

EFFECT OF VARIABILITY OF X-RAY BINARIES ON X-RAY LUMINOSITY FUNCTIONS OF OUR GALAXY

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INTRODUCTION

- X ray emission from normal galaxies (no AGN or hot gas) dominated by emission from X ray binaries.
- Chandra and XMM-Newton telescopes => construction and study of XLF of nearby galaxies.
- XLF for a X ray binary population in galaxy is the number distribution $N(>L)$ of XRBs having luminosity greater than L .
- XLFs of galaxies are indicators of **Star Formation Rate** and **Stellar Mass of galaxies**.

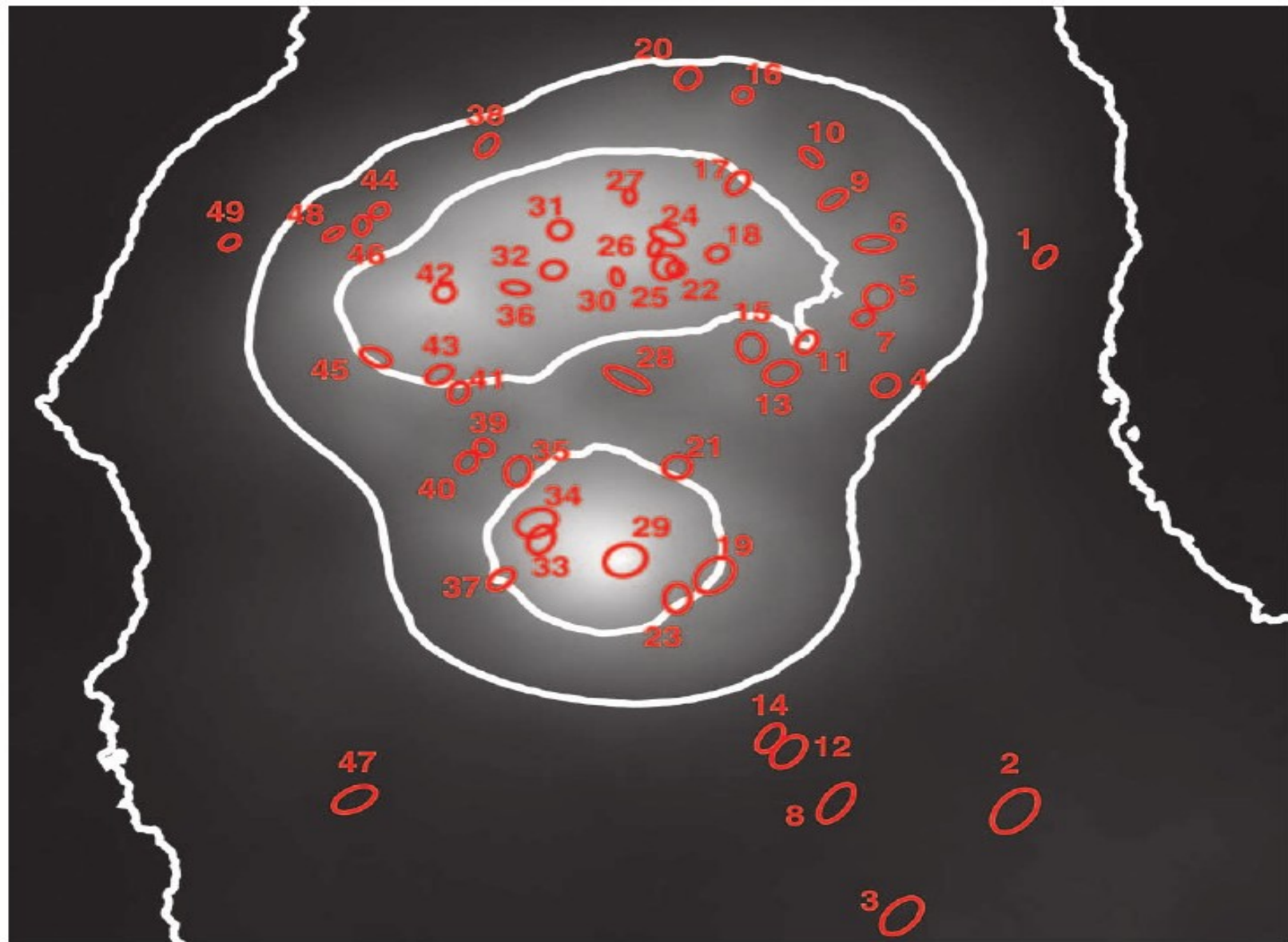


Image of detected sources in Antennae galaxies as calculated by WAVDETECT tool.

Reference: Zezas and Fabbiano (2002) ApJ **557:726-737**.

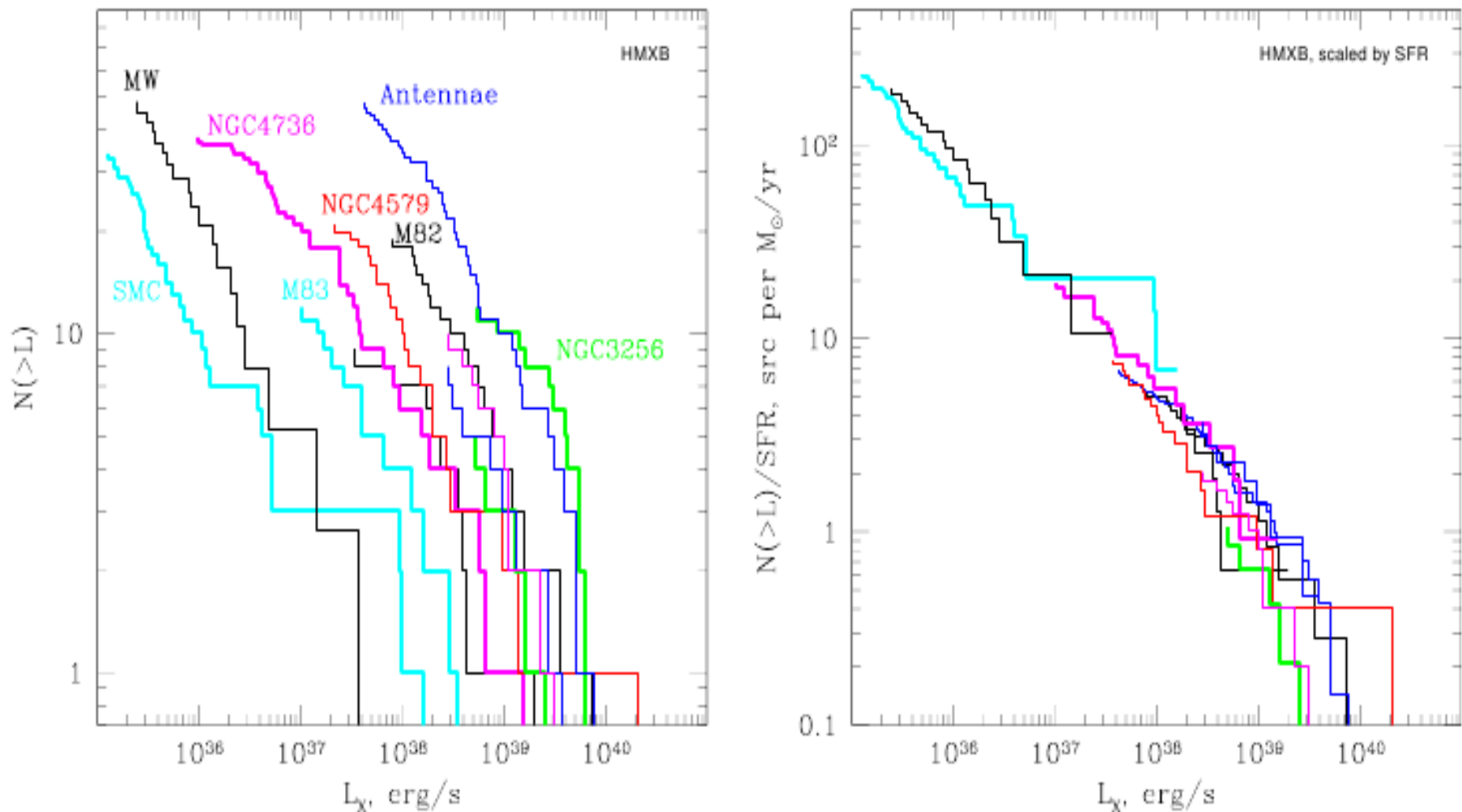


Figure 1: Number versus luminosity distribution for nearby young and starburst galaxies (left panel) and after scaling with SFR (right panel).

Reference: Gilfanov (2004) MNRAS

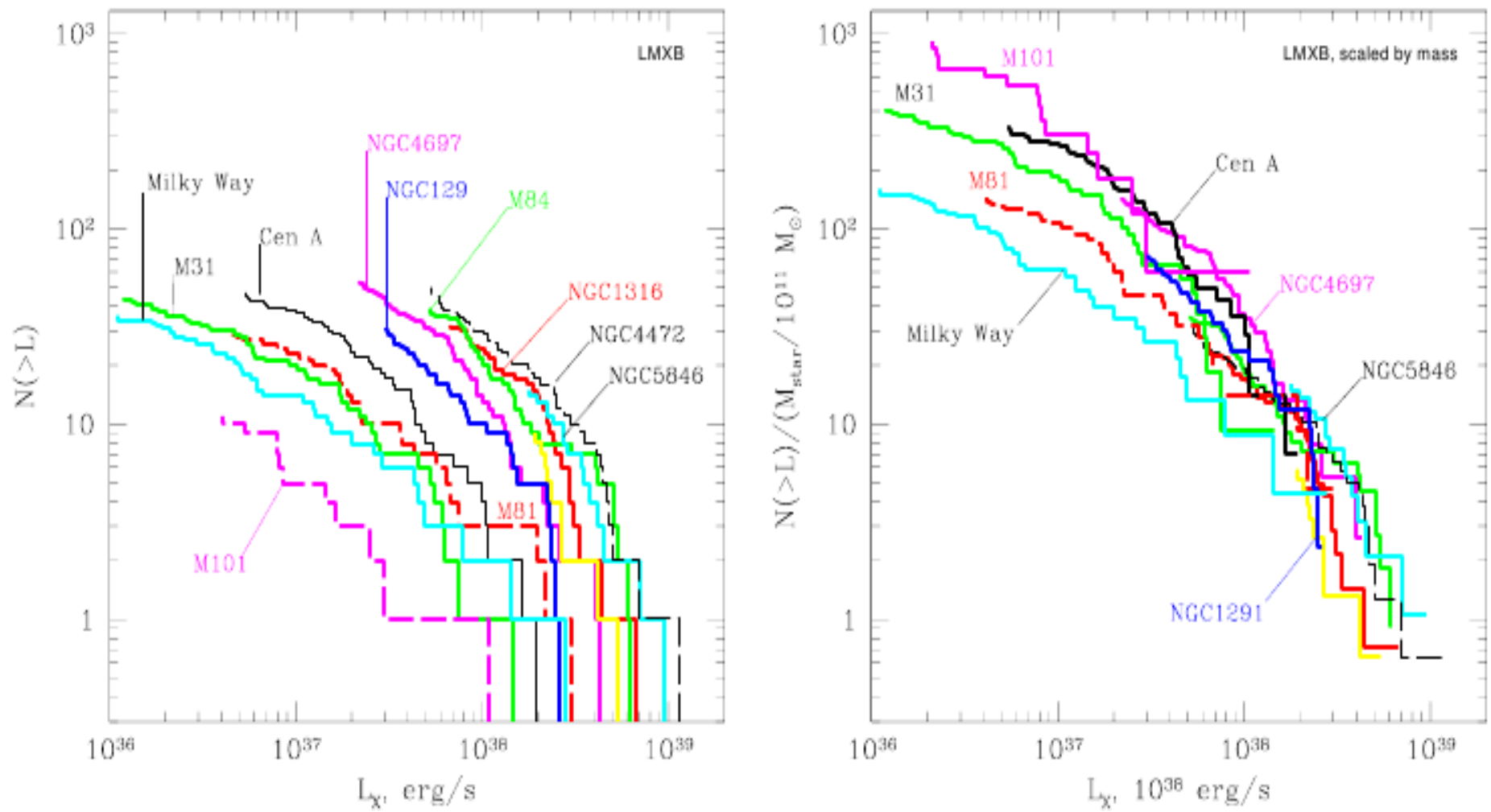


Figure 2: Number versus luminosity distribution for nearby elliptical galaxies (left panel) and after scaling with stellar mass (right panel).

Reference: Gilfanov (2004) MNRAS

EFFECT OF VARIABILITY ON XLF

- X Ray sources are variable on all timescales.
- Influences XLF of galaxies.

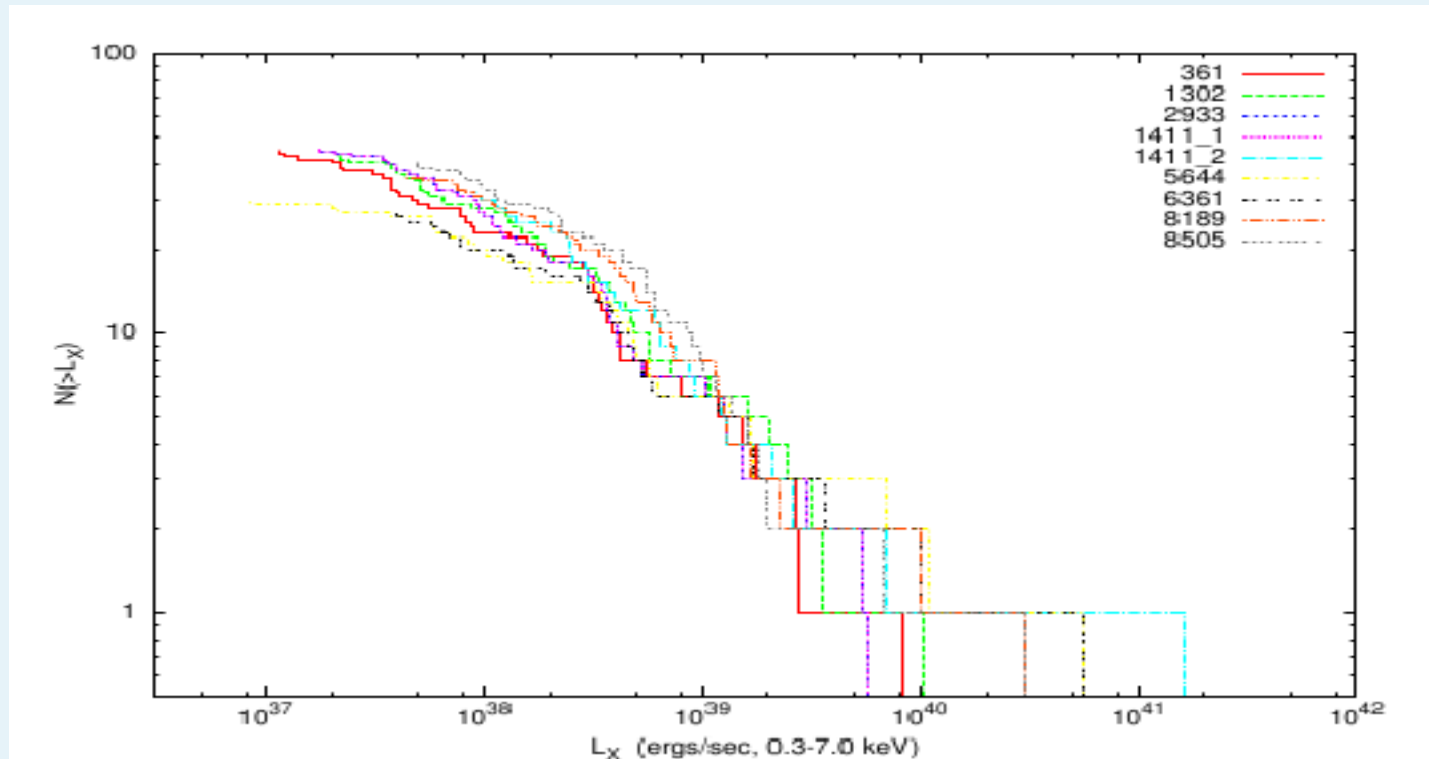


Figure 3: X ray Luminosity Function of M82 for different Chandra observations.

Reference: Chiang and Kong (2010) MNRAS

So, we constructed X ray luminosity functions using the long term light-curves of sources in 2-12 KeV band of RXTE All Sky Monitor and studied the **effect of variability** of X ray binaries on the X ray luminosity functions in our Galaxy.

RXTE All Sky Monitor

- To study the effects of variability, long term light-curves are required.
- RXTE-ASM best suited for the job, due to its all sky nature and long operational time.
- **87 HMXB** and **109 LMXB**, whose distances are known in literature, are used in analysis.
- Light curves are extracted and binned with 1 day bin time.



DATA AND ANALYSIS

- The probability distribution of the true count rate corresponding to each data point in the light curve is assumed to be normally distributed, with observed count-rate as the mean and its error as σ .
- To find the probability distribution corresponding to true count rate, individual distributions corresponding to each data point are summed and normalised.
- Integral probability distributions of each source is used for analysis.

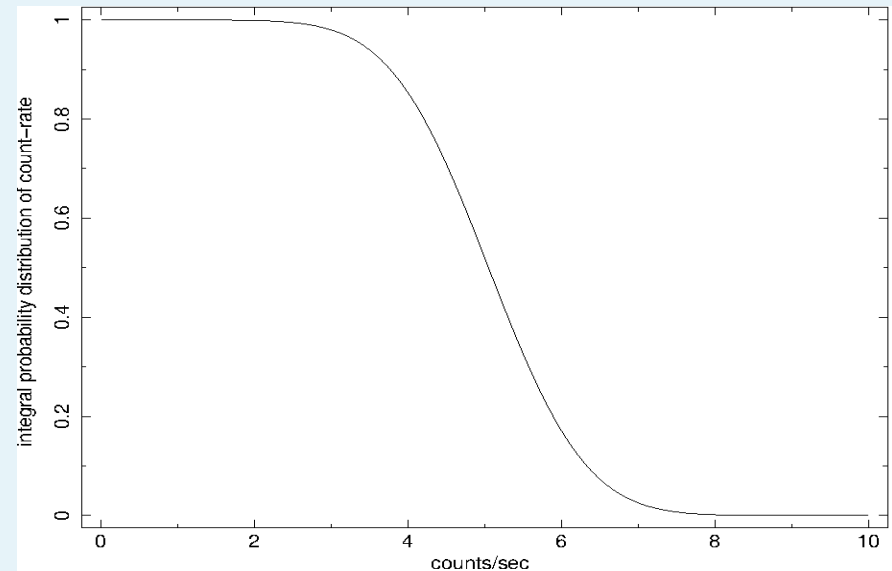
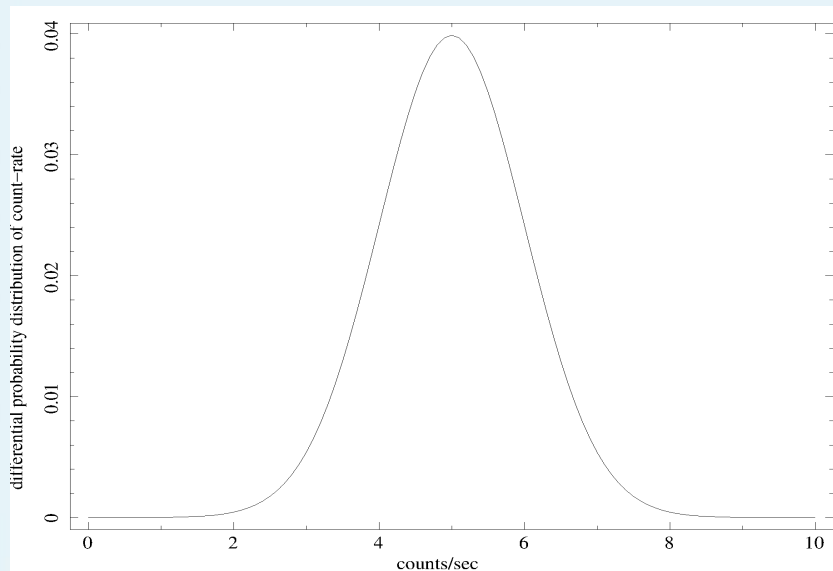
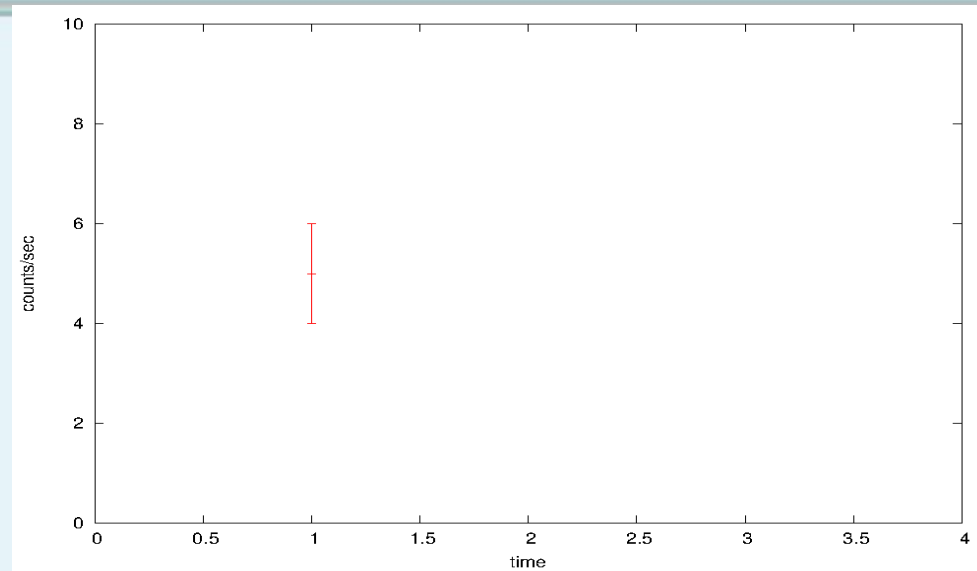


Figure 4: Light-curve consisting of one data point, having observed mean at 5 and its error as 1.0 and differential (left panel) and integral probability distribution (right panel) of count-rate.

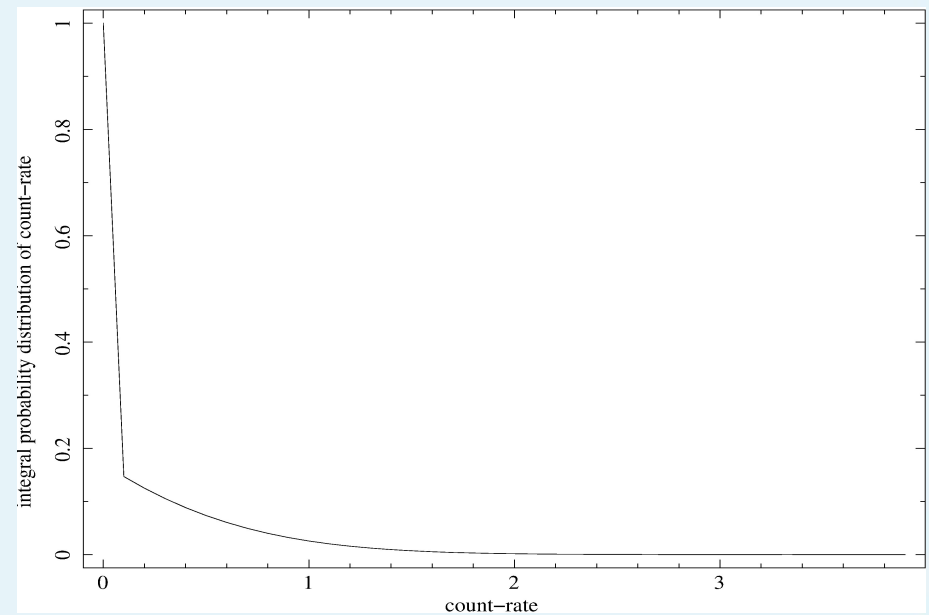
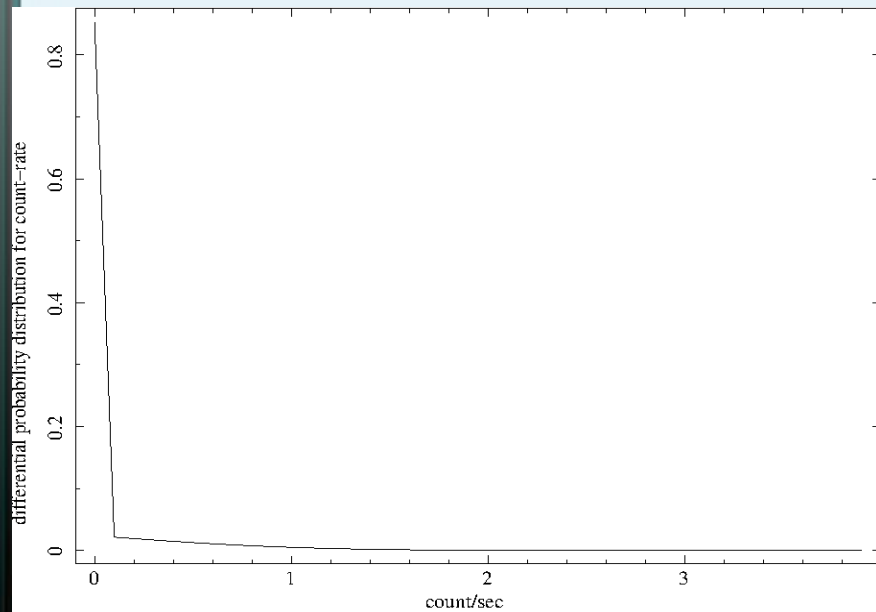
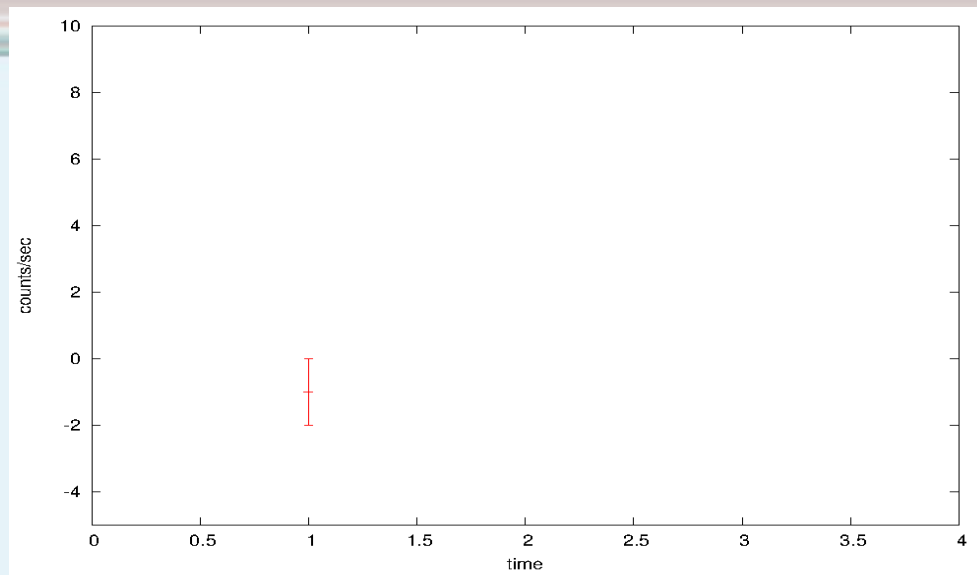


Figure 5: Light-curve consisting of one data point, having observed mean at -1.0 and its error as 1.0 and differential (left panel) and integral probability distribution (right panel) of count-rate.

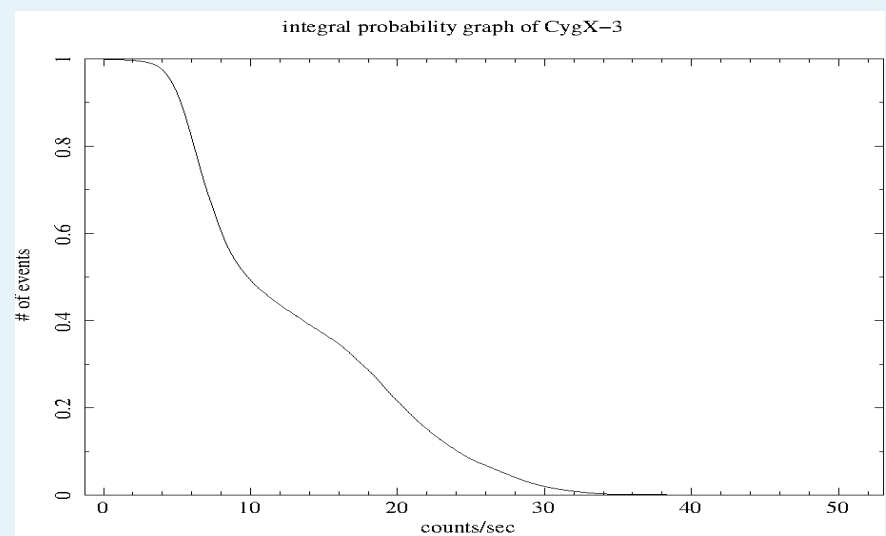
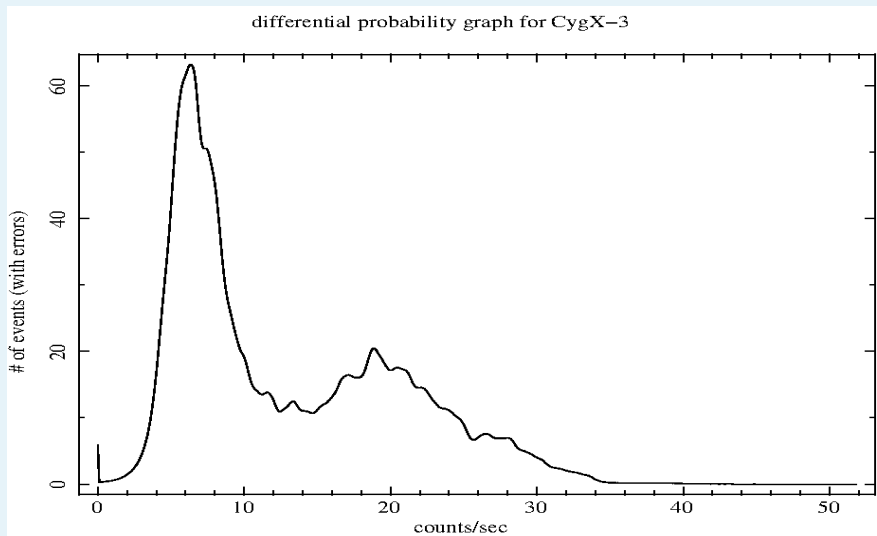
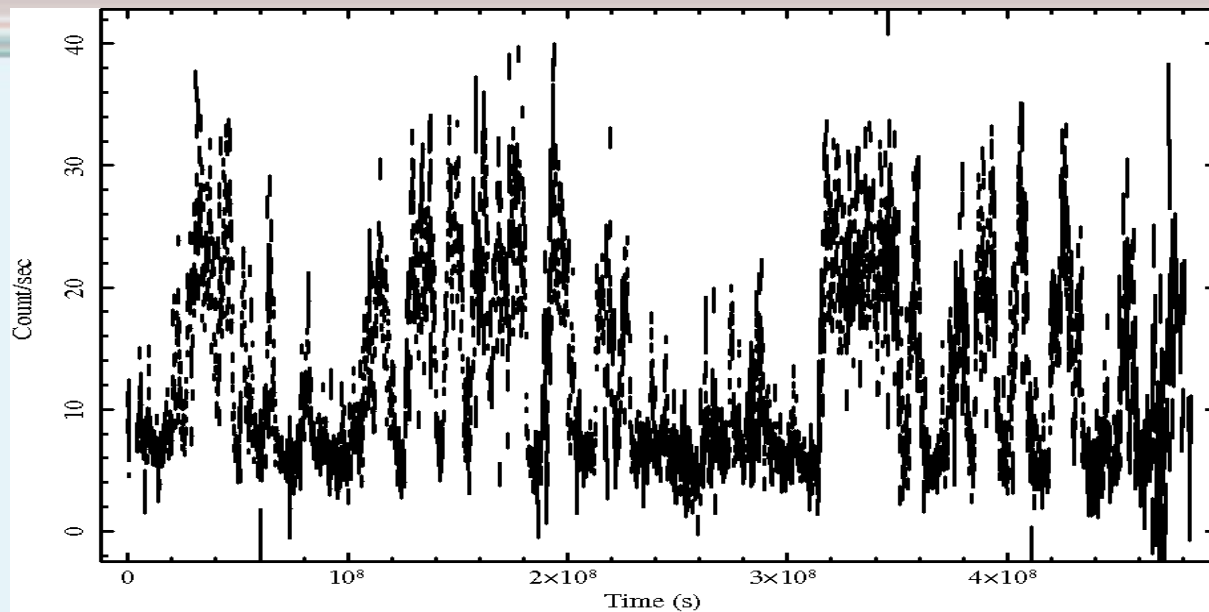


Figure 6: Light-curve of Cyg X-3. The graph on left panel represents differential probability distribution of count-rate and graph on right panel is the integral probability distribution of count-rate.

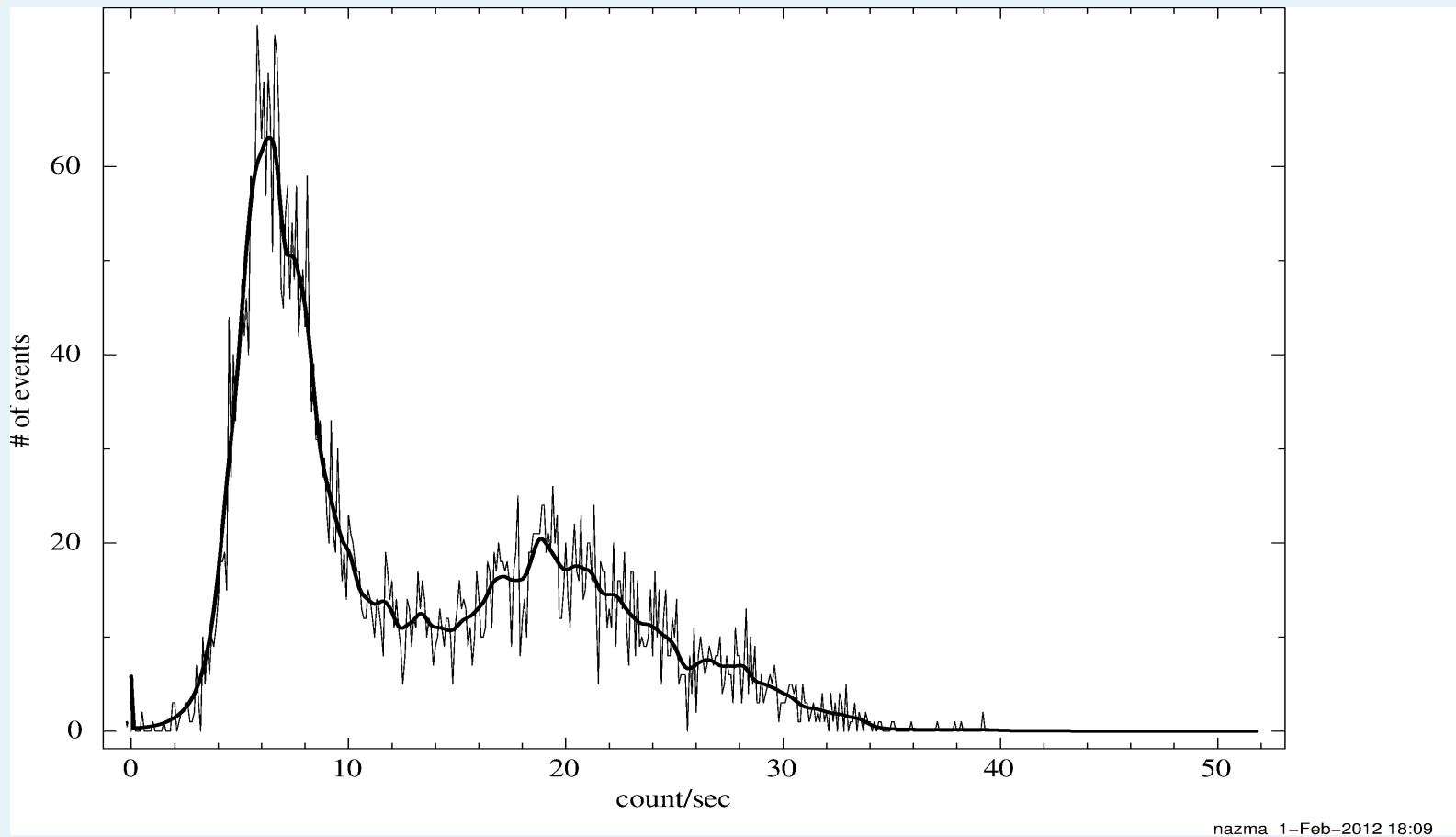


Figure 7: Comparison of differential probability distribution and binned differential histogram of count-rates for Cyg X-3.

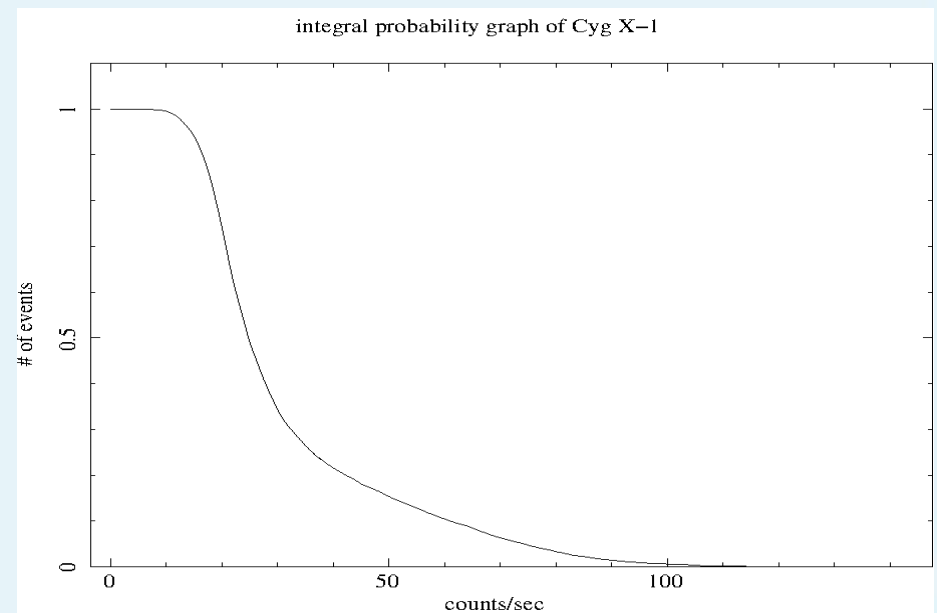
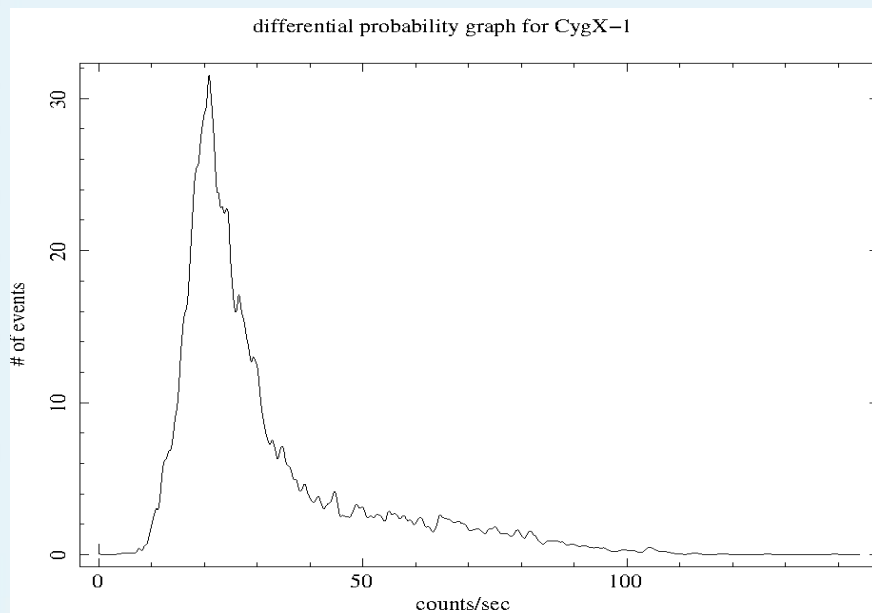
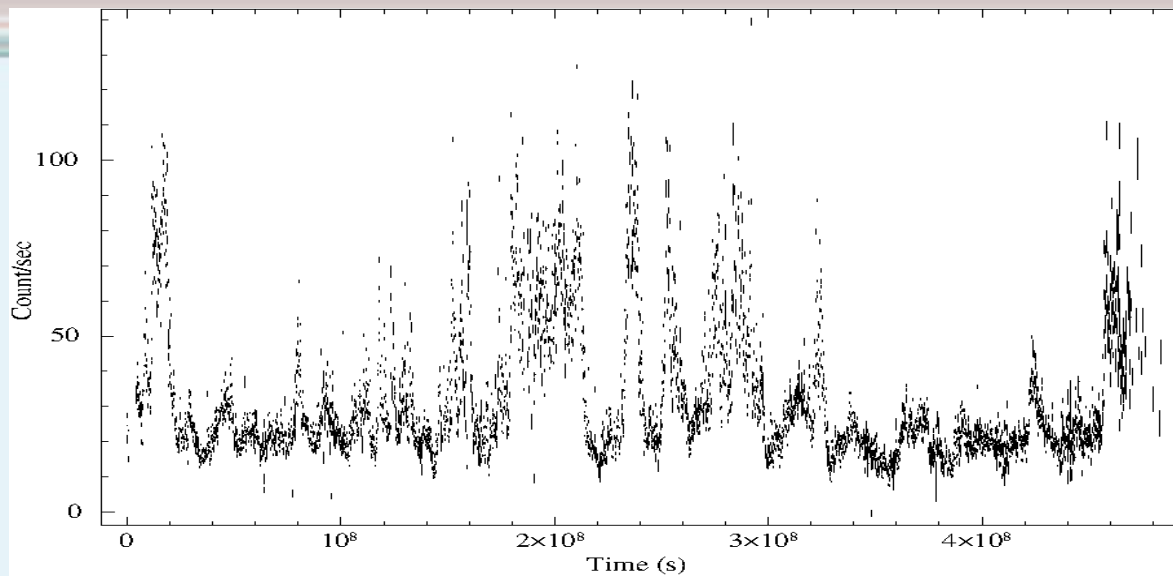


Figure 8: Light-curve of Cyg X-1. The graph on left panel represents differential probability distribution of count-rate and graph on right panel is the integral probability distribution of count-rate.

CONSTRUCTION OF SNAPSHOT OBSERVATION

- A random number is used to determine a particular luminosity for a source, for one iteration.
- X ray luminosity distribution is constructed from the random selection of luminosities of sources.
- For HMXB LF, it is fitted by a **power-law**.

$$N(> L) = K.L^{-a}$$
$$\text{Log}_{10}N = -a.\text{Log}_{10}L + b$$

- For LMXB LF, it is fitted by a **power-law with a cut-off**

$$N(> L) = K.(L^{-a} - L_{max}^{-a})$$
$$\text{Log}_{10}N = b + \text{Log}_{10}(10^{-a.x} - 10^{-a.c})$$

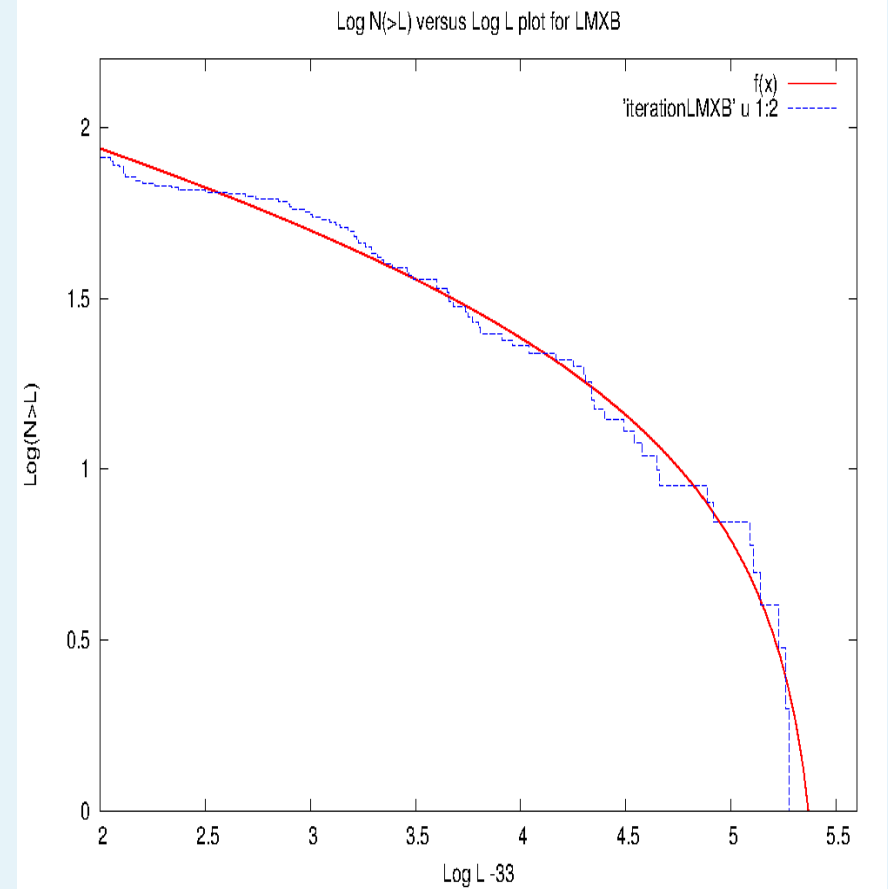
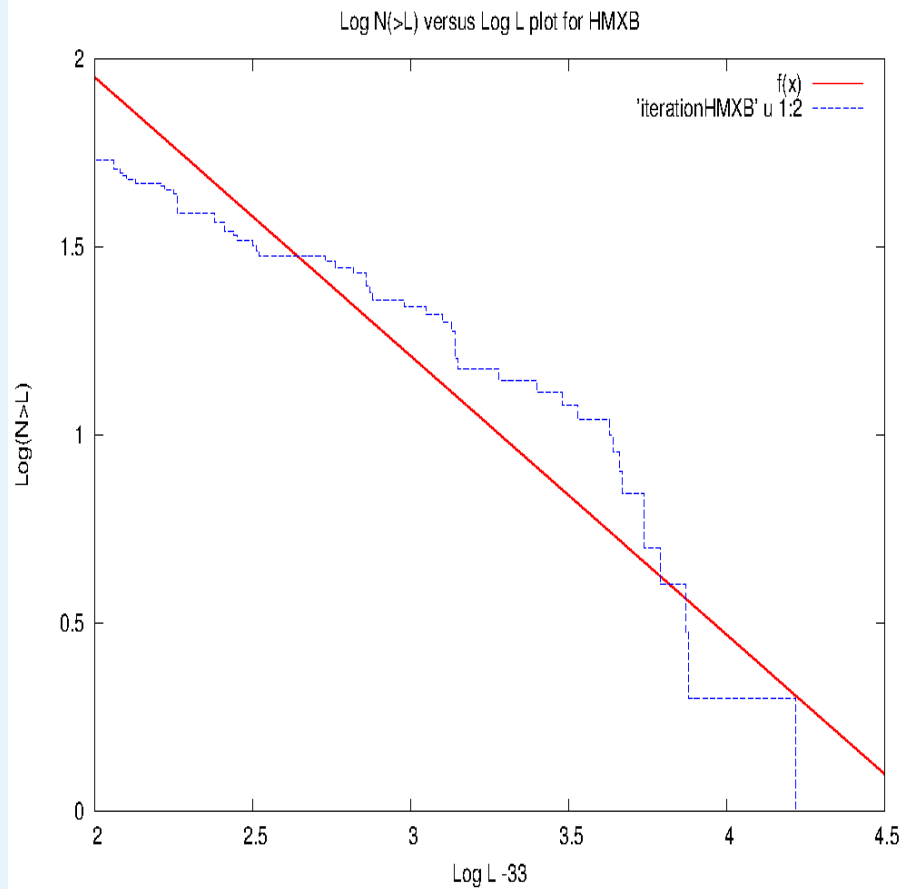


Figure 9: Left panel shows HMXB data and distribution and right panel shows LMXB data and distribution for one iteration

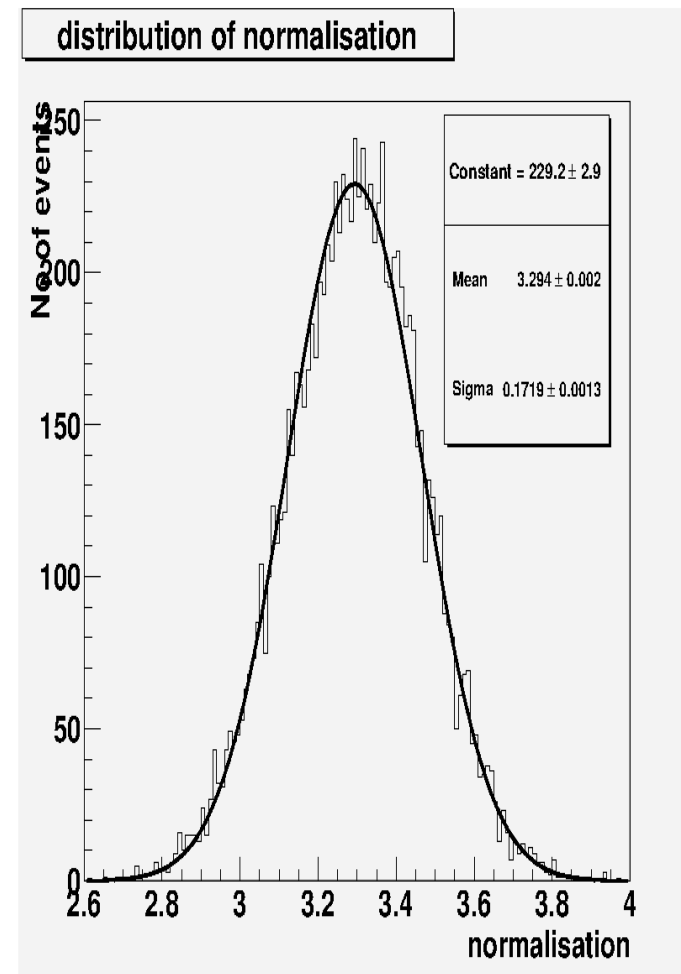
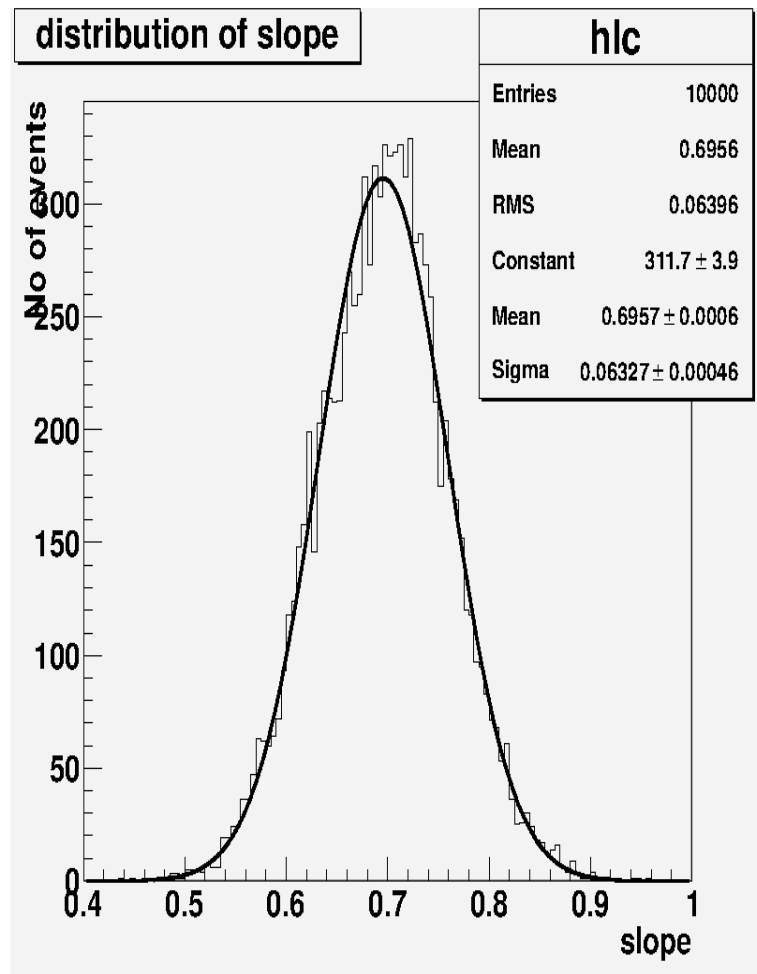


Figure 10 : HMXB fit parameter values for 10,000 iterations

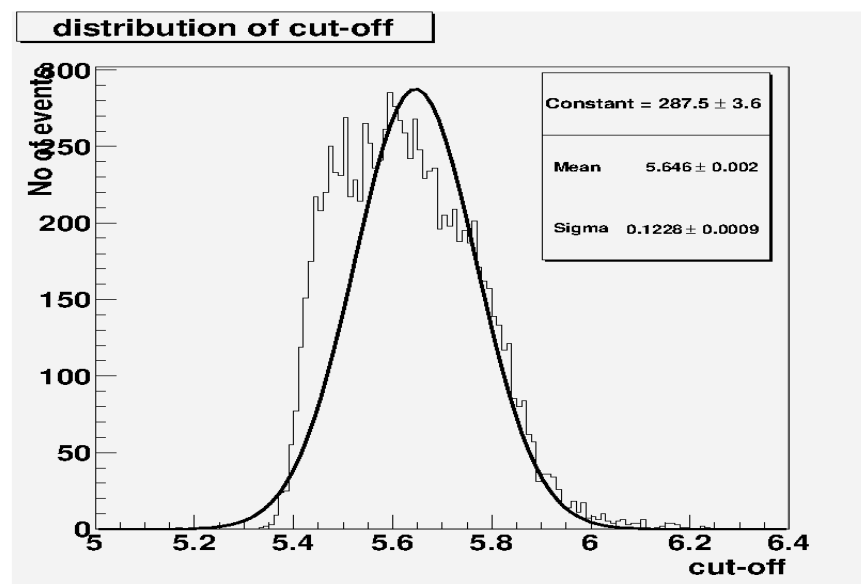
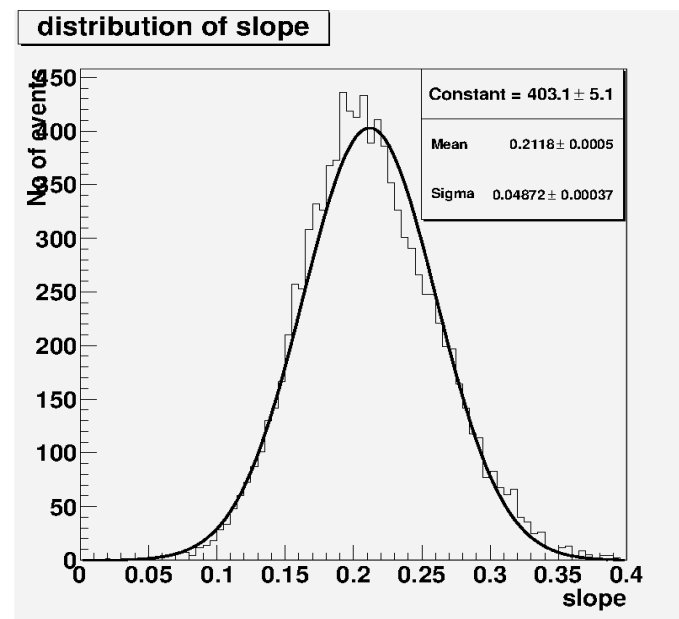
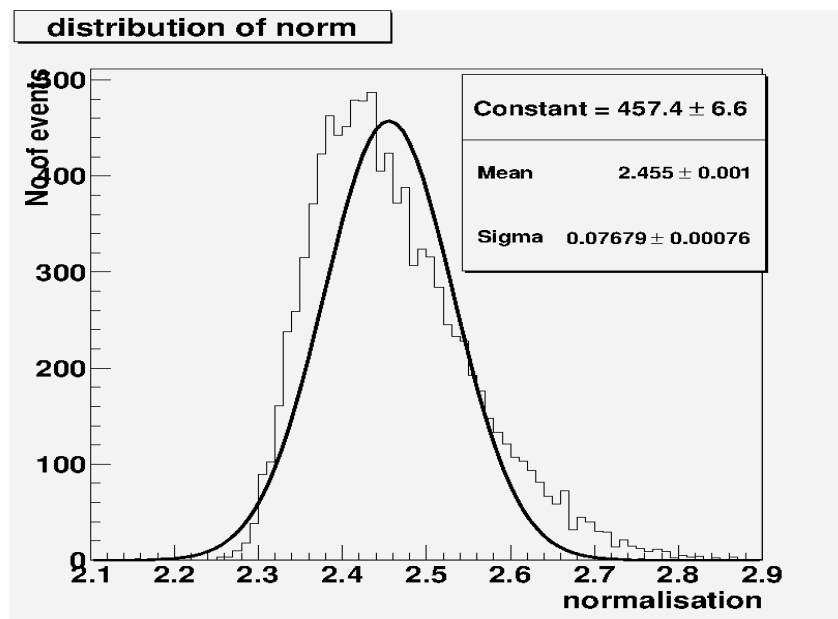


Figure 11 : LMXB fit parameters for 10,000 iterations

AVERAGED X RAY LUMINOSITY FUNCTIONS

- X ray luminosity functions are constructed for 5 years and 15 years averaged data for HMXB and LMXB.

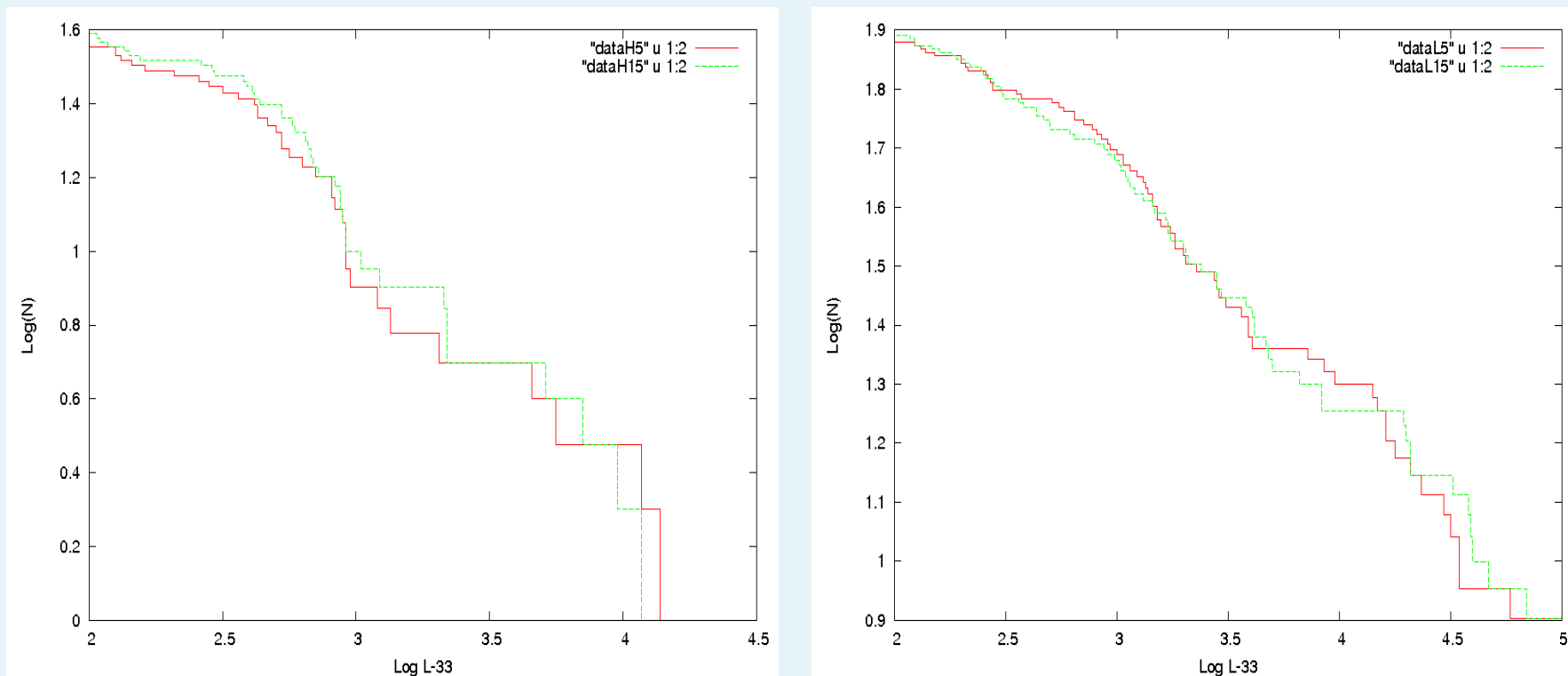


Figure 12 : Comparison of averaged XLF constructed for 5 yr and 15 yr for HMXB (left panel) and LMXB (right panel).

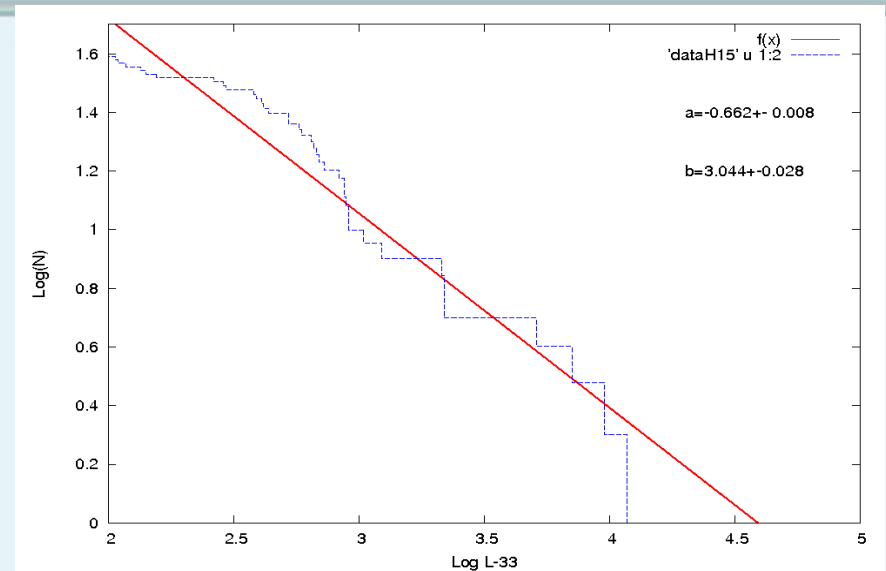
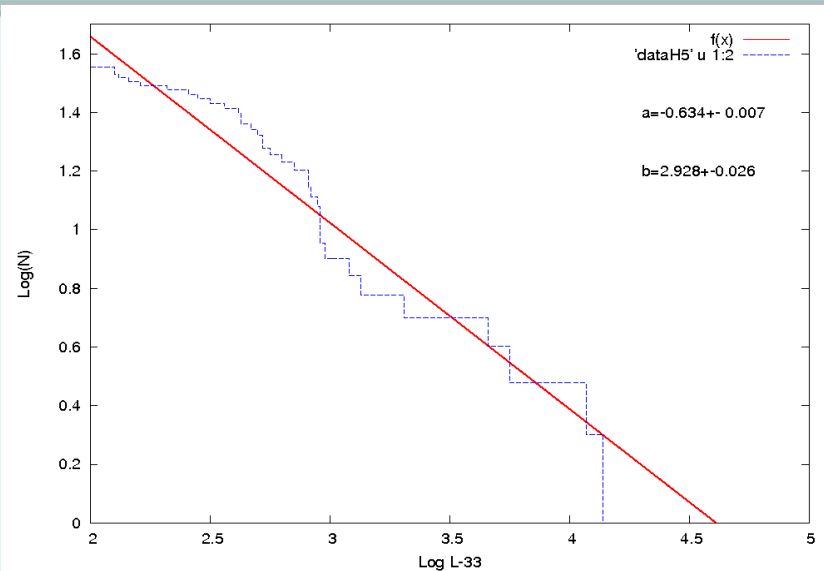


Figure 13: Graph of averaged HMXB XLF for 5 yr (left panel) and 15 yr (right panel) data

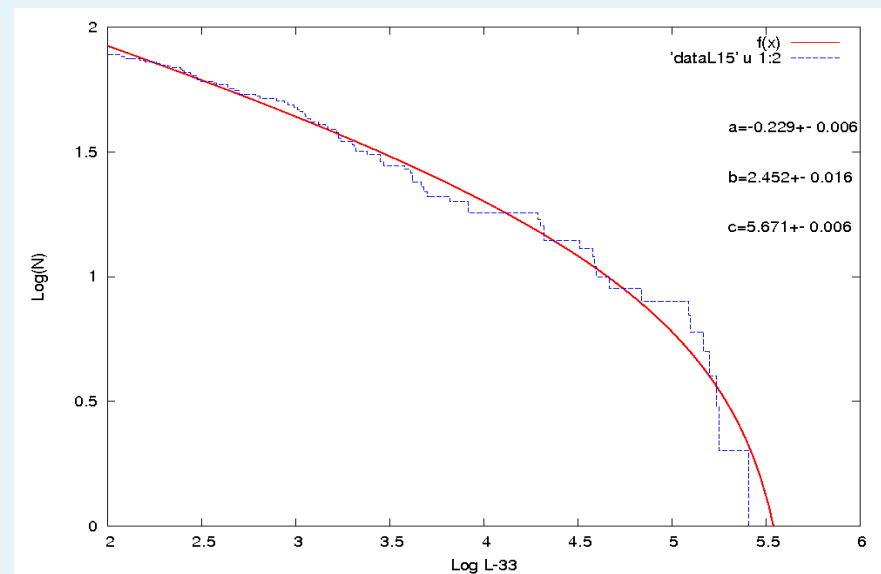
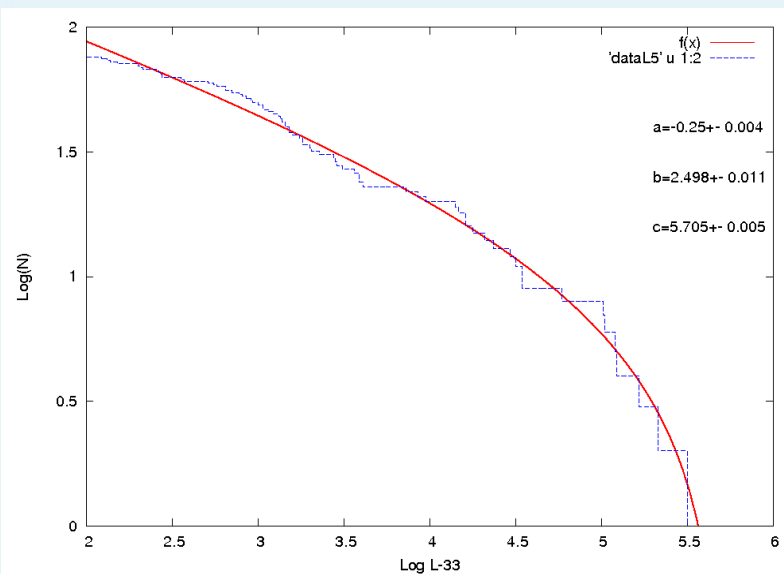


Figure 14: Graph of averaged LMXB XLF for 5 yr (left panel) and 15 yr (right panel) data

DISCUSSIONS AND CONCLUSION

- The **HMXB luminosity function**, taking into account variability of X ray sources

$$N(> L) = (79.909 \pm 1.157) \left(\frac{L}{10^{35} \text{erg/s}} \right)^{-(0.696 \pm 0.063)}$$

- The **LMXB luminosity function**, taking into account the variability of X ray sources

$$N(> L) = (107.497 \pm 1.193) \left(\left(\frac{L}{10^{35} \text{erg/s}} \right)^{-(0.212 \pm 0.049)} - (4425.88 \pm 1.326)^{-(0.212 \pm 0.049)} \right)$$

- Effect of variability of X ray sources introduces a variance in parameter values.

DISCUSSIONS AND CONCLUSION

- The averaged XLF for 5 and 15 years show a deviation in their parameter values, implies the role of variability.
- For M82 (Chiang et.al 2010), the value of slopes are quoted for 7 observations, ranging from -0.63 to -0.72. The range of slope values are found consistent with σ of slope parameter of HMXB LF.
- Future work involves quantifying the variance of XLF in other galaxies (after normalising with suitable parameter) and correlating it to the spread due to variability of X ray sources.
- Effect of number distribution of BH XRBs on the XLF parameter values is being investigated.

THANK YOU