SEATTLE UNIVERSITY

How can I convince you to buy a "C" filter?

Washington & Strömgren Photometry of SDSS dSph Systems:

Test case: The Boötes I dSph Galaxy

Joanne Hughes[a], George Wallerstein[b] & Aaron Dotter[c]

Seattle University[a], University of Washington[b], University of Victoria[c]

Ferah Munshi (UW)

And a rotating cast of Seattle University undergraduates:

Anne Bossi

Jason Luxon

Rebecca Corcoran

The Astrophysical Journal, 647: L111–L114, 2006 August 20

A FAINT NEW MILKY WAY SATELLITE IN BOOTES

V. Belokurov,[1] D. B. Zucker,[1] N. W. Evans,[1] M. I. Wilkinson,[1] M. J. Irwin,[1] S. Hodgkin,[1] D. M. Bramich,[1] J. M. Irwin,[1] G. Gilmore,[1] B. Willman,[2] S. Vidrih,[1] H. J. Newberg,[3] R. F. G. Wyse,[4] M. Fellhauer,[1] P. C. Hewett,[1] N. Cole,[5] E. F. Bell,[5] T. C. Beers,[6] C. M. Rockosi,[7] B. Yanny,[8] E. K. Grebel,[9] D. P. Schneider,[10] R. Lupton,[11] J. C. Barentine,[12] H. Brewington,[12] J. Brinkmann,[12] M. Harvanek,[12] S. J. Kleinman,[12] J. Krzesinski,[12,13] D. Long,[12] A. Nitta,[12] J. A. Smith,[14] and S. A. Snedden[12]

Received 2006 April 17; accepted 2006 June 30; published 2006 August 15

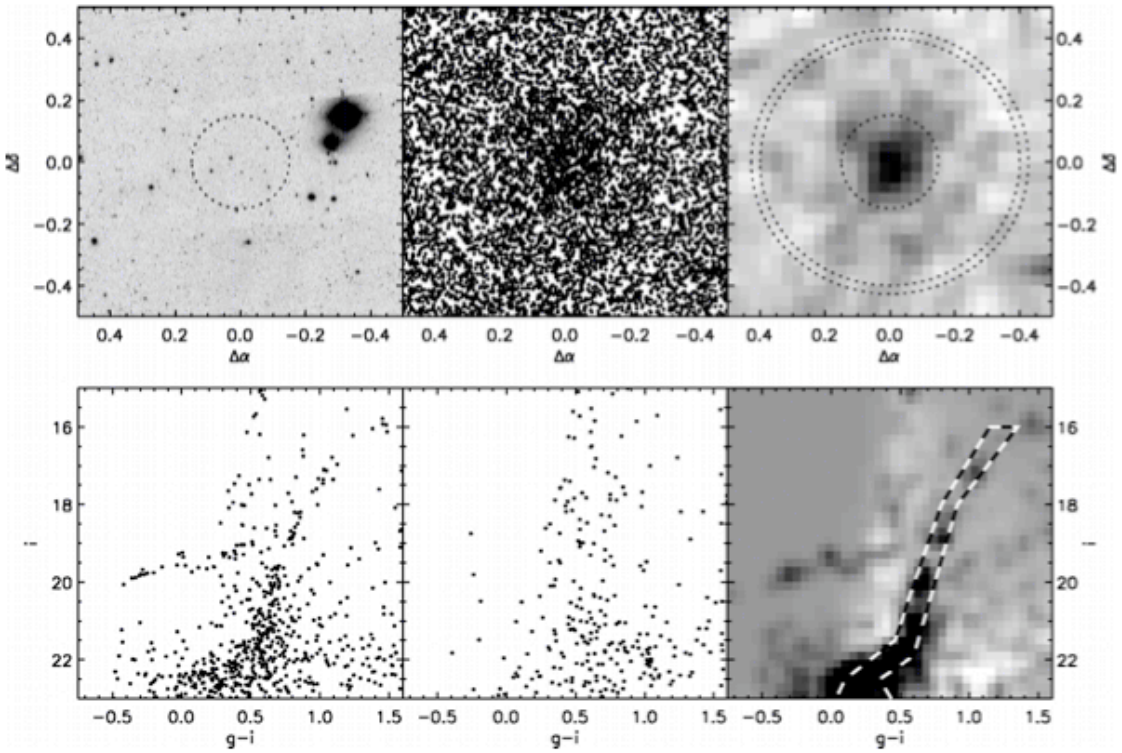
ABSTRACT

We announce the discovery of a new satellite of the Milky Way in the constellation of Bootes at a distance of ~60 kpc. It was found in a systematic search for stellar overdensities in the north Galactic cap using Sloan Digital Sky Survey Data Release 5. The color-magnitude diagram shows a well-defined turnoff, red giant branch, and extended horizontal branch. Its absolute magnitude is $M_v \sim -5.8$ mag, which makes it one of the faintest galaxies known. The half-light radius is ~220 pc. The isodensity contours are elongated and have an irregular shape, suggesting that Boo may be a disrupted dwarf spheroidal galaxy.

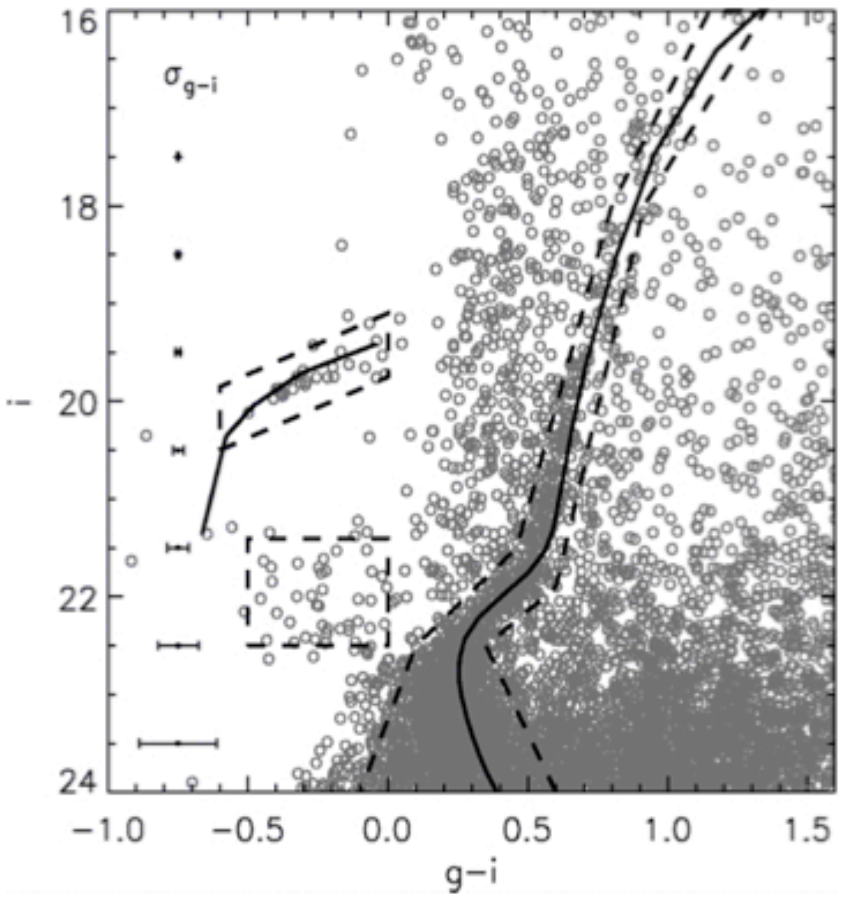
Subject headings: galaxies: dwarf — galaxies: individual (Bootes) — Local Group

PROPERTIES OF THE BOOTES SATELLITE

Parameter[a]	Value
Coordinates (J2000)	$14^h00^m06^s$, $+14°30'00'' \pm 15''$
Galactic coordinates (l, b)	358°.1, 69°.6
Position angle	$10° \pm 10°$
Ellipticity	0.33
r_h (Plummer)	$13'.0 \pm 0'.7$



Belokurov et al.

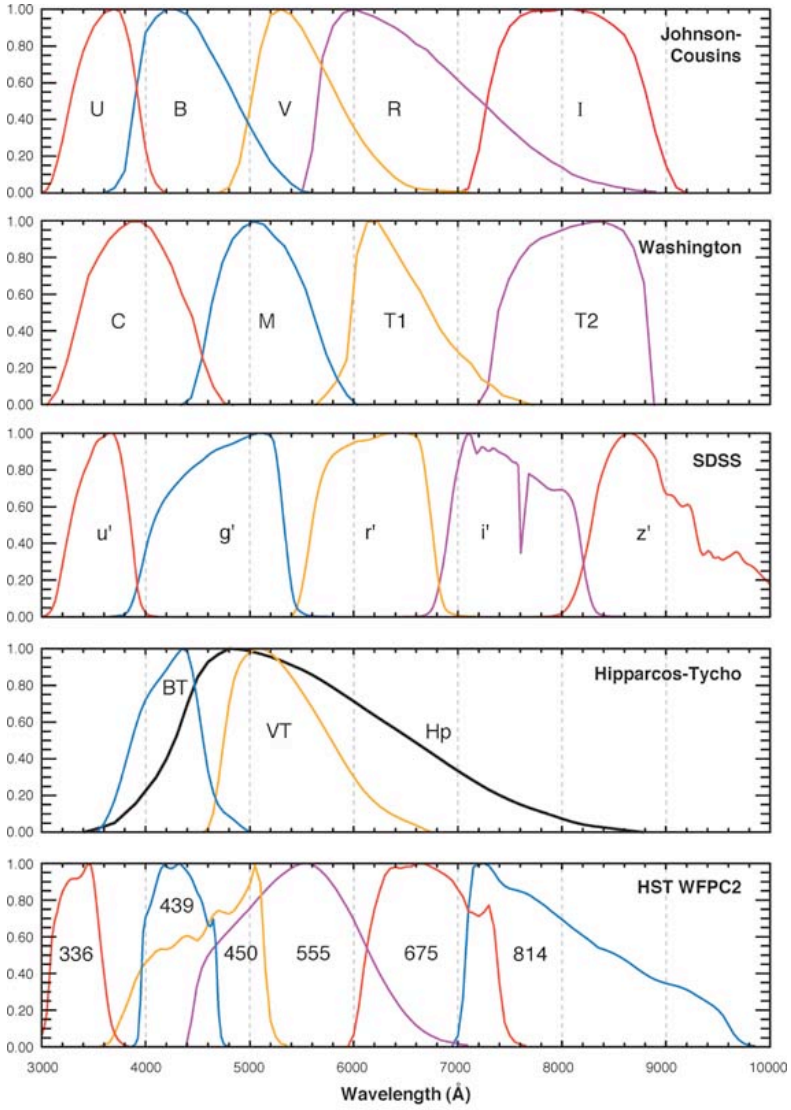


Problem with Sloan filters

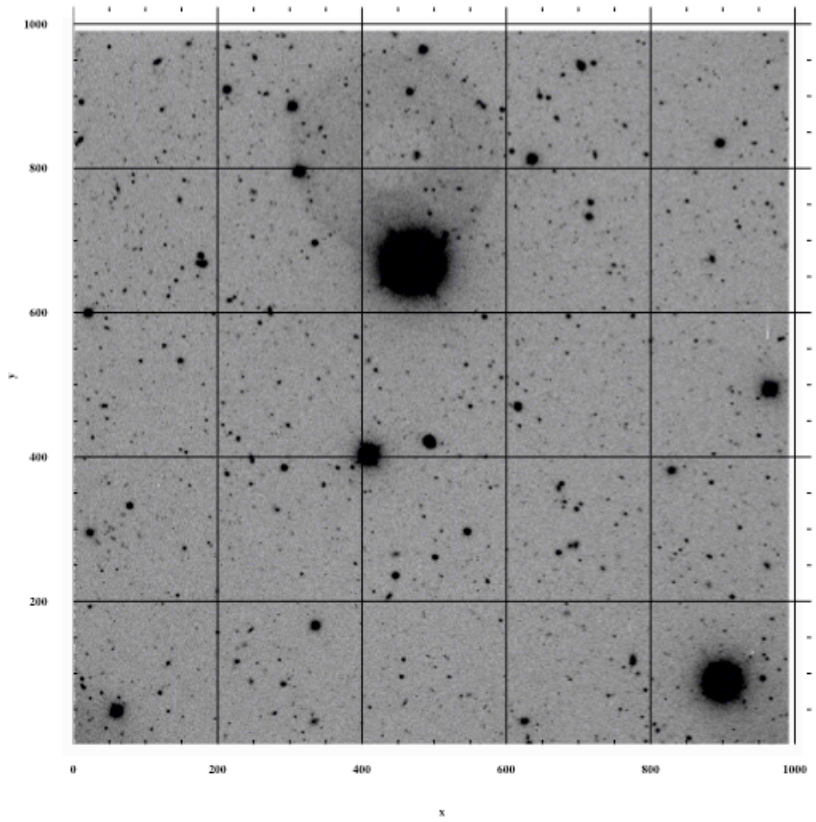
—CMD of Boo derived from CTIO data. Overplotted is the ridge line for the old, metal-poor globular cluster M92. The dashed lines are used to select stars belonging to the main sequence, giant branch, and horizontal branch of the satellite. For each magnitude bin, the mean color error is shown on the left-hand side.

Characterizing dSph Populations

- APO 3.5-m telescope
- SPIcam
- Only 4.78'x4.78' FOV (central field only)
- Washington CT_1T_2
- Strömgren vby

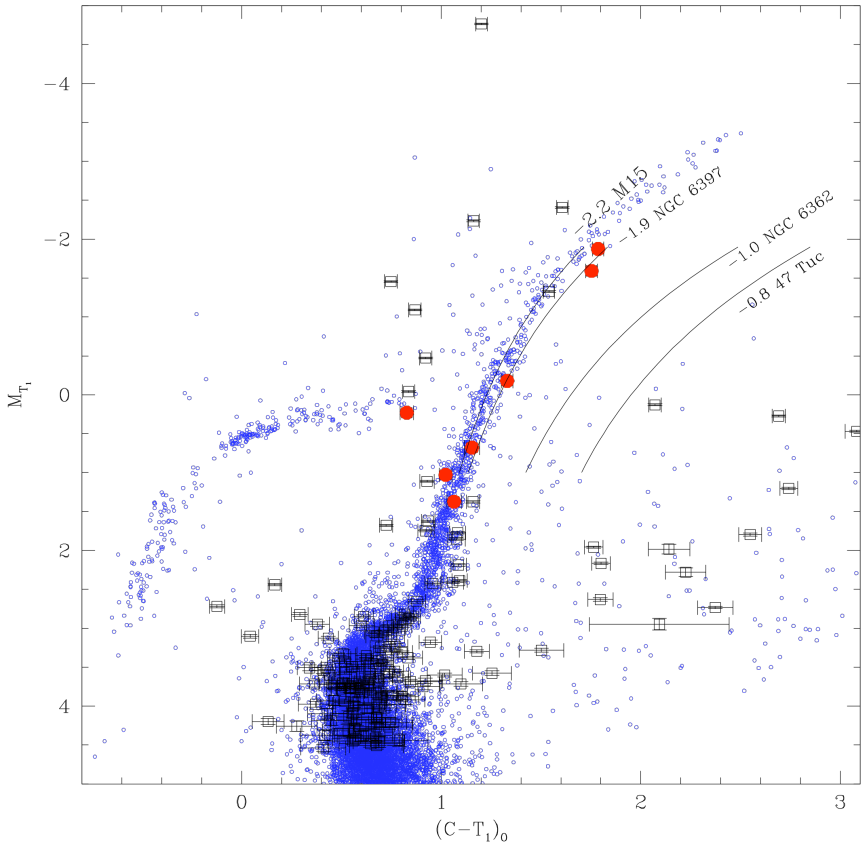


Bessell, MS. 2005
Annu. Rev. Astron. Astrophys. 43: 293–336



APO SPIcam (4.8’x4.8’) 300s R-image, centered on 14h00m30s, 14.5^{o}

Hughes, Wallerstein & Bossi 2008, AJ, 136, 2321



Washington CMD of our data on Boötes I.

We show the Standard giant branches of Geisler & Sarajedini (1999, AJ, 117, 308) & $(m-M)_V$=19.11 & E(B-V)=0.02.

Washington color-color plot

[Fe/H]= −2.1+/-0.4 dex

Weighted mean of 7 brightest stars.

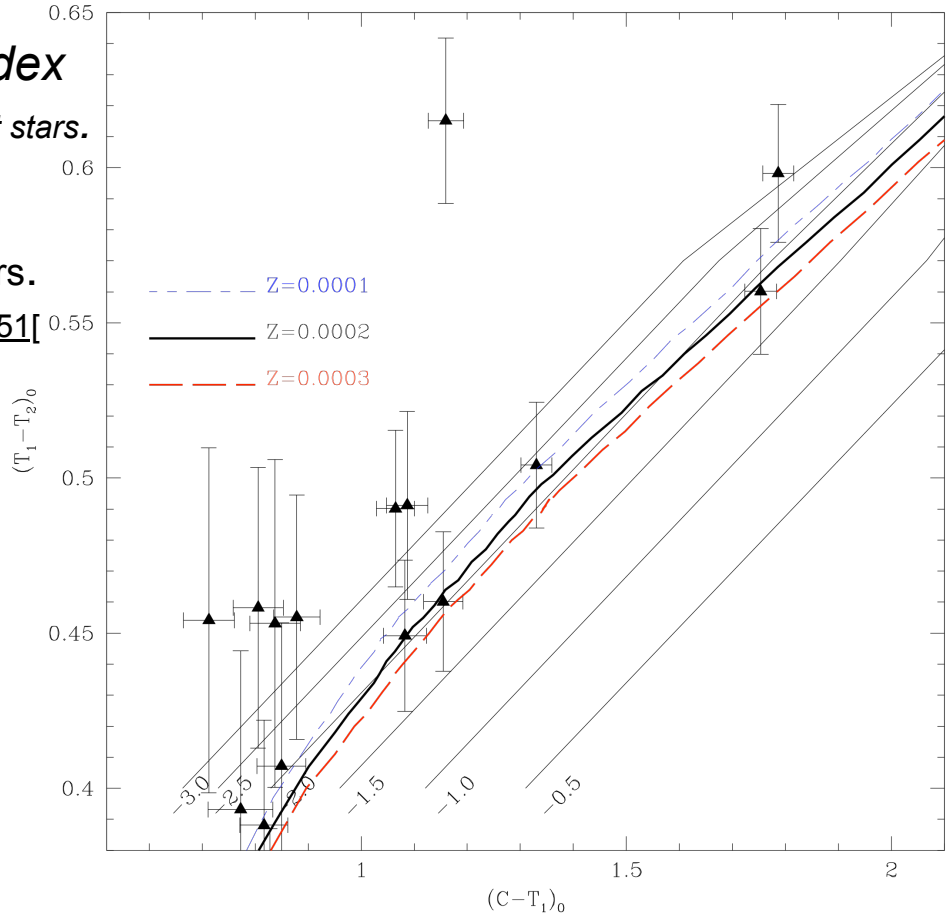
The range is:

−3.5 [Fe/H] −1.8

for the brightest RGB stars.

Munoz et al. 2006, ApJ, 650, L51[

[Fe/H]~ -2.5

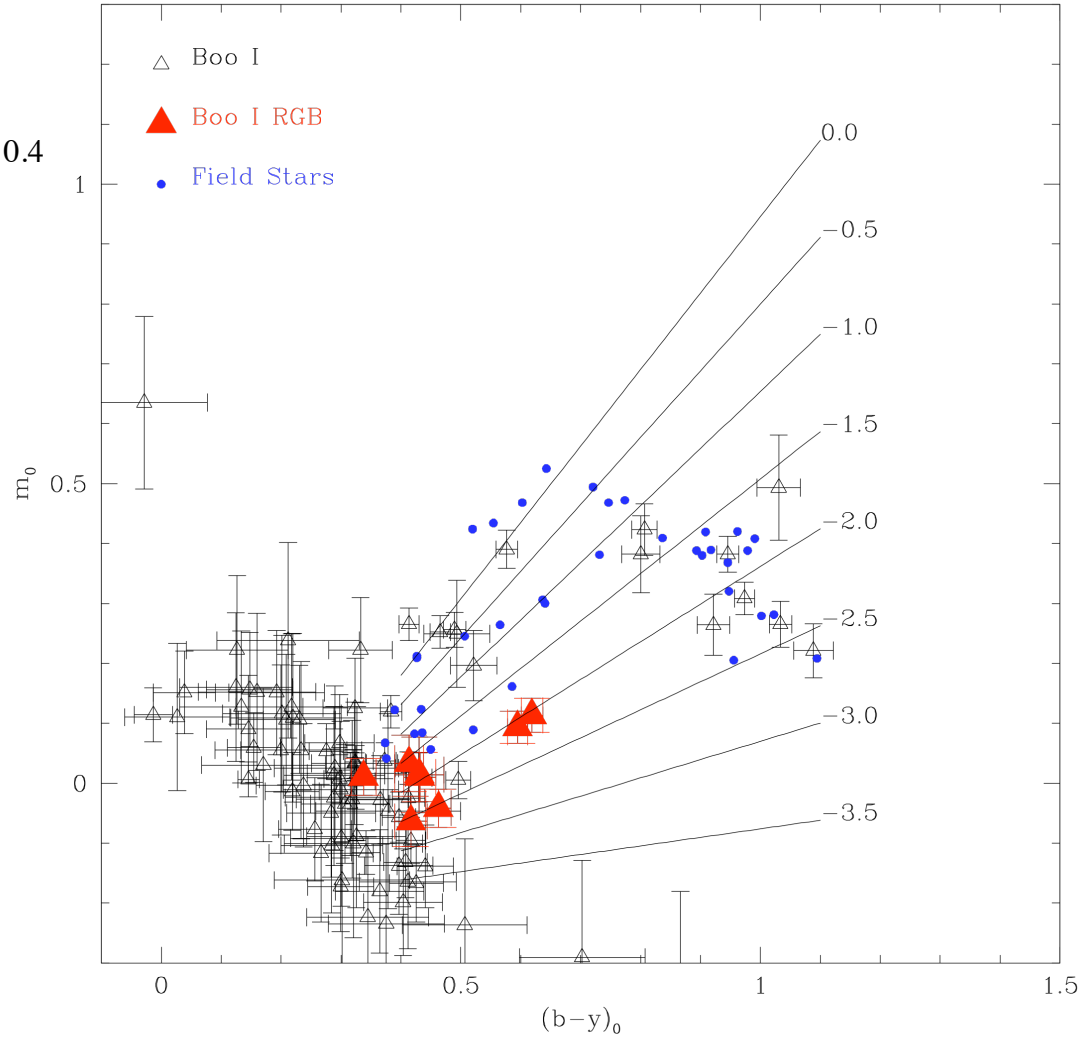


The constant metallicity lines from Geisler, Claria & Minniti (1991, AJ, 102, 1836) are marked. The Z=0.0001, 0.0002, and 0.0003, 12.7 Gyr, isochrones of Marigo et al. (2008, A&A, 482, 833) are plotted from the MSTO to the tip of the RGB. We note that all the isochrones from 10-15 Gyr fall almost on top of each other on this color-color plot, since these colors are only sensitive to metallicity, not age.

Strömgren color-color plot

Hughes, Wallerstein & Dotter 2009, in prep.

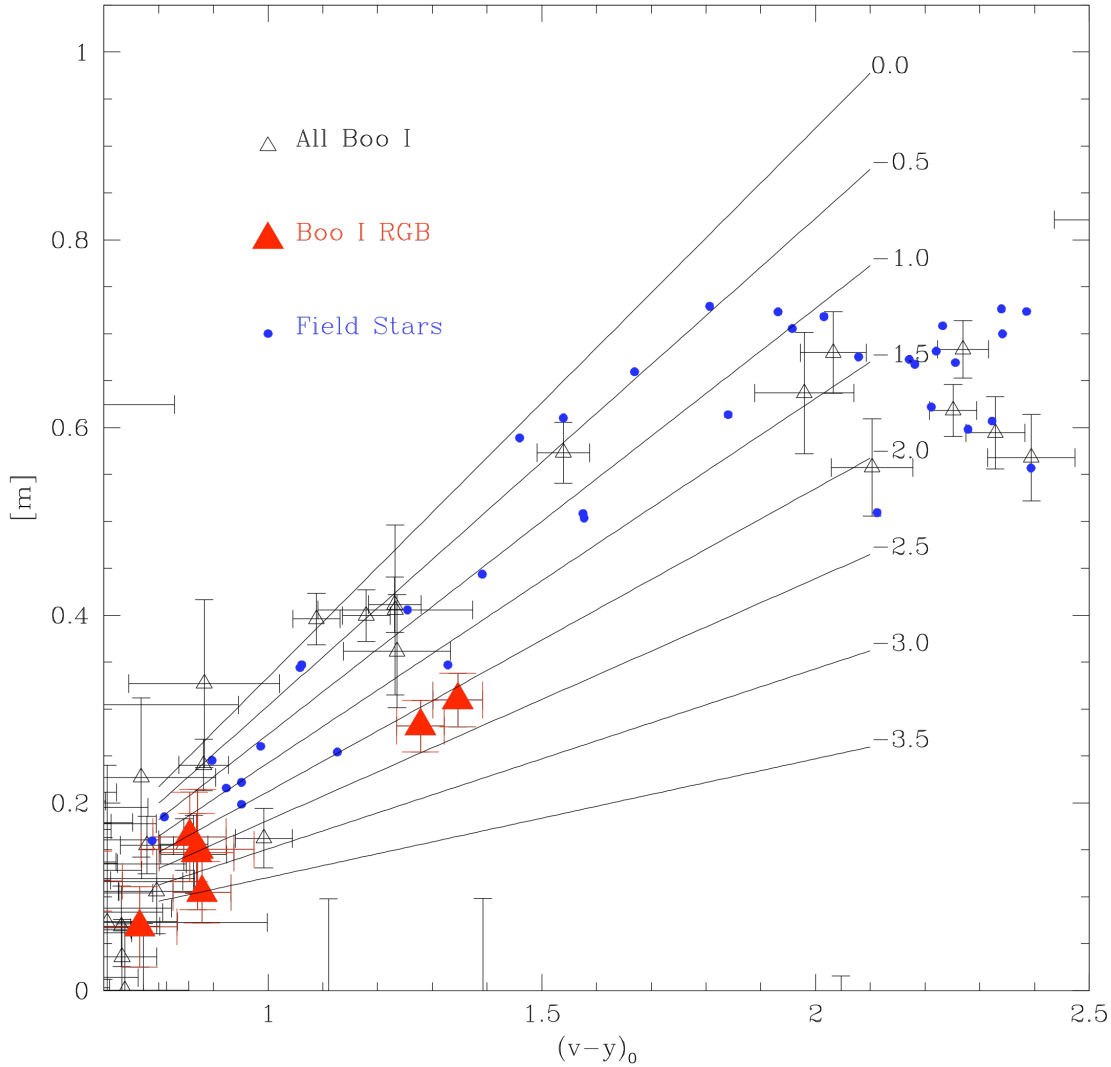
$[Fe/H] = -1.9 \pm 0.4$



m_0 vs. $(b-y)_0$ color-color plot for all Boo I stars and the artificial field stars. We show the metallicity calibration from Hilker (2000, A&A, 355, 994); $m_0=(v-b)_0-(b-y)_0$

Strömgren color-color plot

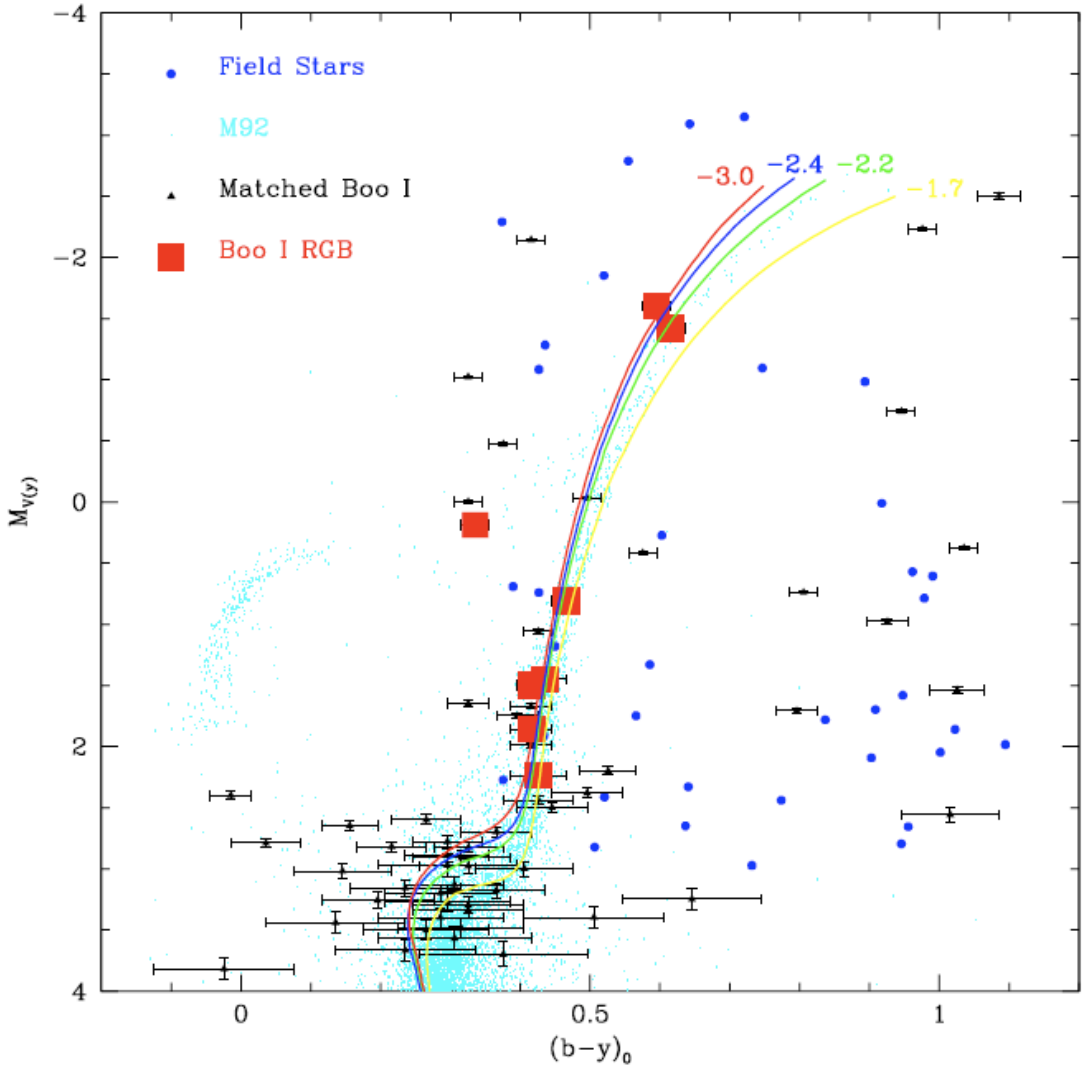
$$[Fe/H] = -2.6 \pm 0.6$$



[m] vs. $(v\text{-}y)_0$ color-color plot for the same data sets, with a [Fe/H] calibration from Calamida et al. (2007, ApJ, 670, 400). Here, $[m]=m_1+0.3(b\text{-}y)$ – the reddening-free index. We use their empirical calibration, based on selected globular clusters. Consistent with spectroscopy.

Norris, J.E., et al. 2008, ApJ, 689, L113; Munoz et al 2006; Ivans et al. 2009, in prep)

Strömgren CMD of our data on Bootes I.



The M92 data was provided by Frank Grundahl (1999). We use the Dartmouth Stellar Evolution Database (http://stellar.dartmouth.edu/~models/). The metallicitiies shown are all for the 12 Gyr isochrones. Once more metal-poor than [Fe/H]=-3.0, the (b-y) colors lose sensitivity to chemical composition.

Conclusions

- The Washington filters are better suited to population studies than the Sloan filters.
- The Strömgren photometry for the RGB is more sensitive to the metallicity than the Washington data for metal-poor systems.
- MSTO stars are better sampled with the C-T_1 color, to give a longer baseline.
- We recommend that Washington filters are used for systems beyond ~100 kpc, or where there is not considerable reddening present.
- WFC3 filter set includes Washington C and the Strömgren filters.
- Can use ***Cri*** and get similar results.