Luminosity functions of LMXBs in different stellar environments

Zhongli Zhang[1], Marat Gilfanov[1], Ákos Bogdán[4], Rasmus Voss[2], Gregory Sivakoff[3], Ralph Kraft[4], Nicola Brassington[4], Arunav Kundu[5], Andrés Jordán[6], Craig Sarazin[3]

[1] *Max-Planck-Institute for Astrophysics, Garching, Germany*
[2] *Radboud University Nijmegen, The Netherlands*
[3] *University of Virginia, USA*
[4] *Harvard/Smithsonian Center for Astrophysics, USA*
[5] *Eureka Scientific, Oakland, USA*
[6] *Pontificia University, Santiago, Chile*

Introduction

- Low-mass X-ray binary

- XLFs of LMXBs in different stellar environments

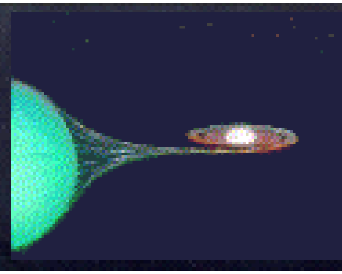
  —— *dependence on stellar density and velocity*

  - globular cluster vs. galaxy field
  - globular cluster vs. galaxy nucleus

- N(LMXB)/M_* dependence on stellar age
- LMXB spatial distribution (effect of supernova kicks?)

- Summary

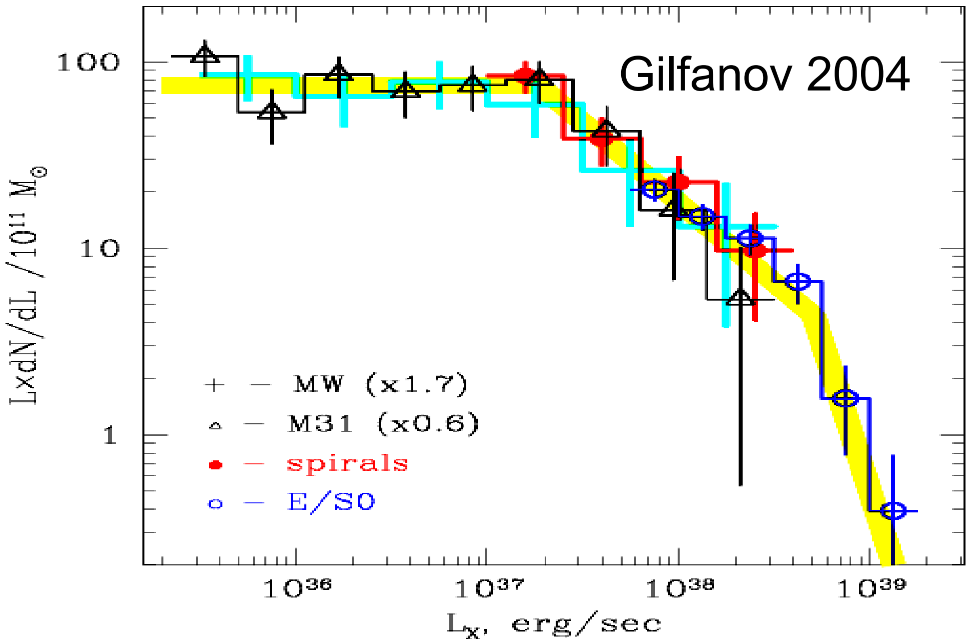
Low-mass X-ray binary



LMXB: A low mass donor star (< 1 $M_\odot$ main sequence, WD, red gaint ...) transfers mass to a compact accretor (NS/BH) by Roche-Lobe filling

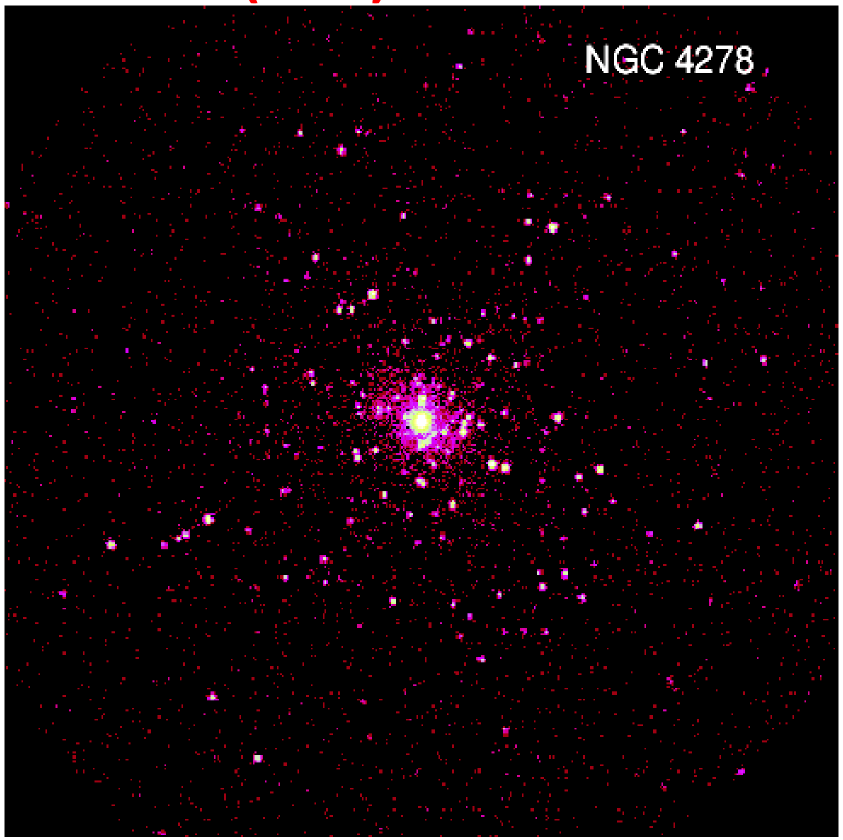
N (LMXB) ~ M* **(old stellar system)**

Universal XLF:



Large fraction of X-ray emission in E/S0

Chandra (0.5")



Formation of LMXB

Primodial channel :

binary star evolution (loss of orbital momentum, or evolution of the donor star) —— X-ray active phase is deplayed

Dynamical channel :

1) Tidal capture of a NS by a non-degenerate single star.

2) A collision between a NS and an evolved single star. (subgiant, RGB, AGB)

3) A NS exchanges place with a star in a binary system.

XLF (GC vs. field)

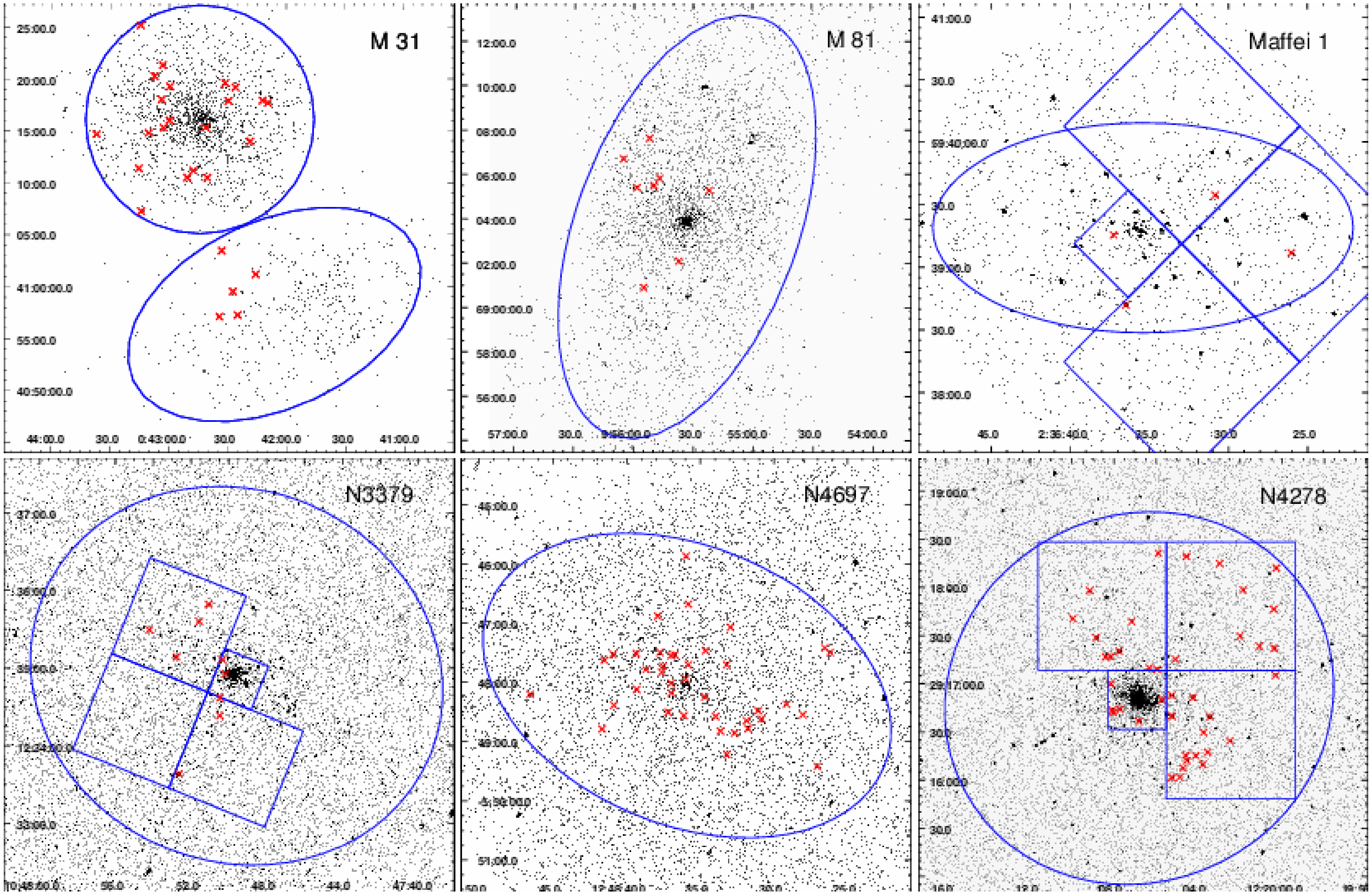
$N\,(LMXB)\,/\,M_*$ is few hundred times higher in galactic globular clusters than in the field (Clark 1975).

GC-LMXB: dynamical formation
Field LMXB: primodial formation

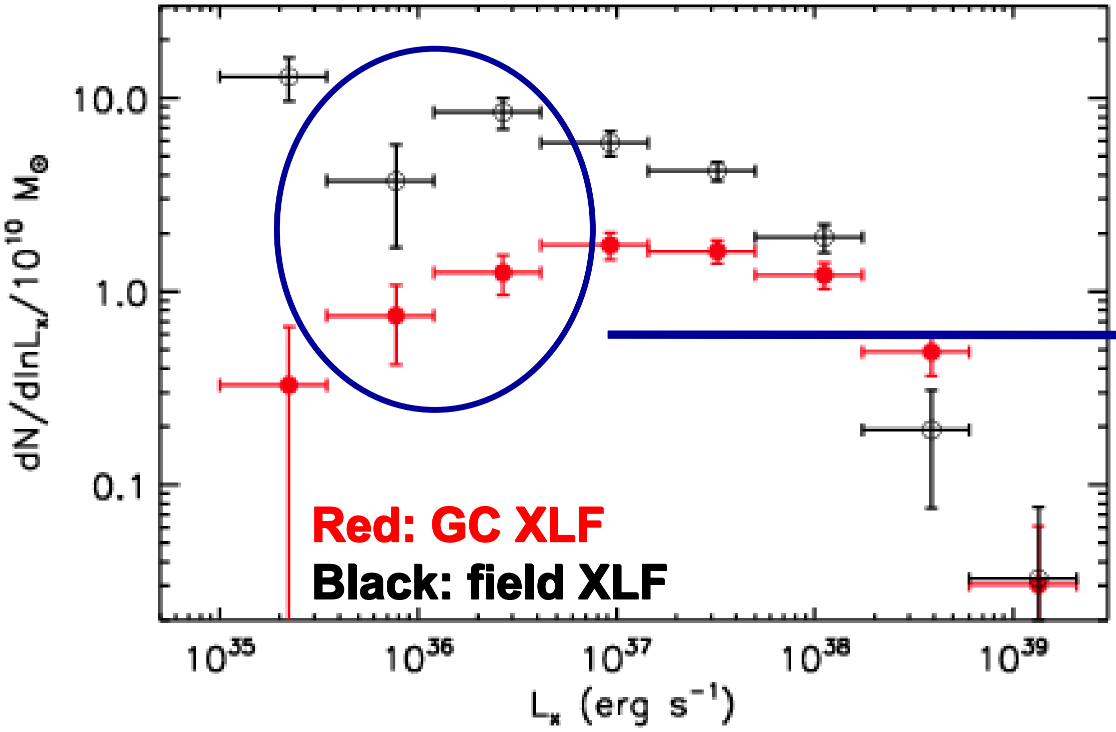
Debate: whether field LMXBs are formed in GCs or formed in situ.

We make the **most accurate LF of GC-LMXBs to date** and compare with field LMXBs.

Sample: the Milky Way, M31, Centauraus A, M81, Maffei1, NGC 3379, NGC 4697, NGC 4278
CenA (Voss et al. 2009)


M 31
M 81
Maffei 1
N3379
N4697
N4278

(185 GC-LMXBs, 496 field LMXBs)



Fraction of faint GC-LMXB :
~ 4 times < field LMXBs

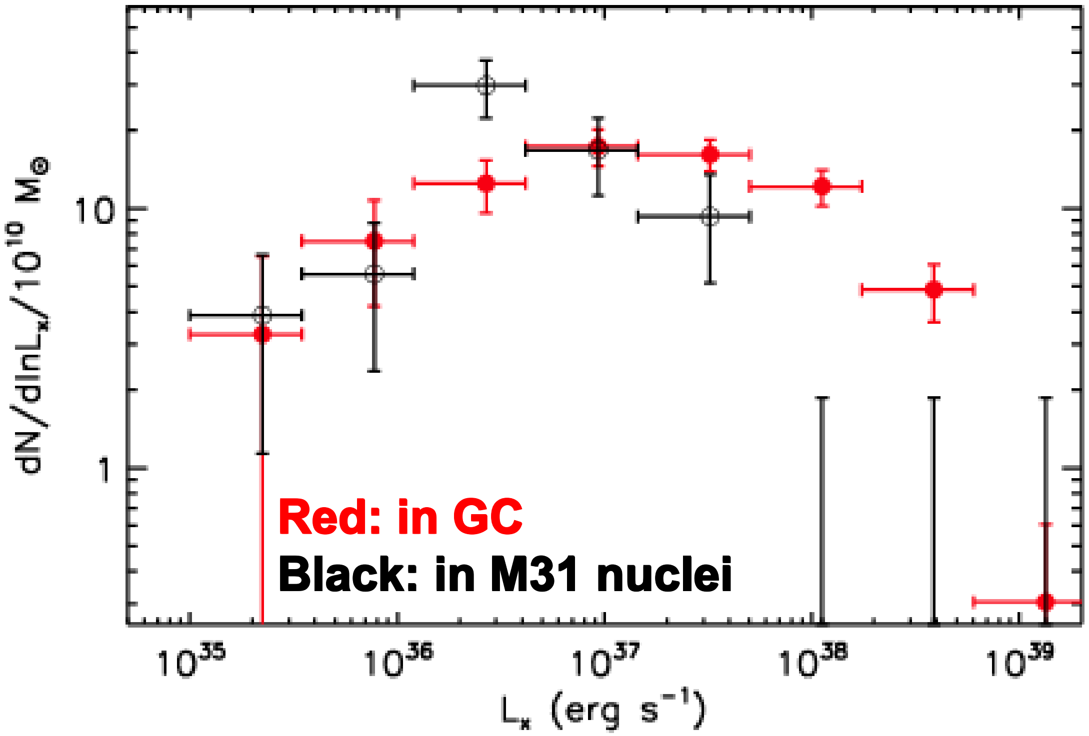
NS collides with a red gaint.
(Voss et al. 2009)

helium accretion system:

4 times higher T_{ion},
~ 20 times higher $\dot{M}_{crit}$
non-persistent < e37 erg/s
(Lasota et al. 2008)

Entire shapes are different!
Not all the field LMXBs are formed in GCs!

XLF (GC vs.Galaxy nucleus)



< 1' bulge of **M31:**
35 dynamically formed LMXBs
(Voss and Gilfanov 2007a)

Comparison:

similar in the faint end
different in the bright end.

Different dynamical formation channel!

Stellar velocities in galactic nuclei is 5~10 times higher than in GCs
In GC: tidal capture of NS by MS star (> 0.3$M_\odot$)
In Galactic nuclei: tidal capture of NS by MS star (< 0.3 $M_\odot$)
(Voss and Gilfanov, 2007b)

N(LMXB)/M* via stellar age

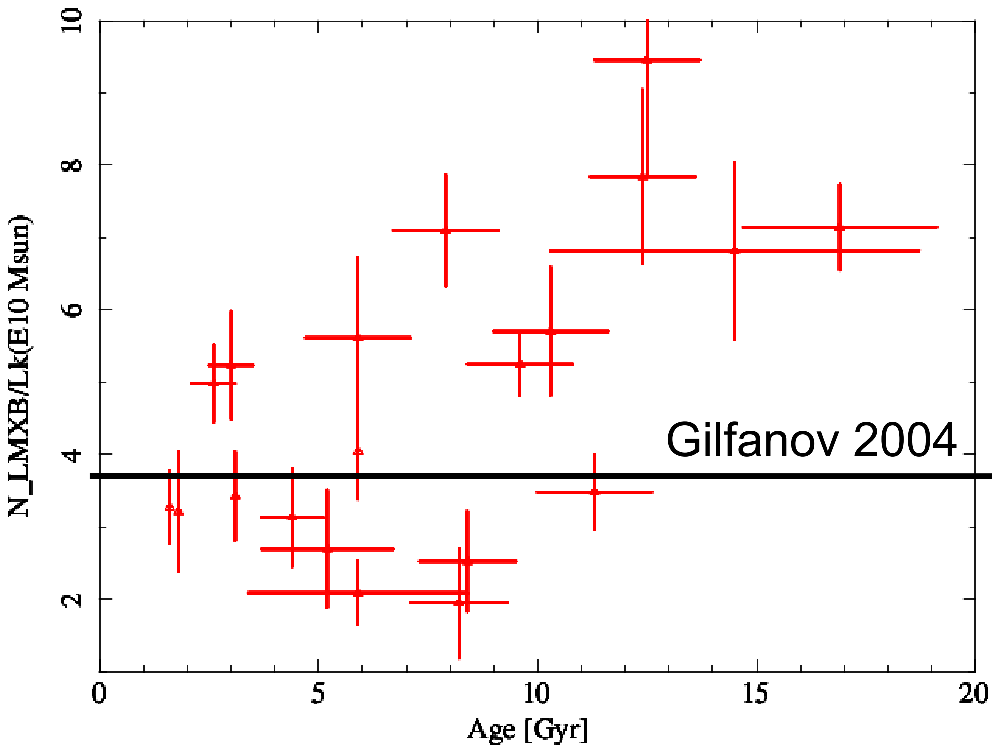
Primodial formation channel:

nuclear evolution time scale of the donor star and/or binary orbit decay (1 ~ 10 Gyr time scale)

stellar age can be secondary correlation to scale N_{LMXB}

A preliminary result

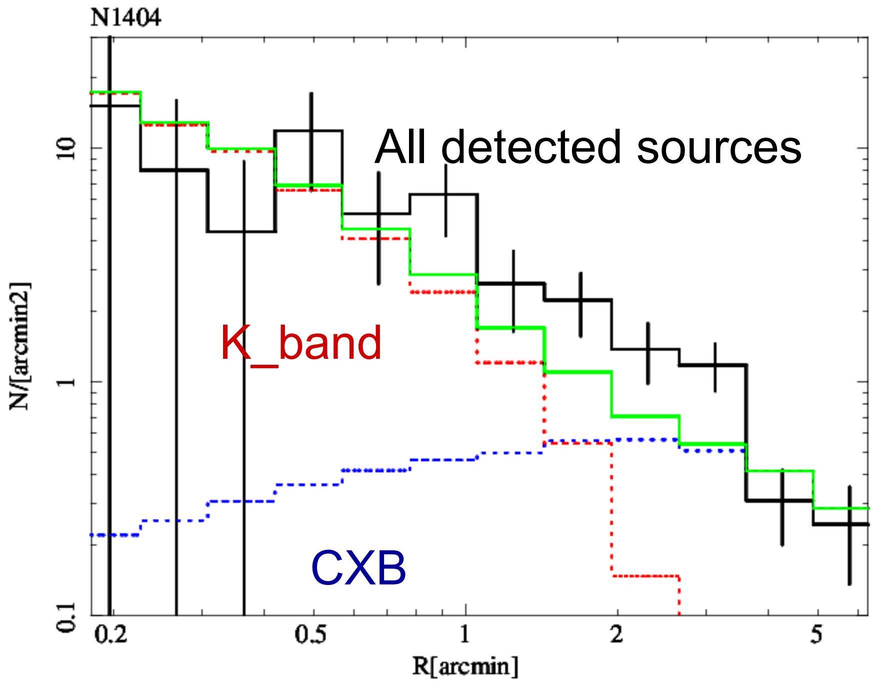
20 galaxies

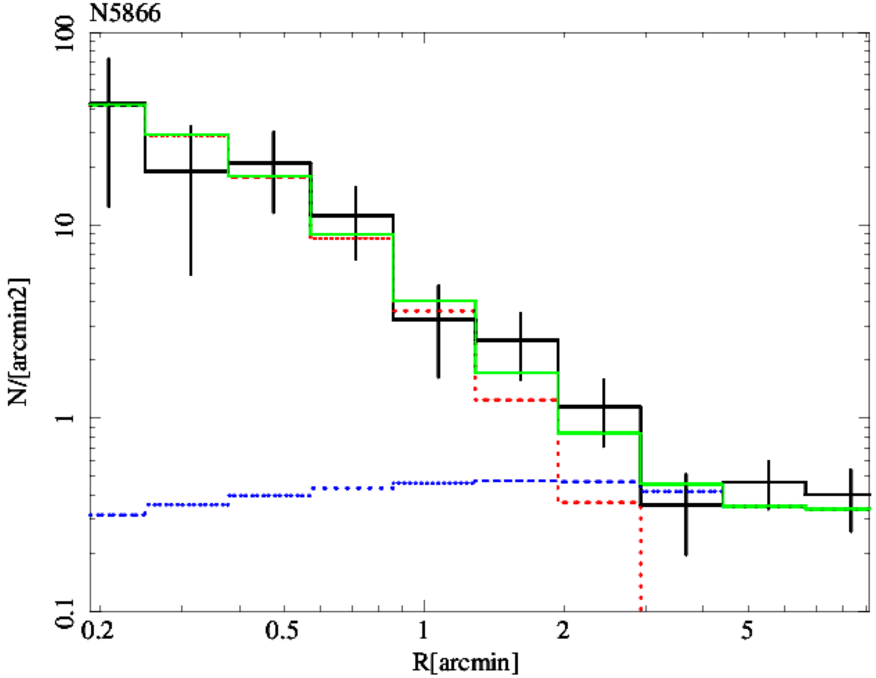


Sample selection:

1) E or S0,
   no recent star formation.
2) D < 25 Mpc
(detection sensitivity > 5.e37 erg/s)
3) $L_k > e10\ L_{k,\odot}$
4) Galaxy age: 1Gyr ~ >10 Gyr.

LMXB spatial distribution





In some galaxies

X-ray point source distribution is broader than K-band light distribution.

Is this effect of supernova kicks?

LMXBs gain average system velocity of 180± 80 km/s

(2 ~ 20 kpc in E07 ~ E08 yr)

Summary

➢ We study environment dependence of population of LMXBs in early- type galaxies, which includes dependence on stellar density (glob. clusters and galactic nuclei vs. field), stellar velocity (glob. clusters vs. galactic nuclei) and stellar age (young vs. old elliptical galaxies)

➢ XLF of GC and field LMXBs differ in the whole luminosity range, with the ratio of faint GC-LMXB much less than field population. This may be caused by helium accretion system in GCs. And proves that not all field LMXBs were formed in GCs.

➢ XLF of GC and LMXBs in nuclei of M31 differ in the bright end, which proves different dynamical formation channel based on different stellar velocity.

➢ N(LMXB)/M* differs between young and old galaxies with significance > 3σ (ongoing)

➢ In some galaxies the spatial distribution of LMXBs is broader than the K-band light distribution, which is possibly an effect of supernova kicks. (ongoing)


Thank you very much !