# Low-Luminosity X-ray Sources in the Galactic Bulge

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## Wang, Gotthelf, & Lang (2002)

- $2^\circ \times 0.8^\circ$
- 30 pointings @ $\sim$10 ks
- $\lesssim$1000 sources
- 1–3 keV, 3–5 keV, 5–8 keV
- $S_\mathrm{X} \gtrsim 10^{-13}$ ergs s$^{-1}$ cm$^{-2}$
- $N_\mathrm{H} \sim 10^{23}$ cm$^{-2}$

## Nature of the Point Sources

- Absorption $\Rightarrow \begin{cases} \text{soft sources } \textit{foreground} \\ \text{hard sources } \textit{intrinsically hard} \text{ and } \textit{distant} \end{cases}$

- Comparable numbers of soft ($\lesssim$3 keV)/hard ($\gtrsim$3 keV) sources.

- $L_{\mathsf{X}} \sim 10^{33}$ ergs s$^{-1}$ at the distance ($\sim$8.5 kpc) of the GC.

- $\sim$1–10% of Galactic star formation in 1.6 deg$^2$ field.

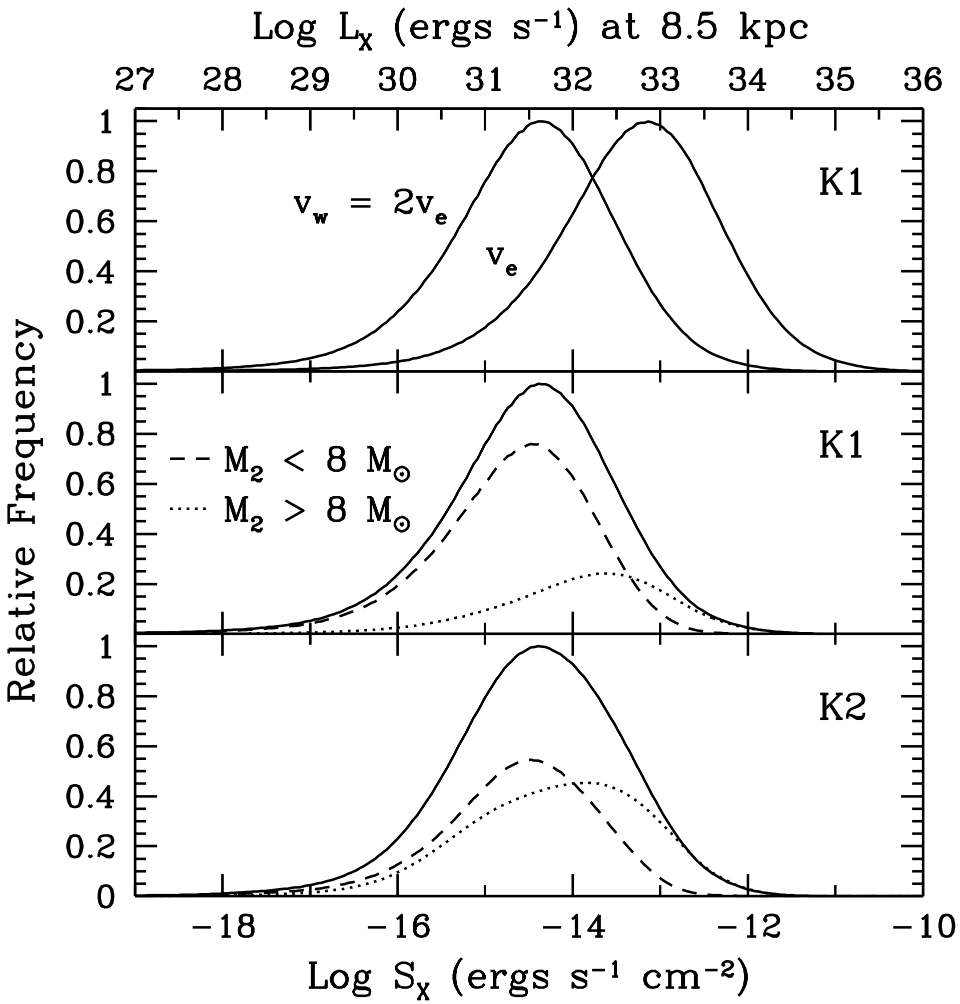
## Nature of the Point Sources (Cont.)

| Type | $\log L_X$ | Spectrum | $N$ (1.6 deg$^2$) |
|---|---|---|---|
| AGN | ... | H | $\sim$50–100 |
| Stars | $\sim$30 | S | lots |
| LMXBs | $\lesssim$34 | H | $<$100 (?) |
| BHBs | $\lesssim$32 | H | $<$100 (?) |
| Iso. NSs | $\lesssim$34 | H | (?) |
| CVs | $\lesssim$33 | S,S,H | $\sim 10^4$ |
| WNSs | $\lesssim$35 | H | $>$100 (?) |

## Wind-Accreting Neutron Stars

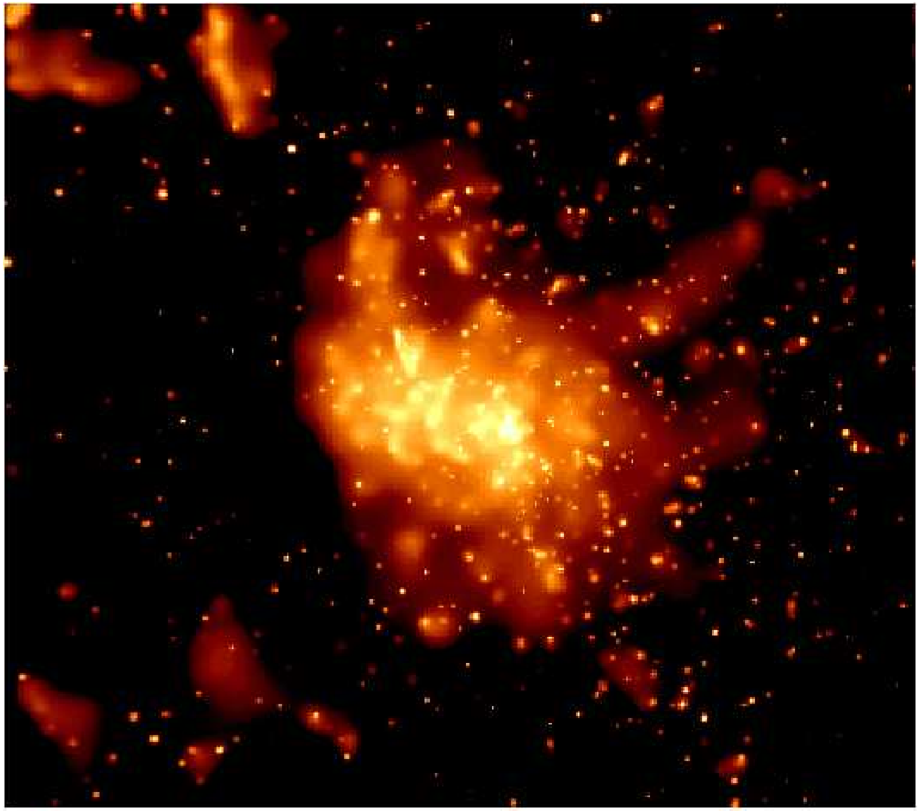
- Rate for core-collapse SNe $\sim 10^{-2}$ yr$^{-1}$.
- Fraction of post-SN binaries with $M_2 \sim 3 - 20\ M_\odot \sim 10\%$.
- $\langle \tau_{\rm MS} \rangle$ of companions from pop. syn. $\sim 10 - 100$ Myr.
- Fraction of PB progenitors in 1.6 deg$^2$ $\sim 1\%$.
- Multiply to obtain $\sim 10^2 - 10^3$ WNSs.

# Wind-Accreting Neutron Stars (Cont.)




- Results of BPS
- 10s to 100s in 1.6 deg$^2$
- $L_X \propto V_{\text{wind}}^{-4}$
- IM systems important
- $K \sim 11$–$16$

# Baganoff, Garmire, Muno et al.



(NASA/MIT/PSU)

Image provided by Michael Muno (MIT)

- $8.5' \times 8.5'$ field
- 500 ks exposure
- $S_X \gtrsim 5 \times 10^{-15}$
- $\log L_X \gtrsim 31$ at GC
- 4–8 keV
- ~1000 sources!!!
- <5% AGN
- ~0.1–1% of Galactic SF

# Baganoff, Garmire, Muno et al. (Cont.)

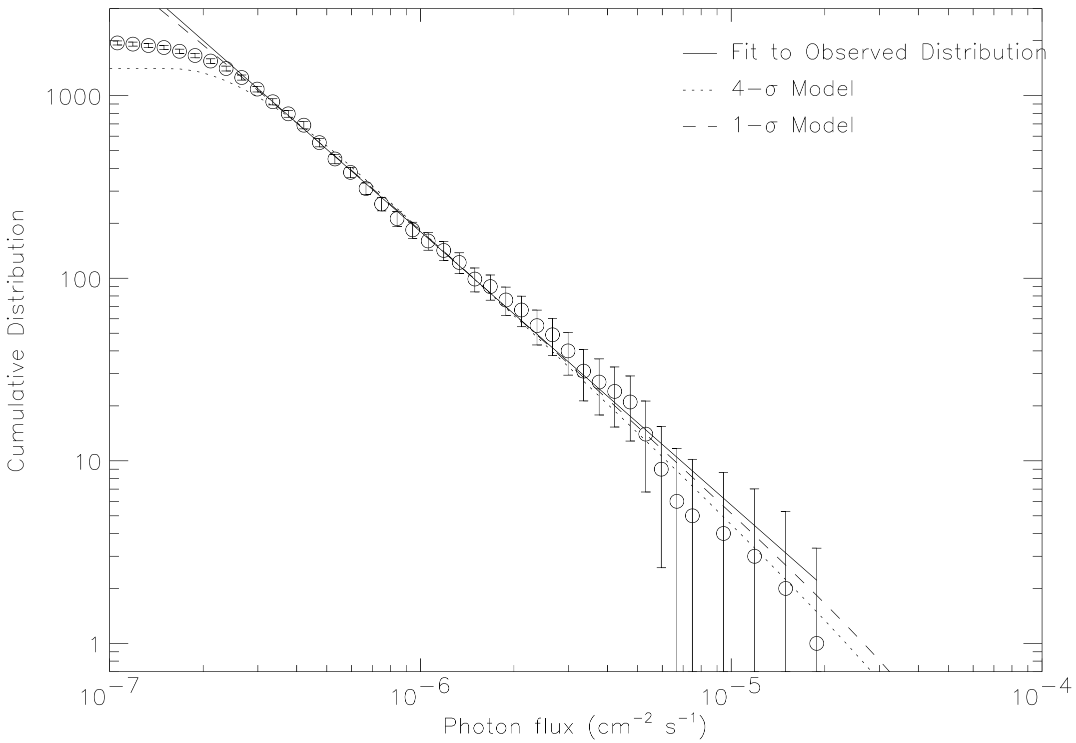



Figure provided by Michael Muno (MIT)

- $17' \times 17'$ field (ACIS-I)
- 0.5–8 keV
- $\sim$2000 total sources
- $\sim$10% with $\log L_X > 32$

# Massive Binary Population Synthesis

(1) Choose the parameters of the *primordial binary*.

(i) primary mass: e.g., $p(M_1) \propto M_1^{-2.5}$

(ii) secondary mass: e.g., $p(M_2/M_1) = \text{constant}$

(iii) semimajor axis: e.g., $p(a) \propto a^{-1}$

(2) Decide if mass transfer is stable or dynamically unstable, and evolve the binary parameters. Only the core of the primary remains.

(i) stable: $a$ changes by, e.g., $\pm 50\%$, and the seconday accretes a substantial amount of material

(ii) dynamically unstable: $a$ decreases by $\sim 99\%$, and the secondary accretes nothing

(3) Compute the changes in orbital parameters that result from the mass loss and NS kick associated with the supernova explosion of the primary's core.