The ChaMPlane Near-Infrared Survey and Database

Mathieu Servillat,
M. van den Berg, J.E. Grindlay, J. Hong, B. Allen, P. Zhao (CfA), S. Laycock (Gemini)
CfA, Cambridge, USA, mservillat@cfa.harvard.edu

The **Chandra Multi-wavelength Plane Survey** (ChaMPlane) is designed to identify the point X-ray sources discovered by the **Chandra** X-ray Observatory along the Galactic Plane and in the Galactic Center region (GCR) [1]. Based on a **multiwavelength** dataset [2,3,4], we aim to identify peculiar Galactic populations of objects such as accreting white dwarfs (**cataclysmic variables**, CVs), neutron stars and black holes (**quiescent X-ray binaries**, XB) in order to study the distribution and the evolution of those populations. We now completed our near-infrared (nIR: J, H, K bands) coverage of 18 fields with high extinction from the interstellar medium. The nIR survey improve our previous optical survey (V, R, I, Ha + spectroscopy of selected sources) [3]. The hard X-ray sources have absorption and spectral index **in**consistent with normal stars, active binaries, or young stellar objects. We show that hard X-ray sources tend to be associated with extincted nIR counterparts, which are likely to be at distances > 2 kpc. We also observed every year since 2004 the Galactic Center region and, in a preliminary analysis, we found 10 variable nIR counterparts to X-ray sources, possibly revealing the population of outbursting/magnetic CVs in the Bulge.

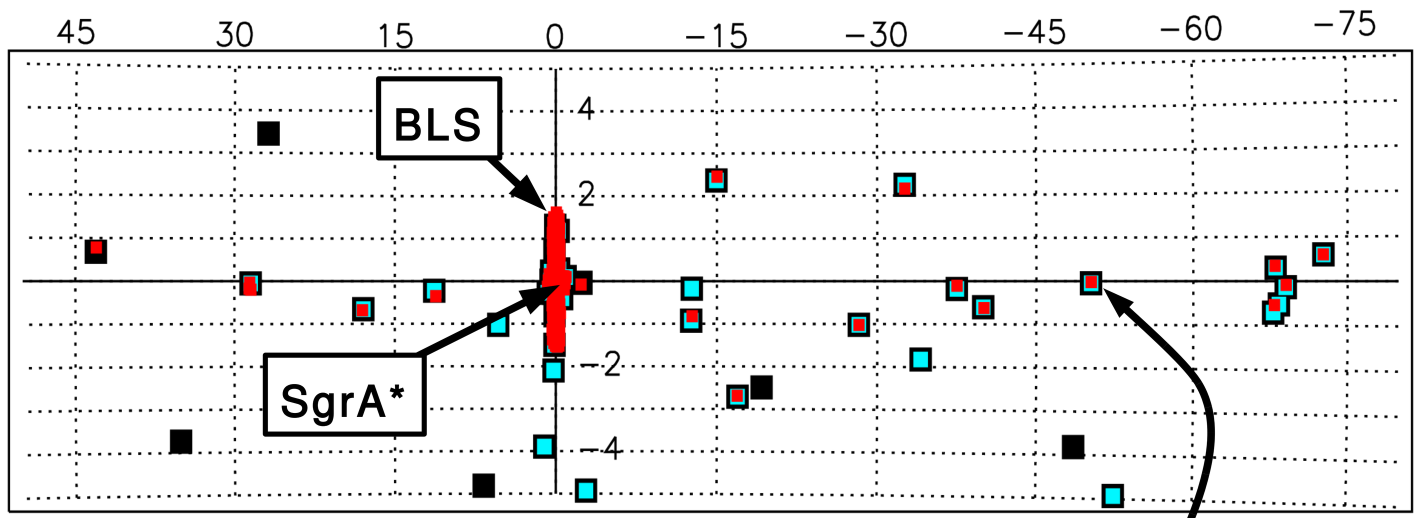
1. The Near-Infrared J, H, K Survey

Why? K extinction is about 10 times lower than V extinction, so we use nIR observations to uncover the most **distant** sources possibly associated to our catalog of X-ray sources. The images on the right show the advantage of nIR for selected fields.

How? Observations were performed with ISPI @ CTIO (10'×10' field of view) in 2007-2009 (NOAO project), and with PANIC @ Magellan (2'×2'):
- 18 fields with extinction Av > 5 (at 8 kpc)
- Bulge Latitude Survey (BLS, 3°×1°)
- Multi-epoch coverage of SgrA* field

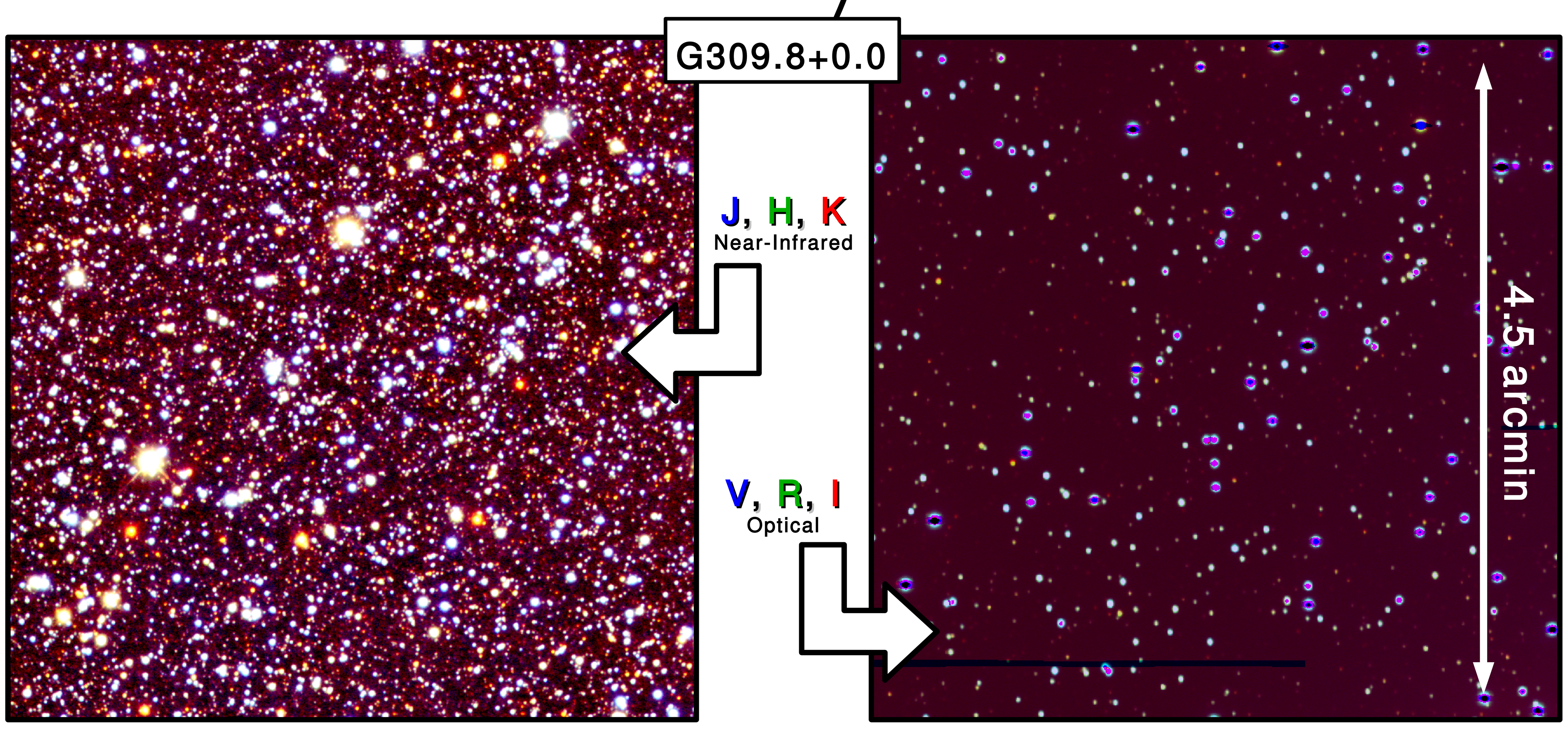
Data processing: We calibrated our nIR catalog using 2MASS, and obtained precisions of ~0.1″ in astrometry and ~0.1 mag in photometry. Due to severe crowding in our images, we developed a specialized data processing using the IRAF/PANIC package, Sextractor, Scamp and our own tools.

Database: the multi-wavelength data (X-ray properties and photometry/spectroscopy in V, R, Ha, I, J, H, K) is stored in a MySQL database accessible though a website that will be public at term.

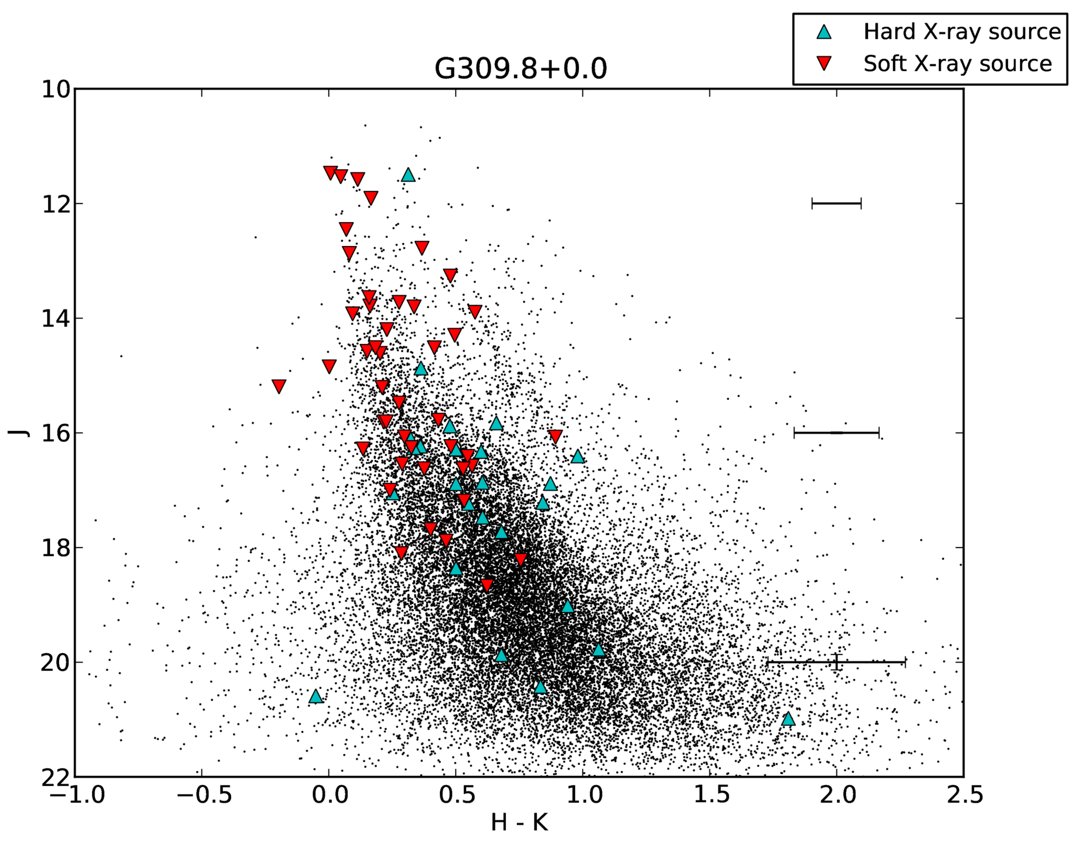


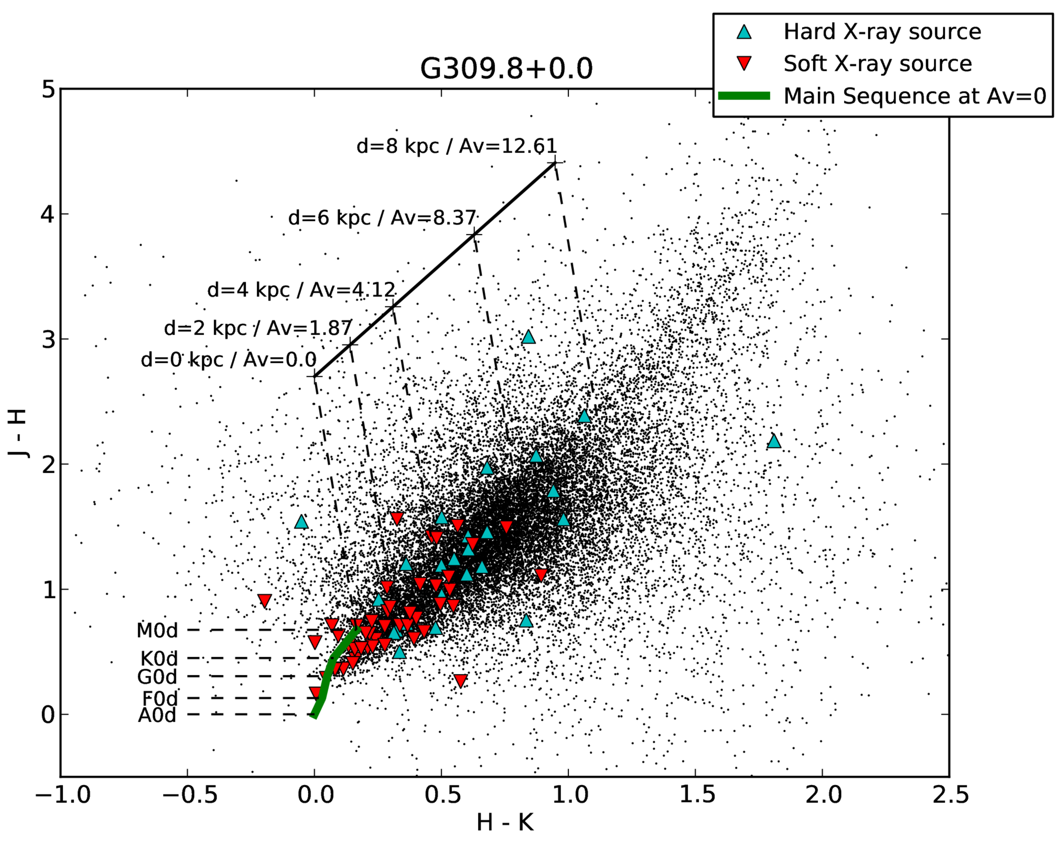
Zoom on ChaMPlane fields around the Bulge in Galactic coordinates (degrees)

Black: fields observed in X-ray and optical
Blue: muti-object optical spectroscopy performed for selected sources
Red: fields observed in near-infrared



2. Populations of X-ray sources along the plane





Colors and Magnitudes: sources are detected in the nIR down to J=20-21 depending on the field. The reddening of the colors due to interstellar extinction is clearly seen in the diagram shown for an example field (G309.8+0.0).

Selection of X-ray sources: we cross-matched our nIR and X-ray catalogs (1261 X-ray sources covered) and find 1778 nIR counterparts to 1148 X-ray sources. Due to an extreme crowding, about 1/4 could be chance matches.

Extinction model and distance: We used the Drimmel et al. (2003) Galactic extinction 3D model to associate extinction (Av) to distance (d in kpc) on the color-color diagram above. We also indicate the main sequence of dwarf stars in this diagram.

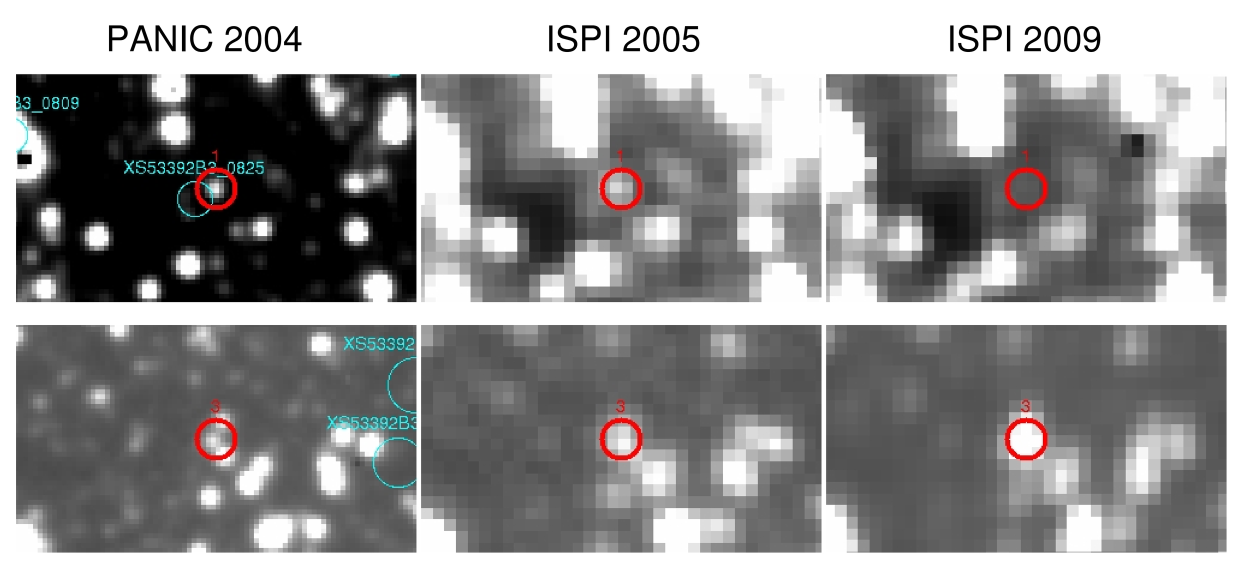
Conclusions

- Soft X-ray sources tend to be associated with **bright foreground objects**, e.g. stars
- Hard sources tend to have **extincted** nIR counterparts likely to be located **> 2 kpc** away
- **Spectroscopy** of those counterparts is now required to determine their nature, however, due to crowding and high extinction, this will require adaptative optics (AO) techniques in the infrared band with the latest or the next generation of instruments.

3. Galactic Center population

About 3000 X-ray sources have been detected in a the 10'×10' GCR [6]. The 2–8 keV X-ray luminosity (10^{31}-10^{33} erg s^{-1}) and spectral index ($\Gamma < 1$) of most of the sources suggest a large population of **magnetic CVs** or non-Roche lobe filling high mass XBs (**HMXBs**). At 8 kpc and extinction Av up to 24:
- HMXBs would have K~14-15 mag
- Bright CVs: K~19-21, and more during outbursts

[7] showed that HMXBs are probably not numerous in the Bulge. Following this work we obtained multi-epoch nIR observations of the GCR. Preliminary variable search (3 epochs in K only) found 10 variables with $\Delta K \lesssim 0.5$, 7 of which are aligned with X-ray sources, for example:



Images for 3 epochs in the K bands. The variable star is indicated by a red circle and X-ray sources with a blue circle. Each image is 8 arcsec large.

Identifying those sources through **IR spectroscopy** could answer the long standing questions: what is the **population of X-ray sources in the GCR**? Is there an excess of **magnetic CVs**? This would shed light on the Galaxy evolution processes occurring in the GCR.

References

[1] Grindlay et al. 2005 [2] Hong et al. 2005 [3] Zhao et al. 2005 [4] Hong et al. 2004 [5] Drimmel et al. 2003 [6] Muno et al. 2009
[7] Laycock et al. 2005
See also the website: http://hea-www.harvard.edu/ChaMPlane/index.html