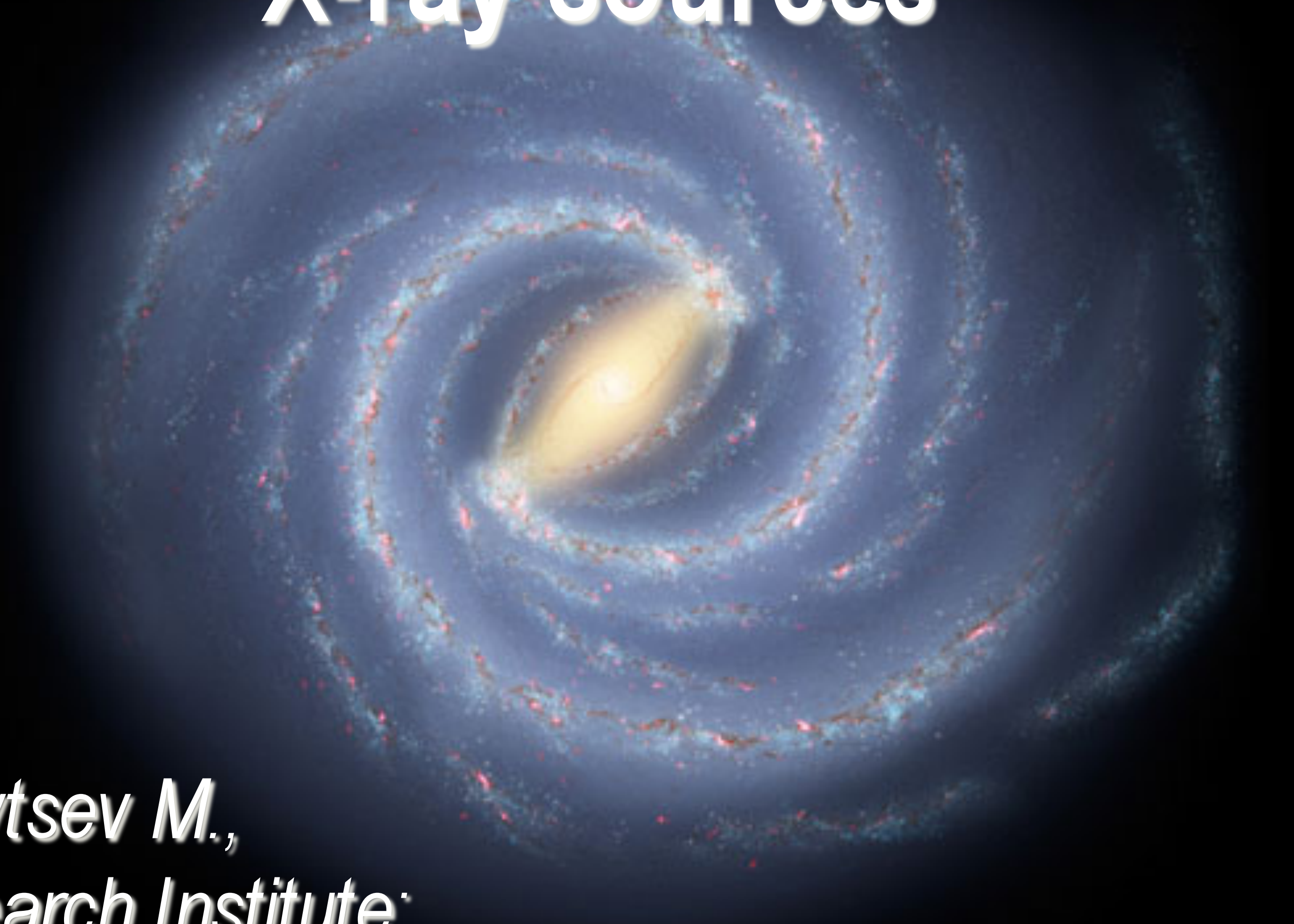
Populations of Galactic X-ray sources



Revnivtsev M.,
Space Research Institute;
Moscow, Russia

Discrete X-ray emitters in the Galaxy

1. Binaries with relativistic objects – X-ray binaries. High mass and low mass companions
2. Single relativistic objects: cooling neutron stars, rotation powered pulsars..
3. **Binaries with accreting white dwarfs**
4. Stars with active coronae, binary stars

Why population studies?

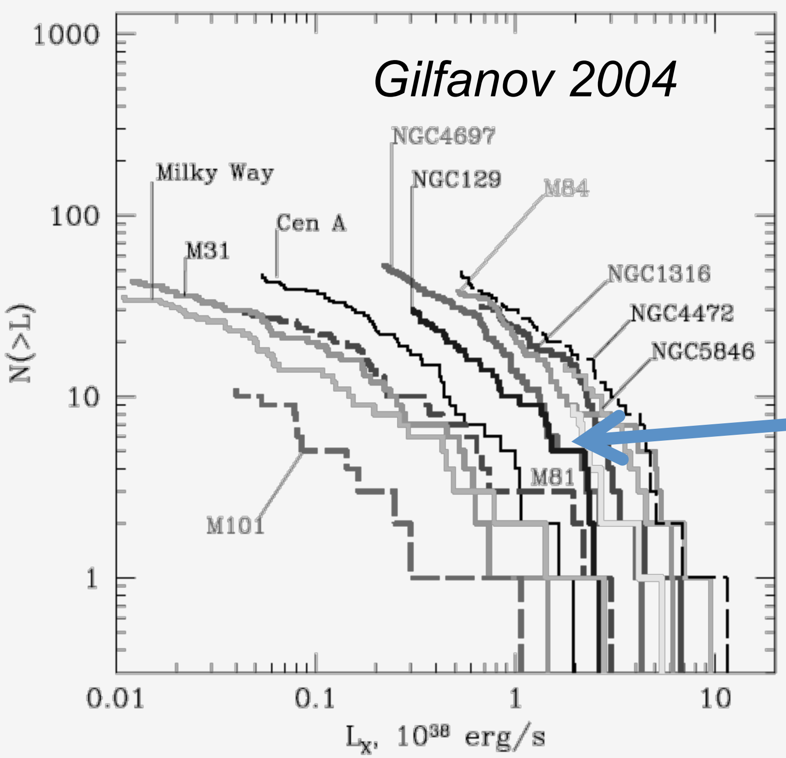
1. Search for sources to be studied individually
2. Properties of populations can tell us about their formation

… about interactions in binary systems (MSW, GW, outflows?)

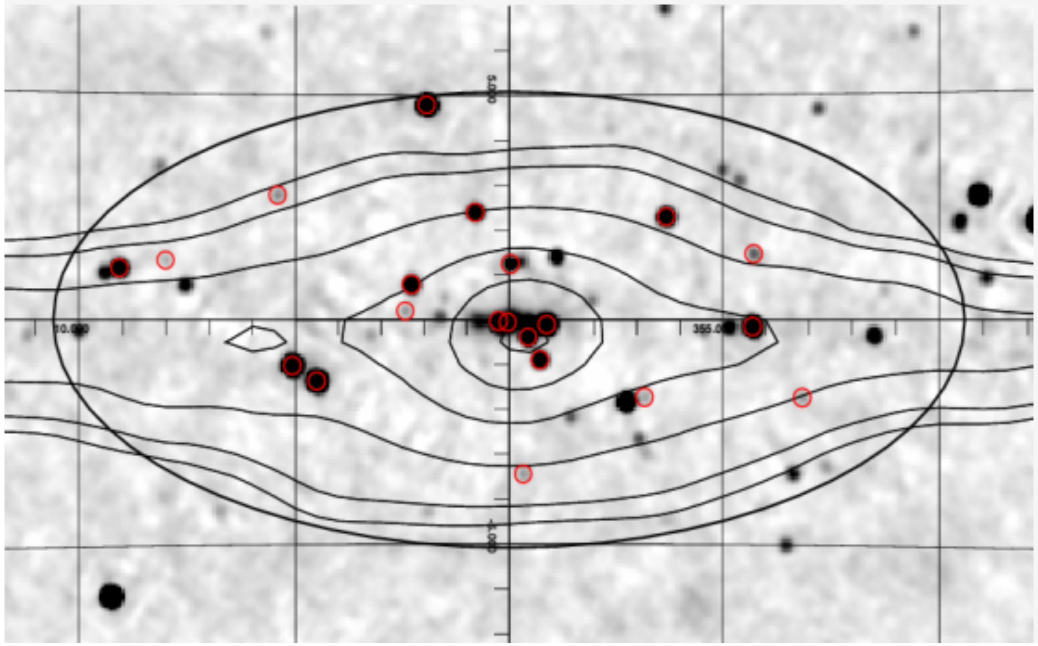
3 …. about average properties of compact objects (e.g. magnetic field, rotation rates at birth etc)

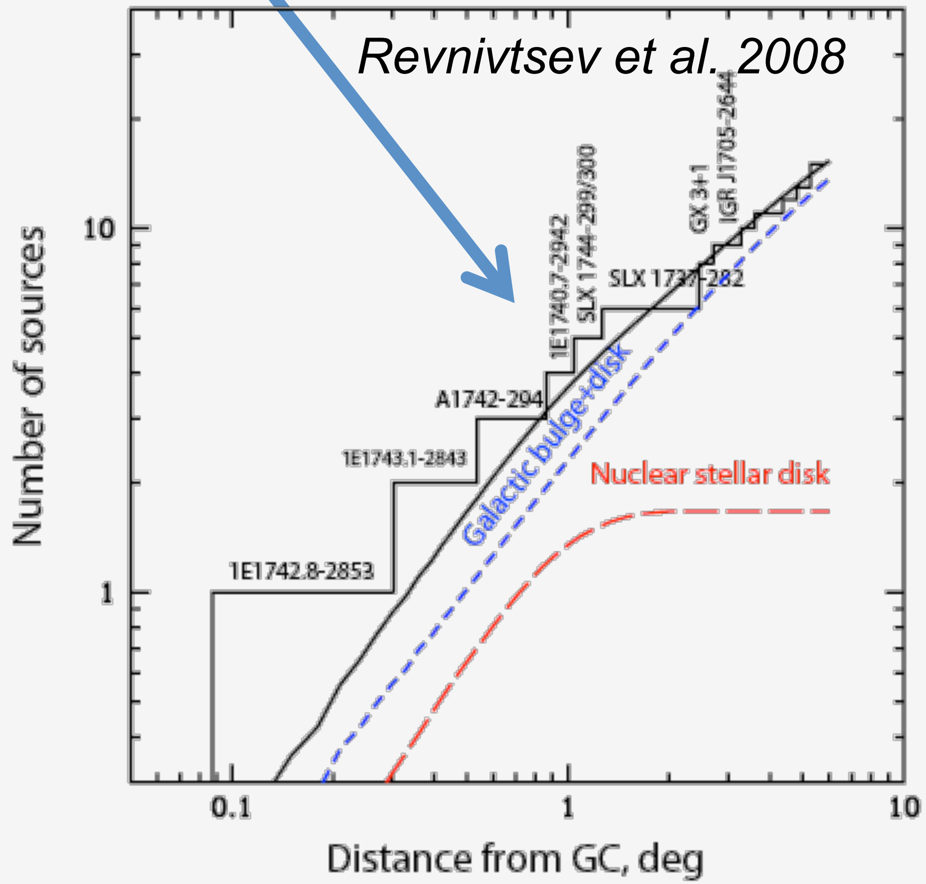
4 … about long term evolution of objects (e.g. accumulation/erosion of WD masses etc)

LMXBs in galaxies

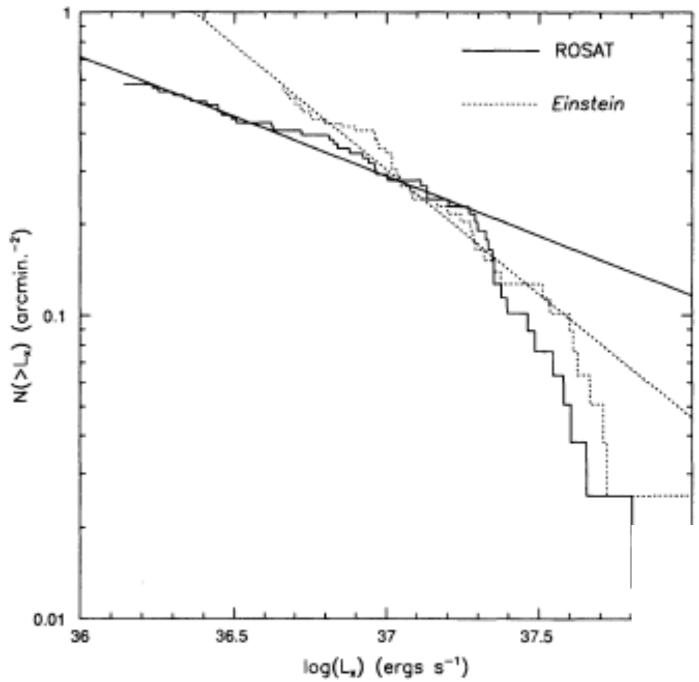


LF normalization traces the stellar mass

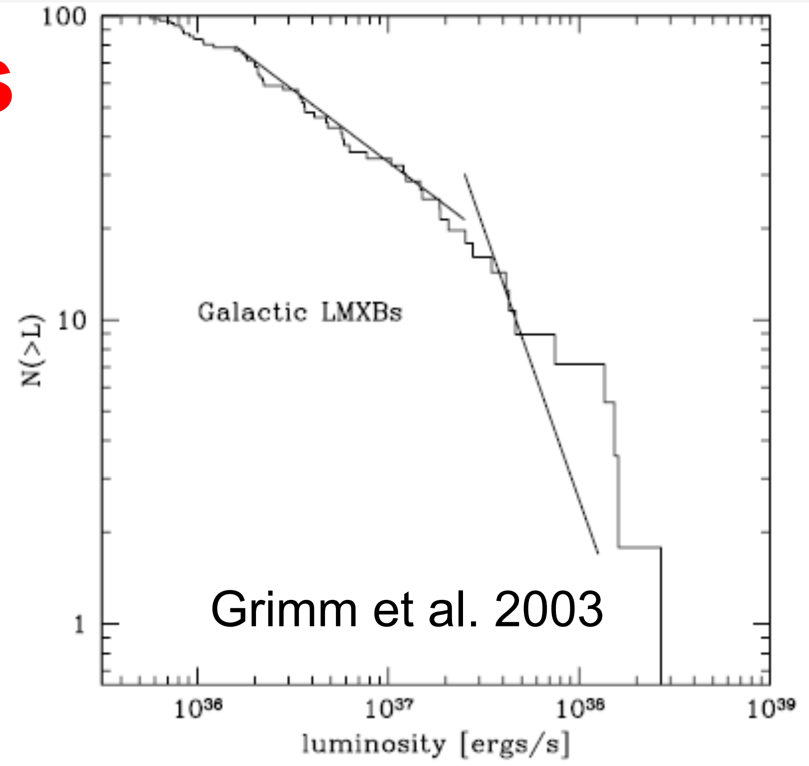




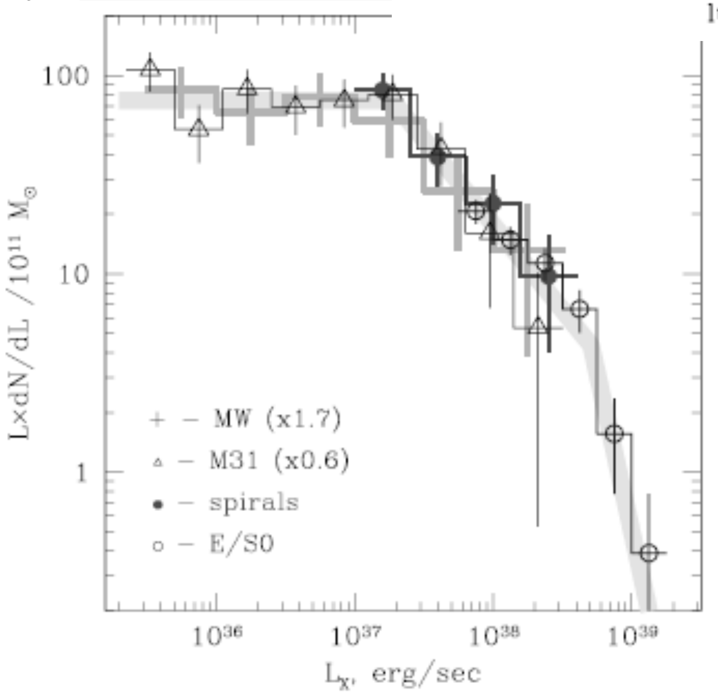
Breaks in LF of LMXBs



Primini, Forman, Jones 1993

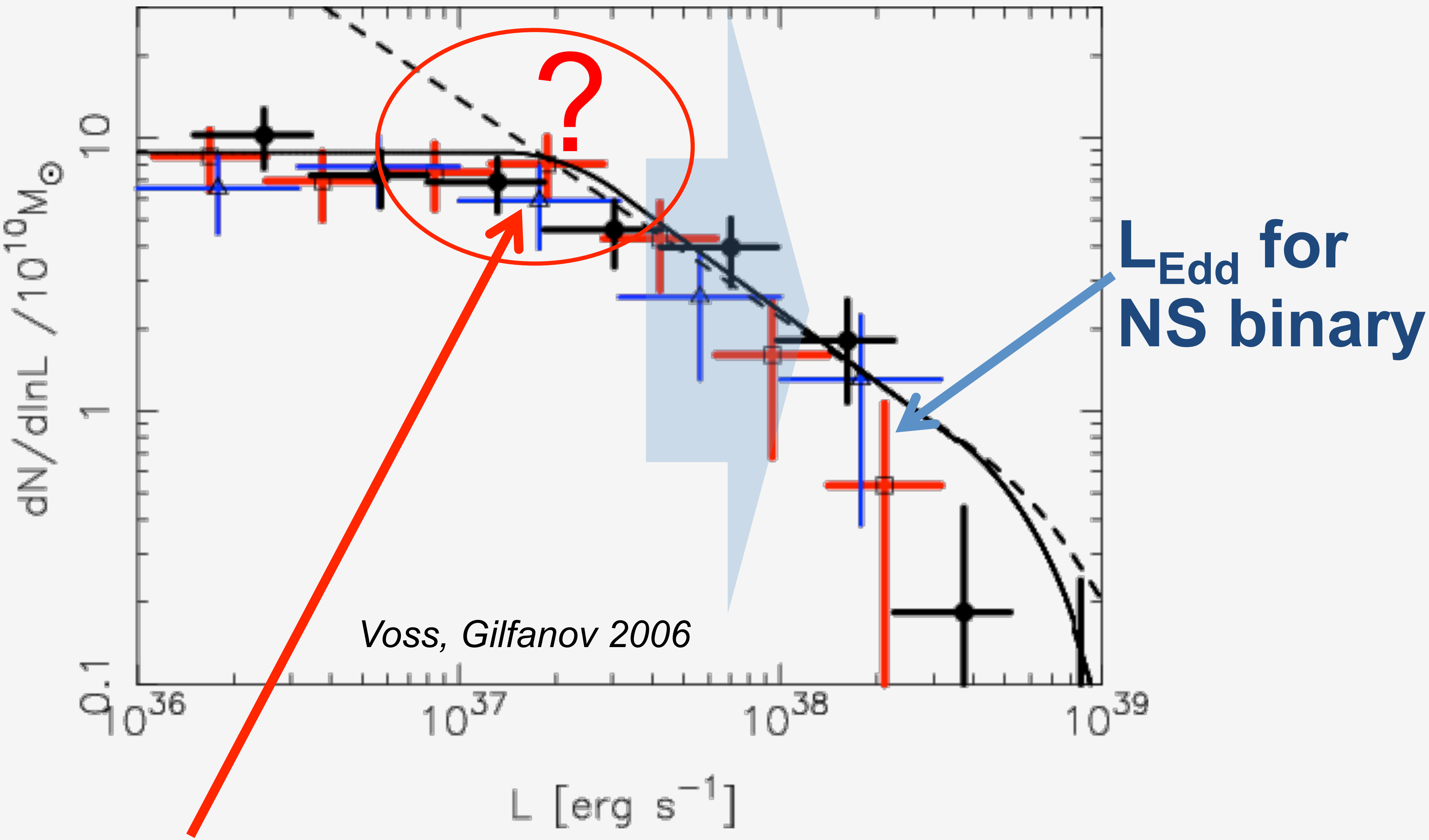


Grimm et al. 2003



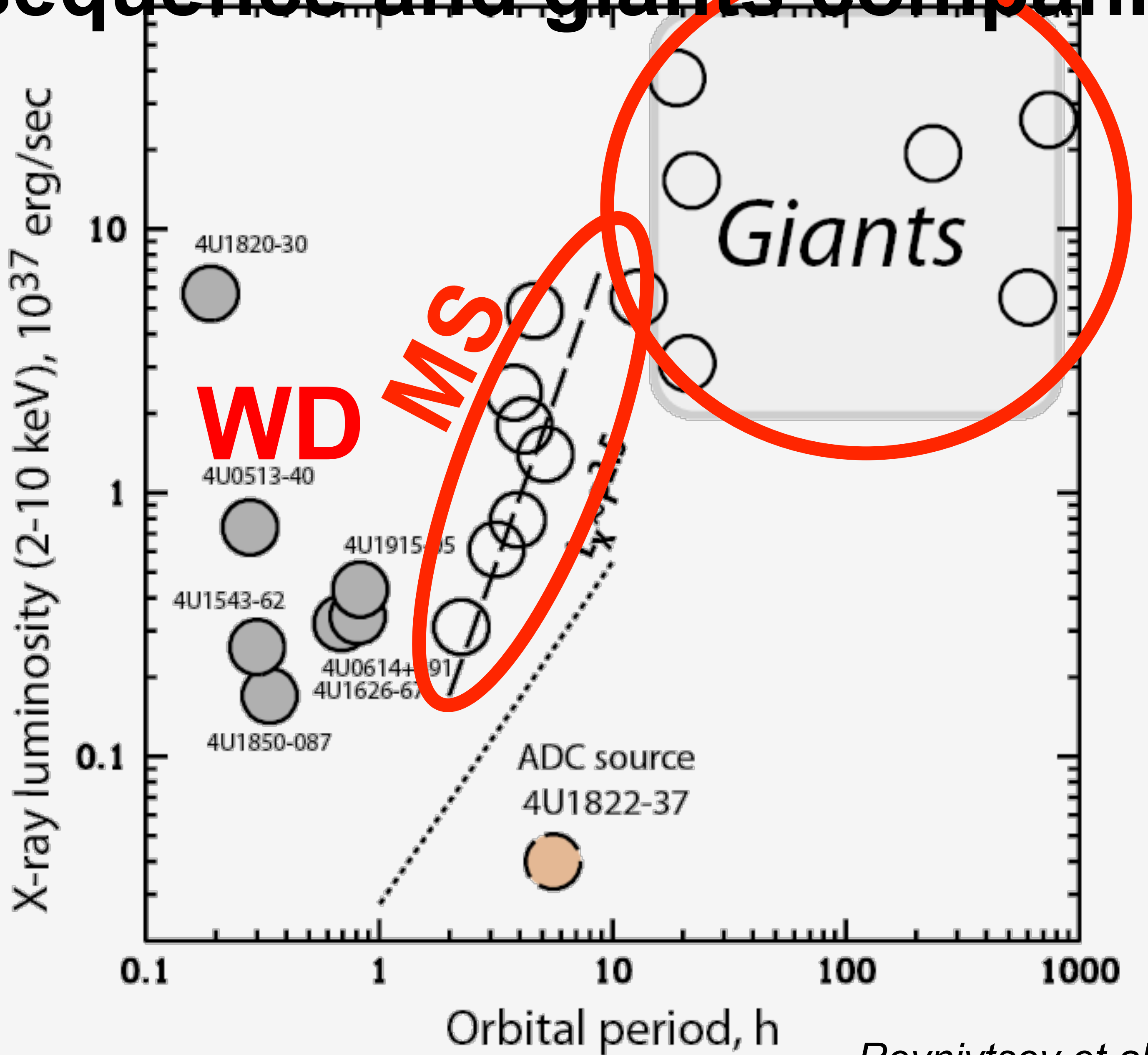
Gilfanov 2004

LMXBs in galaxies



What is the origin of this break?

LogLx~37 -- boundary between main sequence and giants companions



Revnivtsev et al. 2011

$$\frac{dN}{dL_x} \propto \frac{\tau(P)}{T} n(P) \frac{dP}{dL_x}$$

$$L_x \propto P^\alpha \Rightarrow \frac{d\log L_x}{d\log P} \sim const$$

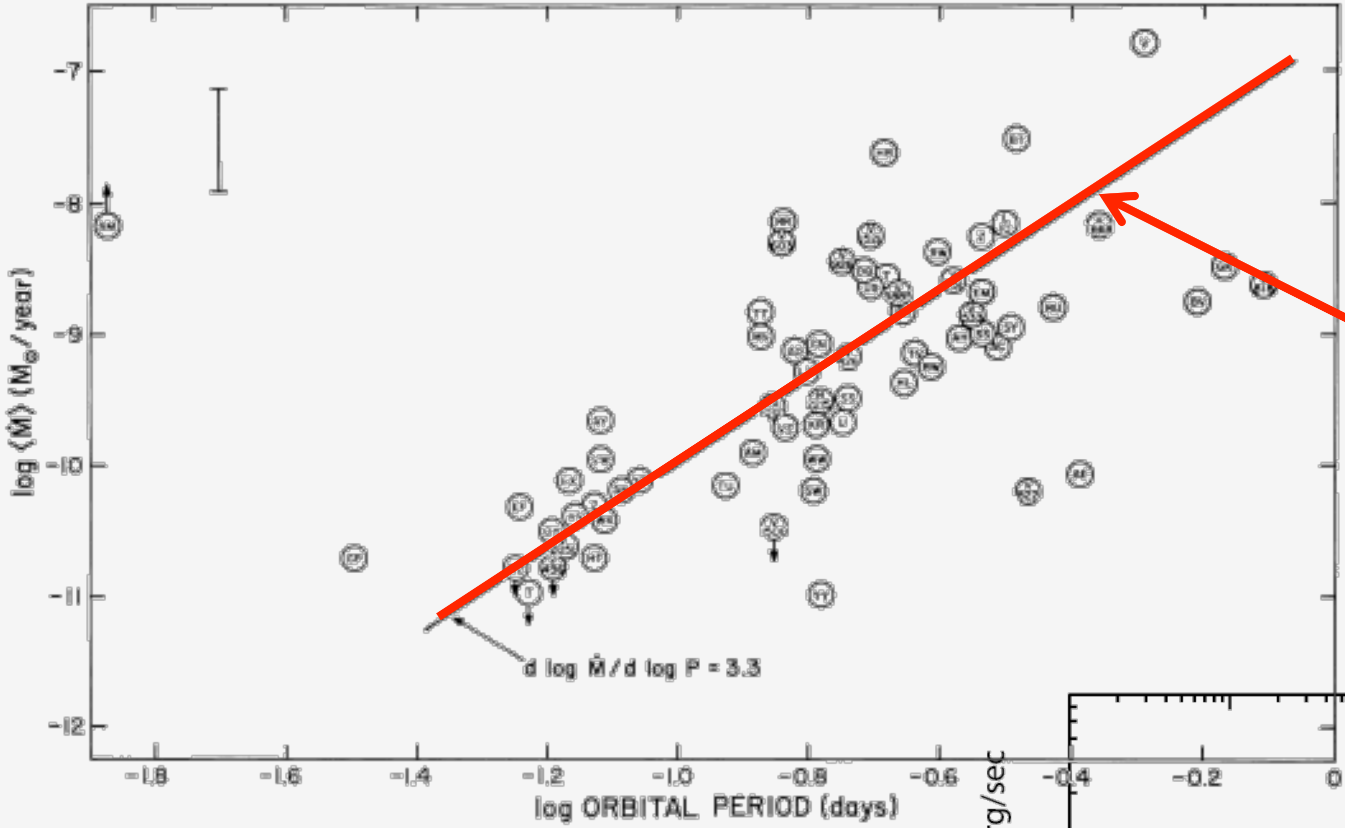
MS $$n(L_x) \propto \frac{1}{L_x} \frac{dN}{d\log P} \frac{d\log P}{d\log L_x} \sim \frac{1}{L_x} \frac{dN}{d\log P}$$

$dN/d\log P$ =const

(Popova, Tutukov, Yungelson 1982)

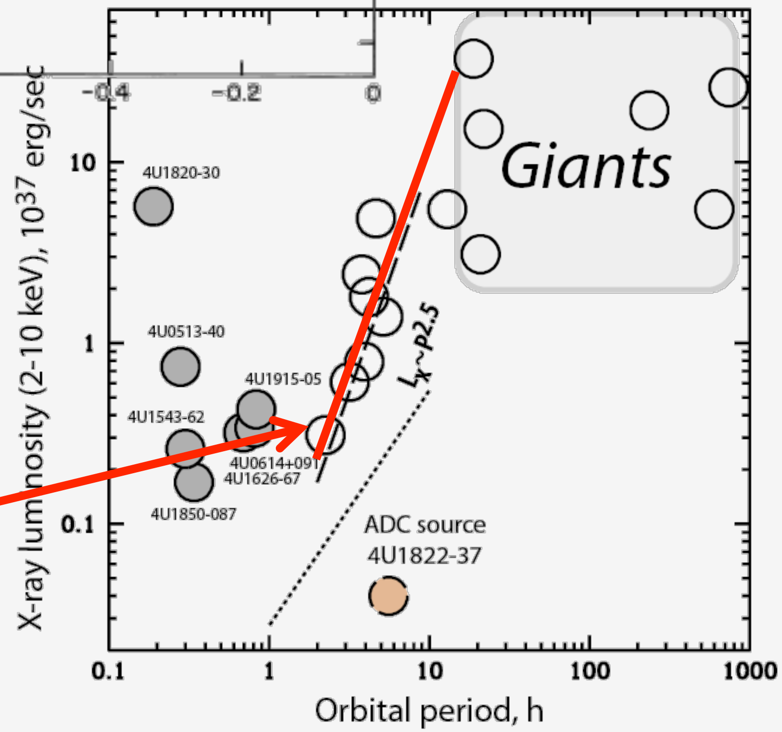
Giants $$\tau \propto L_x^{-1}$$ (e.g Webbink et al.. *1983*)

$$\frac{dN}{dL_x} \propto \frac{1}{L_x P} \frac{dP}{dL_x} \propto \frac{1}{L_x^2} \frac{d\log P}{d\log L_x} \approx L_x^{-2}$$



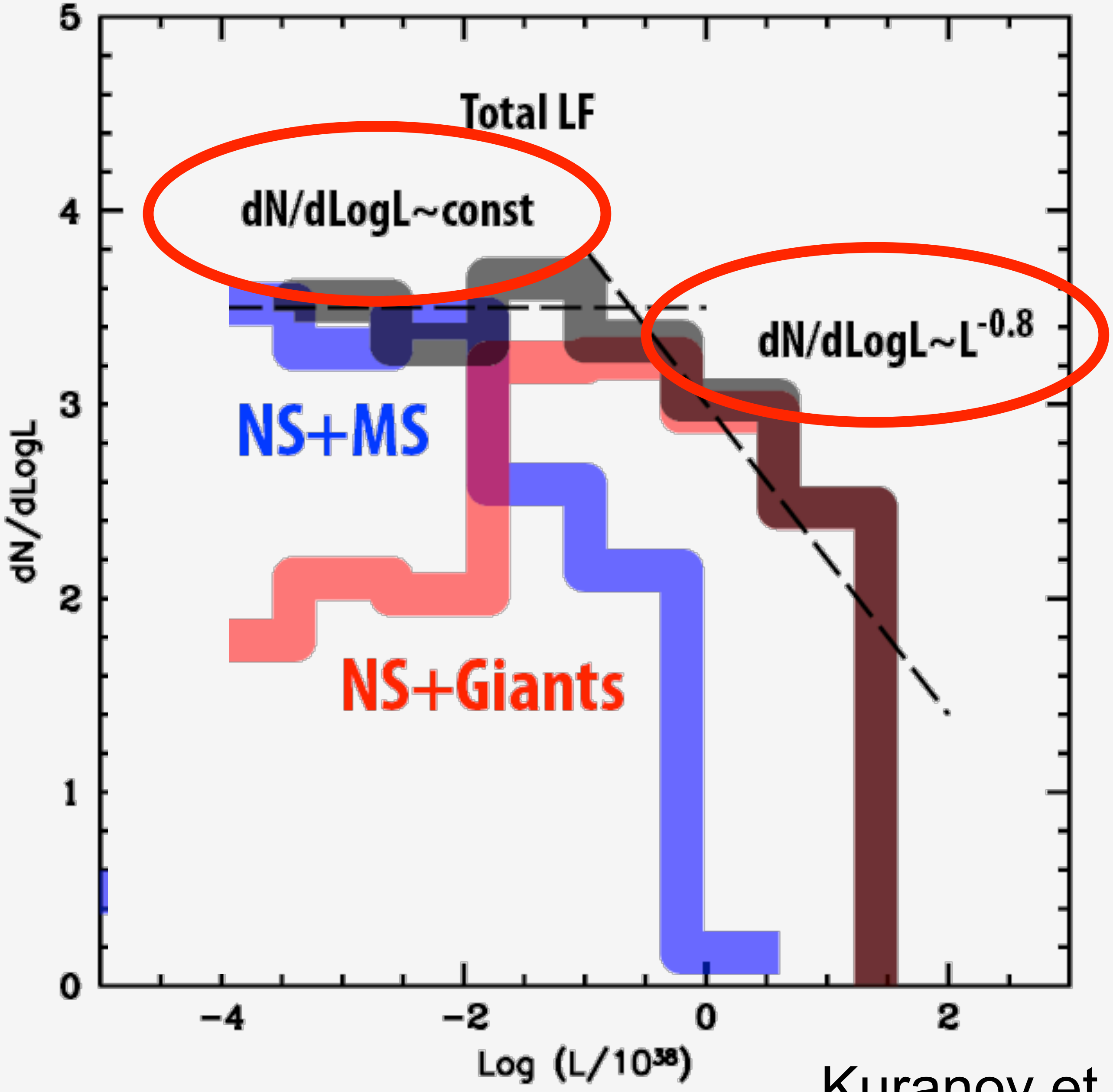
Patterson 1984

$$\frac{d\log L_x}{d\log P} \sim 3.3$$



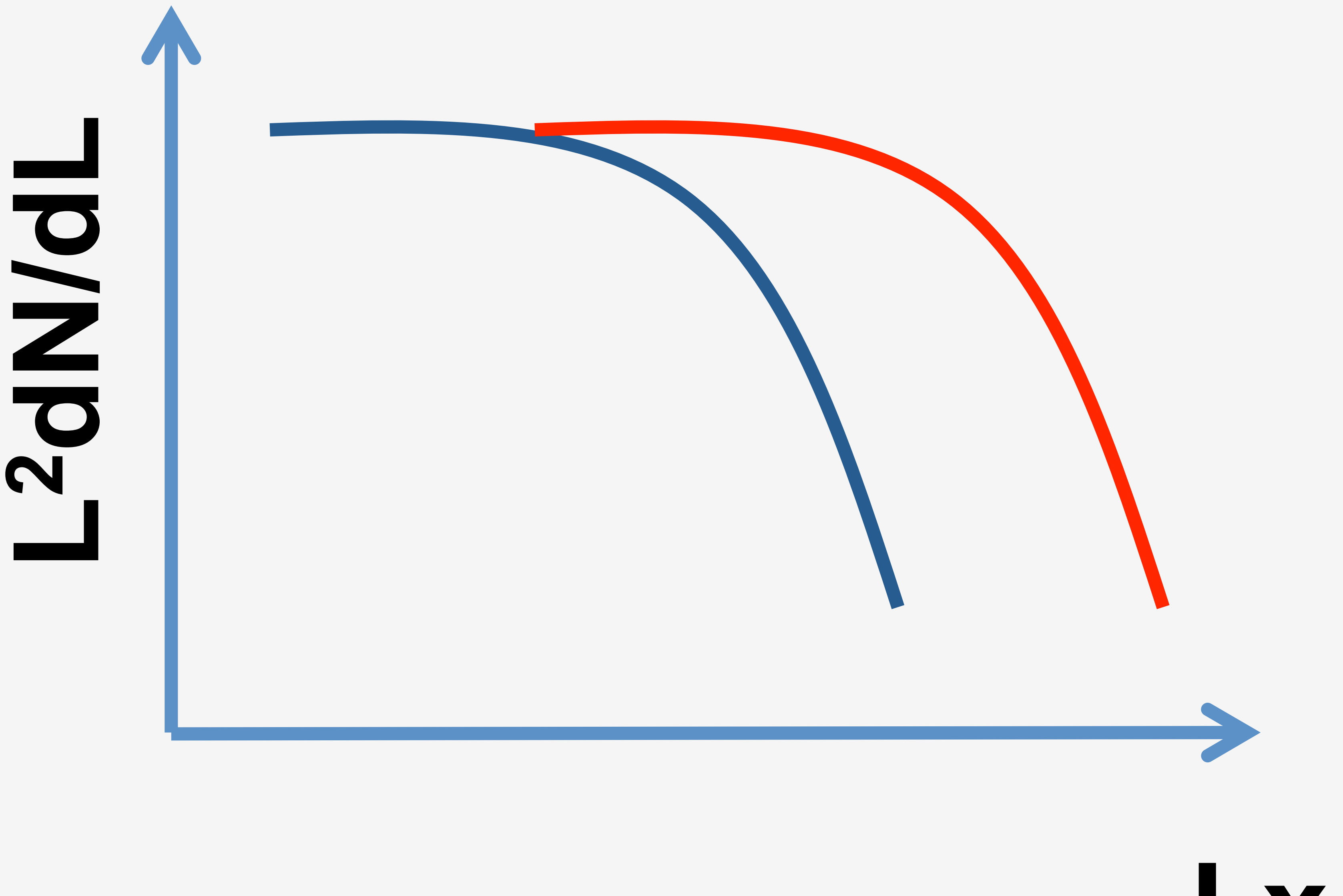
$$\frac{d\log L_x}{d\log P} \sim 2.5$$

(Iben, Tutukov 1984)

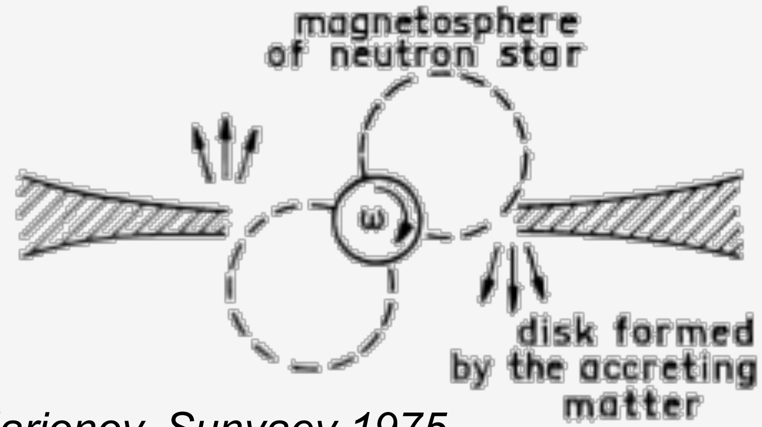


Kuranov et al..
(preliminary)

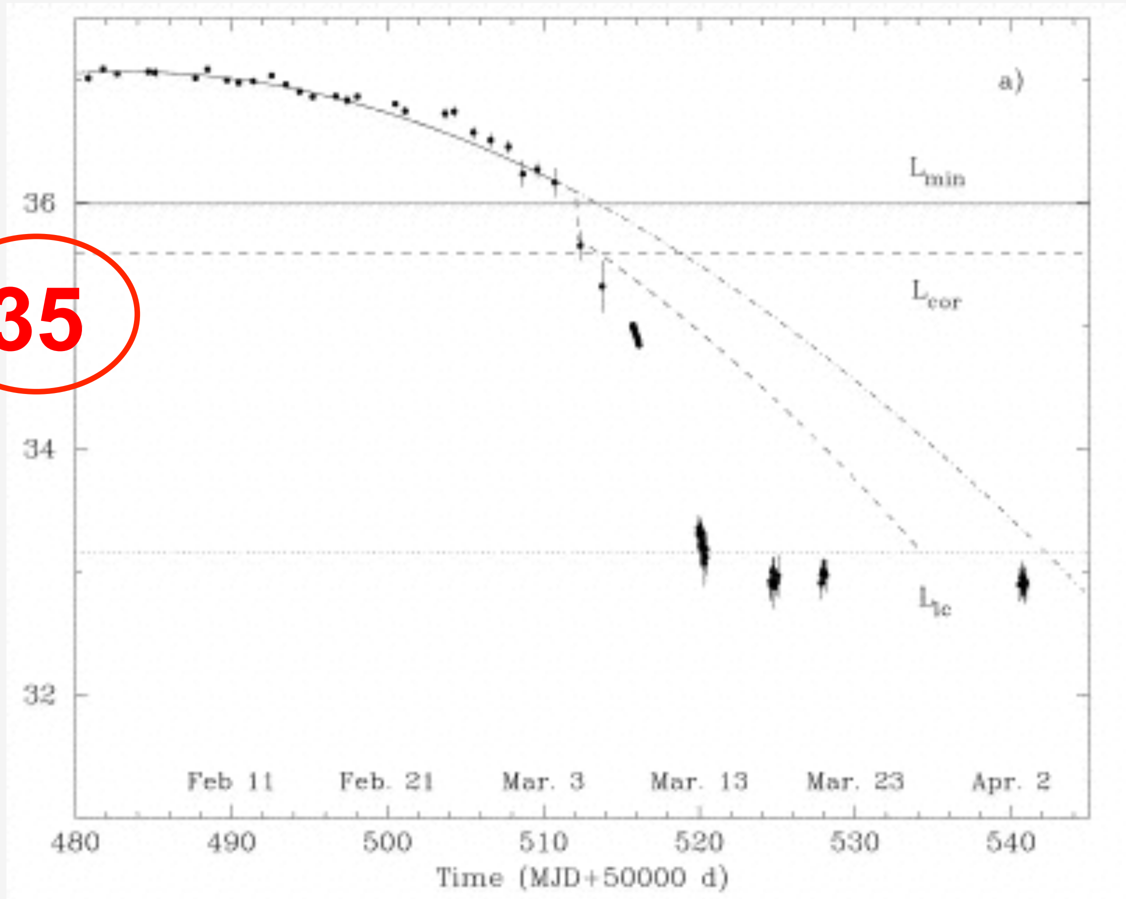
LMXB age evolution?



Propeller effect



Illarionov, Sunyaev 1975

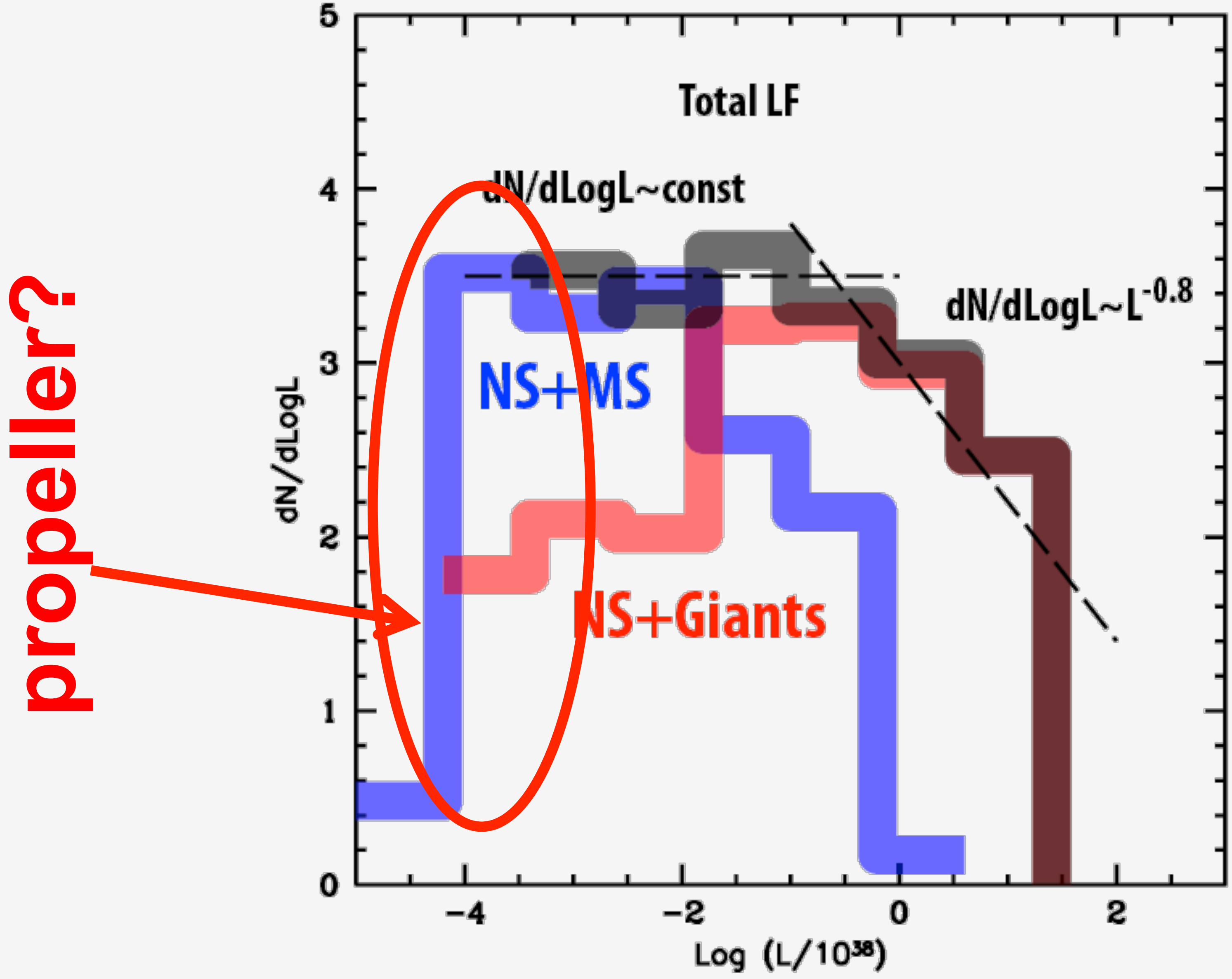


35

$$L_{\min} \approx 4 \cdot 10^{36} B_8^2 P_{-3}^{-7/3} ergs/\sec$$

$$B \sim 1-6 \cdot 10^8 \text{ G}$$

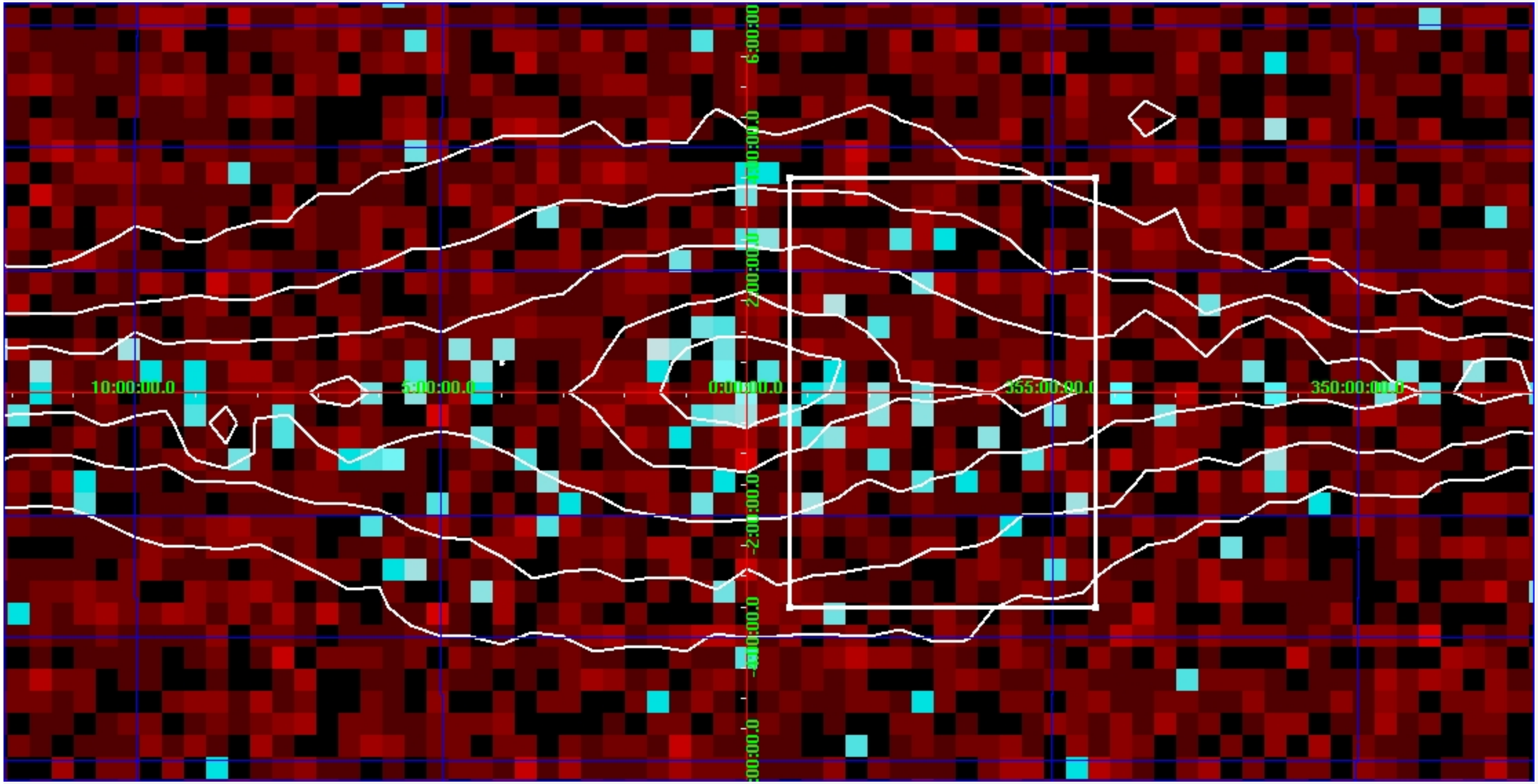
Campana et al. 1998



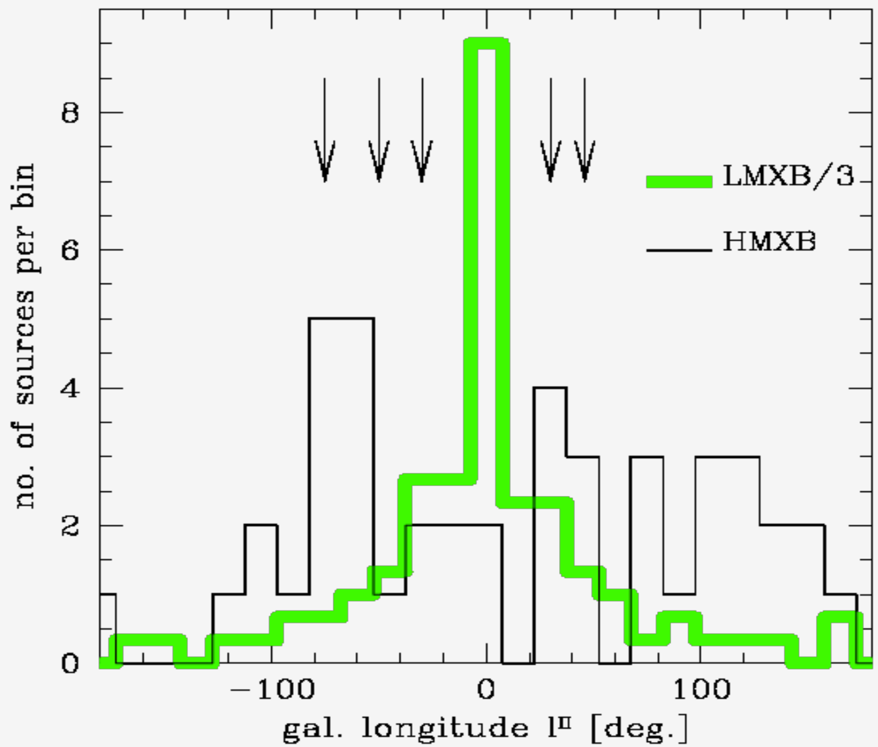
This is the reason of absence of faint LMXBs

Simulated LMXBs in the Galactic bulge

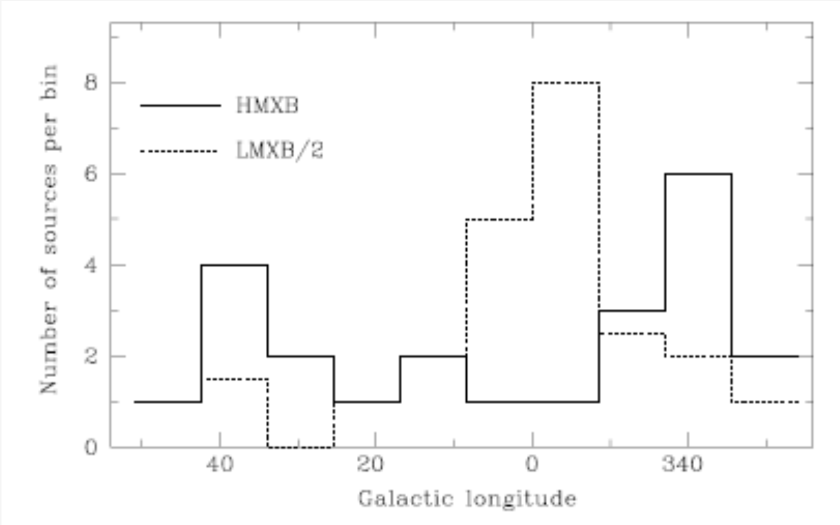
(sensitivity 10-13 erg/s/cm^2, no absorption)



HMXBs are concentrated to star formation regions



Grimm et al. (2002)

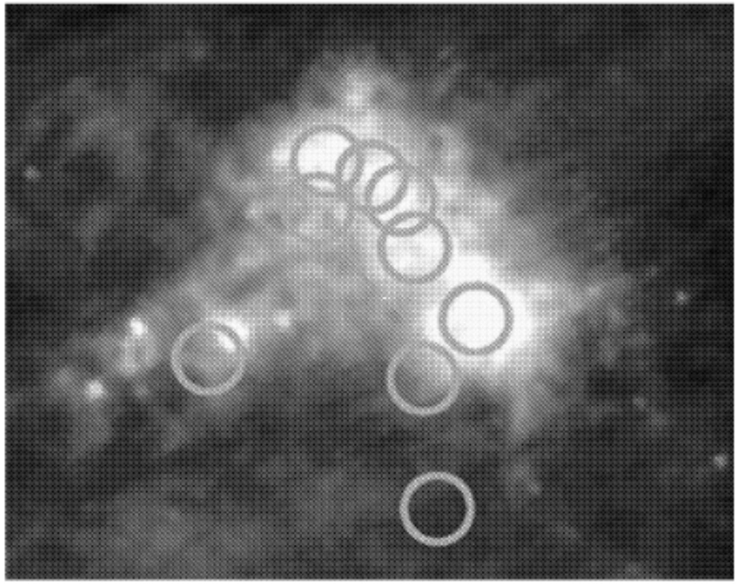


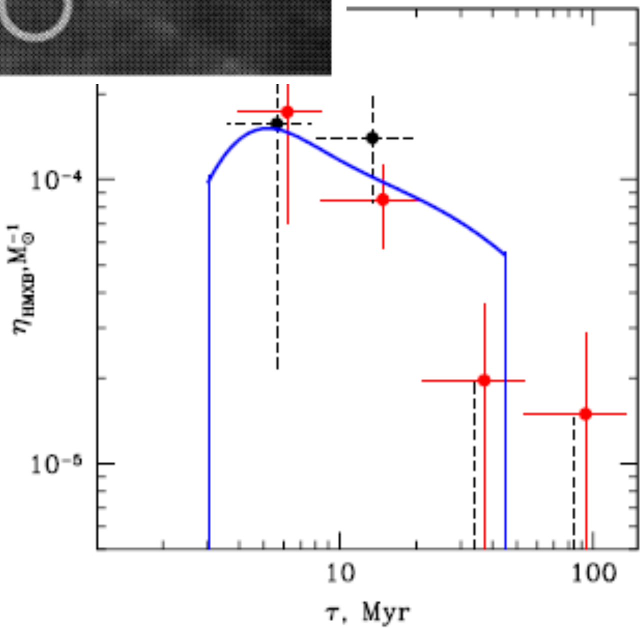
Lutovinov et al. 2005

Dynamical age of HMXBs?

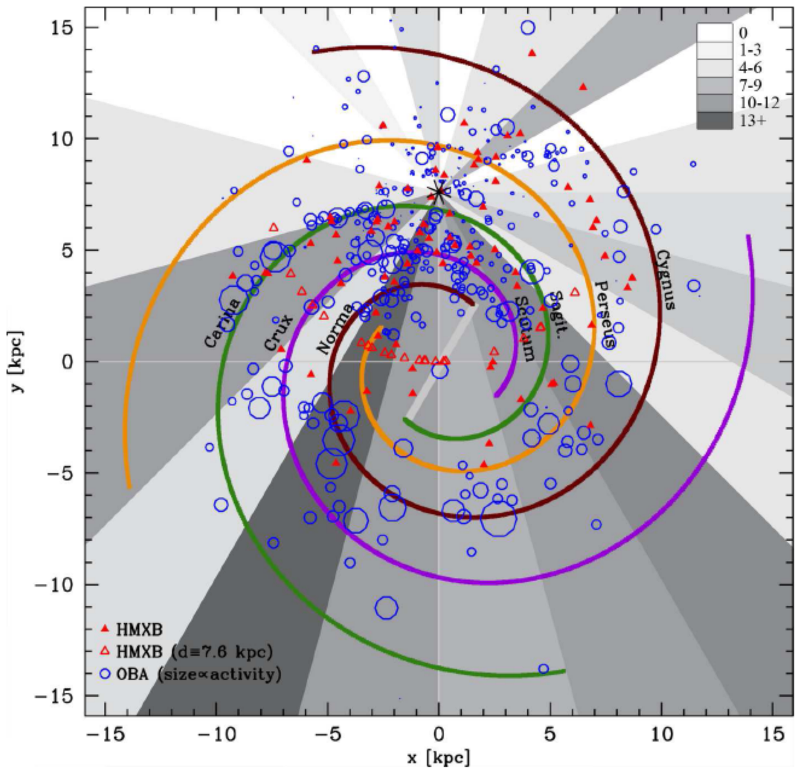
HMXB – starforming regions connection

HMXB – OB complexes clustering:



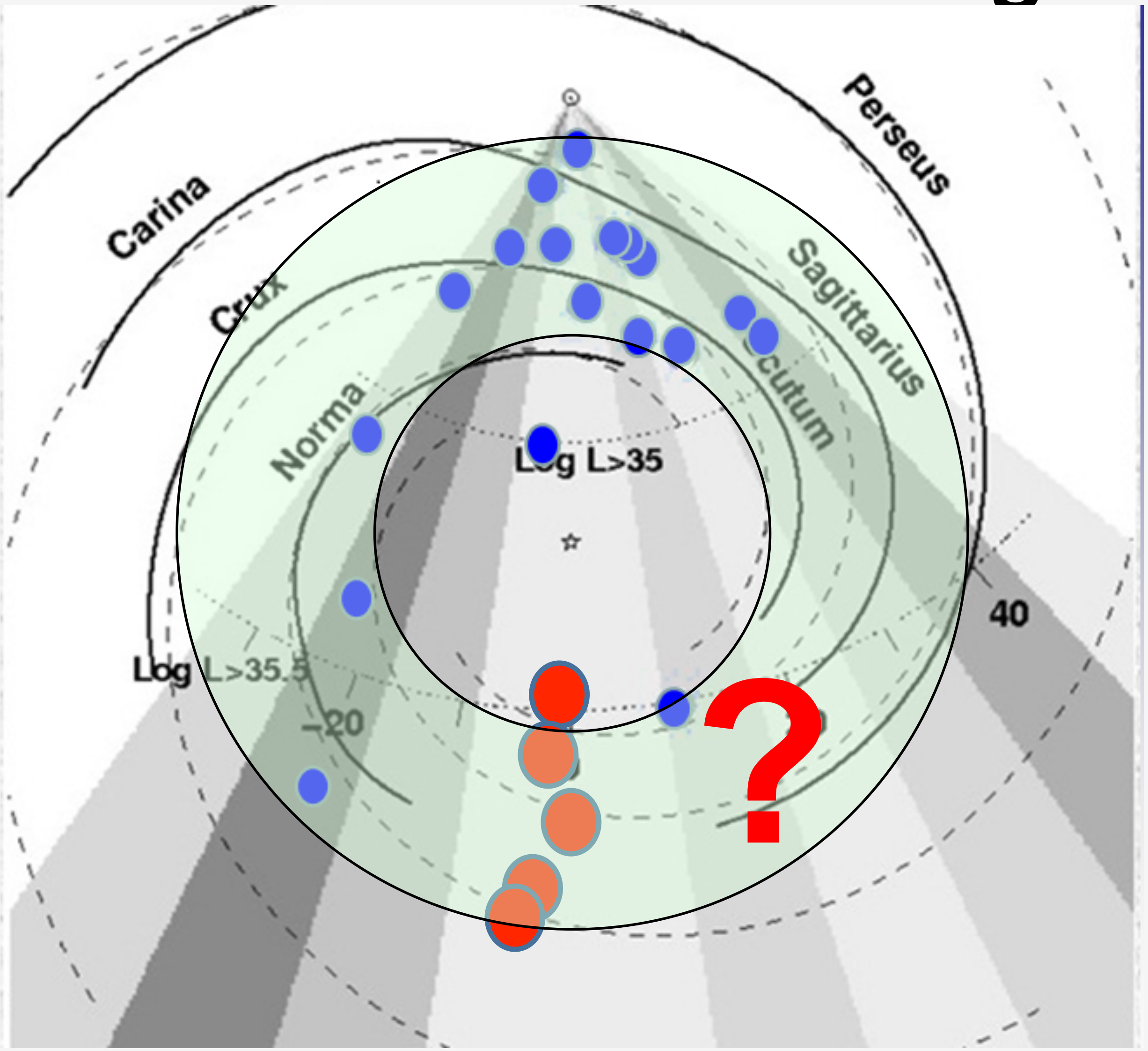


Shtykovskiy
Gilfanov
2005, 2007



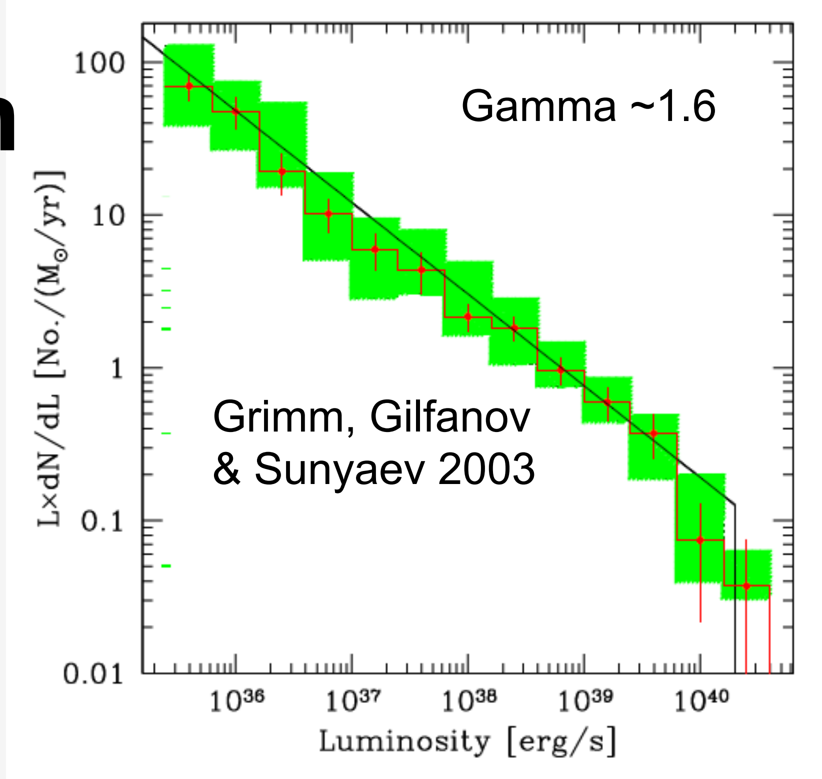
Bodaghee et al. 2011

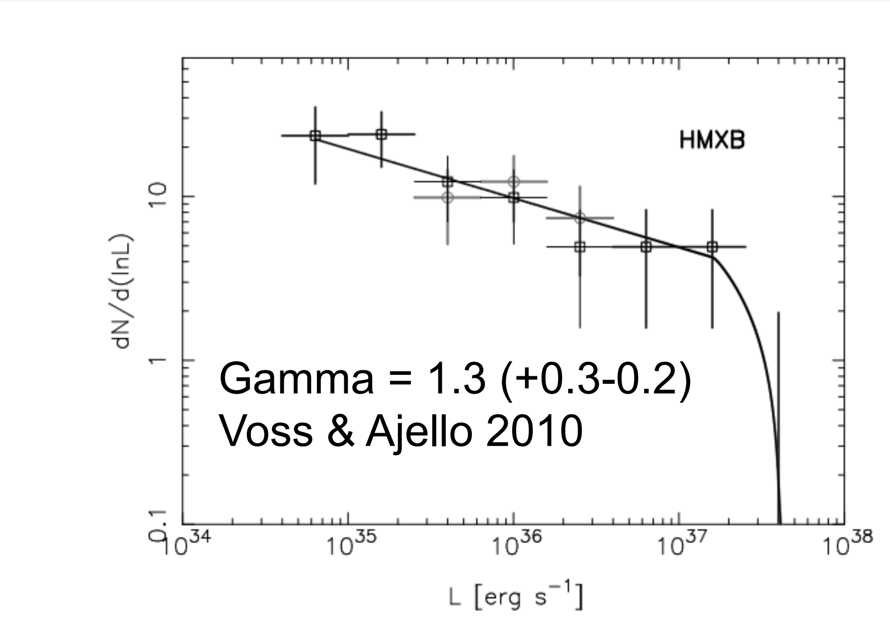
Hole in the Galactic bulge?
Absence of SF in the bulge?

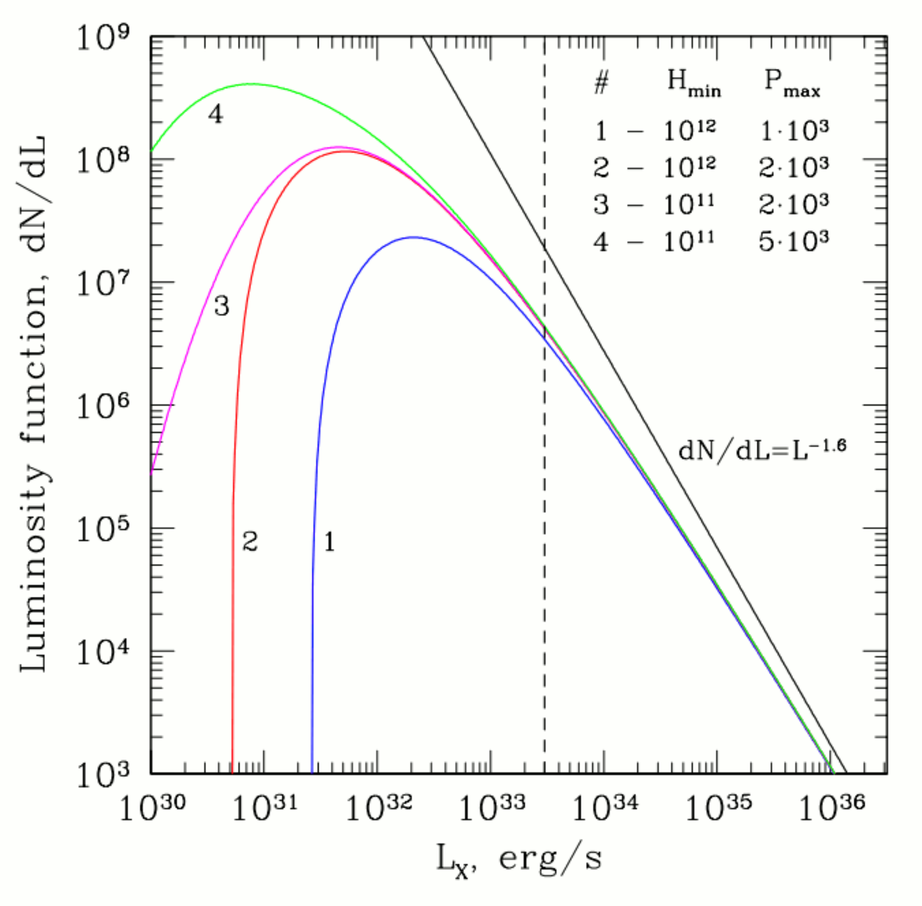


Lutovinov et al. (2011, prepared for publication)

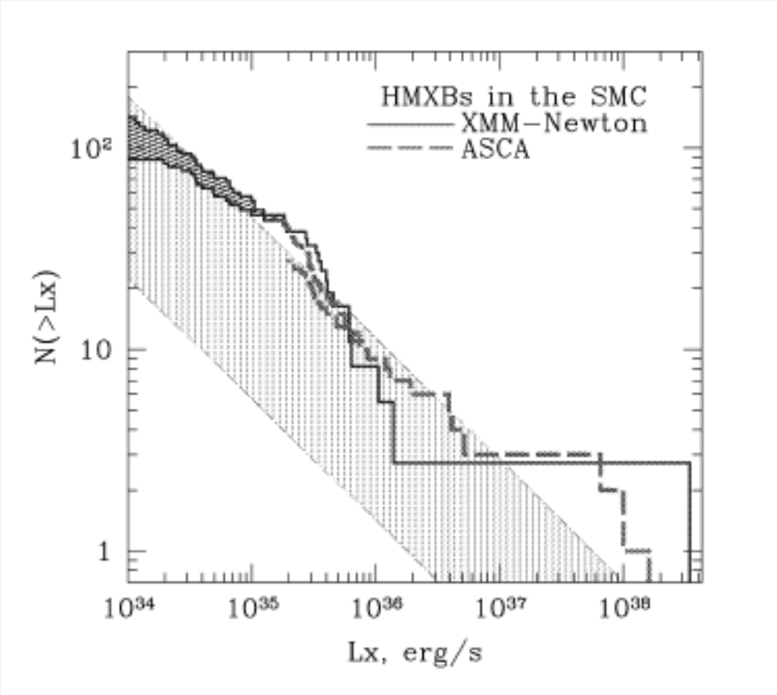
Luminosity function of HMXBs in the Galaxy





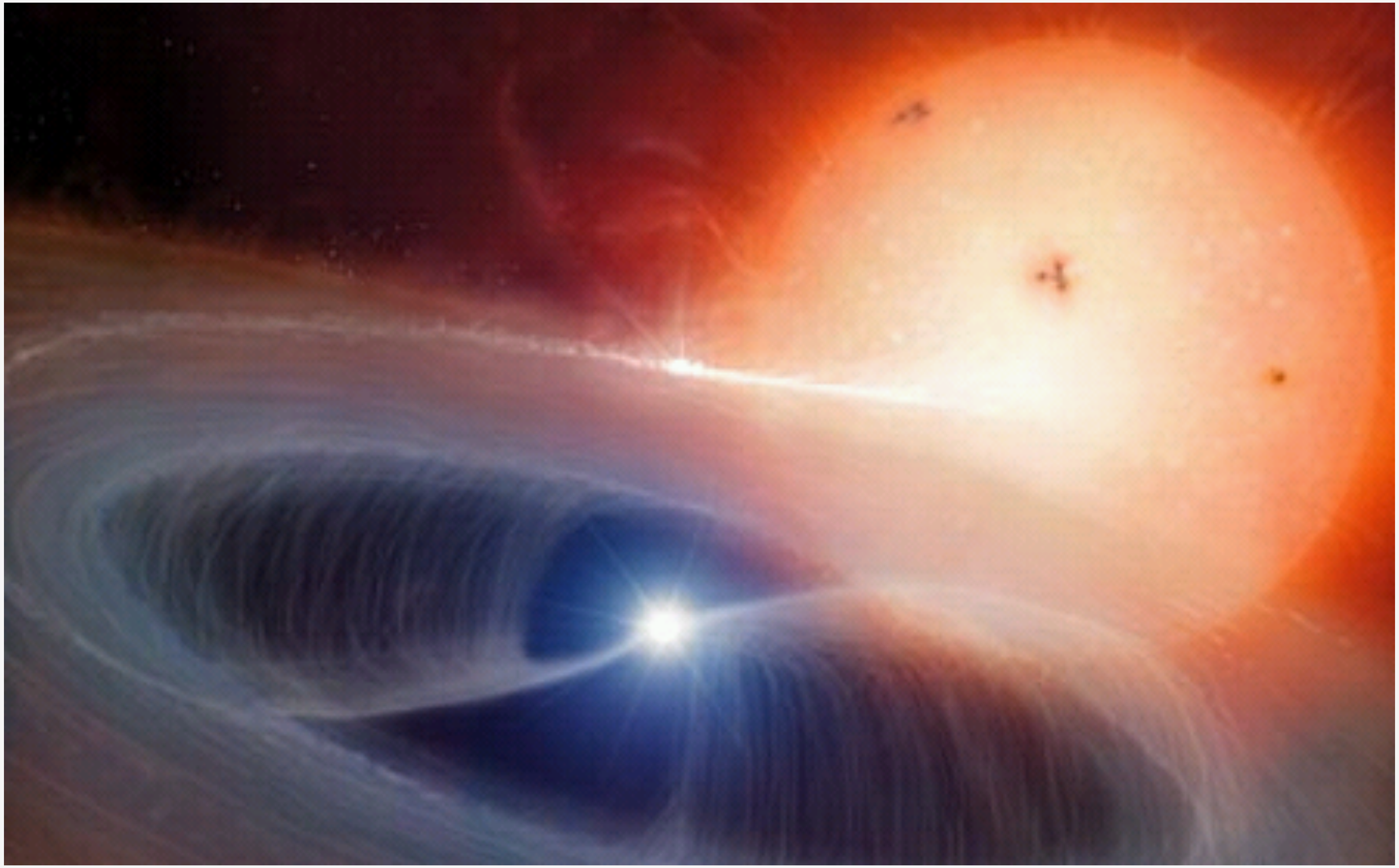


Shtykovskiy, Gilfanov 2005



Propeller effect?
Magnetic field in young NSs?

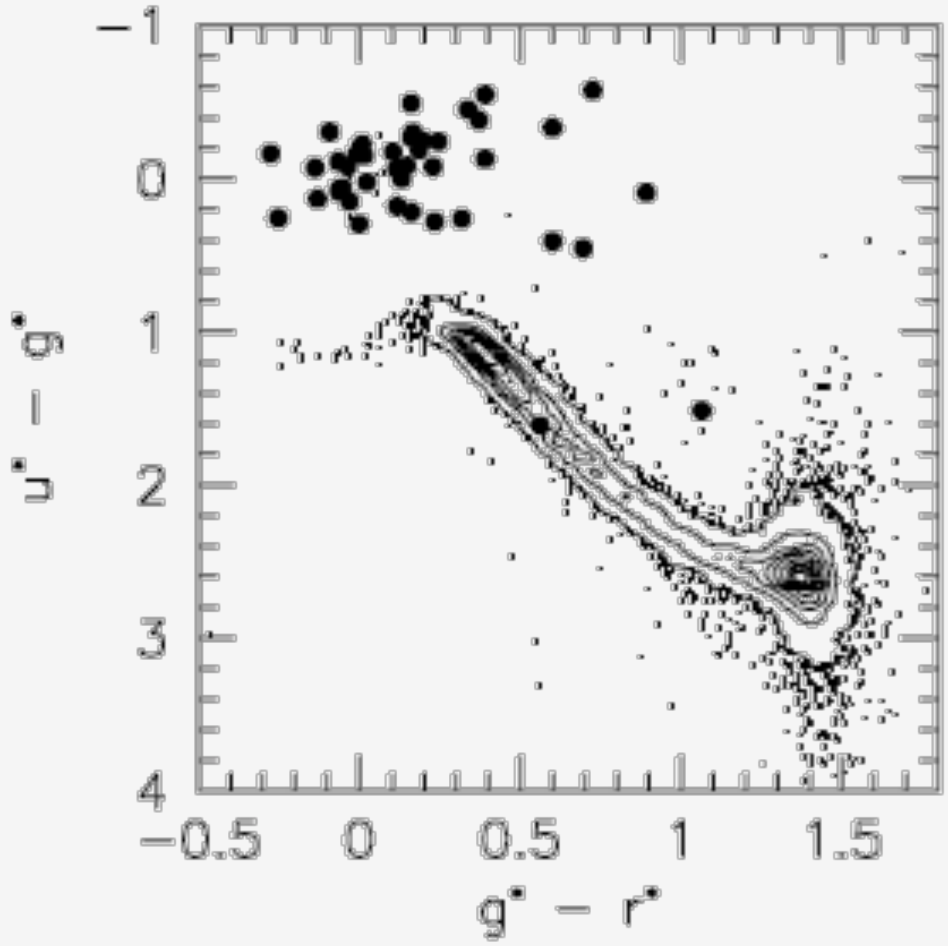
Cataclysmic variables



Counting CVs in the Galaxy is a complicated problem: biases

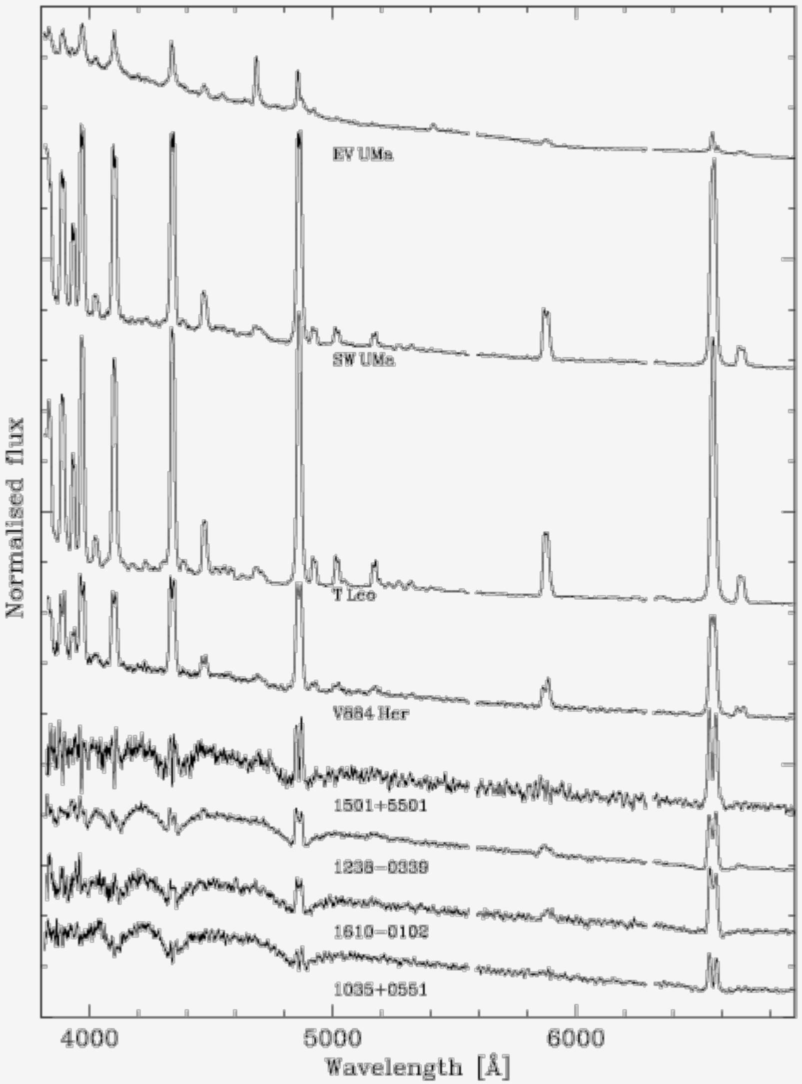
Typical CV discovery:
1)Dwarf nova outbursts,
2)classical nova
3)UV color excess
…………

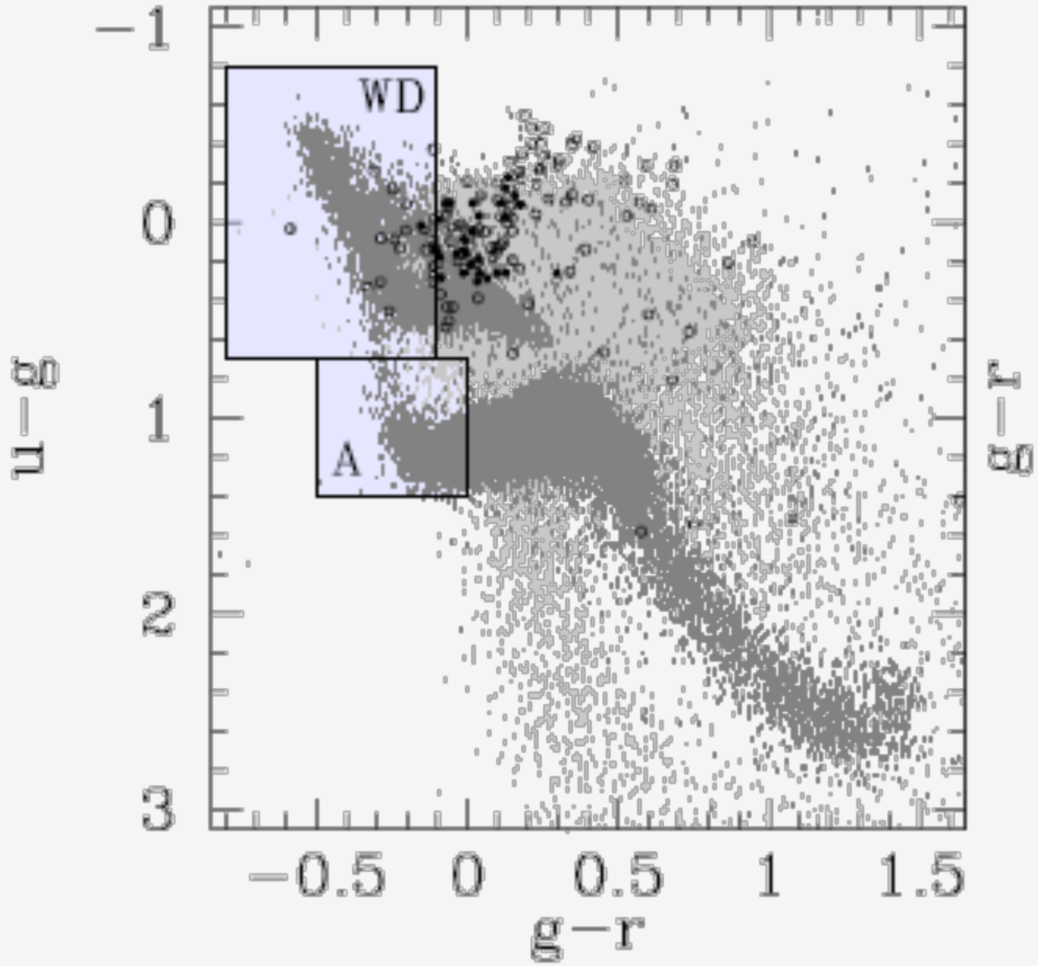
One of the latest results:usage of wide uniform surveys of the sky - SDSS



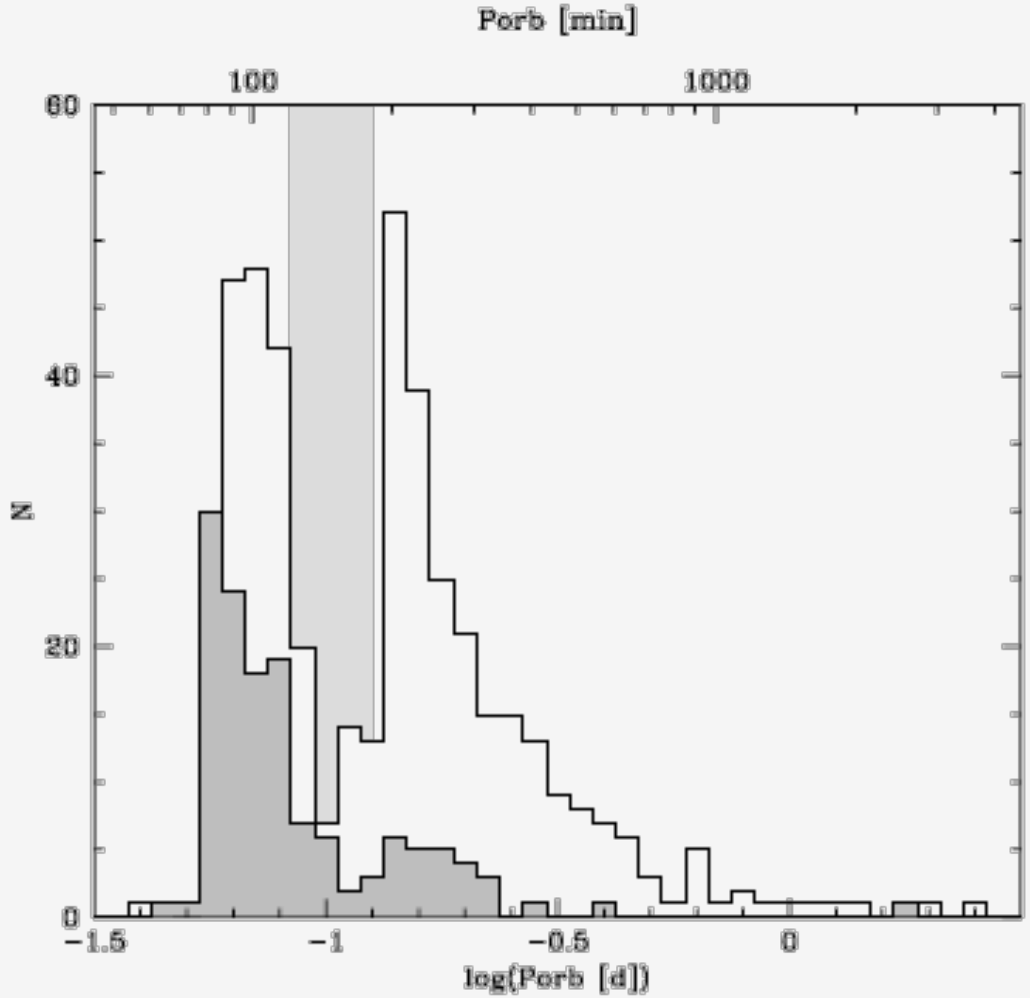
Szkody et al. 2003

Optical selection of CVs

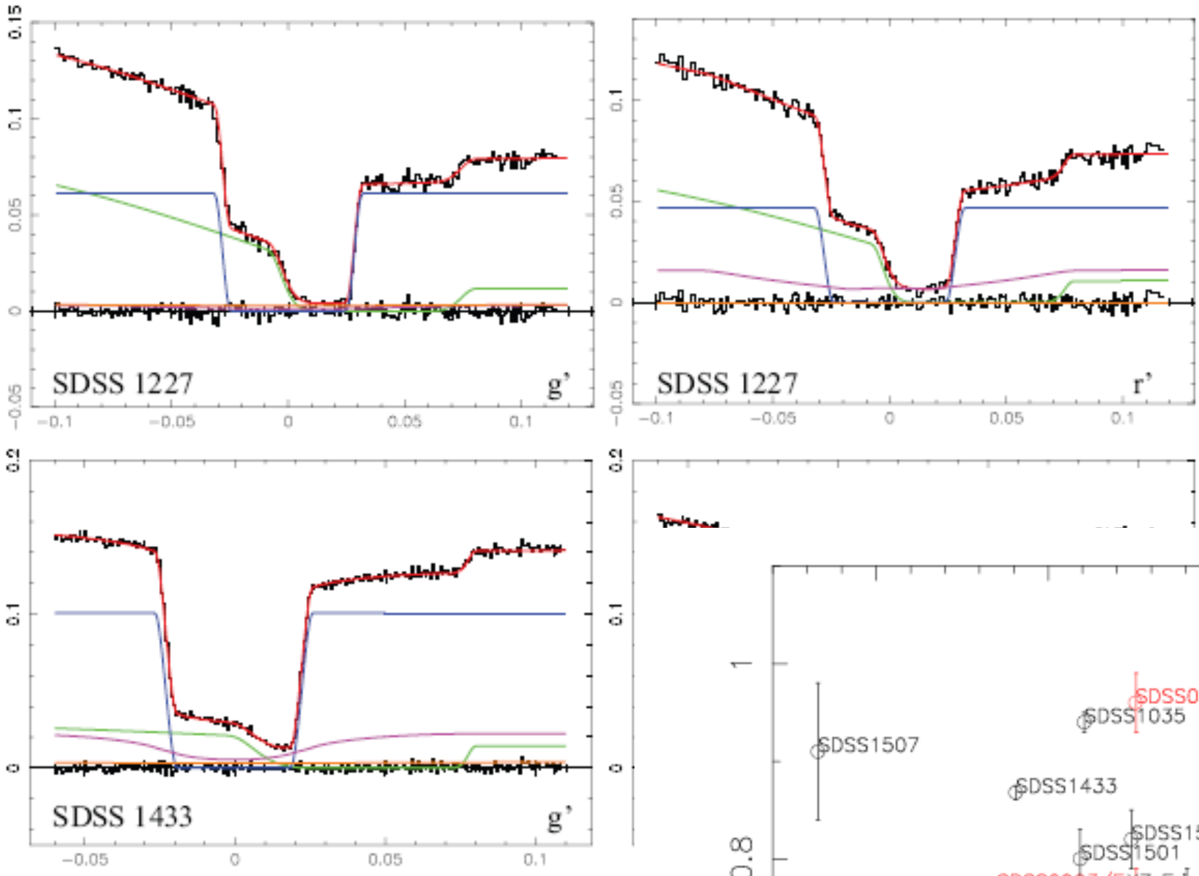




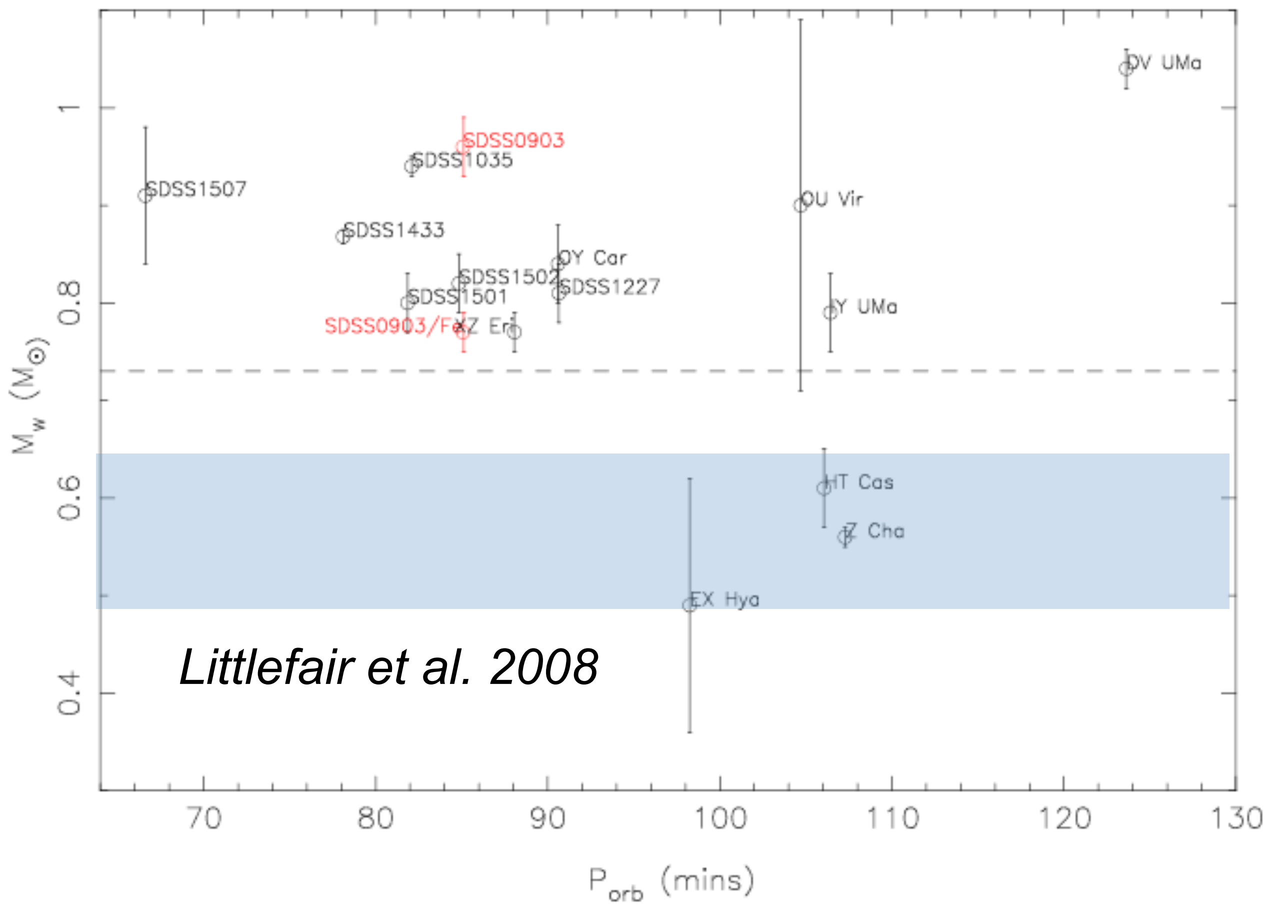
Even this simple attempt to have less biased search revealed a completely different CV population



Gansicke et al. 2009



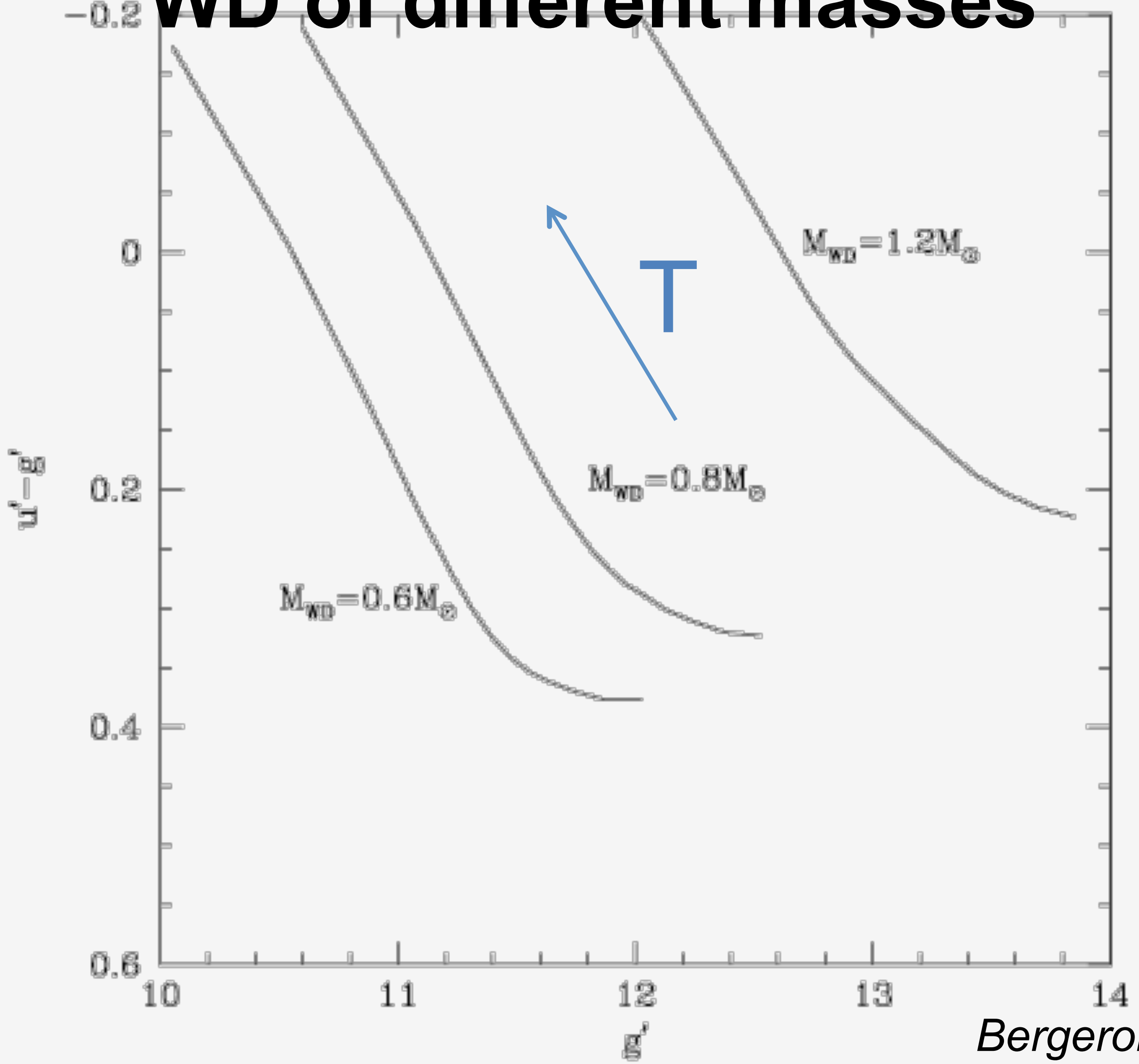
Low Mdot CVs accumulate mass in a long run? No WD erosion?



Littlefair et al. 2008

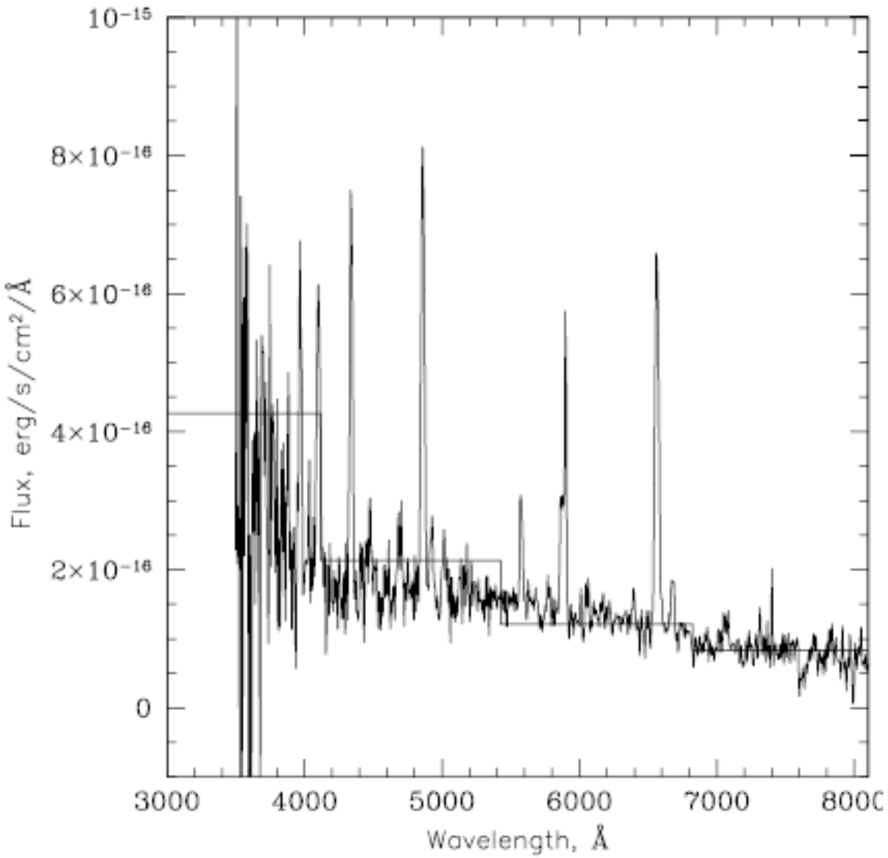
We need bias-free surveys!

Colors and brightnesses of WD of different masses

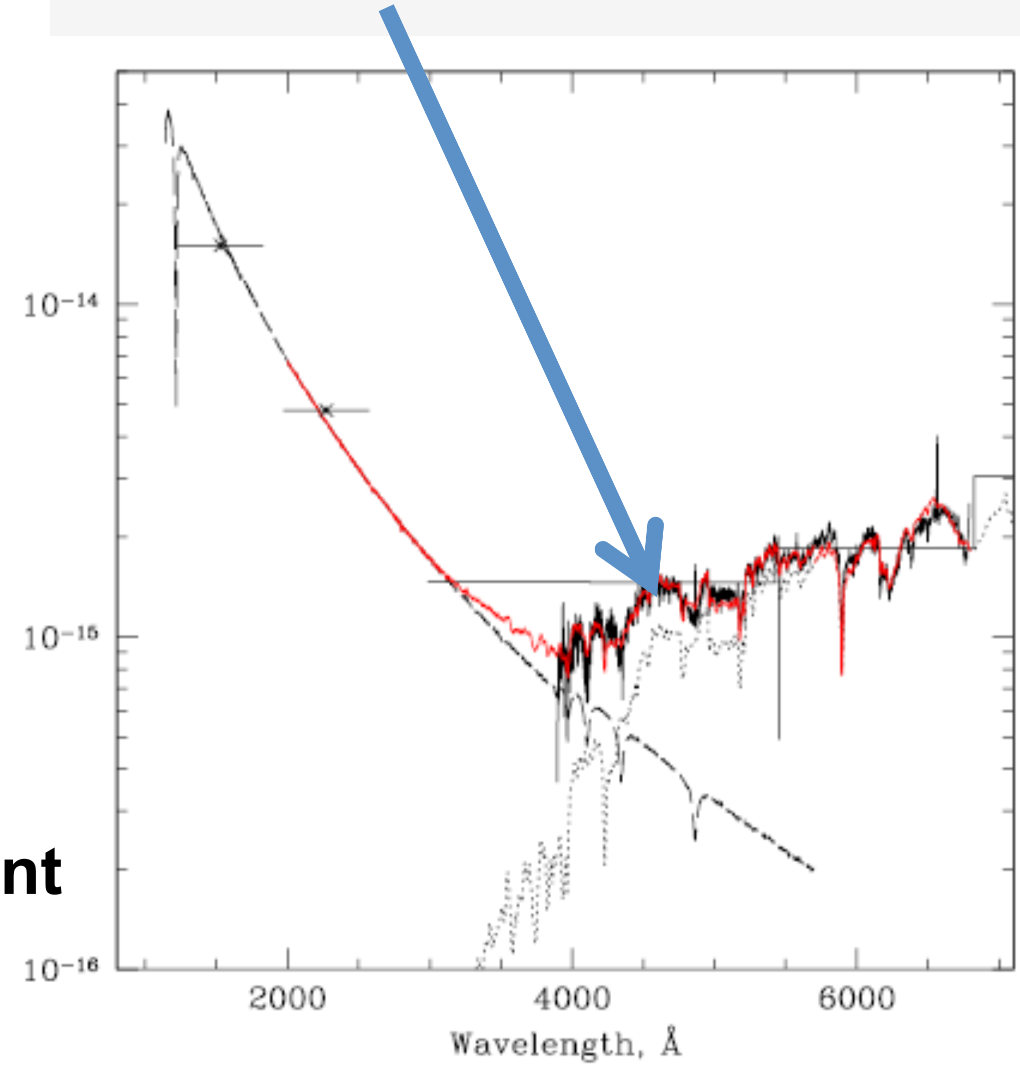


Bergeron et al. 1995

Bias toward lower masses WDs?

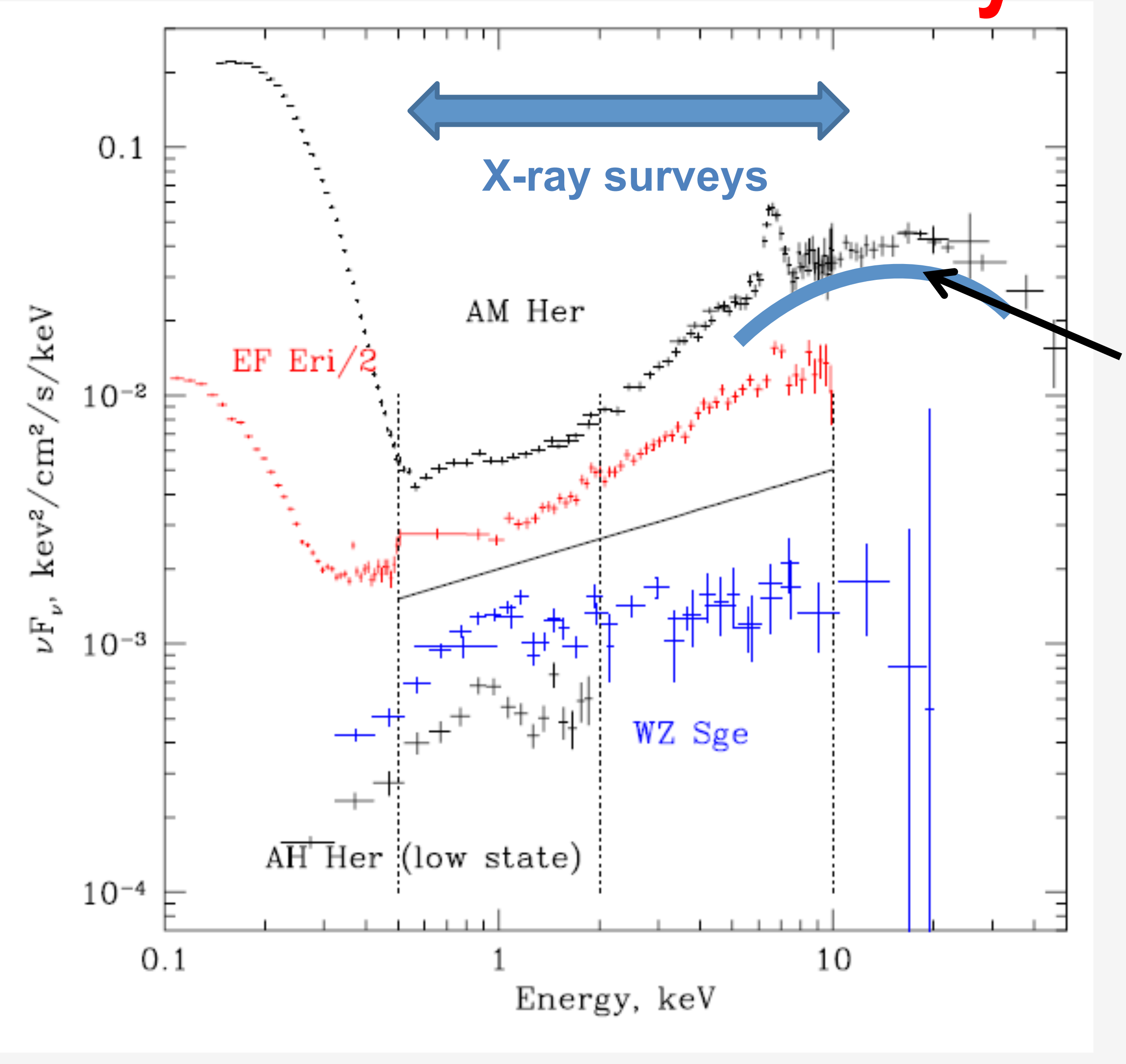


This CV have properties on a boundary of the selection box



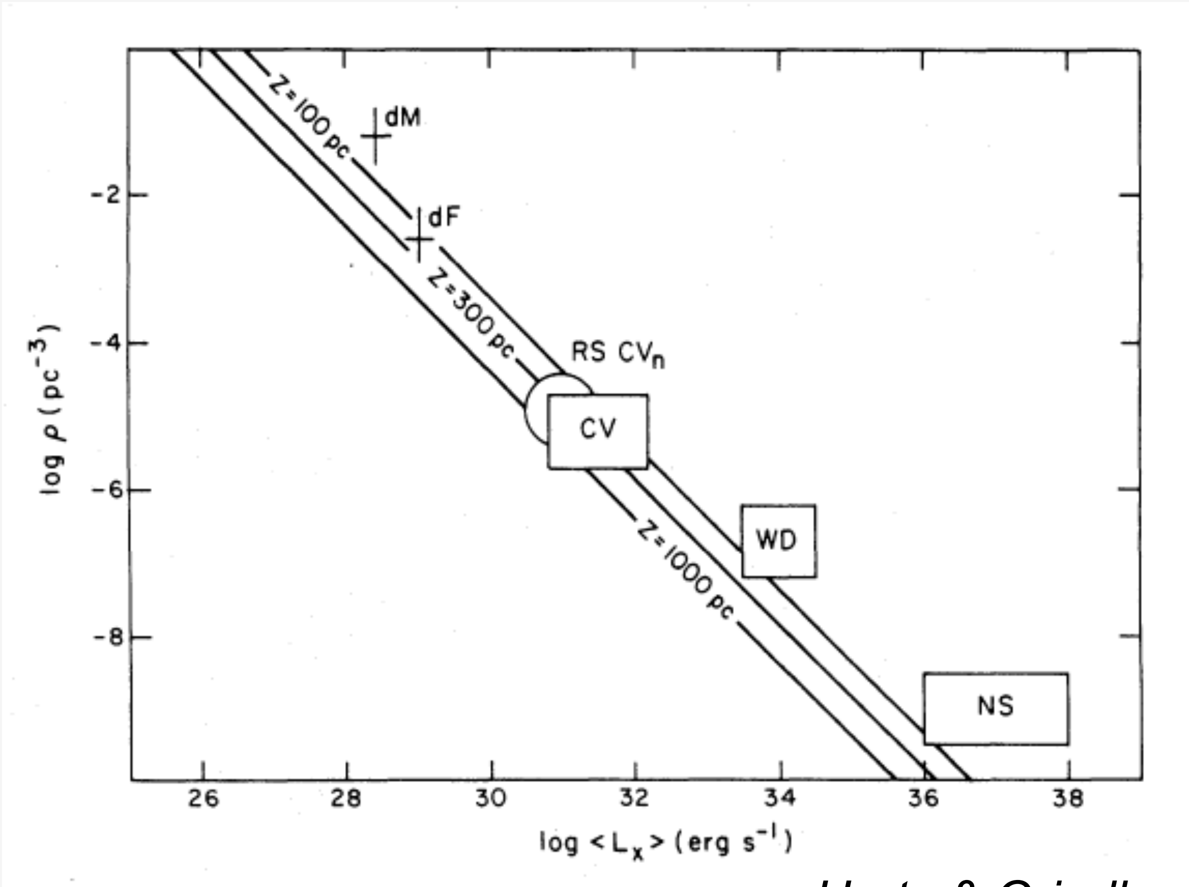
A bit more mass of WD
-> fainter the blue component
-> CV will be missed

CVs in X-rays



Depends on mass of WD and B-field

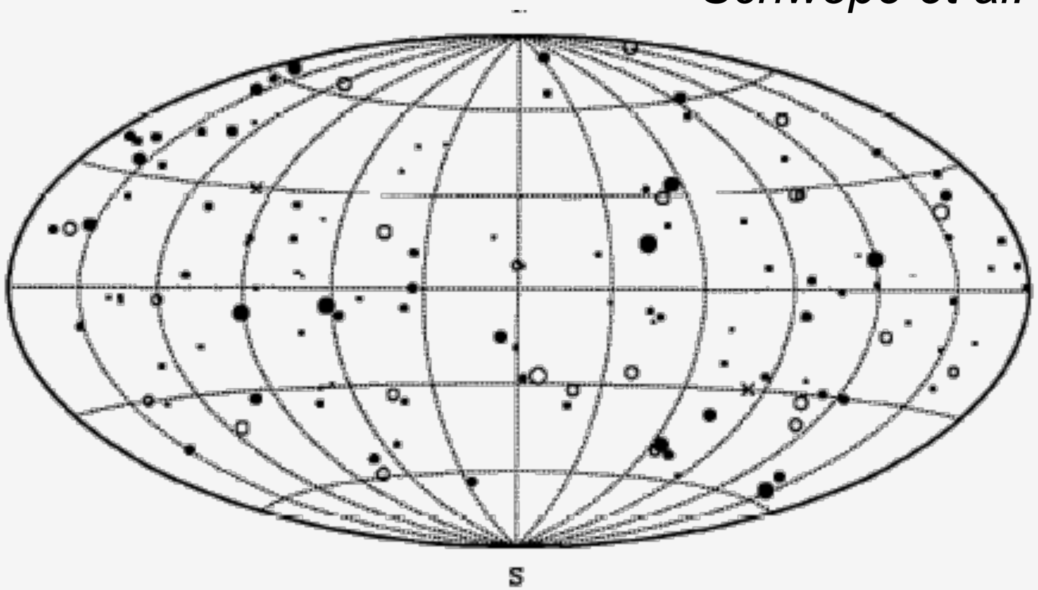
One of the first surveys of CVs in X-rays– EINSTEIN observatory

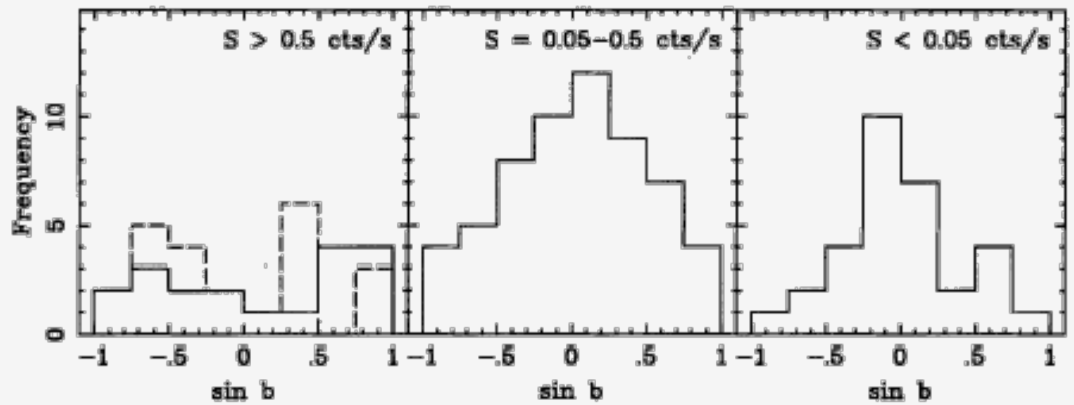


Hertz & Grindlay 1984

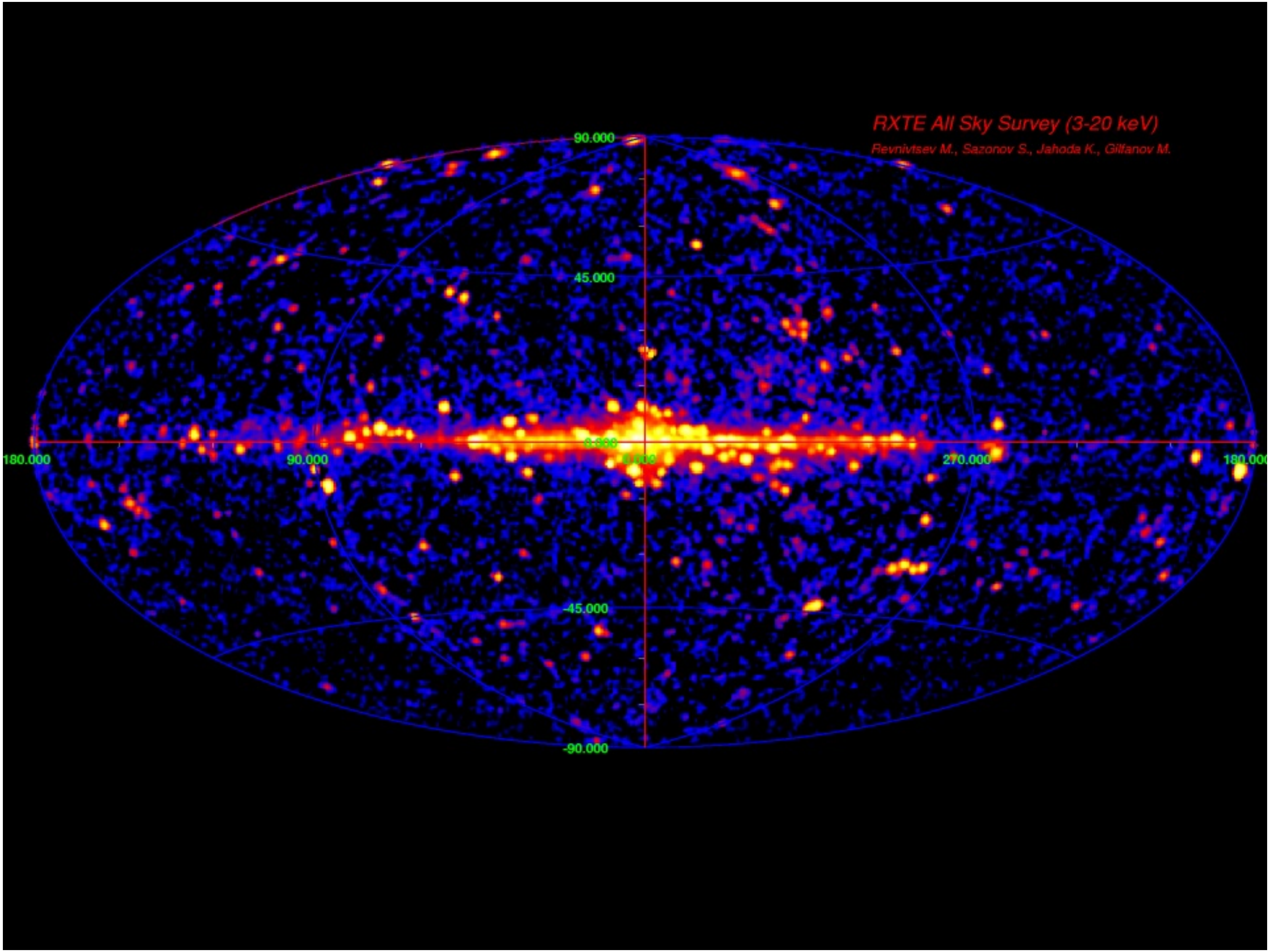
Beuermann & Thomas 1993

Schwope et al. 2002

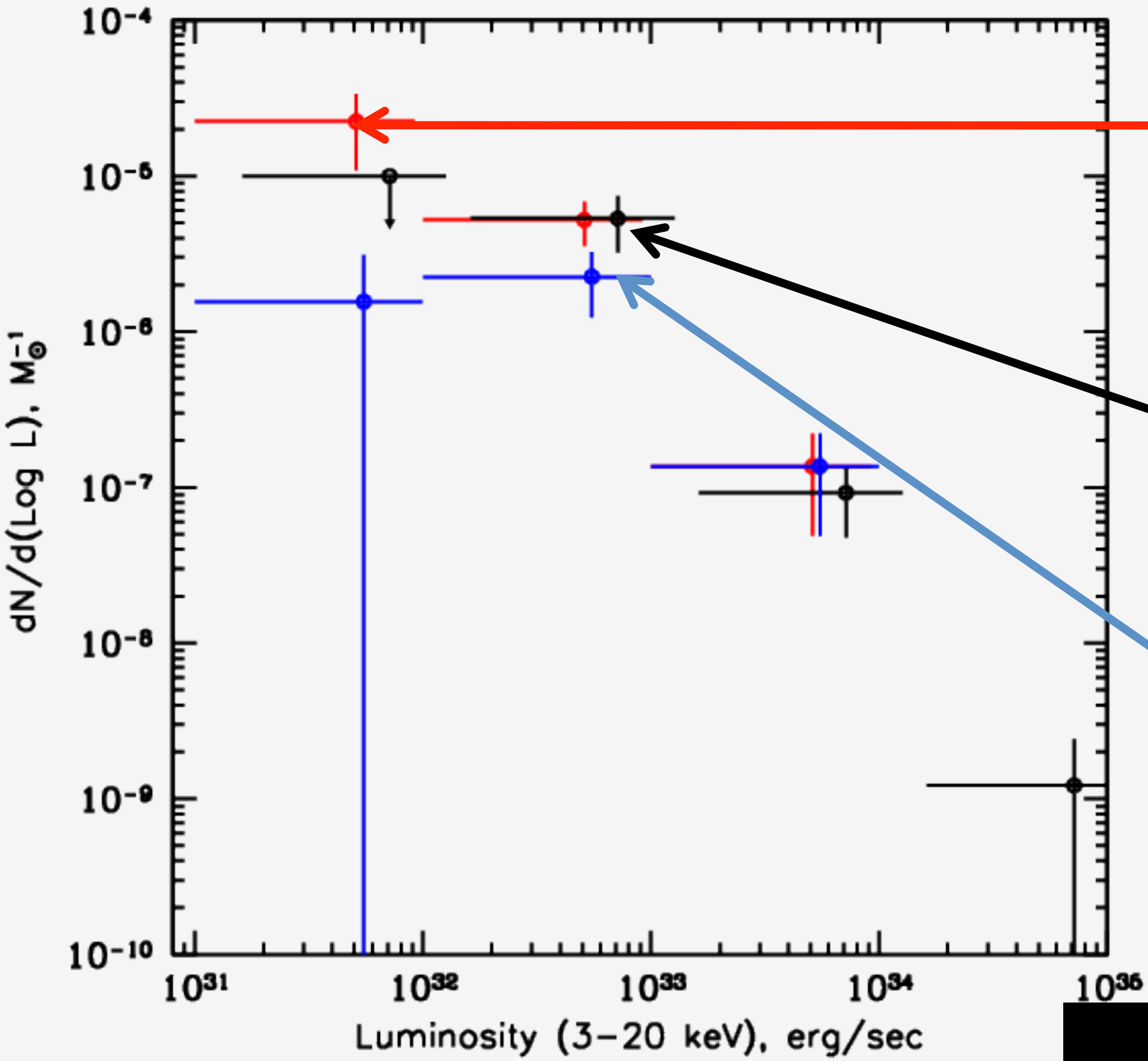




CVs from ROSAT all sky survey


RXTE All Sky Survey (3-20 keV)
Revnivtsev M., Sazonov S., Jahoda K., Gilfanov M.
90.000
45.000
0.000
0.000
-45.000
-90.000
180.000
90.000
270.000
180.000

Revnivtsev et al. 2008

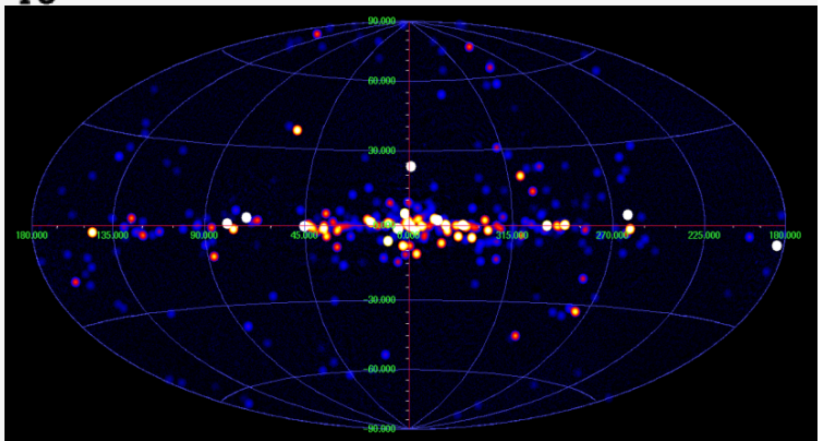


RXTE (all CVs)

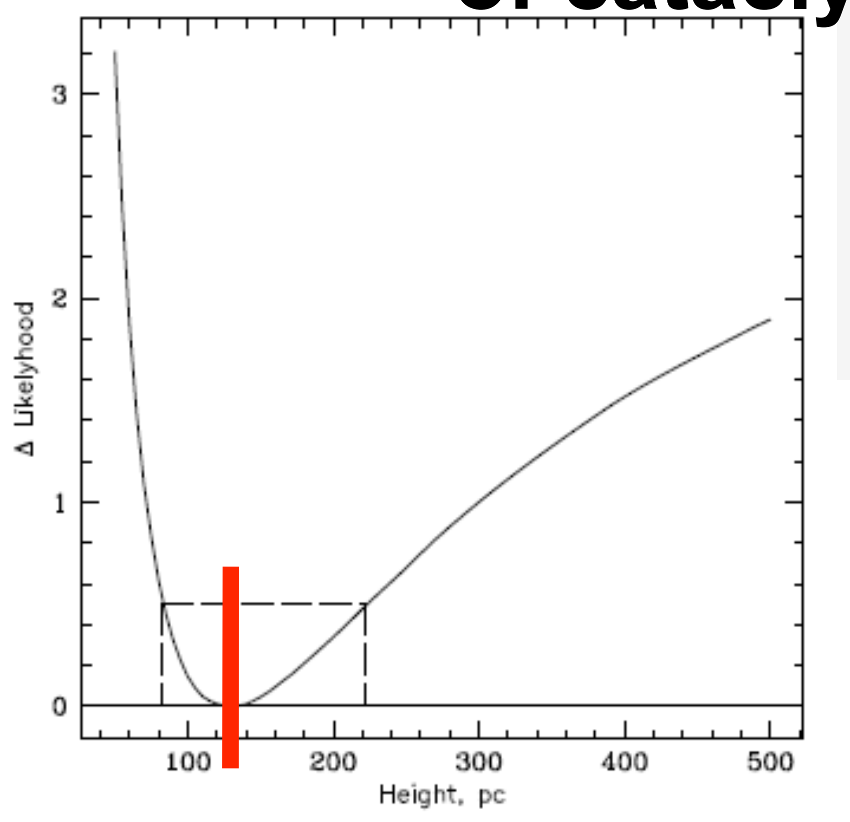
INTEGRAL

RXTE (IPs)

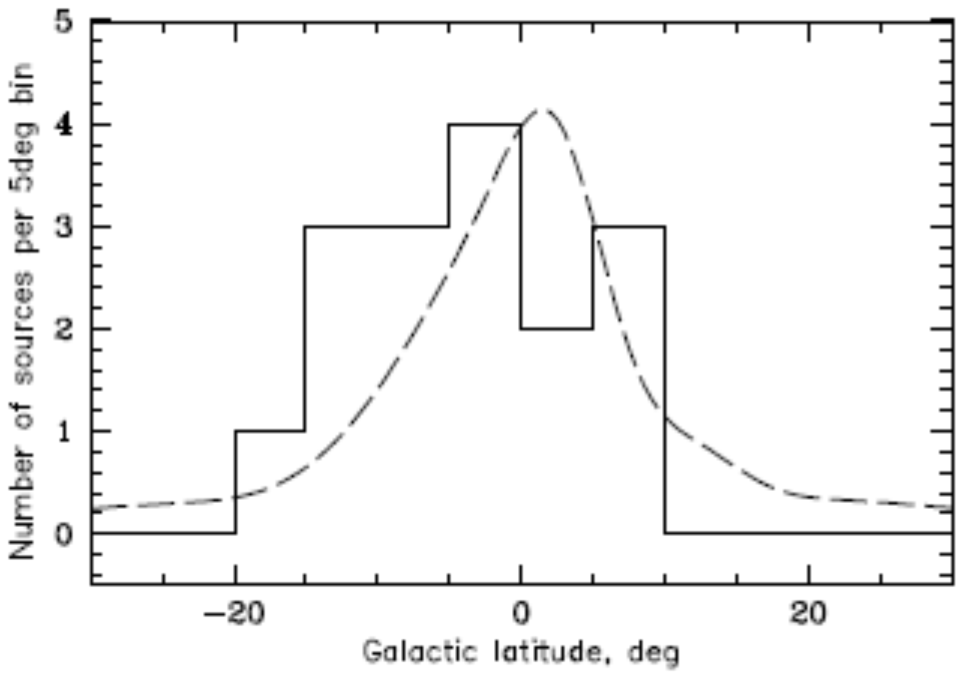
INTEGRAL
All sky survey



All sky survey – spatial distribution of cataclysmic variables



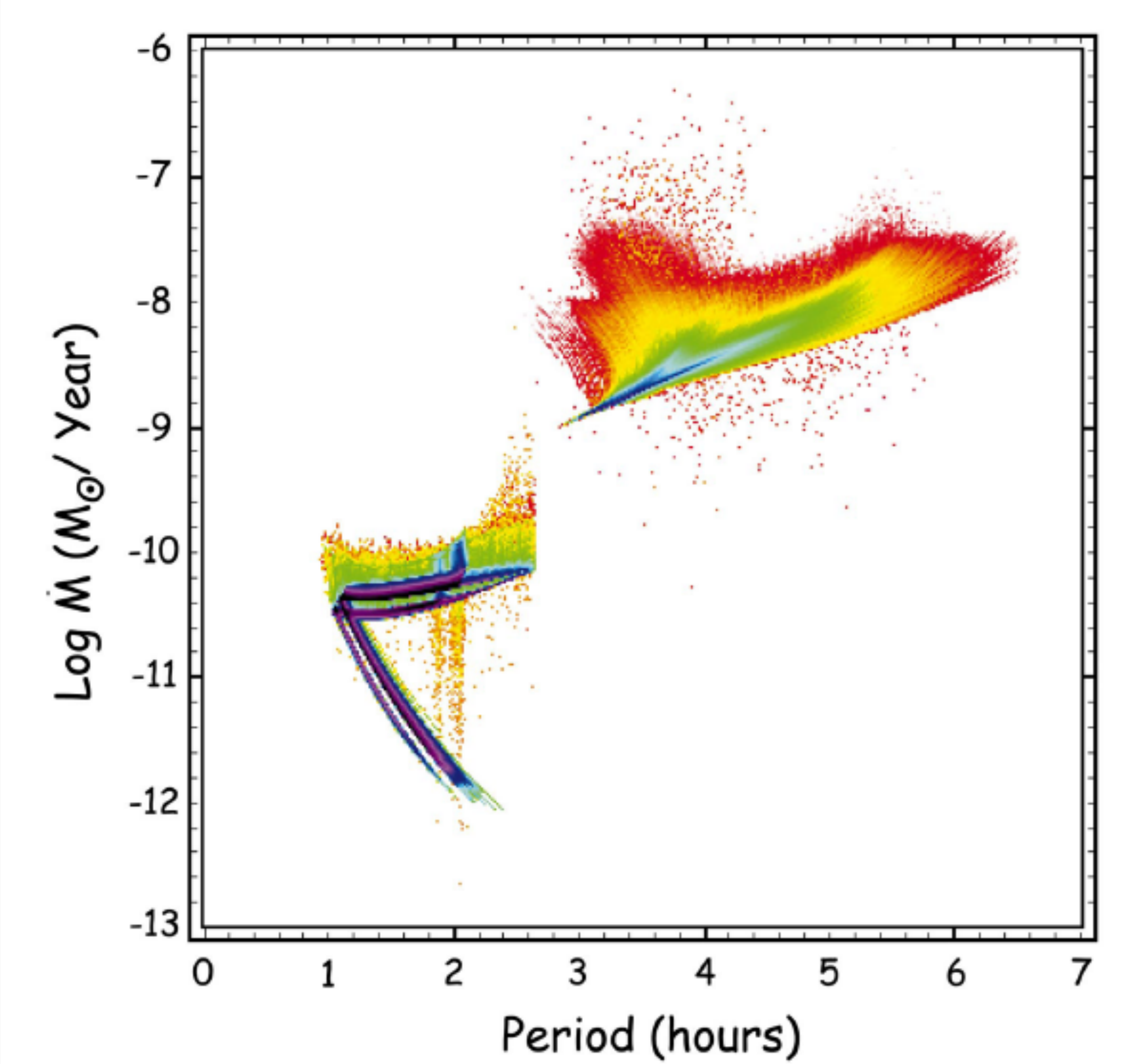
Post bounce (older?) systems wider spreaded?



h~130 pc

Revnivtsev et al. 2008

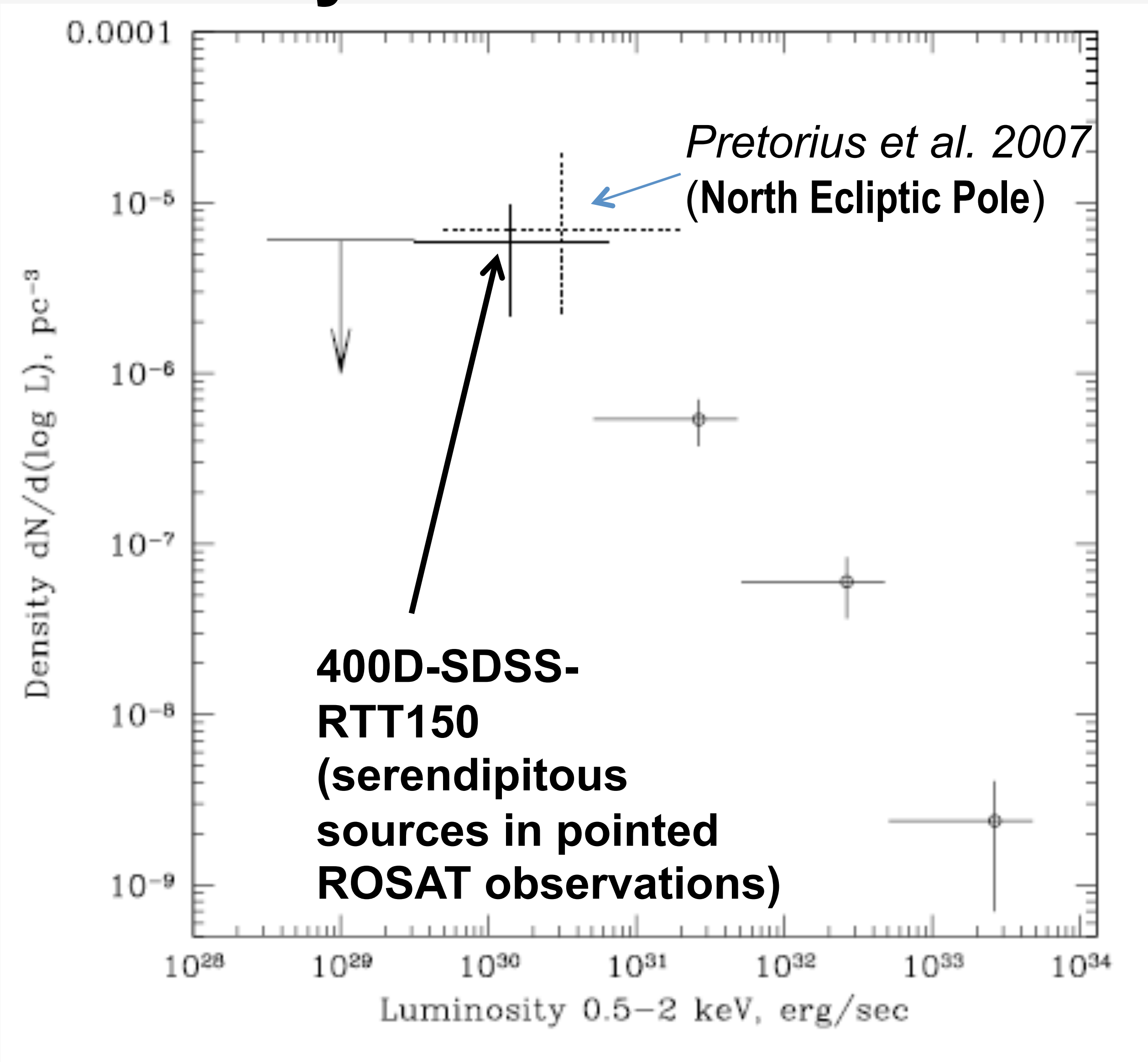
Numerical modeling of cataclysmic variables



Howell et al. 2001

… at faint luminosities

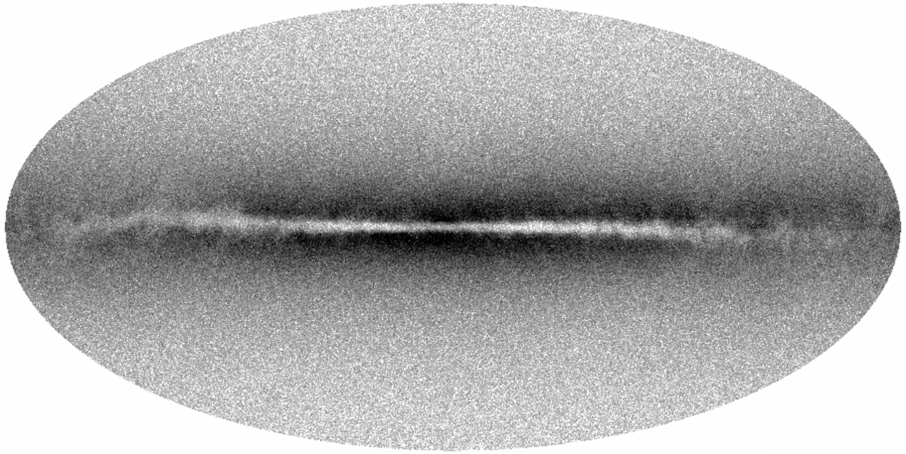
Survey 400D-SDSS-RTT150



Revnivtsev, Burenin et al. 2011

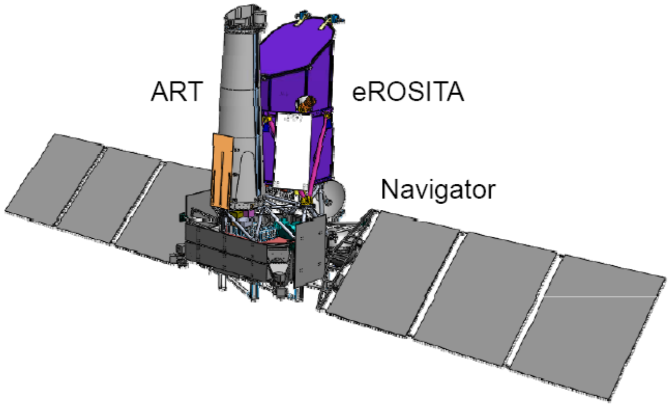
For populations studies – future X-ray surveys

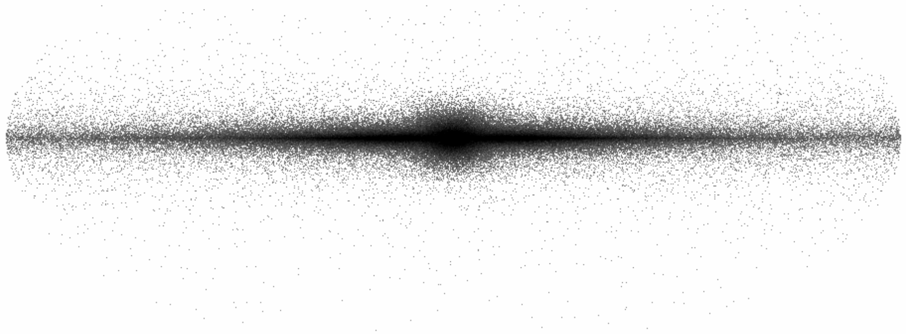
Spectrum-XG (eROSITA+ART)



Stars - millions

CVs – 100 000 -500 000





Summary:

Studies of populations provide us handles on:

1. formation of binaries
2. on mechanisms of their long term evolution
3. On averaged properties of populations (compact objects magnetic fields, spatial distribution/kinematic age etc…

We should prepare the algorithms of identification of Galactic sources which will be discovered with Spectrum-XG/eROSITA survey