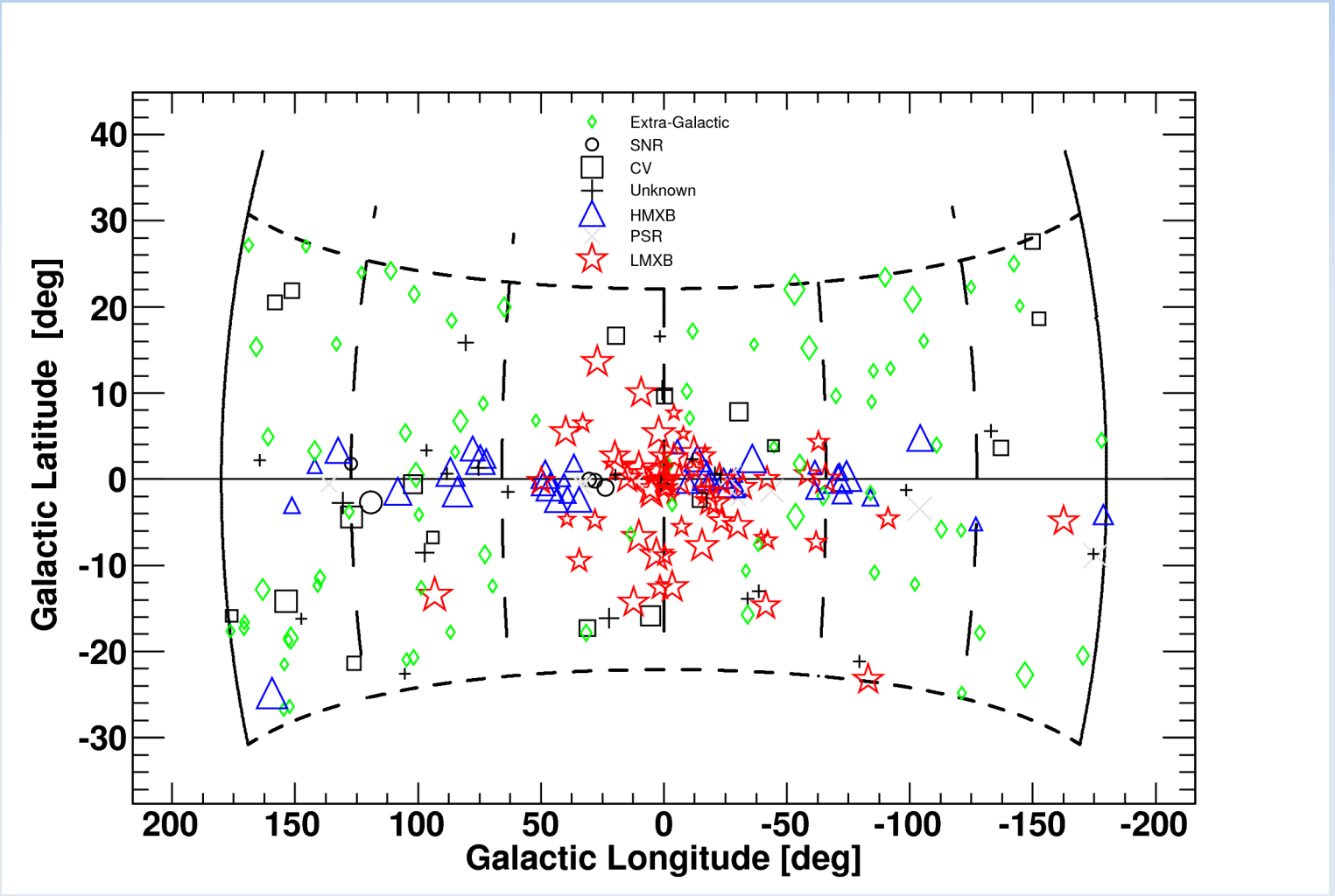
Faint LMXBs in the Galaxy

Rasmus Voss
Lennart van Haaften
Gijs Nelemans

Radboud University Nijmegen (NL)

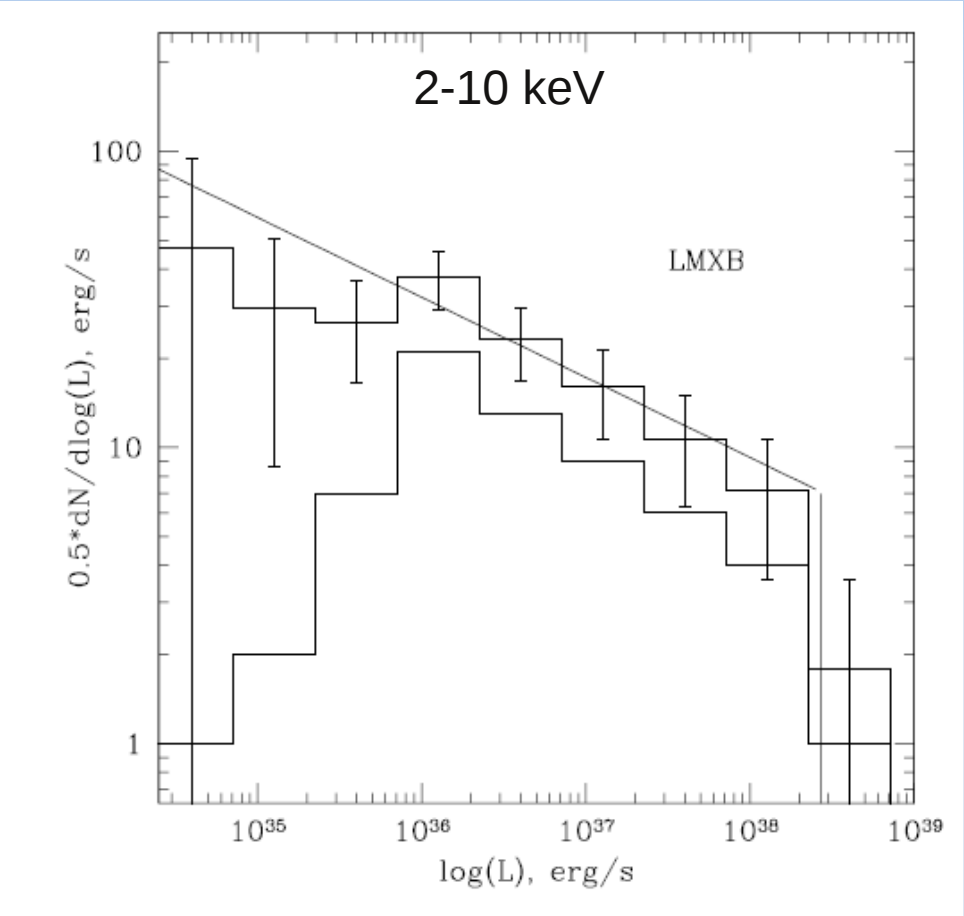
Bright X-ray binaries in the Galaxy

Swift BAT (15-55 keV) survey of the Galactic plane



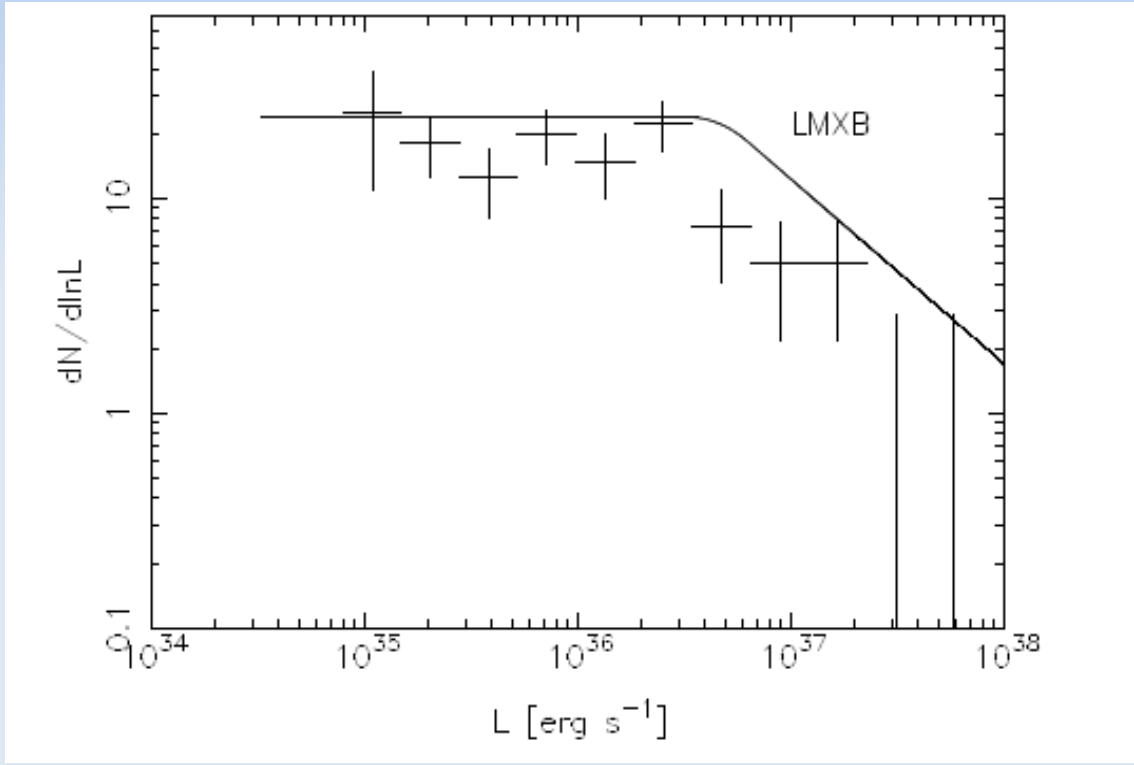
Voss & Ajello 2009

Bright LMXB luminosity function



Grimm, Gilfanov & Sunyaev 2002

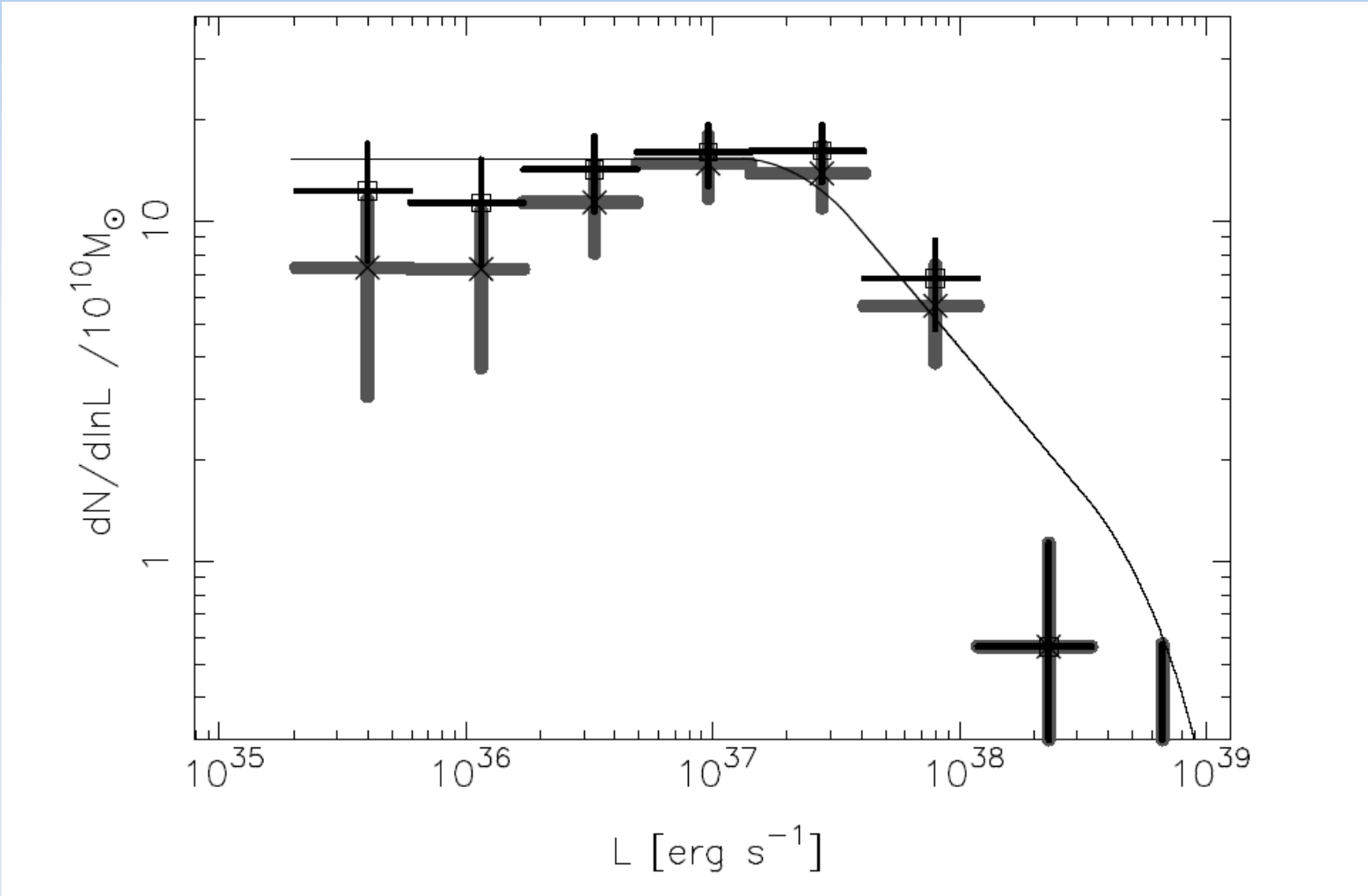
15-55 keV



Voss & Ajello 2009

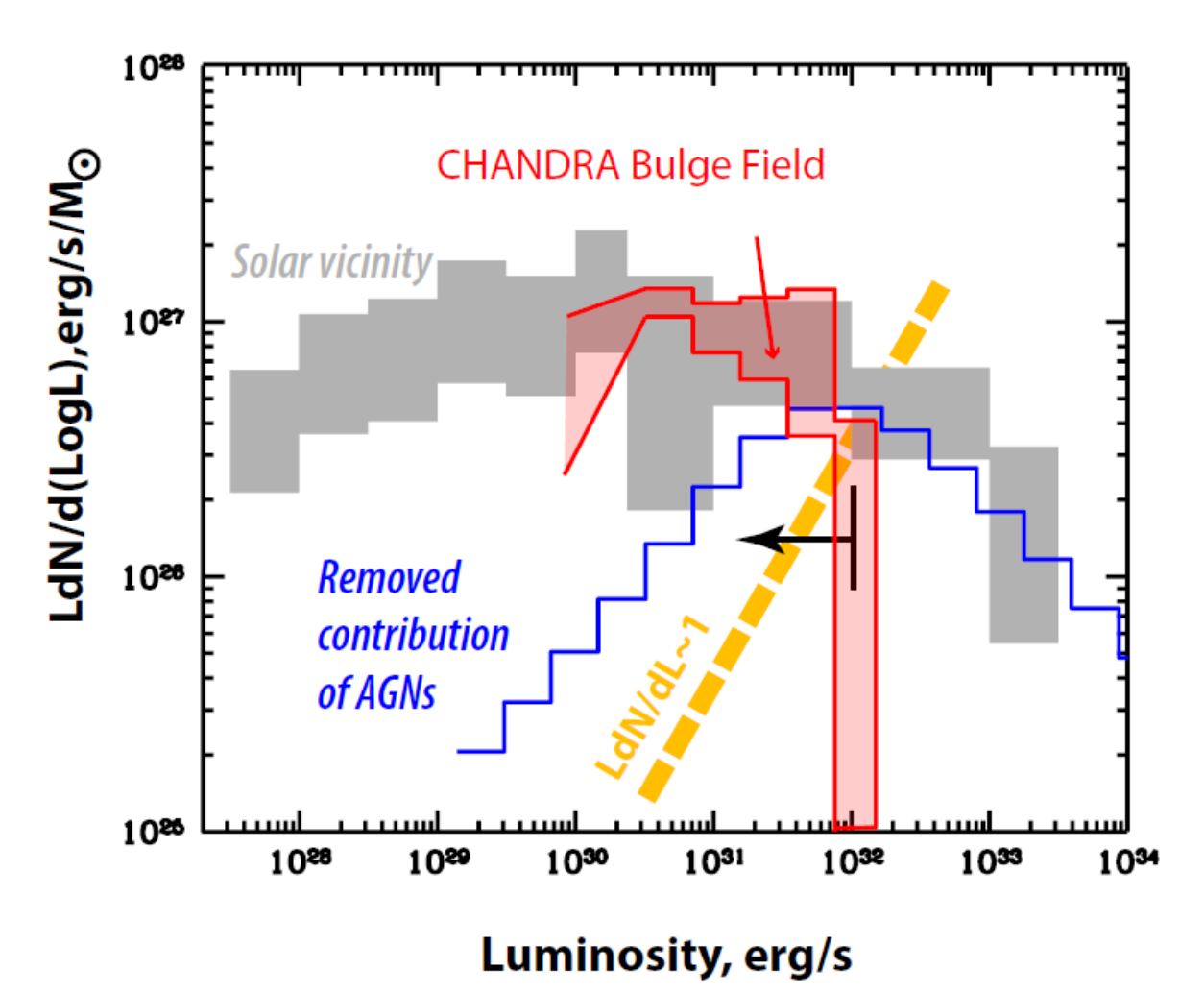
Bright LMXB luminosity function

M31 Chandra (0.5-8 keV)



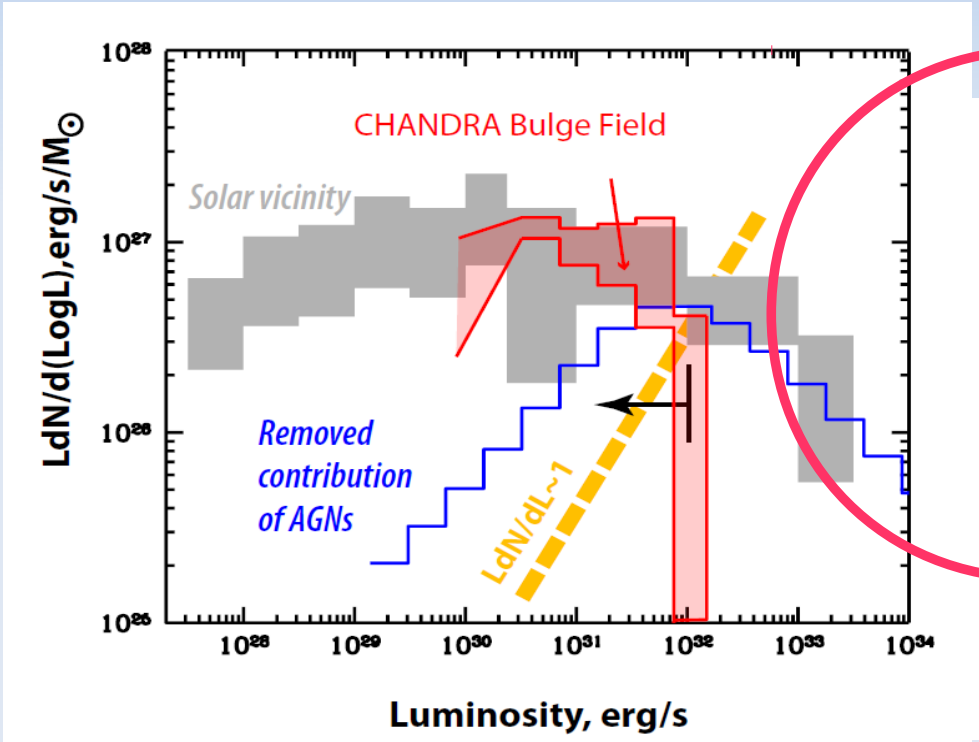
Voss & Gilfanov 2007

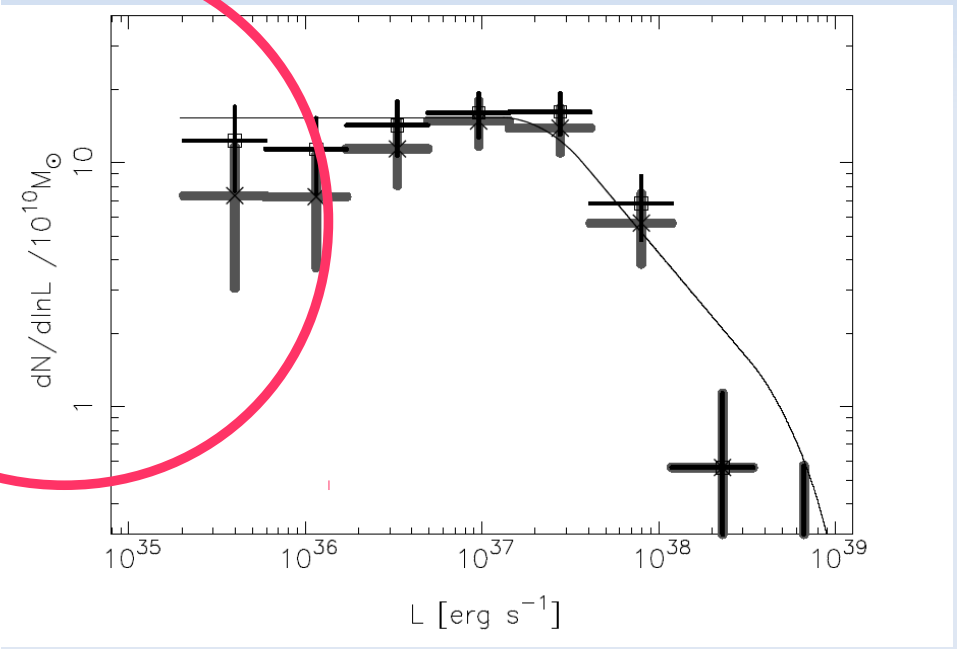
Faint X-ray sources



Revnivtsev et al. 2011

Faint LMXBs



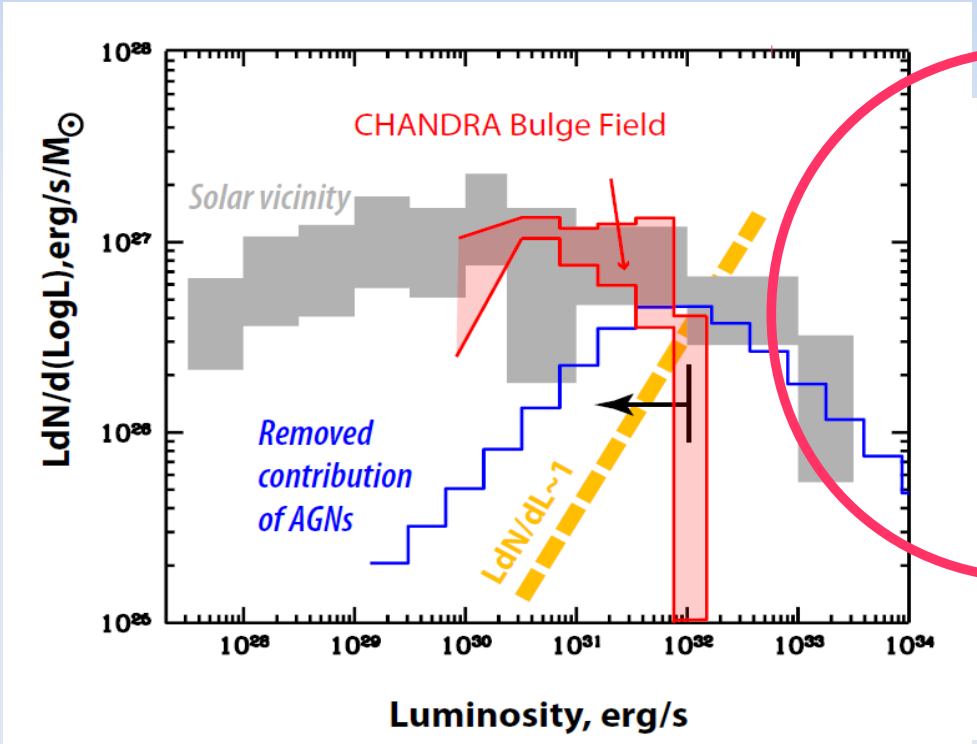


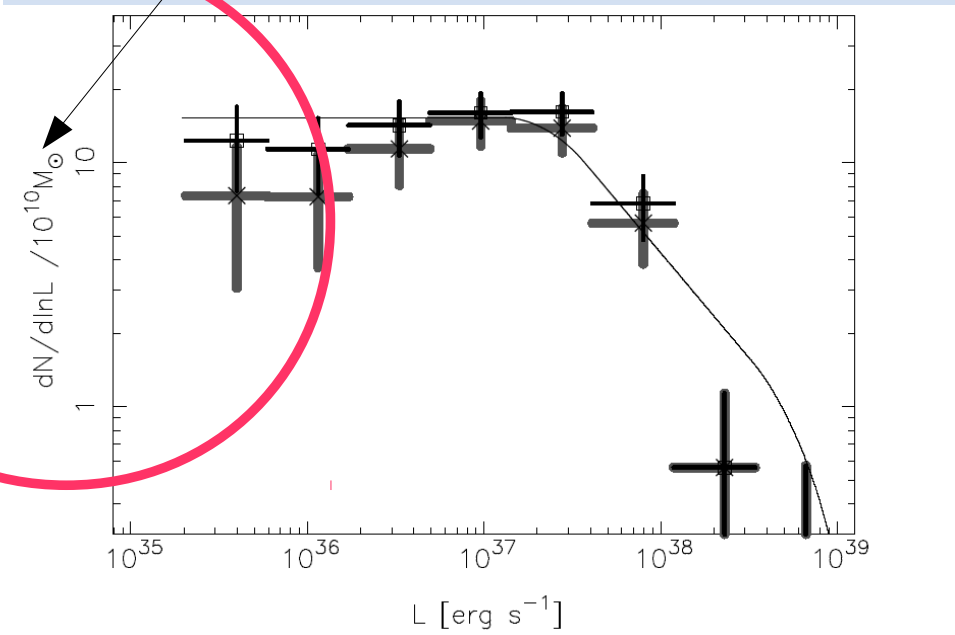
Revnivtsev et al. 2011

Voss & Gilfanov 2007

Faint LMXBs

Ultra-compact X-ray binaries (UCXBs)



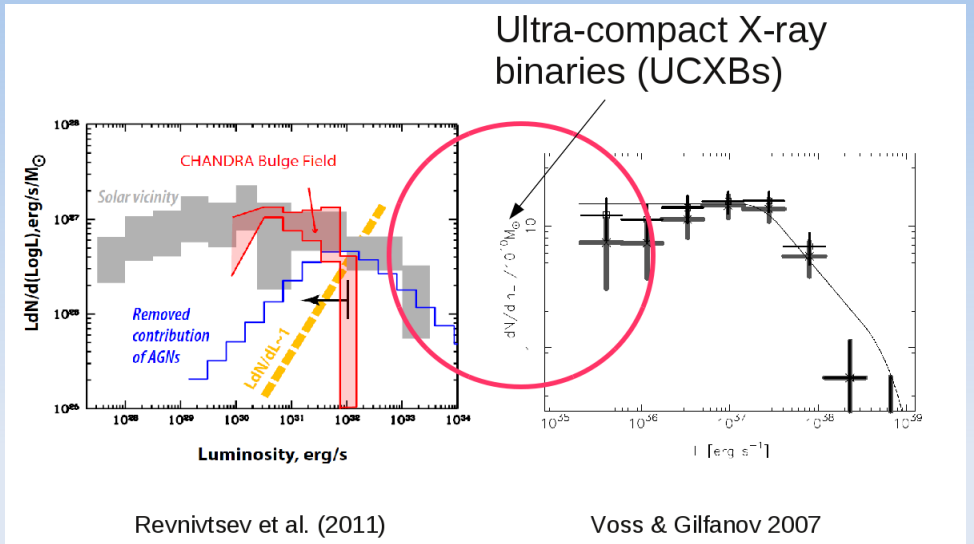


Revnivtsev et al. 2011

Voss & Gilfanov 2007

UCXBs

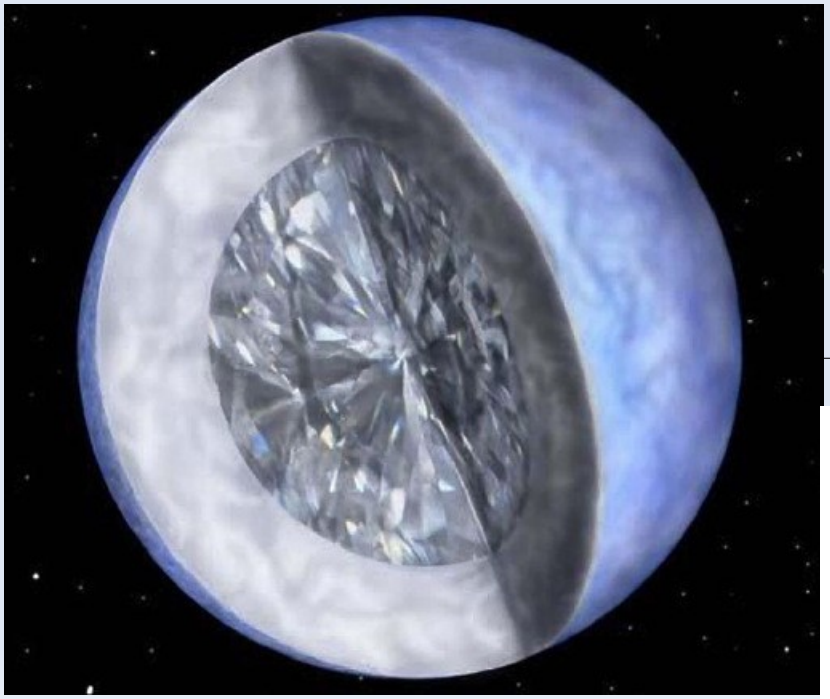
What are UCXBs?



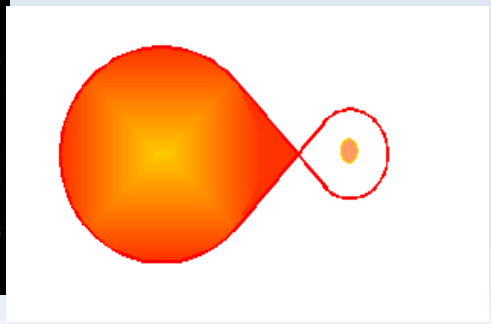
Revnivtsev et al. (2011)

Voss & Gilfanov 2007

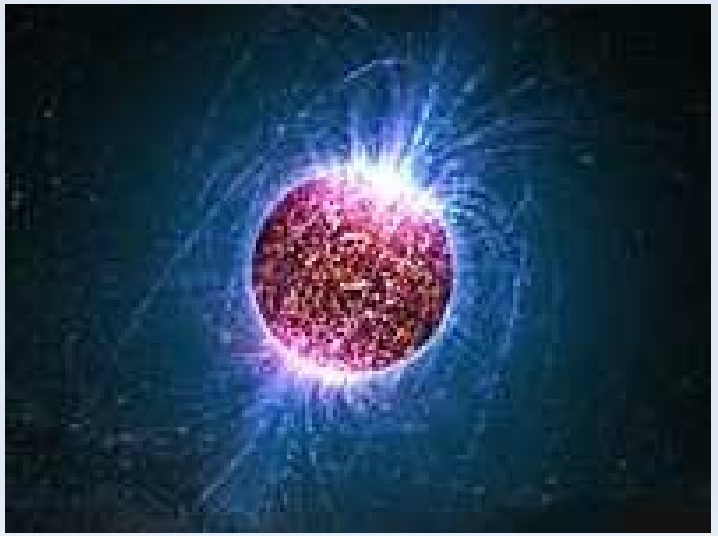
White dwarf



Mass transfer

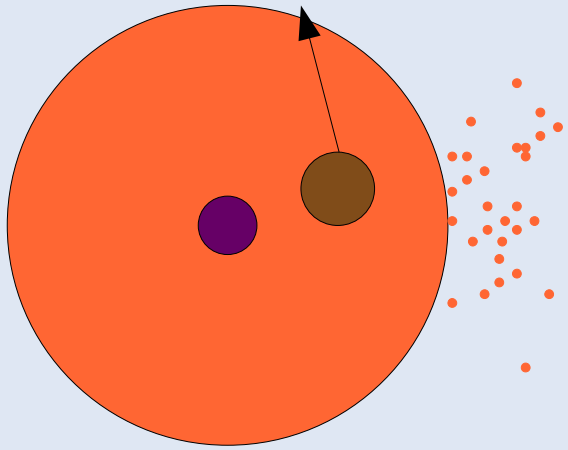


Neutron star



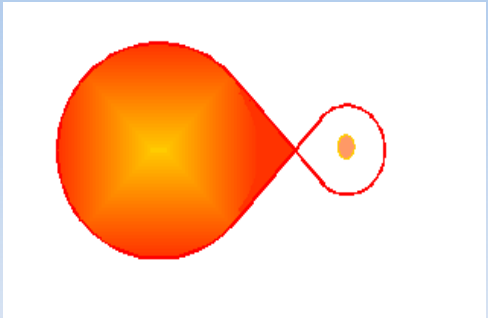
UCXB formation

Common envelope



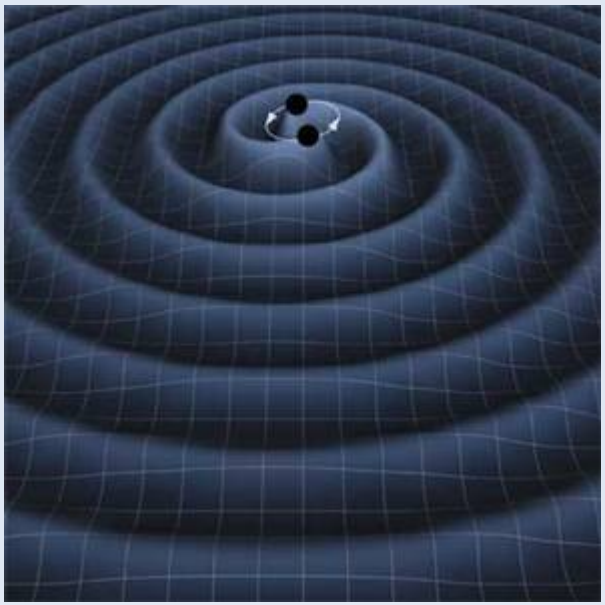
UCXB evolution

How do they work?

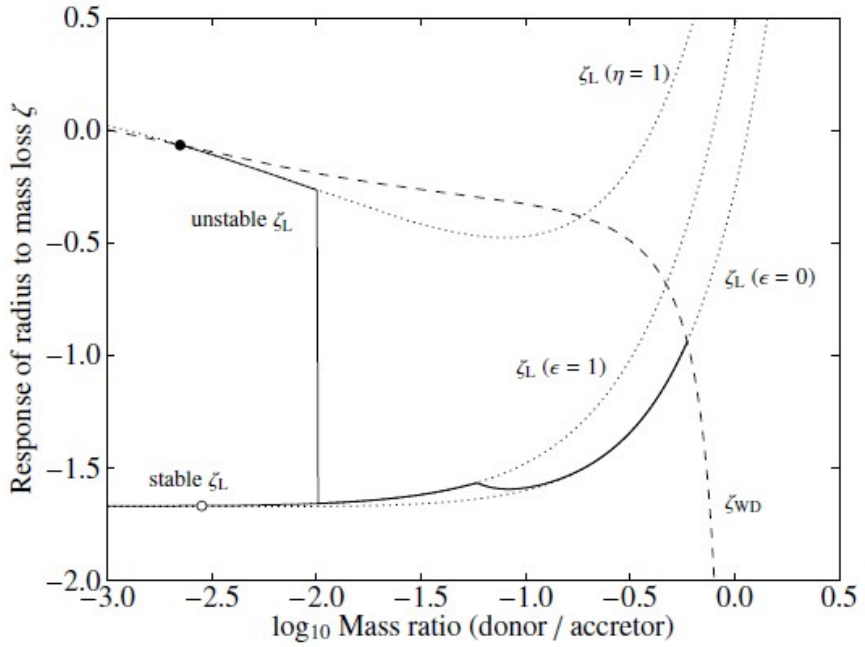


Gravitational radiation

$$\frac{d \ln J_{\rm GR}}{dt} = -\frac{32}{5} G^3 c^5 \frac{M_1 M_2 (M_1 + M_2)}{a^4}$$



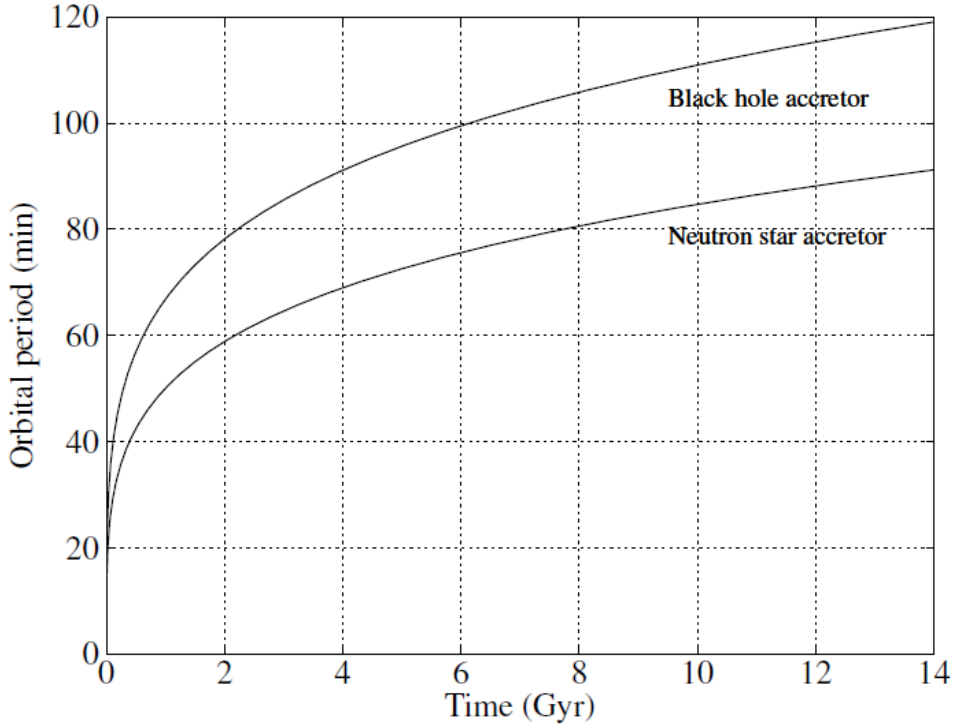
Reaction of donor star

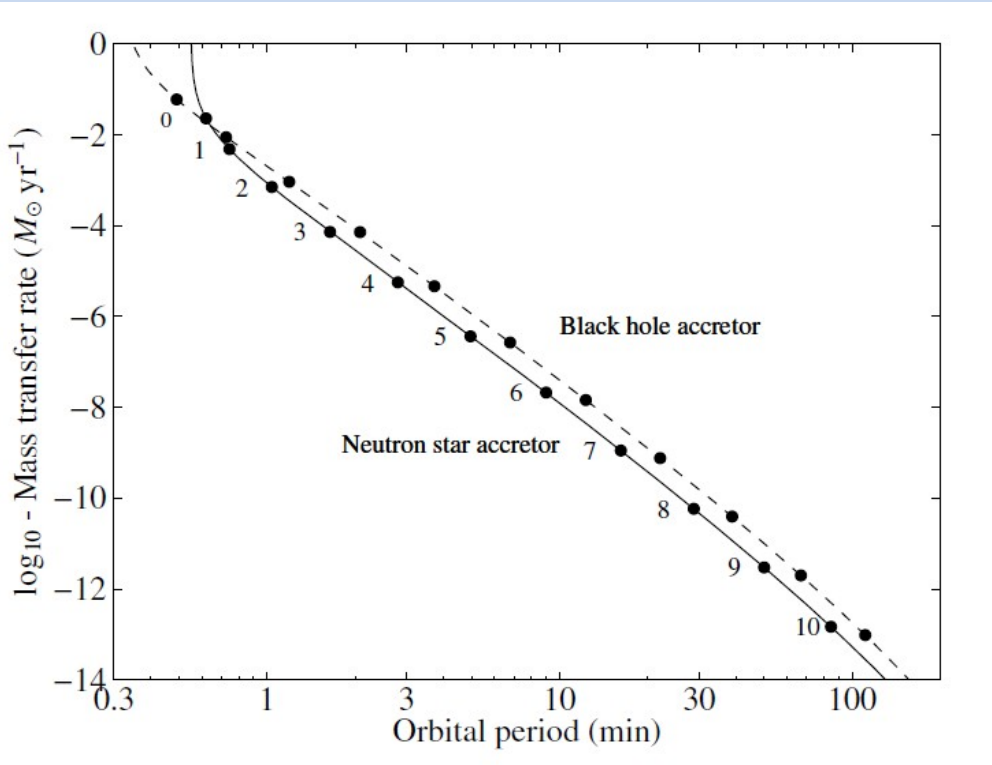


UCXB evolution

Period and separation
increases

Accretion rate and X-ray luminosity
decreases





Van Haaften, Voss, Nelemans, et al. (submitted)

Observed UCXBs

13 Confirmed

Name	P_{orb} (min)	d (kpc)	Location	Composition	Lightcurve	References
4U 1820–30	11.42	7.6 ± 0.4	NGC 6624	He (burst-model)	ASM, *MAXI*	1-p, 2,3,4-c, 5-d
4U 0513–40	17	12.2	NGC 1851	He	ASM, *MAXI*	6-pc
2S 0918–549	17.4	4.8 ± 0.6	Disk	C,O? (opt), He (burst)	ASM, *MAXI*	7-p, 8,9-c, 10,11-d
4U 1543–624	18.2	7	Disk	C,O? (opt), O (X)	ASM, *MAXI*	12-p, 8,13-c
4U 1850–087	20.6	8.2?	NGC 6712	Ne-excess	ASM, *MAXI*	14-p, 15-c
M 15 X-2	22.58	10.3	M 15	He,C	ASM, *MAXI*	16-pc
XTE J1807–294	40.07	8.3 ± 1.5?	Bulge?		ASM, *MAXI*	17-p
4U 1626–67	41.4	8		C,O (opt), O (UV,X)	ASM, *MAXI*[a]	18-p, 19,20,21,22-c
XTE J1751–305	42.42	8.3 ± 1.5?	Bulge?		ASM	23-p
XTE J0929–314	43.58	10		He,C,N	ASM, *MAXI*	24-p, 24,19-c
4U 1916–05	49.48	8.9		He,N (opt)	ASM, *MAXI*	25-p, 19-c
SWIFT J1756.9–2508	54.70	8.3 ± 1.5?	Bulge?	He (model)	ASM	26-pc
NGC 6440 X-2	57.3	8.5 ± 0.4	NGC 6440		ASM	27-p

Van Haaften, Voss & Nelemans (also submitted)

Observed UCXBs

13 Confirmed

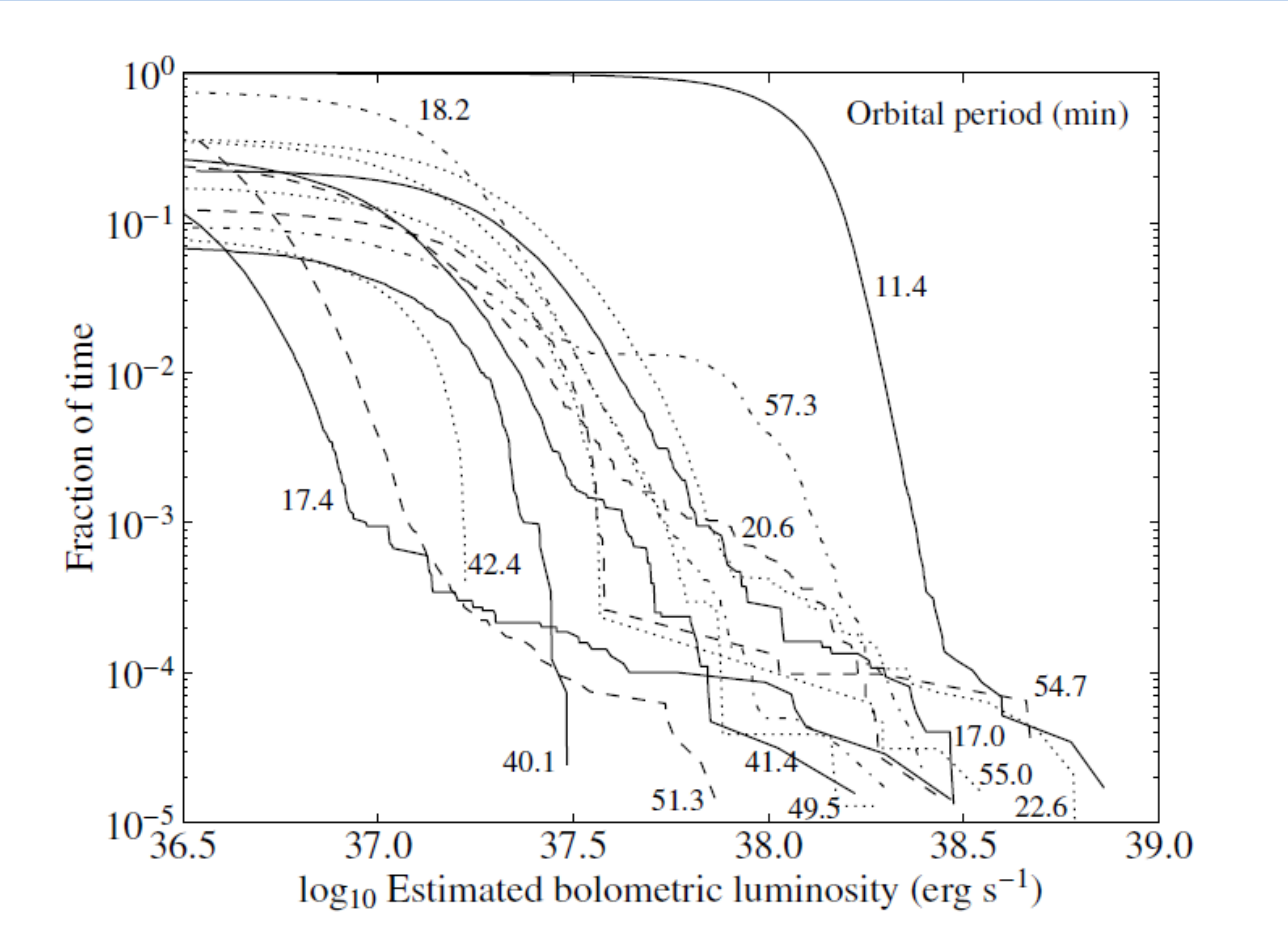
And candidates

Name	P_{orb} (min)	d (kpc)	Location	Composition	Lightcurve	References
4U 1820–30	11.42	7.6 ± 0.4	NGC 6624	He (burst-model)	ASM, *MAXI*	1-p, 2,3,4-c, 5-d
4U 0513–40	17	12.2	NGC 1851	He	ASM, *MAXI*	6-pc
2S 0918–549	17.4	4.8 ± 0.6	Disk	C,O? (opt), He (burst)	ASM, *MAXI*	7-p, 8,9-c, 10,11-d
4U 1543–624	18.2	7	Disk	C,O? (opt), O (X)	ASM, *MAXI*	12-p, 8,13-c
4U 1850–087	20.6	8.2?	NGC 6712	Ne-excess	ASM, *MAXI*	14-p, 15-c
M 15 X-2	22.58	10.3	M 15	He,C	ASM, *MAXI*	16-pc
XTE J1807–294	40.07	8.3 ± 1.5?	Bulge?		ASM, *MAXI*	17-p
4U 1626–67	41.4	8		C,O (opt), O (UV,X)	ASM, *MAXI*[a]	18-p, 19,20,21,22-c
XTE J1751–305	42.42	8.3 ± 1.5?	Bulge?		ASM	23-p
XTE J0929–314	43.58	10		He,C,N	ASM, *MAXI*	24-p, 24,19-c
4U 1916–05	49.48	8.9		He,N (opt)	ASM, *MAXI*	25-p, 19-c
SWIFT J1756.9–2508	54.70	8.3 ± 1.5?	Bulge?	He (model)	ASM	26-pc
NGC 6440 X-2	57.3	8.5 ± 0.4	NGC 6440		ASM	27-p
NGC 6652 B	43.6?	9.2	NGC 6652(B)			28-p 29-d
4U 0614+091	51.3?	3.2		C,O (opt), O (X)	ASM, *MAXI*	30,31-p, 32-d, 8,20,33-c
XB 1832–330	55?	9.2	NGC 6652(A)		ASM, *MAXI*	29-d 34-p
1A 1246–588		4.3			ASM, *MAXI*	35,36-d
4U 1812–12					ASM	35
4U 1822–000					ASM, *MAXI*	37
4U 1905+000		8			ASM	38
ω Cen qLMXB			NGC 5139			39
1RXS J170854.4-321857					ASM	40
SAX J1712.6-3739					ASM	37
1RXS J171824.2-402934					ASM	40
4U 1722-30			Terzan 2			37
1RXS J172525.2-325717					ASM	37
SLX 1735-269					ASM	37
SLX 1737-282						37
SLX 1744-299					ASM	37

Van Haaften, Voss & Nelemans (also submitted)

Observed UCXBs

Observed luminosities, RXTE ASM

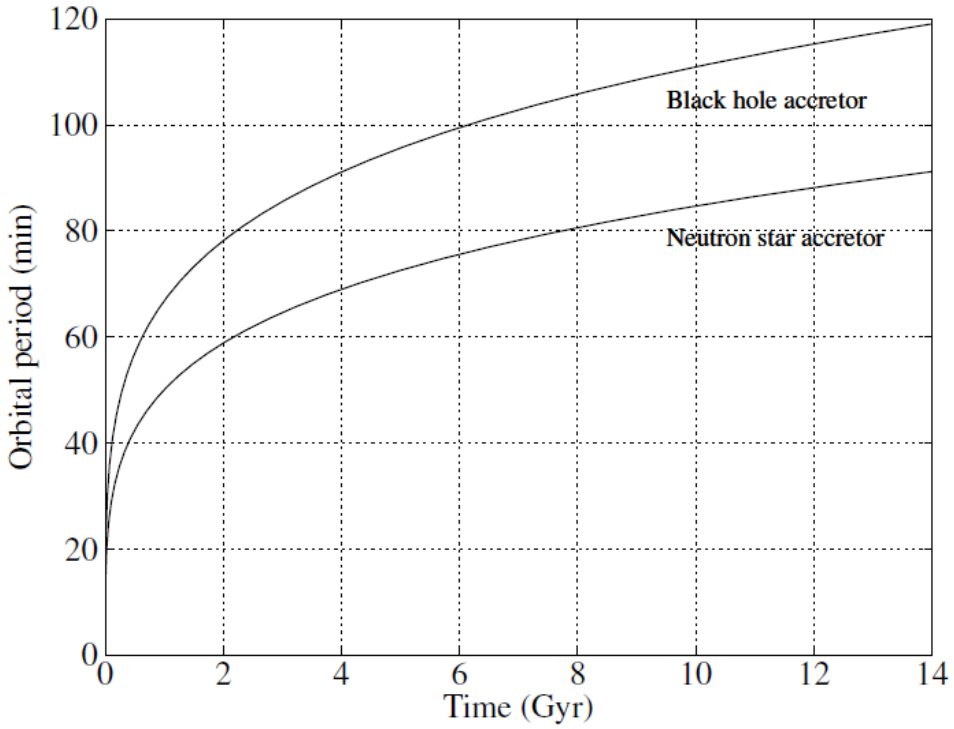


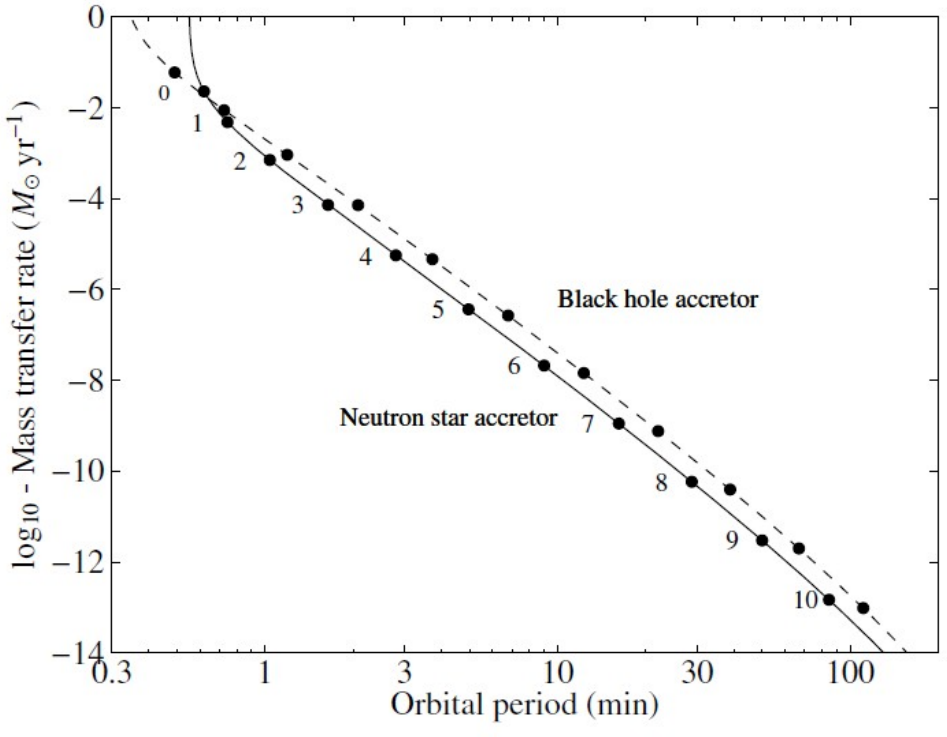
Van Haaften, Voss & Nelemans (submitted)

UCXB evolution

Period and separation
increases

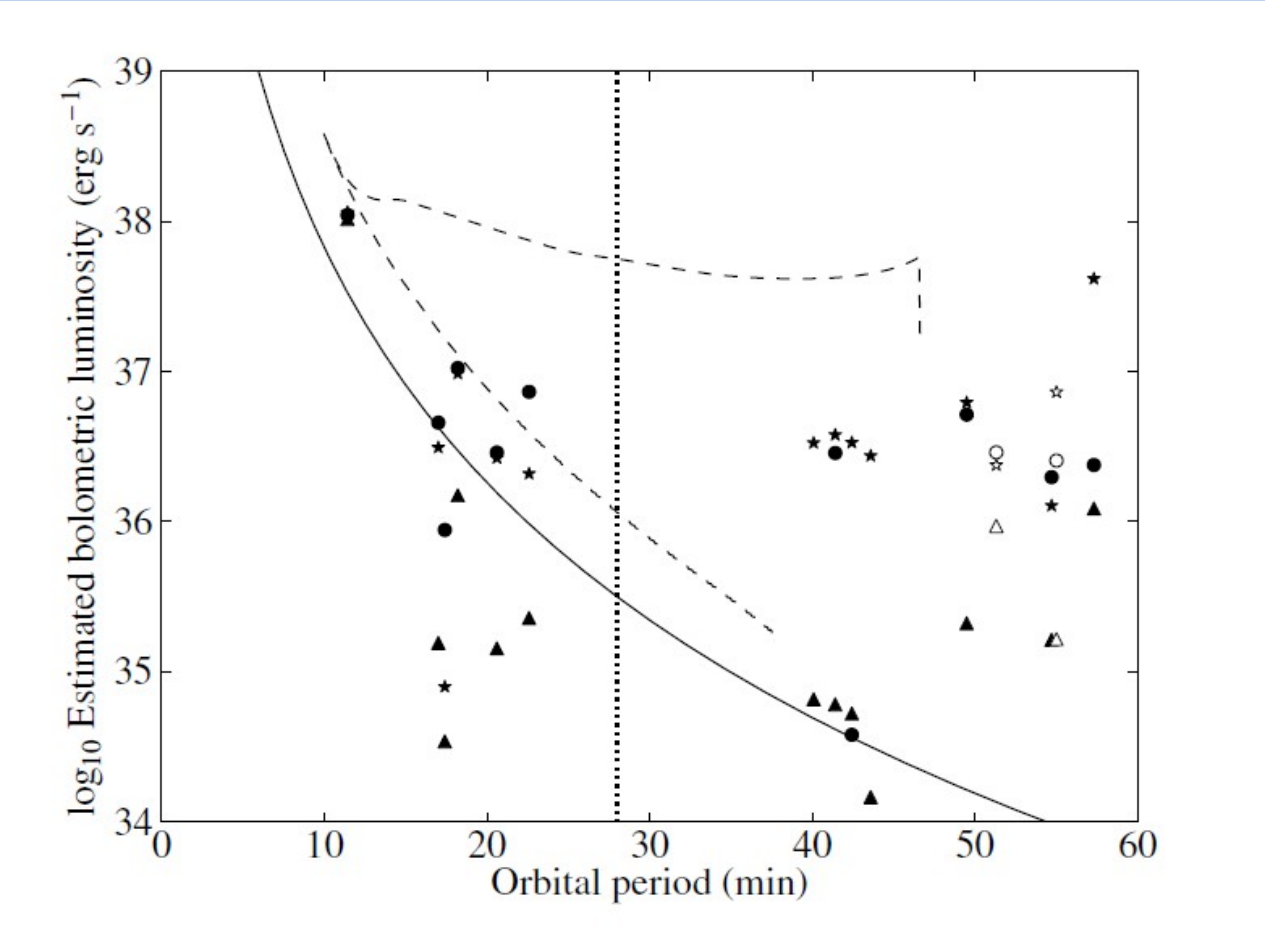
Accretion rate and X-ray luminosity
decreases





Van Haaften, Voss, Nelemans, et al. (submitted)

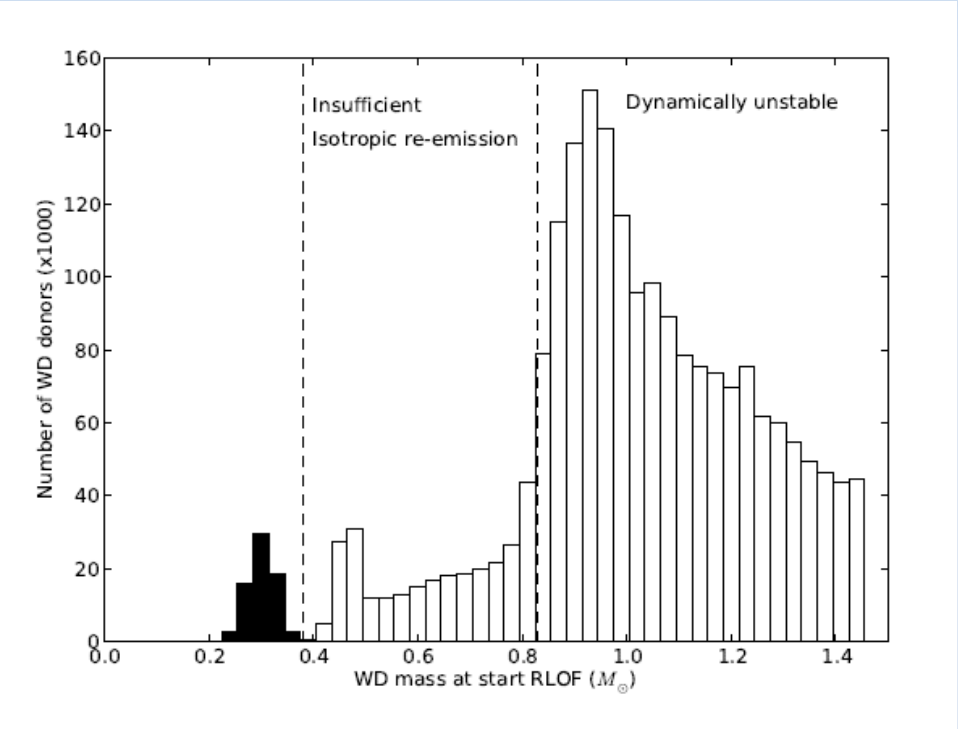
UCXB evolution vs. observations



Van Haaften, Voss & Nelemans (also submitted)

Modelling the population

Survival of initial mass transfer event

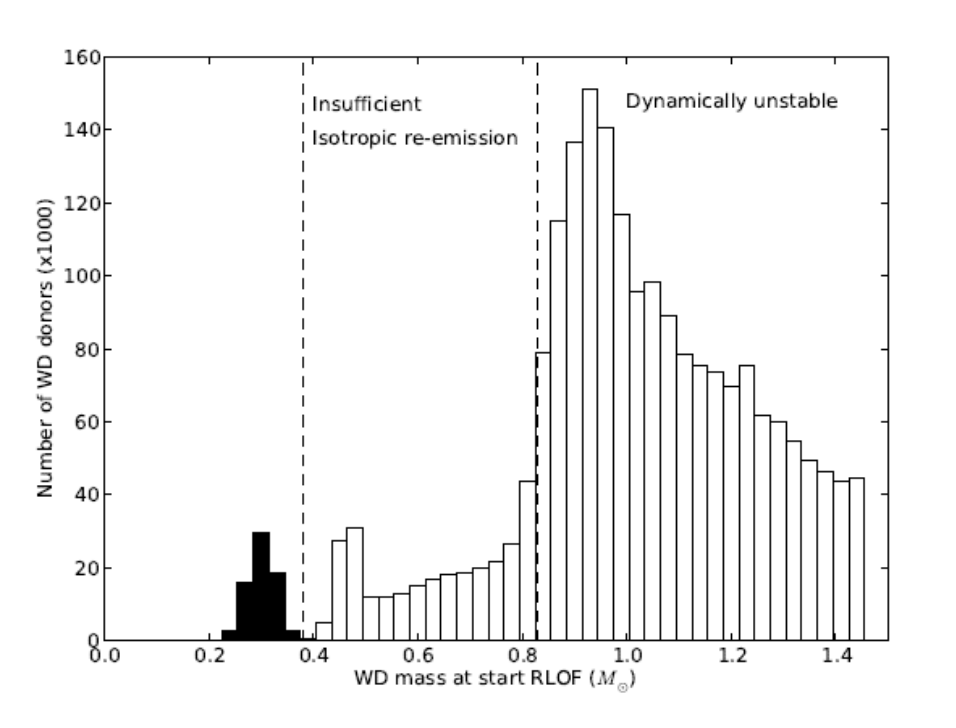


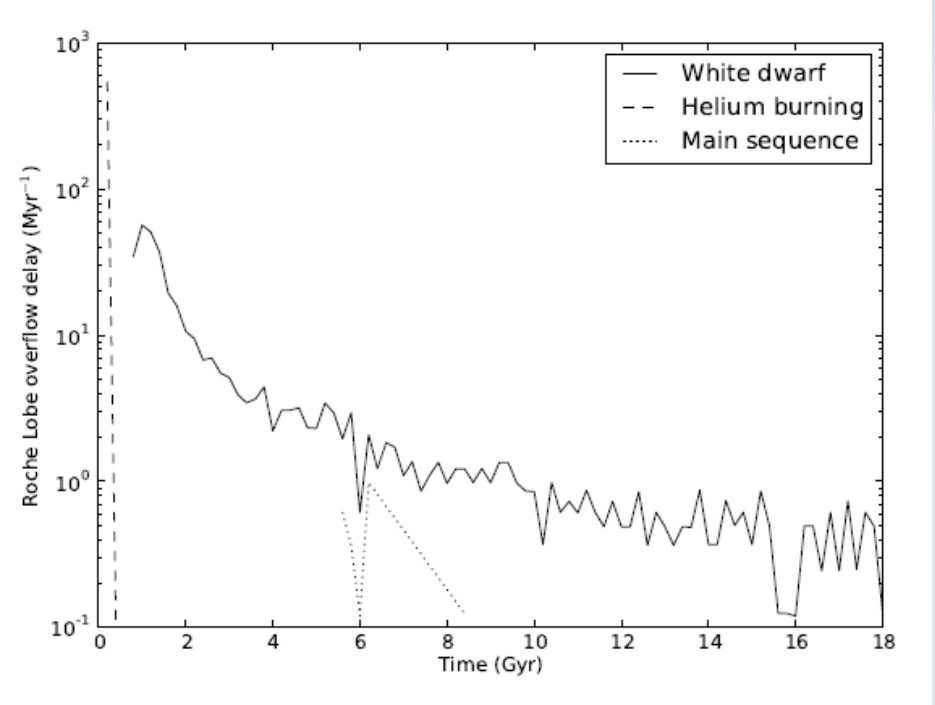
Van Haaften, Nelemans, Voss et al. (almost ready for submission)

Modelling the population

Survival of initial mass transfer event

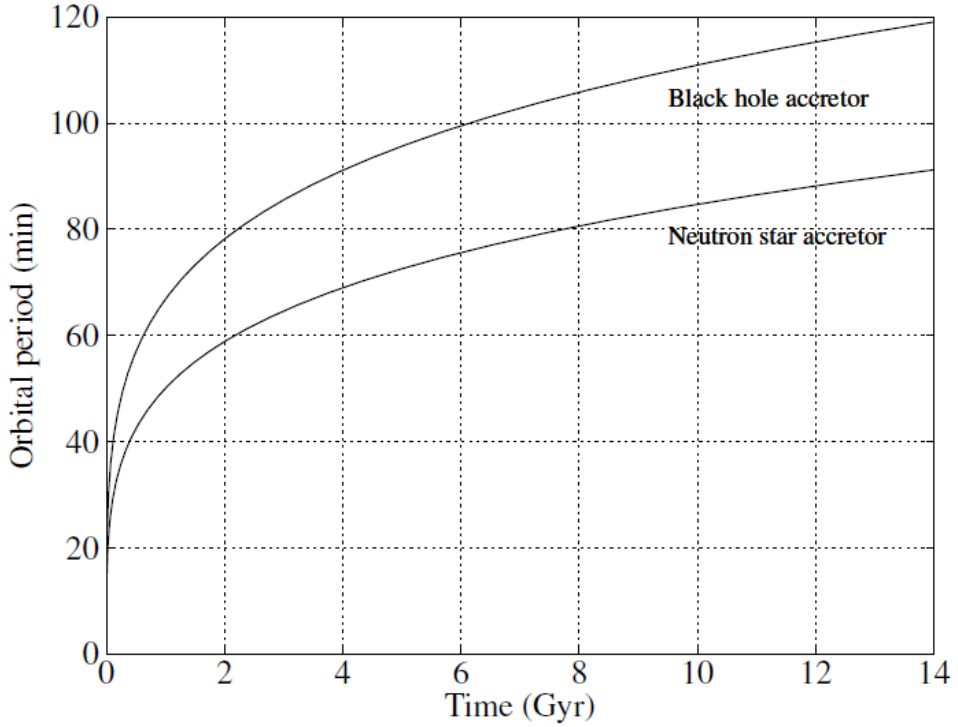
Time between ZAMS and onset of mass transfer

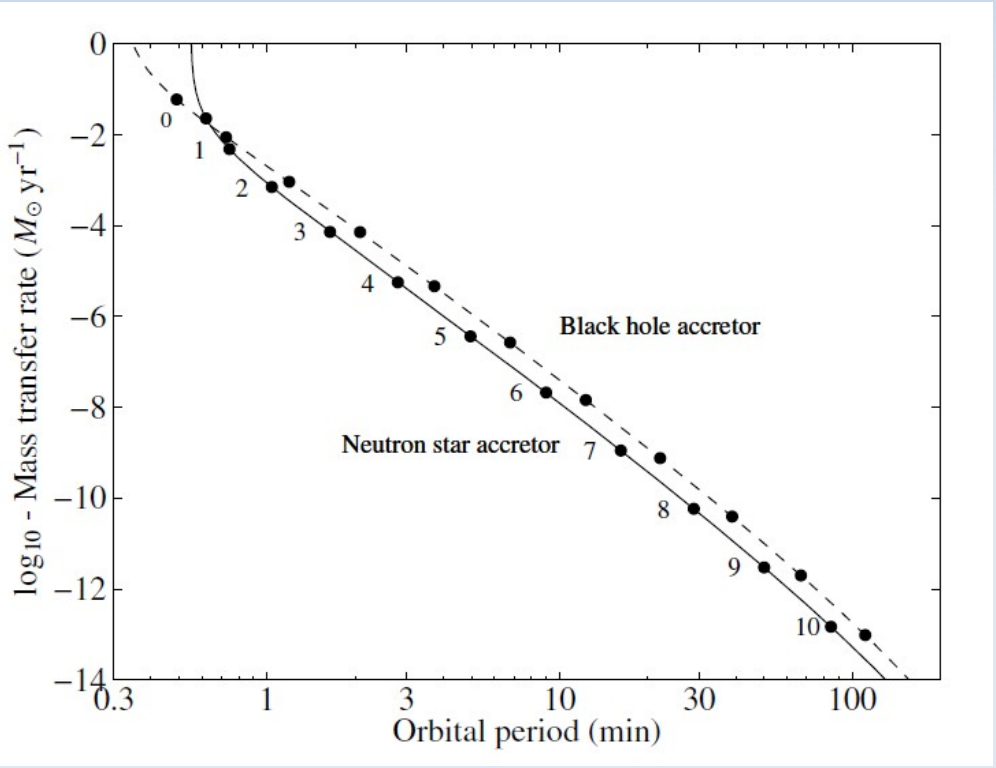




Van Haaften, Nelemans, Voss et al. (almost ready for submission)

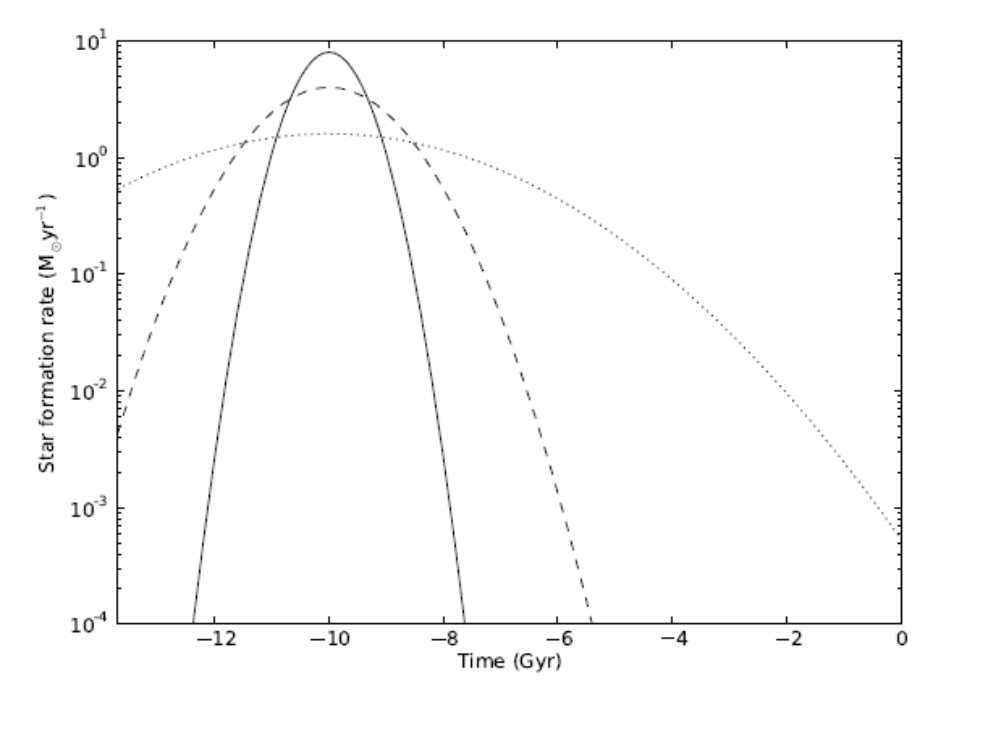
Modelling the population



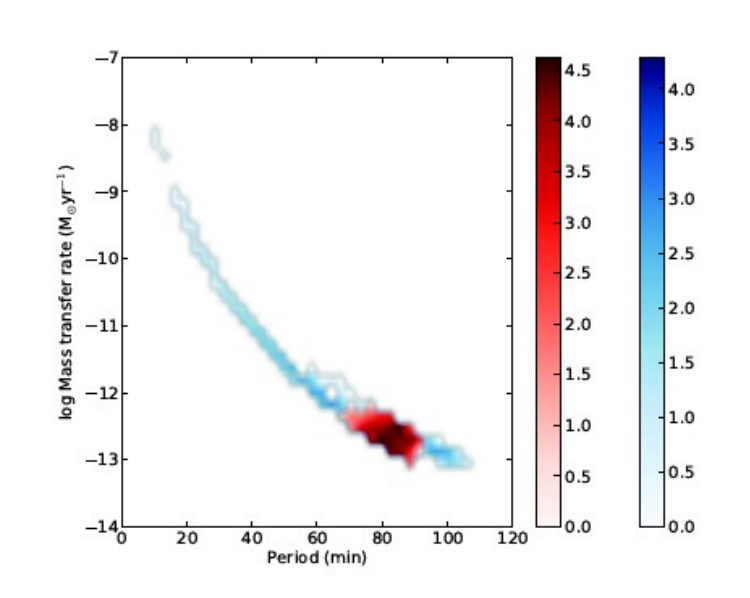


Van Haaften, Voss, Nelemans, et al. (submitted)

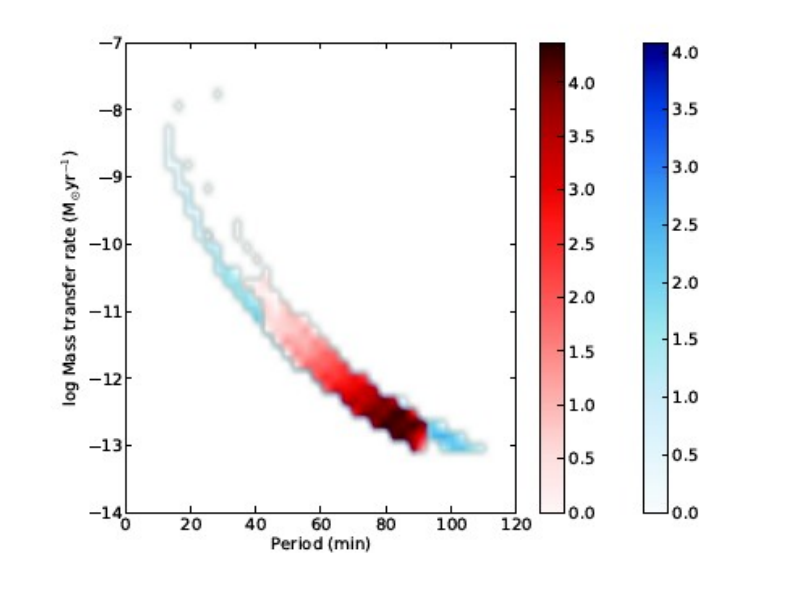
Current population



bulge



disk



Van Haaften, Voss, Nelemans, et al. (almost submitted)

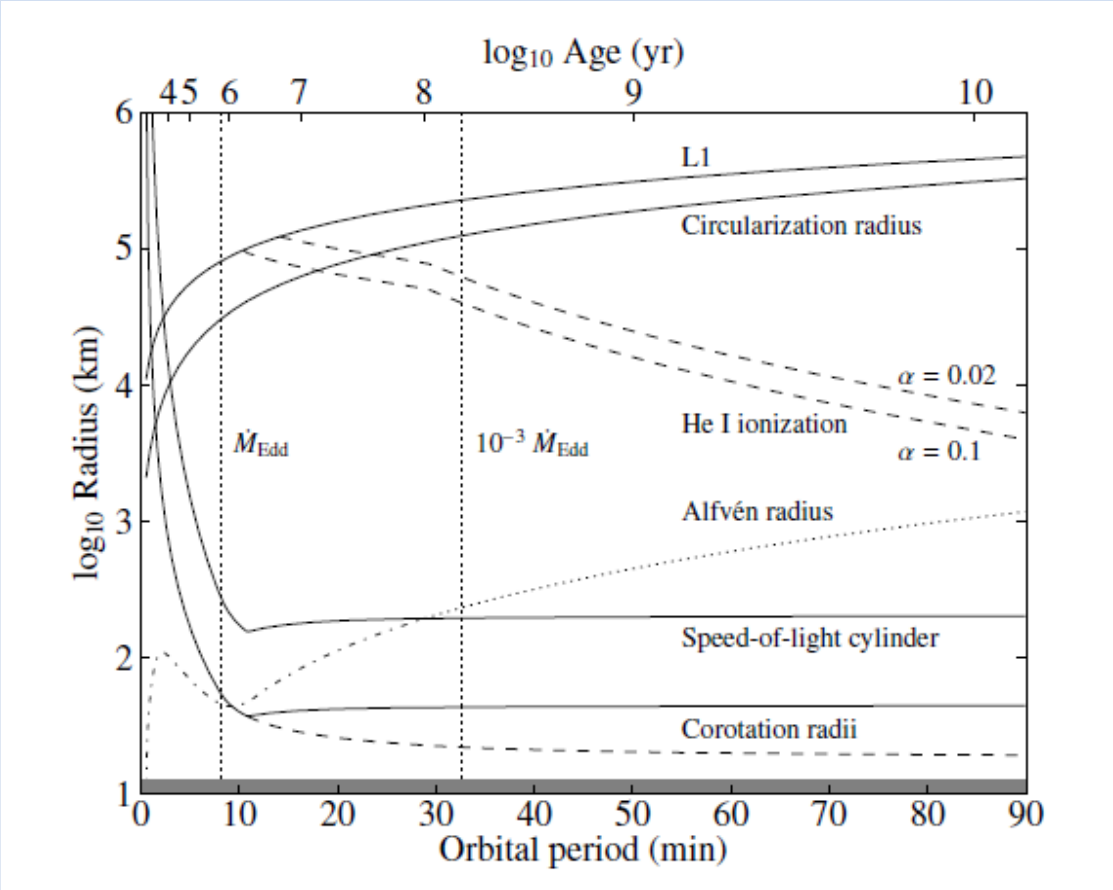
How many can we observe?

Total number ~10^5

But majority below 10^{34} erg/s
Where eROSITA is complete

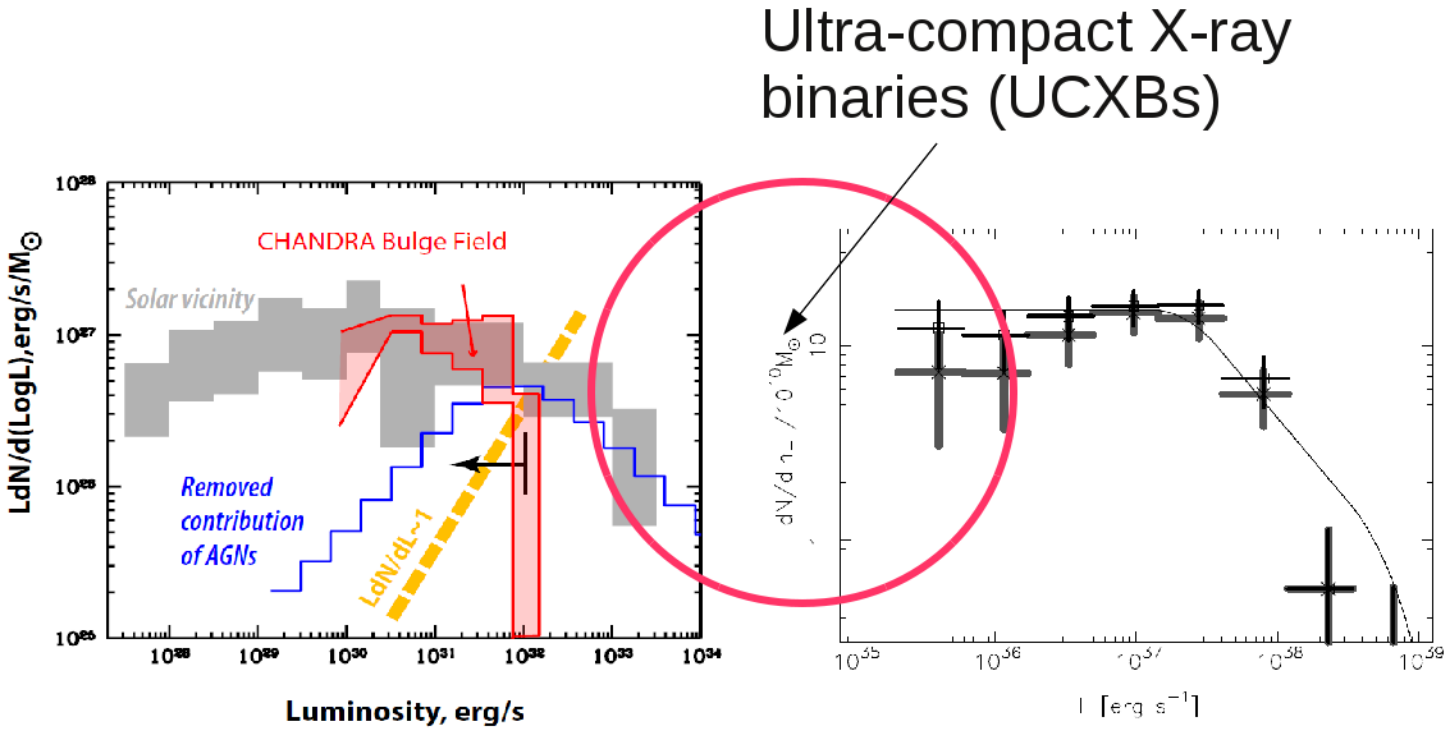
Depends strongly on the details of the accretion physics:

- Ionization disk instabilities
- Angular momentum feedback
- Magnetic fields



eROSITA

eROSITA is the only mission with the potential to close the observational gap!



Main problem to solve is the identification of observed sources!