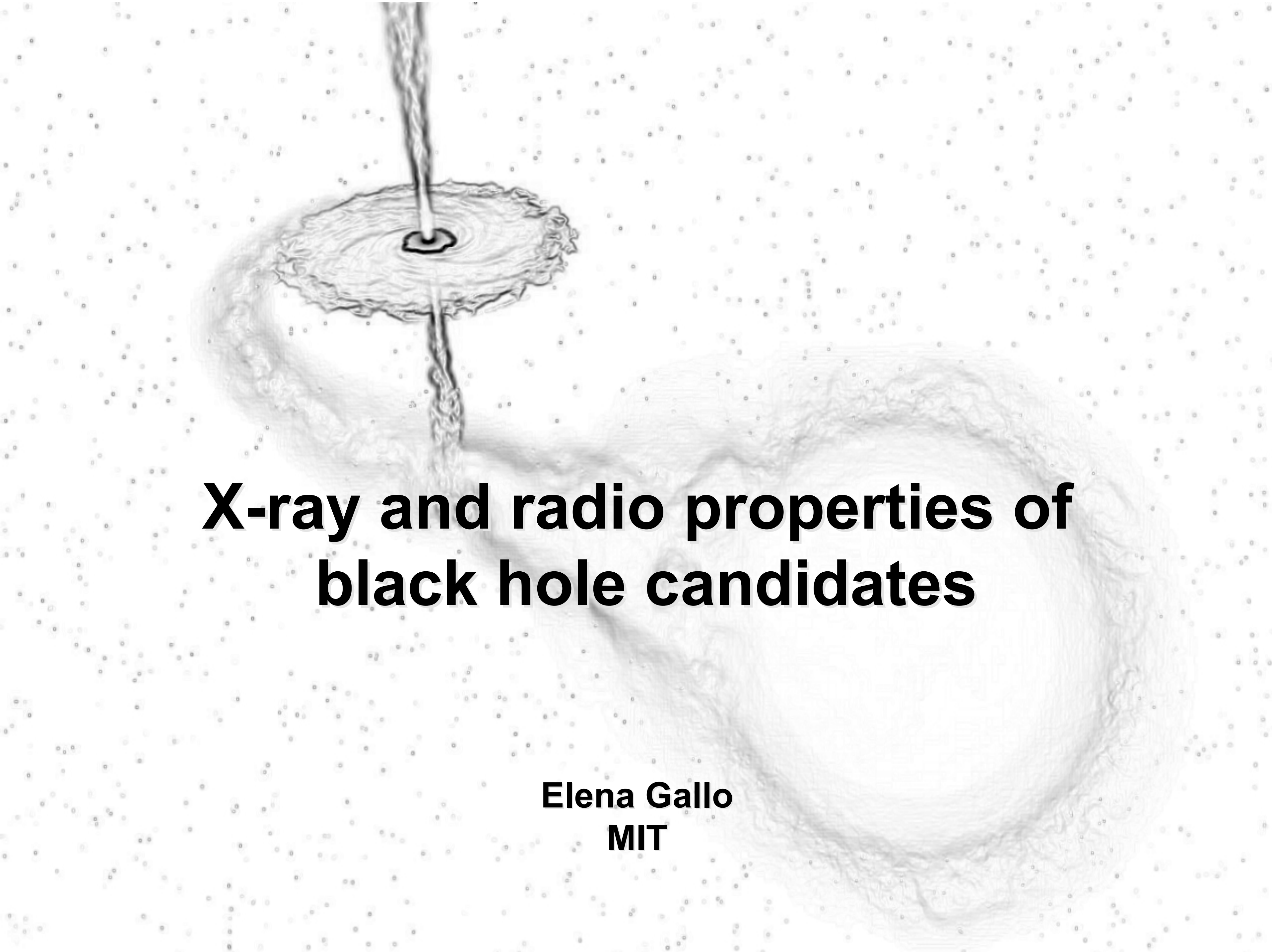


X-ray and radio properties of black hole candidates

Elena Gallo
MIT

Outline

Something old

X-ray states and radio jets, unified model, radio/X-ray diagram, jet vs accretion power

Something new

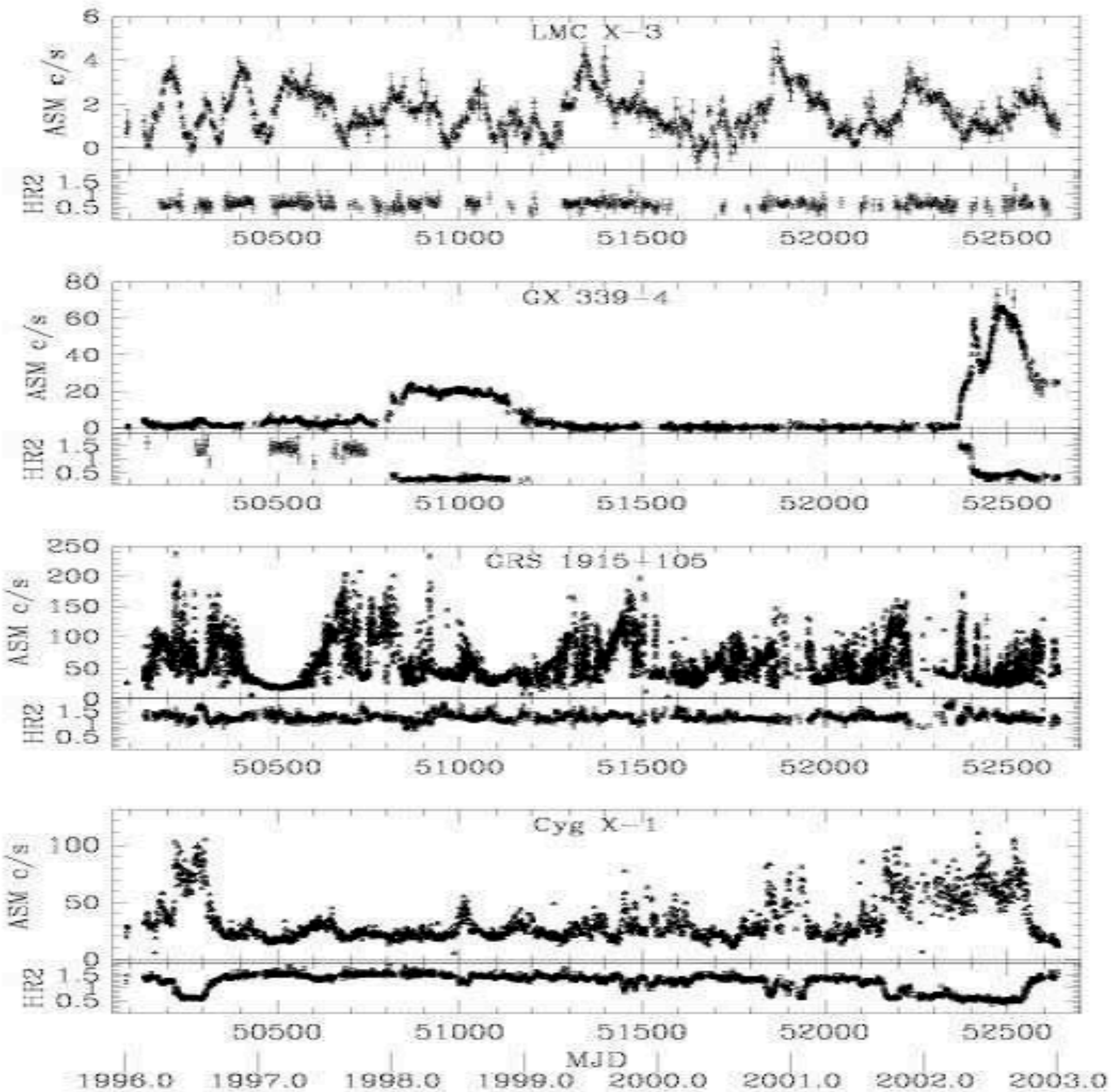
Spins and Lorentz factors: observational constraints on spin-powering of jets

Something borrowed

First accurate parallax distance to a black hole candidate

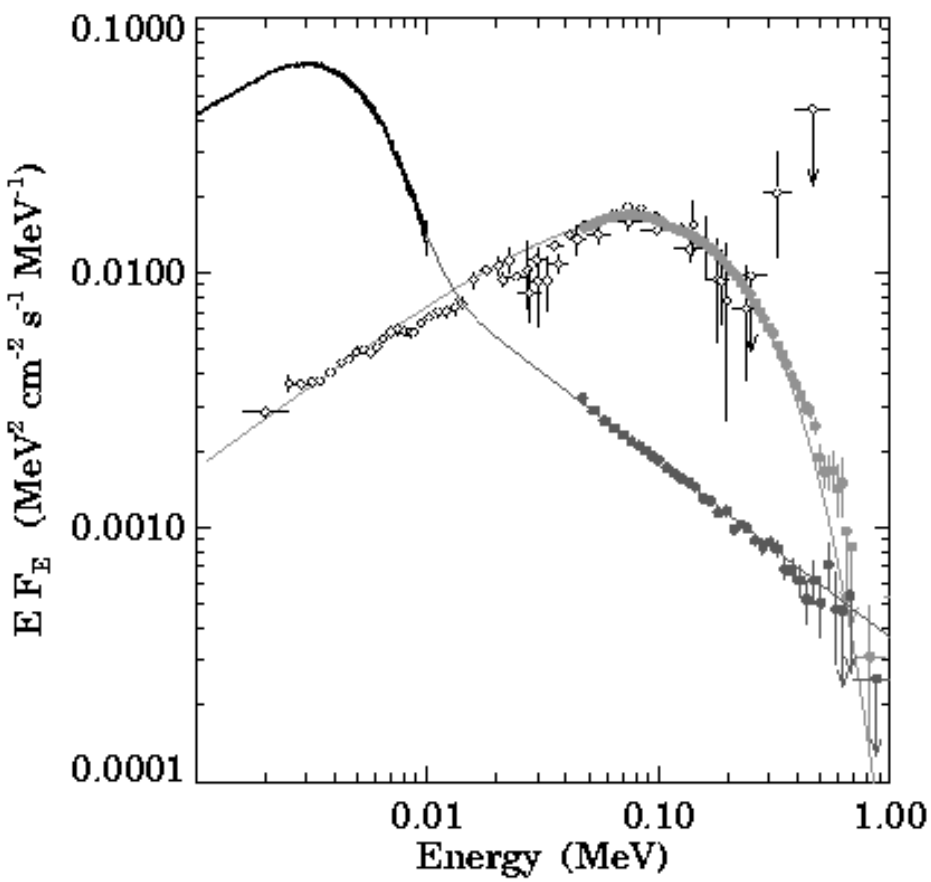
Neutron stars vs. black holes: the complete SED

Black hole X-ray binary outbursts

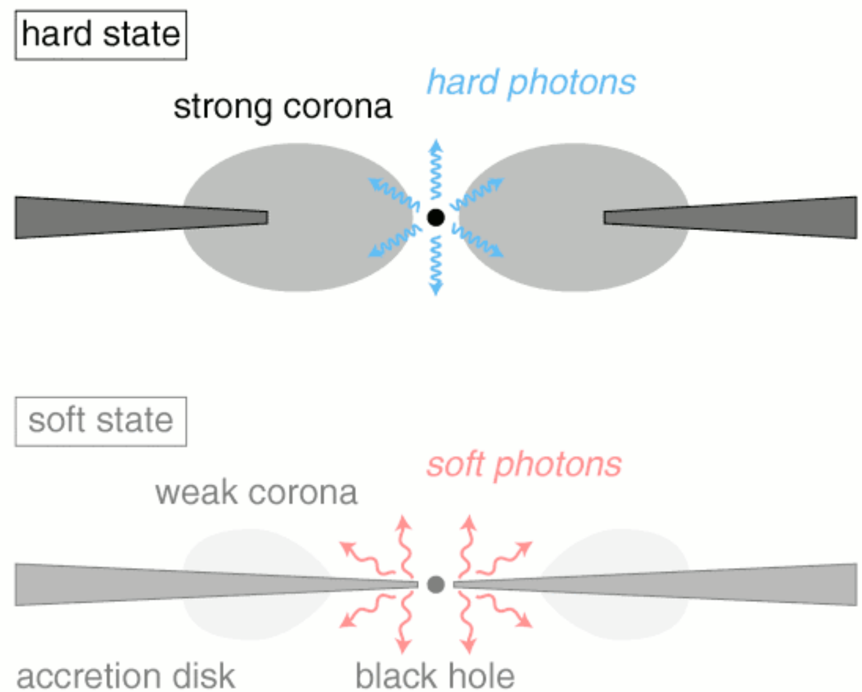


X-ray states: (low/)hard & quiescent

McClintock & Remillard 2006



Radiatively inefficient inflow (ADAF, CDAF, JDAF, ADIOS..)

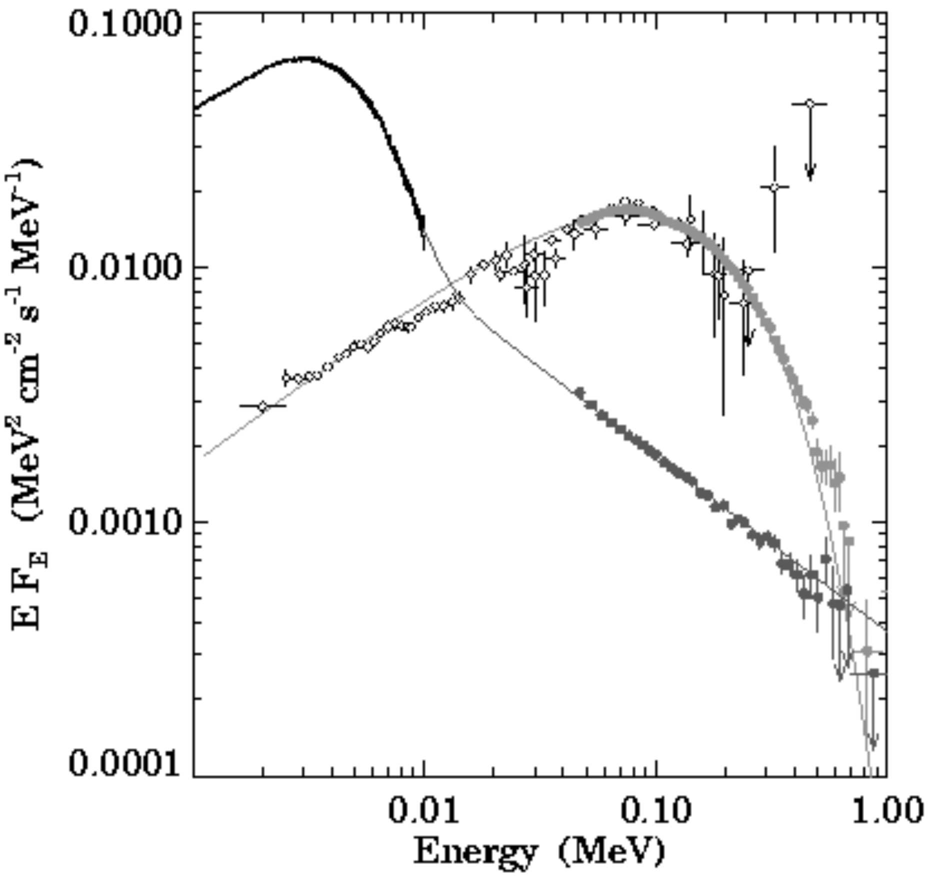


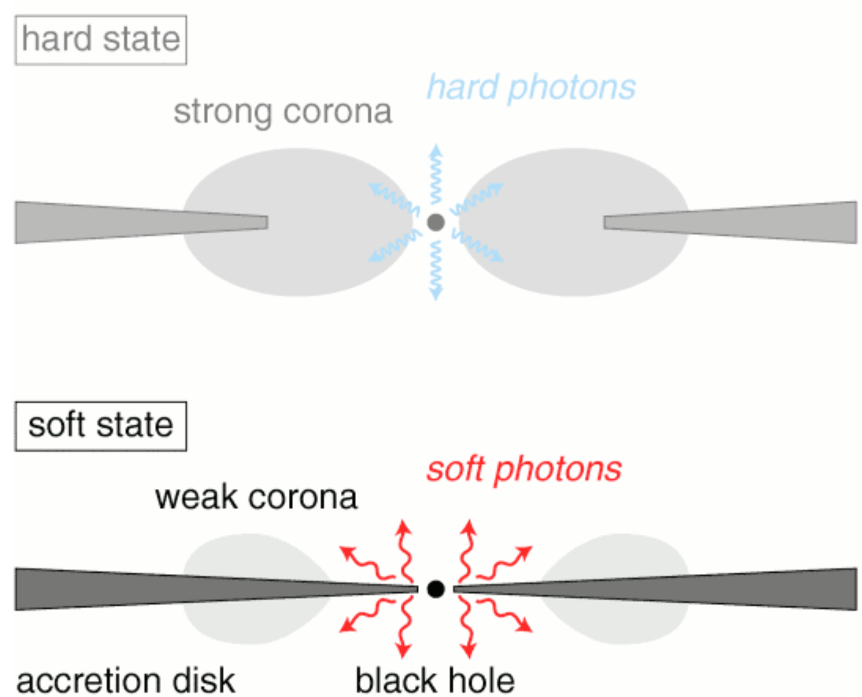
Meyer, Liu & Meyer-Hofmeister 2006

X-ray states: (high/)soft

McClintock & Remillard 2006

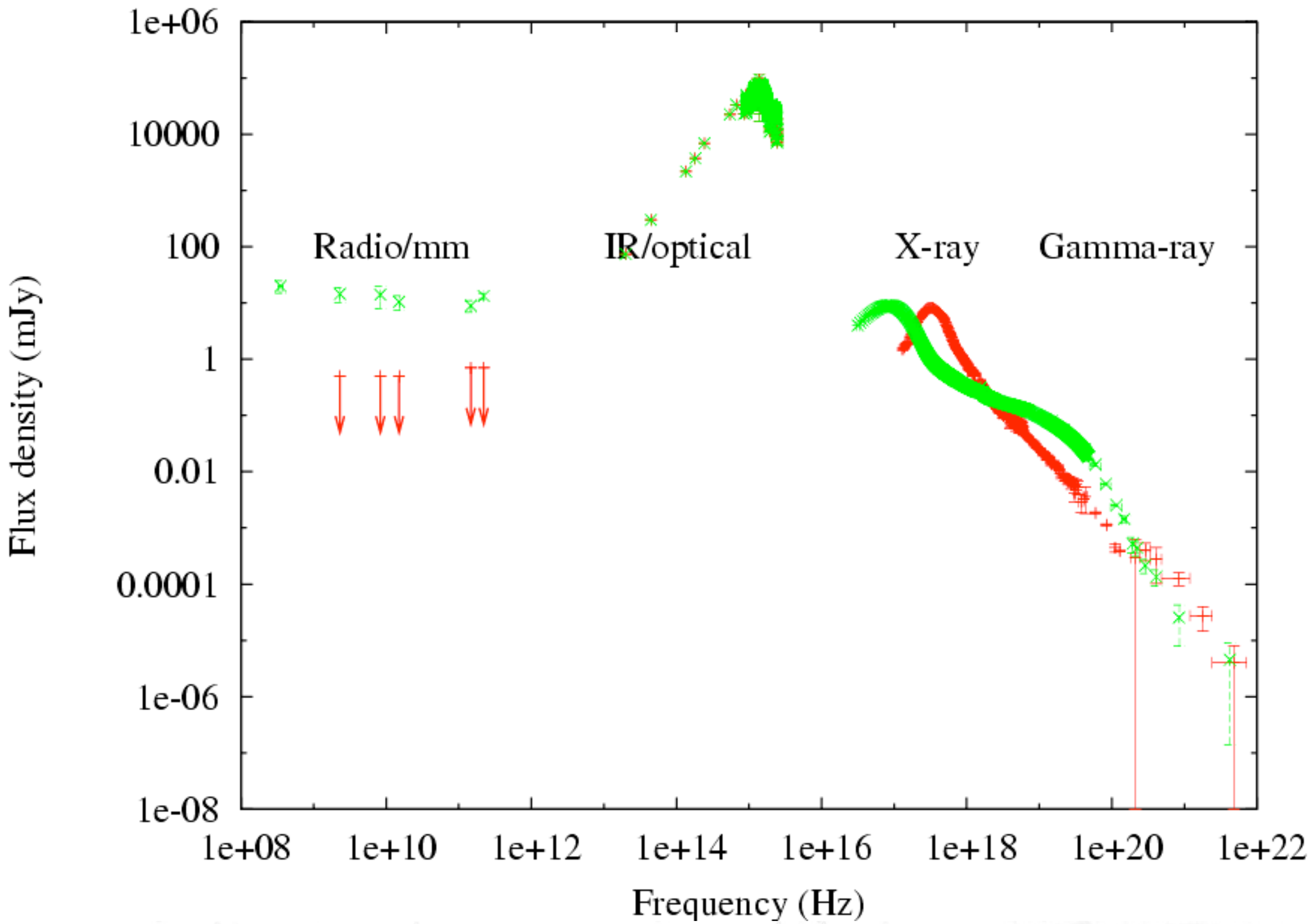
Radiatively efficient inflow (thin disc)





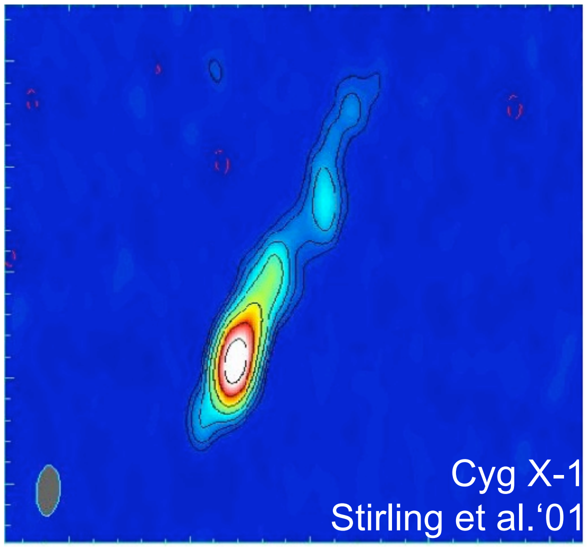
Meyer, Liu & Meyer-Hofmeister 2006

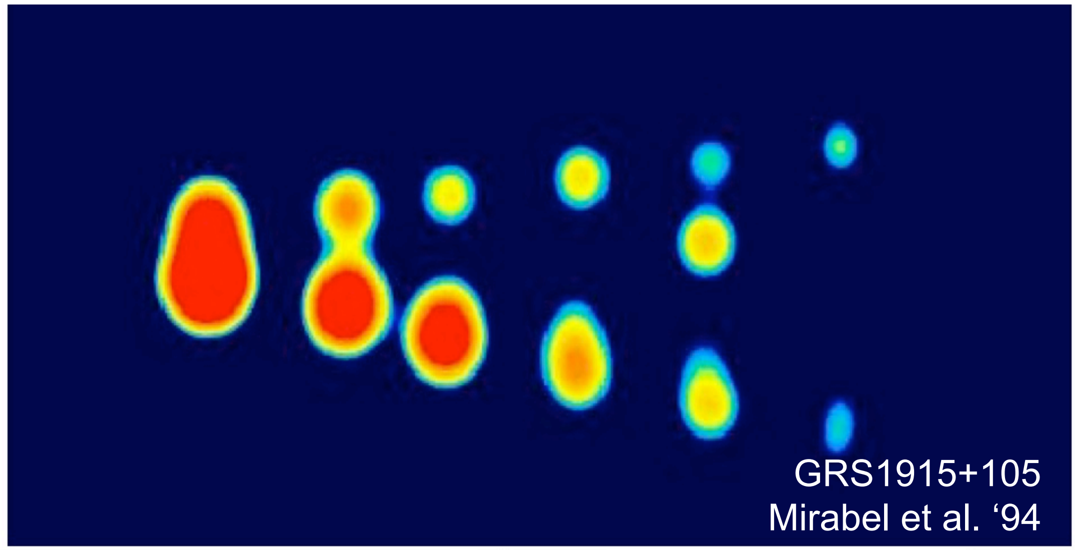
Spectral energy distribution

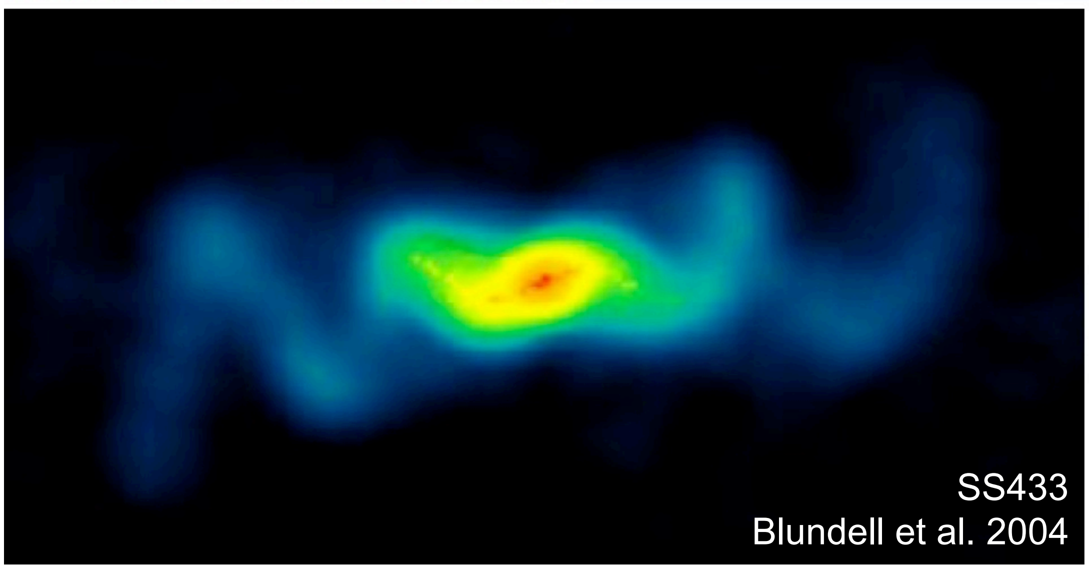


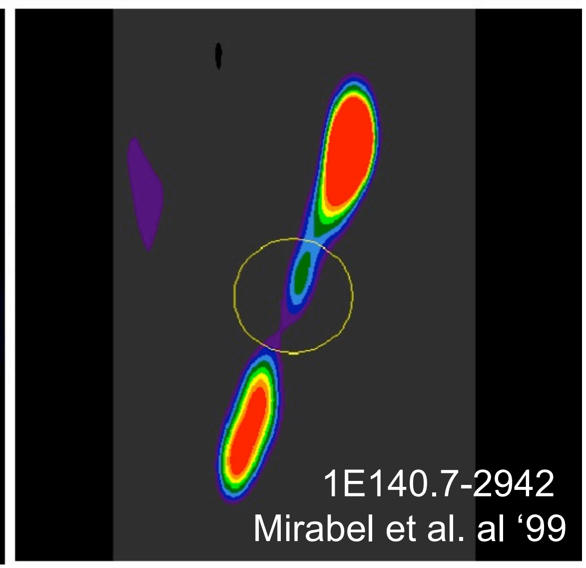
Tigelaar et al. 2004

Not all jets are created equal

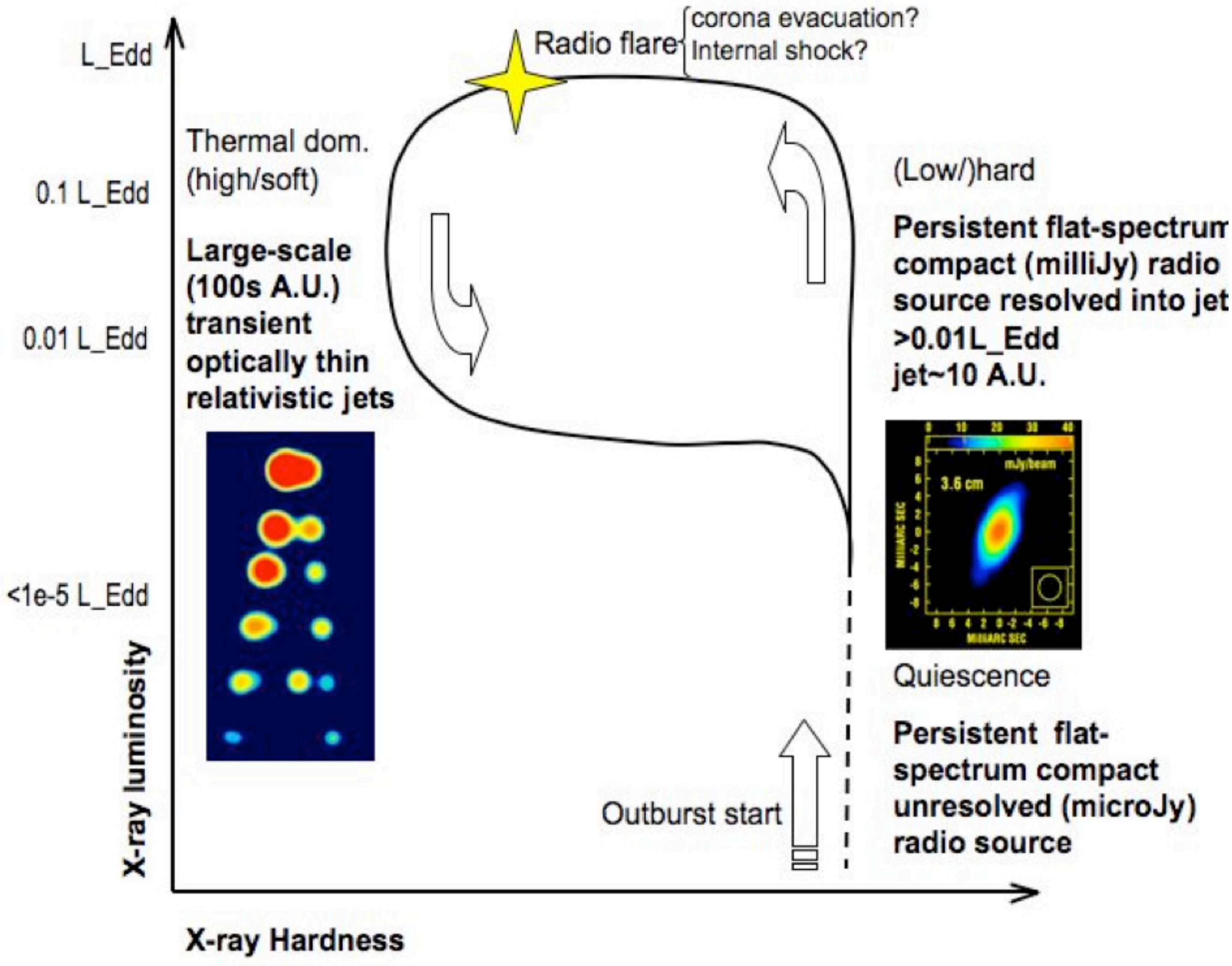








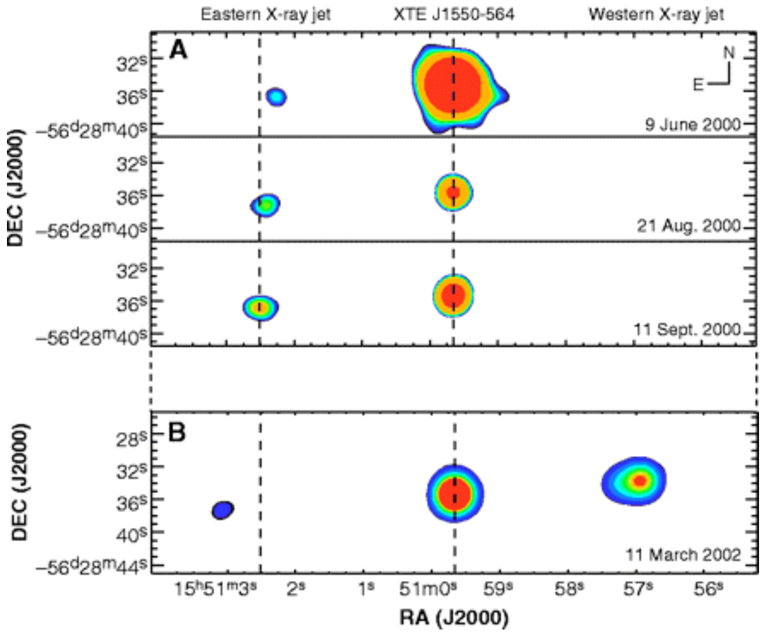
Black hole outburst: a journey



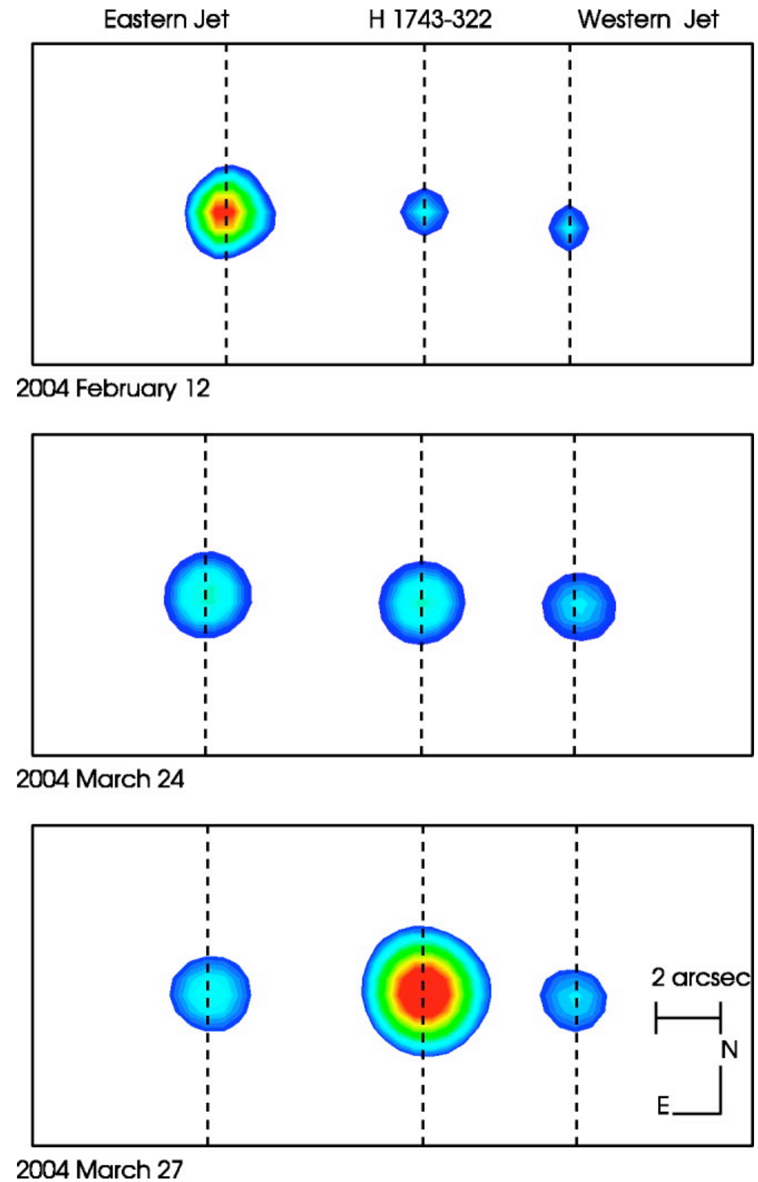
Fender Belloni Gallo 2004; Fender Homan Belloni 2009 (more later: Belloni's talk)

X-ray jets

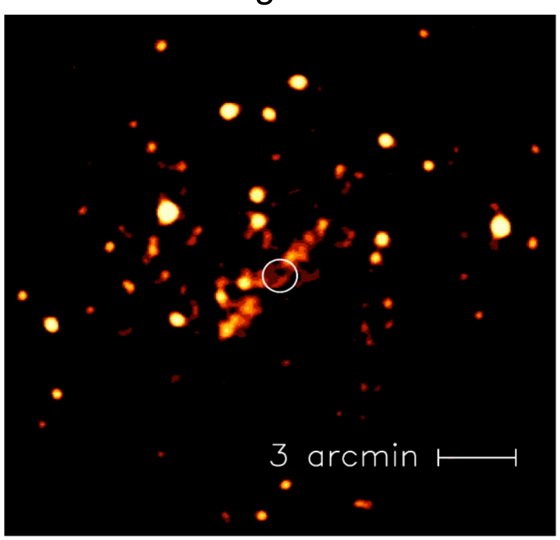
Corbel et al. 2003



Corbel et al. 2005

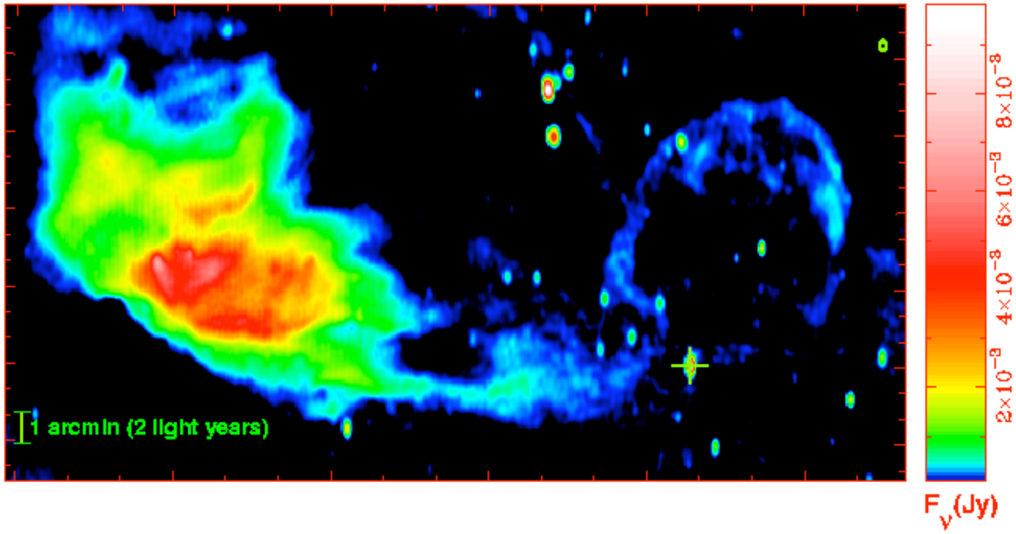


4U1755-33 Angelini et al. 2003

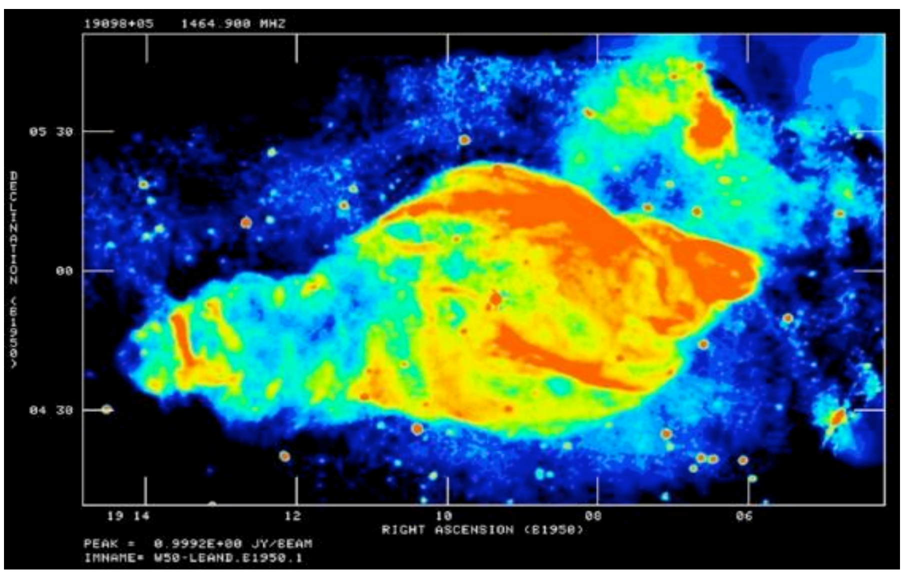


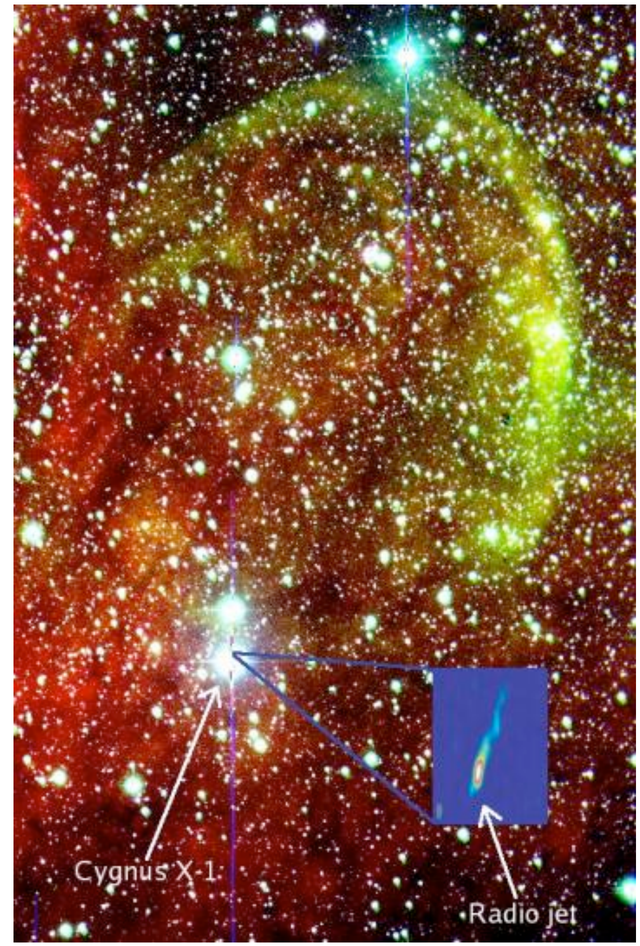
Radio nebulae

Cyg X-1, WRST Gallo et al. 2005



SS433 W50, VLA



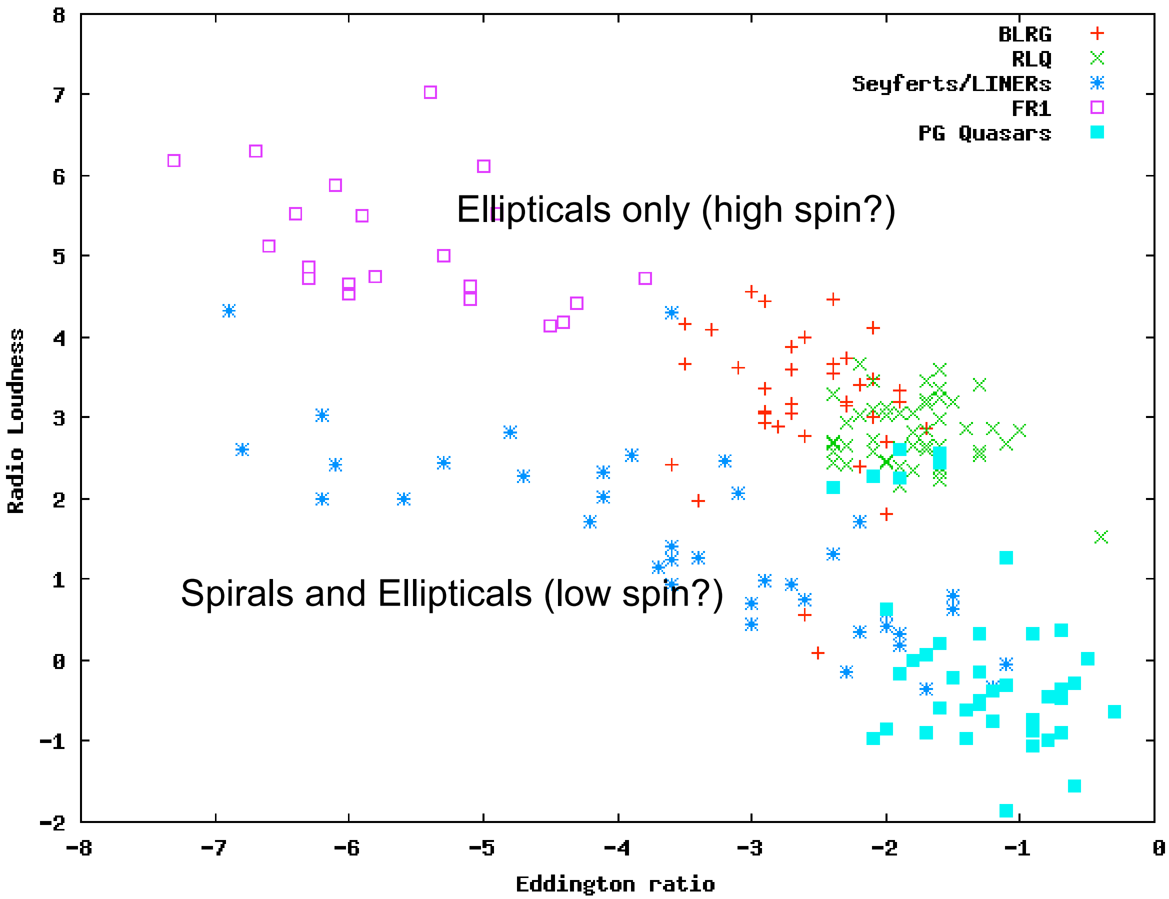


Russell et al. 2006

Tapping on black hole spin

Extraction of energy from a rotating black hole (Penrose ‘69) ,

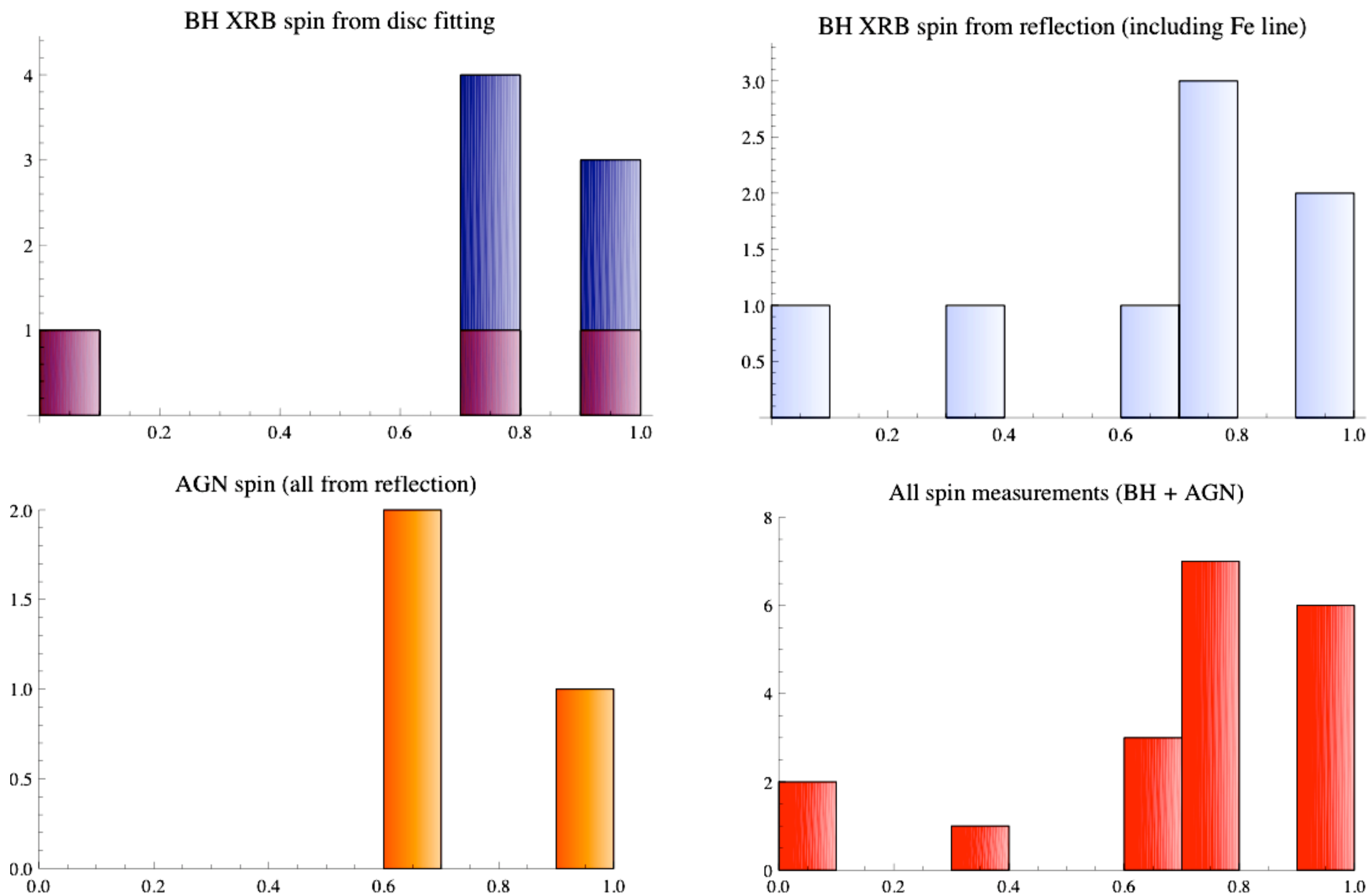
to power relativistic jets (Blandford-Znajek ‘77, McKinney ‘05)



Sikora Swartz & Lasota 2007

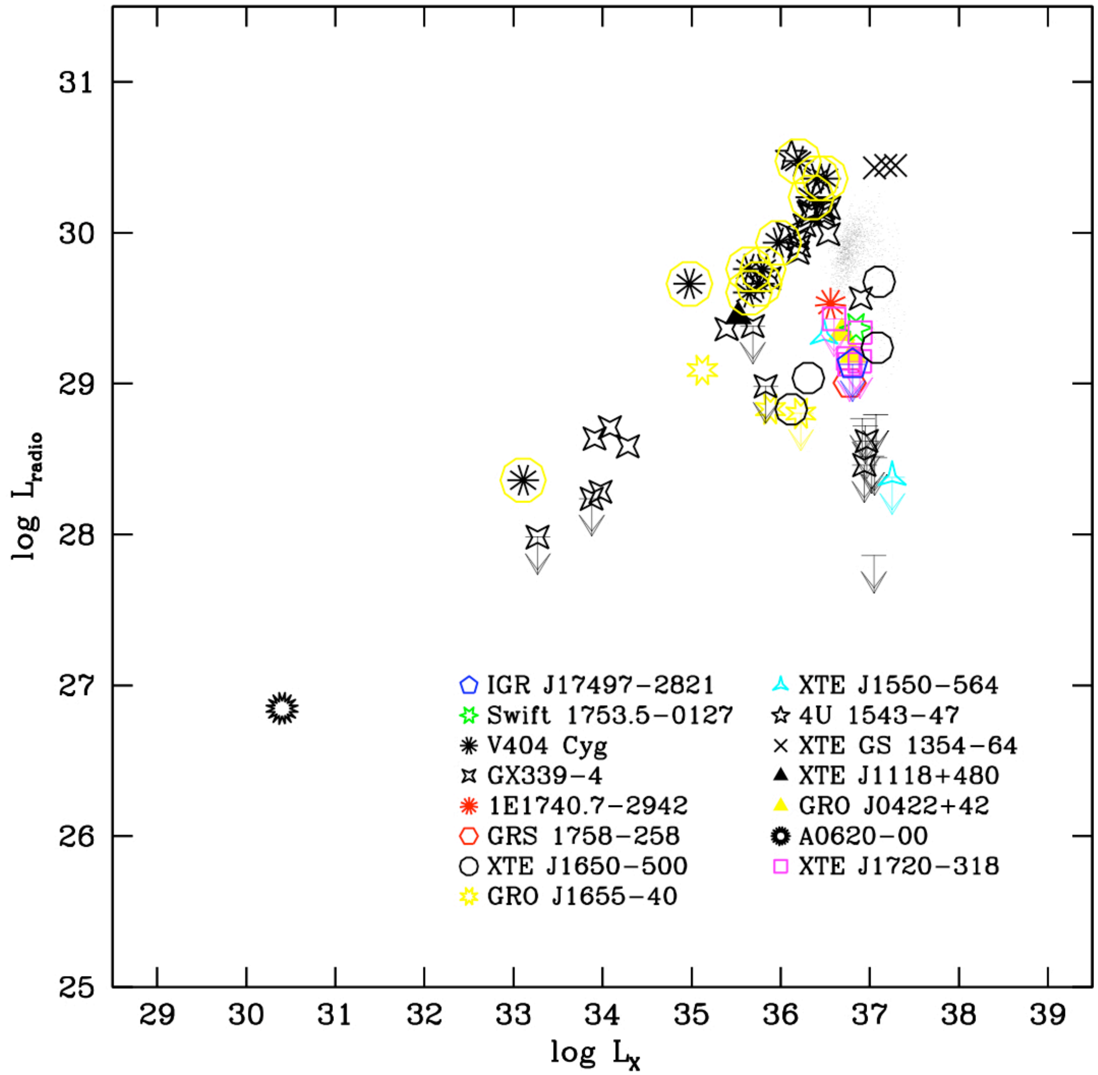
(Volonteri et al 2008 for interpretation)

Constraints on spin powering of jets I.



Fender Gallo & Russell (submitted)

Constraints on spin powering of jets II.



Gallo Fender Pooley 2003, Gallo et al. (in prep.)

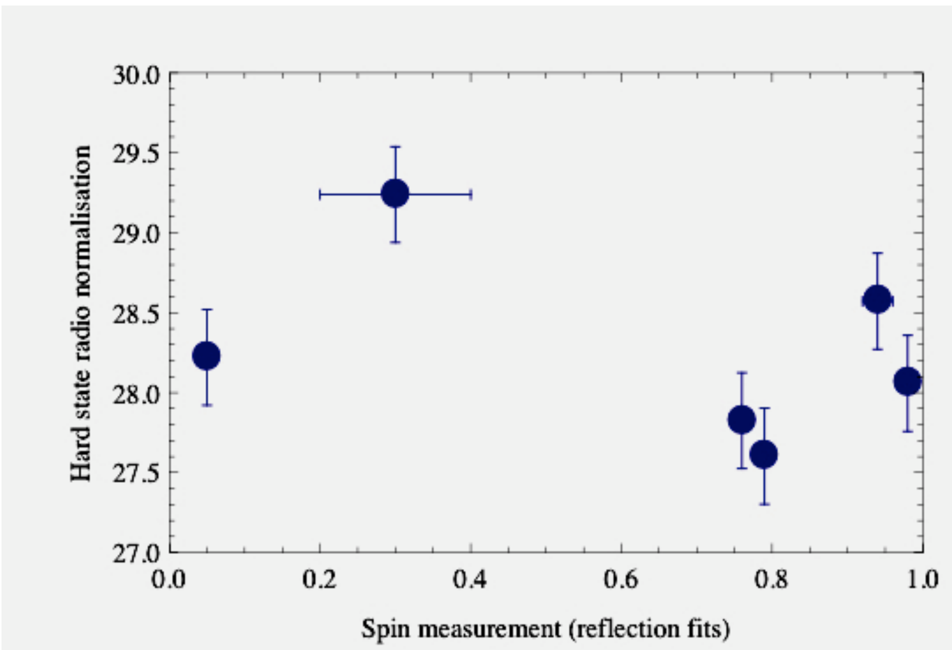
Constraints on spin powering of jets III.

Source	Mass ($M_\odot$	Spin estimate Disc	Spin estimate Reflection	Radio	Refs
M33 X-7	15.6 ± 1.5	0.77 ± 0.05		No radio	1,6,7
LMC X-1		$0.90^{+0.04}_{-0.09}$		No radio	1,7
LMC X-3		< 0.8		No radio	4,7
		-0.03			13
GS 2000+25		0.03			13
GS 1124-68		-0.04			13
4U 1543-47	9.4 ± 1.0	0.7–0.85	0.3 ± 0.1	Radio data	2, 3,7,8
GRO J1655-40	6.30 ± 0.27	0.65–0.8	0.98 ± 0.01	Radio data	2, 3,7,9
		0.93			13
GRS 1915+105	14 ± 4	0.98–1.0		Radio data	2,5,7
		0–0.15			10
		~ 0.7			11
		0.998			13
XTE J1550-564	9.7–11.6	< 0.8	0.76 ± 0.01	Radio data	4,7
XTE J1650-500	5 ± 2		0.79 ± 0.01	Radio data	7
GX 339-4	≥ 6		0.94 ± 0.02	Radio data	7
SAX J1711.6-3808			$0.6^{+0.2}_{-0.4}$		7
XTE J1908+094			0.75 ± 0.09	Radio data	7
Cygnus X-1	10 ± 5		0.05 ± 0.01	Radio data	7
4U 1957+11	3–16	0.8–1.0	No radio	12	

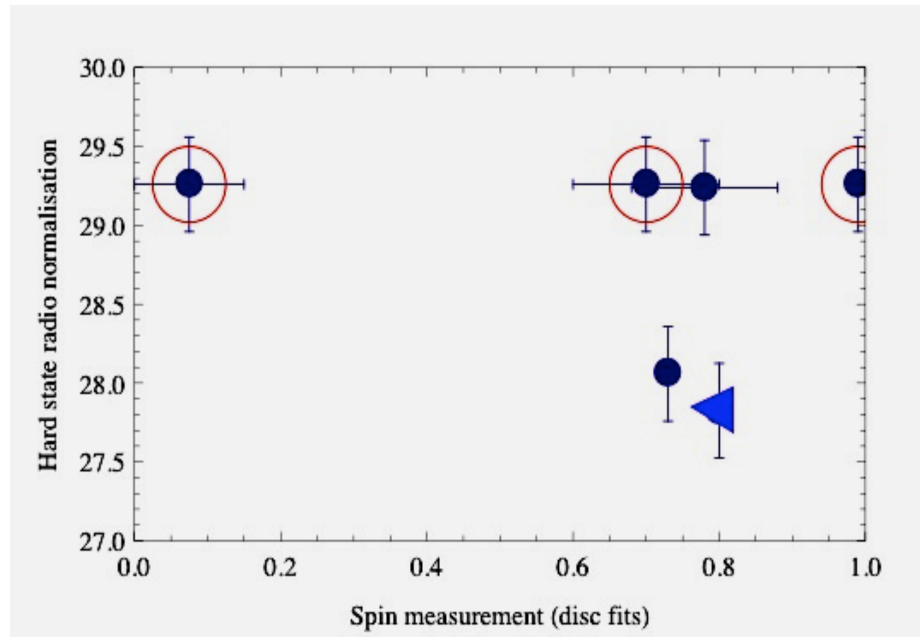
Fender Gallo & Russell (submitted)

Constraints on spin powering of jets IV. Hard state

Reflection



Disk

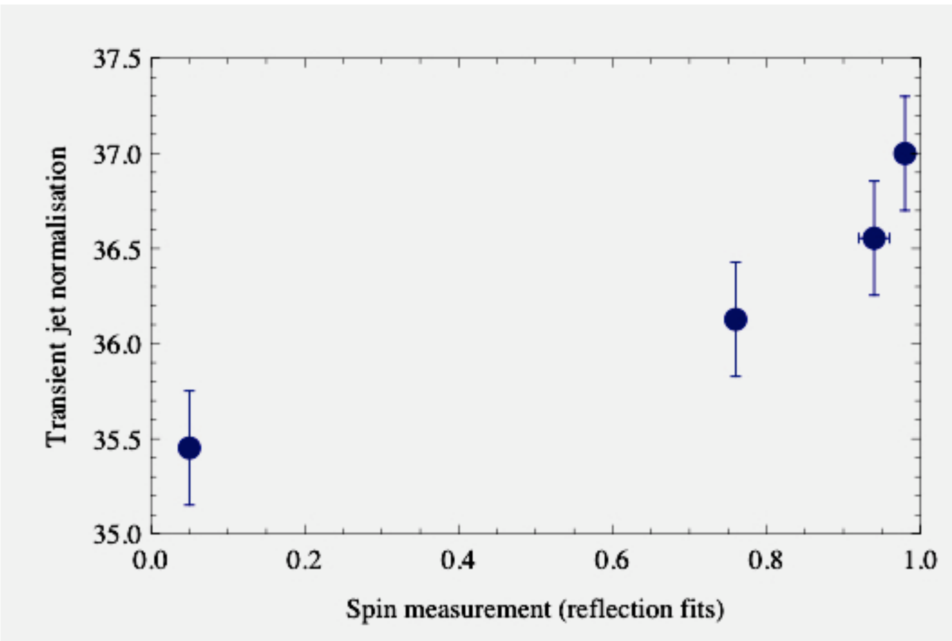


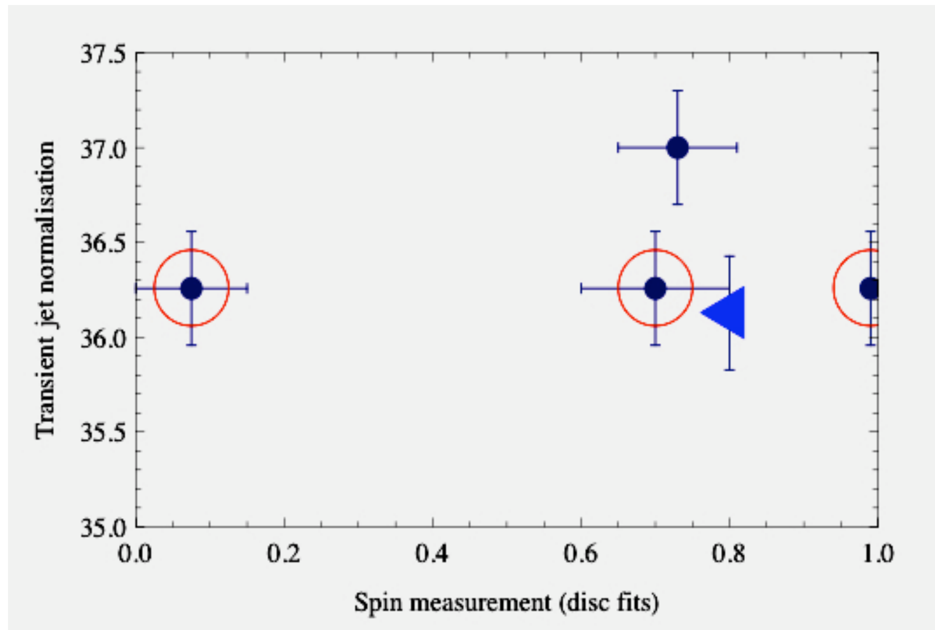
Fender Gallo & Russell (submitted)

Constraints on spin powering of jets IV. Ejections

Reflection

Disk

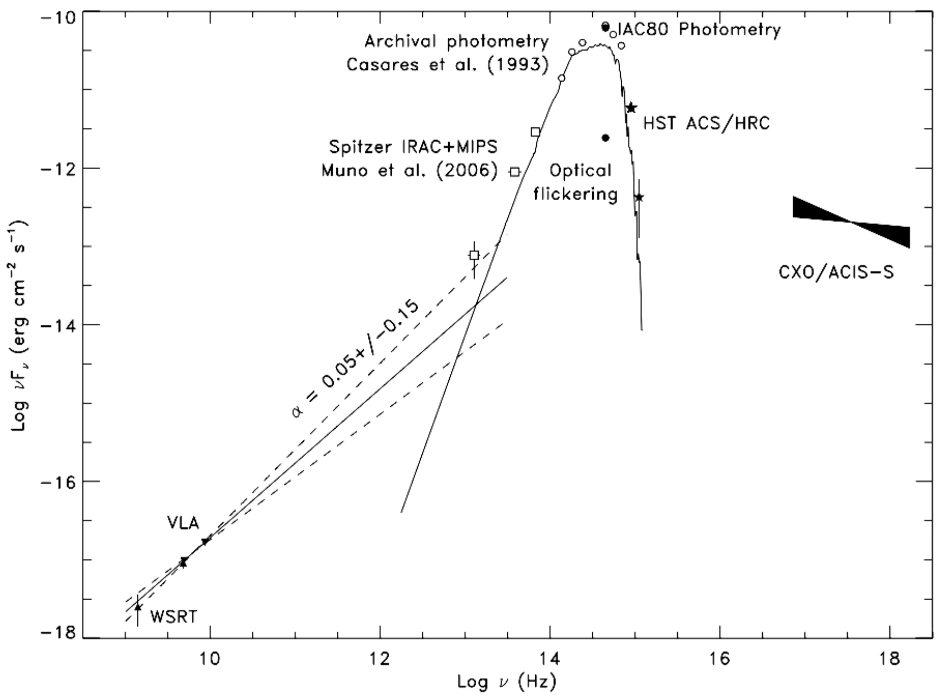




Fender Gallo & Russell (submitted)

Black holes vs neutron stars: SEDs

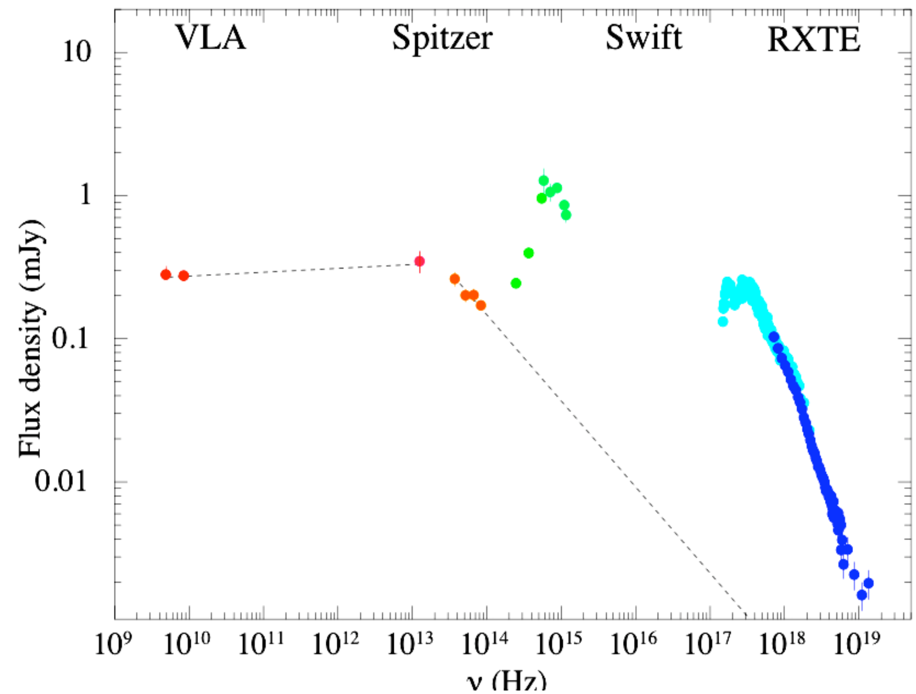
V404 Cygni



Hynes et al. 2009

Jet vs. accretion power: >30%

4U 0614+091



Migliari et al. (submitted)

Jet vs. accretion power: 10%

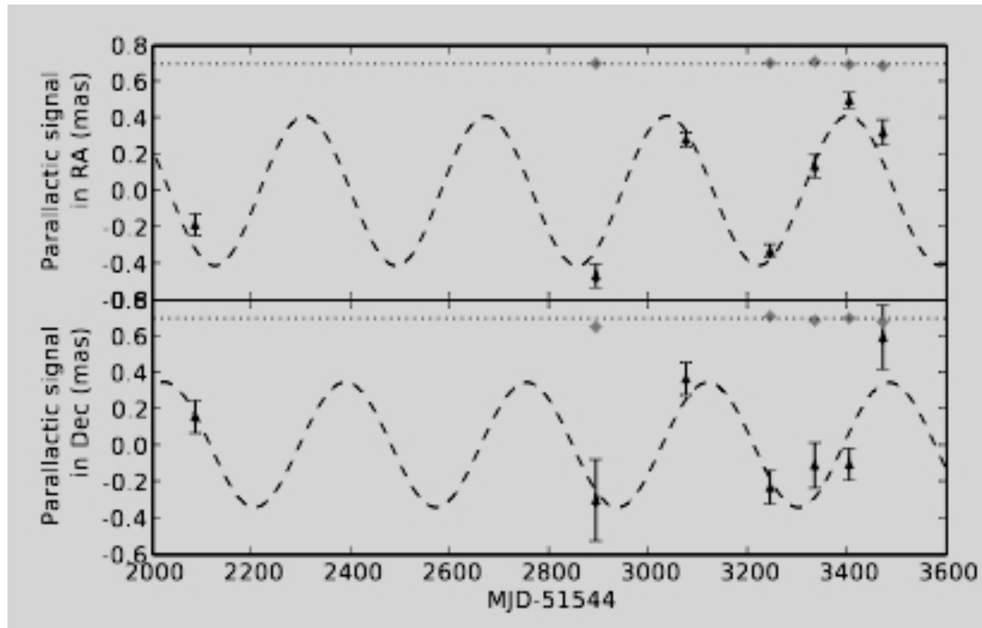
First accurate parallactic distance to a black hole candidate

V404 Cygni

7 epochs: VLBA, phsed VLA, EVN, GBT

D=2.37±0.14 kpc

Next generation radio telescopes (EVLA, eMERLIN etc.) will get them all!



Miller-Jones et al. (to be submitted)

X-ray and radio properties of black holes: Summary

Something old

X-ray states and radio jets, unified model, radio/X-ray diagram..So far, so good. More in next talk.

Something new

No observational evidence for spin-powering of jets: either

-one or more method fopr estimating jet power is wrong

-one or more method for estimating spin is wrong

-jet power/velocity are NOT related to spin

Something borrowed

- Accurate parallax distance to V404 Cyg, $d=2.37\pm 0.17$ kpc
- Neutron stars vs. black holes: 10% vs 30% of accretion power channeled into a jet