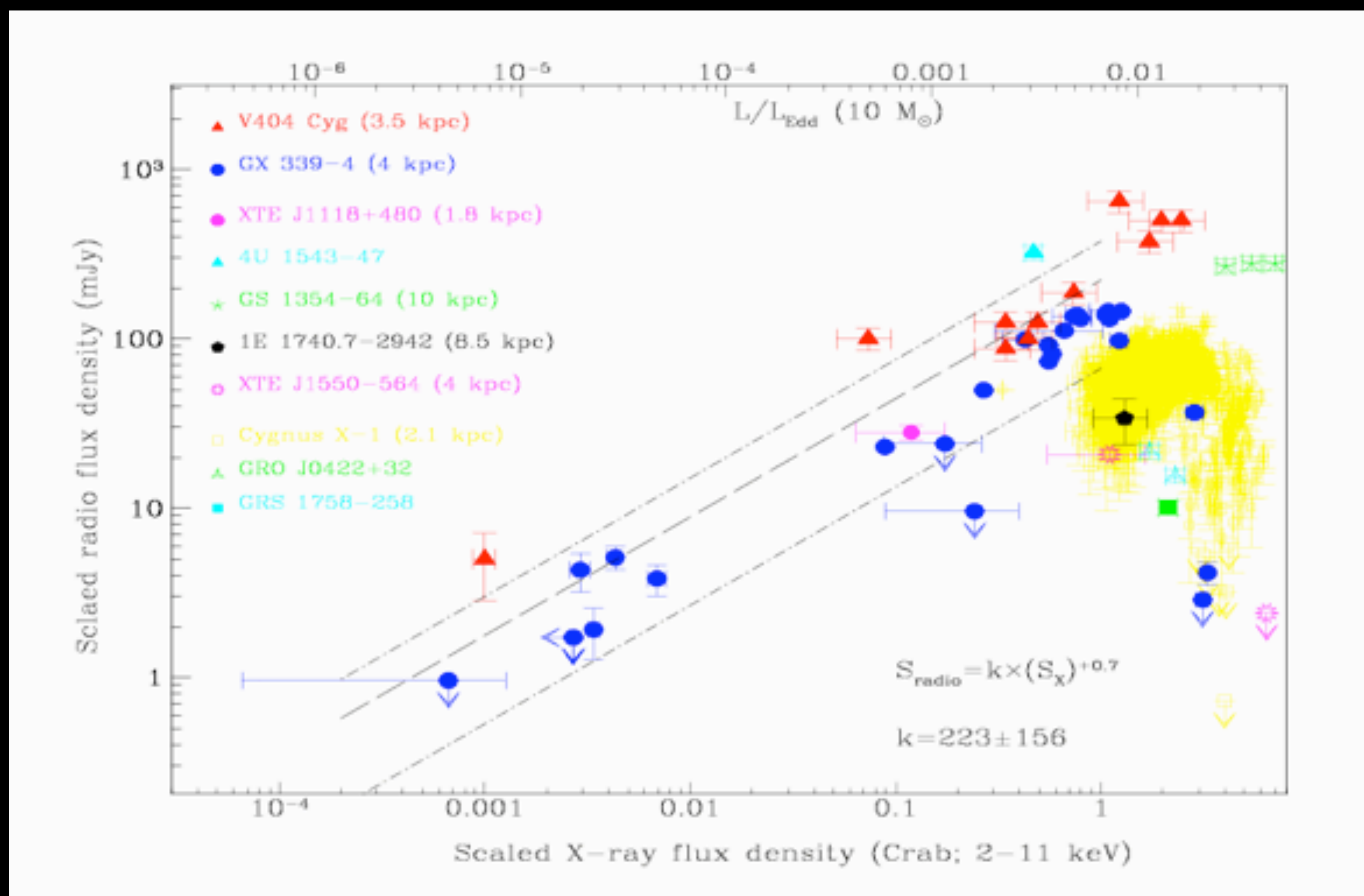




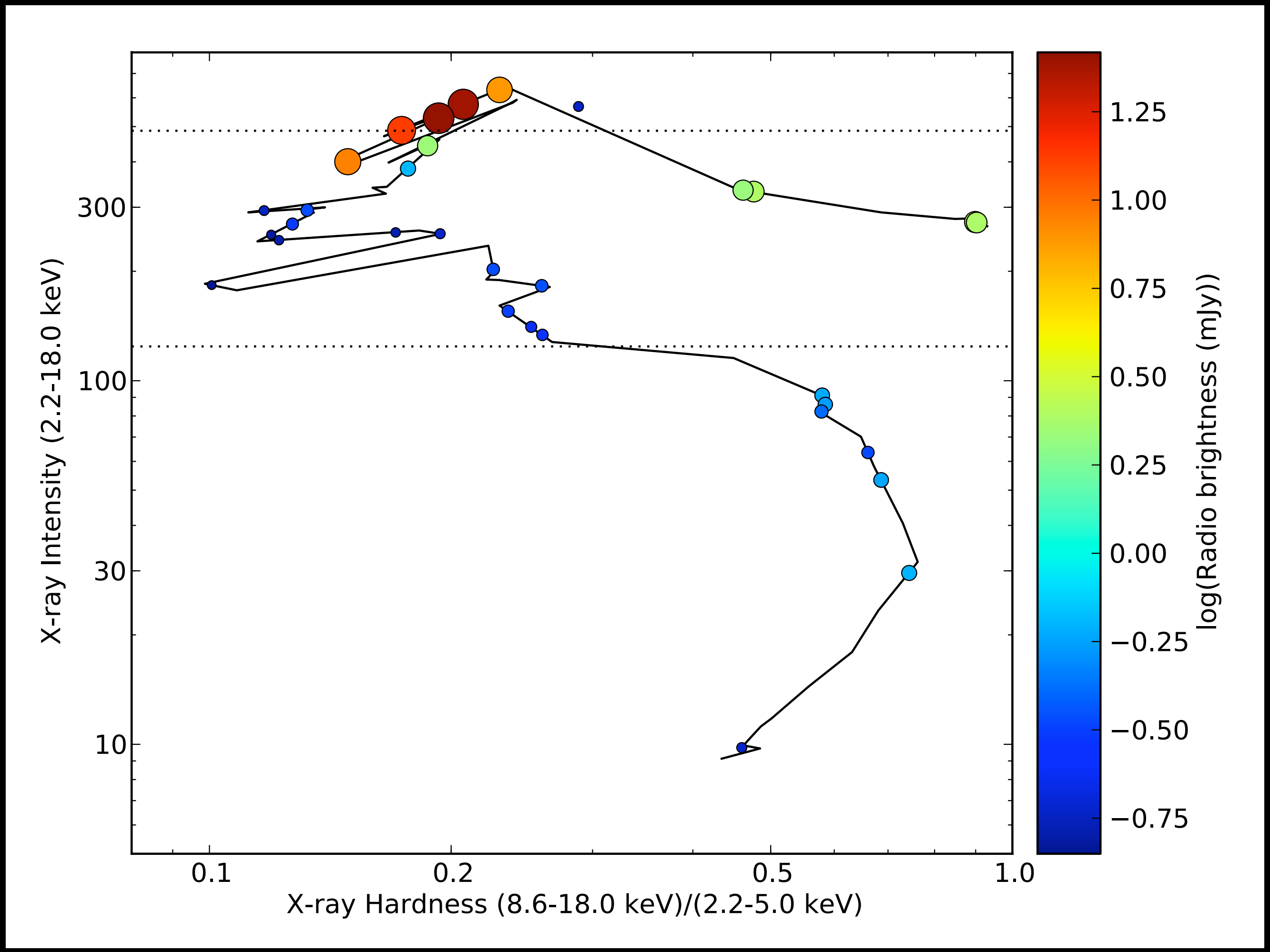
Gallo et al. 2002



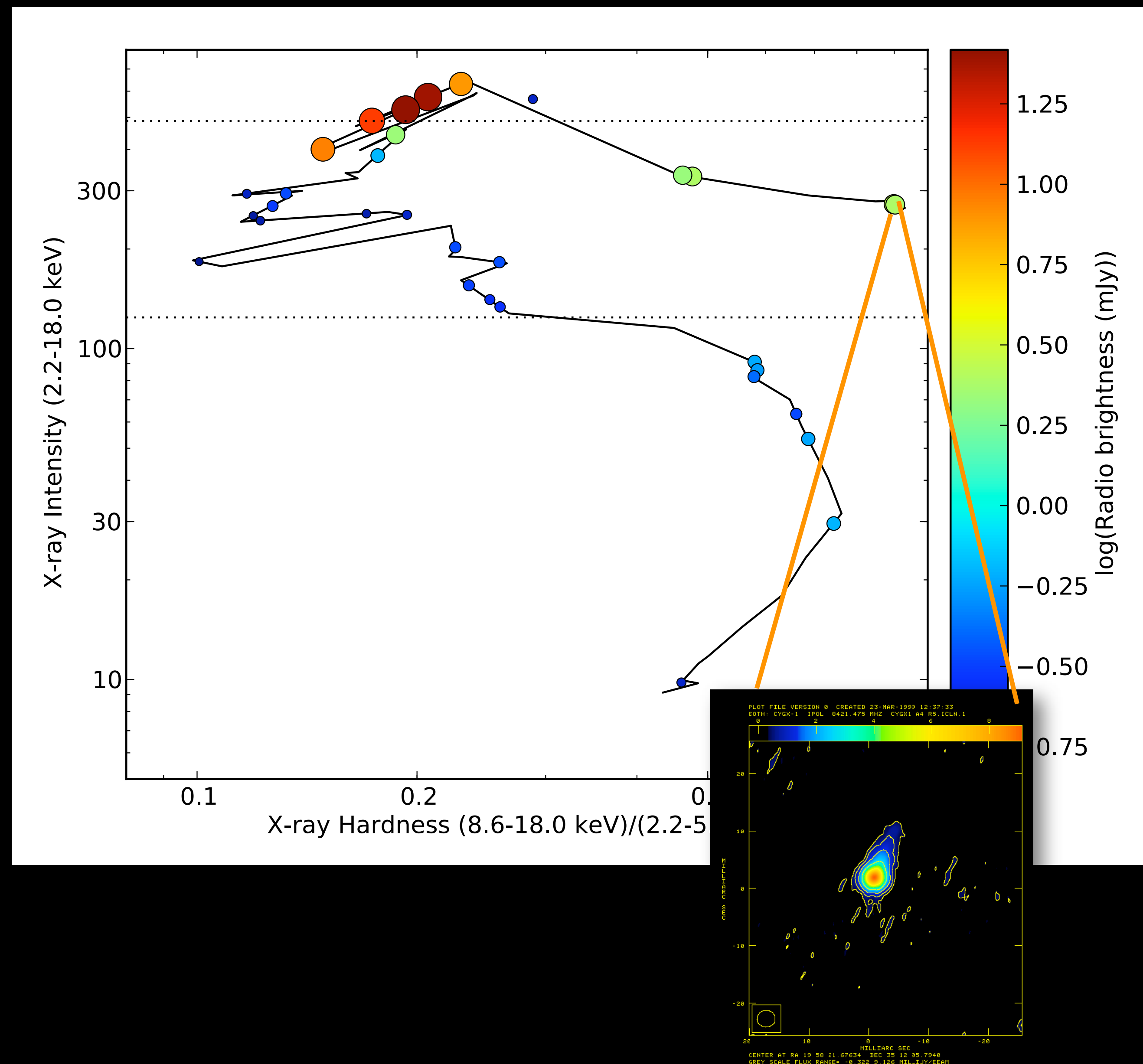




Gallo et al. 2002

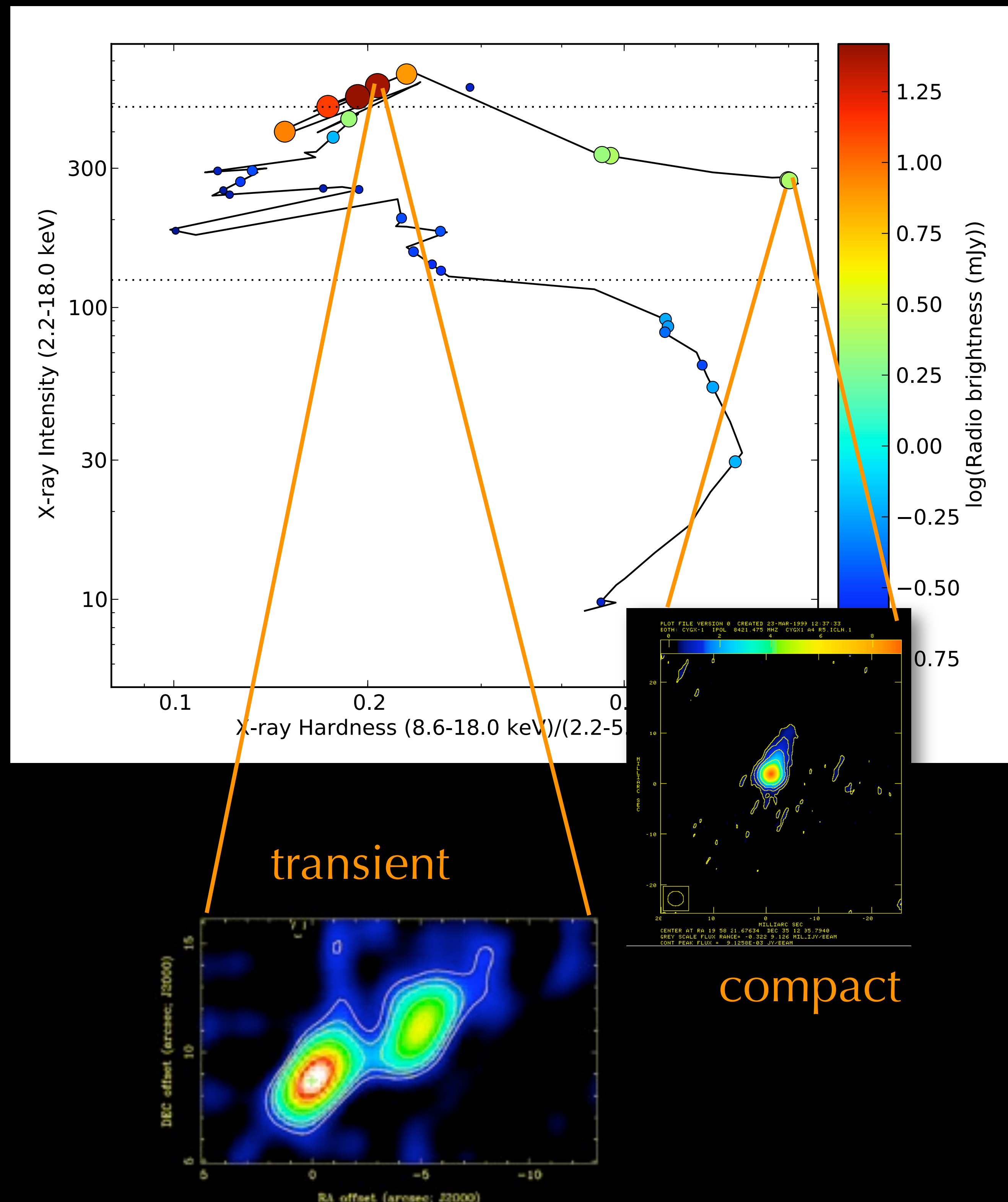


Miller-Jones et al.: JACPOT collaboration
http://www.astro.virginia.edu/xrb_jets/



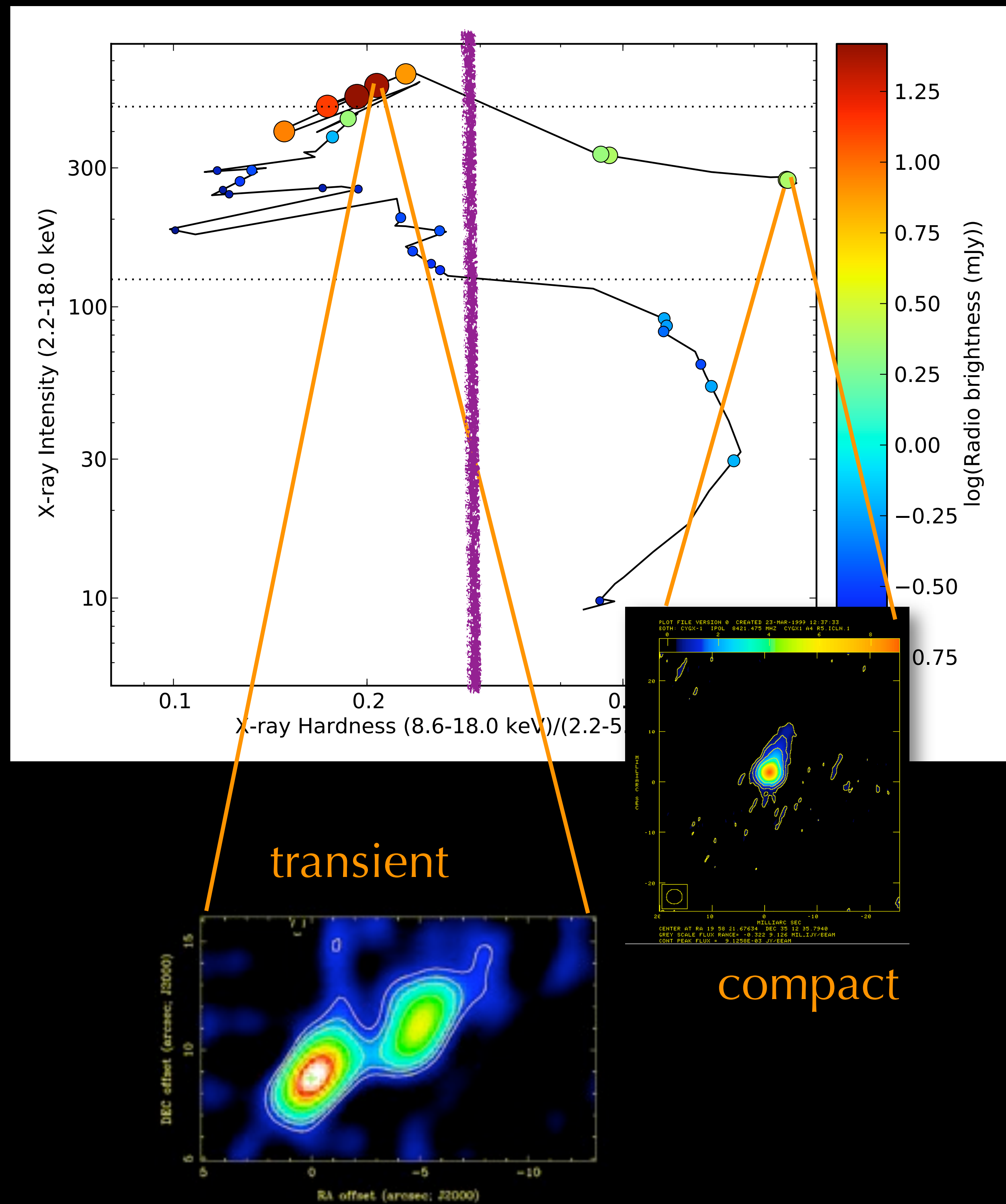
compact

Miller-Jones et al.: JACPOT collaboration
http://www.astro.virginia.edu/xrb_jets/



Miller-Jones et al.: JACPOT collaboration
http://www.astro.virginia.edu/xrb_jets/

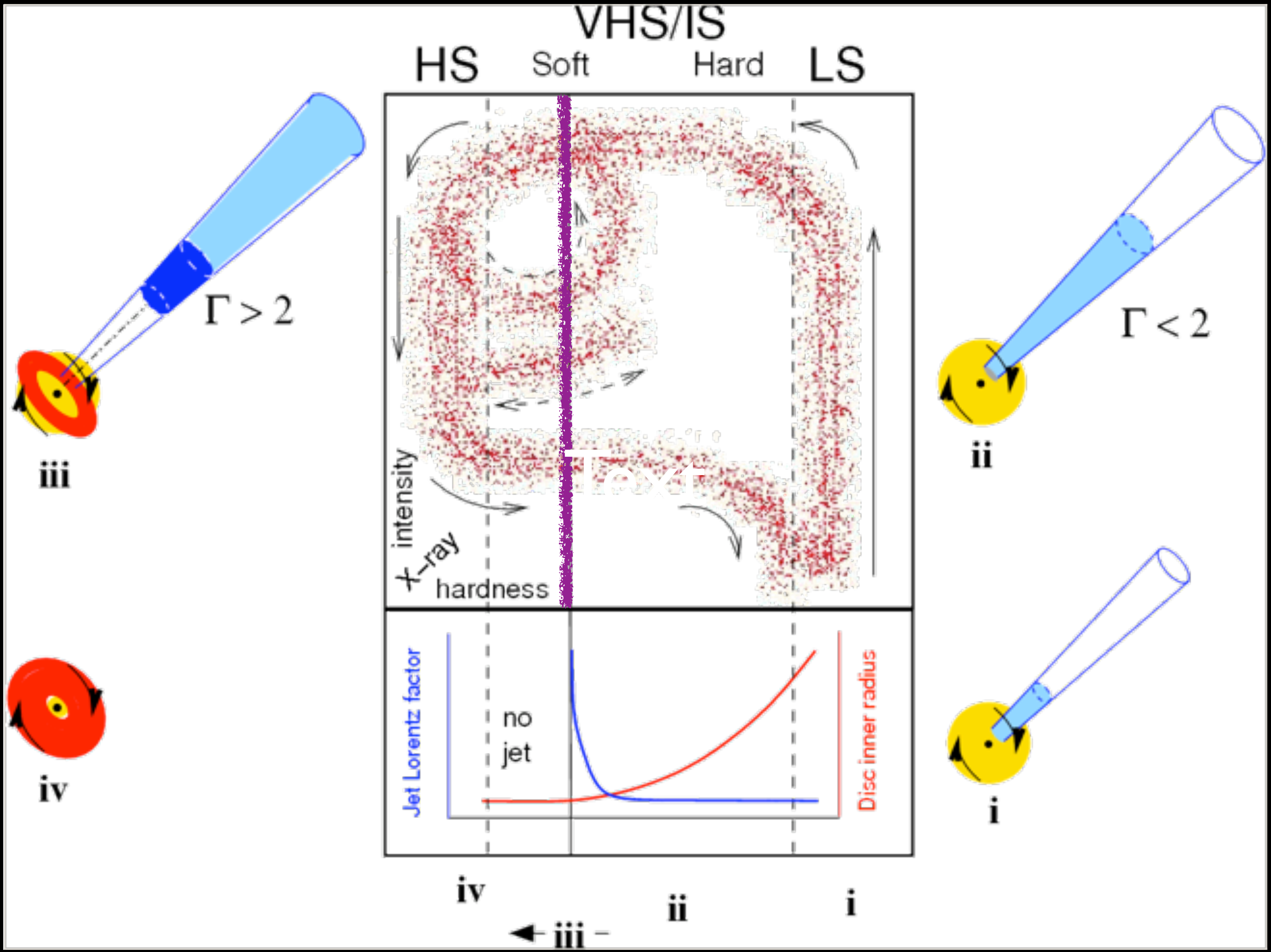
jet line



Miller-Jones et al.: JACPOT collaboration
http://www.astro.virginia.edu/xrb_jets/

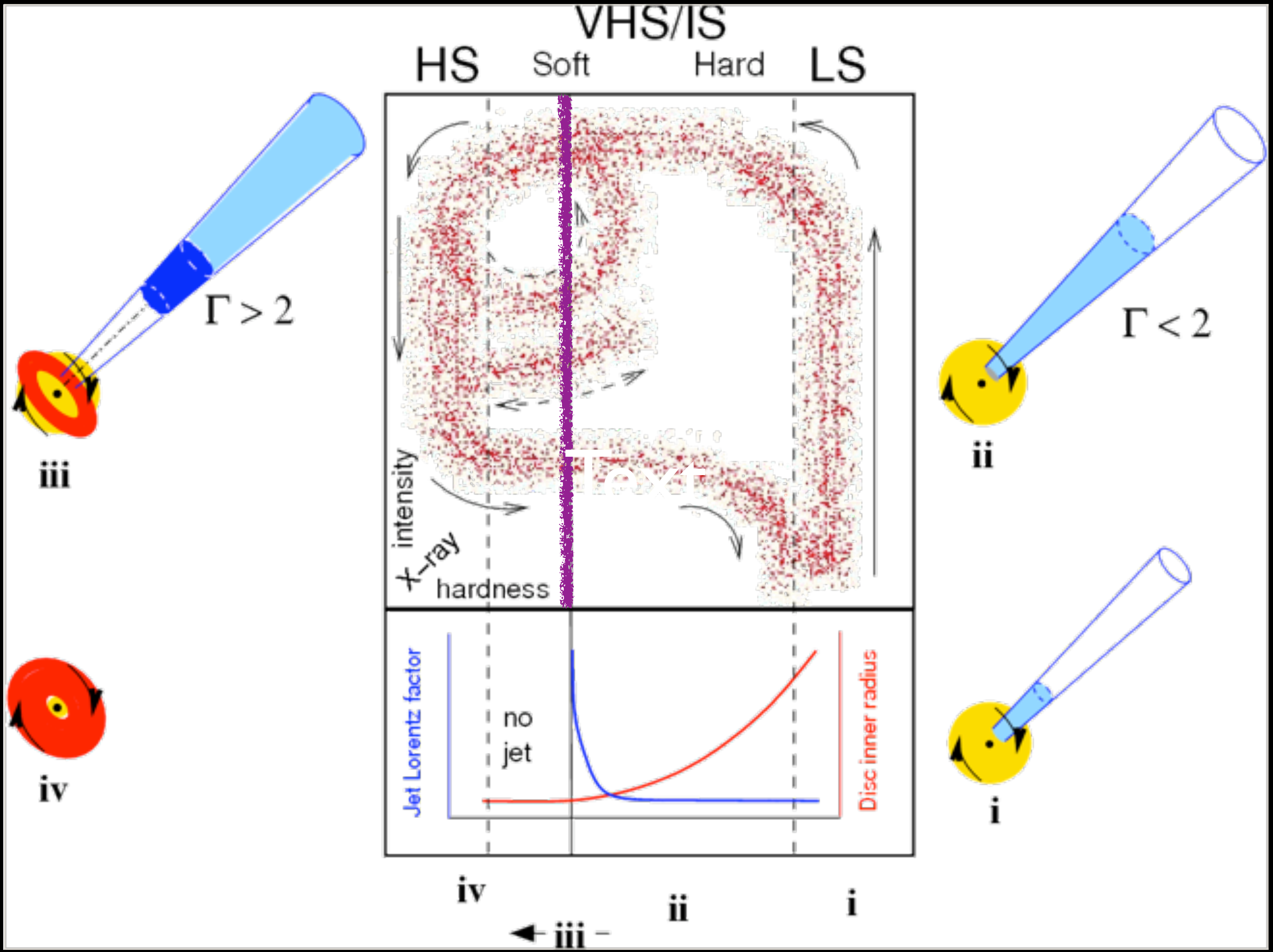
proposed Unified Scenario

Fender et al. 2004



proposed Unified Scenario

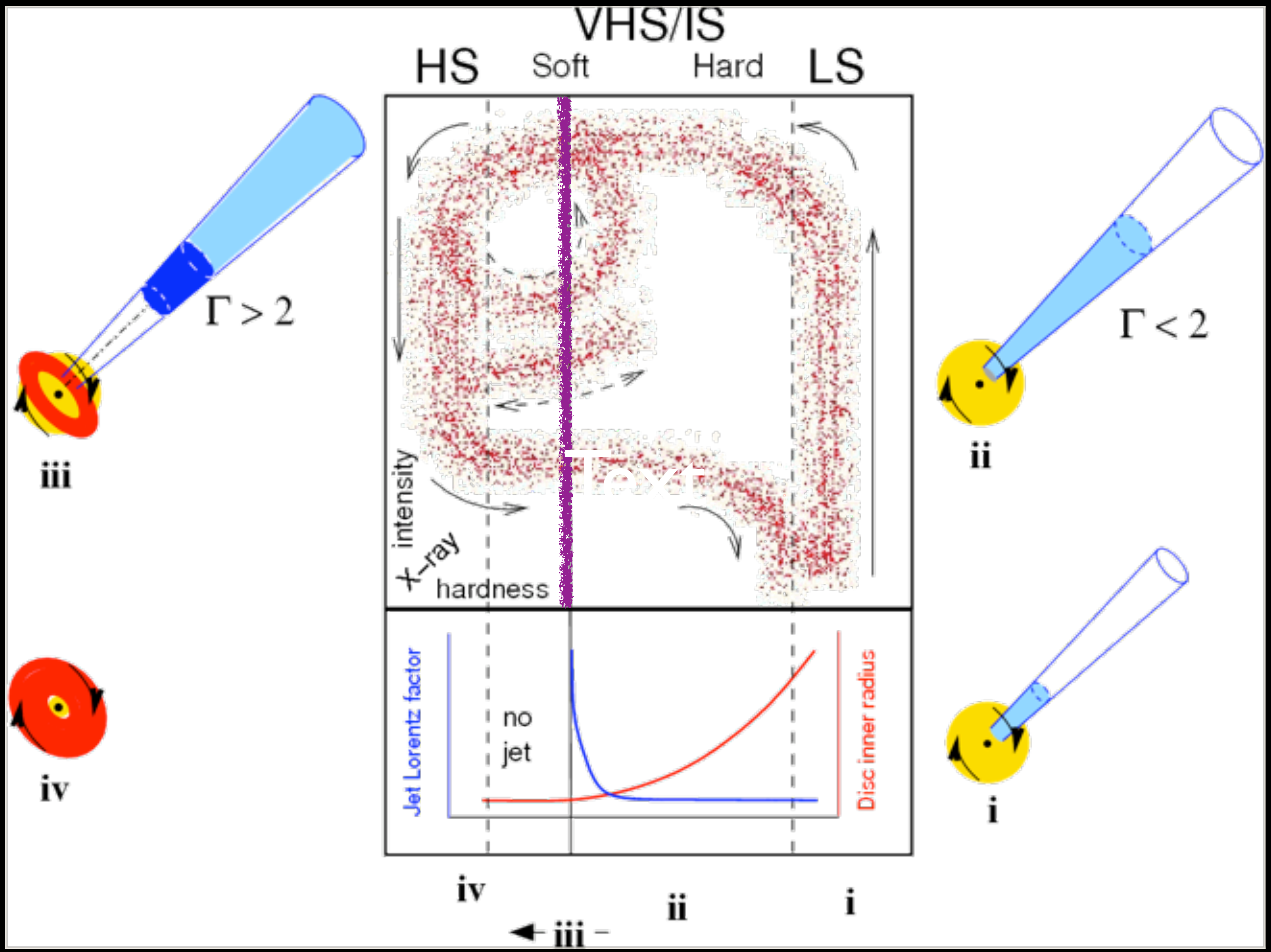
Fender et al. 2004



- does the disk radius vary?
- correlation slope?
- Lorentz factor?
- does the jet speed increases as increases potential well.
- is there a jet line? is it vertical?

proposed Unified Scenario

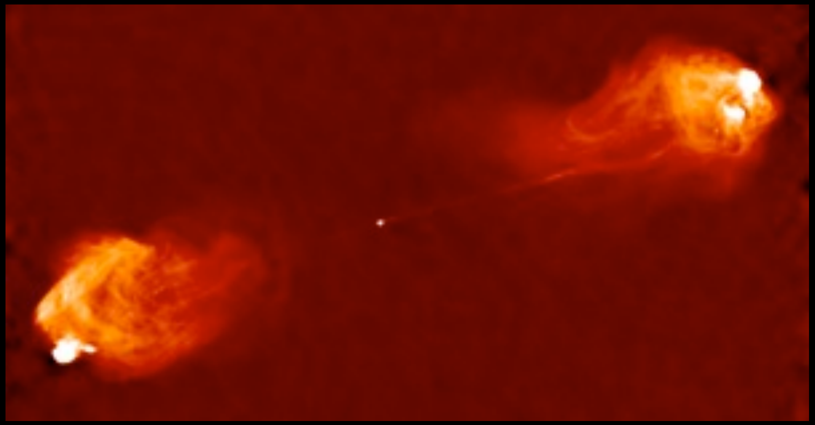
Fender et al. 2004



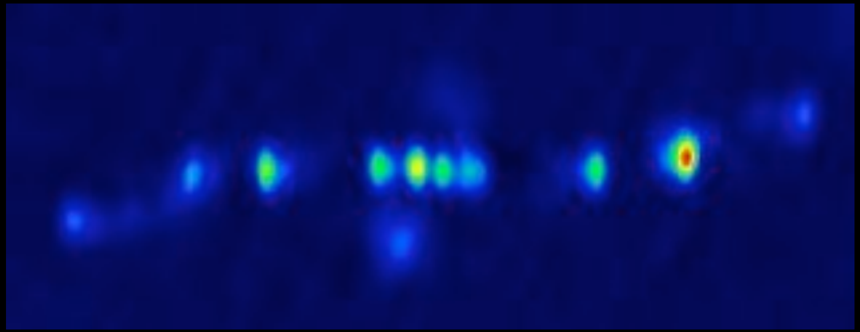
- does the disk radius vary?
- correlation slope?
- Lorentz factor?
- does the jet speed increases as increases potential well.
- is there a jet line? is it vertical?

- is the ejection, an ejection of the corona?
- does the core jet quench? when exactly during the outburst?
- at what hardness/the core jet reforms back?
- do subsequent ejecta vary speed?
- and what about QPOs and jets?
- ...

AGN



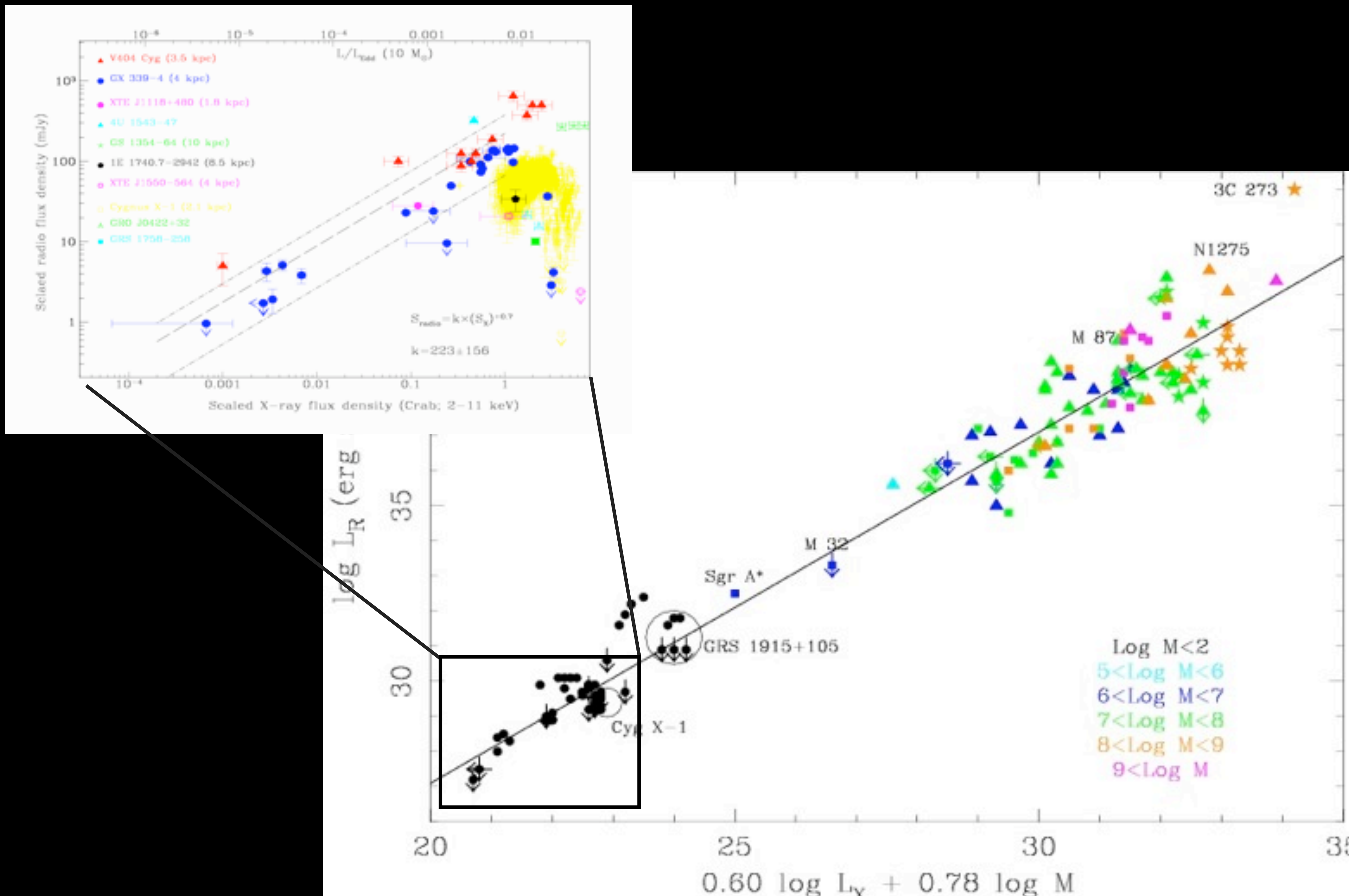
X-ray binaries



WD binaries

YSOs

stellar-mass/super-massive BH connection



Merloni et al. 2003

The search for the grand unification scheme

NS X-ray binaries

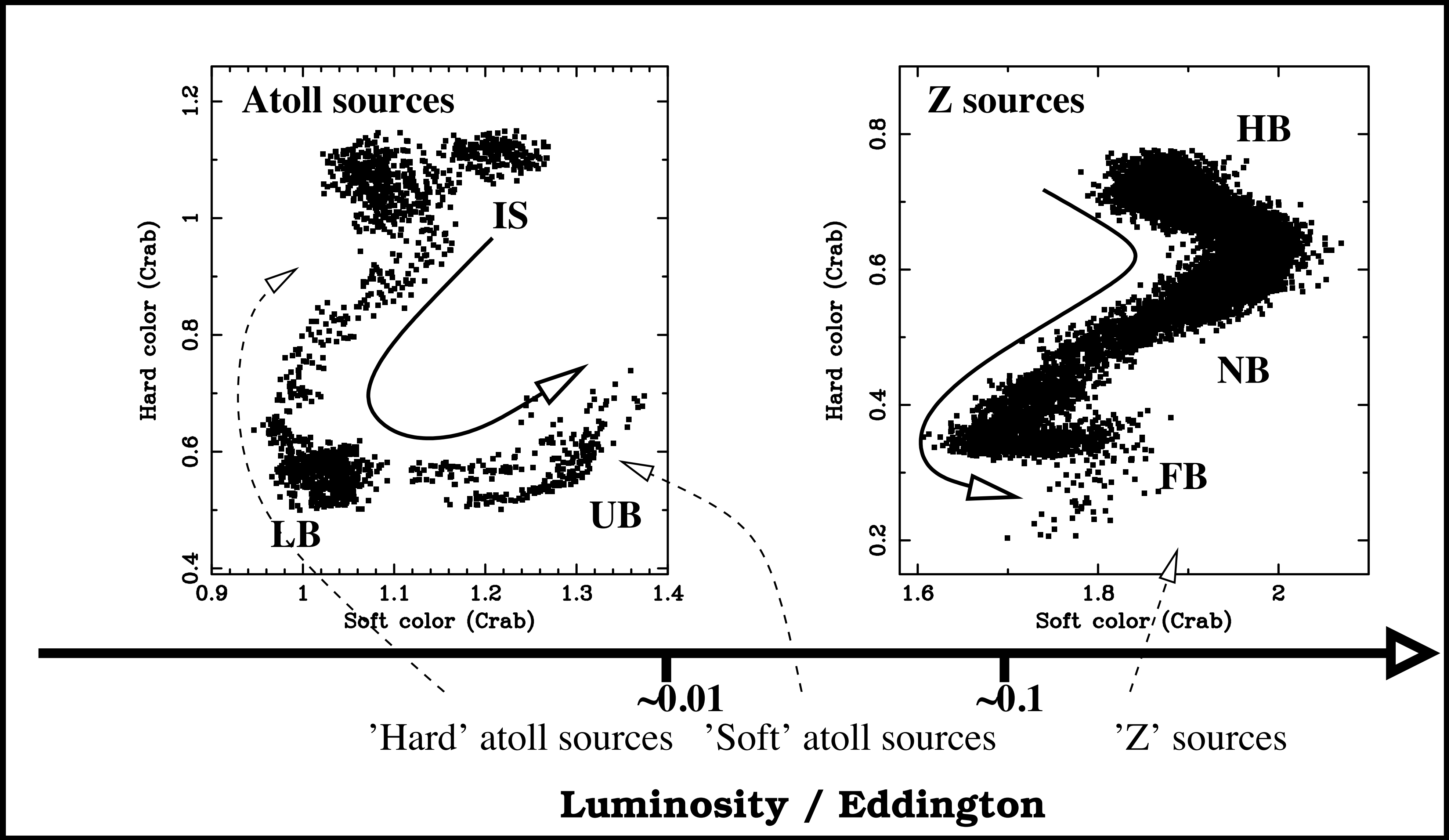
Which parameters are involved in jet formation?

$\dot{M}$

Spin

Magn. field

Nomenclature: NS classes



van der Klis 2006
Migliari & Fender 2006

X-ray binary population

sample: 264 XRBs (Liu et al. 01/06)

X-ray binary population

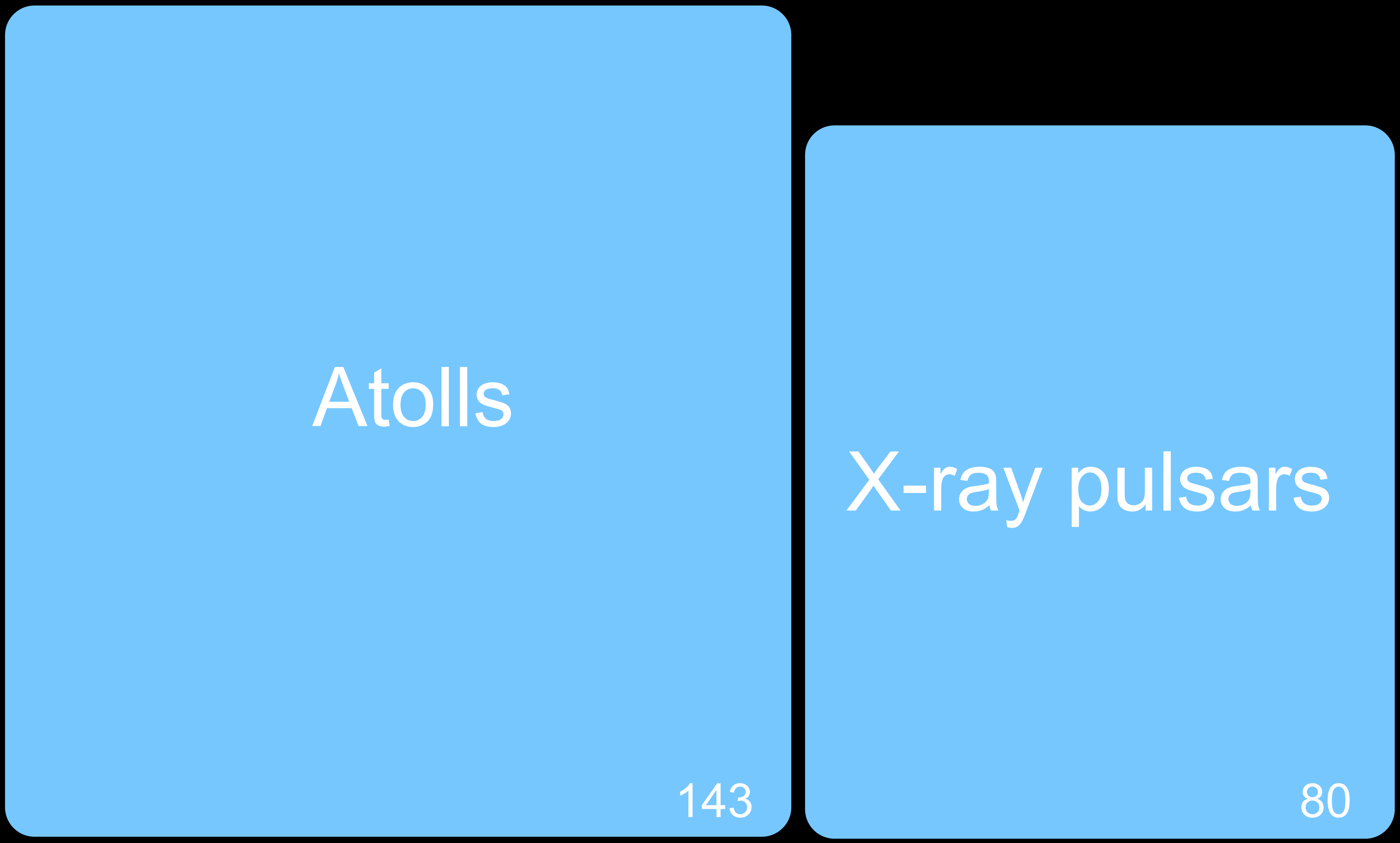
sample: 264 XRBs (Liu et al. 01/06)

Atolls

143

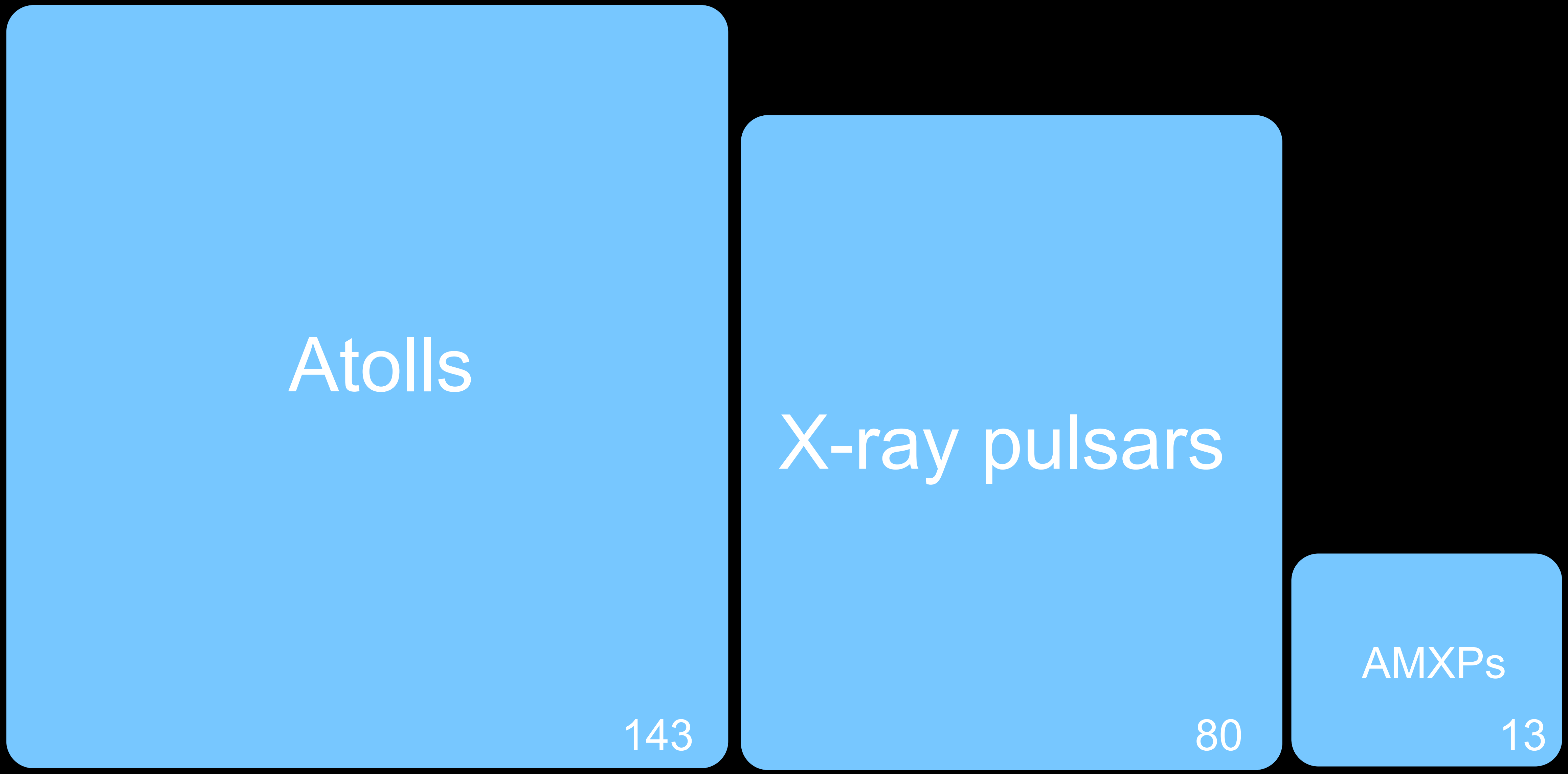
X-ray binary population

sample: 264 XRBs (Liu et al. 01/06)



X-ray binary population

sample: 264 XRBs (Liu et al. 01/06)



X-ray binary population

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X-ray binary population

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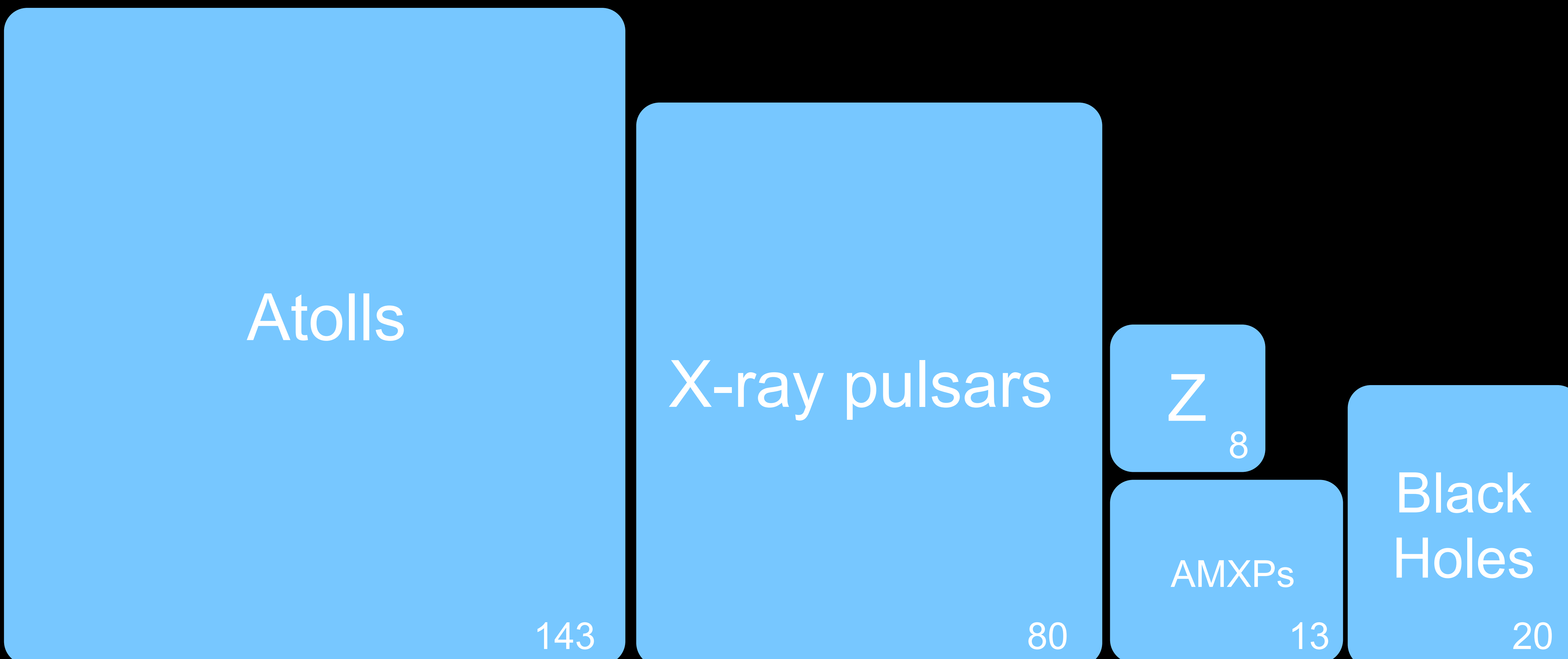
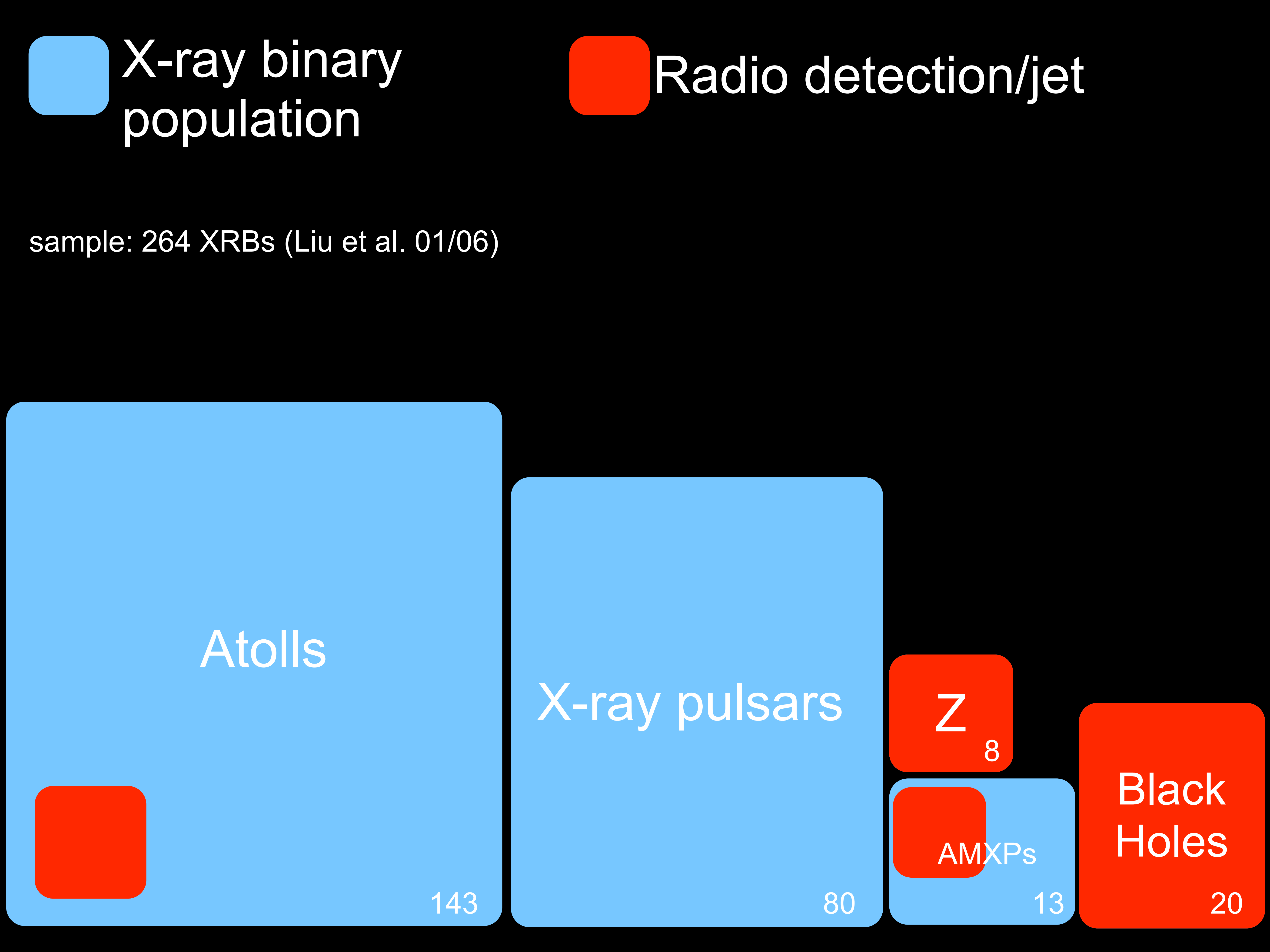
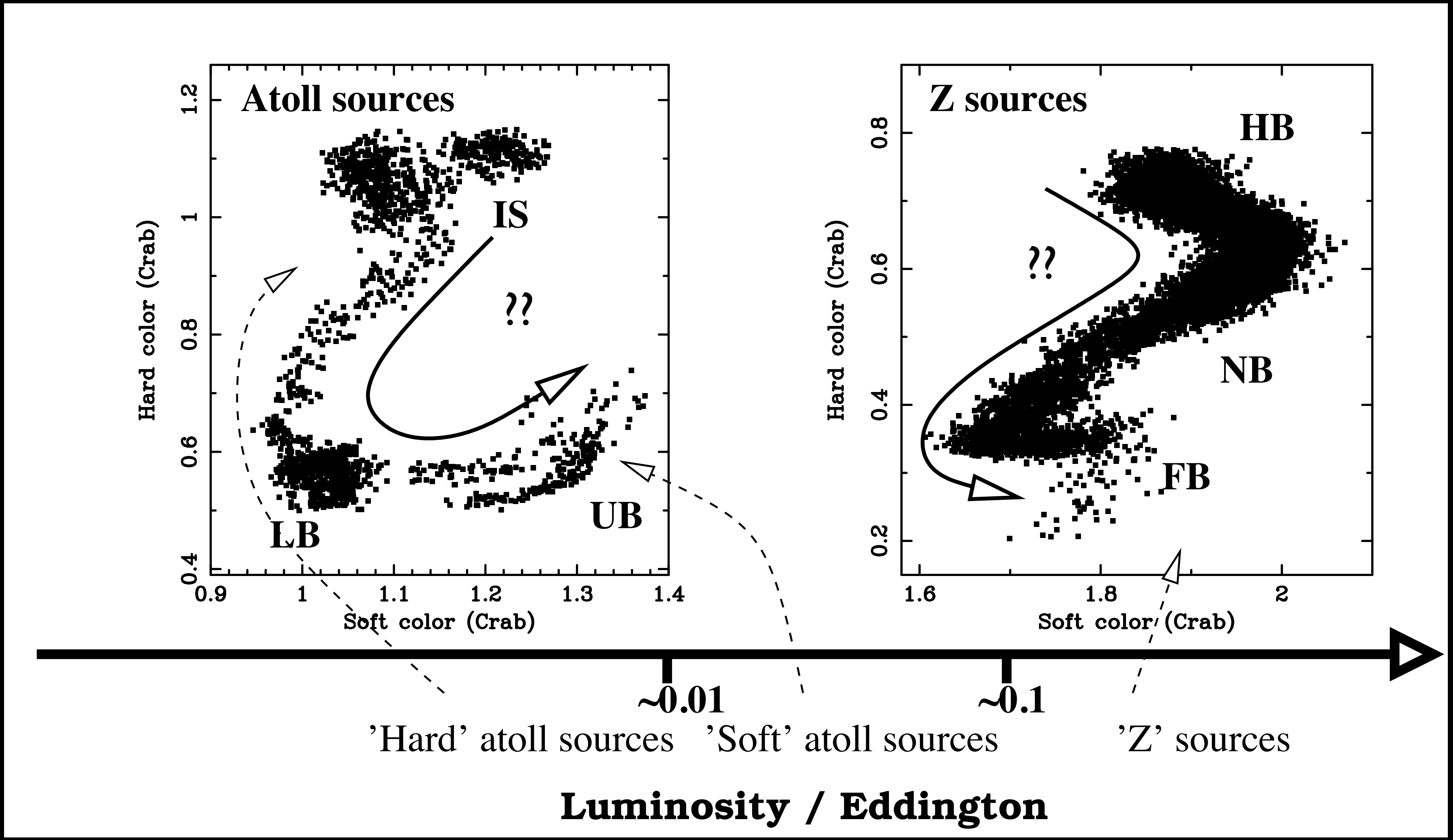


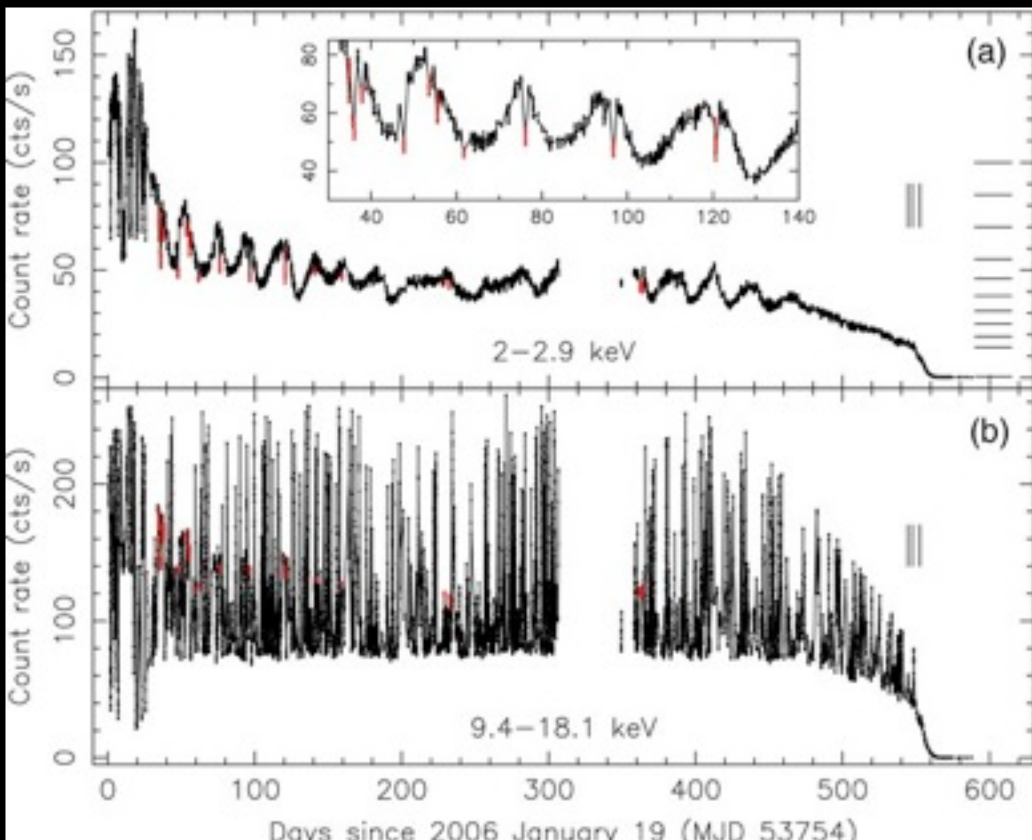

X-ray binary population
Radio detection/jet
sample: 264 XRBs (Liu et al. 01/06)
Atolls
143
X-ray pulsars
80
Z
8
AMXPs
13
Black Holes
20

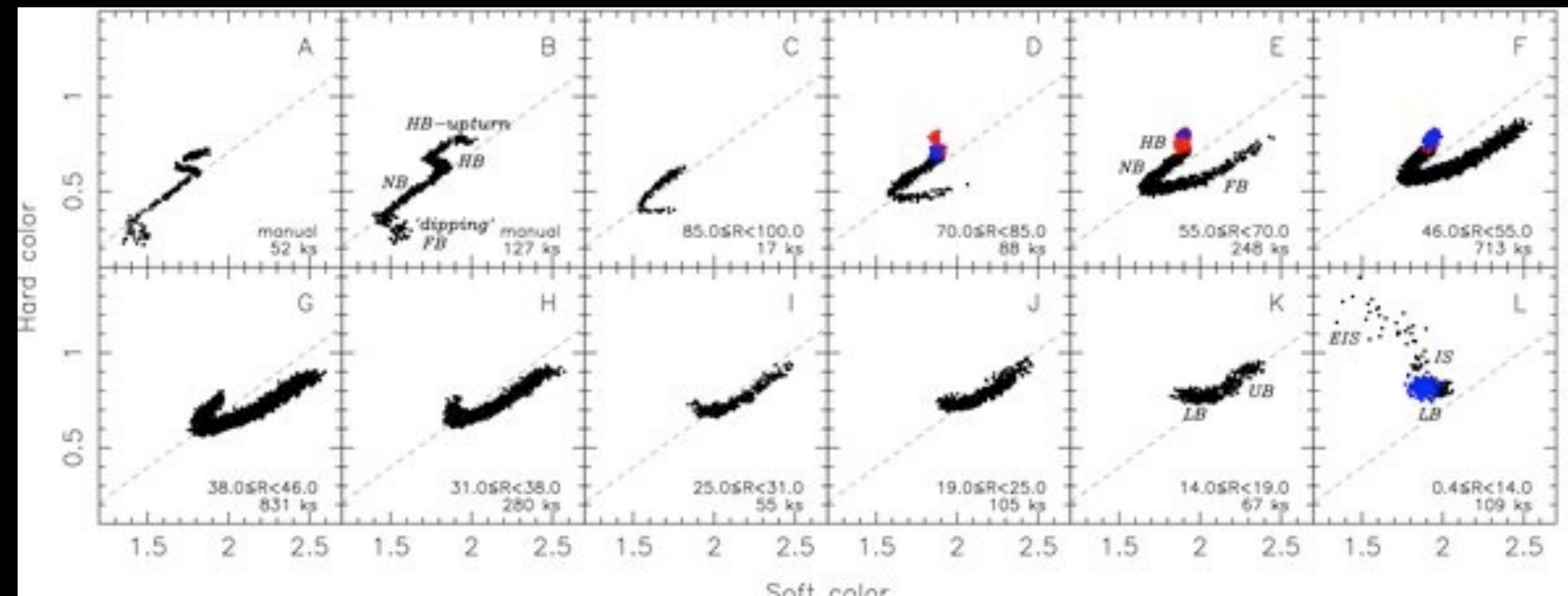
Nomenclature: NS classes



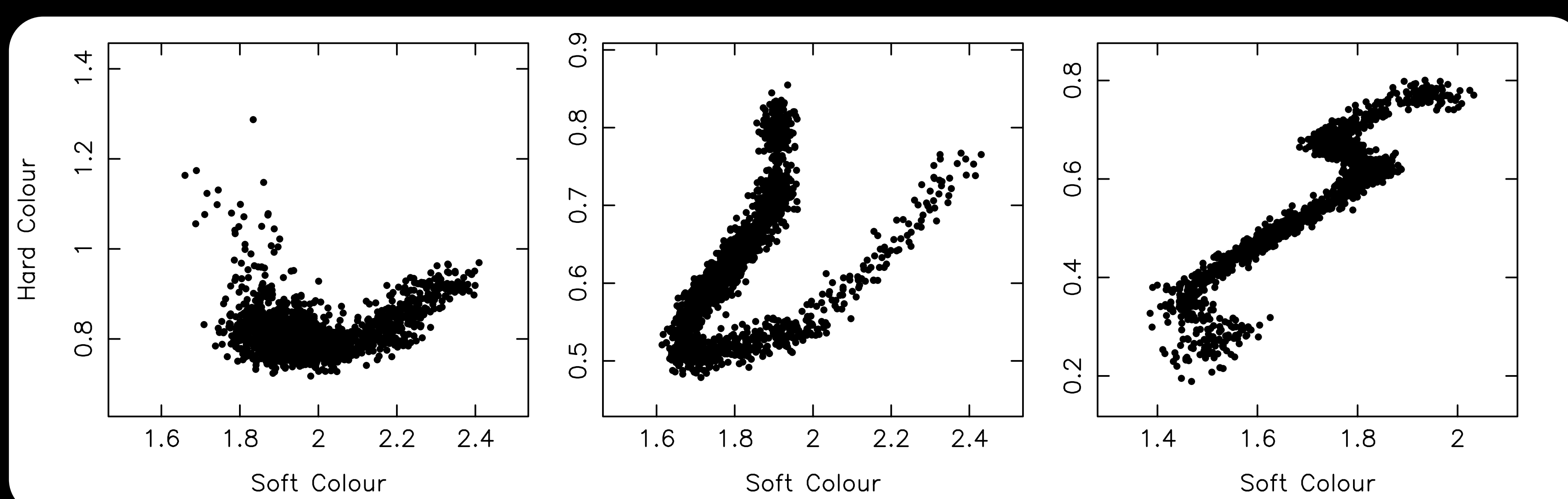
van der Klis 2006
Migliari & Fender 2006

XTE J1701-462: the Rosetta Stone

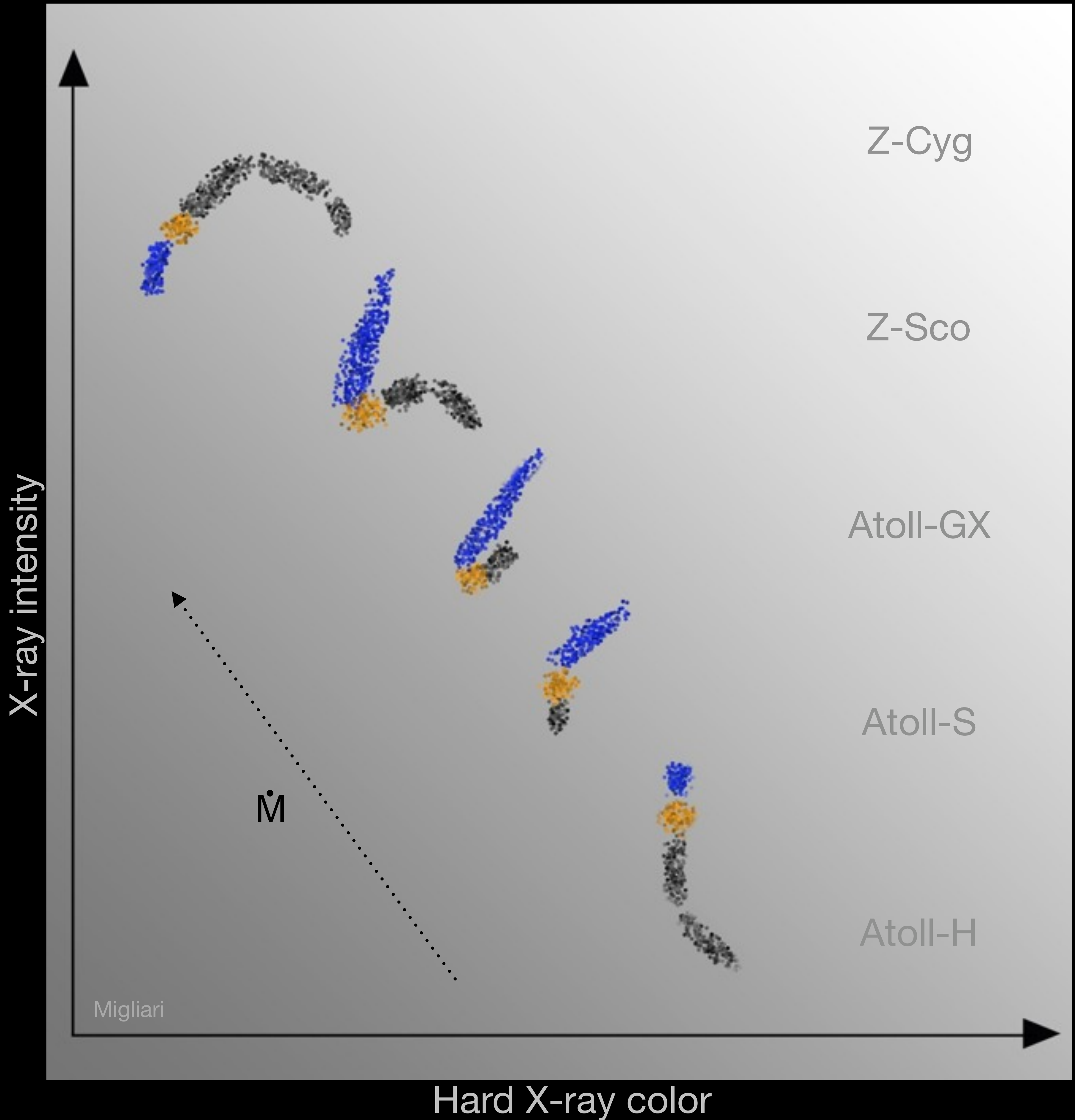


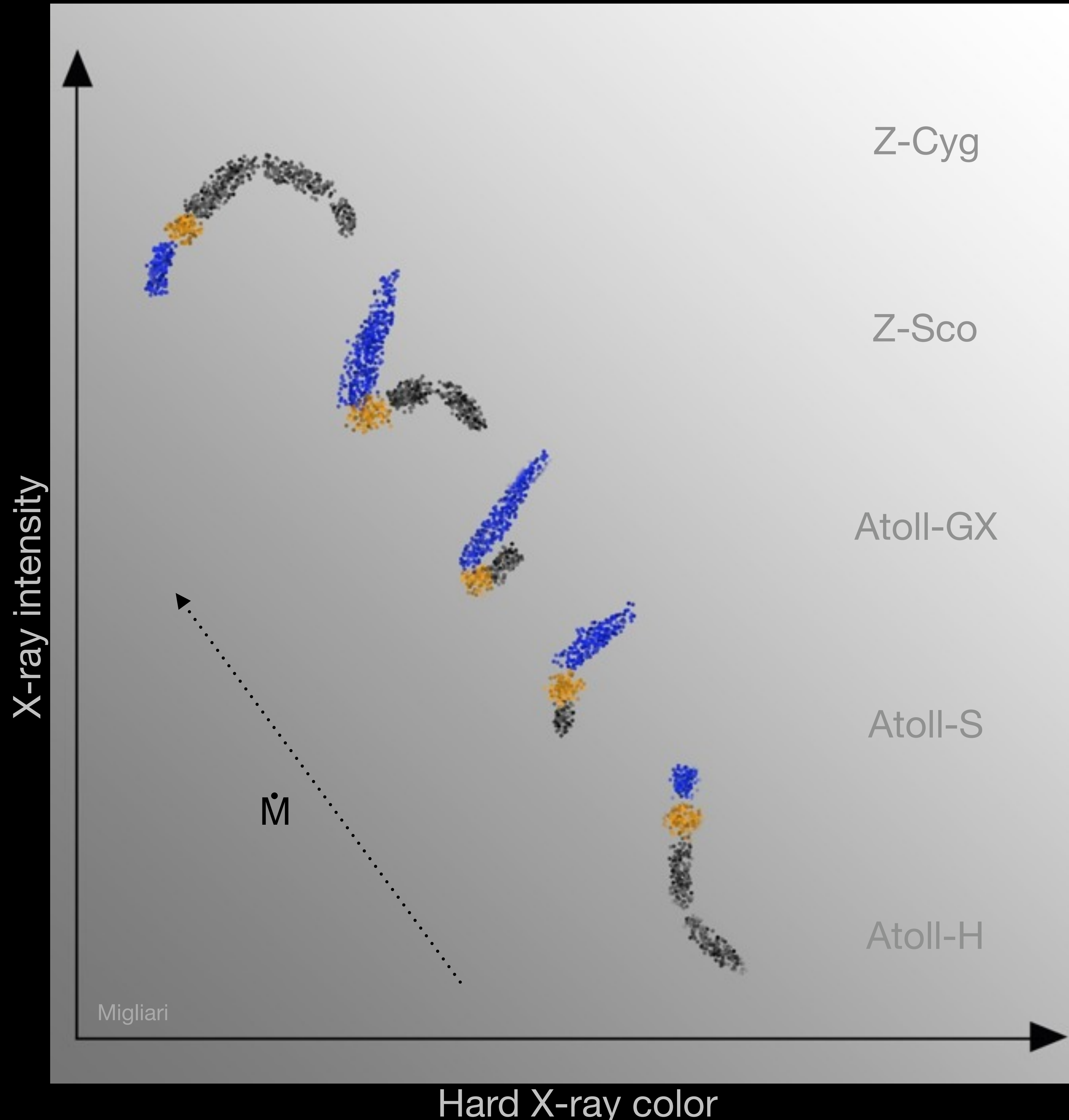


Atoll Z-Sco Z-Cyg



Homan et al. 2010


Z-Cyg
Z-Sco
Atoll-GX
Atoll-S
Atoll-H
Ṁ
Migliari
X-ray intensity
Hard X-ray color



GX5-1
4U1701-462
CygX-2

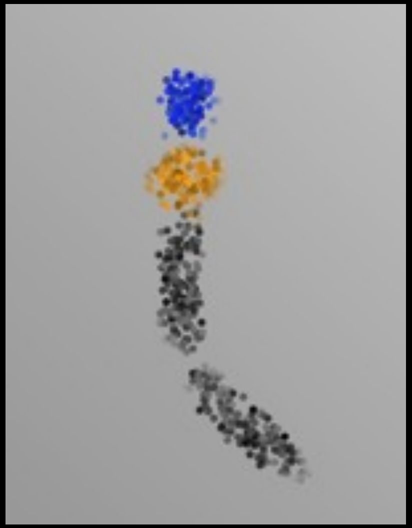
CygX-2
4U1701-462
ScoX-1
GX17+2

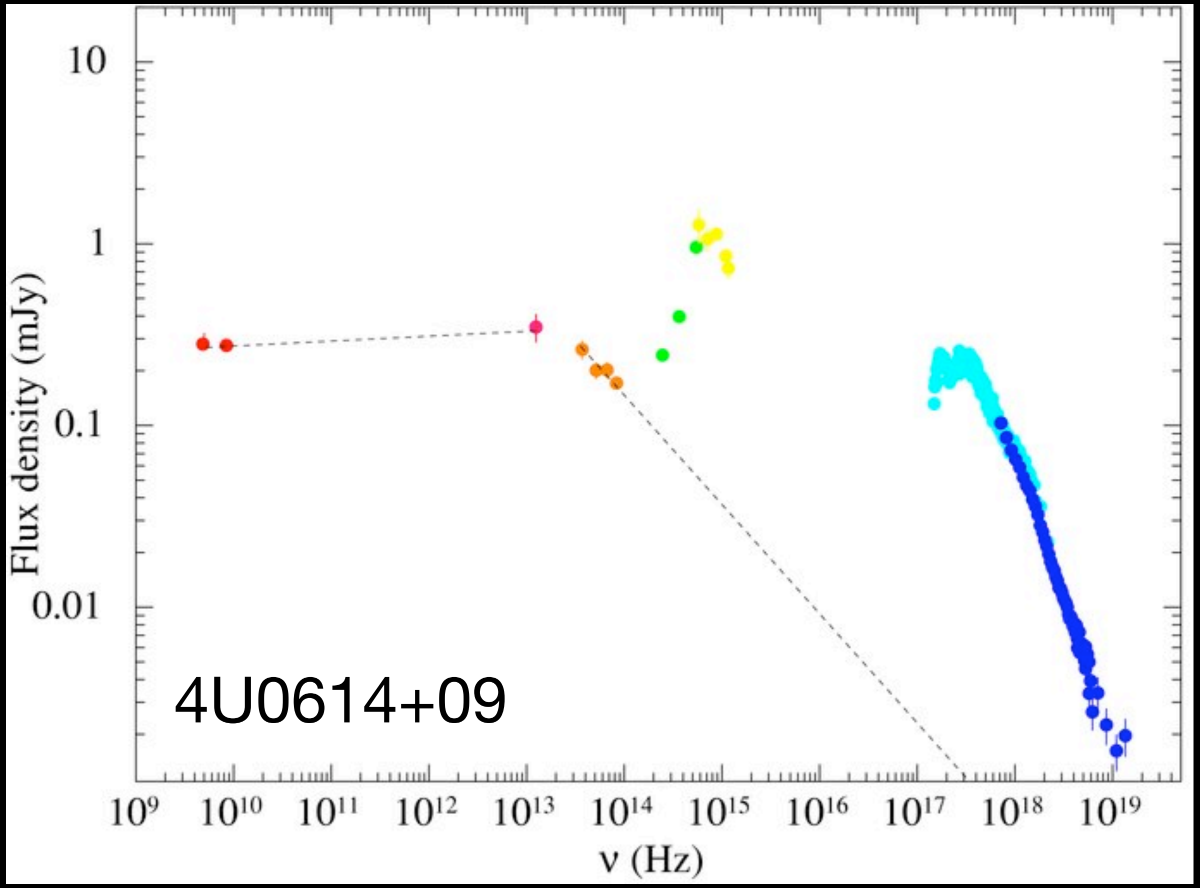
GX9+9...

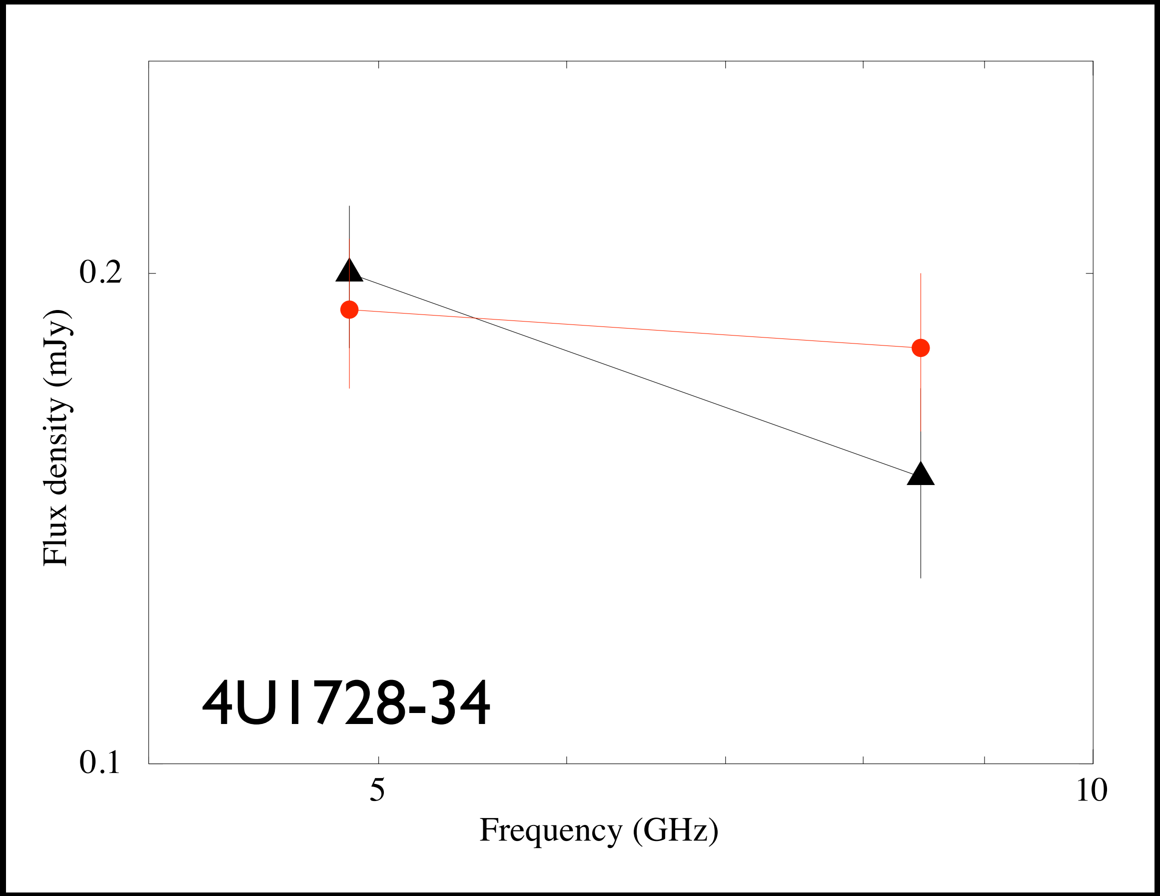
MXB1730-33
4U1820-30
SerX-1
AqlX-1

AqlX-1
4U1728-34
4U0614+091

Atoll-H

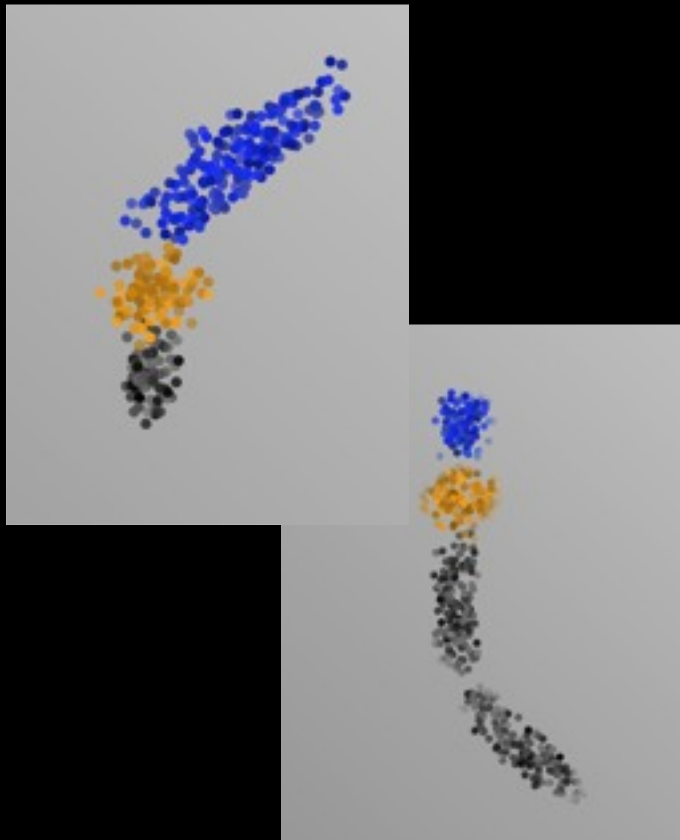


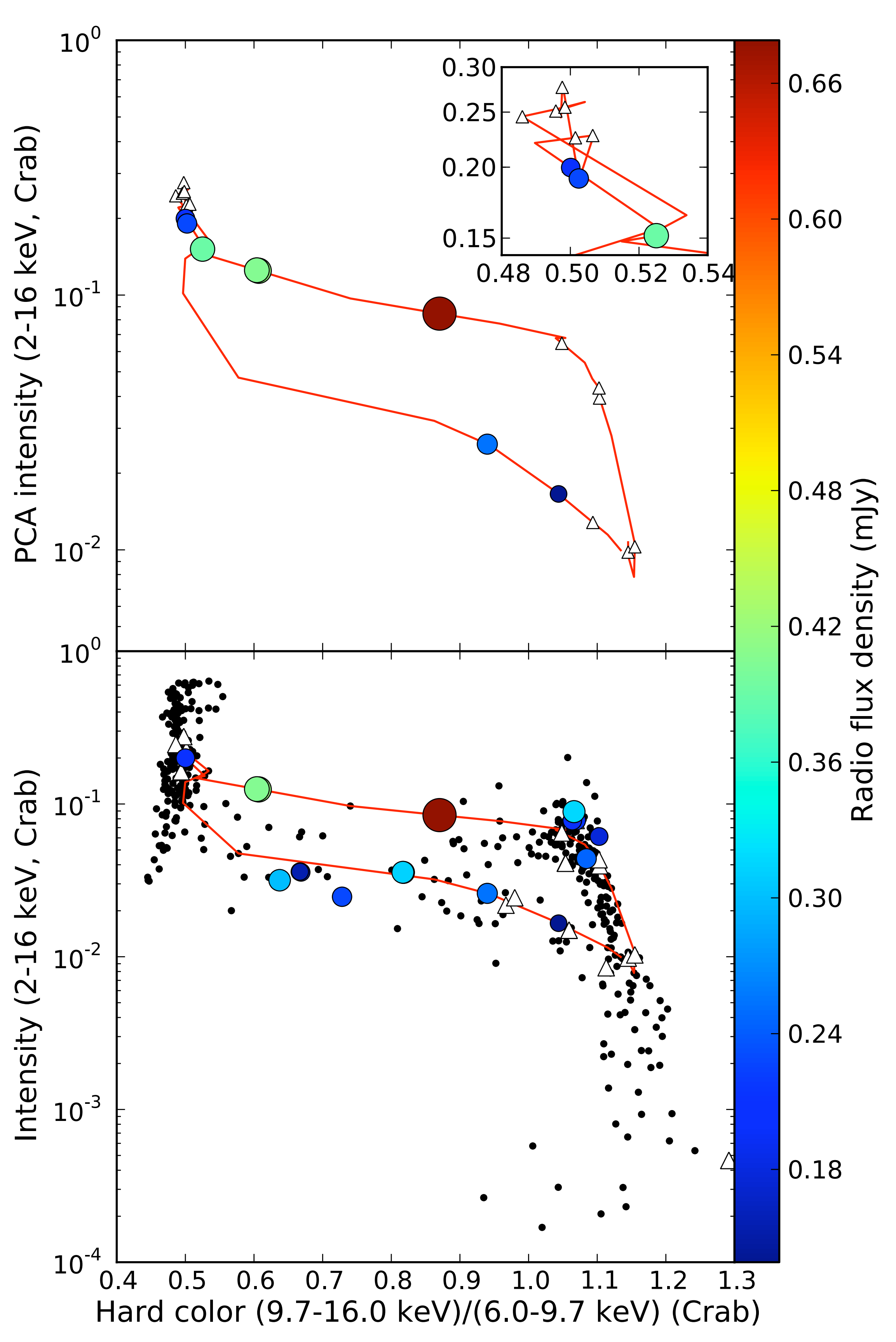




Migliari et al.
2003,2006,2010

Atoll-H-S transitions

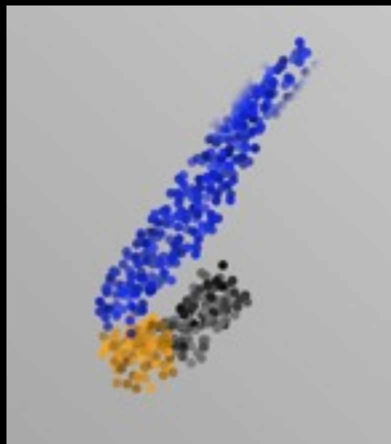


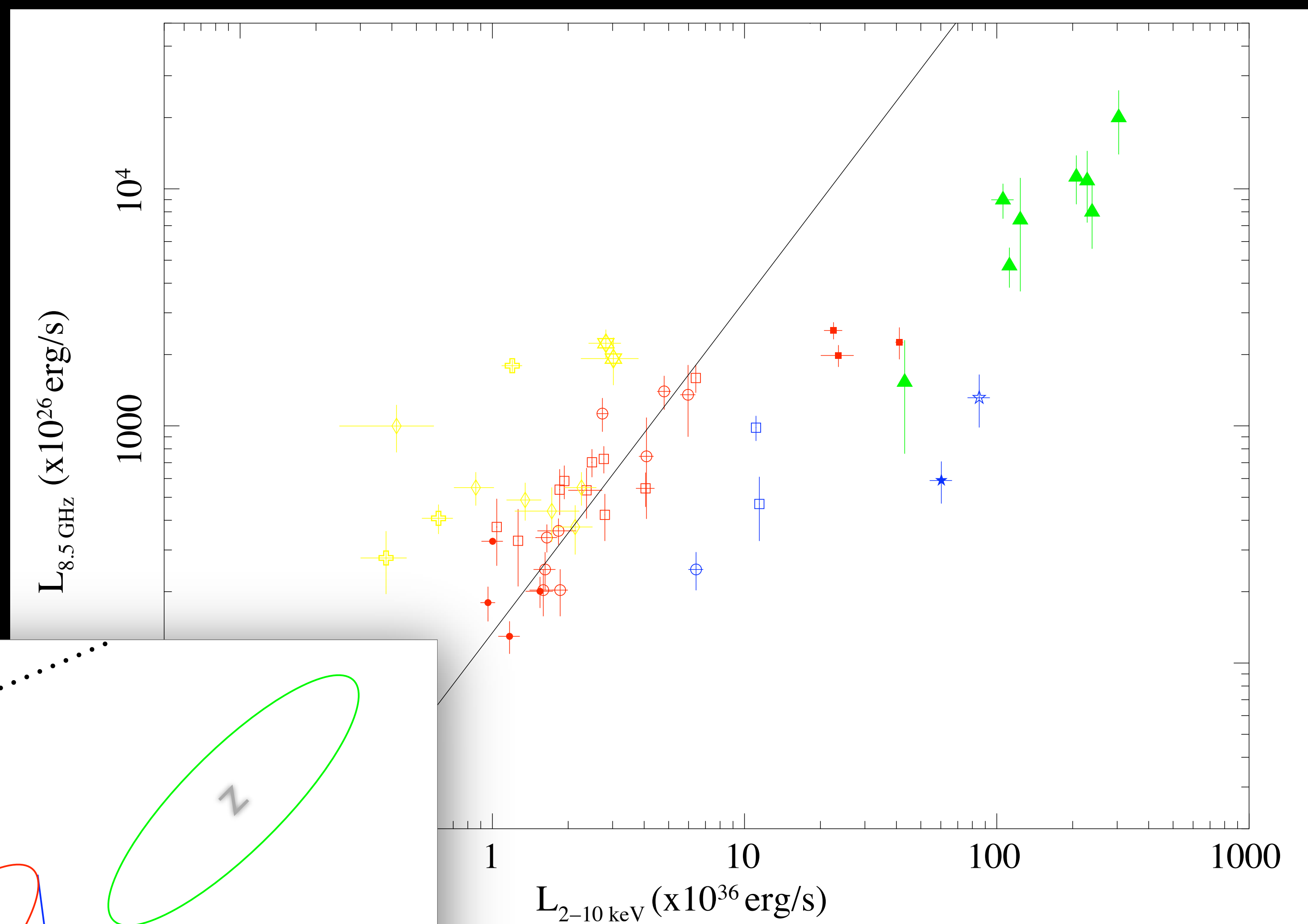


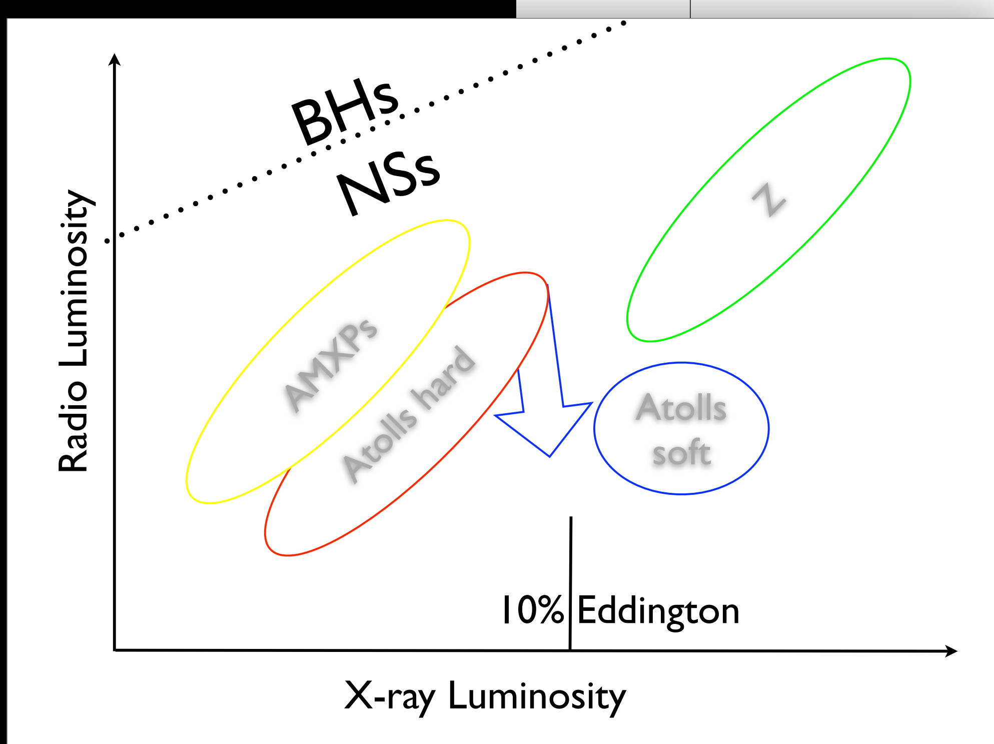
Miller-Jones et al. 2010: JACPOT collaboration
http://www.astro.virginia.edu/xrb_jets/

Atoll-GX

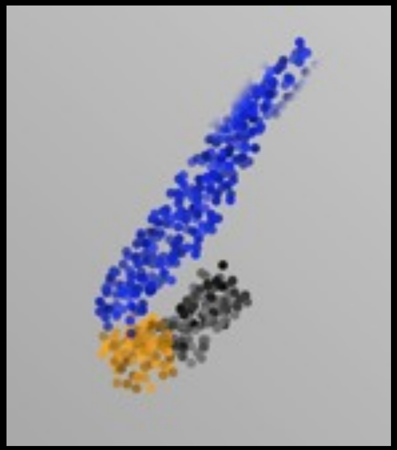
quenching at ~10% Eddington?





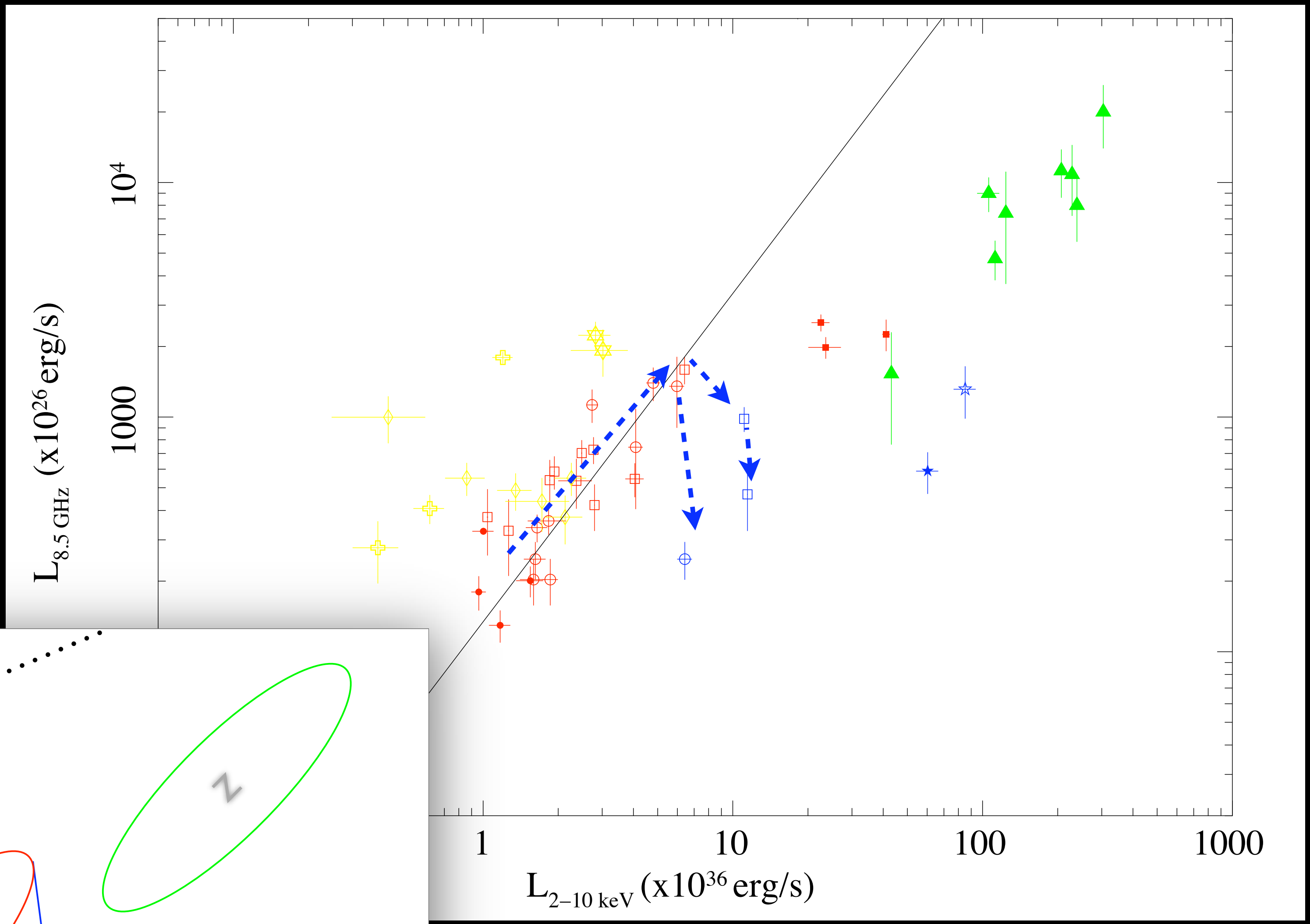


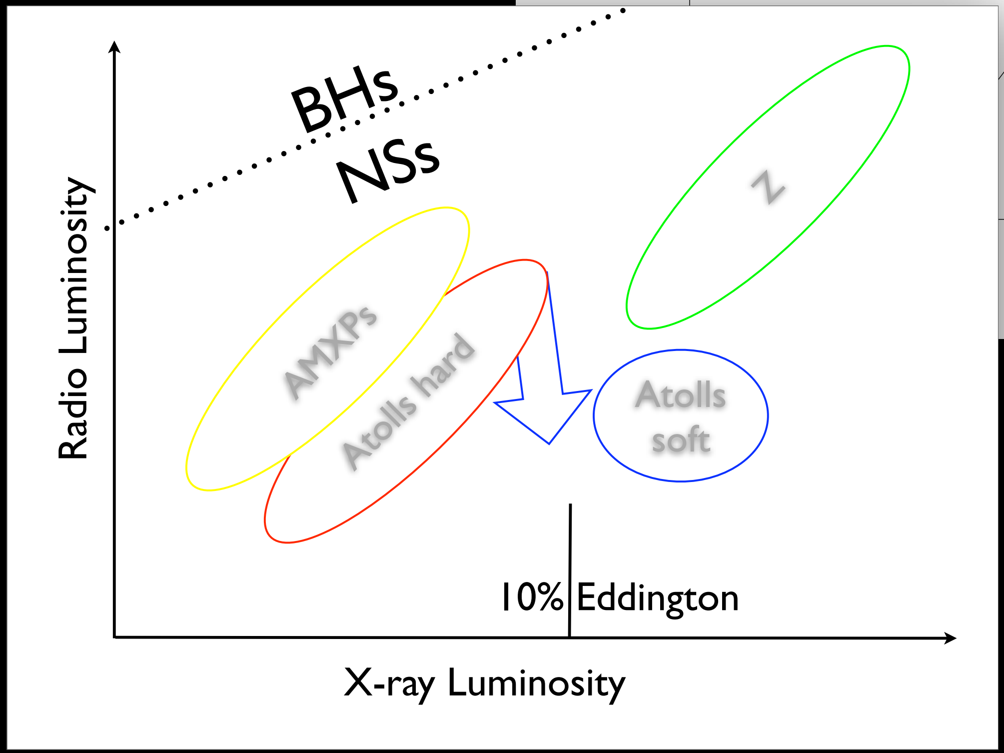
Migliari & Fender 2006
Migliari et al. in prep.



Atoll-GX

quenching at ~10% Eddington?

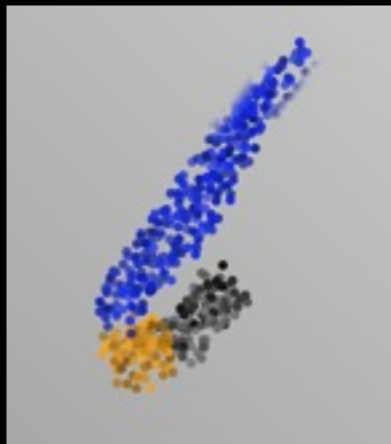


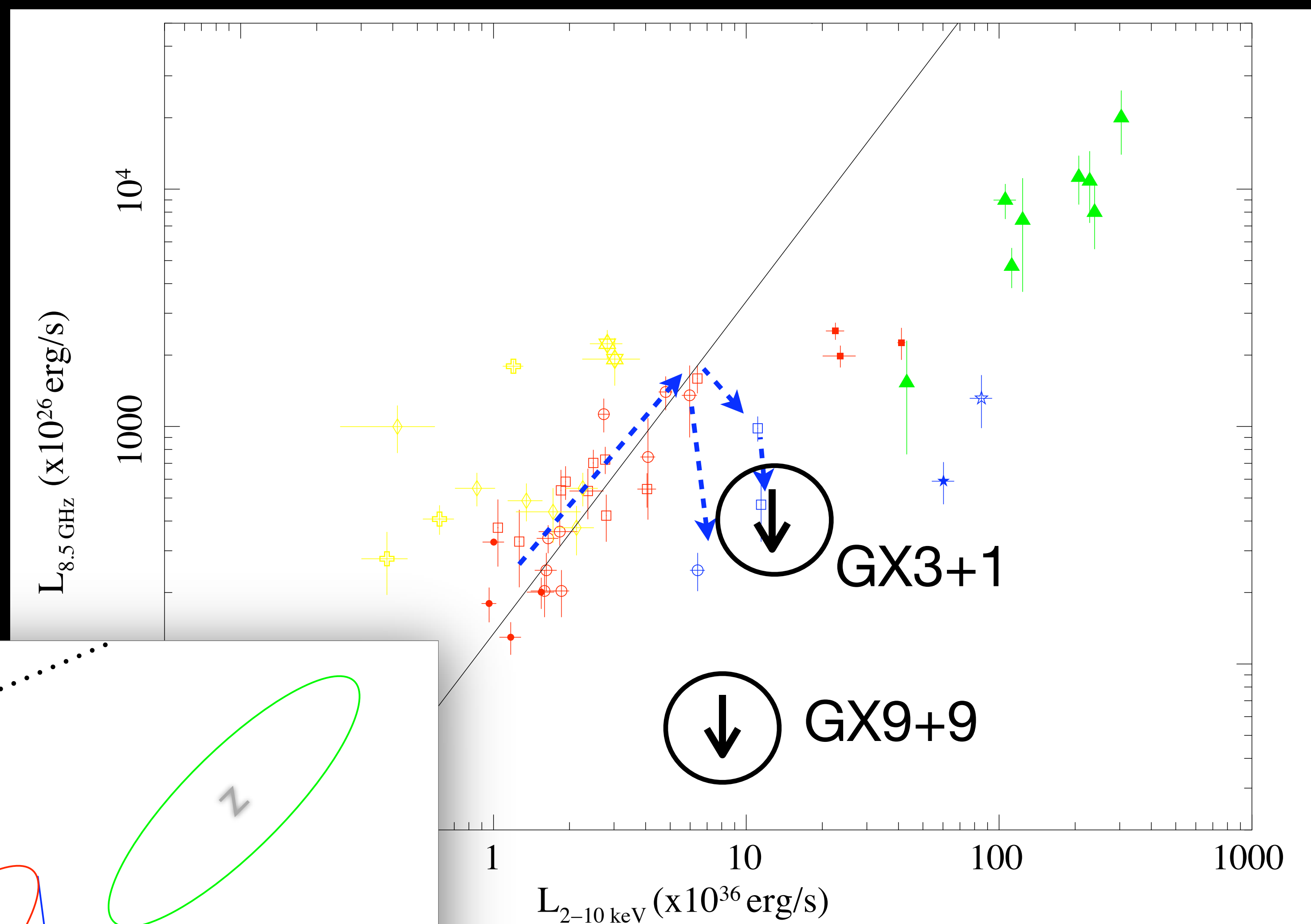


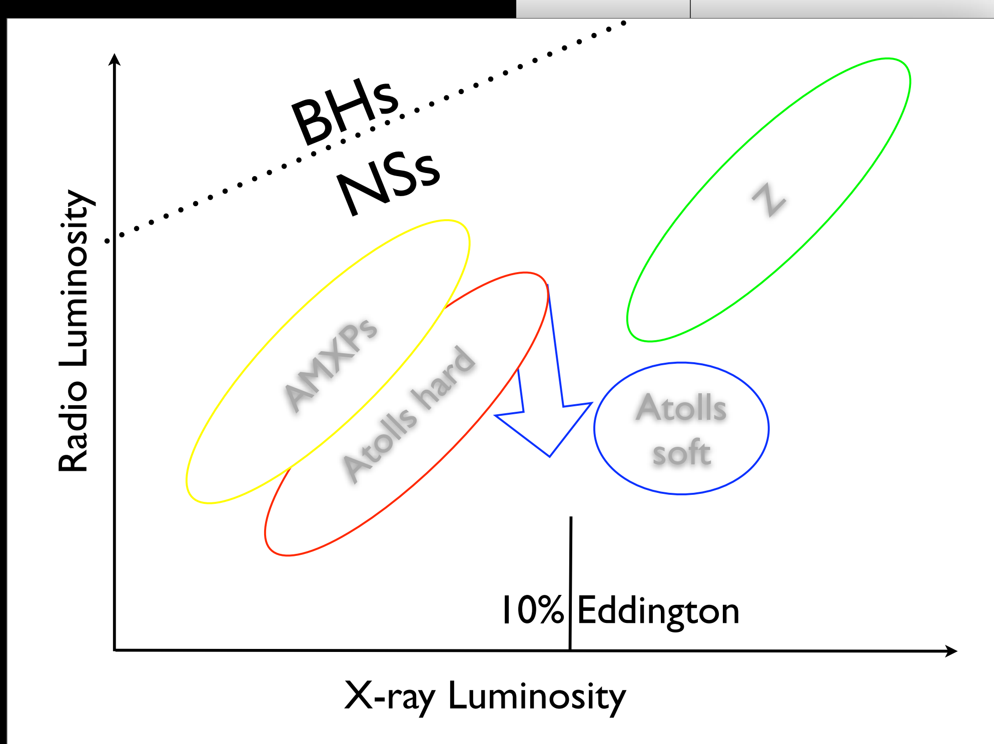
Migliari & Fender 2006
Migliari et al. in prep.

Atoll-GX

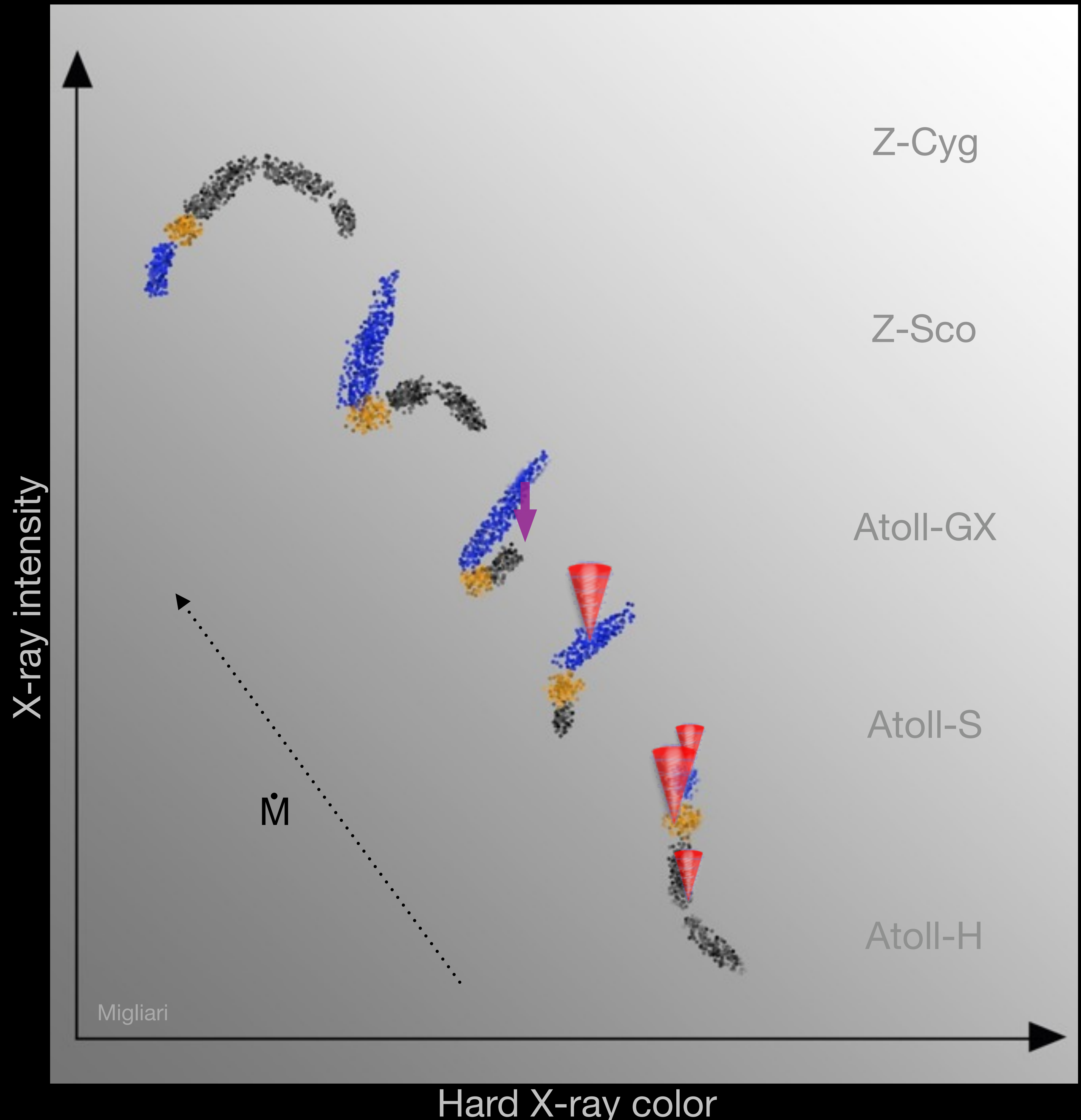
quenching at ~10% Eddington?







Migliari & Fender 2006
Migliari et al. in prep.



Atolls

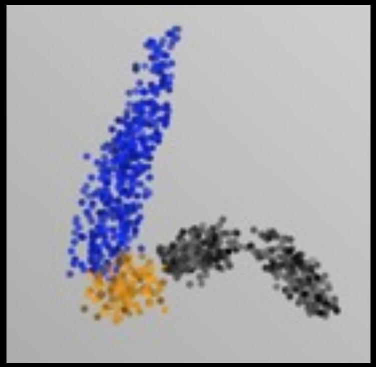
Detection:
all X-ray states

Brightest:
transitions

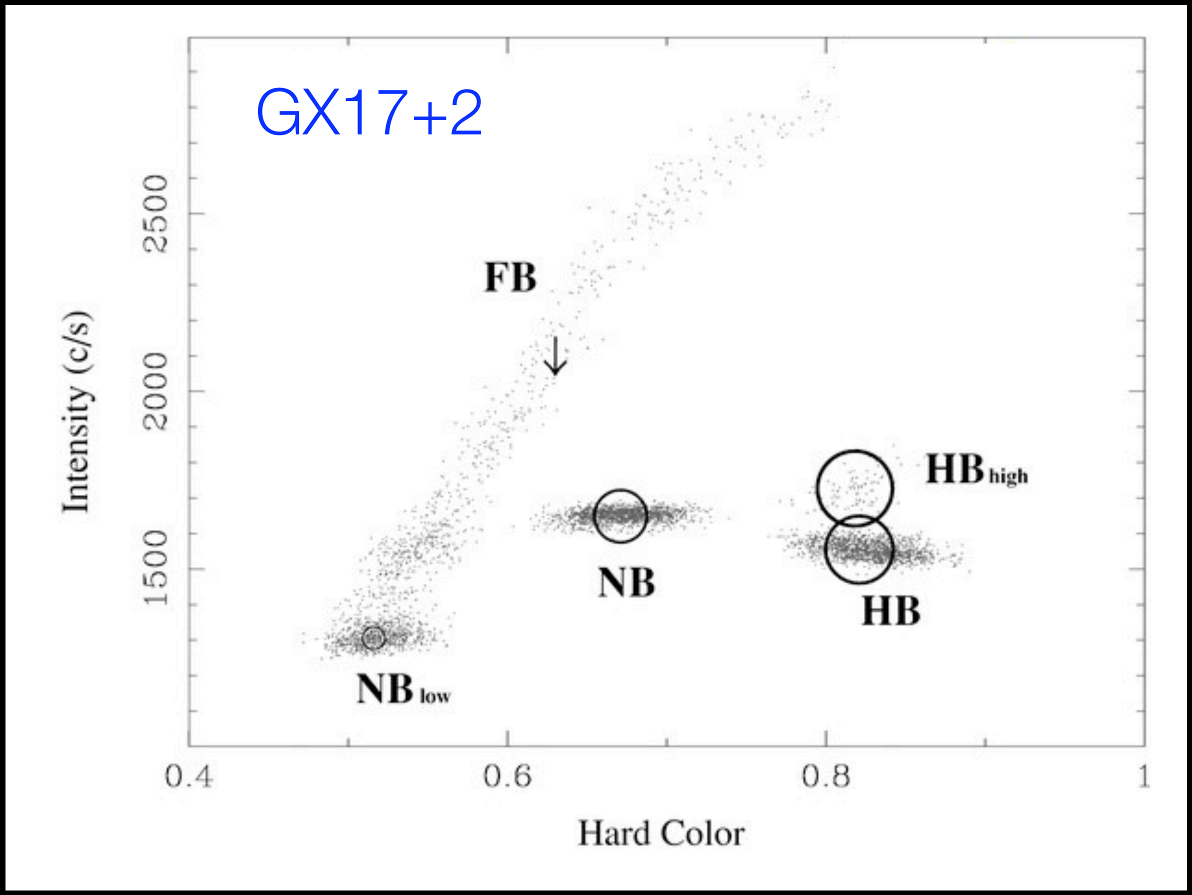
Type of Jet:
always compact

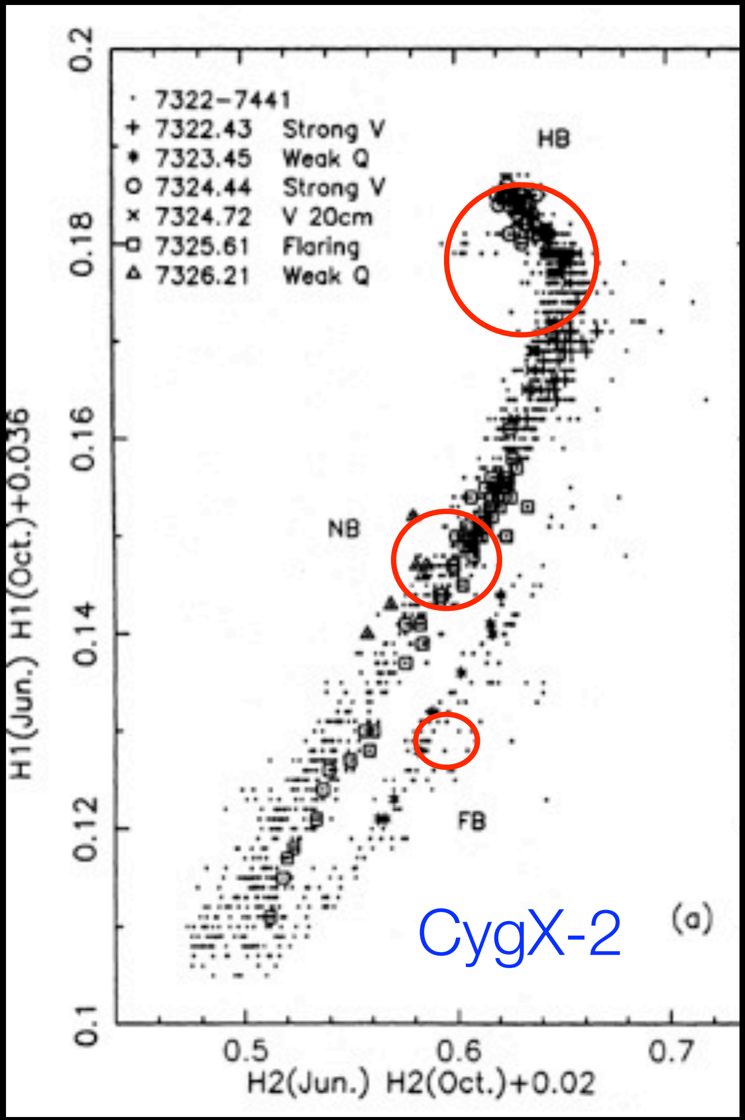
Quenching:
possibly ~10% Edd

Z



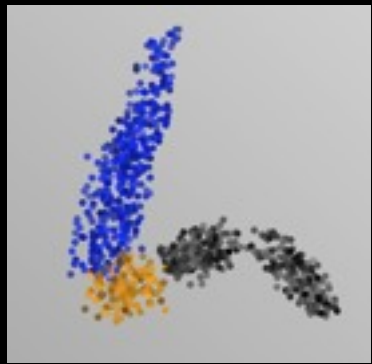
Migliari et al. 2007



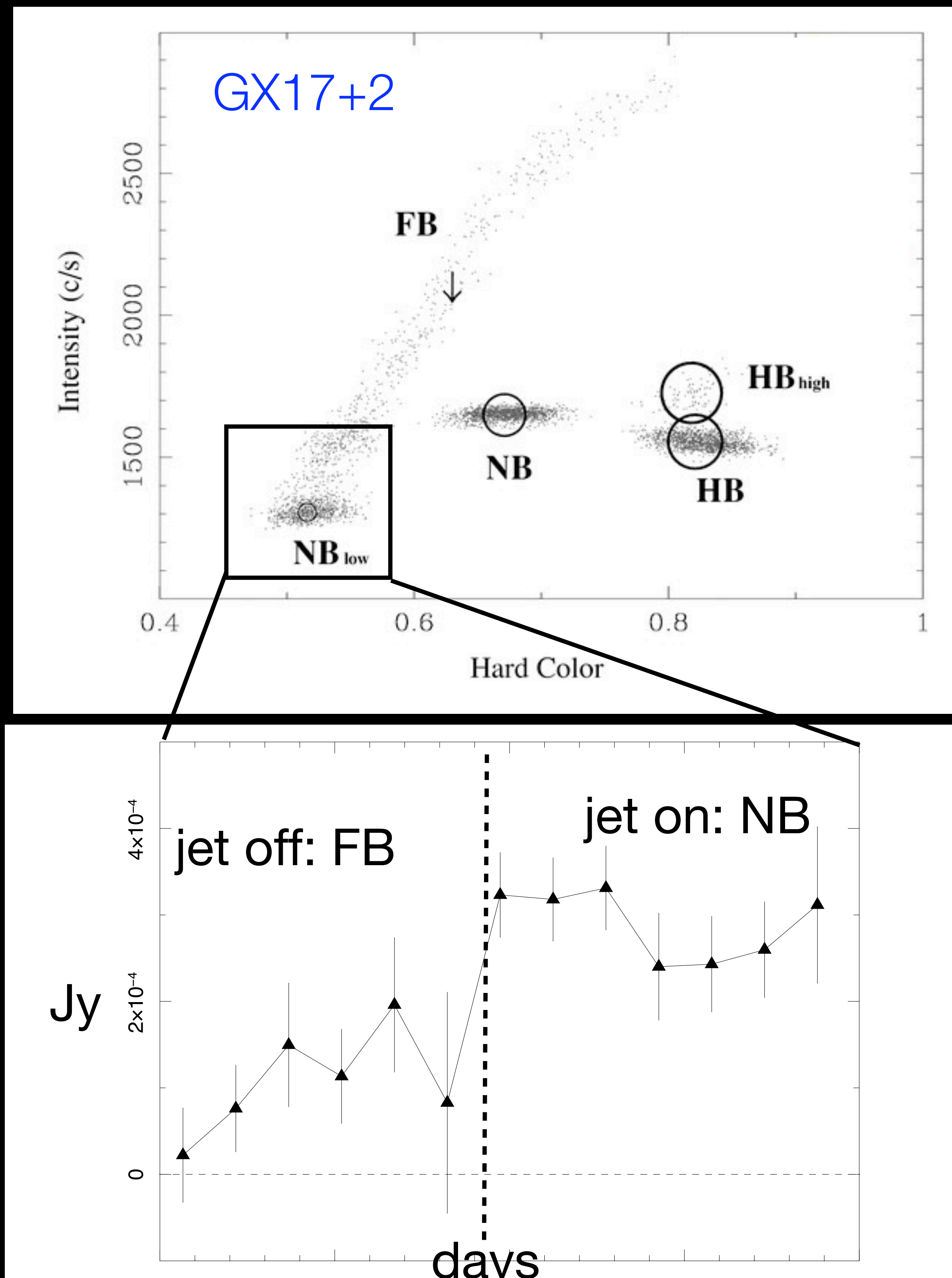


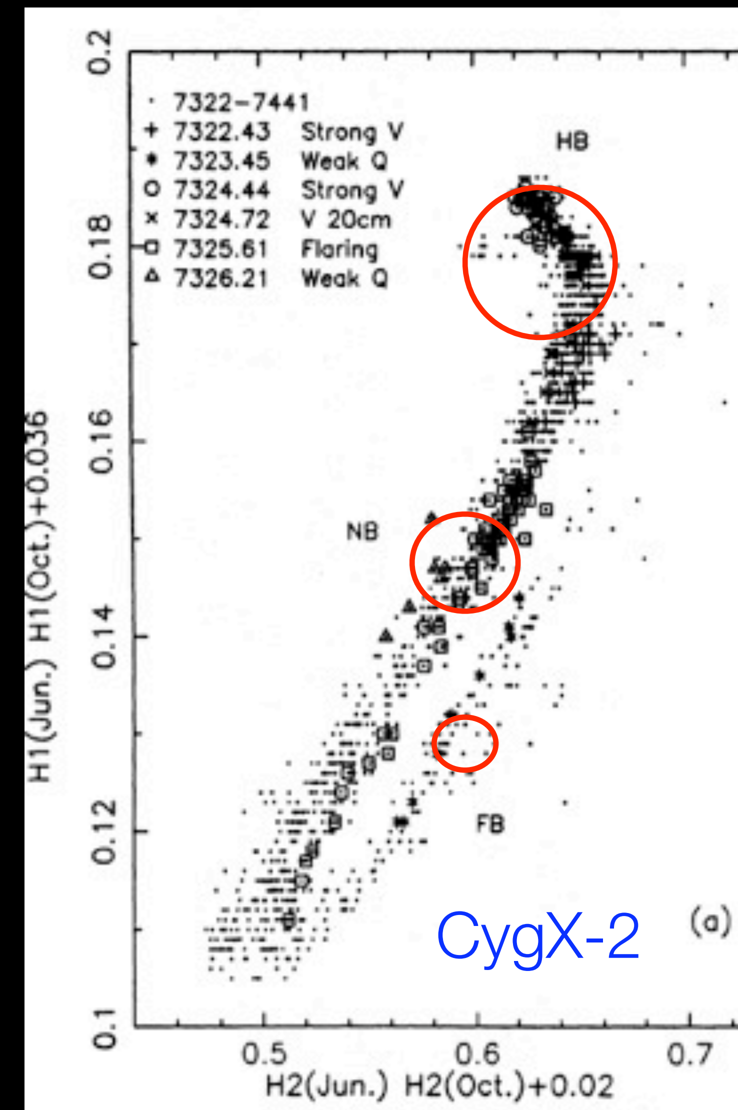
Hjellming et al. 1990

Z



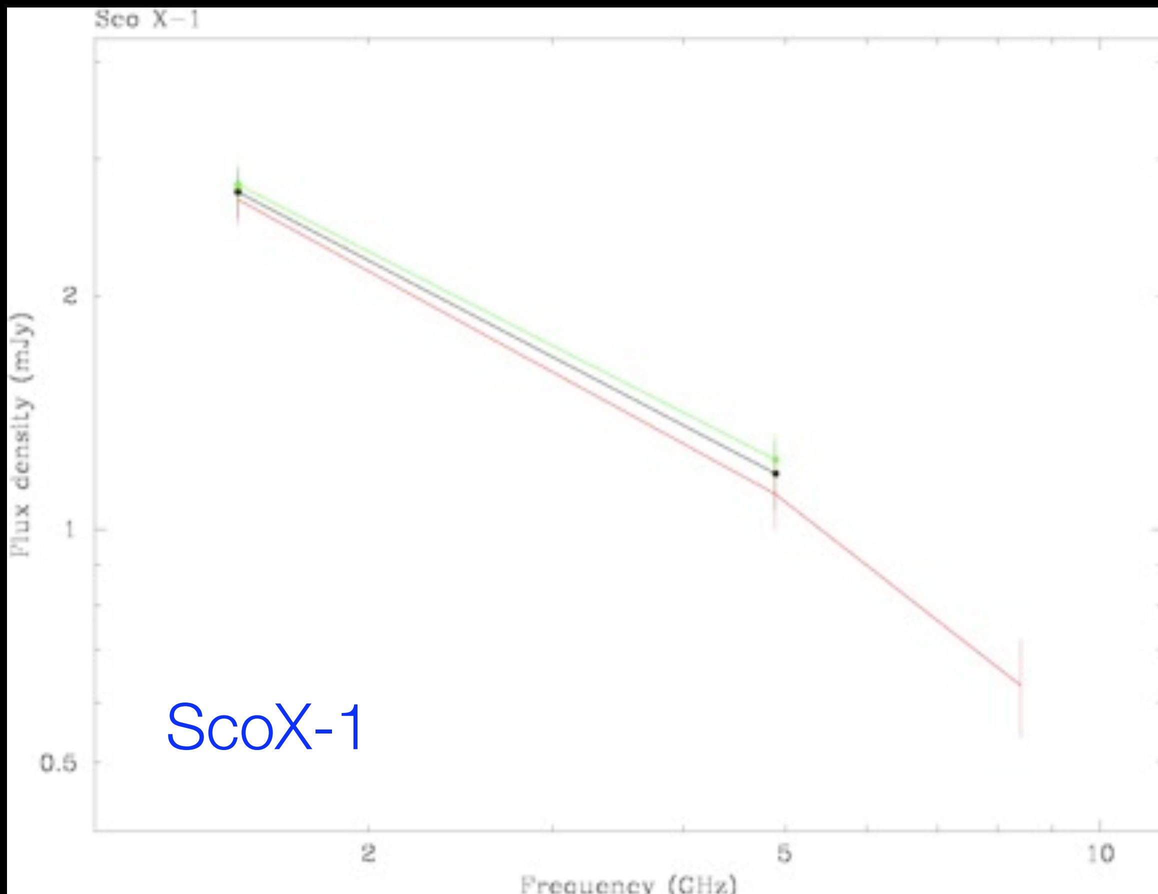
Migliari et al. 2007



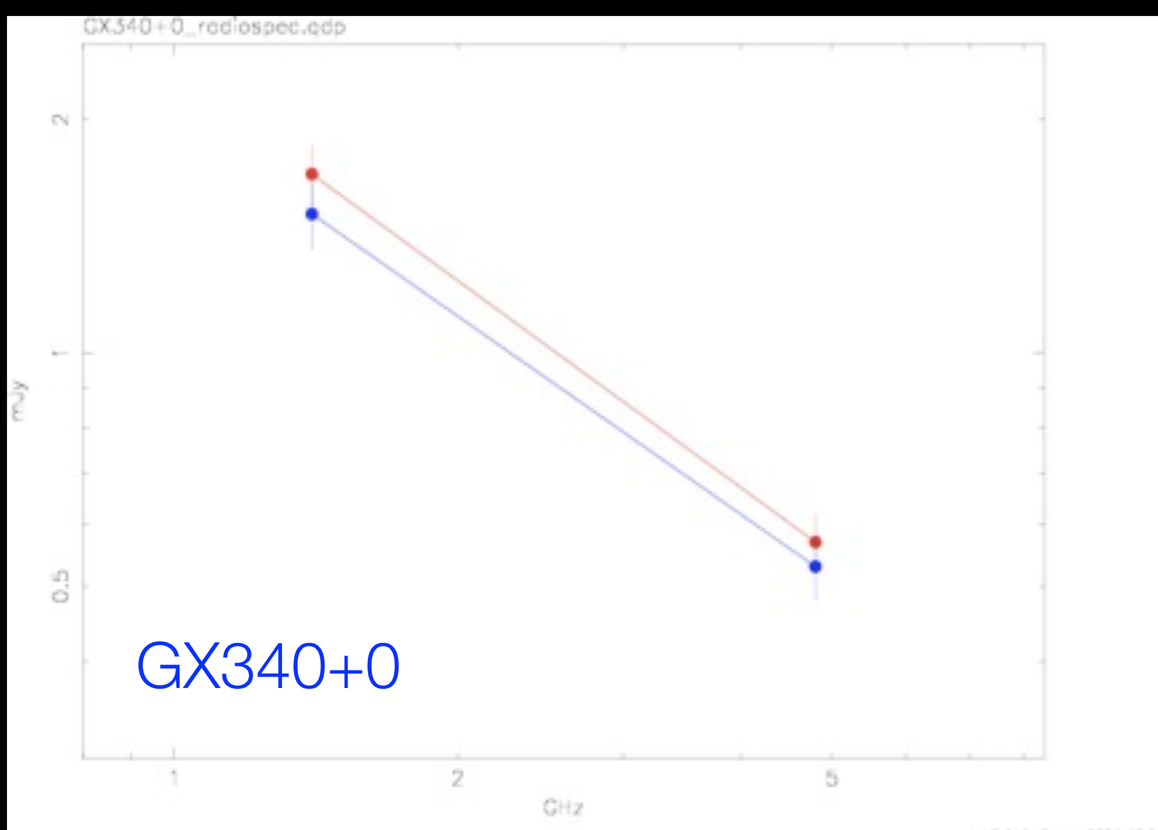


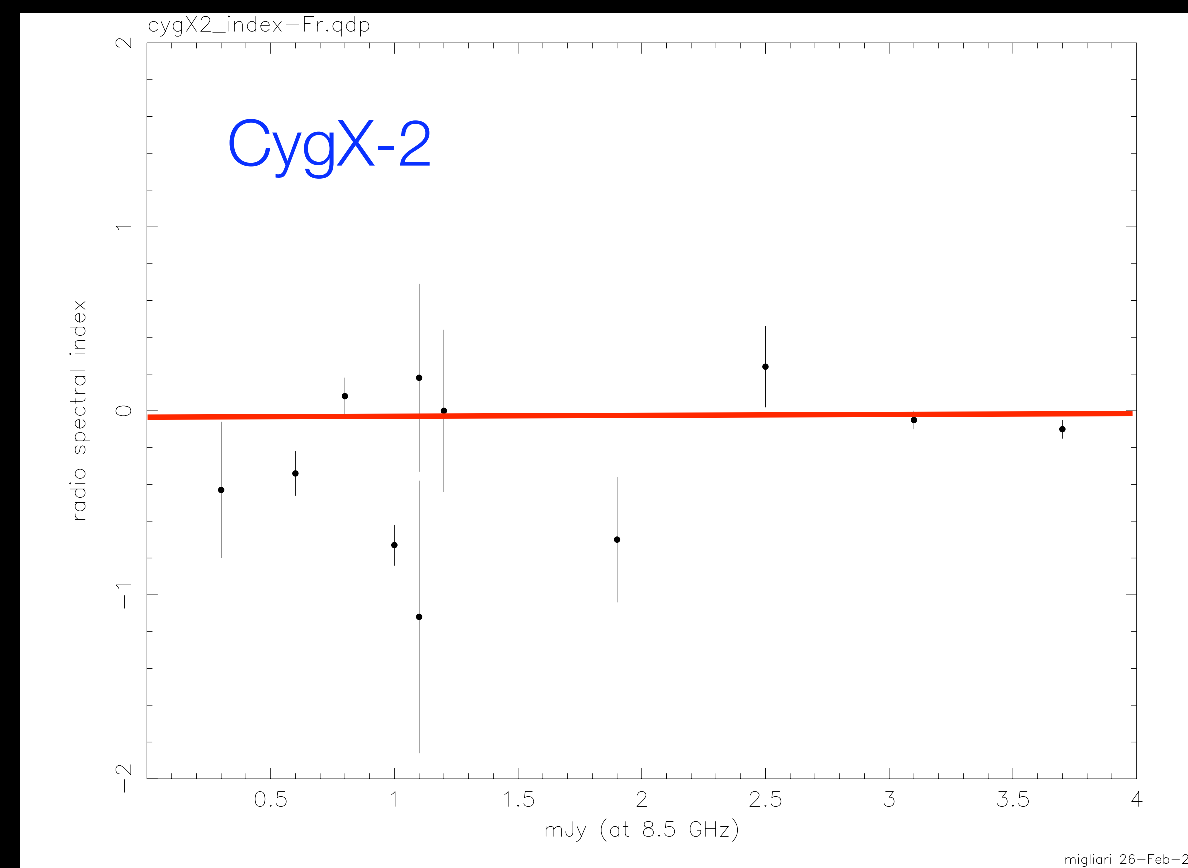
Hjellming et al. 1990

Z

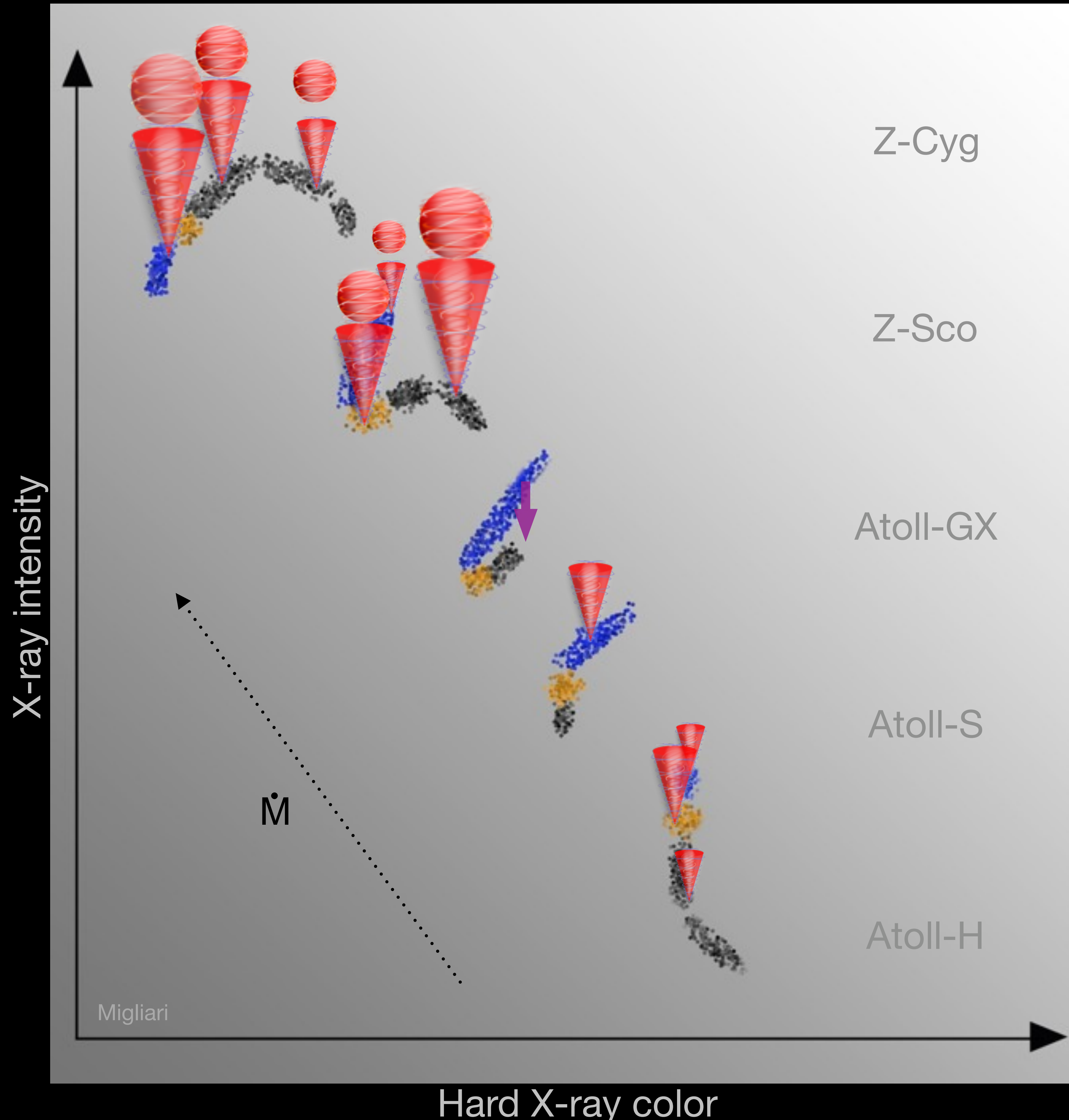


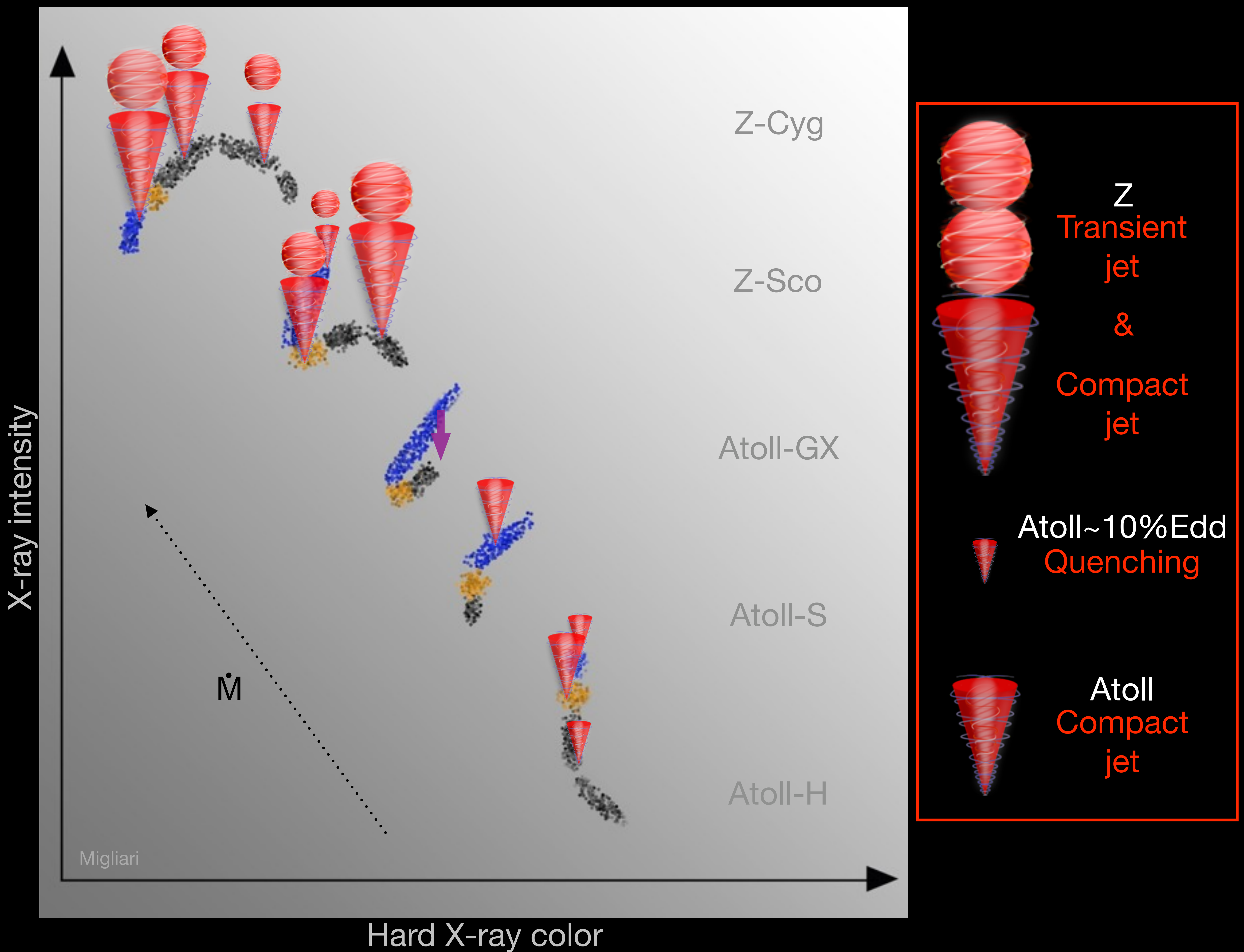
Fomalont et al. 2001





Hjellming et al. 1990

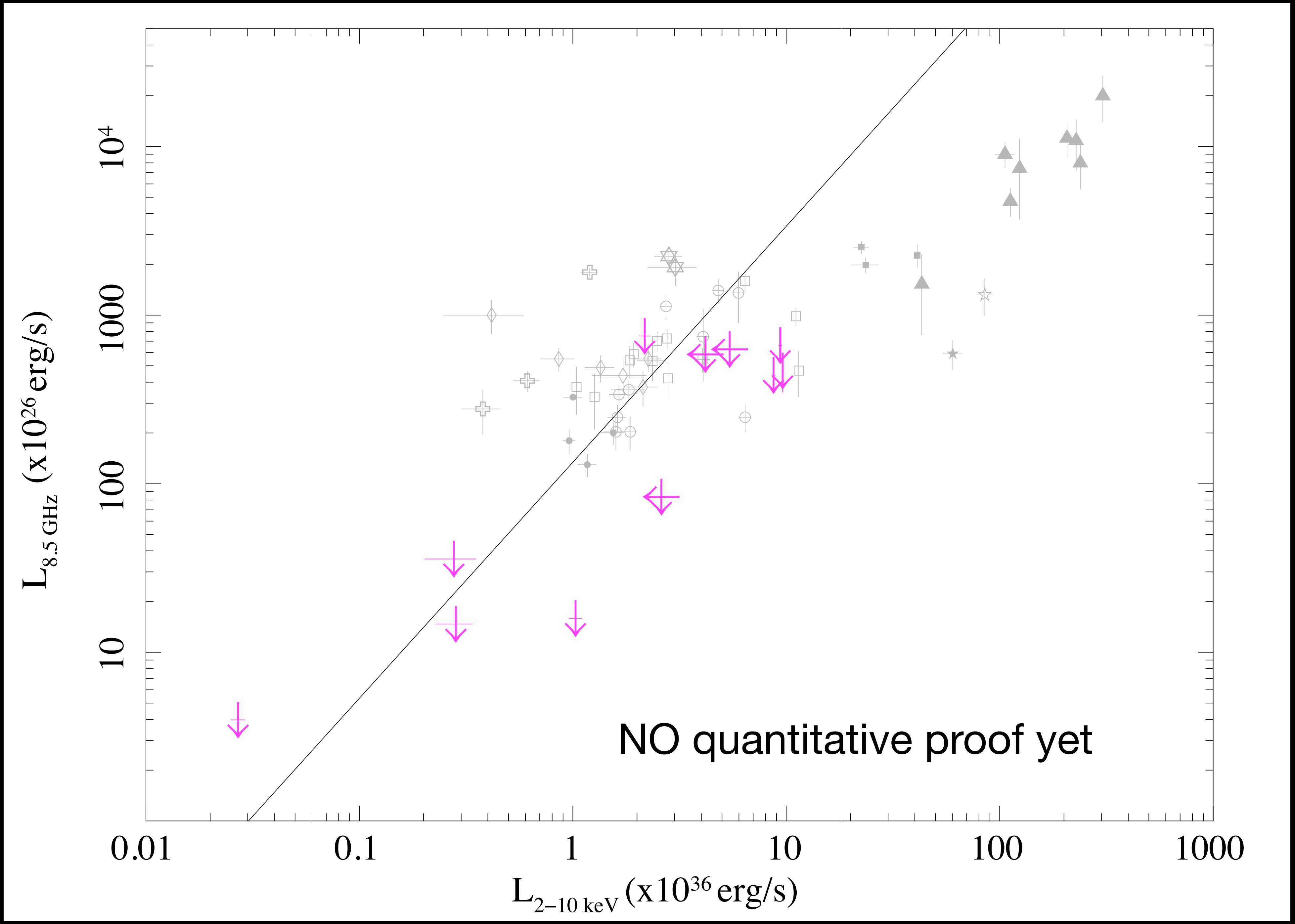

Z-Cyg
Z-Sco
Atoll-GX
Atoll-S
Atoll-H
$\dot{M}$
Migliari
X-ray intensity
Hard X-ray color


X-ray intensity
Hard X-ray color
Z-Cyg
Z-Sco
Atoll-GX
Atoll-S
Atoll-H
Ṁ
Migliari
Z
Transient
jet
&
Compact
jet
Atoll~10%Edd
Quenching
Atoll
Compact
jet

Role of the NS magnetic field?

X-ray pulsars

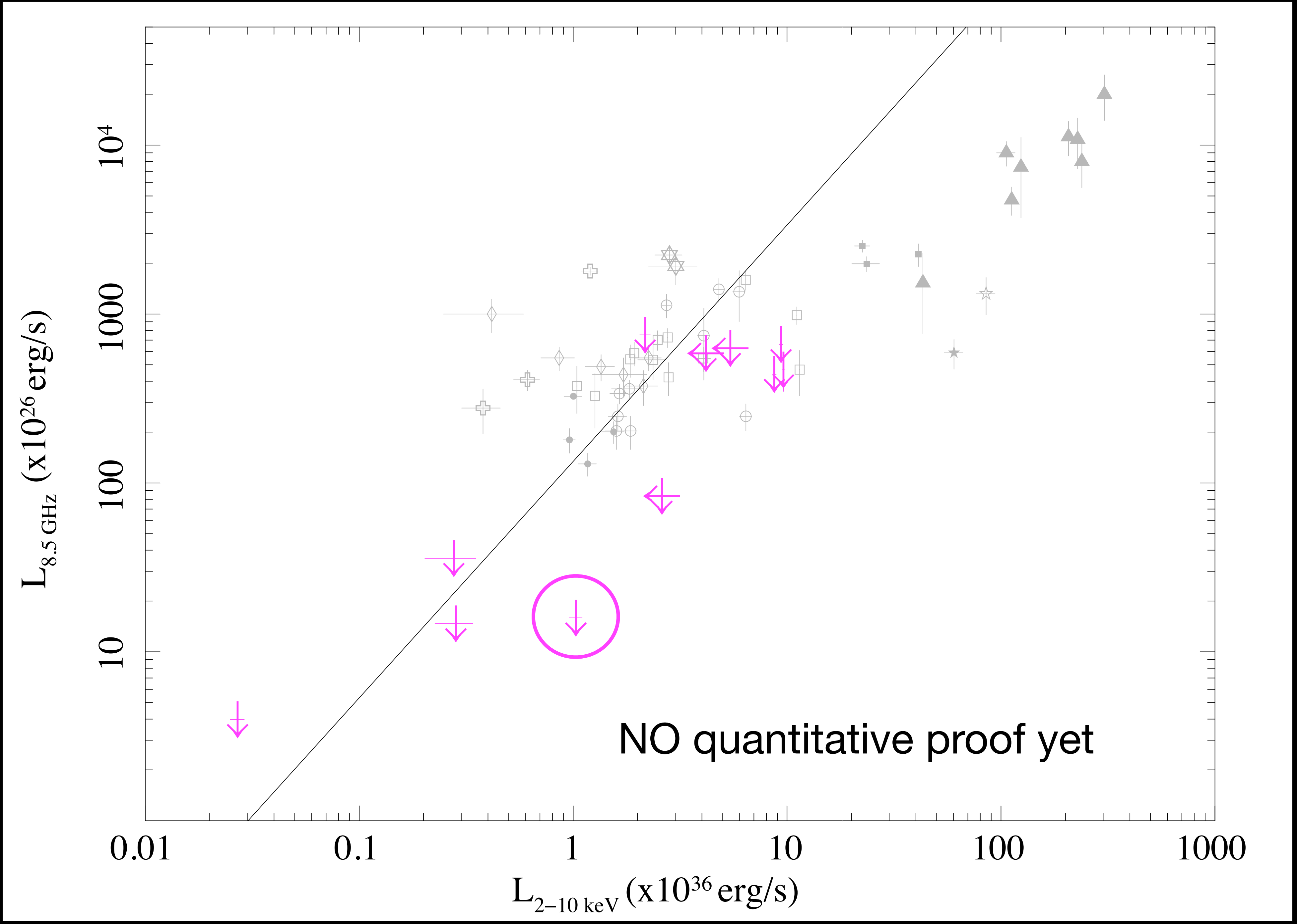
$B > 10^{12}$ G



Migliari 2010

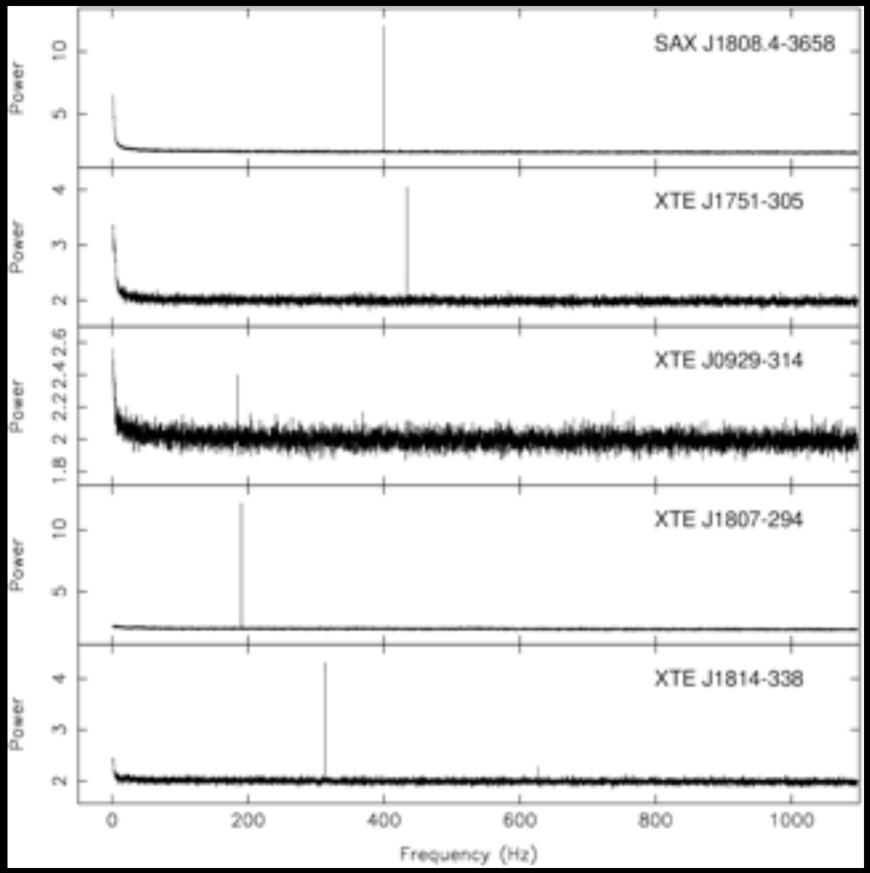
X-ray pulsars

↓ B> 10^{12} G

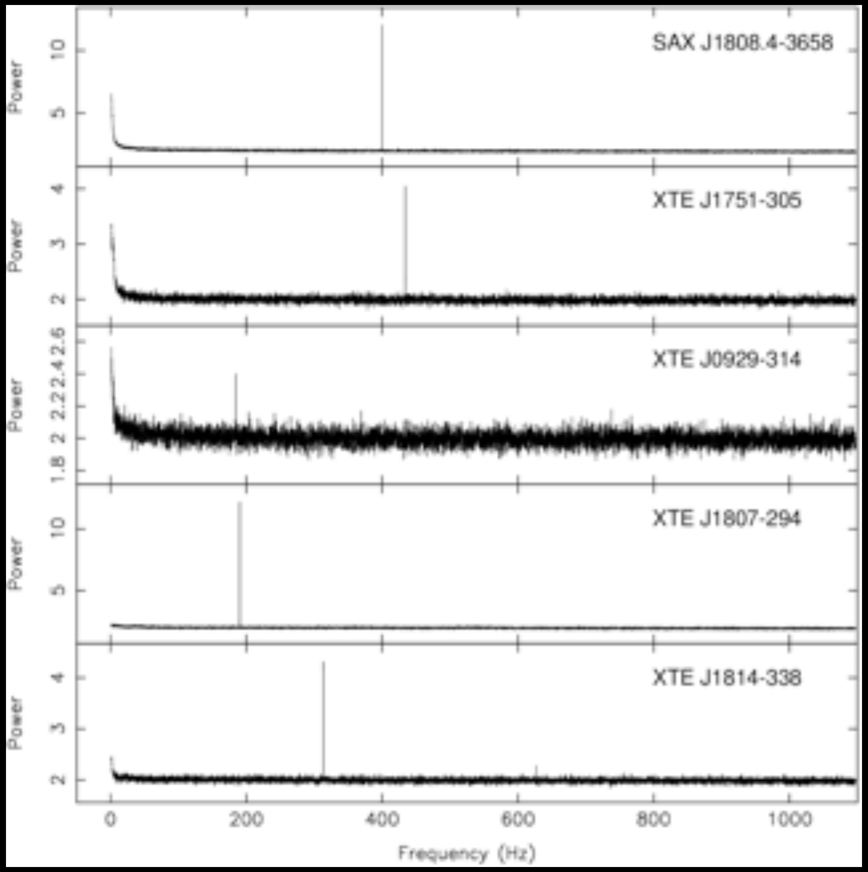


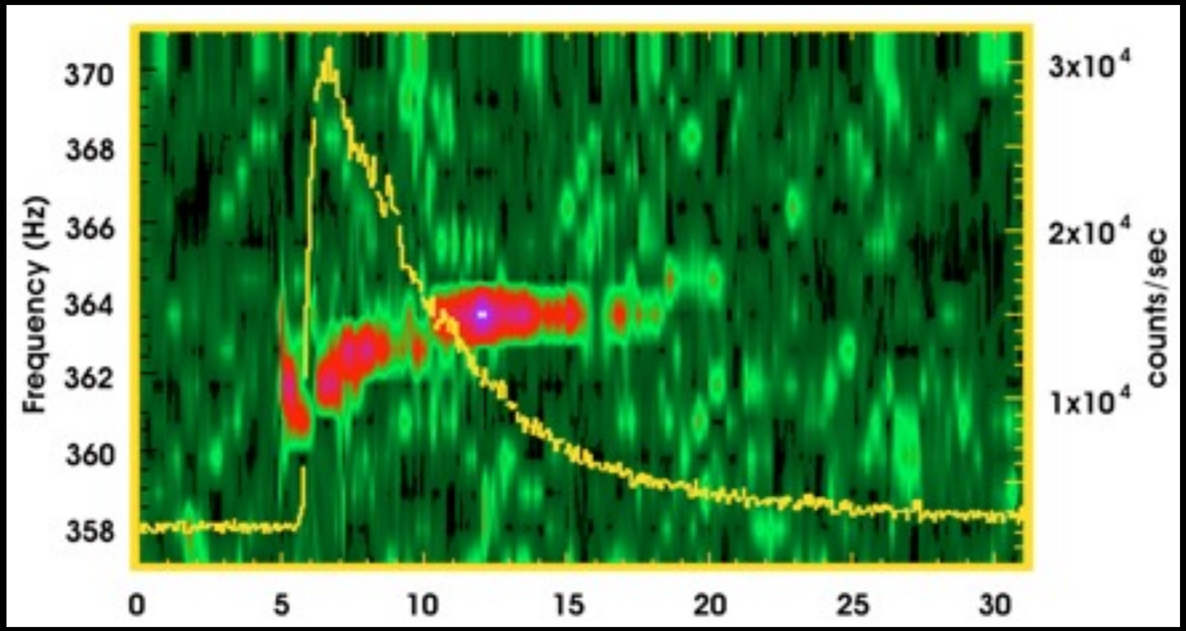
Migliari 2010

Role of the NS Spin?

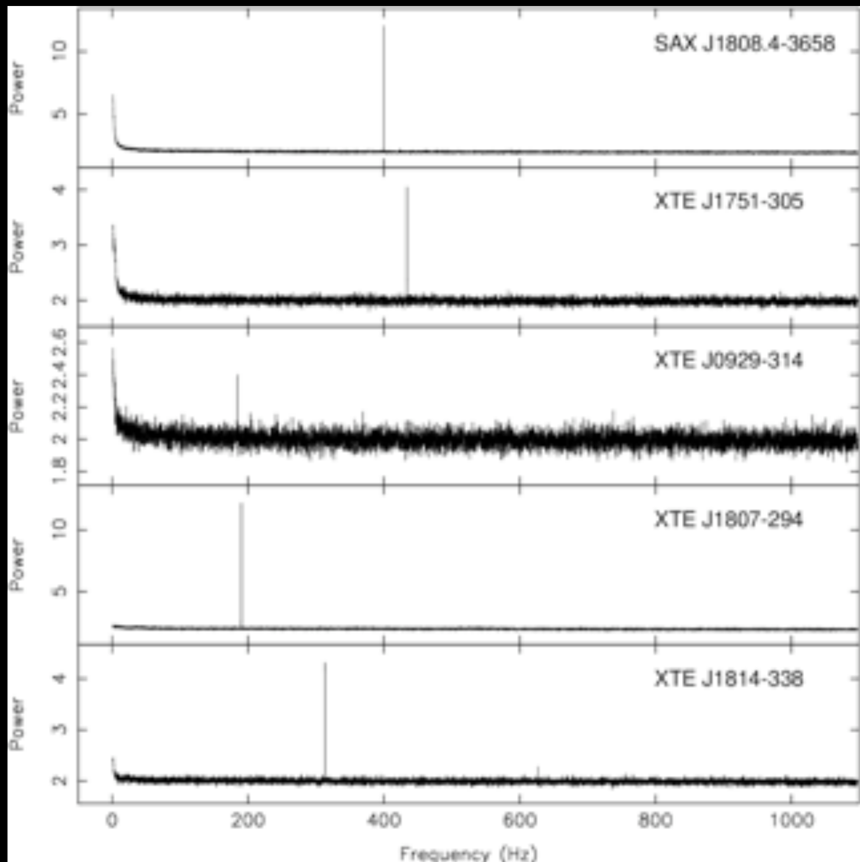


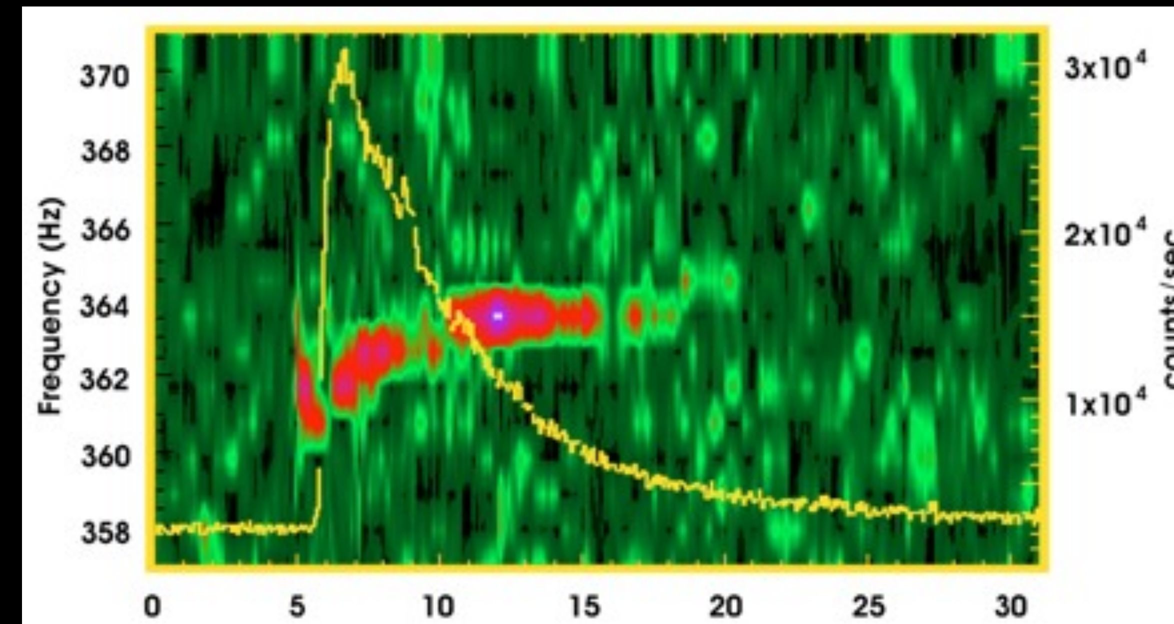
Role of the NS Spin?



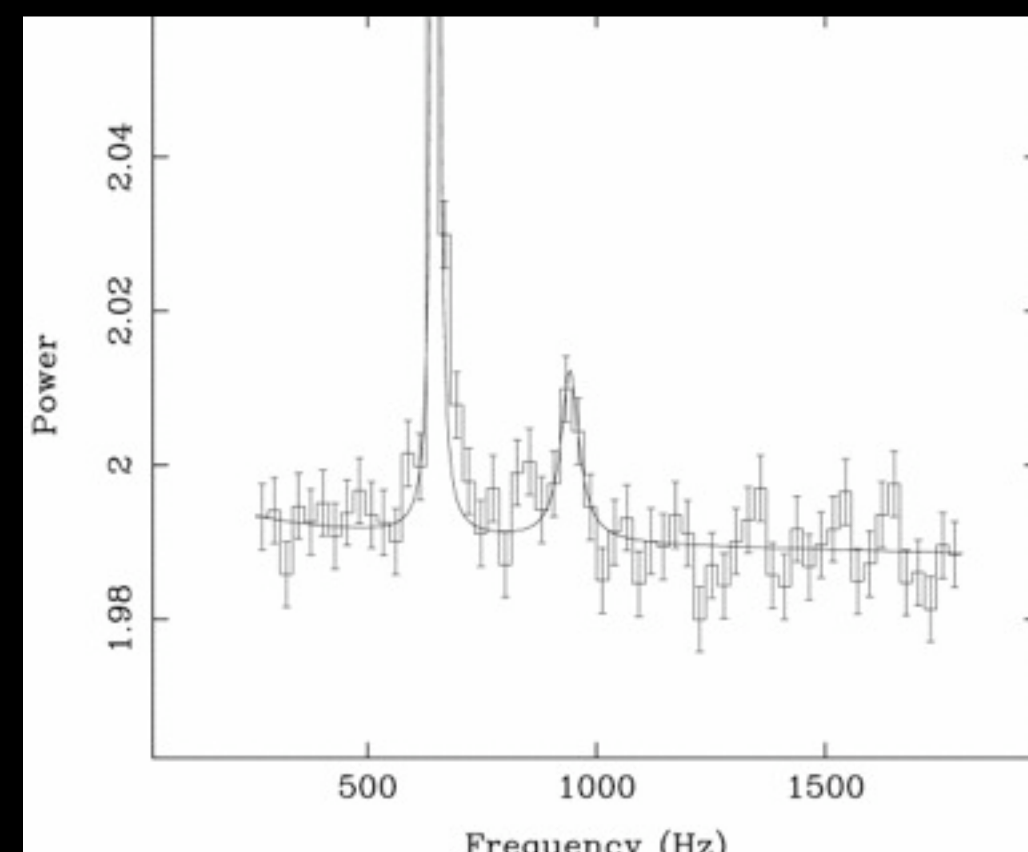


Role of the NS Spin?

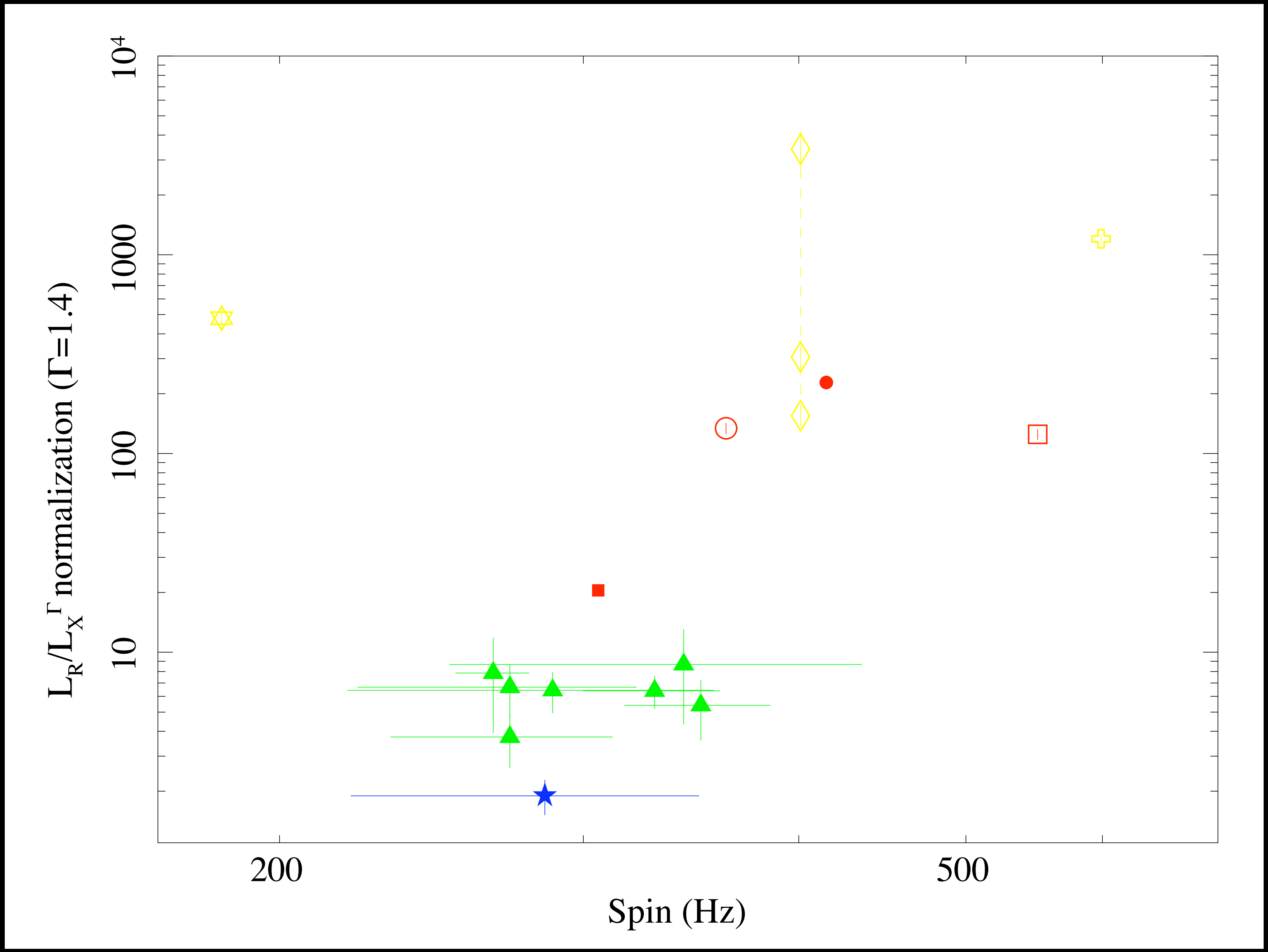




Role of the NS Spin?



spin vs jet power



Migliari 2010
Migliari, Miller-Jones & Russell in prep.

Models for jets in NSs: what are we looking for?

_when liberated, the average jet power is correlated with average Mdot

_within a sub-class, the jet activity depends on a second parameter which regulates the output channel (jet, wind?) and is related to state transitions: instantaneous Mdot? disk instabilities? ...?

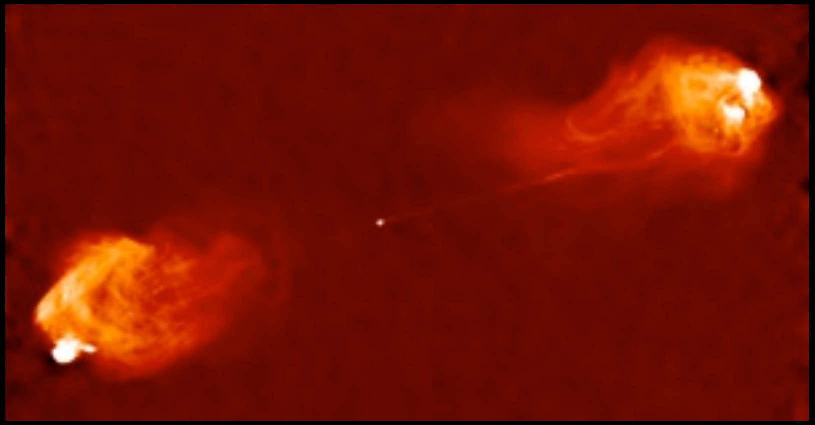
_transient jets observed only > ~10% Eddington

_parameters of the NS involved? magn. field/spin? NO quantitative proof yet.

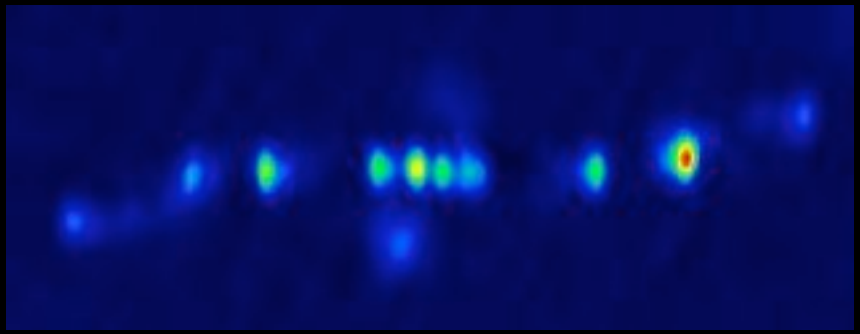
hints: 1) high mag field - quenched jet? (growing)

2) higher spin - stronger jet? (weak)

AGN



X-ray binaries



WD binaries

YSOs