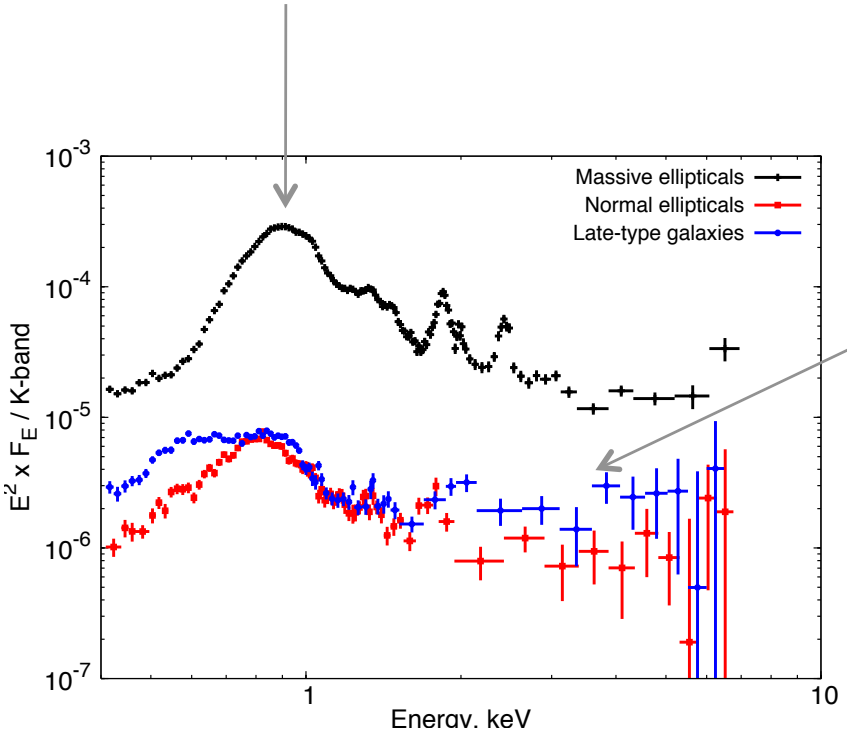
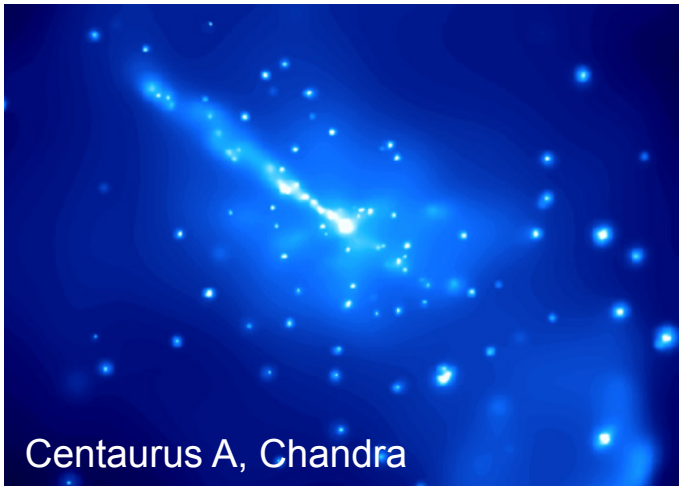
Normal galaxies and eRosita all-sky survey

Marat Gilfanov

X-ray emission from normal galaxies

- no AGN
- hot ISM



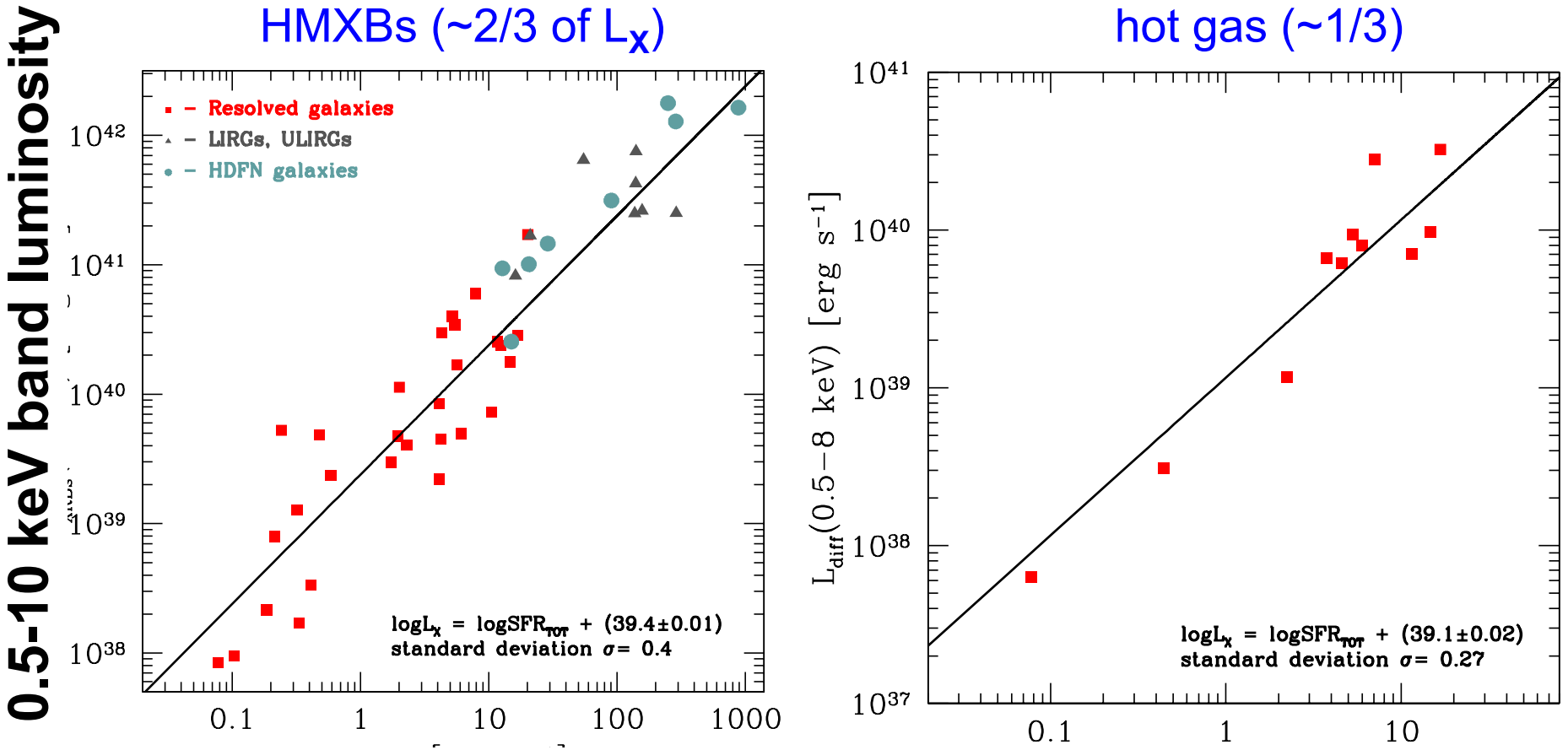


- X-ray binaries:
  - old galaxies – LMXBs
  - star-forming galaxies – HMXBs
- faint compact objects

Star-forming galaxies

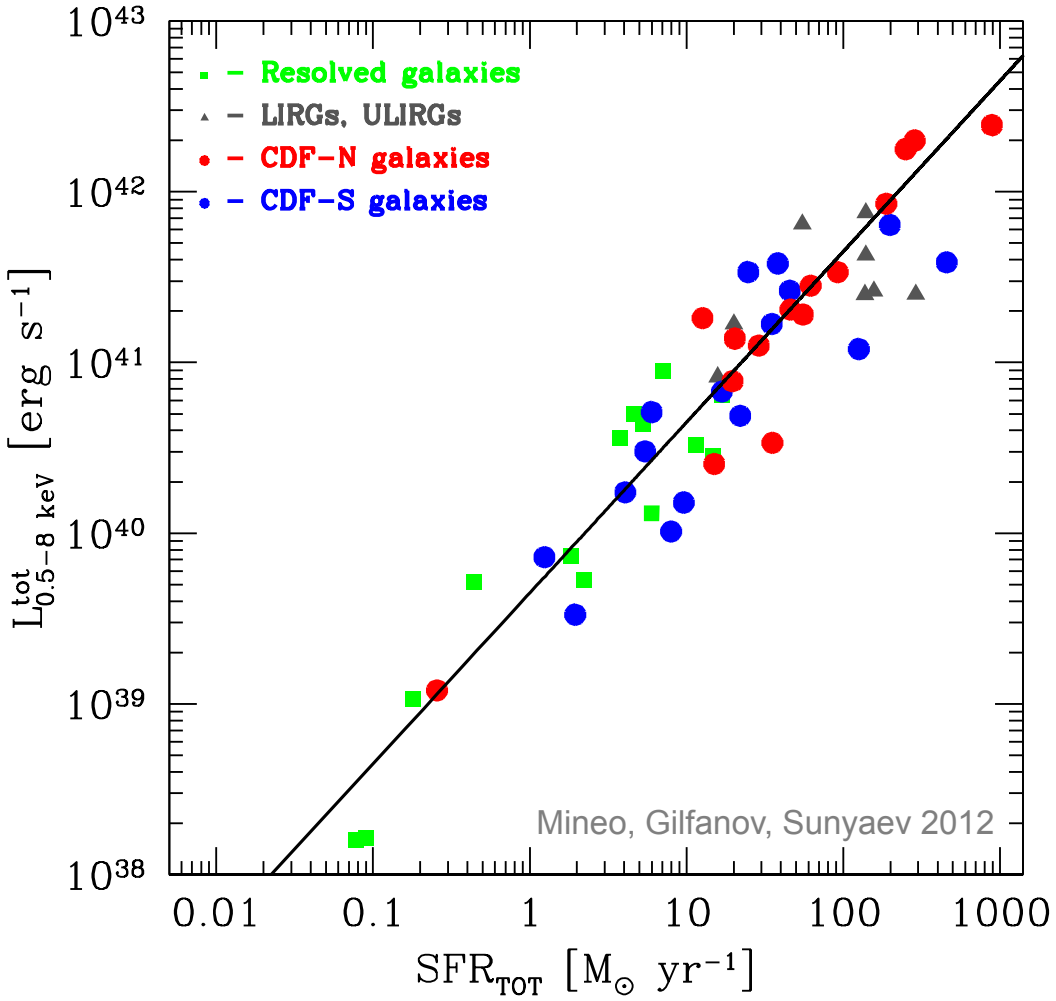
HMXBs (~2/3 of L_X)

hot gas (~1/3)



Grimm, Gilfanov, Sunyaev 2003
Mineo, Gilfanov, Sunyaev 2011, 2012

Star-forming galaxies – total Lx

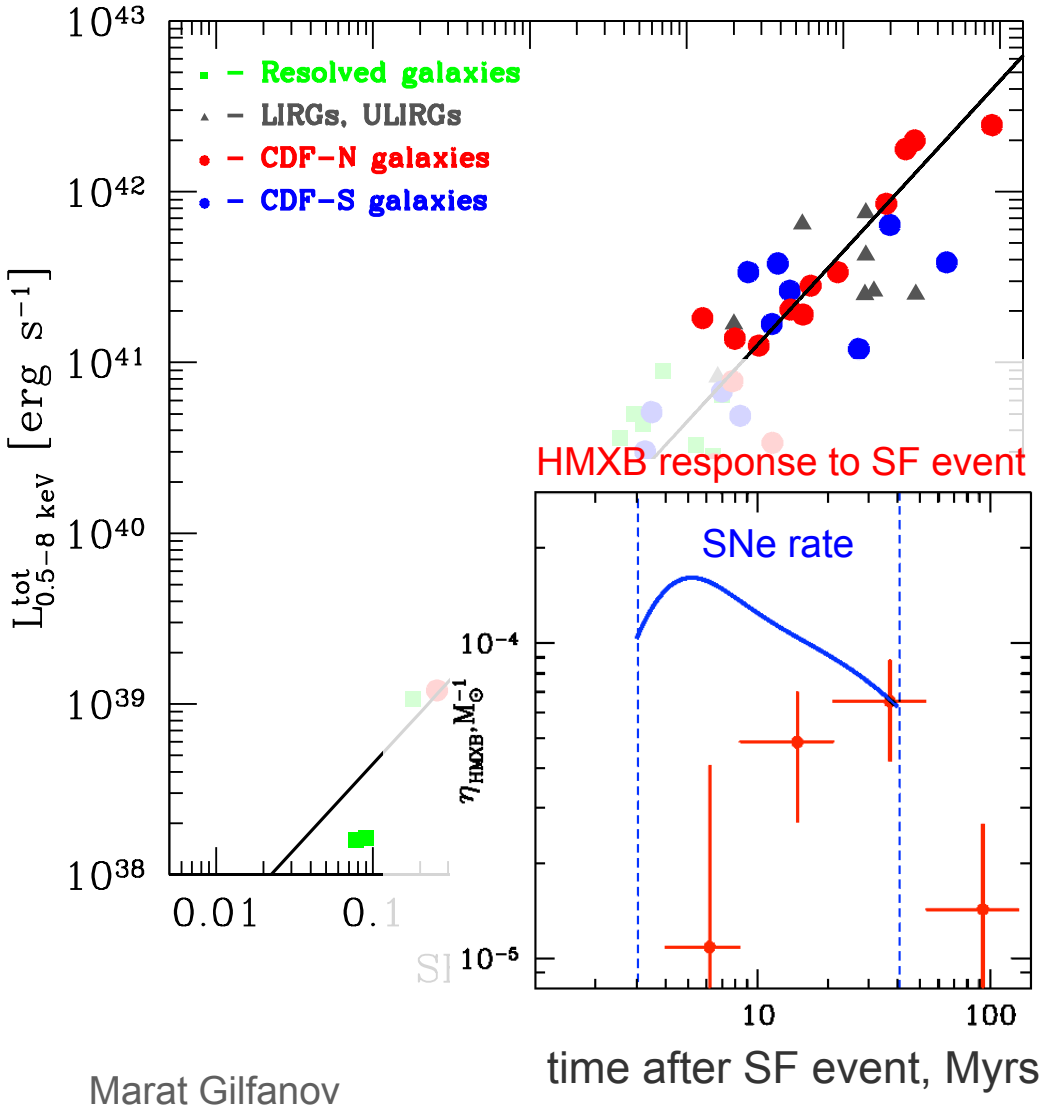


$$L_X \approx SFR \times 4 \cdot 10^{39}\ \text{erg/s}$$

redshift range z~0–1.3

rms~0.4 dex scatter is real
possible origin:
age, metal abundances ...

Star-forming galaxies – total Lx



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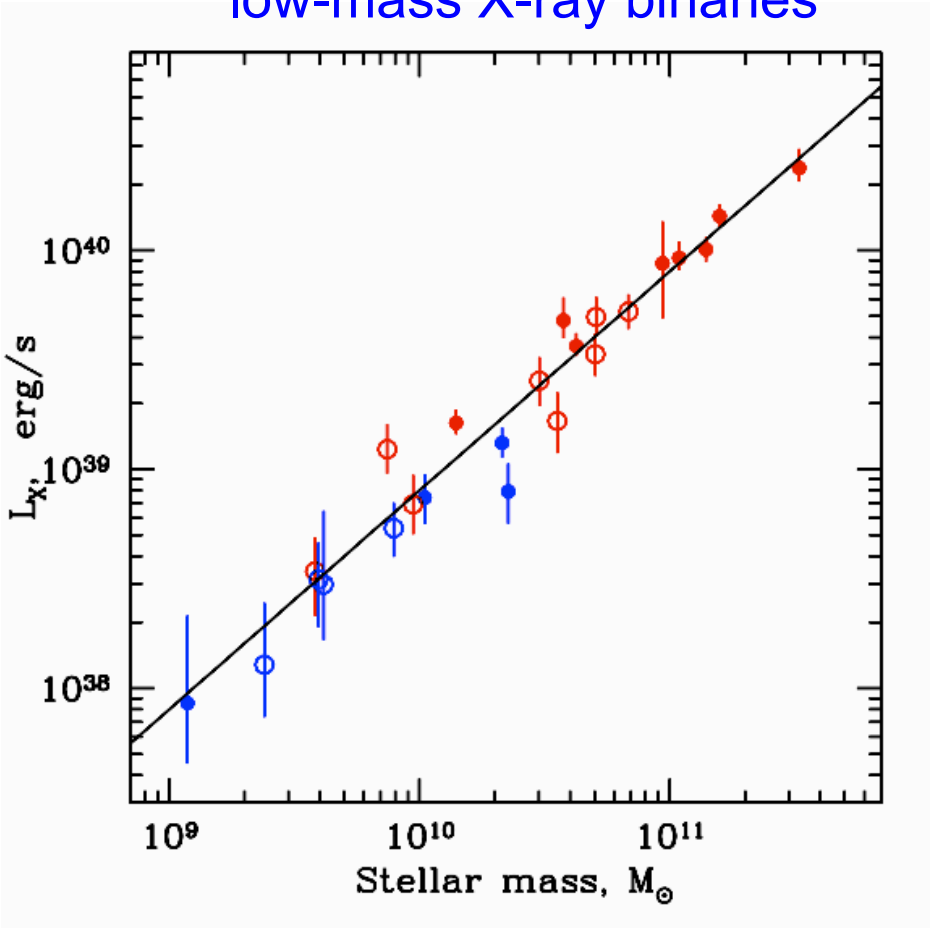
Shtykovsky & Gilfanov 2007

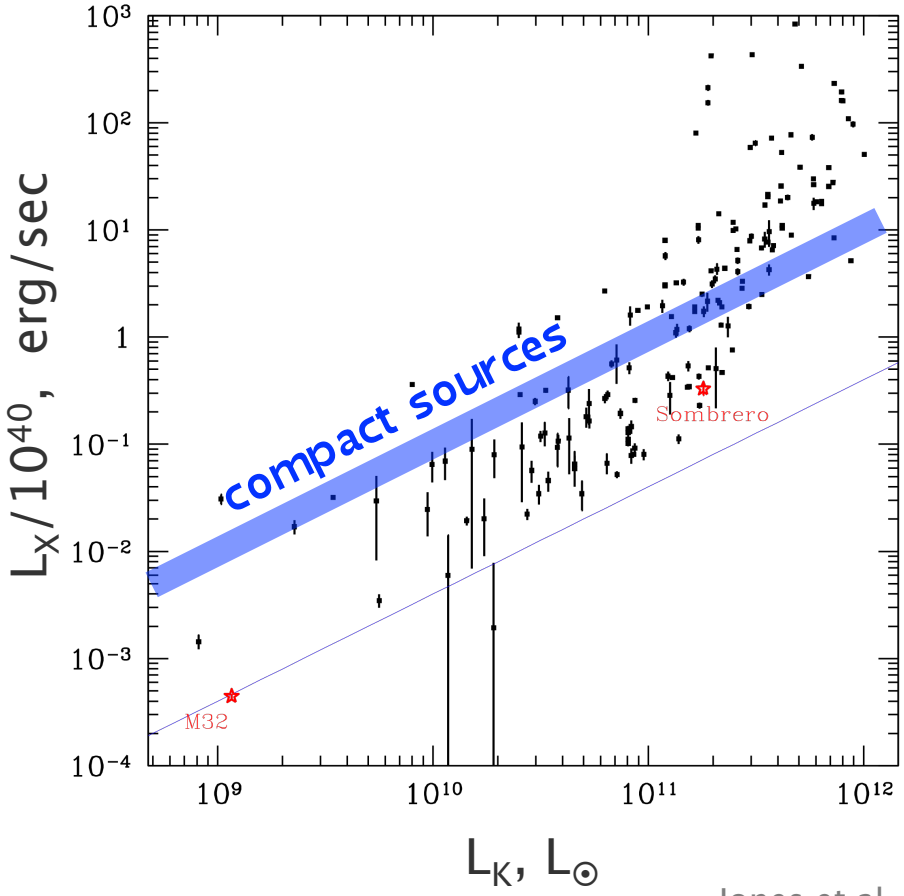
Elliptical galaxies

low-mass X-ray binaries



Gilfanov 2004

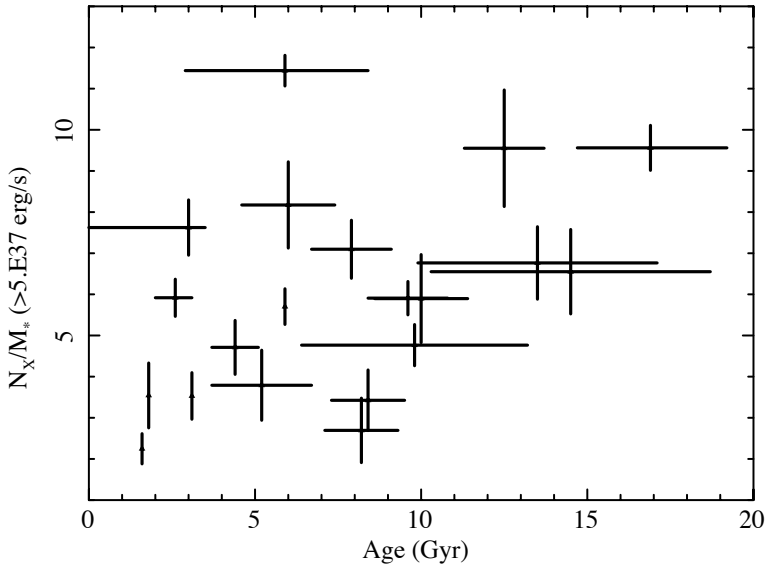
hot gas

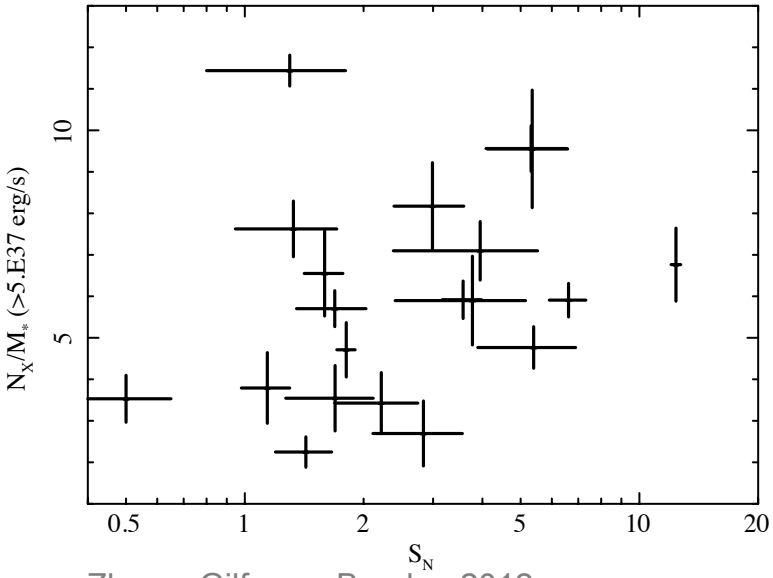


Jones et al

Populations of LMXBs

depend on the age… ➡



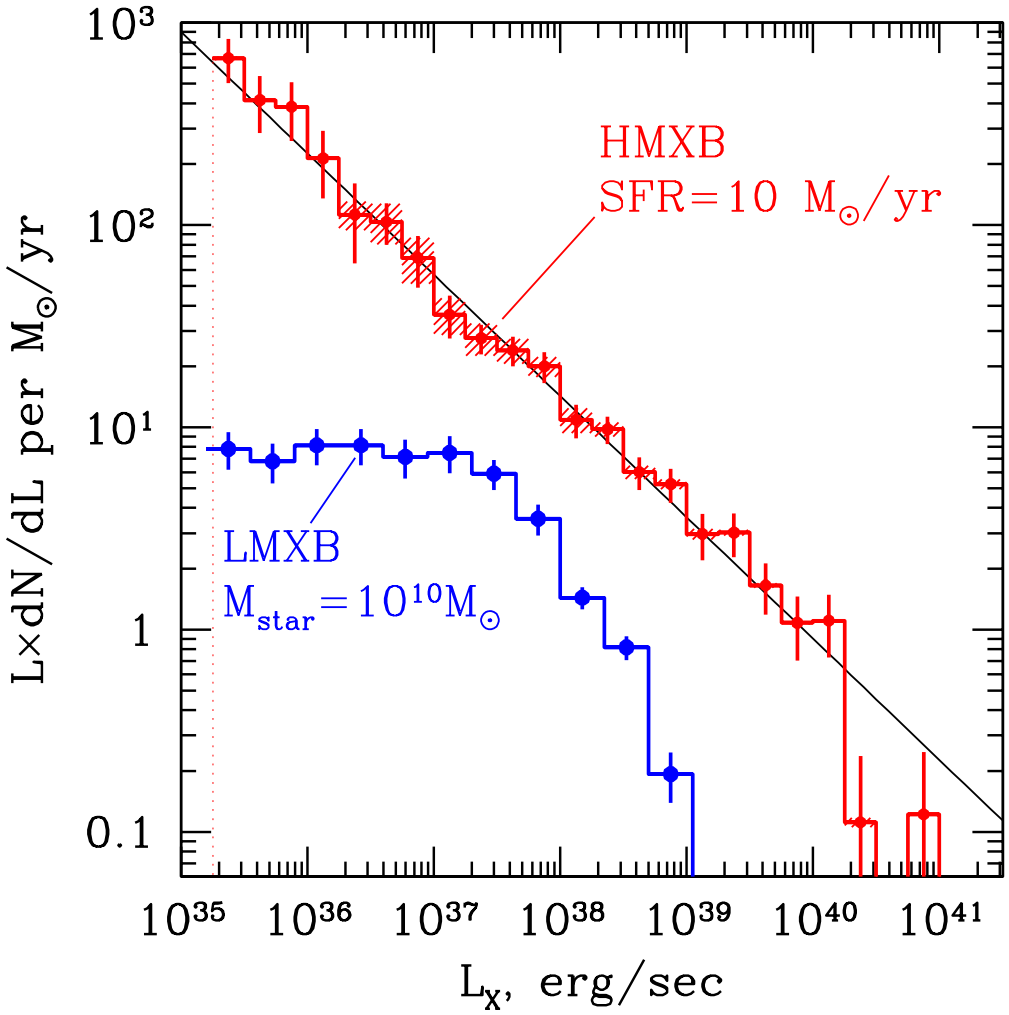


Zhang, Gilfanov, Bogdan 2012

⬅ … globular cluster content of the galaxy

etc…

X-ray luminosity functions

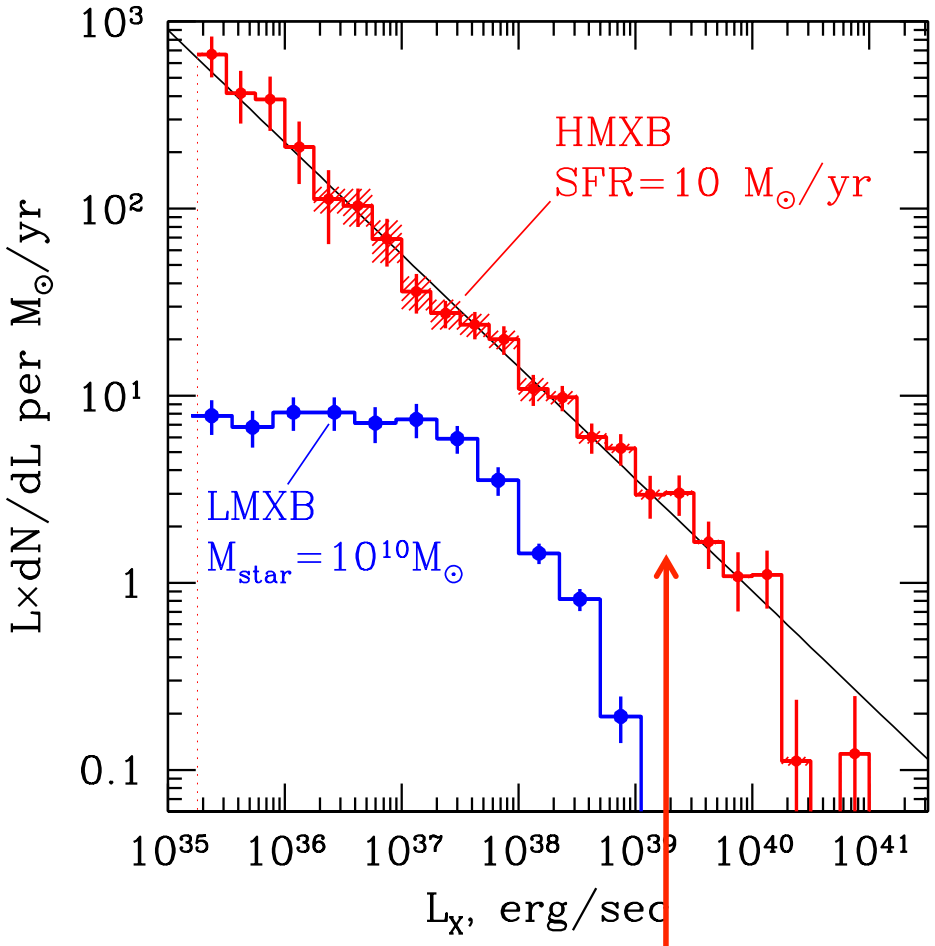


compact X-ray sources in spiral and elliptical galaxies have different XLFs

different accretion regimes in LMXBs and HMXBs:

- Roche lobe overflow
- accretion from the stellar wind

Ultra-luminous X-ray sources (ULX)



- ULXs are associated with star-formation
- $\log(L_X) \leq 40$ sources – must be a tail of the distribution of "usual" HMXBs
- nature of $\log(L_X) \geq 40$ sources still unclear:
  - unexplored accretion regimes
  - intermediate mass black holes

Implications for the binary evolution

- the large specific frequency of HMXBs, per unit SFR

$$N_{HMXB}(L > 10^{35}) \approx 135 \times \mathrm{SFR}$$

- implies high efficiency of HMXB formation
- 20-30% of NS and BH become X-ray sources within 100 Myrs from their formation
- 3-4% of BHs become X-ray sources with $L_X > 10^{39}$ erg/s
- LMXBs are extremely rare – 1 out of 10^6 NS becomes bright X-ray source in an LMXB
- accreting NS and BH of stellar mass account for ~5-7% of Cosmic X-ray Background

Implications for the massive stars IMF

accretion of radiation pressure driven stellar wind

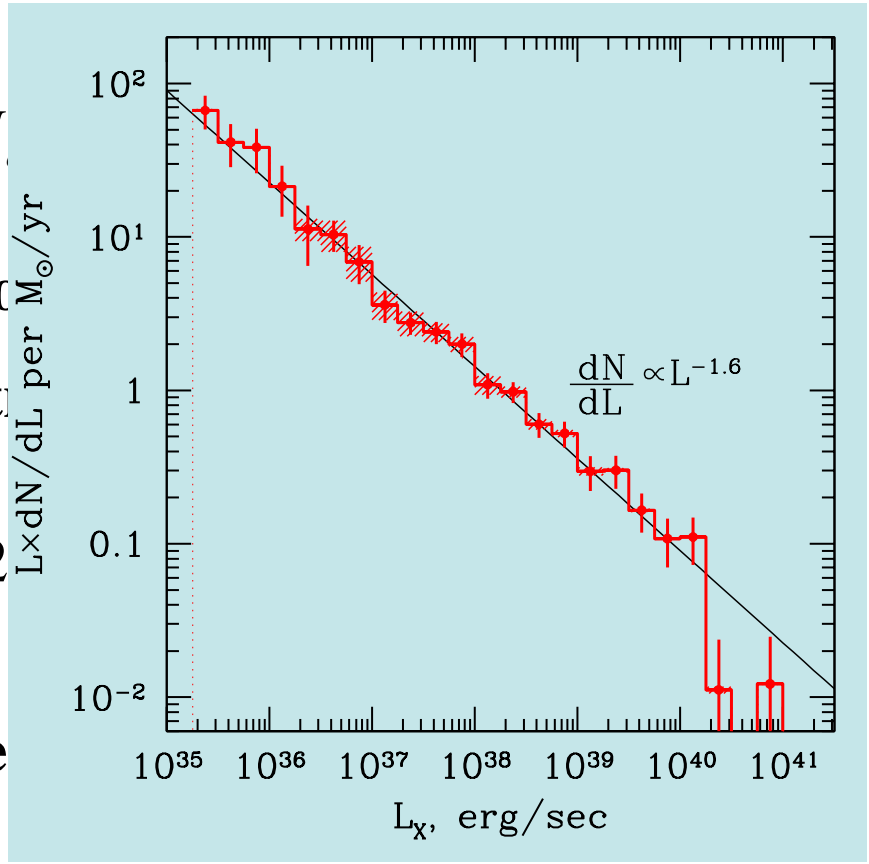
$$\left.\begin{array}{l}\dot{M}_{wind} \propto L_* \\ L_* \propto M_*^3\end{array}\right\} \Rightarrow \dot{M}_{wind} \propto M_*^3 \Rightarrow \dot{M}$$

more accurate consideration (Bo

$$\dot{M}_{acc} \propto M_*^{2.5} \Rightarrow L_x \propto M_*^{2.5}$$ **(Post**

$$\frac{dN}{dL_x} = \frac{dN}{dM_*} \times \left(\frac{dL_x}{dM_*}\right)^{-1} \Rightarrow \alpha_{IMF} = 2$$

$\alpha_{IMF}, \alpha_{XLF}$ – **IMF and XLF slope**

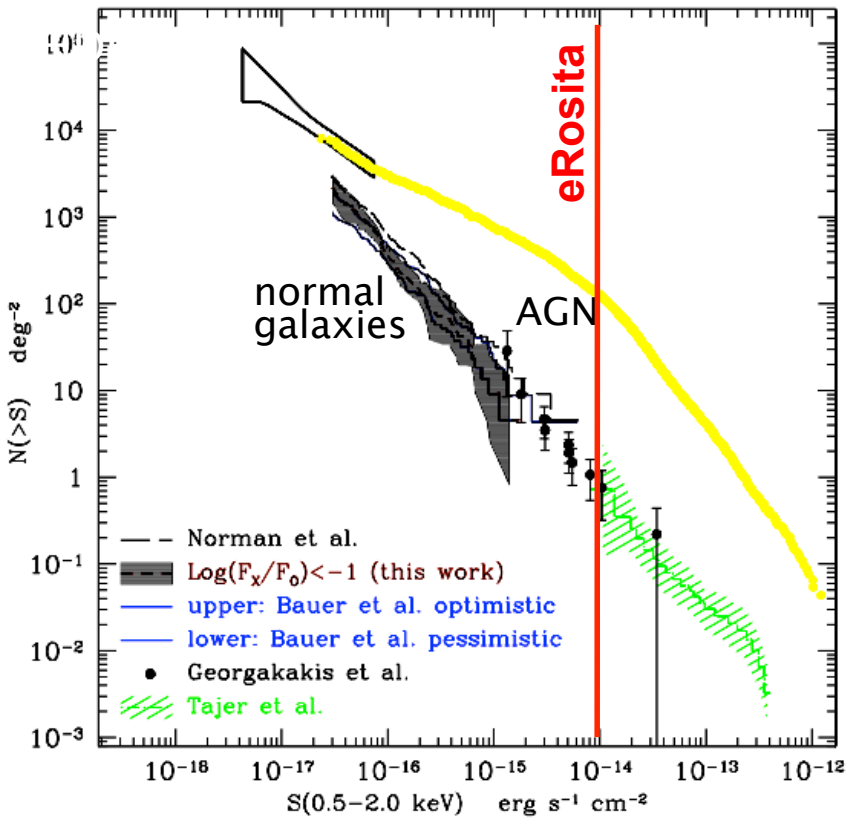


$$\alpha_{XLF} = 1.6 \pm 0.15 \Rightarrow \alpha_{IMF} = 2.5 \pm 0.4$$ **(Salpeter :** $\alpha_{IMF} = 2.35$**)**

Normal galaxies in the eRosita all-sky survey survey

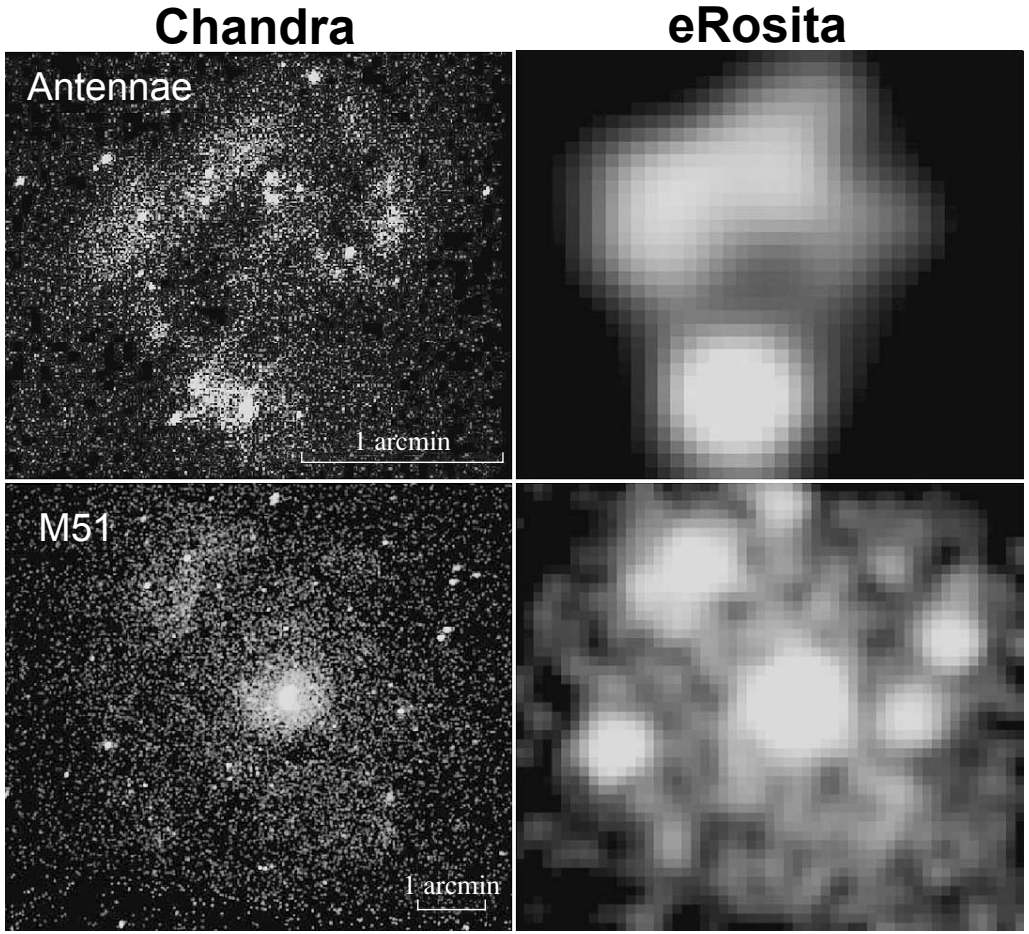
- ✓ ~100 AGN per sq.degree
- ✓ ~2 galaxies per 3-4 sq.degrees (~1 elliptical, ~1 spiral)
- ✓ ~15-20 thousand normal galaxies in the survey

source counts



Ranalli et al., 2006

…as seen by eRosita



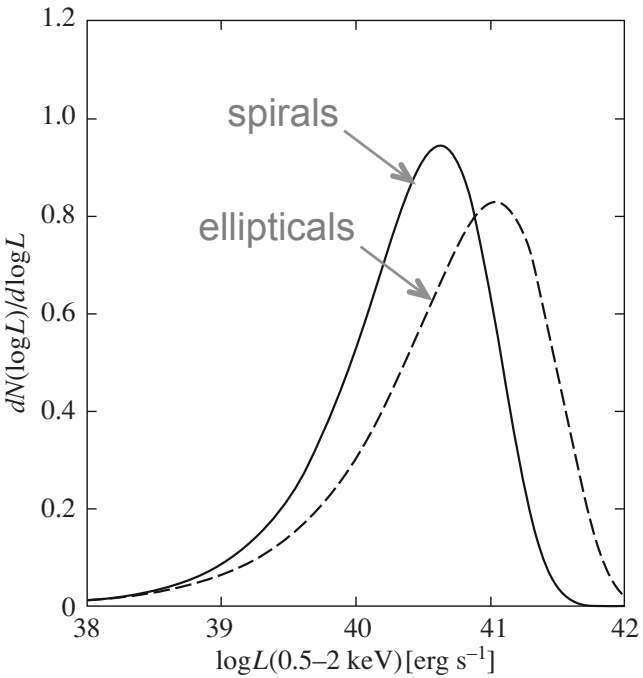
10 kpc=40 arcsec
@ D=100 Mpc

effective angular resolution in the survey ~30 arcsec HPD

⇒ eRosita will mostly measure total luminosity

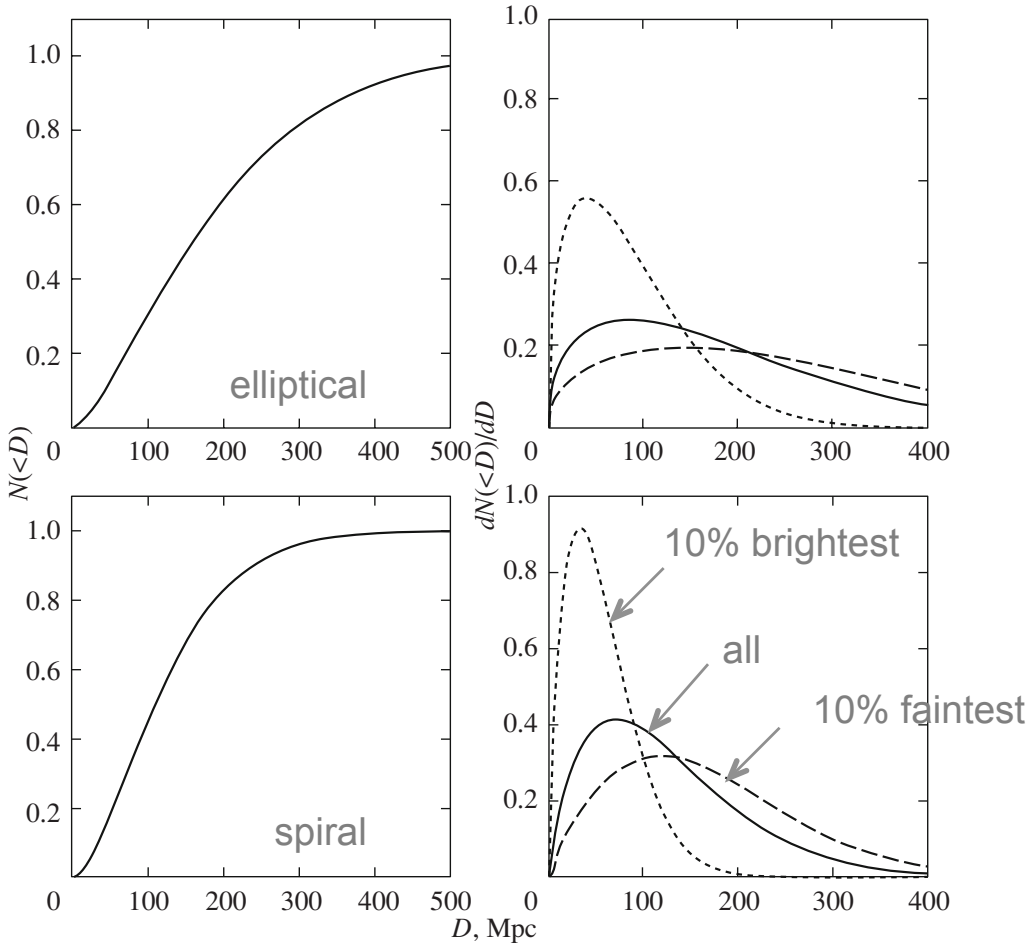
Distributions of detected galaxies

luminosity



Prokopenko & Gilfanov, 2009

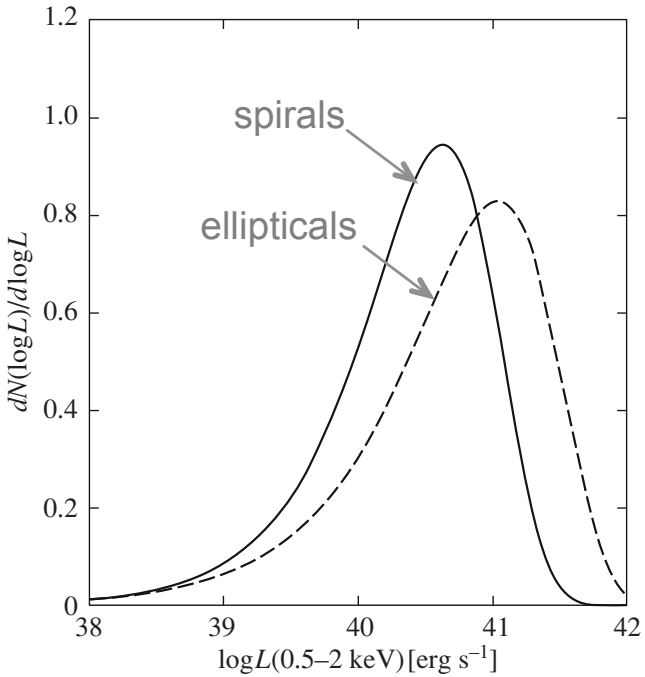
distance



Normal galaxies in the survey

- ✓ ~2 galaxies per 3-4 degr^2 (~1 elliptical, ~1 spiral)
- ✓ ~15-20 thousand galaxies in total
- ✓ 90% – closer than ~200–400 Mpc
- ✓ a typical galaxy in the survey:
  - D ~ 70-90 Mpc
  - log(L_X) ~ 40.5 – 41
  - star-forming SFR~20 $M_\odot$/yr
  - elliptical log(M_*)~11.3
  - listed in the IRAS and/or 2MASS catalogs

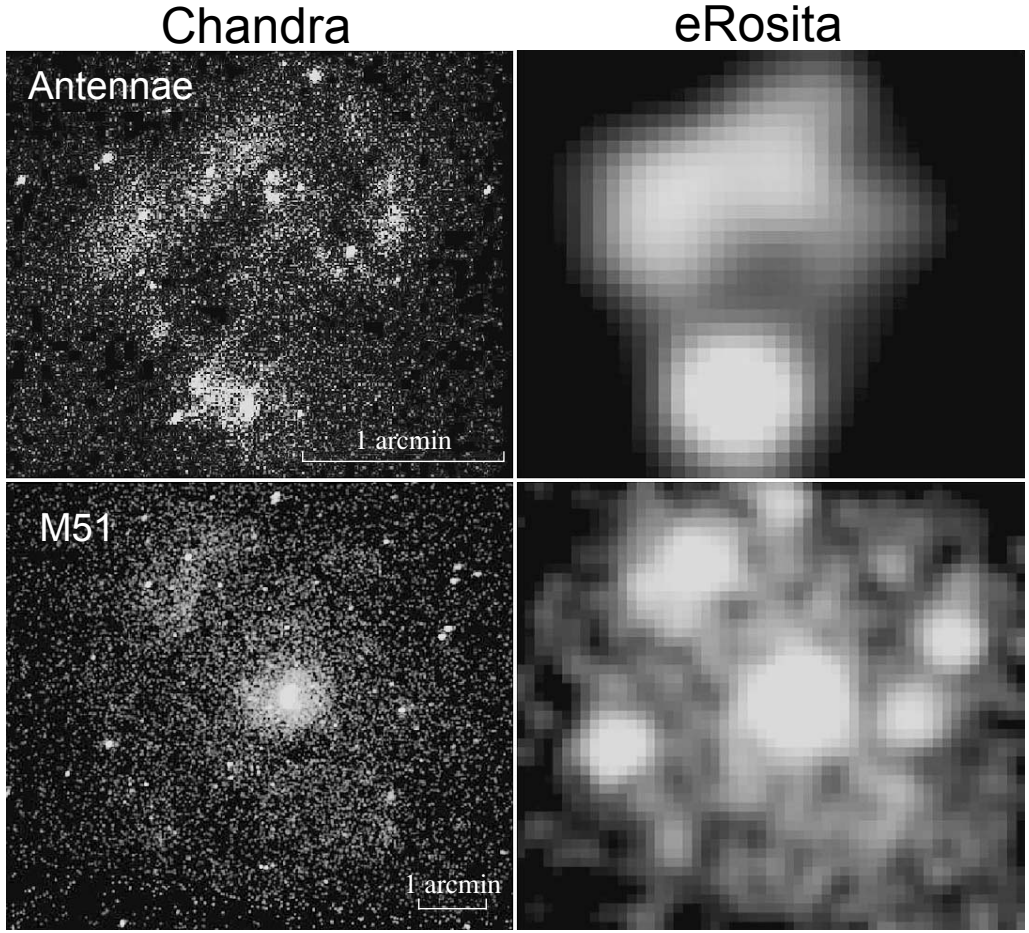
luminosity distributions



Prokopenko & Gilfanov, 2009

Ultra-luminous X-ray sources

- ~85 sources with $\log(L_X)>40$ within 35 Mpc
- ~80% $\log(L_X)>40$ sources – the only ULX in a galaxy
- XLF of brightest ULXs may be possible



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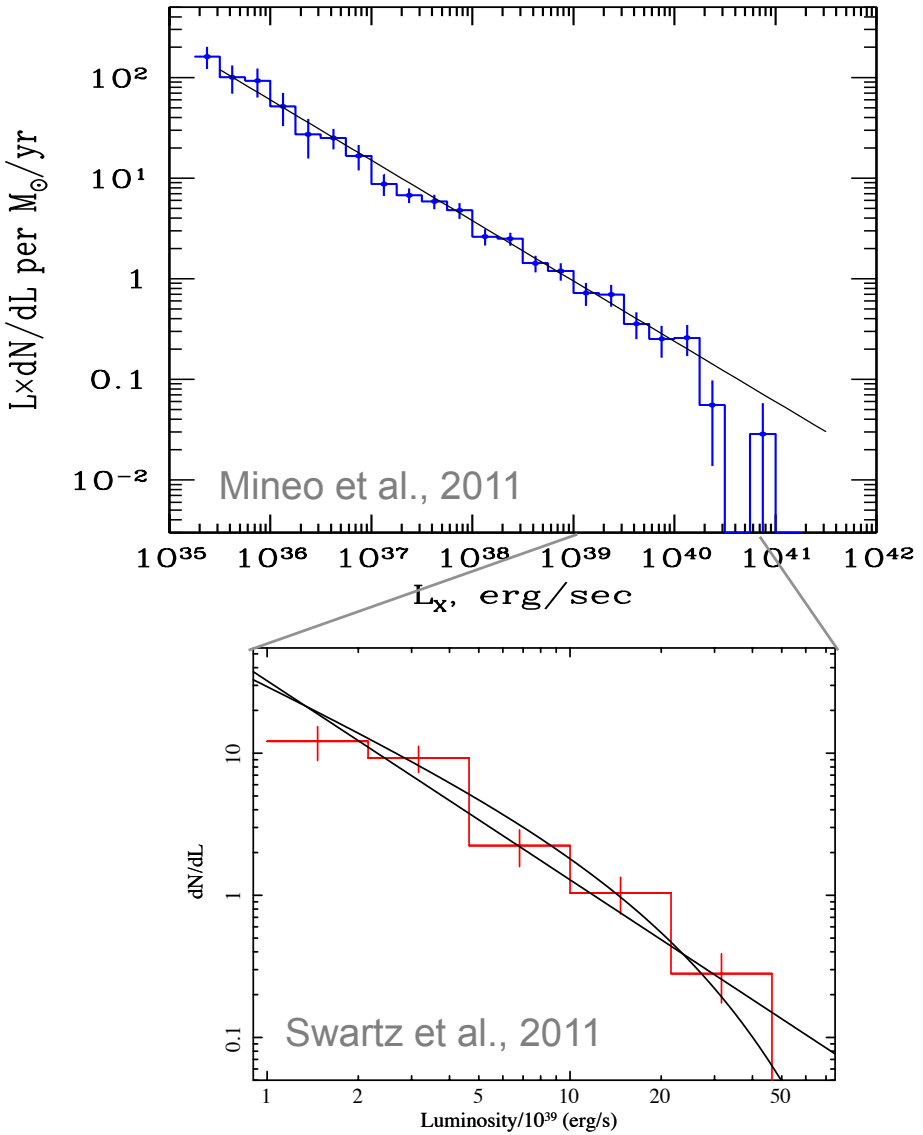
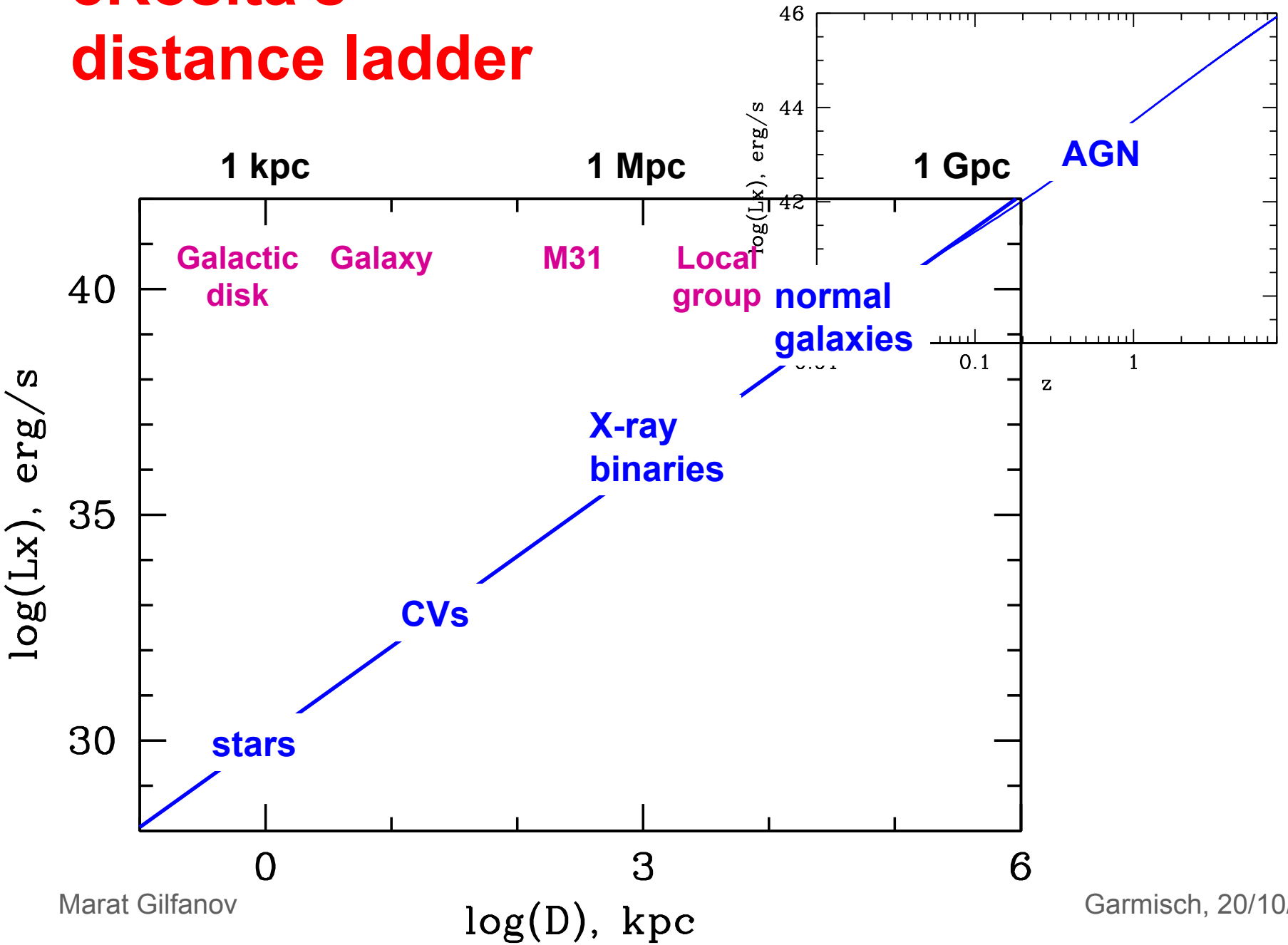
- ~85 sources with $\log(L_X)>40$ within 35 Mpc
- ~80% of $\log(L_X)>40$ sources – the only ULX in a galaxy
- XLF of brightest ULXs may be possible
- investigation of potentially most exotic type of compact sources in galaxies



eRosita's distance ladder



The End