Stellar Populations in the Local Volume
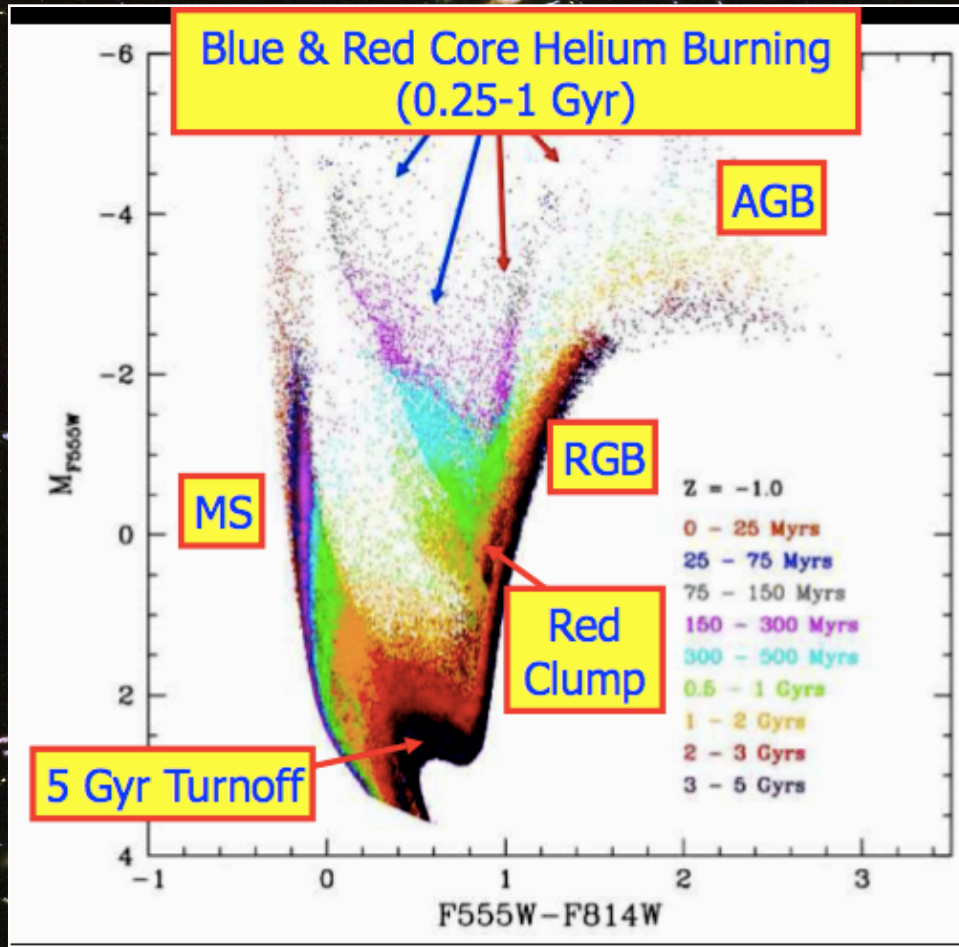
Jason Kalirai (STScI)

Outline

Part 1: Resolved Populations in the Milky Way

- The role that Galactic stellar populations play in astrophysics
- The current "State of the Art" – The ACS Survey of Galactic Globular Clusters
- Why go to the IR? Hints from an HST survey of 47 Tuc
- Synergies with a "Wide Field IR Telescope in Space"

Part 2: Resolved Populations in the Nearby Universe

- Galaxy buildup processes
- High resolution tests to ΛCDM simulations
- Current limitations
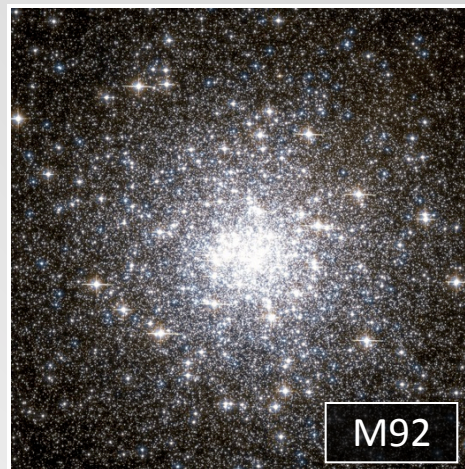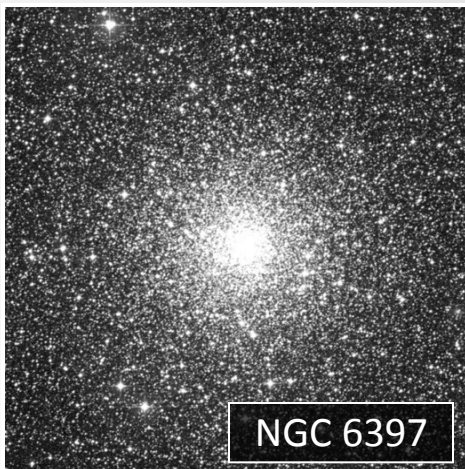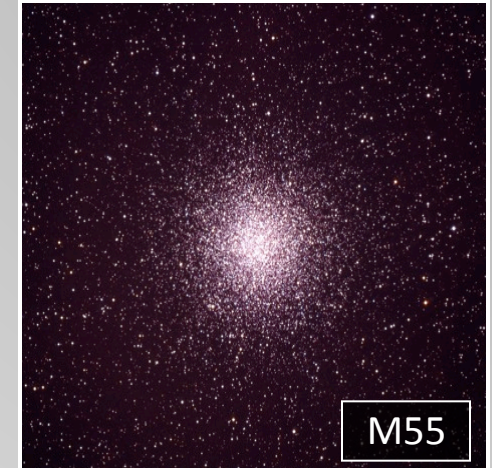- Future prospects and synergies

Stellar Populations in the Local Volume

Blue & Red Core Helium Burning
(0.25-1 Gyr)

AGB

RGB

MS

Red Clump

5 Gyr Turnoff

M_{F555W}

F555W−F814W

Z = −1.0

0 − 25 Myrs
25 − 75 Myrs
75 − 150 Myrs
150 − 300 Myrs
300 − 500 Myrs
0.5 − 1 Gyrs
1 − 2 Gyrs
2 − 3 Gyrs
3 − 5 Gyrs

J. Dalcanton (2010, priv comm)

Stellar Populations in the Local Volume

The Milky Way's globular clusters
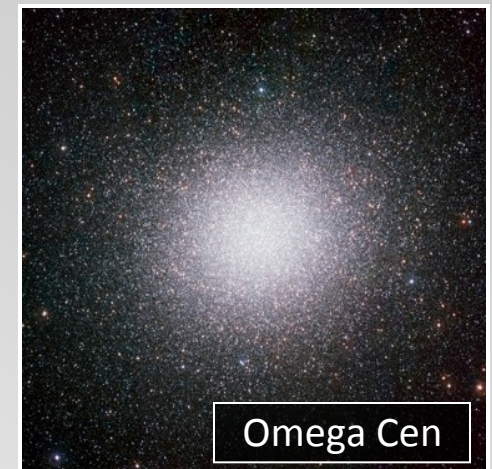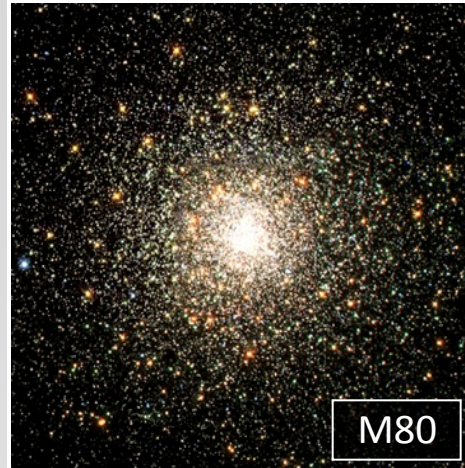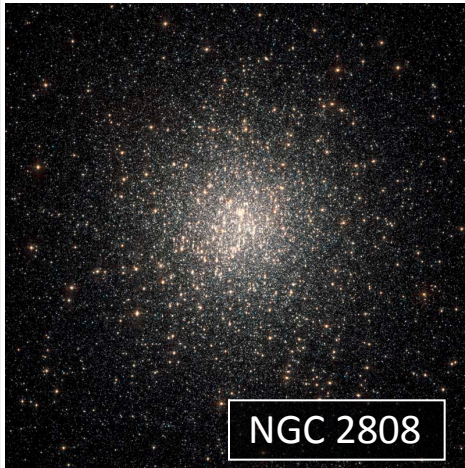
NGC 2808

M80

M55

NGC 6397

M92

Omega Cen

Stellar Populations in the Local Volume

The Current State of the Art

The HST/ACS Survey of Galactic Globular Clusters (Sarajedini et al. 2007)

- Homogenous photometry and reduction.
- Modeled consistently with updated physics.
- Large sample of 60+ clusters.
- Only V and I optical filters.
- Small fields of view.
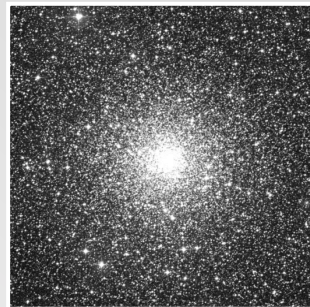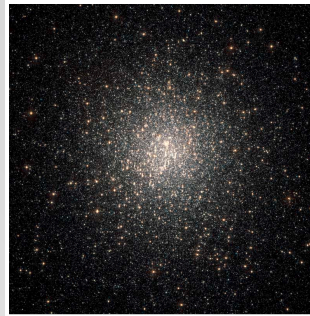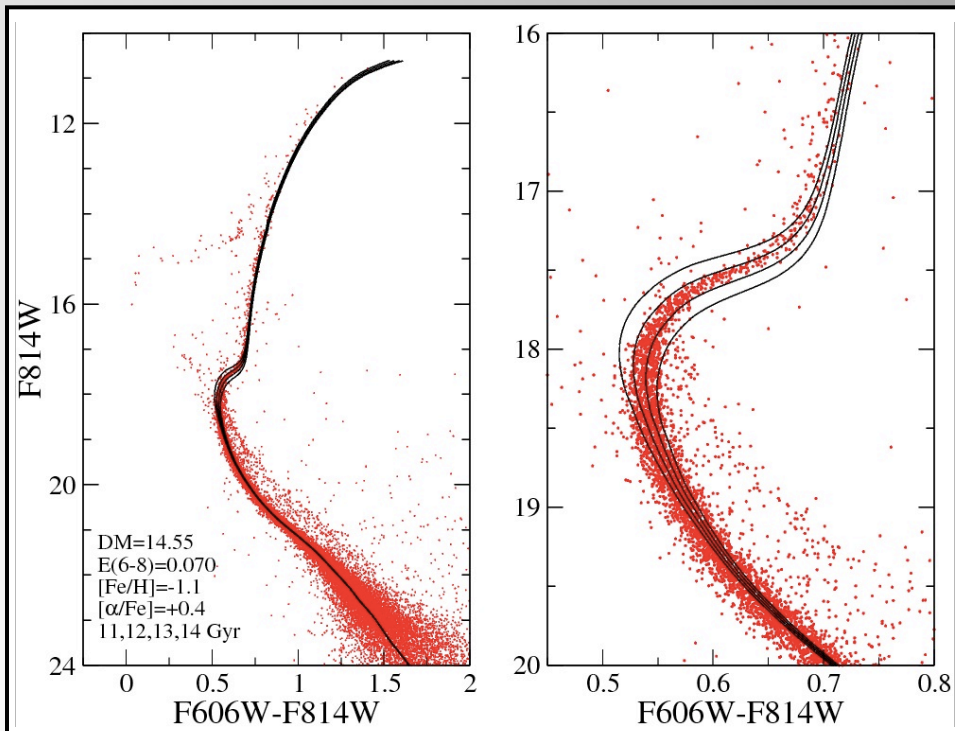
The Milky Way's Globular Clusters
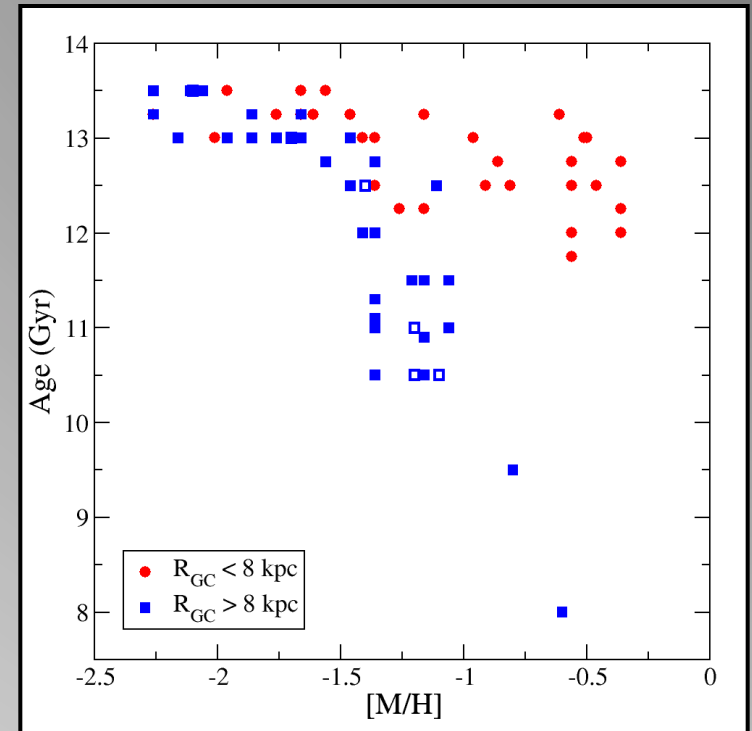
Stellar Populations in the Local Volume

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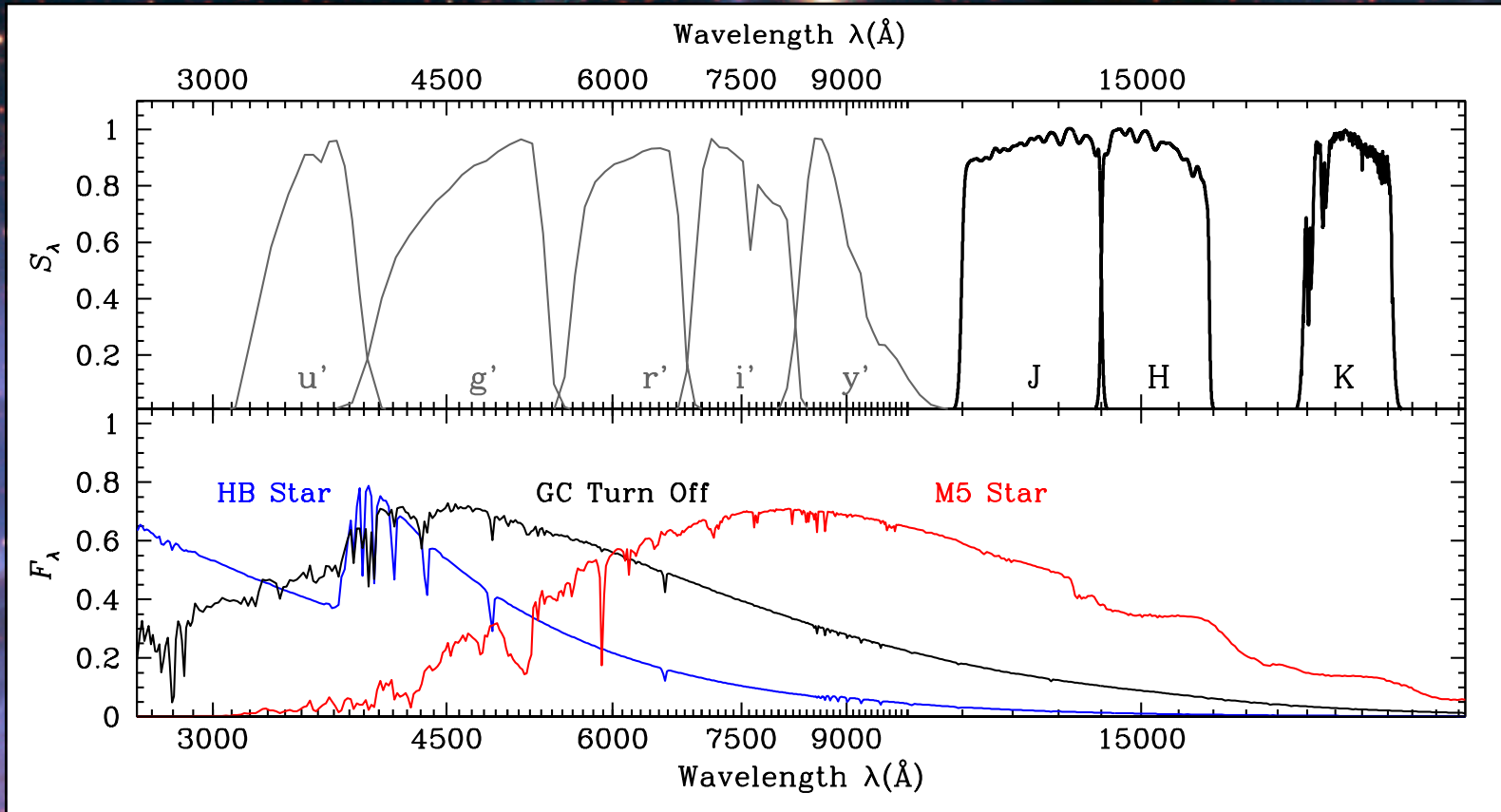

NGC 6362 - Dotter et al. (2010)

Dotter et al. (2010)

Stellar Populations in the Local Volume
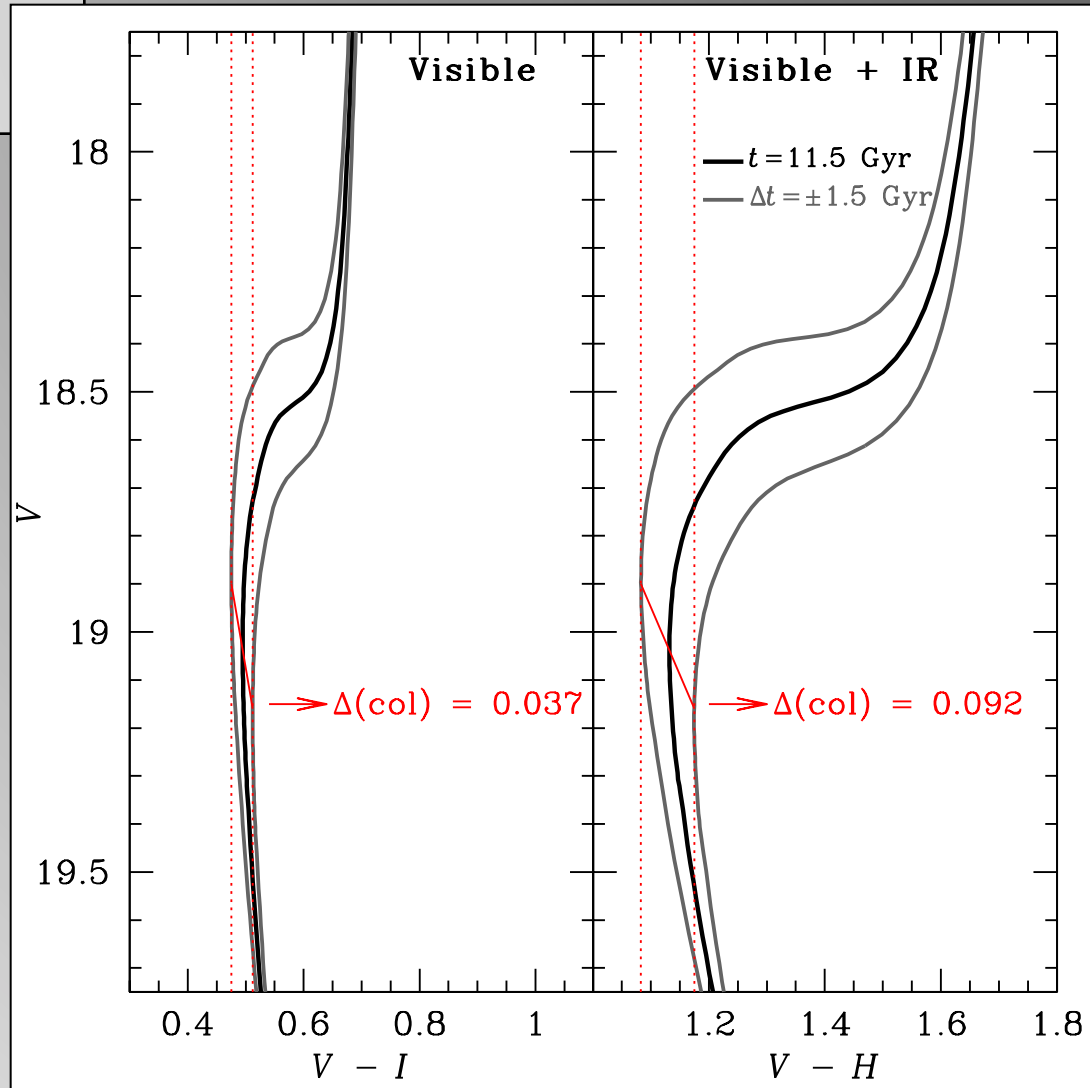
WFIRST enables panchromatic datasets

→ Calibrate UV – IR color-magnitude relations.

→ Increase the sensitivity of main-sequence turnoff fitting methods.

→ Probe complete stellar populations, from the cores to periphery.

Stellar Populations in the Local Volume

Main-Sequence Turnoff Sensitivity

- Well separated filters in λ.
- Superb sensitivity.
- Large field of view.

Stellar Populations in the Local Volume

Snapshot of WFIRST Survey Science Opportunities inside the Milky Way

1.) Towards the next generation of population synthesis models

 - Stretch the color-magnitude diagram

 - Better ages and metallicities for nearby calibrators

 - Color-magnitude relation and LF of RG and AGB phases in IR bandpasses

 - Easy to develop science case using current pencil beam probes

2.) A complete stellar census and the Galactic mass budget

 - Stellar mass function is steep, dominated by cool stars

 - Map the IMF in different environments

 - The H-burning limit as a function of stellar properties

 - L and T dwarfs, structure of low mass dwarfs

The Cosmic Perspective (Pearson)
Bennett/Donahue/Schneider/Voit
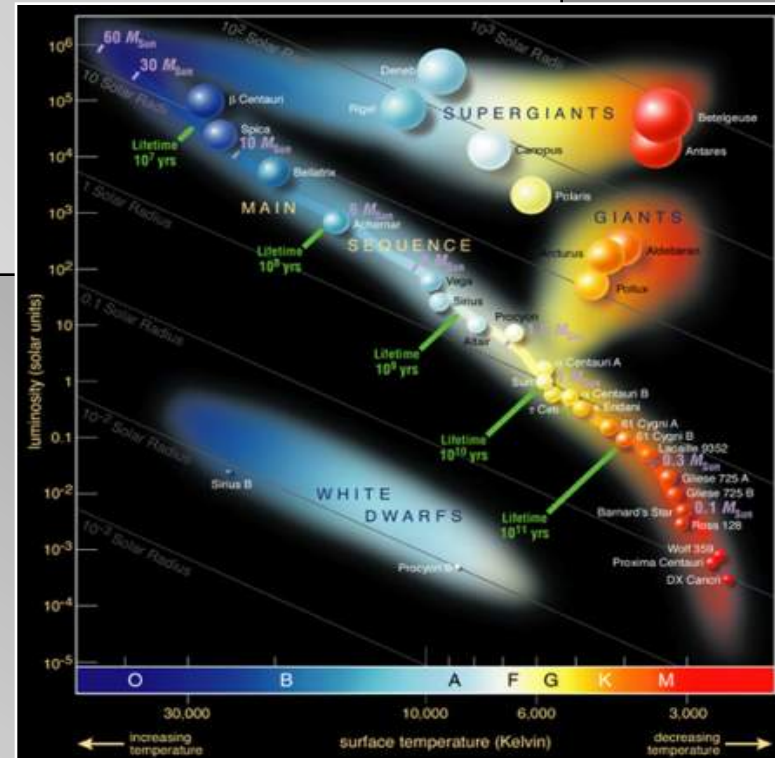
Stellar Populations in the Local Volume

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- L and T dwarfs, structure of low mass dwarfs

3.) Stellar remnants as fossils

- 98% of all stars will end their lives as white dwarfs

- Cooling ages and temperatures from photometry

- Luminosity functions hold clues on the evolved stellar mass function and Galactic SFR

- Population II IMF through halo searches

Stellar Populations in the Local Volume

Based on HST/ACS and HST/WFC3 Data Collected as a Part of GO-11677 (PI H. Richer)
UBC: Harvey Richer
AMNH: Mike Shara, David Zurek
HIA/NRC: Greg Fahlman, Peter Stetson
Swinburne: Jarrod Hurley
STScI: Jay Anderson, Aaron Dotter
UBC: Jeremy Heyl, Ryan Goldsbury, Kristen Woodley
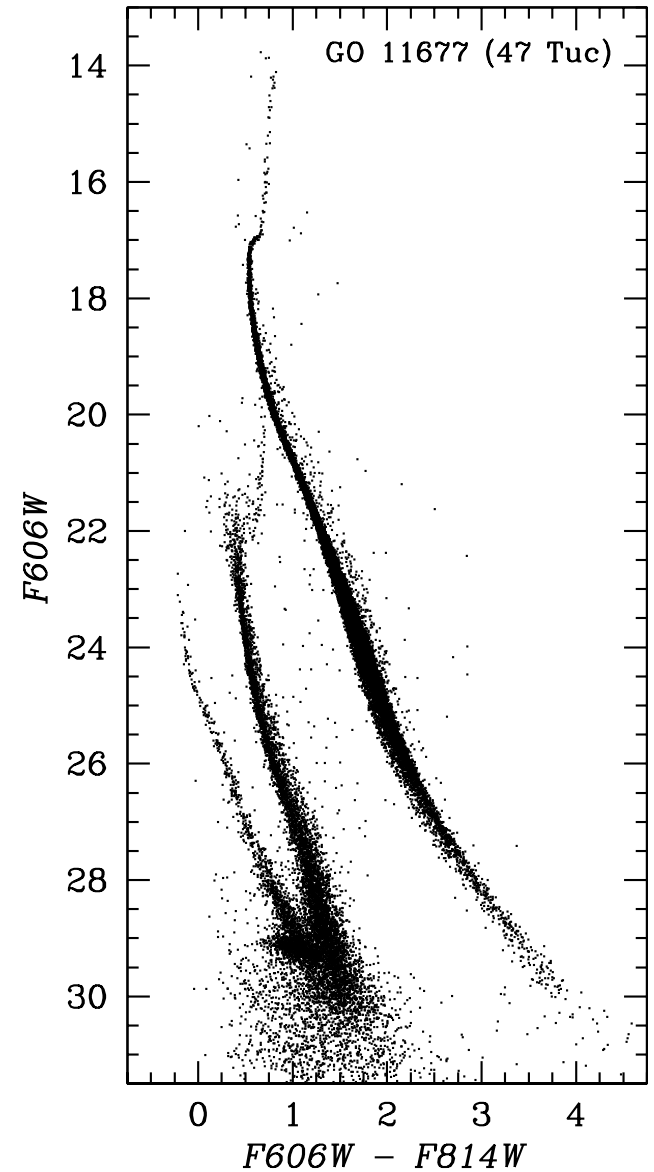UCLA: Brad Hansen, Mike Rich, David Reitzel
UW: Ivan King

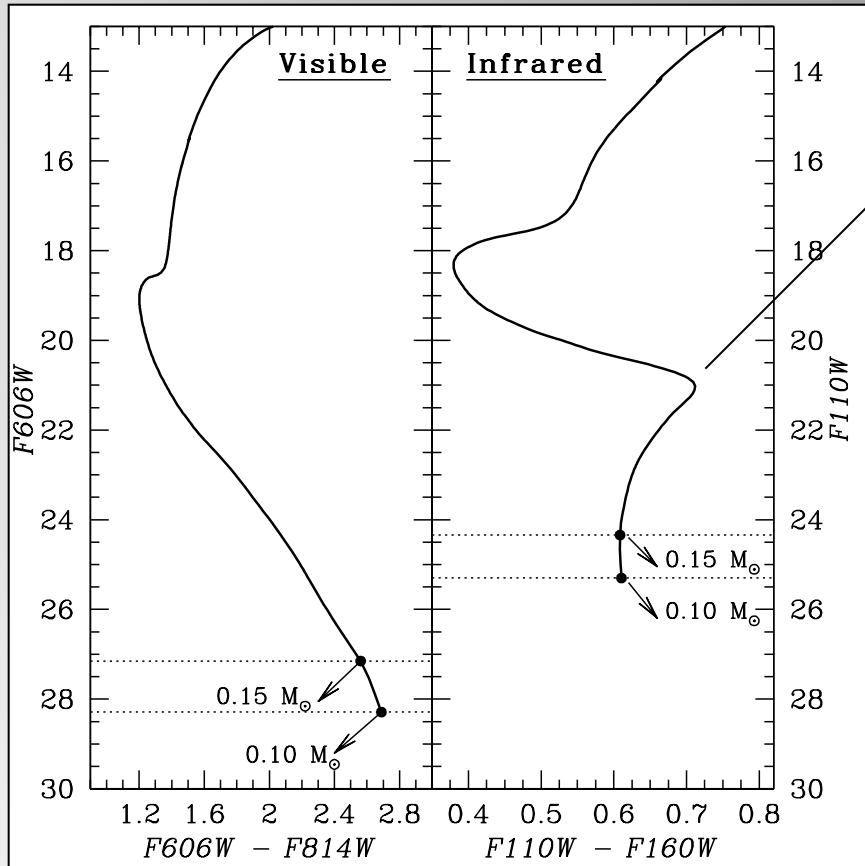Stellar Populations in the Local Volume

Stellar Populations in the Local Volume
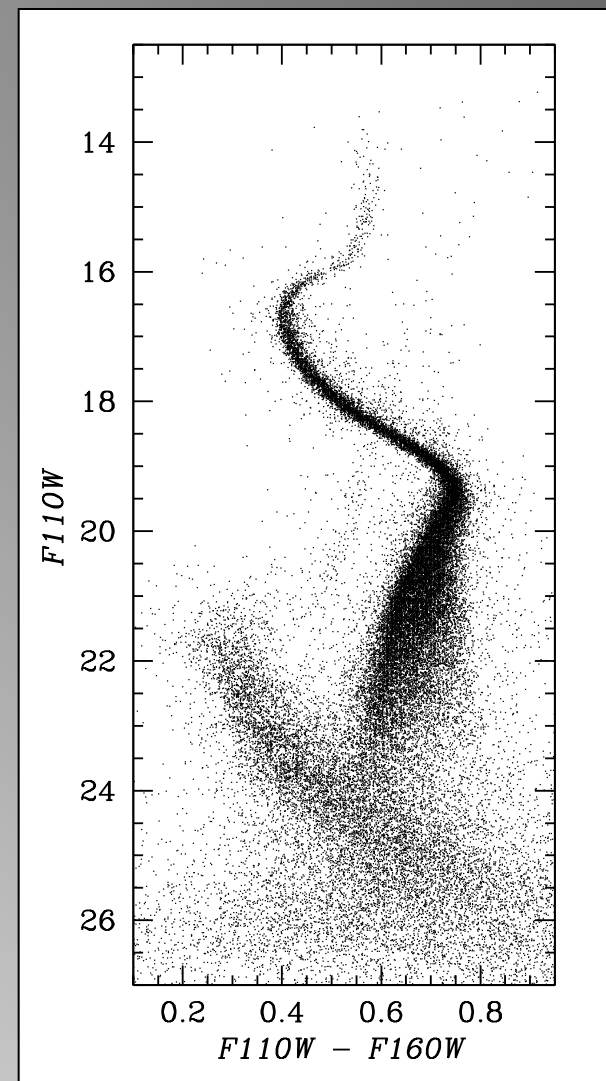
Kalirai et al. (2012)

Stellar Populations in the Local Volume
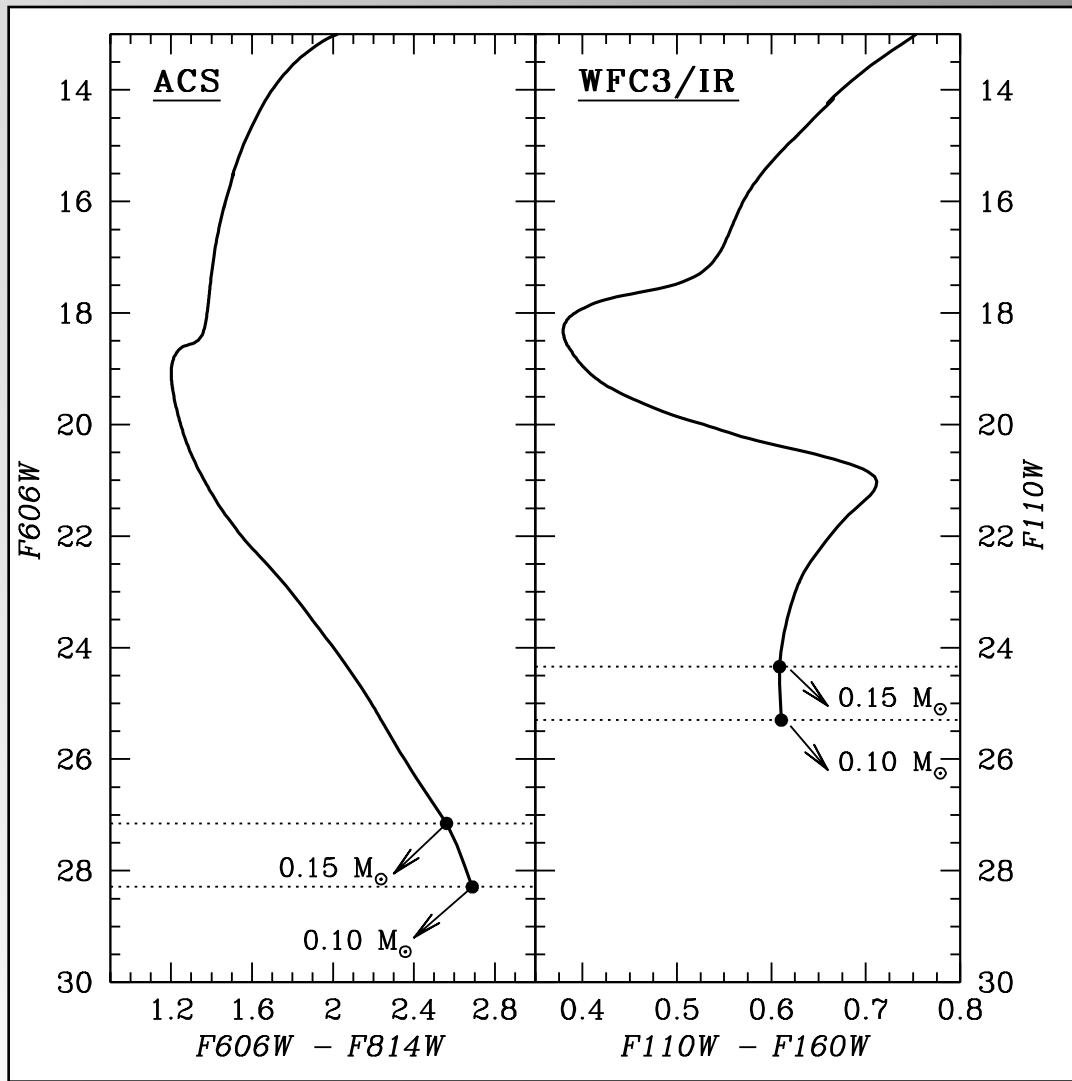

The predicted IR color-magnitude diagram
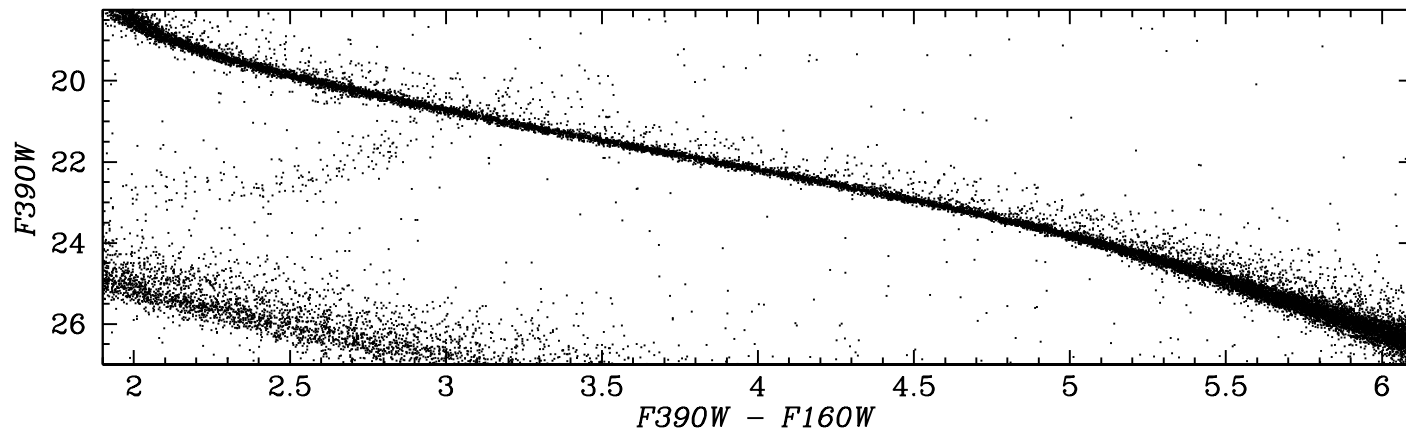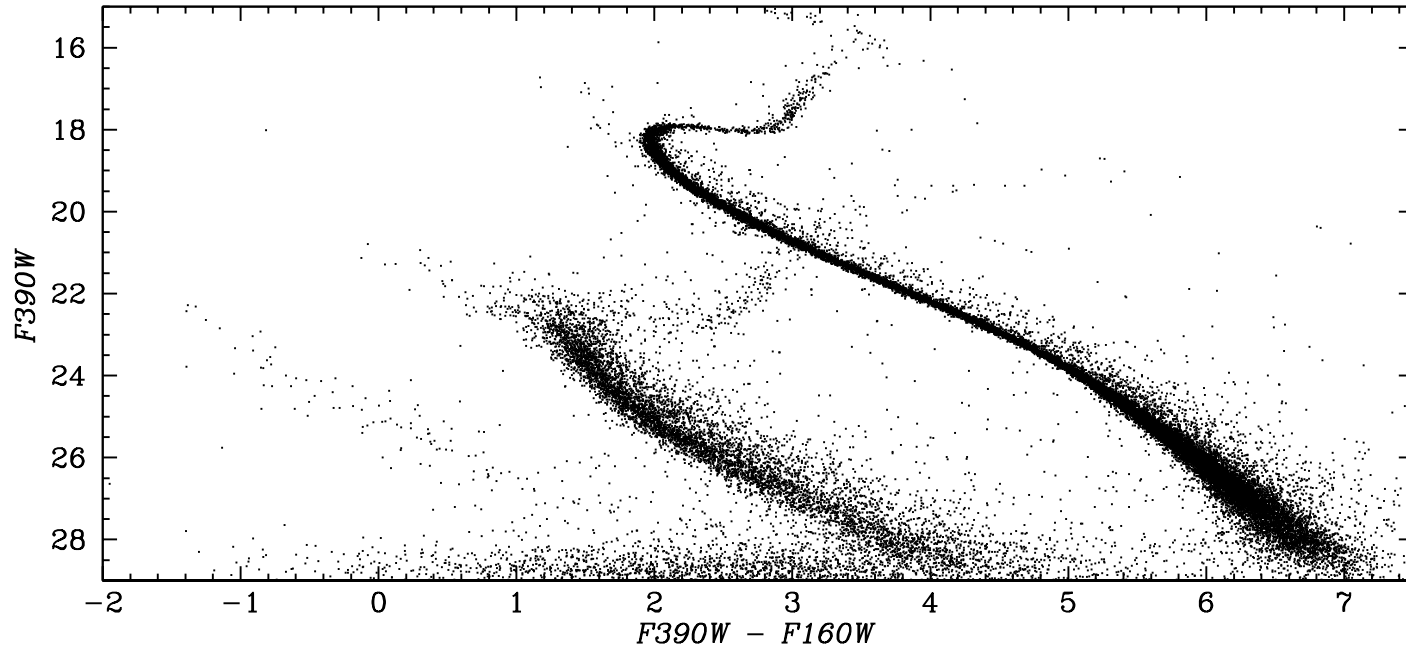shape for a coeval population at 10 kpc

- "Kink" is age insensitive, remove degeneracies
- Accurate fundamental parameters
- New tests of IR stellar evolution models
- Measure total stellar pop more efficiently

Stellar Populations in the Local Volume

Kalirai et al. (2012)

Stellar Populations in the Local Volume

Stellar Populations in the Local Volume

Jason Tumlinson
Jay Anderson
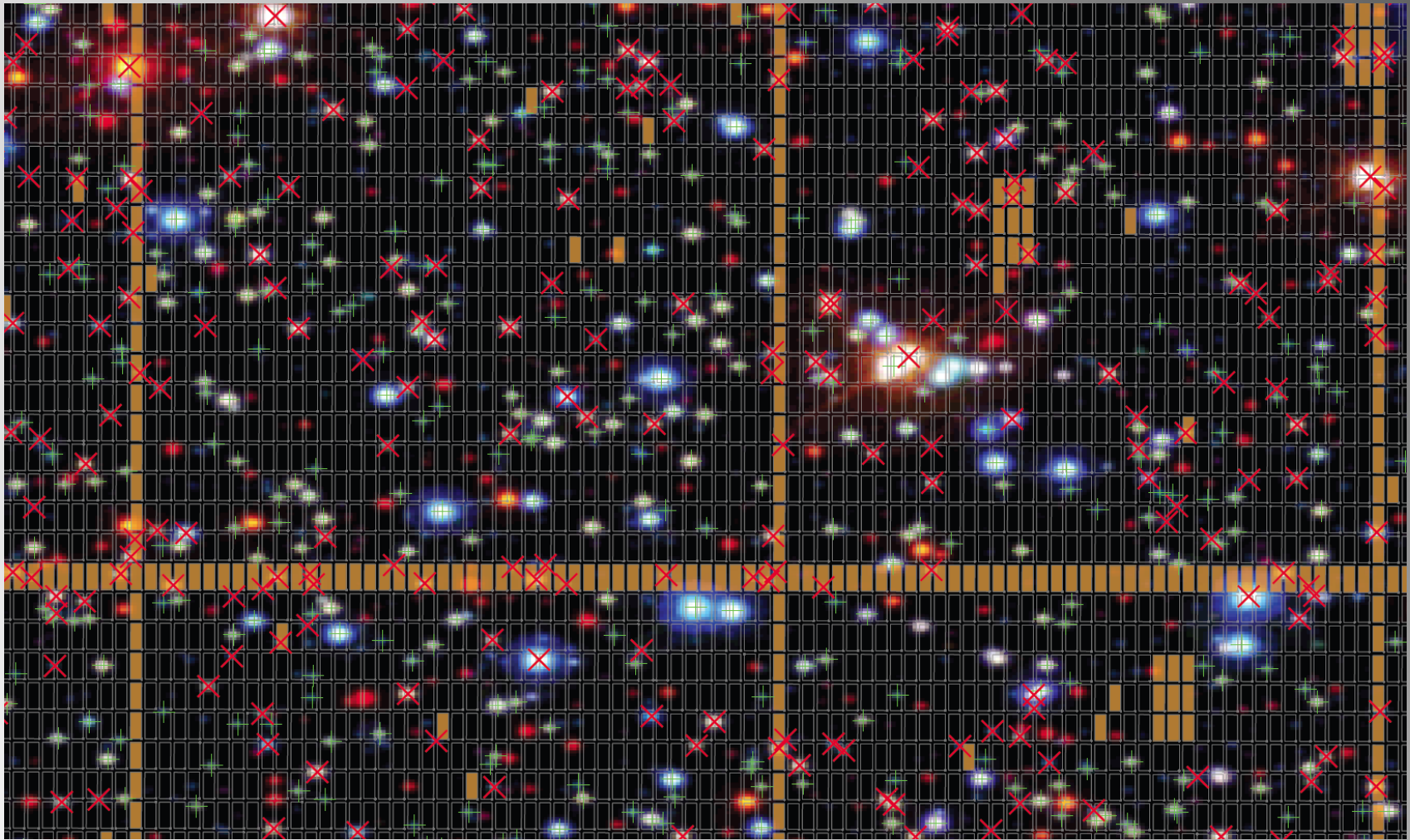
JWST NIRSpec MSA in dense stellar fields:
- Globular clusters, star forming regions, the Galactic disk, etc.

+ Targets in operable shutter

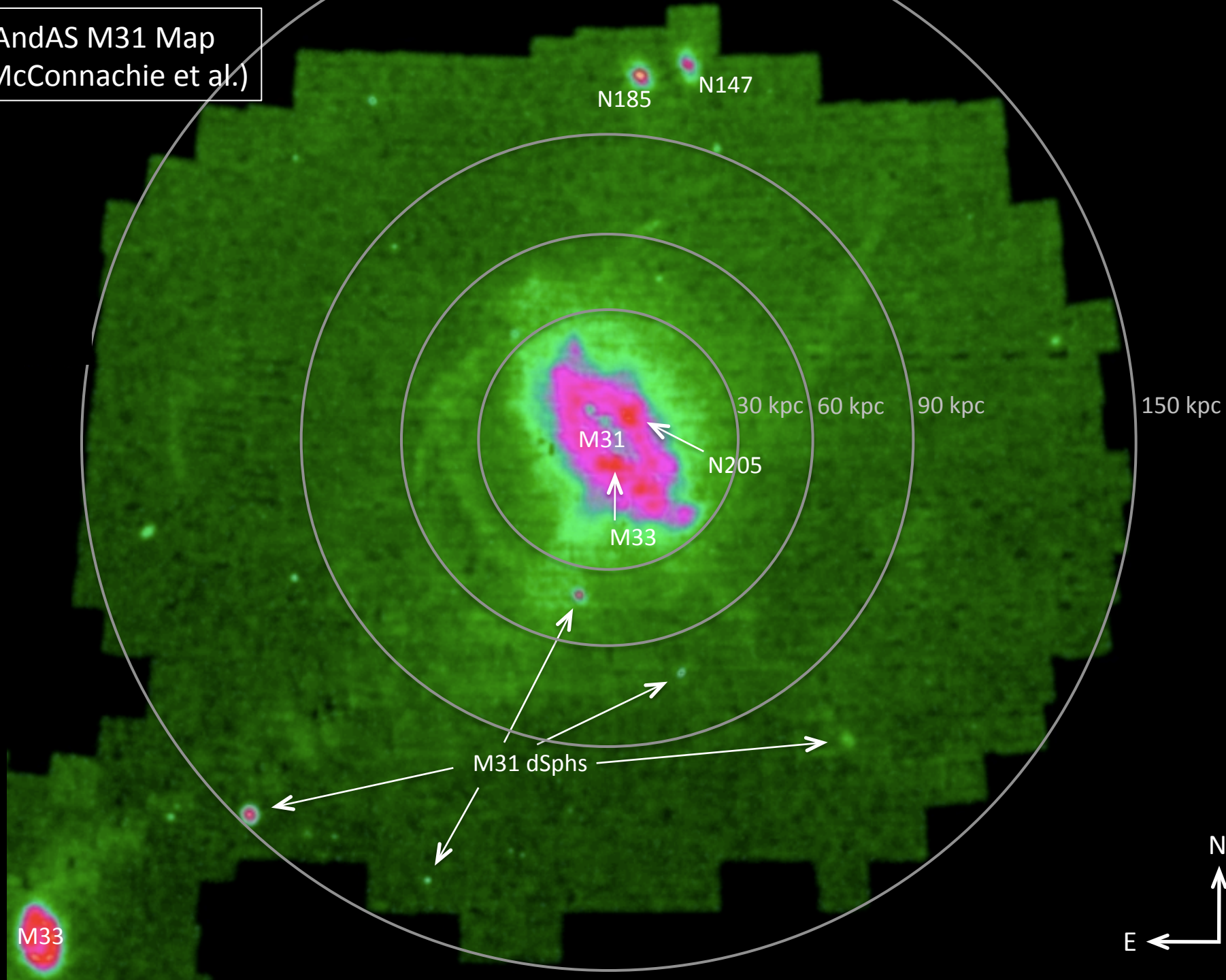x Targets outside shutters

Stellar Populations in the Local Volume

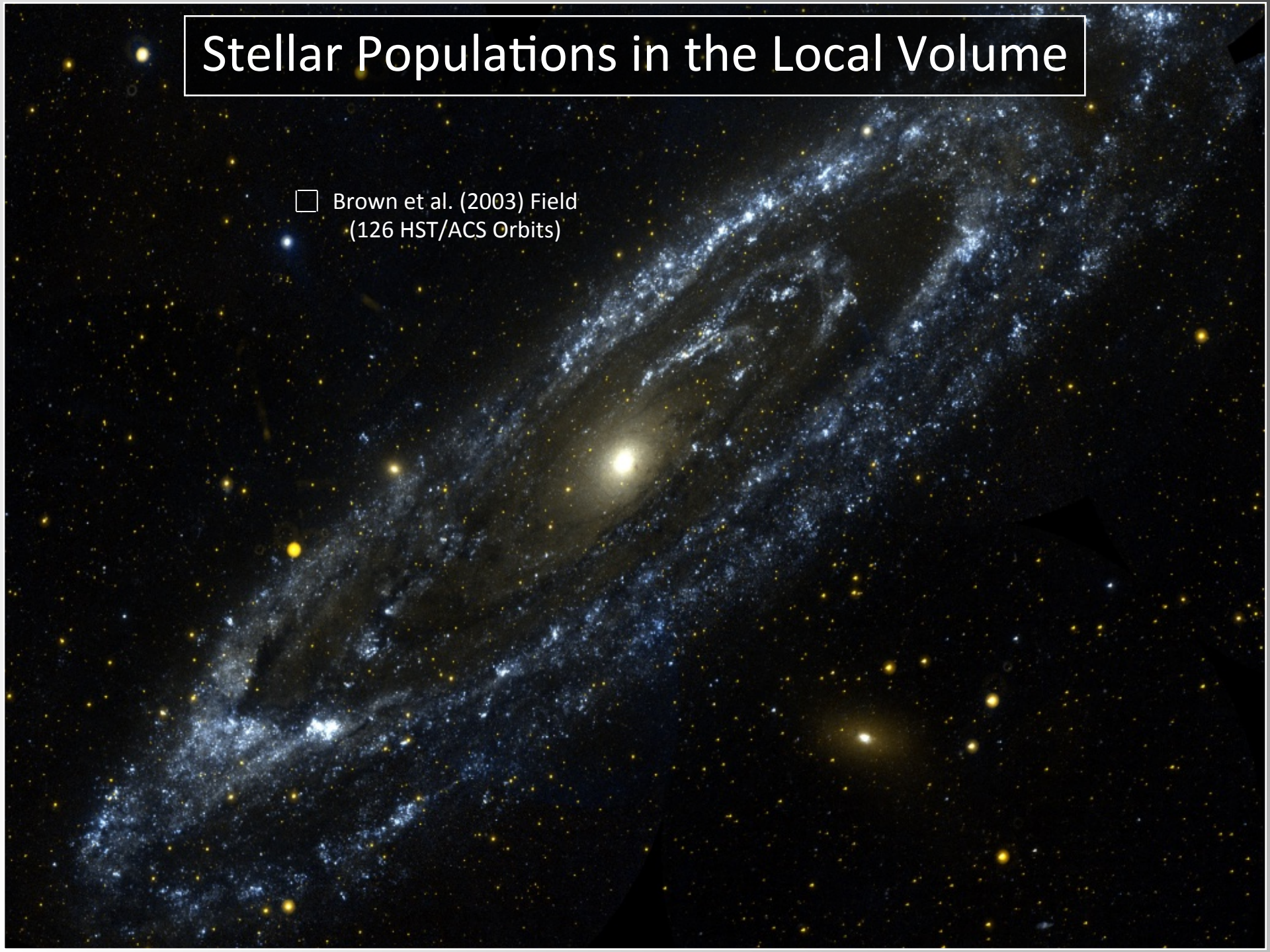**Part 2: Resolved Populations in the Nearby Universe**

- Stellar populations as high resolution tests of ΛCDM simulations
- Current limitations
- Future prospects and synergies

PAndAS M31 Map
(McConnachie et al.)

N185
N147

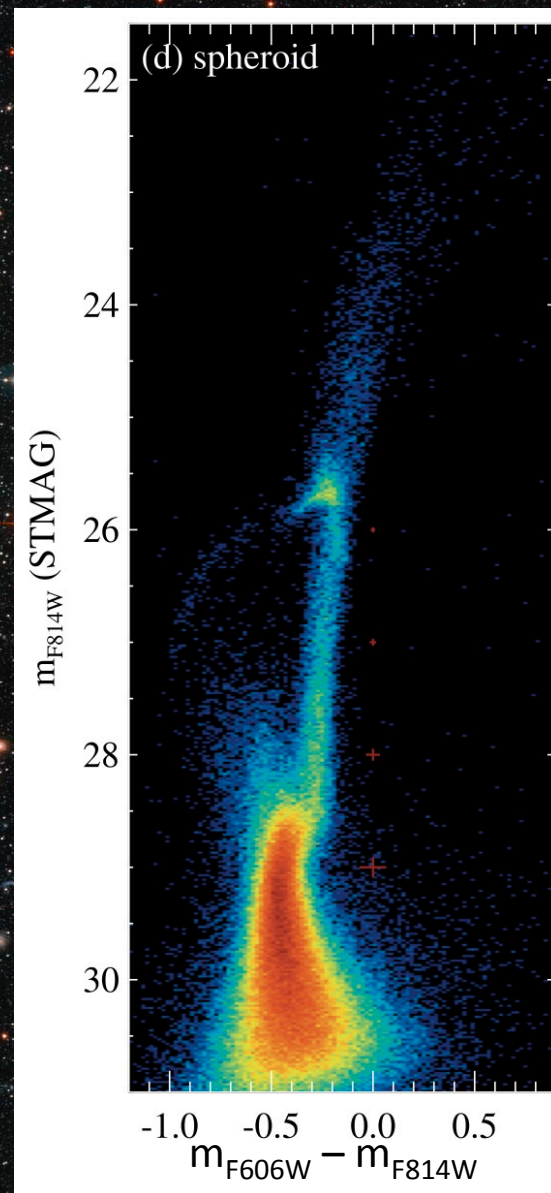30 kpc 60 kpc 90 kpc   150 kpc

M31
N205
M33
M31 dSphs

M33

N
E

Stellar Populations in the Local Volume

Brown et al. (2003) Field
(126 HST/ACS Orbits)

Stellar Populations in the Local Volume

(d) spheroid

Brown et al. (2003)

Stellar Populations in the Local Volume

Observational Design
- Keck II 10 meter telescope (on Mauna Kea)
- DEIMOS spectrograph (R = 6000, FOV = 16$'$ x 4$'$, λ = 6000 − 9000 Ang, # = 200 stars)

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Recent Results (SPLASH + PAndAS + Other)
- Discovered M31's stellar halo and measured its SB (Guhathakurta et al. 2006; Irwin et al. 2006)
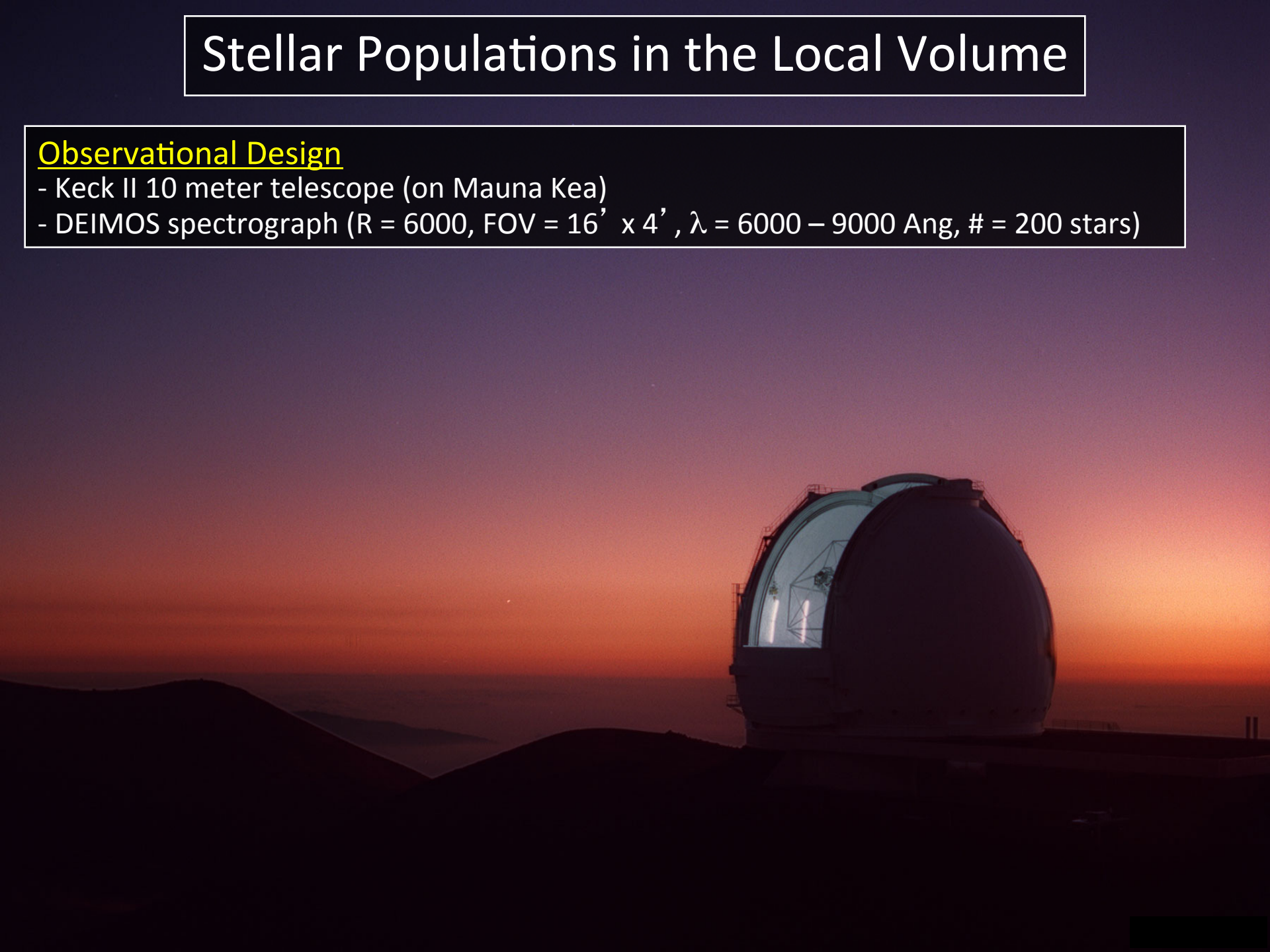- Measured the spatial extent of the halo - R > 150 kpc (Gilbert et al. 2006; Ibata et al. 2007)
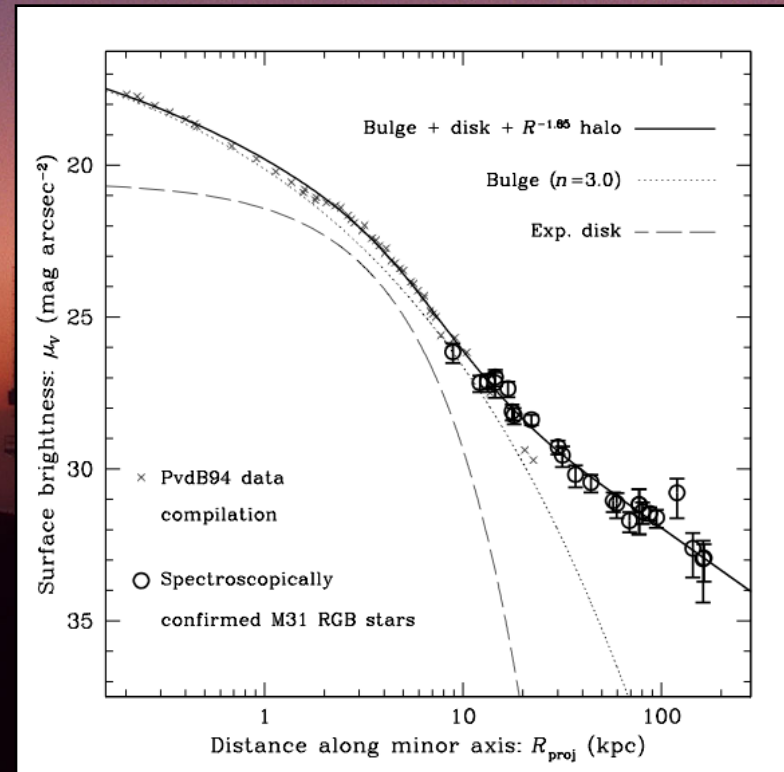
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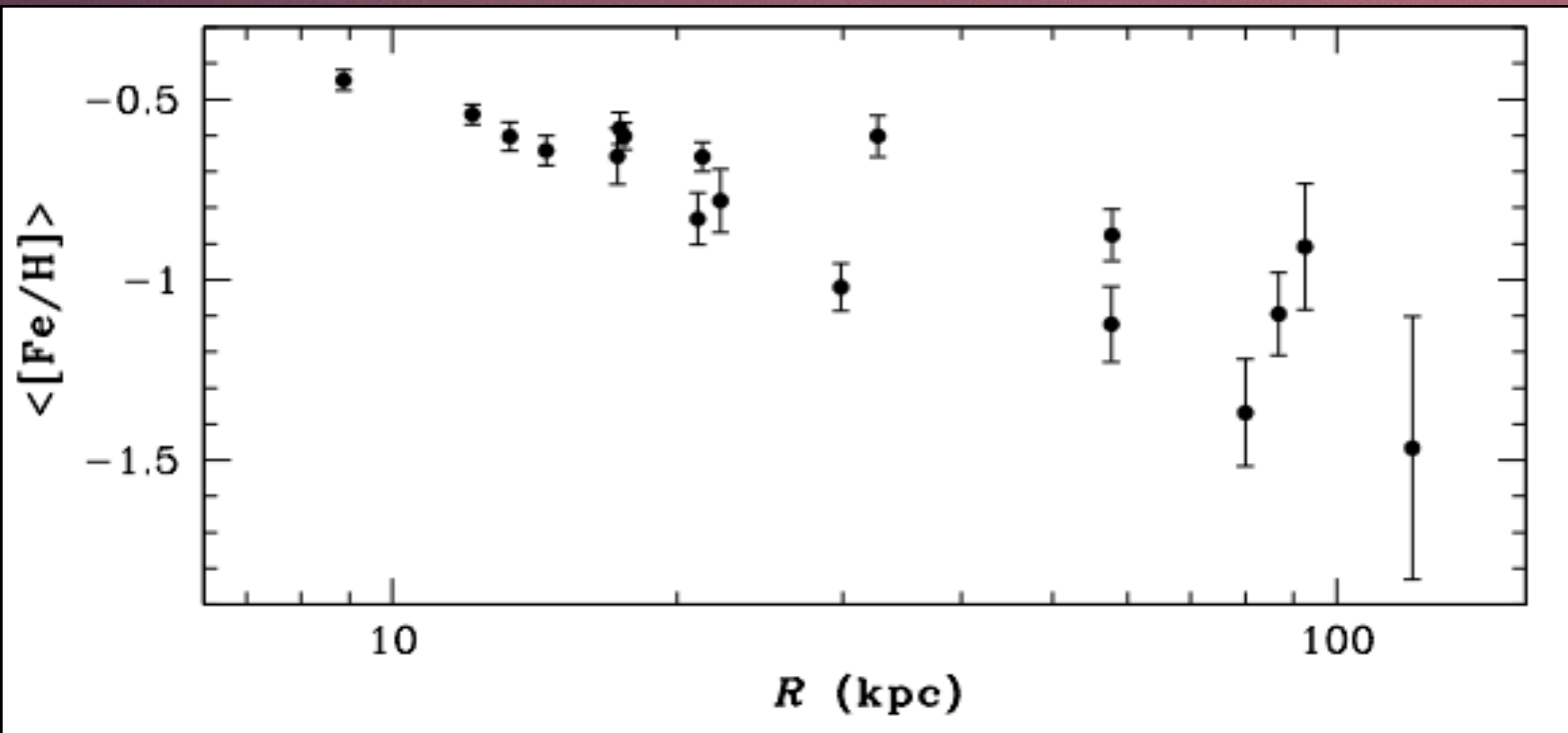- Characterized the halo metallicity distribution function (Kalirai et al. 2006; Chapman et al. 2006)

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- Measured the spatial extent of the halo - R > 150 kpc (Gilbert et al. 2006; Ibata et al. 2007)
- Characterized the halo metallicity distribution function (Kalirai et al. 2006; Chapman et al. 2006)
- Discovered and characterized new substructures (Ibata et al. 2007; McConnachie et al. 2009; Kalirai et al. 2006; Gilbert et al. 2007; 2009a; 2009b; Fardal et al. 2007; 2008; 2009; Guhathakurta et al. 2006)
- Measured the SFH in M31's disk, spheroid, and stream (Brown et al. 2003; 2005; 2007; 2008)

Stellar Populations in the Local Volume

8 Mpc Deprojected
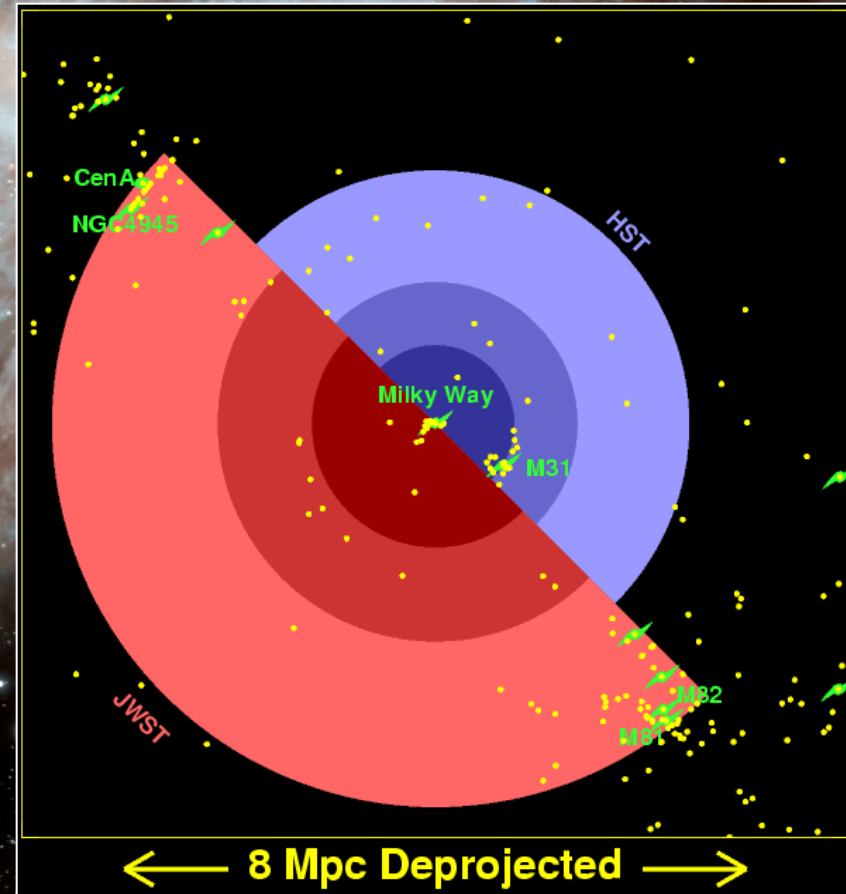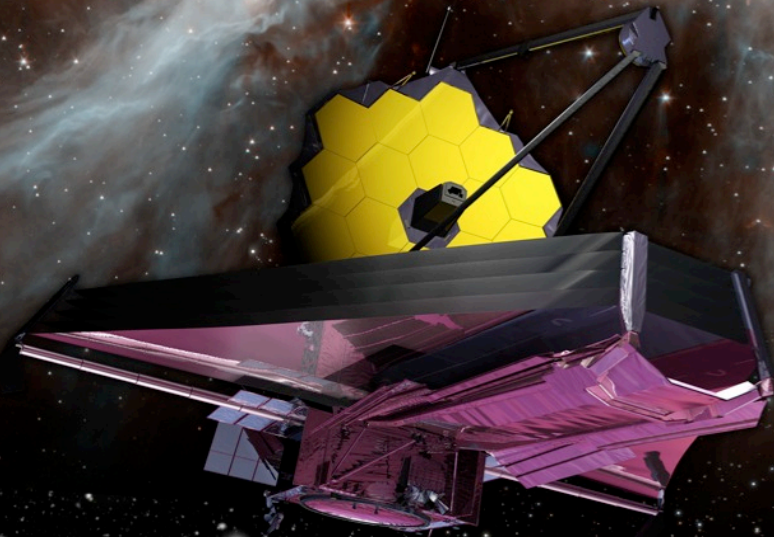
T. Brown (priv communication)

Future Roadmap for Dissecting Samples of Nearby Galaxies
- WFIRST and LSST wide-field imaging (substructure and shapes of galaxy halos)
- GSMT spectroscopy (kinematics, abundances)
- JWST ultradeep imaging (SFHs)

Stellar Populations in the Local Volume

Snapshot of WFIRST Survey Science Opportunities outside the Milky Way

1.) Dissecting local galaxies to establish fully resolved halos

- **WFIRST will fully map 100 nearby galaxies over their full extent in 1 month.**
- Star count maps
- Substructure fraction
- Surface brightness profiles
- Metallicity gradients

2.) Consider a set of "WFIRST Deep Imaging Fields"

- LMC, SMC, M31