ChaMPlane Deep Galactic Bulge Survey: constraining the Bulge CV population

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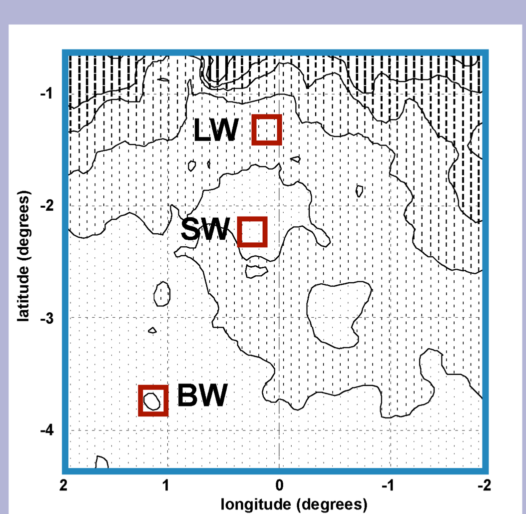
The Chandra Multiwavelength Plane (ChaMPlane) Deep Galactic Bulge Survey consists of nearly simultaneous Chandra/ACIS and HST/ACS pointings of three low-n_H windows located at 4^o, 2^o and 1.5^o from the Galactic Center (GC). Using optical colors, we select candidate cataclysmic variables (CVs) to constrain the CV space density in the Bulge. ***Initial results from the windows 4^o and 2^o away from the GC indicate that, to first order, the ratio of the CV-to-star space density in the Bulge is consistent with the local value of $n_{cv} / n_* \sim (10^{-5}$ pc^{-3} / $10^{-1.1}$ pc^{-3}).***

Survey

We selected three low-extinction ***windows*** in the Bulge as targets for deep Chandra/ACIS observations. Simultaneously, the central regions of the fields were observed with the ACS/Wide Field Camera on HST. 95% confidence radii on Chandra source positions typically contain several stars. We have to rely on special properties, like Hα-R color excess, to select likely counterparts.

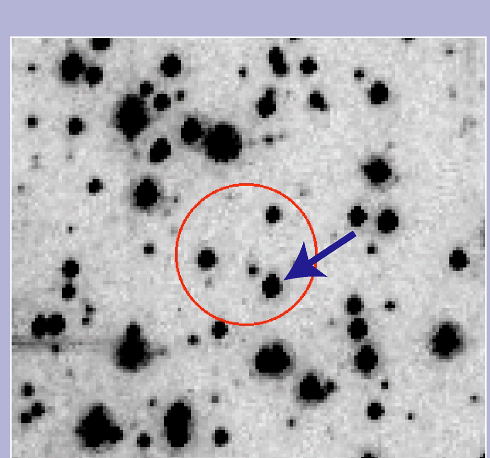


Extinction map of the Galactic Center region showing the location of our survey windows.

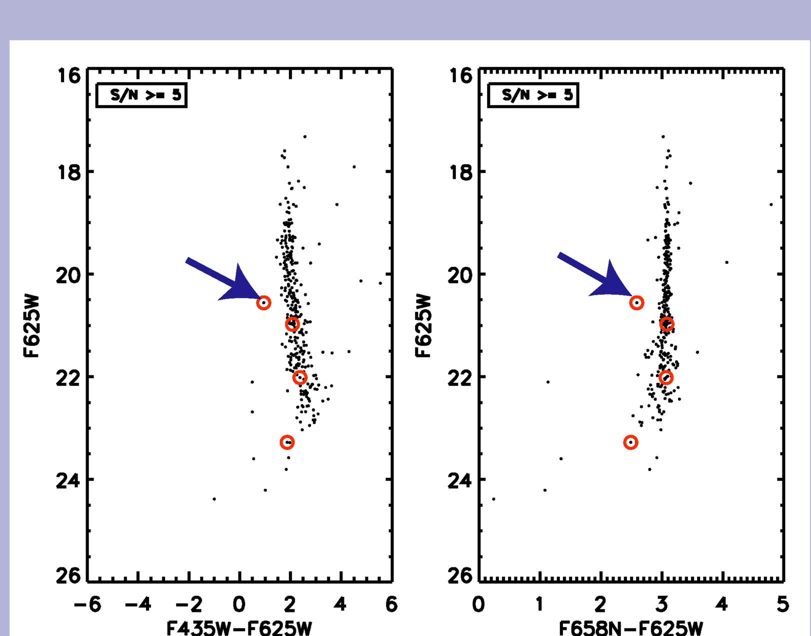
BW = Baade's Window, A_V = 1.3
SW = Stanek's Window, A_V = 2.6
LW = Limiting Window, A_V = 3.9

Selecting CV candidates

Candidate CV counterparts are identified based on their optical colors. We select blue, Hα-excess stars, and Hα-excess stars with Hα-R ~ 0.3 and larger (corresponding to an Hα emission-line EW ~ 30 A for ACS filters and a K-star continuum). X-ray active dMe stars typically do not have such large Halpha-excess emission. An example:



ACS/F625W image centered on a source in BW. The 1" 95%-confidence radius is shown in red.



F435W-F625W ("B-R") and F658N-F625W ("Hα-R") color-magnitude diagrams of stars in a 20" x 20" region around this source. Stars inside the error circle are marked in red. One source stands out as relatively blue and Hα bright.

Modeling the CV space density distribution

The Galactic Bulge CV population is poorly constrained, but of importance for understanding the X-ray point source population in the GC region. We model the Galactic CV space density distribution with DISK and BULGE components that follow the stellar distributions (Wainscoat et al. 1992, ApJS 83, 111; Revnivtsev et al. 2006, A&A 452, 169) and assume that the ratio of the CV-to-star space density in the Bulge has the local value. We use this to predict the number of CVs we observe in our survey.

DISK : $n_{CV\text{-}disk} = n_{0,CV\text{-}disk} * \exp(- (z/200pc) - (R\text{-}8.5kpc)/3.5kpc - (3kpc/R)^3)$

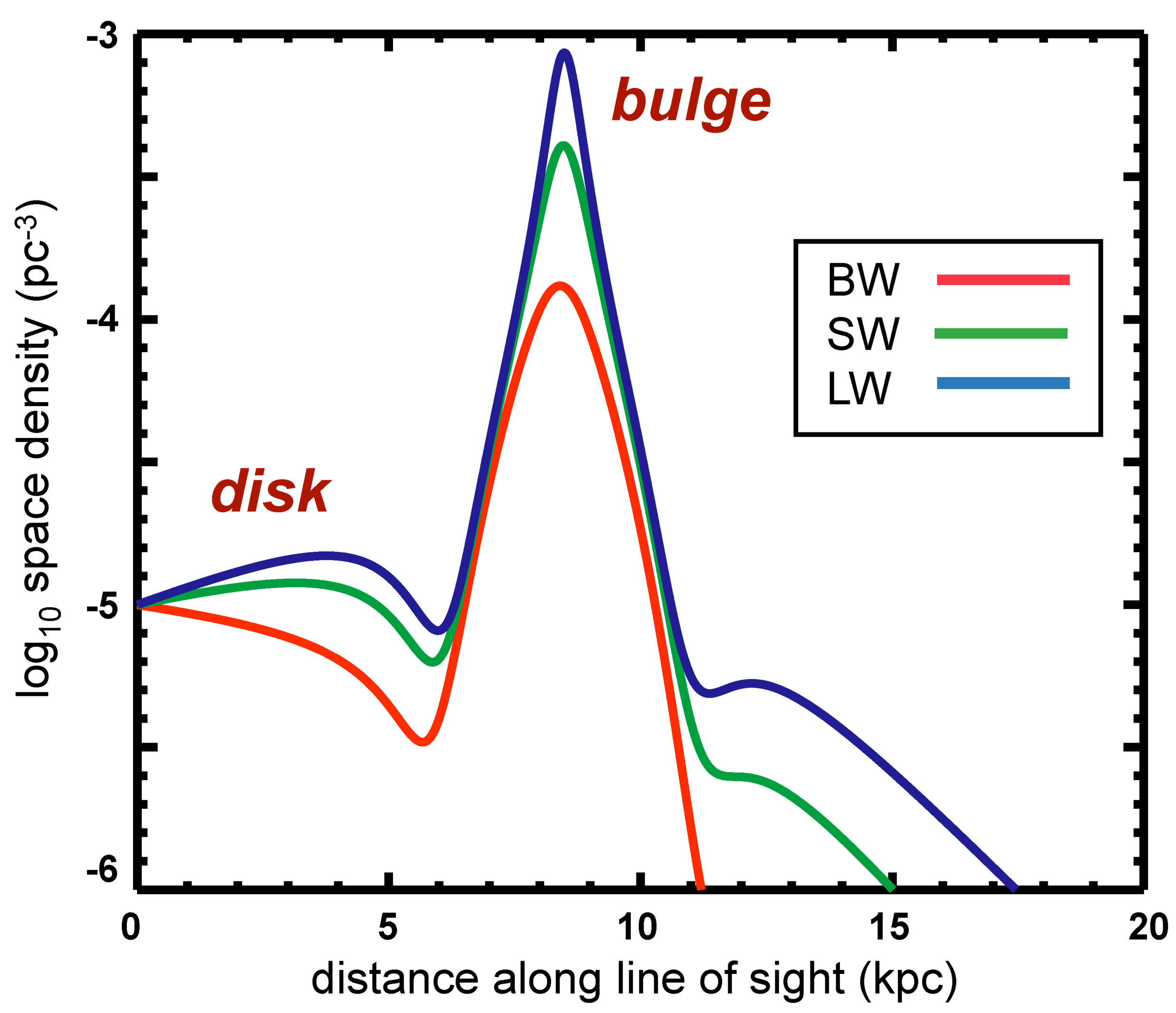
$n_{0,CV\text{-}disk} = 10^{-5}$ pc^{-3} (Patterson 1998, PASP 110, 1132)

BULGE : $n_{CV\text{-}bulge} = n_{0,CV\text{-}bulge} * x^{-1.8} \exp(-x^3)$

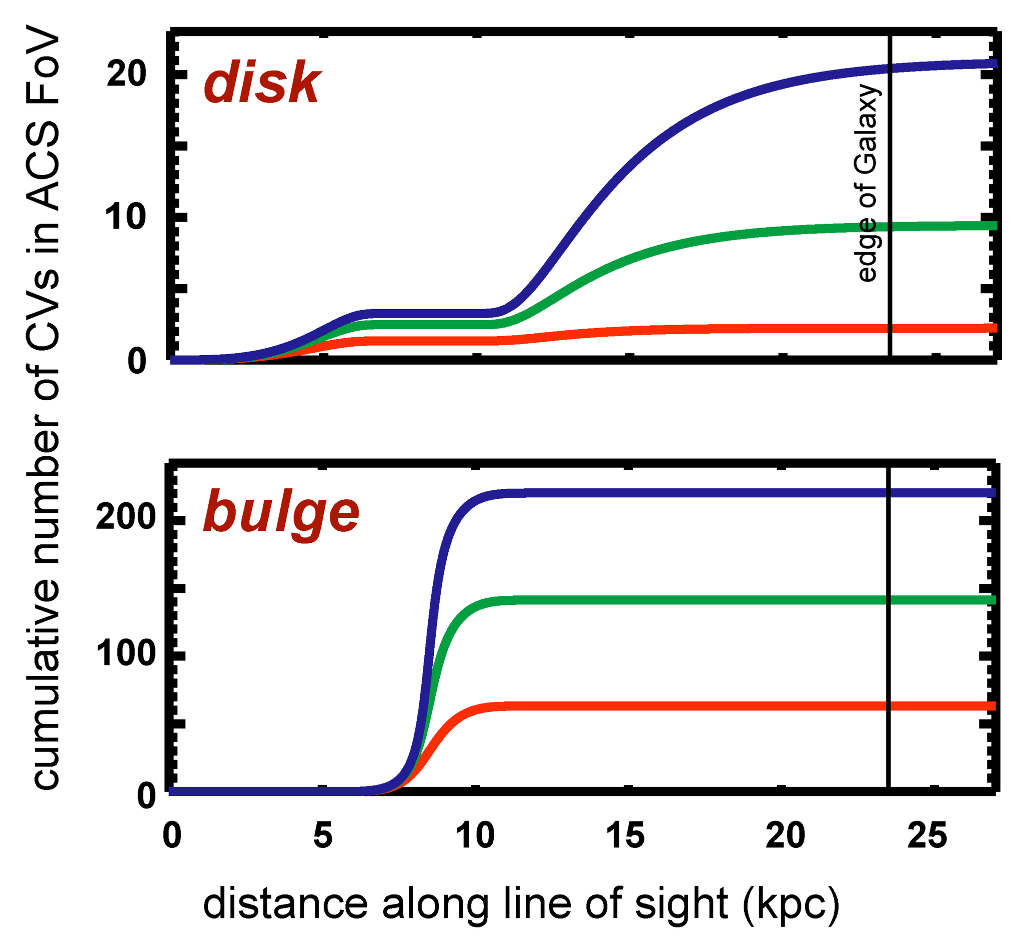
$n_{0,CV\text{-}bulge} = n_{0,CV\text{-}disk} / n_{0,stars\text{-}disk} * n_{0,stars\text{-}bulge} = 3.5\ 10^{-5}$ pc^{-3}

z=height above plane; R=distance from GC; x = sqrt(R^2 + 2.6 z^2) / 2kpc

CV space density → number of CVs in ACS FoV



The CV space density is integrated over the volume corresponding to the ACS FoV of our survey (6.5'x6.5' for each window) up to the distance where our line of sight leaves the Galaxy.



Comparison with our observations

Using Monte-Carlo simulations we model our efficiency for detecting CVs, adopting the ROSAT CV log L_X and log F_X/F_{opt} distributions. Distances are sampled following the disk and bulge space density distributions of the model (see above).

	predicted number of CVs in ACS FoV (disk/bulge)	detection efficiency# (disk/bulge)	***predicted*** number of CVs observed (disk/bulge)	***observed*** total number of candidate CVs (R mag <24)
BW	2.2 / 63.3	28.1% / 10.6 %	0.62 / 6.7	4* - 9**
SW	9.3 / 141.4	12.2% / 8.9 %	1.1 / 12.6	2* - 10**
LW	20.4 / 220.5	6.1% / 5.7 %	1.2 / 12.6	*to be analyzed ....*

optical detection limit R=24; 2-8 keV 3σ X-ray detection fluxlimits are 2.0 10^{-15} (BW, SW), 2.4 10^{-15} (LW) erg s^{-1} cm^{-2} (averaged over ACS FoV) for 10 keV thermal bremsstrahlung. Incompleteness due to our Hα-excess selection criterion (Hα-R >~ 0.3) is not accounted for.
* blue+Hα-excess objects
**including Hα-excess (Hα-R > 0.3) objects

Conclusions

Our simple model for the Galactic CV distribution predicts a number of observed CVs comparable to the number of CV candidates actually observed. It is consistent with a relative (to main-sequence stars) CV space density in the Bulge similar to the local value, but uncertainties remain in the distributions of CV X-ray properties (luminosity, X-ray/optical flux ratio), the model for the Bulge profile, and our optical completeness corrections.