Galactic X-ray Source Populations

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Plan

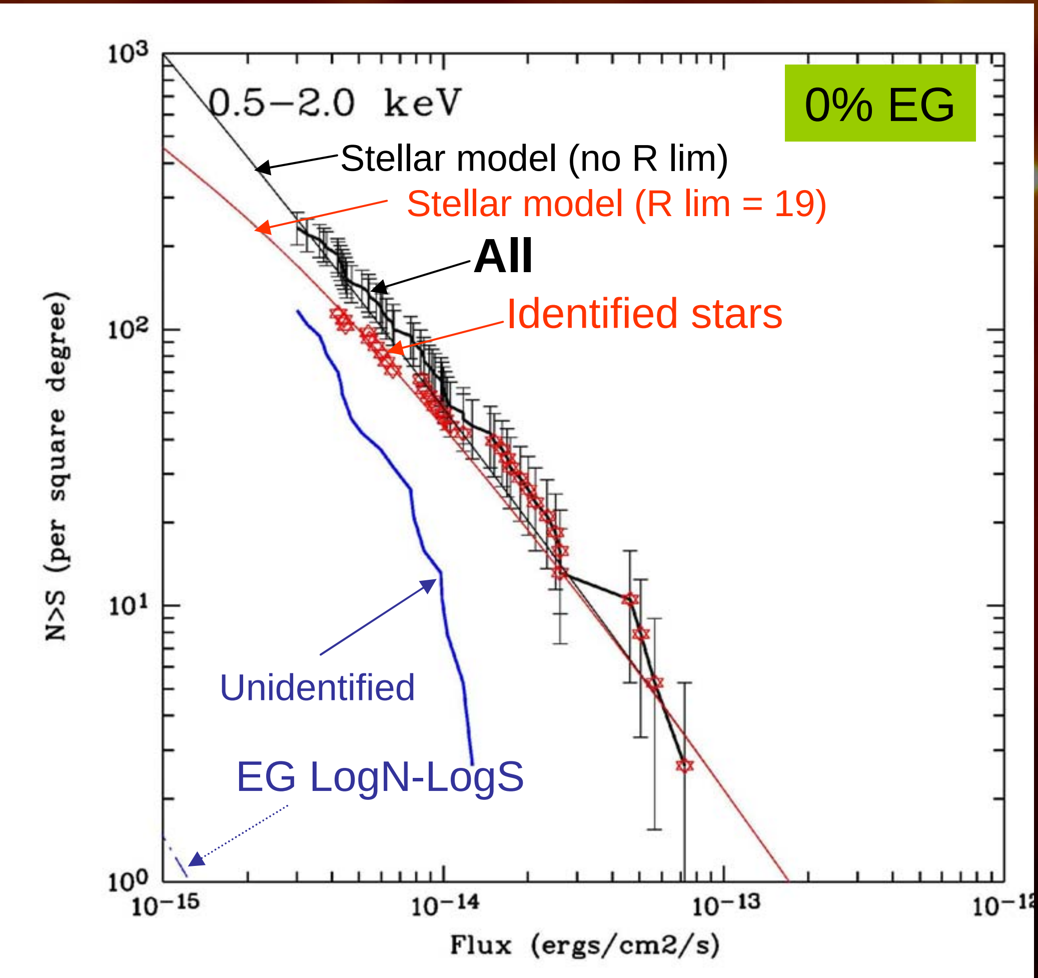
- Source populations
- Galactic Ridge Emission
- New classes of sources
- Science drivers
- A legacy slew Galactic Plane Survey

Source populations

- Galactic sources emit X-rays through quite different mechanisms:
  - "Classical" high and low-mass X-ray binaries Lx ~10^{33-39} erg/s (accretion onto a neutron star or a black hole, active and quiescent states)
  - Cataclysmic variables; dwarf novae, magnetic systems, supersoft sources (accretion onto a white dwarf) Lx ~ 10^{30-32} erg/s
  - Active coronae, TTauri, RS CVn binaries (magnetic coronal activity) Lx ~ 10^{28-31} erg/s
  - Massive stars (shocked and colliding winds) Lx~10^{29-34} erg/s
  - Young cooling isolated neutron stars Lx ~10^{29-36} erg/s
- Dominating source population depends on energy range and flux level.

Soft sources

The "average" soft X-rays galactic plane (b ~0°; l~20°-30°)



Stars dominate X-ray counts in the soft X-rays.

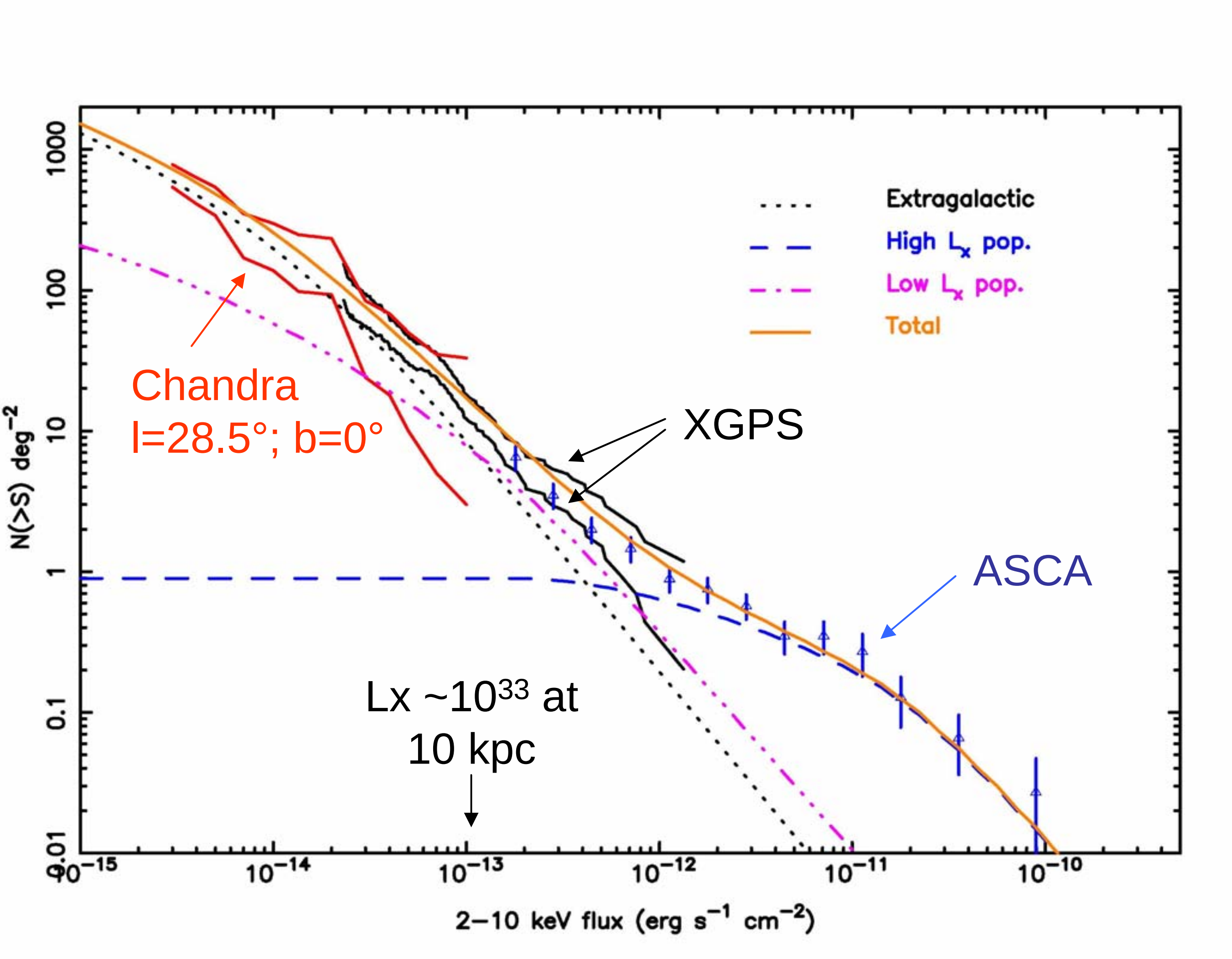
Density of active stars mainly varies with galactic latitude (young stars are still close to their birthplace).

At intermediate latitudes (> 2-3°), AGNs start contributing to the detected soft X-ray population

CVs contribute marginally to the soft band

Hard sources

The “average” hard X-rays galactic plane (b ~0°; l~20°-30°)

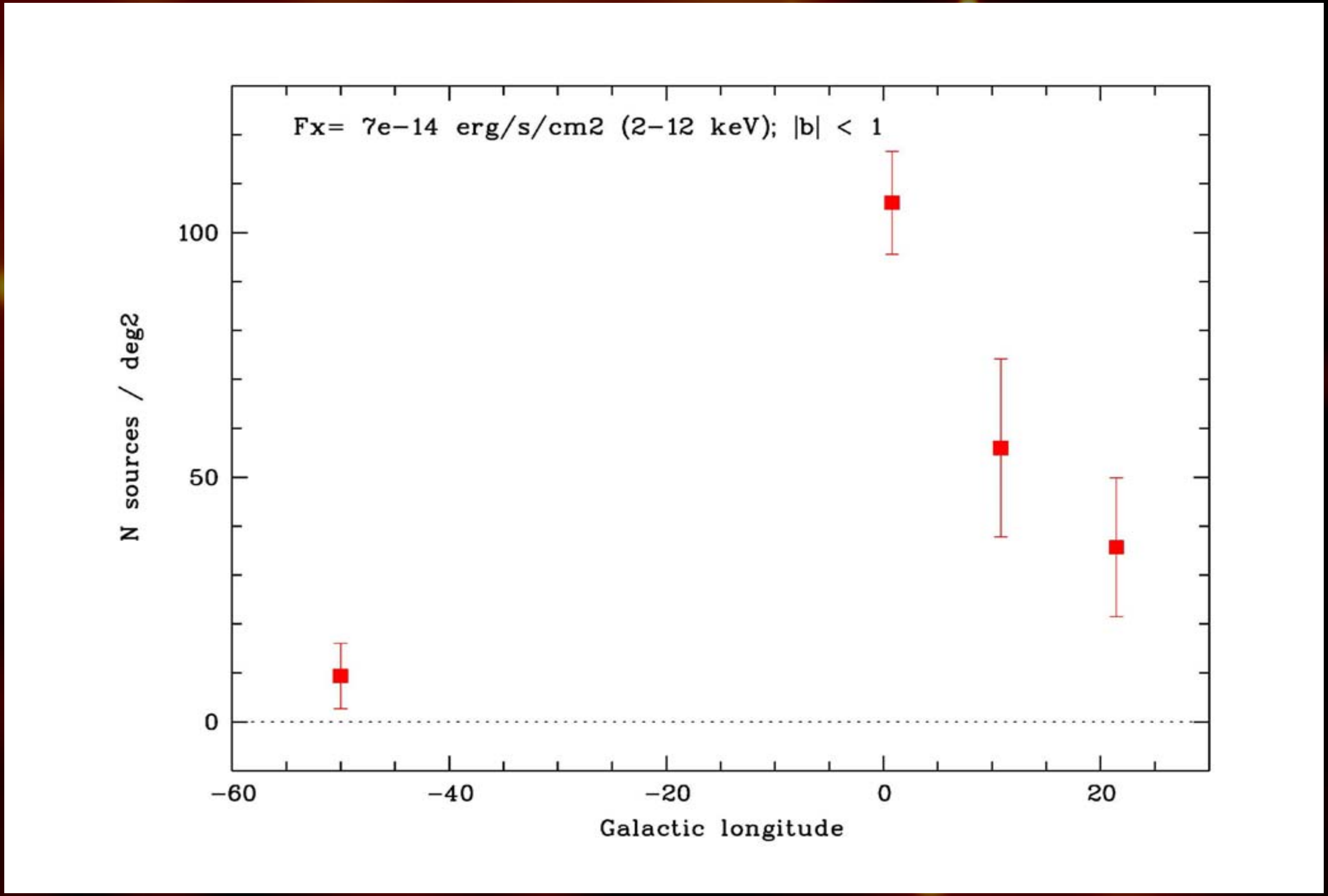


A population of “hard” galactic X-ray sources emerges at F_x > 5 10^{-14}ergs/s/cm^2

Hands et al. 2004

Hard sources

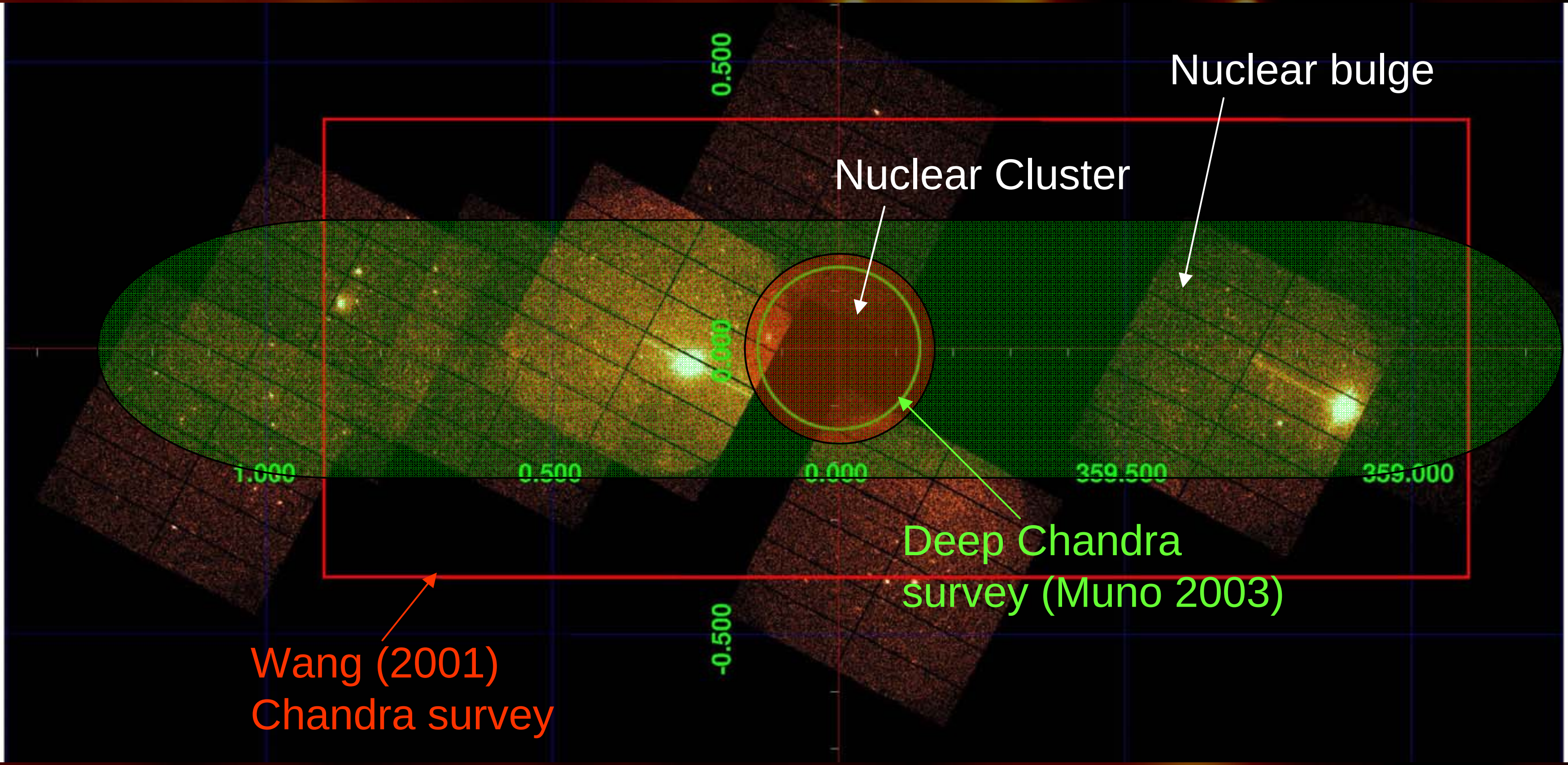
Density of hard X-ray sources above the extragalactic background
(based on XMM-Newton observations)



Motch et al. 2007

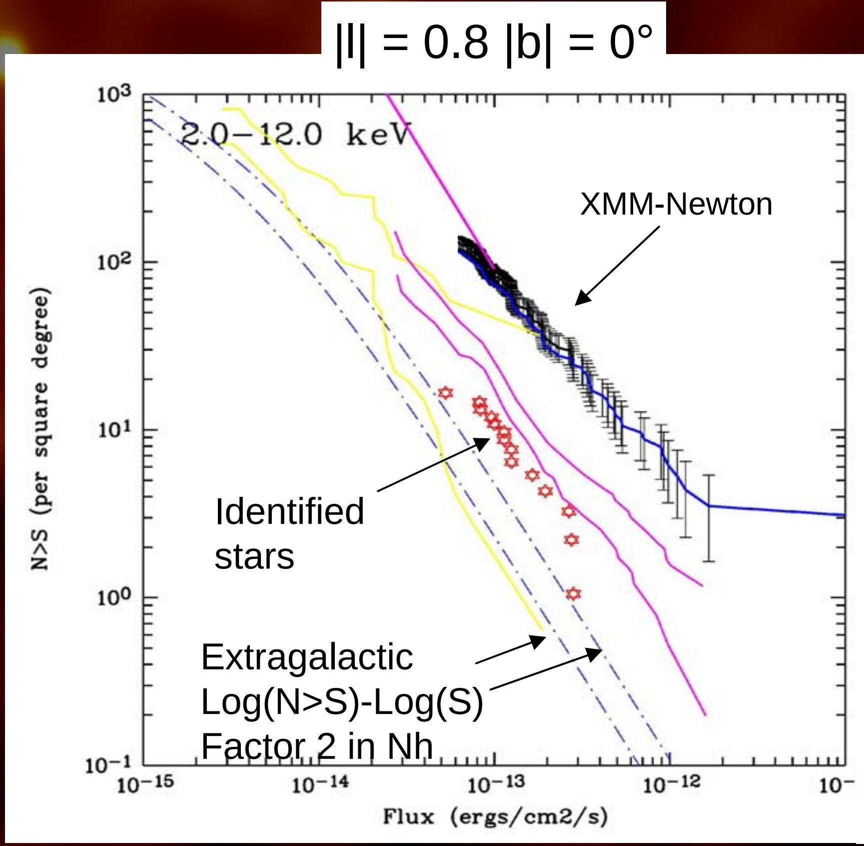
Chandra and XMM-Newton observations of the Galactic Center region

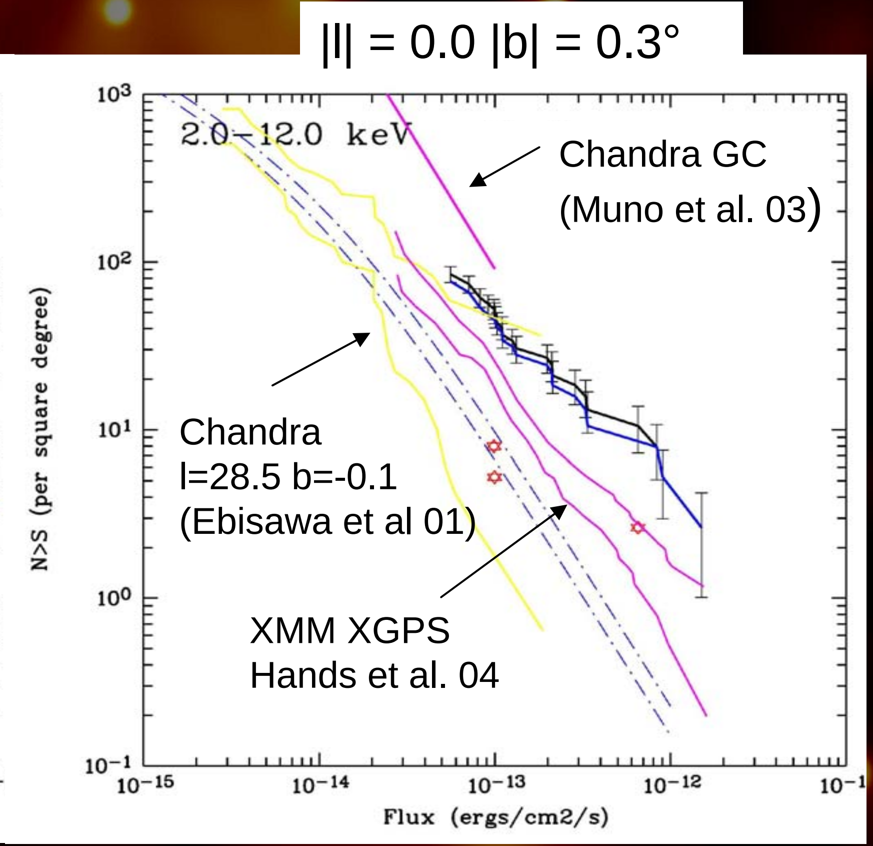
Nuclear bulge: flat disc-like structure with high stellar density and ongoing SF (R ~ 230 pc, z ~45 pc; Launhardt et al. 2002)
Nuclear cluster: Very high stellar density varying as R^{-2}



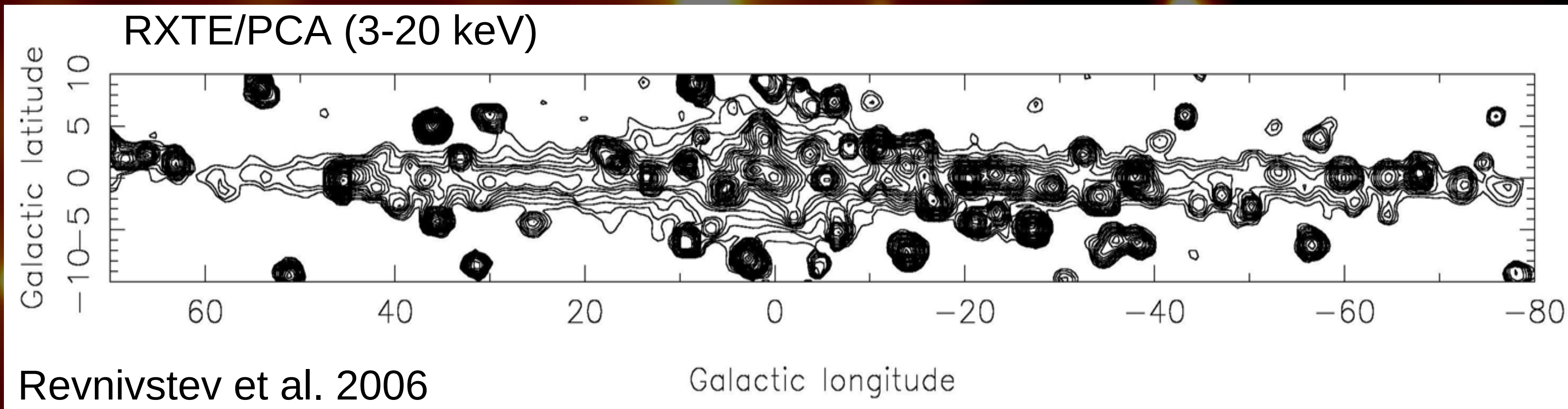
XMM-Newton survey of the nuclear bulge region

- A strong excess of hard sources is detected up to ~1 deg in longitude from GC
- No clear density change with longitude but a decrease with latitude possibly consistent with the nuclear bulge scale height (45 pc) (see also Muno et al. 2006)





Galactic Ridge unresolved emission

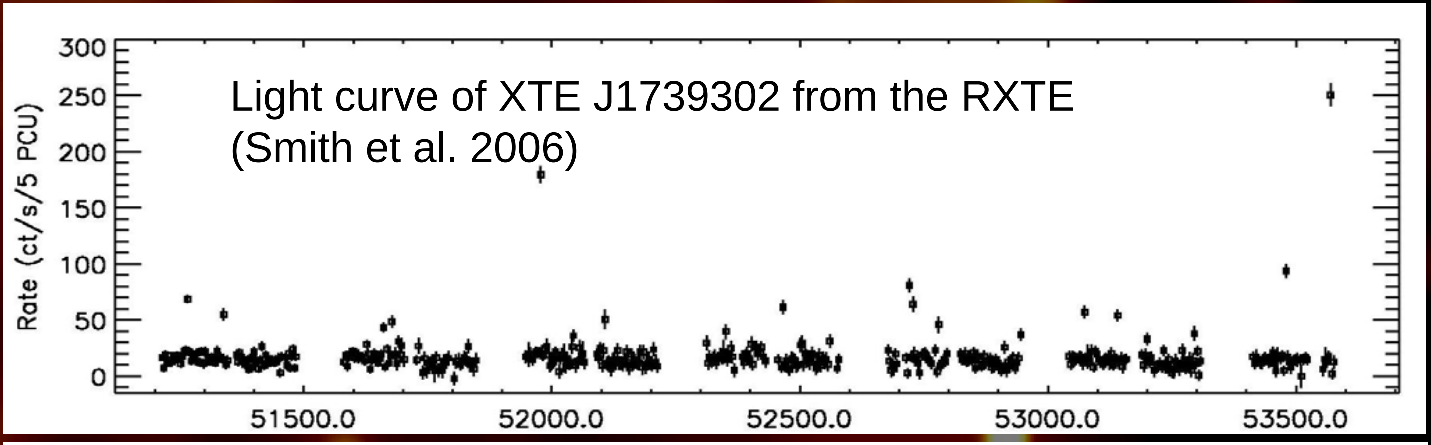


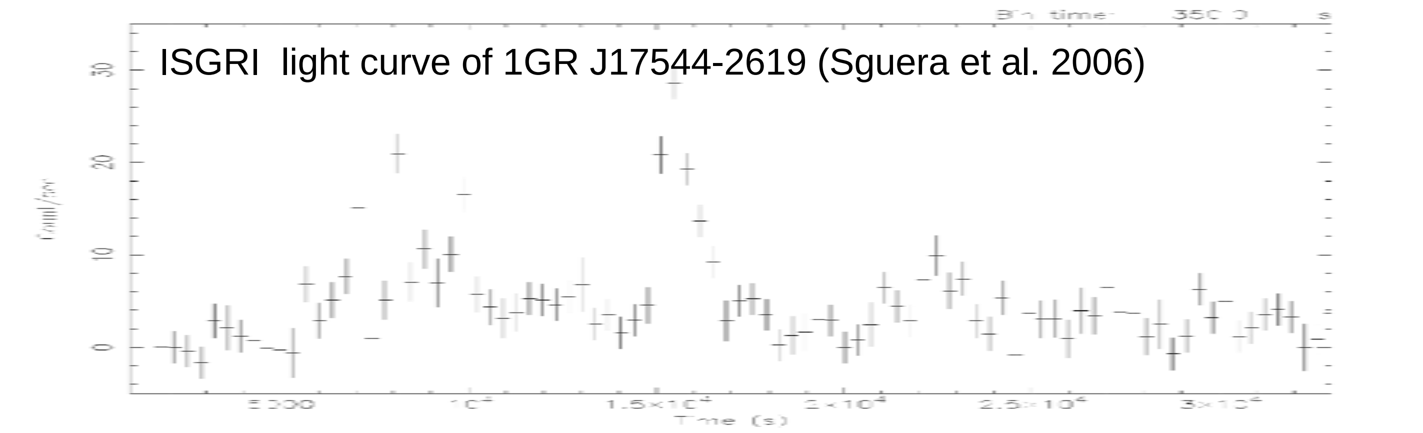
- Extended hard X-ray emission discovered by Warwick et al. 1985 from EXOSAT scans
- Intensity follows the Galactic stellar mass distribution
- Has a thermal-like continuum with kT ~ 10 keV but line intensities apparently do not fit.
- Gas temperature is much higher than can be bound by galactic gravity
- Debated contribution of unresolved source
- Currently, no accepted theoretical model

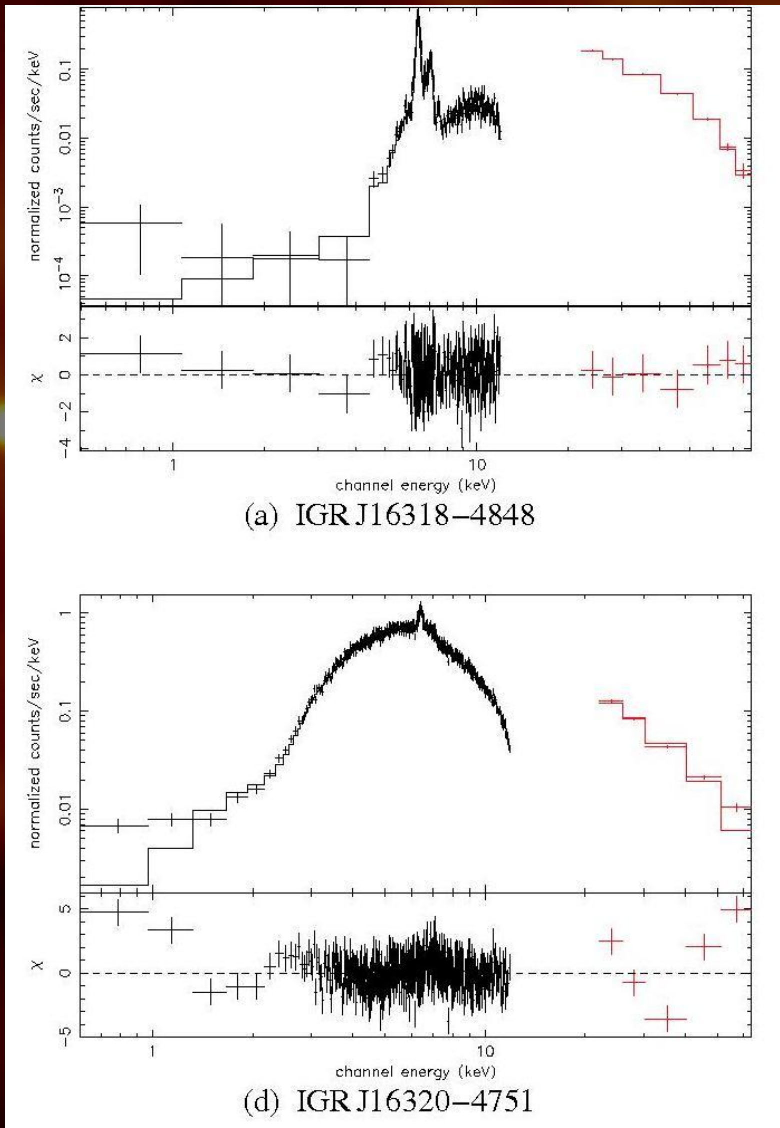
<u>See R. Warwick talk today</u>

A new class of Supergiant Fast X-ray Transients

- Discovered in the INTEGRAL galactic plane survey and RXTE
- Many sources remain undetected apart during short outbursts







Walter et al. (2006)

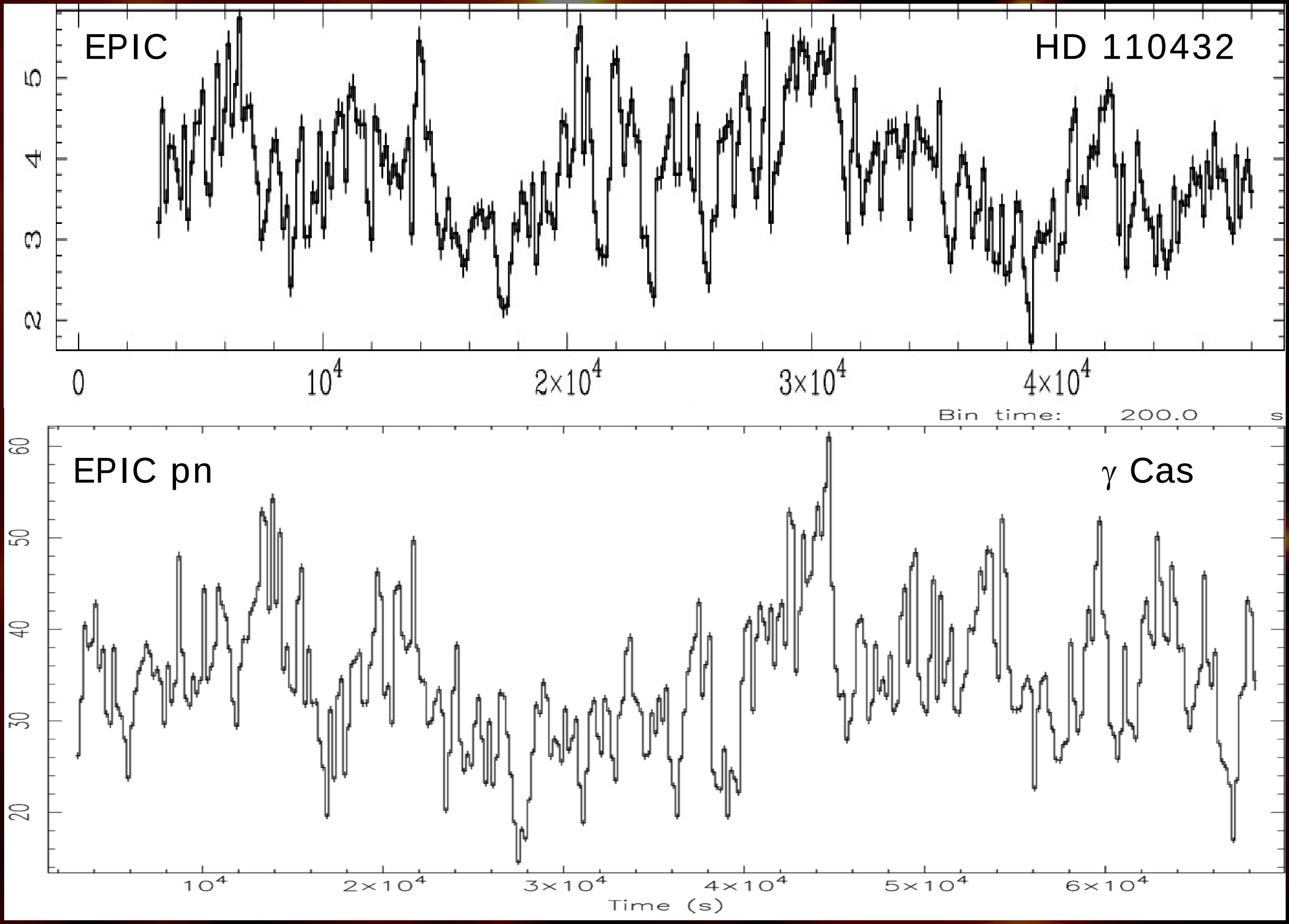
- Follow-up XMM-Newton observations revealed a high intrinsic absorption (NH > 10^{23} cm^{-2}) and provided accurate positions.
- Optically identified with supergiant stars (Negueruela et al. 2007)
- Concentrate in the Norma arm
- High absorption in the dense SG wind
- Mechanism leading to the transient behaviour remains unknown
- Very significantly enlarges the number of known SG XRBs

A new class of γ-Cas analogs

- Serendipitous discoveries in X-ray surveys (XMM-Newton is the main contributor)
- "Normal" Be stars (all B0.5-Ie)
- X-ray luminosities ~ 10^{32}erg/s (10 x those of normal OB stars and < 0.1 those of Be/X-ray transients in quiescence)
- Hard thermal X-ray spectra (kT > 7-20 keV) much harder than those of normal OB stars (kT ~ 0.5-1.5 keV)
- Variable on various time scales (hours to few seconds)
- Two interpretations considered so far:
  - Accretion onto a compact object ? (a white dwarf, as predicted by massive binary evolution)
  - Magnetic star – circumstellar disc -star interaction ? (fossile B ?, progenitor of magnetars ?)

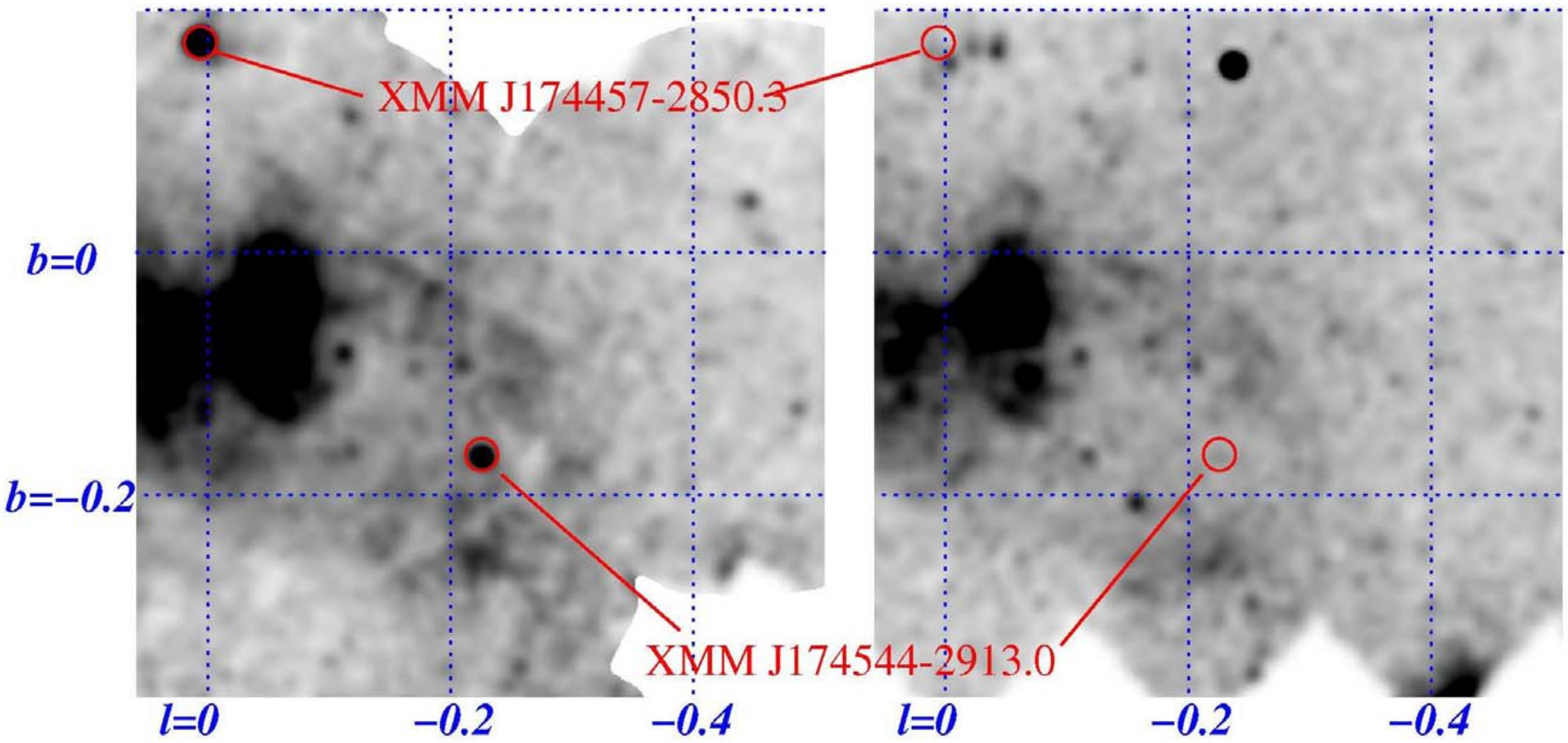
Lopes de Oliveira et al. 2006, 2007

γ-Cas analogs: short time scale variability



Very faint X-ray transients

Sakano et al. 2005



Very faint X-ray transients

- A new class of X-ray transients with peak luminosities of ~ few 10^{34}erg/s (Hands et al; 2004; Sakano et al. 2005)
- Factor ~100 change in one year
- Concentrated in the region of the Galactic Center
- Likely low-mass X-ray binaries (no bright optical counterparts)
- Some show X-ray bursts
- Why is Mdot so small ?

Science Drivers (1)

- “Low” Lx galactic sources allow to study various emission mechanisms and evolutionary processes that cannot be constrained from observations in external galaxies (too faint flux and spatial resolution).
  - Specific source populations in the central regions, arms, bulge
  - Past SFR. Remnants of early stellar formation. Search for IMBHs and old Pop III binaries.
  - Origin of the Galactic Ridge. Separate truly diffuse from unresolved emission

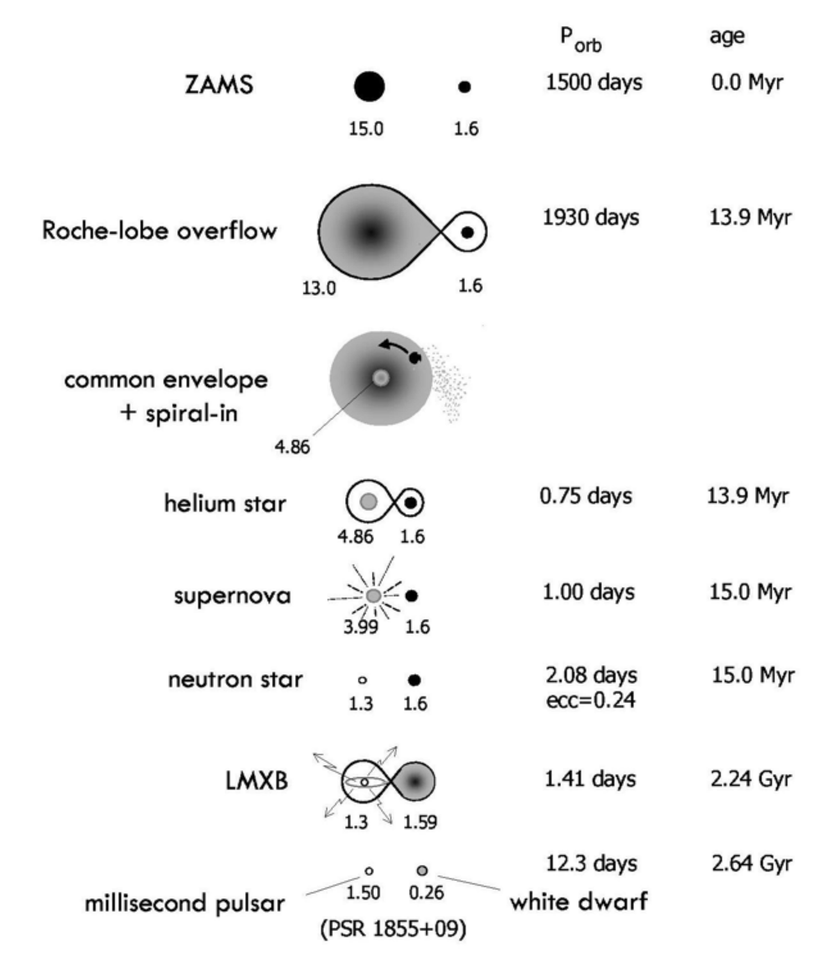
Science Drivers (2)

- Properties of the young stellar galactic population (scale height, recent SFR, spatial distribution, clustering). Young stars are the most X-ray luminous !
- CV demography (10^{6-7} CV expected in the Galaxy). Density, Scale height, Distribution in the Galaxy. Impacts on galactic novae rate. Connects to origin of LMXB and SNIa.

Science Drivers (3)

- Low X-ray luminosity evolutionary states of classical X-ray sources. Strong test of binary evolution models.
  - High mass systems:
    - Massive binaries with white dwarf companions (e.g. Be + WD).
    - Short lived supergiant wind accreting X-ray binaries
    - Accretion mechanisms at low Mdot (ADAF, propeller effects, neutron star crust heating, etc..)

- Low mass systems:

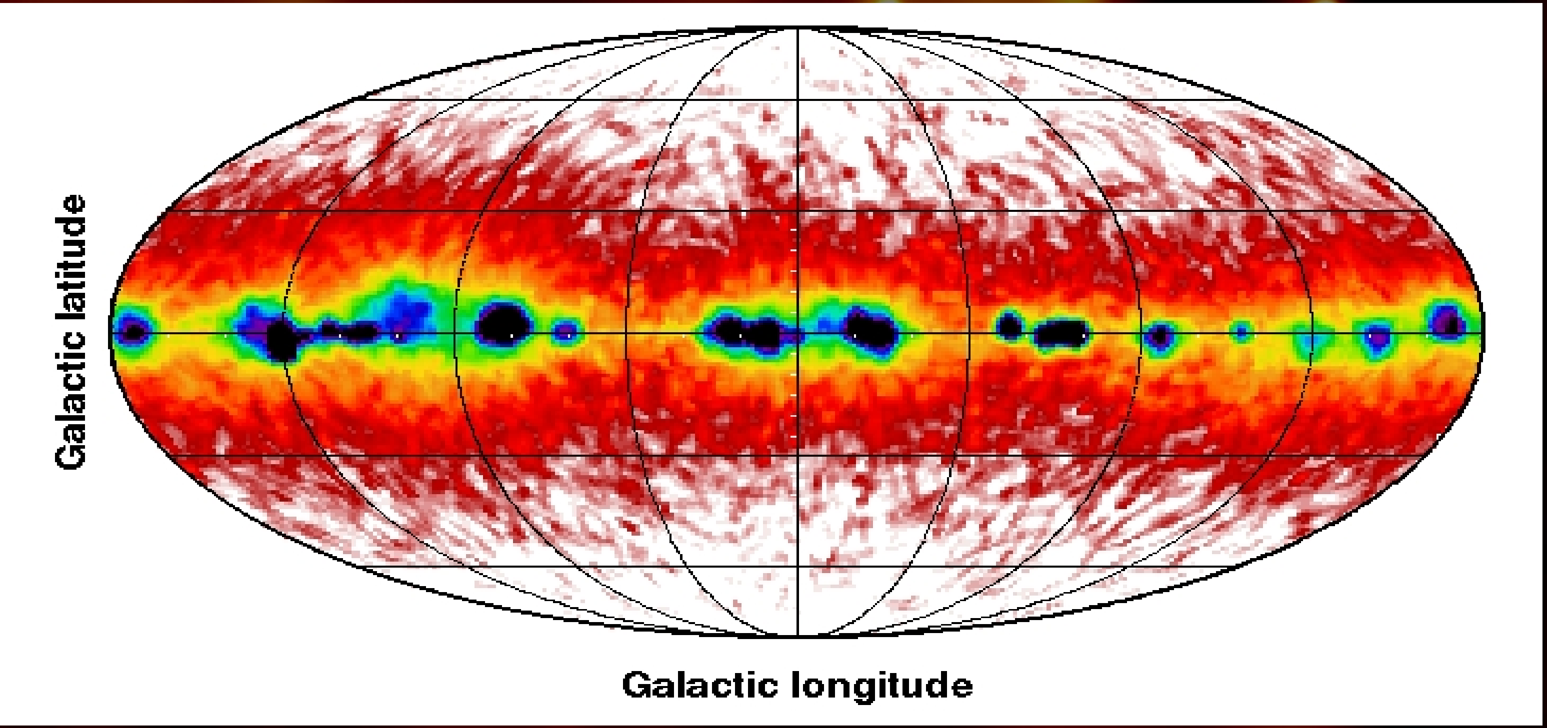


Binary evolution leading to a Low-Mass X-ray binary
(Tauris & Van den Heuvel (2006)

- Wind accreting X-ray binaries (10^6 in the Galaxy?) (Pfahl et al. 2002)
- Wind accreting neutron stars in evolutionary precursors of LMXB. (10^{4-5} expected) (Willems & Kolb 2003)
- Transients in quiescence

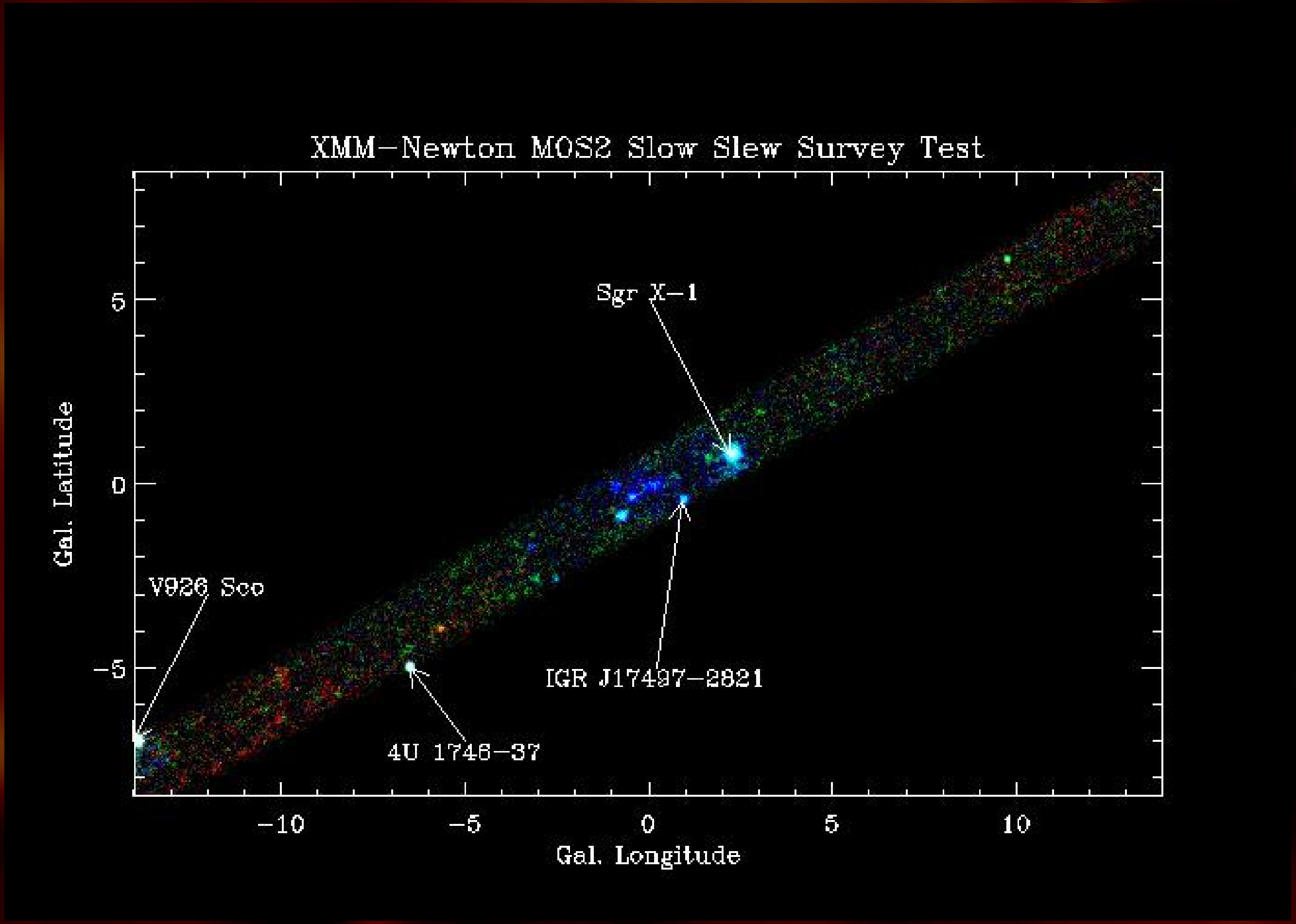
Science Drivers (4)

- Isolated compact objects
  - Past and recent massive star formation.
  - What is the actual proportion of radio-quiet young neutron star ?



Expected detectable density of thermally emitting young neutron stars in the Galaxy (Posselt et al. 2007)

The XMM Slow Slew Survey Test

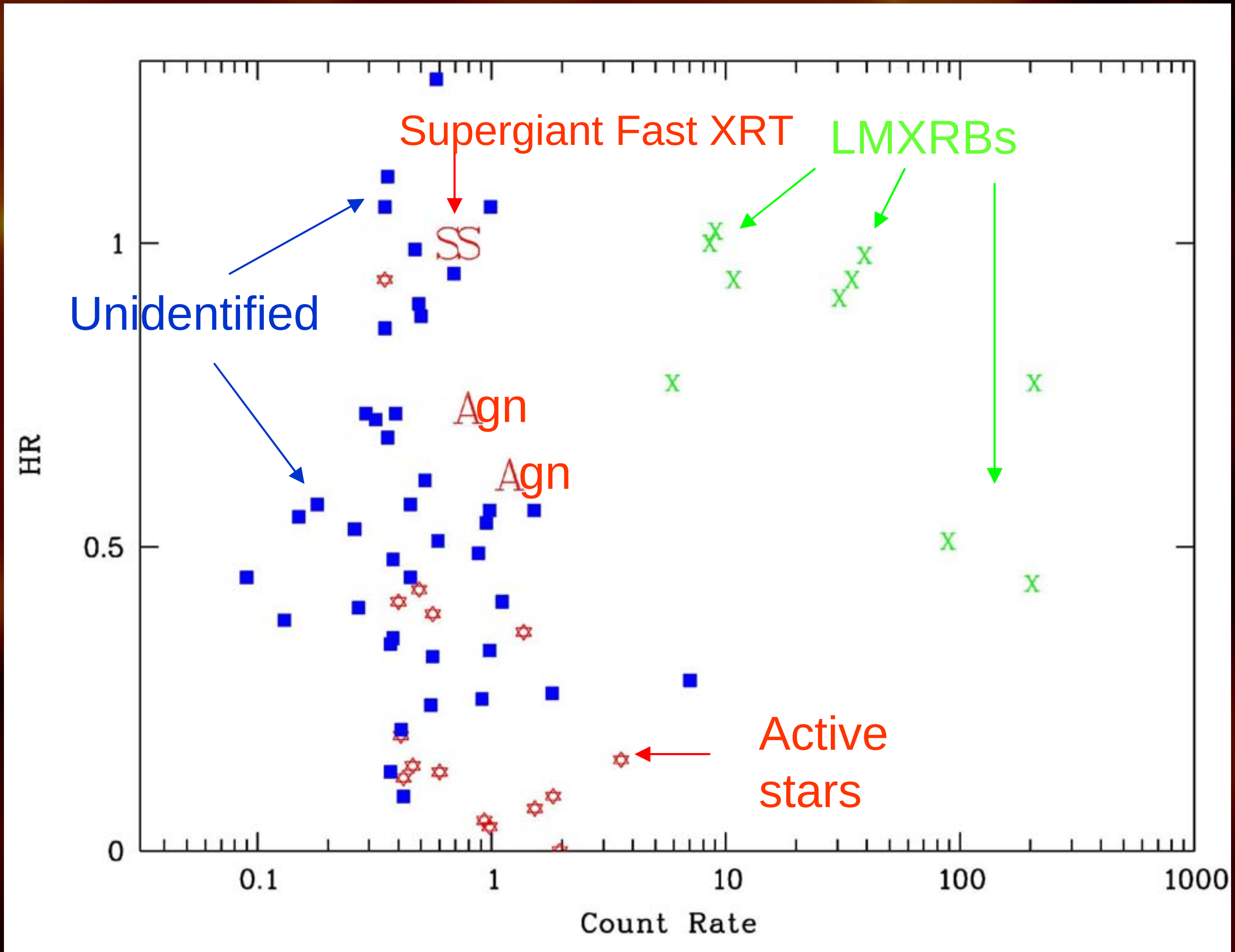


Slew rate: 30”/s
Texp: 42,700s
Effective: 40s (pn)
Overlap: 15’
Area: 43°x2°
b = +/-9°
l = +/-15°
Pos accuracy: < 4”
Flim (soft):
2.0 10^{-13} erg/s/cm^2
Flim (hard):
1.3 10^{-12} erg/s/cm^2

72 sources detected: identifications in Simbad:
8 LMXBs + 2 candidates LMXB, 1SNR, 2 supergiant Fast Transient candidates, 16 active stars, 2 AGNs

Slow Slew Survey Test

Source content

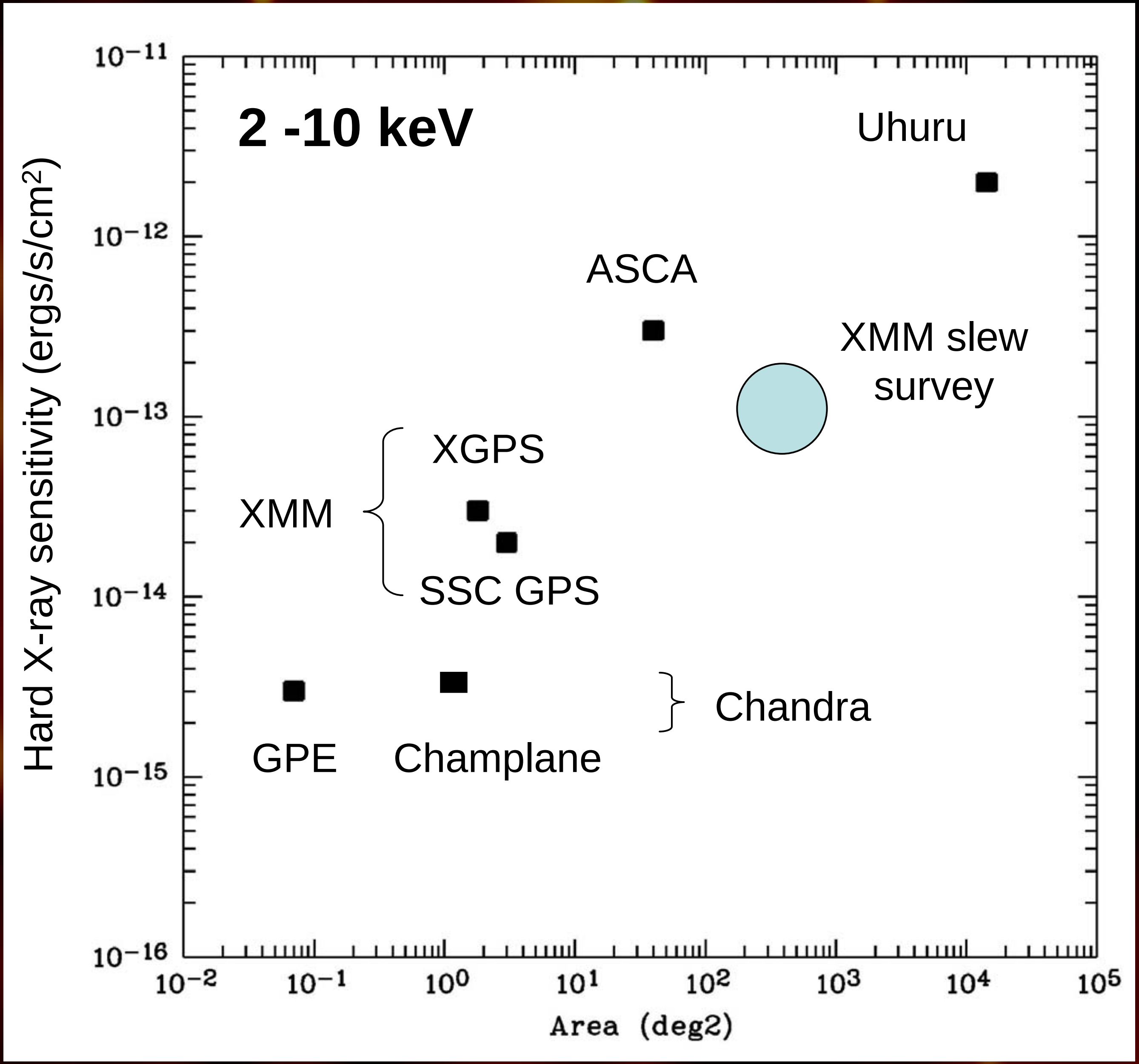


Identified sources well separated in the HR diagram

Unidentified sources are a likely mixture of all classes

Ideas for a legacy slew Galactic Plane Survey

- A number of hard X-rays GP surveys exist but:
  - They are either of low sensitivity or covering only a small fraction of the plane
  - There is no uniform coverage of the main galactic structures, arms, bulge, central regions….
- Example:
  - a slew survey covering *l* = +/- 30° and *b* = +/-2.5° with T_{exp} ~400s yields a 2-10 keV sensitivity of ~10^{-13} erg/s/cm^{-2} in 1.6 Msec (+ overheads)
  - Reaches Lx (hard) ~ 10^{33} erg/s at galactic center
  - Expected number of hard sources ~ 10,000
- Observing strategy open. For instance, bulge and deep plane could be observed at different depths.
- Overlapping slews allow time variability studies
- However, main issue is the possibility to make accurate slew along the galactic plane (minimize overheads)



Forman et al. 1978

Sugizaki et al. 2001

Hands et al. 2004

Motch et al. 2005

Grindlay et al. 2005

Ebisawa et al. 2005

Thanks !