Seattle University and APO

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Seattle University

Seattle University, founded in 1891, is a Jesuit Catholic university and law school located on 50 acres in Seattle's Capitol Hill neighborhood. More than 7,400 students are enrolled in undergraduate and graduate programs within eight schools and colleges.

- Joined as a member of ARC last year.
- Murdock Summer Undergraduate Research Program ~40 students and ~25 faculty. Grant support, M.J. Murdock Charitable Trust, NSF, NASA, Research Corporation, private donors.
- Astronomers: Joanne Hughes & Jeff Brown.
- 5 half-nights per year (plus extra time through collaborations at UW since 2007).
- **Past and current projects on stellar populations involve SPICam and the WIYN pODI.**

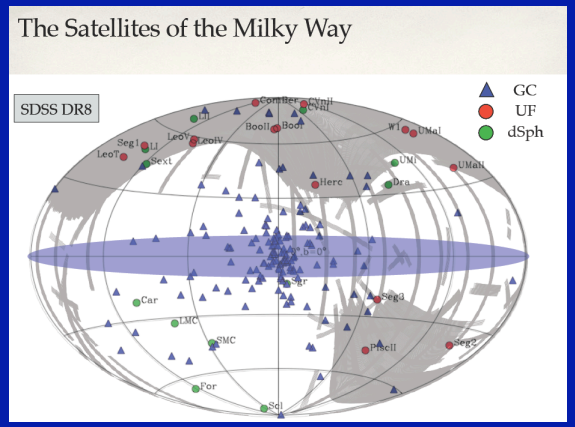
Formation of a Milky Way-Like Spiral Galaxy

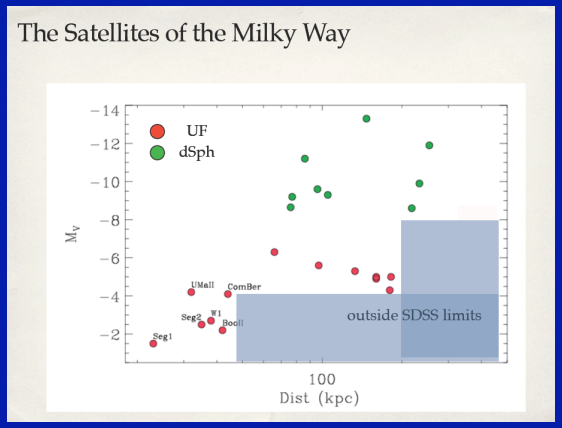
Classical dwarf spheroidal (dSph)~ 11
Ultra-faint dSphs ~ 16

ΛCDM predicts ~100s. Where are they?

Low L ($300 < L_{\odot} < 100{,}000$)
M/L > 100
[Fe/H] ~ -2.5

Origin of UF dSphs

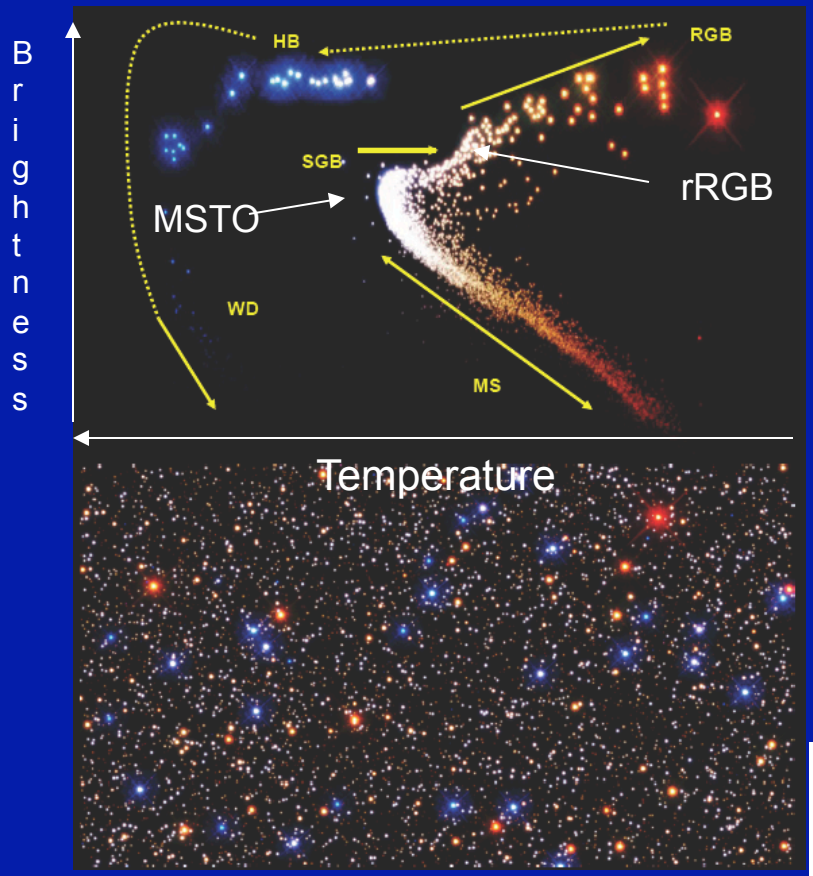




- Primordial?
- Tidal?
- Need age and chemical enrichment history.
- Where is the cut off where dark matter haloes can't attract enough gas to form stars?

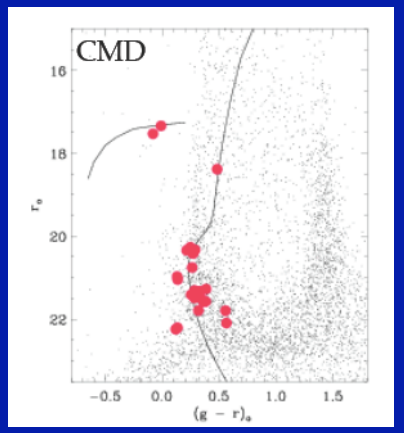
Observational Challenges of UFDS: *very metal-poor & sparse RGB*

Omega Cen data courtesy Jay Anderson.



Unlike globular clusters, UF galaxies have few upper RGB stars bright enough for spectroscopy, and the faintest stars take ~17 hours with Keck.

Geha et al. (2009)



Description	Solar value
Hydrogen mass fraction	$X_{\rm sun} = 0.73$
Helium mass fraction	$Y_{\rm sun} = 0.25$
Metallicity	$Z_{\rm sun} = 0.02$

$$[\mathrm{Fe/H}] = \log_{10}\left(\frac{N_{\rm Fe}}{N_{\rm H}}\right)_{\rm star} - \log_{10}\left(\frac{N_{\rm Fe}}{N_{\rm H}}\right)_{\rm sun}$$

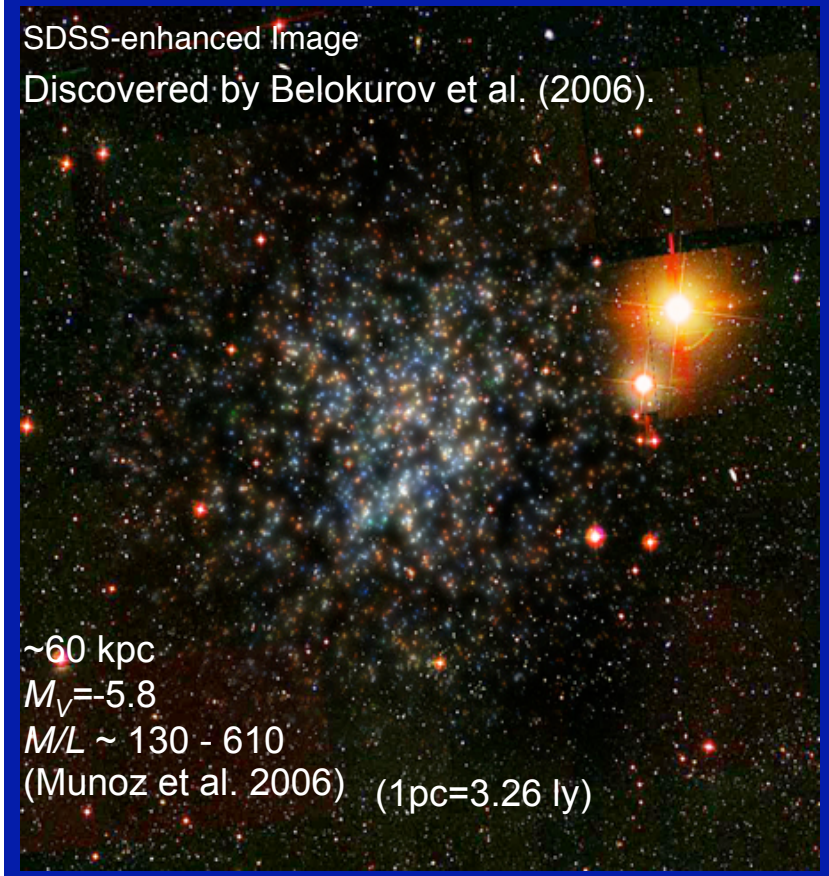
GC~[Fe/H]=-2.3 (0.005) but some Boo I stars as low as -3.7=0.0002 solar value!

APO 3.5-m Project:

Imaging studies of SDSS-discovered dwarf galaxies

The Boötes I Dwarf Galaxy

Hughes et al. (2008; 2011) & Hughes, Wallerstein, Dotter & Geisler (2014)



- What filter combinations are best to determine age and chemical composition of metal-poor dSphs and Ultra-Faint Dwarfs (UFDs)?

UV IR

U B V R I

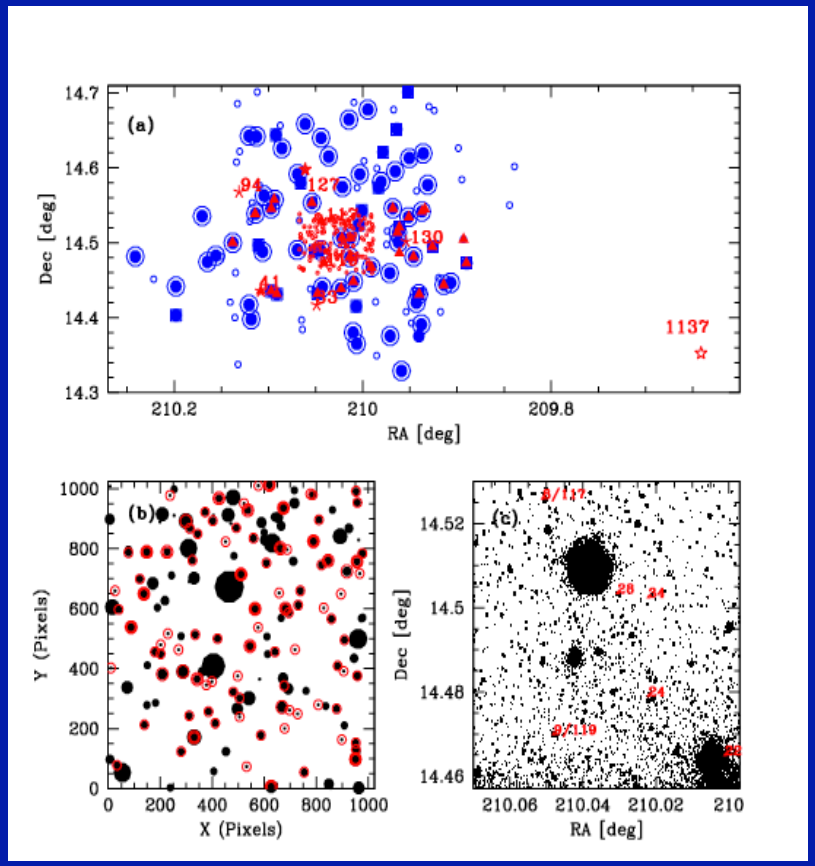
u v b y

u' g' r' i' z'

C M T_1 T_2

SPICam Data

Red=Boo I stars from radial velocity studies (Munoz et al. 2006; Martin et al. 2007)

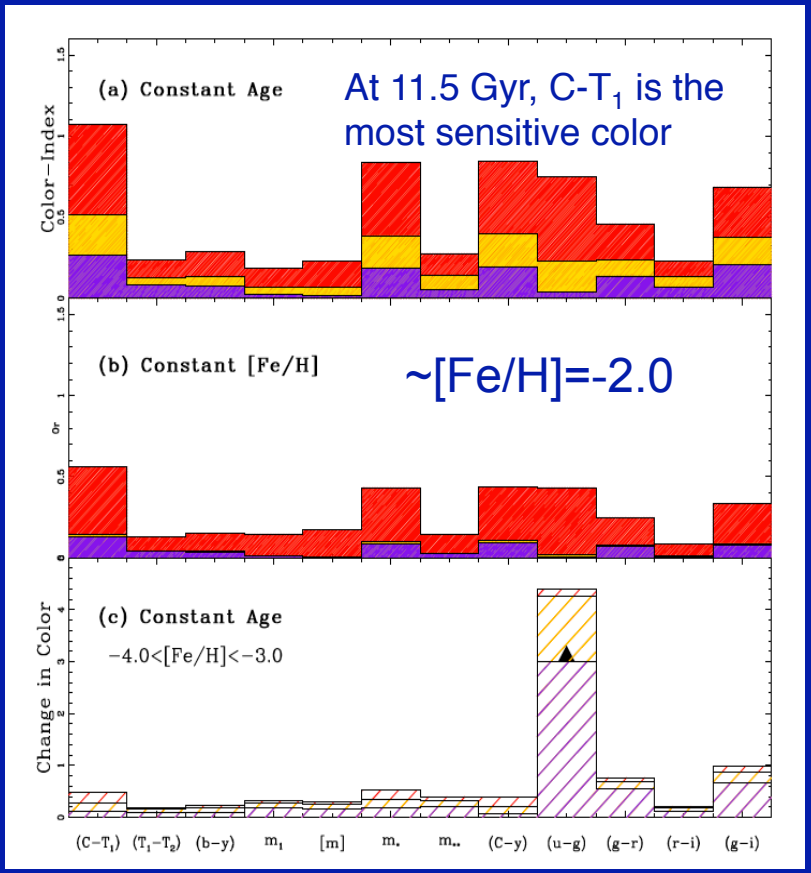


- 4.8'x4.8' FOV in the center of Boo I~150 stars.
- Imaged 2 RGB stars outside central field.
- Which filter combination is best to break the age/ metallicity degeneracy?

From Dartmouth Stellar Models:

Models simulating Boo I from Dartmouth Isochrones - Color ranges:

RGB-red
SGB-gold
MSTO-violet

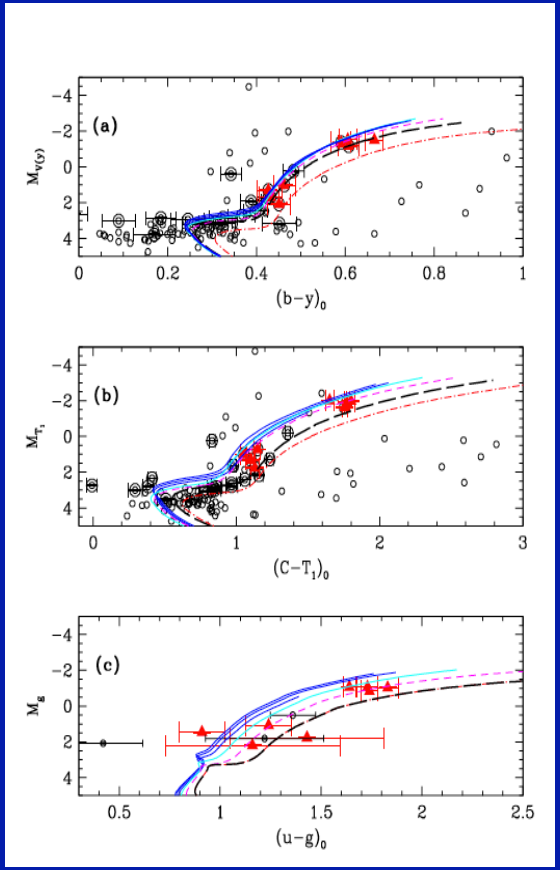


The most effective colors are Washington **C-T_1** and SDSS **u'-g'** & **g'-i'**

<- This region is where we need to test the models with real stars!

At [Fe/H]<-3.0, u'-g' is the most metal-sensitive color at the MSTO

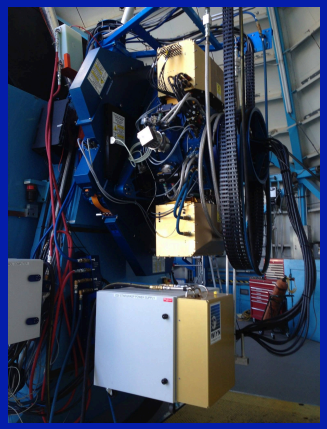
Boo I is a Primordial Dwarf

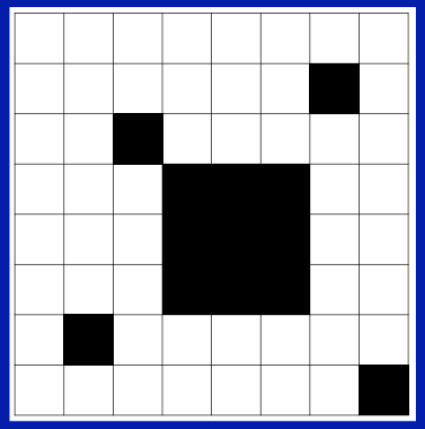


- 11.5+/-0.4 Gyr
- -3.4<[Fe/H]<-1.6
- [Fe/H] spread is **real**, +/- 0.2 dex for an individual RGB star.
- Lower rRGB stars are not AGE-sensitive.
- Star formation must last 0.5 Gyr to produce the ***inhomogeneous*** spread in [Fe/H], before ISM was lost-enriched by only a few SN II in places.
- SDSS photometry alone is insufficient-we need to go deeper with SPICam and pODI.

Current Project: WIYN pODI

- Currently 24’x24’ FOV (being expanded soon to 40’x40’).
- SDSS filters *g’r’i’z’* (plus some narrow band filters)





New Project: ARCSAT

- **0.5-meter Astrophysical Research Consortium Small Aperture Telescope**
- **Provide research experiences for undergraduates beyond current numbers.**
- **Pilot programs for APO 3.5-m or WIYN pODI using SurveyCam.**
- **Developing a "research methods" course to expose all undergraduates to research experiences.**