WFIRST Infrared Nearby Galaxy Survey

Ben Williams (University of Washington)
Nearby Galaxies Are Great for Astrophysics

- Detailed view and context simultaneously
- Sensitive to galaxy evolution and cosmology
- Anchor our knowledge for interpretation of more distant universe
- Large samples - Subdivide sample for specific goals
- Cover a wide range of galaxy properties
Huge Potential Data Set

<table>
<thead>
<tr>
<th>Sample Property</th>
<th>Value/Range</th>
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</thead>
<tbody>
<tr>
<td>N(_{\text{galaxies}})</td>
<td>~500</td>
</tr>
<tr>
<td>Distances</td>
<td>&lt;10 Mpc</td>
</tr>
<tr>
<td>Metallicities</td>
<td>-2([\text{Fe/H}])&lt;+0.2</td>
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<tr>
<td>Stellar Masses</td>
<td>(10^5-10^{11} M_{\odot})</td>
</tr>
<tr>
<td>Luminosities</td>
<td>-21&lt;M(_B)&lt;-1</td>
</tr>
<tr>
<td>Angular Sizes</td>
<td>0.05°&lt;(\theta)&lt;10°</td>
</tr>
<tr>
<td>Point depth</td>
<td>+7&gt;M(_{F160W})&lt;3</td>
</tr>
<tr>
<td>Proper Motion</td>
<td>(D_{\text{Max}}&lt;100 \text{ kpc})</td>
</tr>
<tr>
<td>FoV/Galaxy</td>
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</tr>
<tr>
<td>N(_{\text{satellites}})/Galaxy</td>
<td>&lt;100</td>
</tr>
<tr>
<td>N(_{\text{streams}})/Galaxy</td>
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</tr>
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<td># Resolved Stars</td>
<td>~1,000,000,000</td>
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</table>

- N\(_{\text{galaxies}}\): ~500
- Distances: <10 Mpc
- Metallicities: -2<\([\text{Fe/H}]\)<+0.2
- Stellar Masses: \(10^5-10^{11} M_{\odot}\)
- Luminosities: -21<M\(_B\)<-1
- Angular Sizes: 0.05°<\(\theta\)<10°
- Point depth: +7>M\(_{F160W}\)<3
- Proper Motion: \(D_{\text{Max}}<100 \text{ kpc}\)
- FoV/Galaxy: 1-100
- N\(_{\text{satellites}}\)/Galaxy: <100
- N\(_{\text{streams}}\)/Galaxy: <100
- N\(_{\text{clusters}}\)/Galaxy: <500
- # Resolved Stars: ~1,000,000,000
## Projects and Lead Co-Is

**PI:** Williams (U. Wash.)  
**Deputy PI:** Dalcanton (U. Wash.)

<table>
<thead>
<tr>
<th>Topic</th>
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<tr>
<td>Photometry</td>
<td>Dolphin (Raytheon)</td>
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<tr>
<td>Stellar Halos</td>
<td>Bell (Mich.), Johnston (Columbia), Bullock (Irvine)</td>
</tr>
<tr>
<td>Dwarf Satellites</td>
<td>Sand (TTU), Bullock (Irvine)</td>
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<tr>
<td>Small Scale Dark Matter</td>
<td>Walker (CMU), Johnston (Columbia)</td>
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<tr>
<td>Globular Clusters</td>
<td>Seth (Utah)</td>
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<tr>
<td>Star Formation Histories</td>
<td>Weisz (Berkeley)</td>
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<tr>
<td>Dust &amp; ISM</td>
<td>Gordon (STScI), Dalcanton (UW)</td>
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<tr>
<td>Stellar Evolution</td>
<td>Boyer (Maryland)</td>
</tr>
</tbody>
</table>
Collaborators

Raja Guhathakurta (UCSC)
Denija Crnojevic (TTU)
Marina Rejkuba (ESO)
Antonela Monachesi (MPA)
Alan McConnachie (HIA)
Laura Sales (UCR)
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Julia Roman-Duval (STScI)
Alberto Bolatto (Maryland)
Josh Peek (STScI)
Jay Anderson (STScI)
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Beth Willman (LSST)
Phil Rosenfield (CfA)
Margaret Meixner (STScI)
Leo Girardi (Padova)
Nicolas Martin (MPIA)
Cliff Johnson (UCSD)
Jay Strader (MSU)
Robyn Sanderson (Columbia)
Adrian Price-Whelan (Columbia)
Sergey Koposov (Cambridge)
Julio Chaname (Catolica)
Jorge Penarrubia (Edinburgh)
Coral Rose Wheeler (UCI)
Stellar Halos

Details from HST

Brown et al. 2006

Context from ground

Ibata et al. 2014
Cen-A - Megacam

Williams: WFIRST Infrared Nearby Galaxy Survey

WFIRST should reach <1 star/arcmin²

Crnojevic et al. 2015
For HST, Even relatively far away coverage is sparse

M101: 7.4 Mpc
WFIRST gets full coverage
WFIRST gets full coverage

M101: 7.4 Mpc

Representative Ground-Based

WFC3-IR-PID: 12298

0.9 kpc

1.9 kpc

130 kpc
WFIRST gets full coverage

M101: 7.4 Mpc

WFC3-IR-PID: 12298

Representative Ground-Based

Representative Space-Based

1.9 kpc

0.9 kpc

130 kpc
Stellar Halo Structures

Number, luminosity, shape of streams → Types, timing and orbits of galaxies accreted.
Disrupted streams → Small-scale dark matter halos.
Dwarf Satellites

Lots of dark, sub-galactic halo satellites predicted

See Poster
Wide Binaries

Dark sub-halos disrupt wide binary systems. Their would put stress on Lambda-CDM.

Faint Nearby Galaxies
Avoid non-DM perturbs Old Dwarfs
Allow disruption time Old Dwarfs
~0.05” separation High resolution
Changes across galaxy Wide FoV

0.1% in bound subhalos
1% in bound subhalos
10% in bound subhalos
100% in bound subhalos

Penarrubia et al. 2010
Globular Clusters

- Old: Probe early epochs of galaxy assembly and halo formation
- WFIRST partially resolves >90% of GCs in galaxies <10 Mpc
- Individual RGB stars can give information on metallicity
- Spectroscopy Targets

Virgo intracluster globulars (Williams et al. 2007)
Huge increase in sampling of short-lived, high-luminosity phases
Star Formation Histories

Weisz et al. 2011

Blue & Red Core
Helium Burning

[Fe/H] = -0.5 ± 0.15

MS

RGB

Local Volume Dwarfs

SFH Variety

Williams: WFIRST Infrared Nearby Galaxy Survey
Star Formation Histories

Wide Field Coverage Probes Trends with Radius
Large Sample Probes Trends with Galaxy Mass.
Lowest masses sensitive to reionization.
Dust and Population Maps

- RGB Width $\rightarrow$ Dust Absorption
- RC/RGB Color $\rightarrow$ Metallicity
- Main Sequence $\rightarrow$ Star Formation Rate
Conclusions

Maximizing the value of a WFIRST survey of nearby galaxies

Sample Selection: Number/properties we need for variety of projects

Distance Distribution: More tiling vs. longer exposures

Depth: What is optimal for various sub-projects?

Area: How far out in the halo does the science return decrease?

Filters: How many bands? Which bands?

Scheduling: Proper motion possibilities

Data Products: Crowded field photometry (including quality metrics)