

A Test of Λ -CDM:
Probing the Stellar Age Distributions in Halos
Across the Local Volume

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Carnegie Observatories

Motivation: Galaxy Halos



Via Lactea: Diemand+ 2008

LCDM predicts Milky Way sized galaxies are filled with DM substructure.

What does this mean observationally?

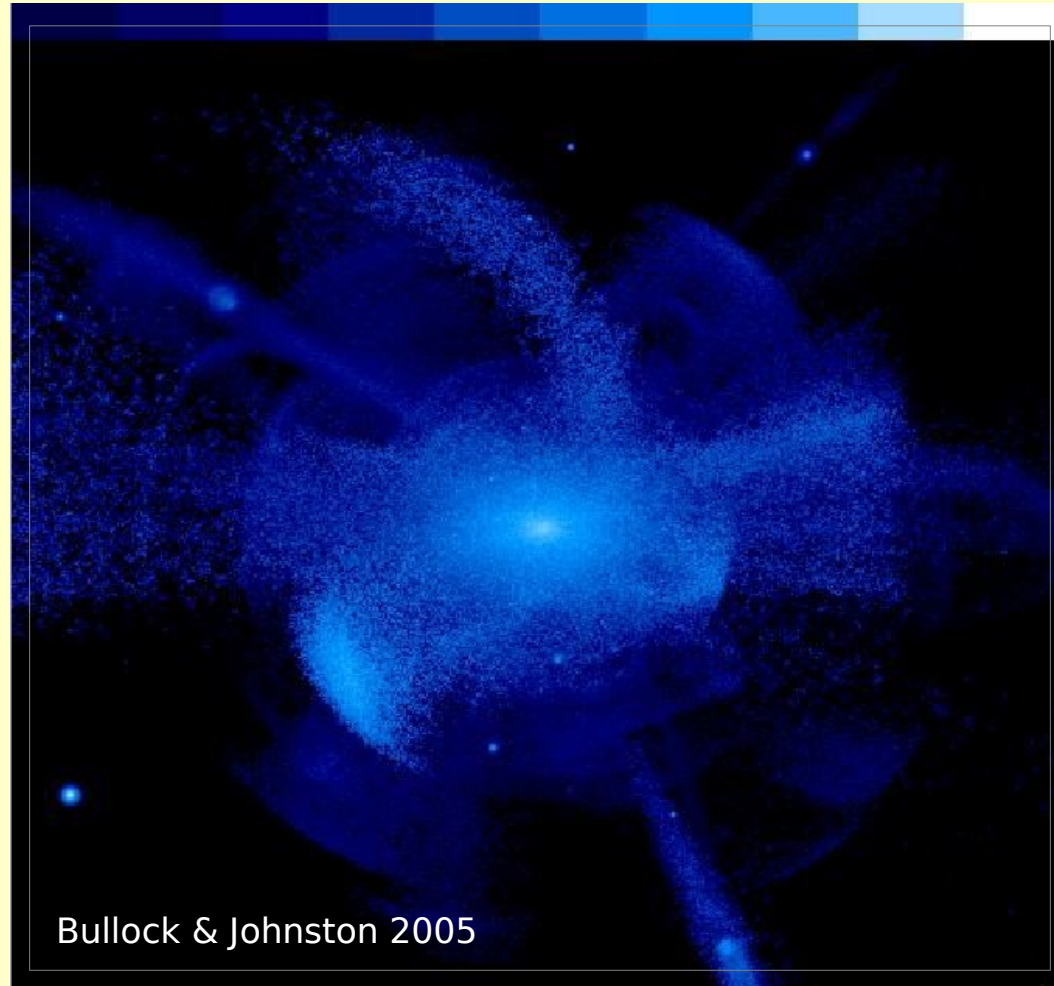
Motivation: Galaxy Halos

Surface Brightness mag arcsec⁻²

38

~30

23



Motivation: Galaxy Halos

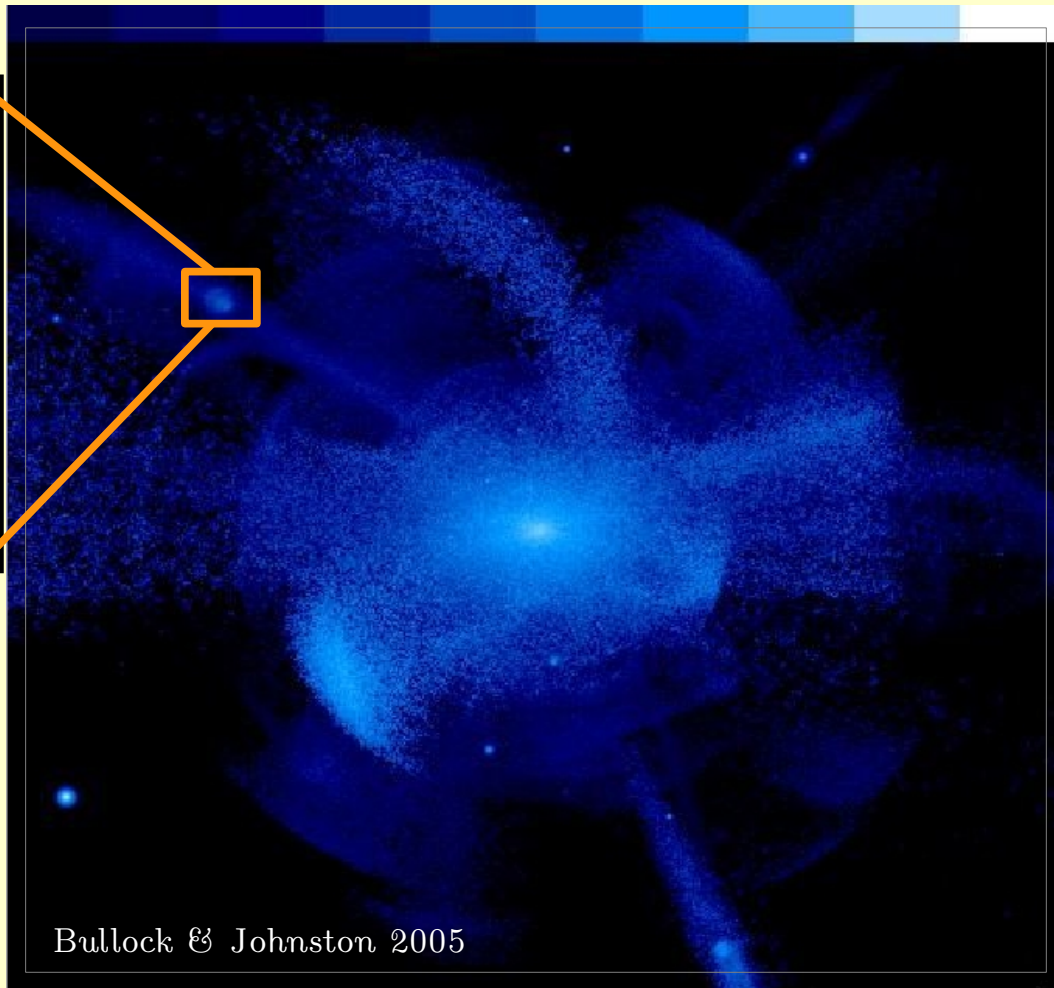
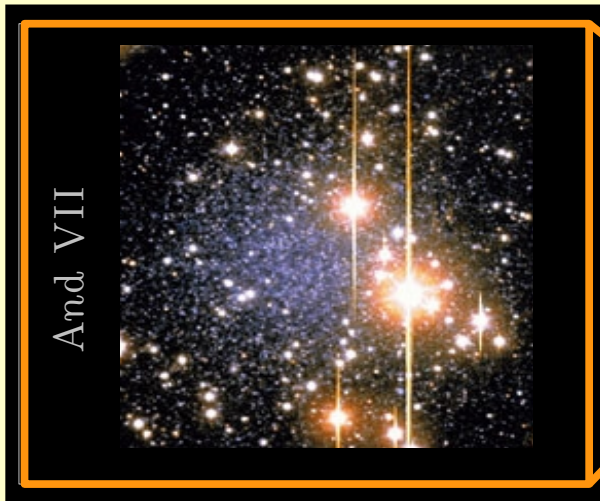
Surface Brightness mag arcsec⁻²

Satellites =
“future” accretions

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23



Motivation: Galaxy Halos

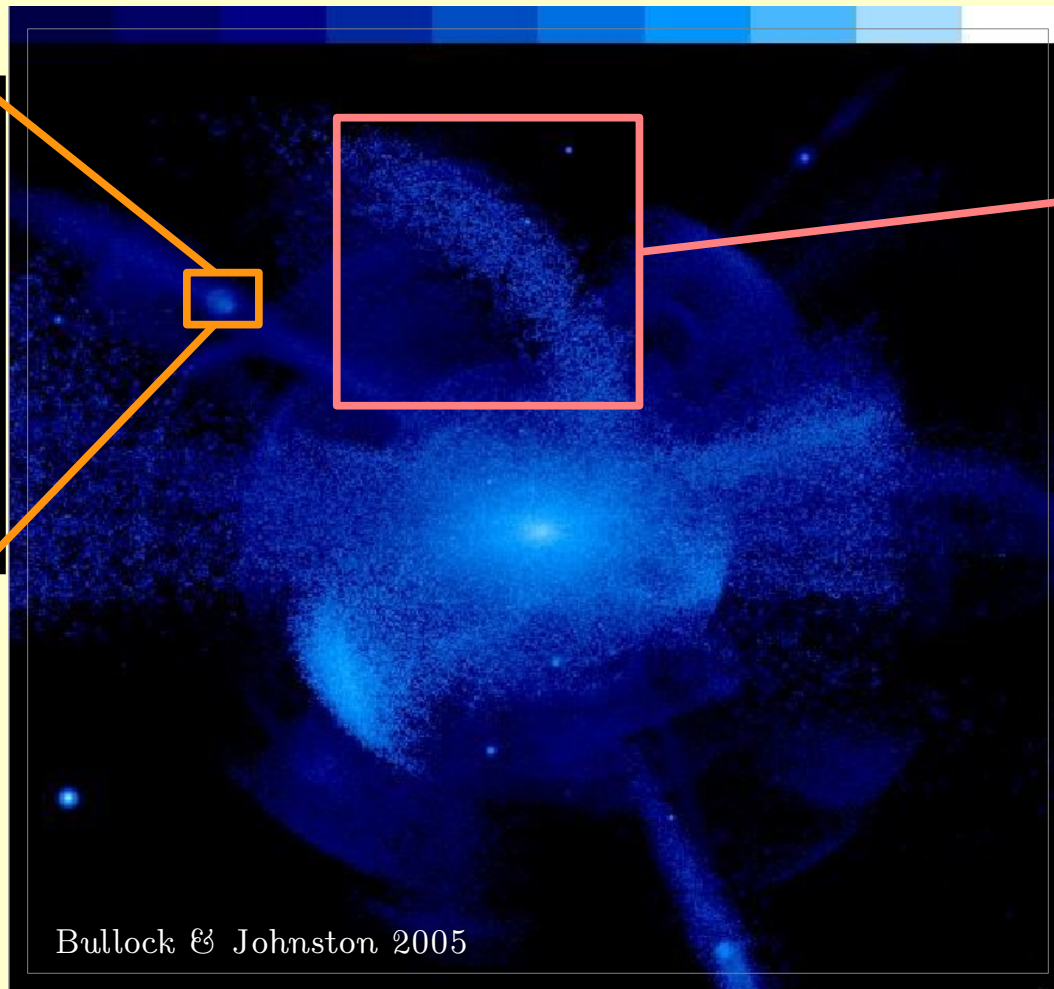
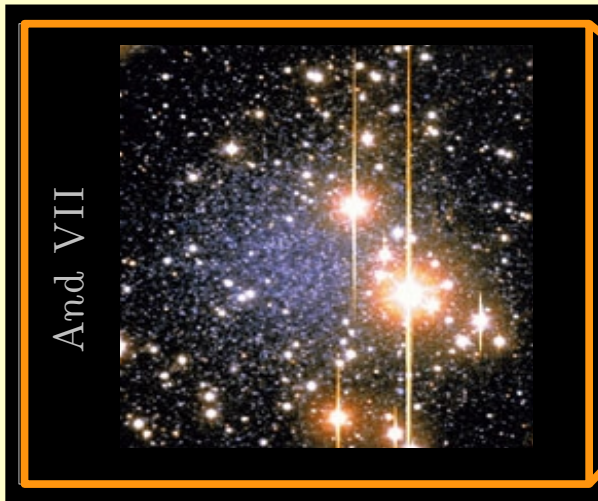
Surface Brightness mag arcsec⁻²

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Streams =
“on-going”
accretions

Bullock & Johnston 2005

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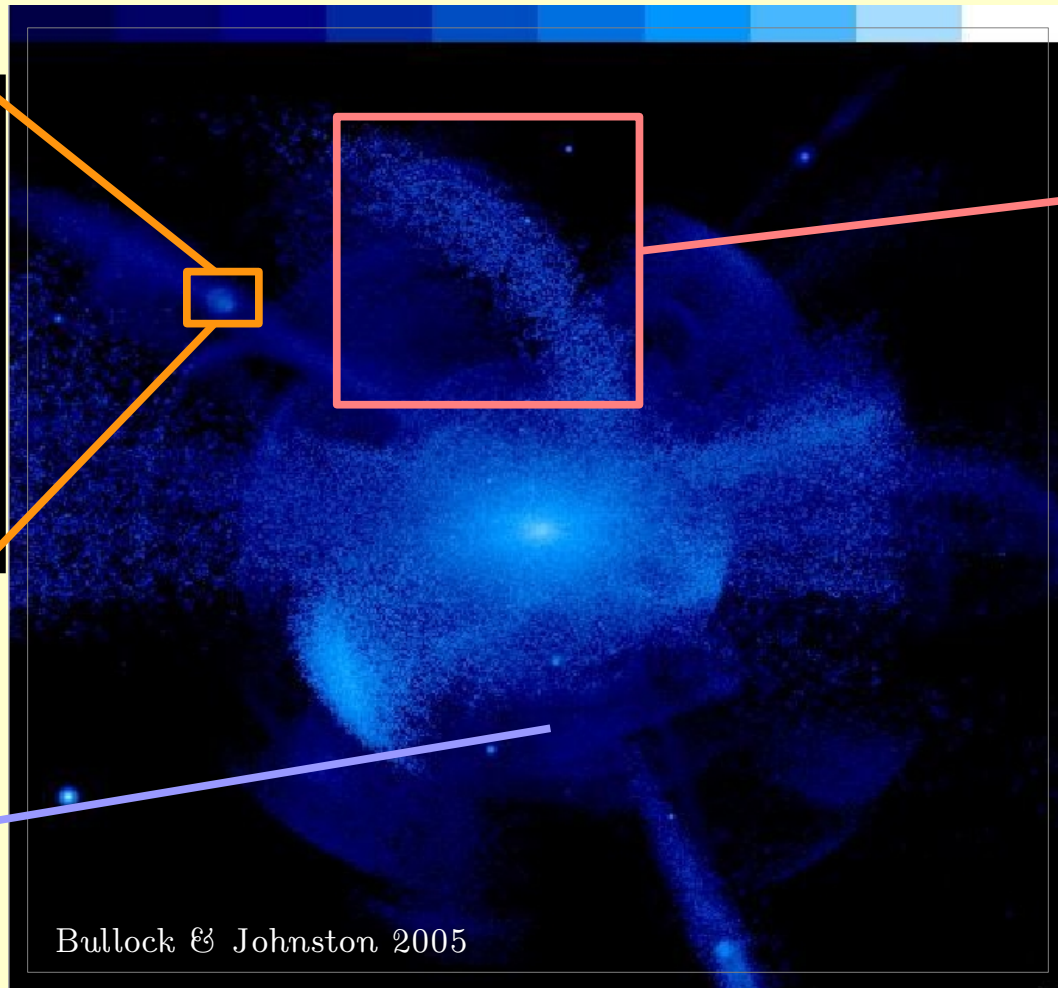
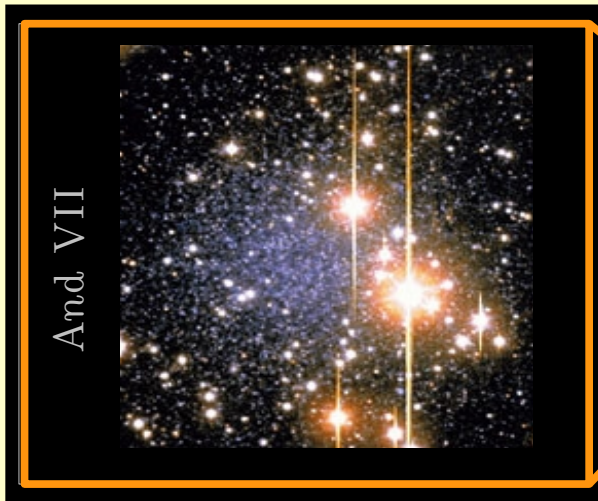
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Streams =
“on-going” accretions

Smooth =
“past” accretions

Bullock & Johnston 2005

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Surface Brightness mag arcsec⁻²

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Peg dSph

All phases of hierarchical galaxy
assembly are preserved
and are accessible to us in the halo.

Streams =
“on-going”
accretions

Smooth =
“past” accretions

Bullock & Johnston 2005

Motivation: Galaxy Halos

Surface Brightness mag arcsec⁻²

Satellites =
“future” accretions

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~30

23

Peg dSph

... but at low surface brightness
and large physical & angular scales.

Streams =
“on-going”
accretions

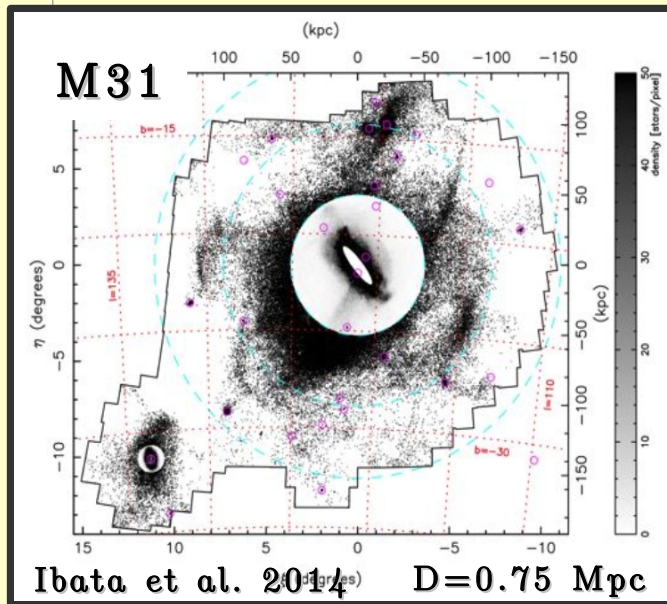
Smooth =
“past” accretions

$R_{\text{virial}} \sim 300 \text{ kpc}$

Bullock & Johnston 2005

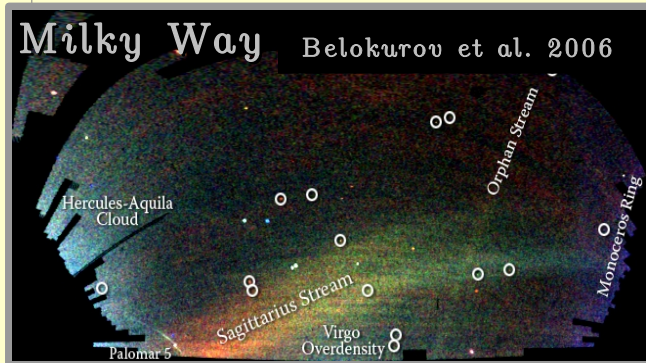
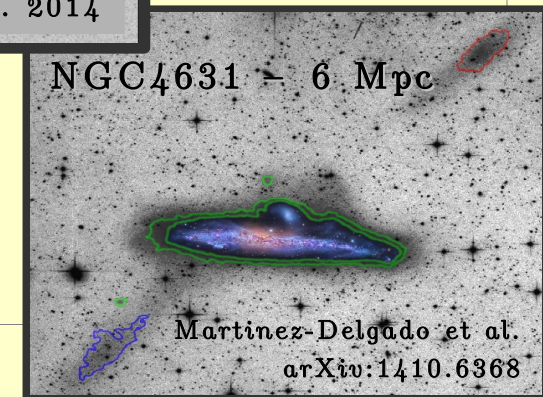
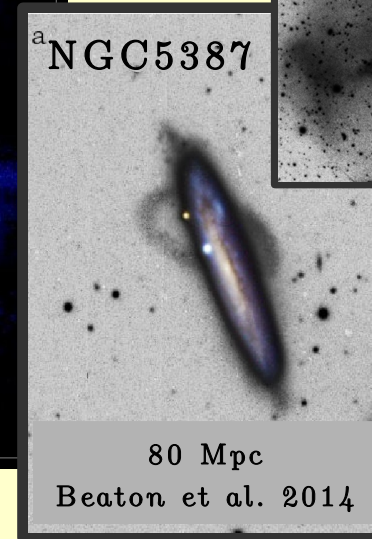
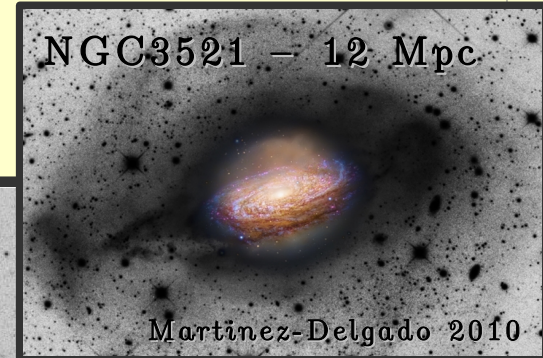
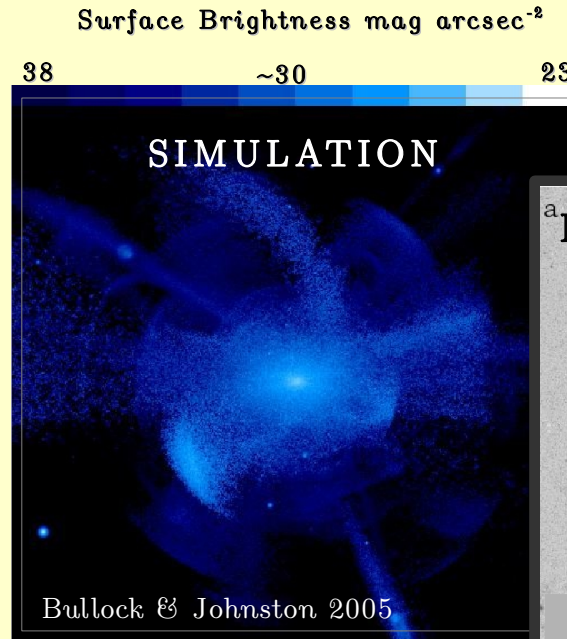
Motivation: Galaxy Halos

Resolved Stars



*See also Gilbert et al. 2012, 2014

Integrated Light

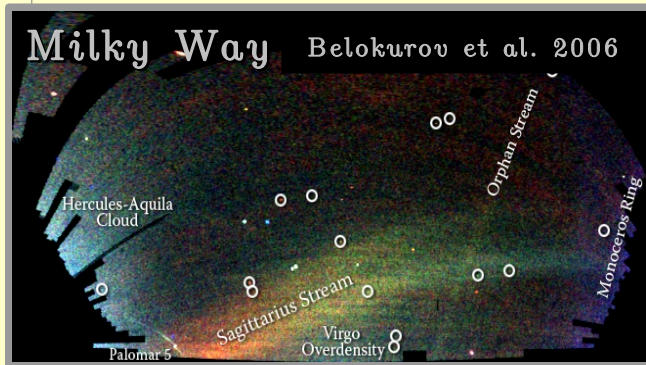
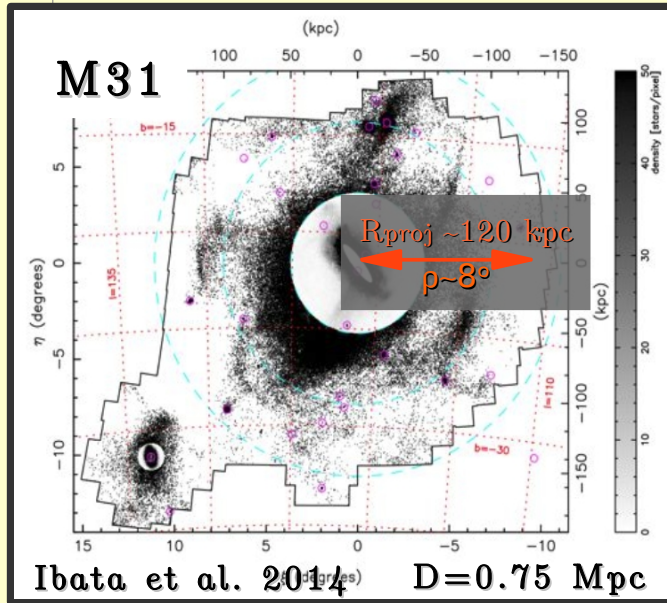


November 17, 2014

Rachael L. Beaton

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Resolved Stars



November 17, 2014

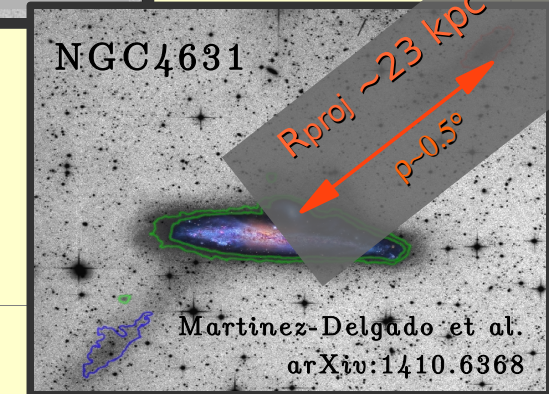
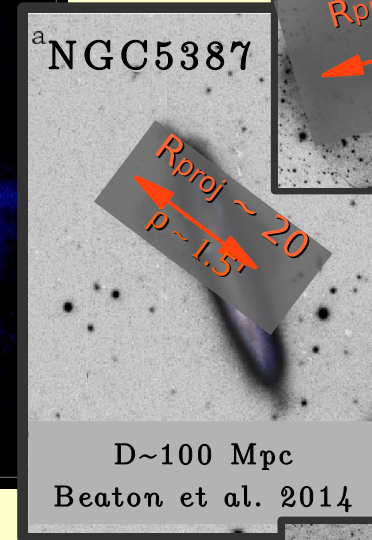
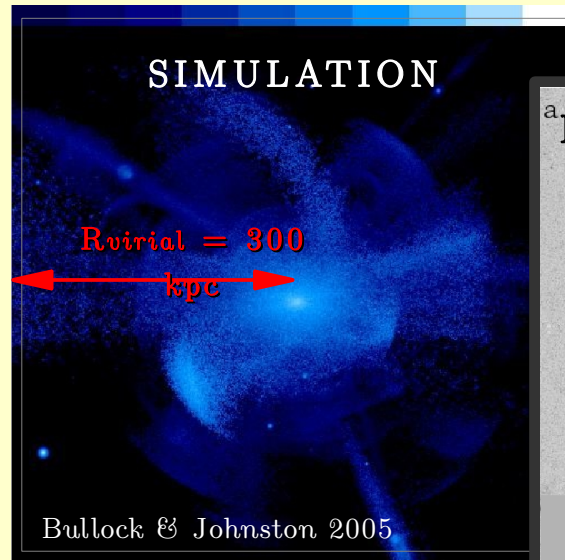
$R_{\text{proj}} \sim 60 \text{ kpc}$

$\rho \sim 30^\circ$

Integrated Light

Surface Brightness mag arcsec^{-2}

38 ~ 30 23

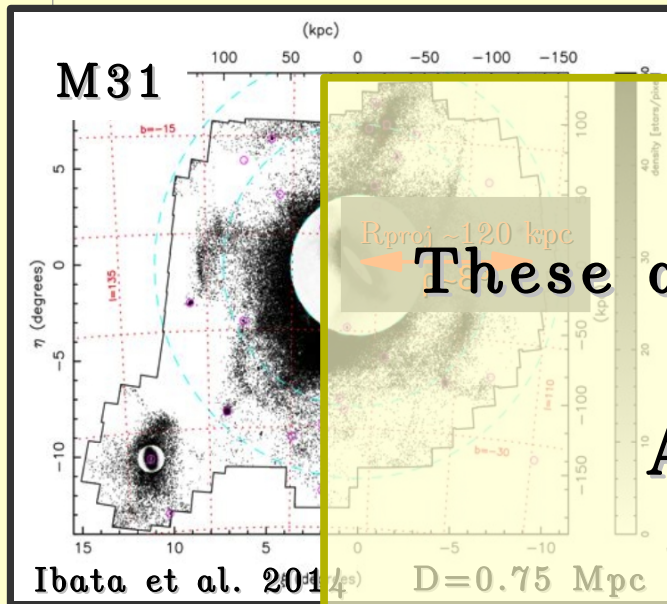


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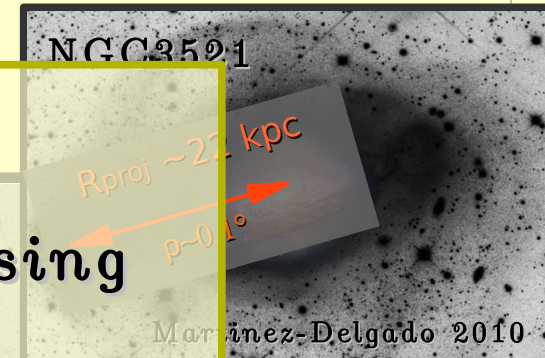
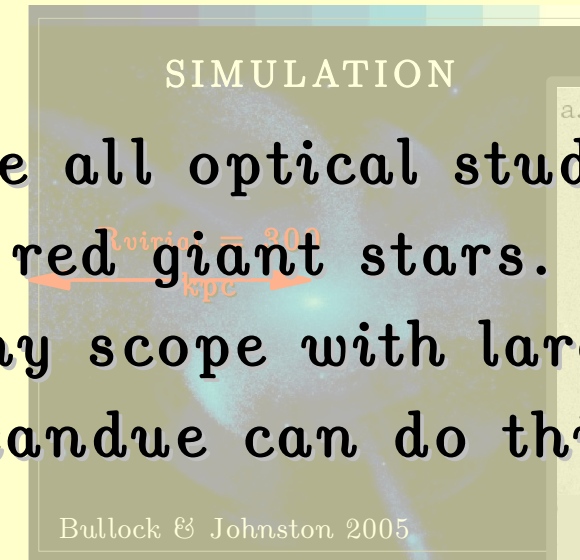
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Resolved Stars

Integrated Light



Surface Brightness mag arcsec⁻²



These are all optical studies using red giant stars.

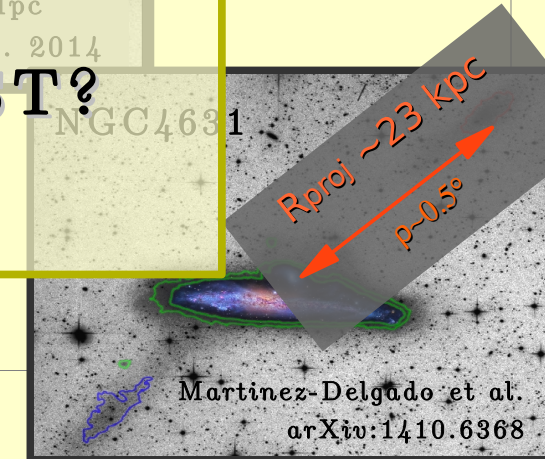
Any scope with large etendue can do this.



Rproj ~ 60 kpc
p ~ 30°

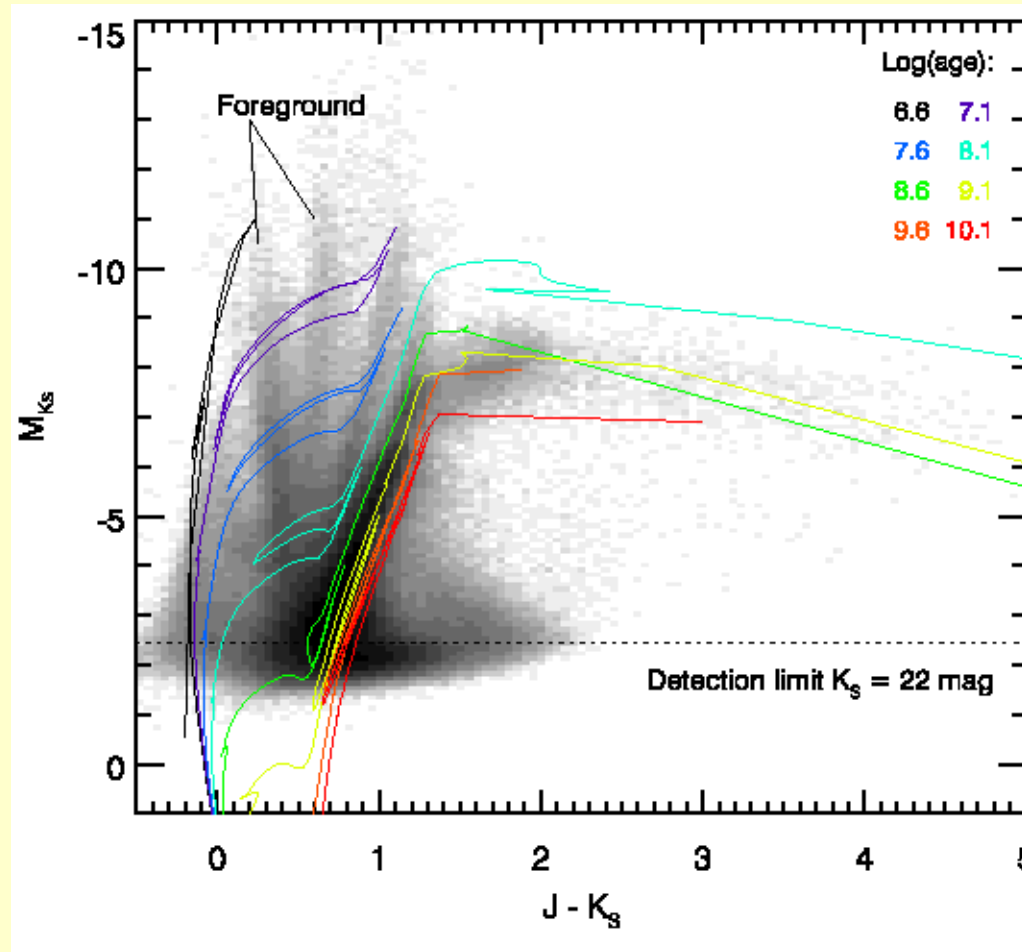
D ~ 100 Mpc
Beaton et al. 2014

Ask: What is unique to WFIRST?



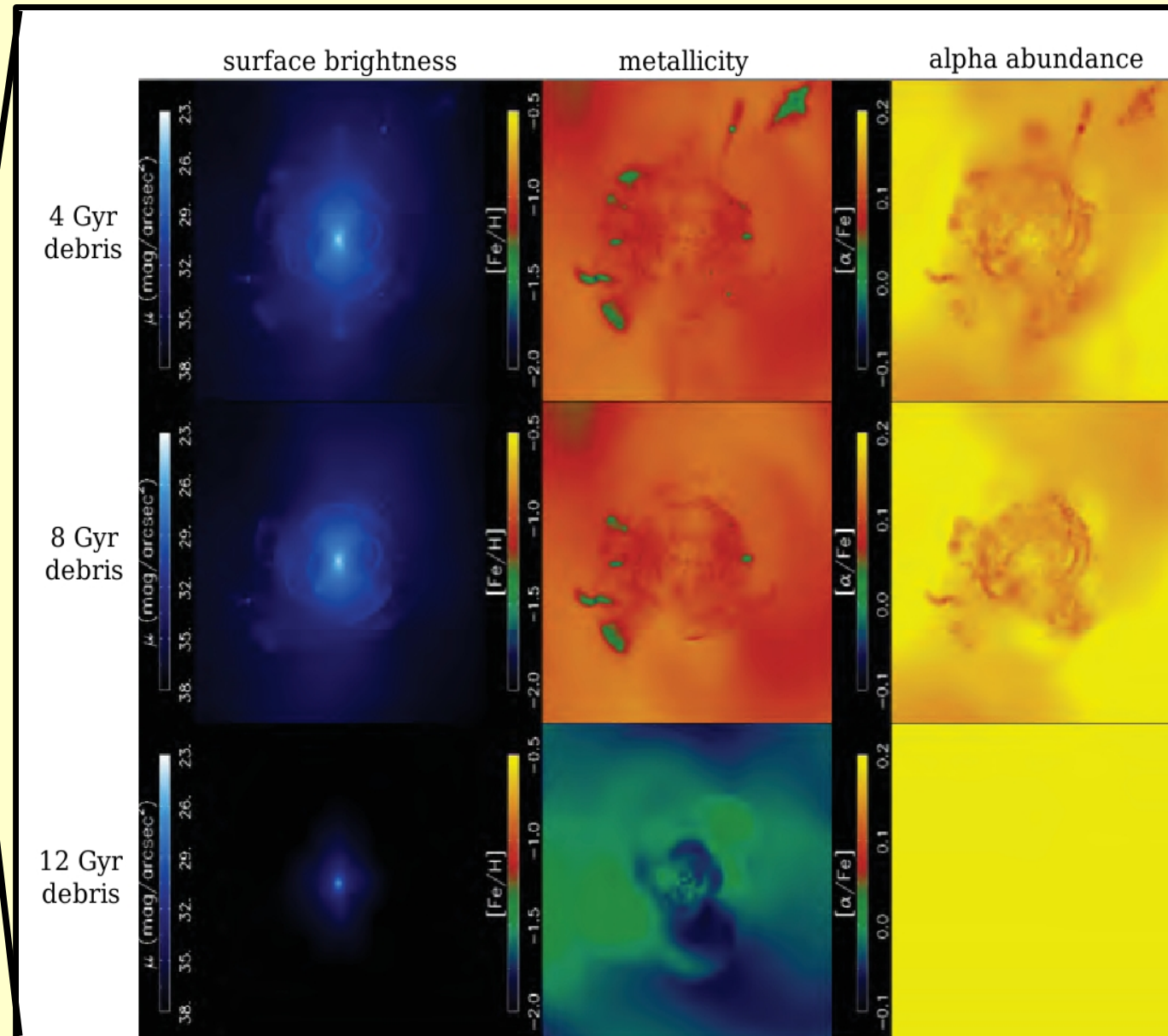
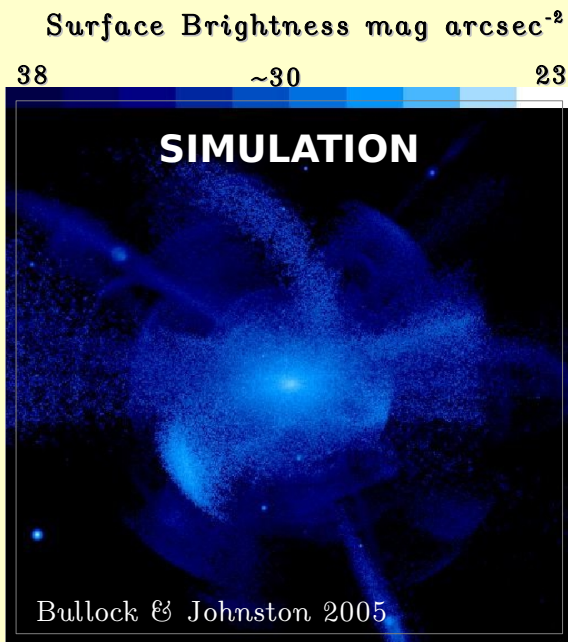
Rproj ~ 23 kpc
p ~ 0.5°

IR Stellar Populations



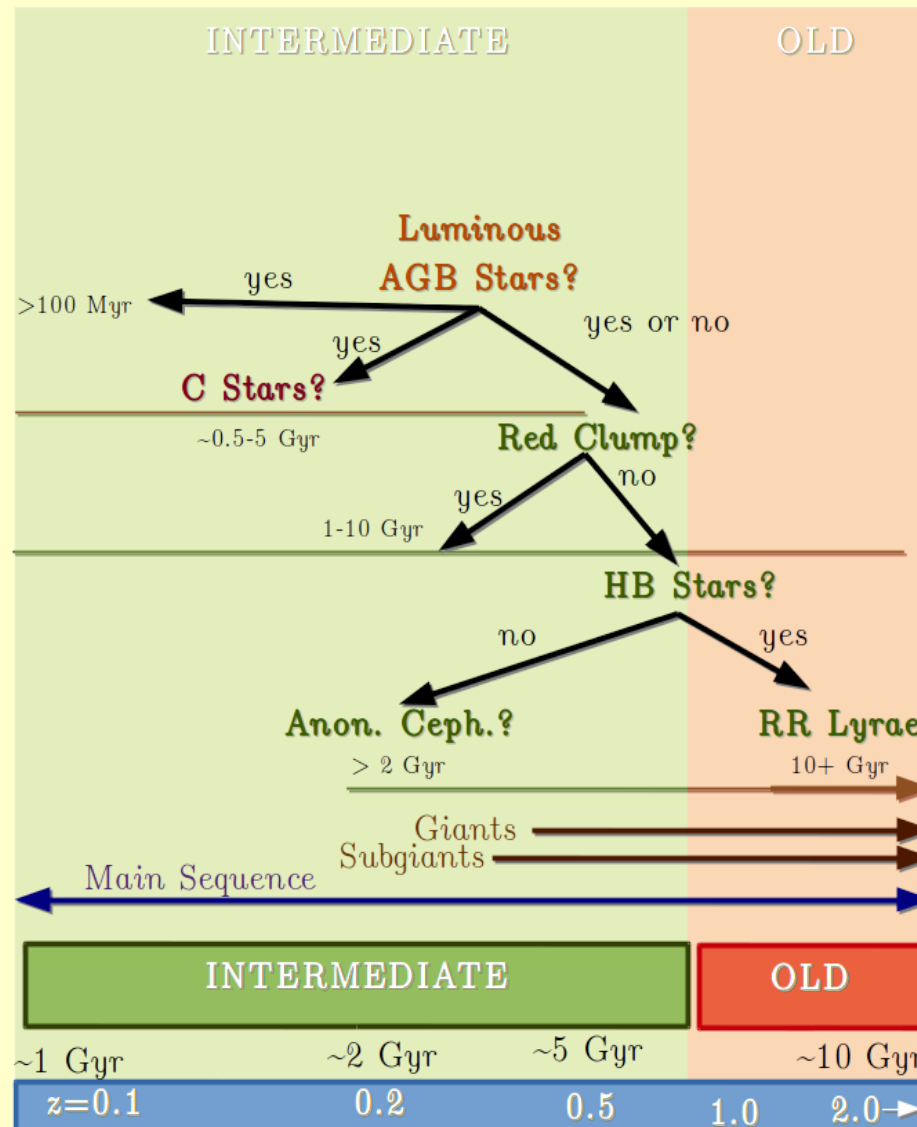
AGB stars nicely by age (mass) in NIR CMDs.

What do ages get you?



IR Stellar Populations

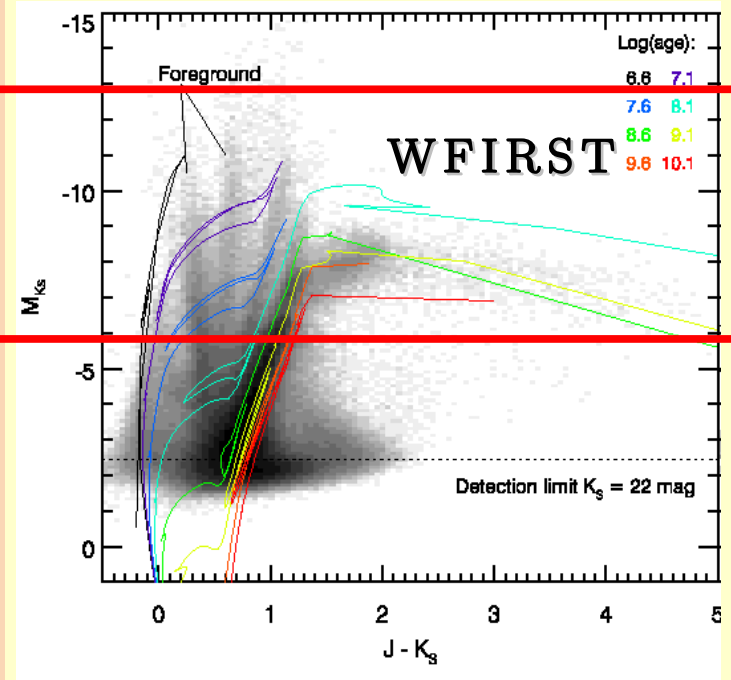
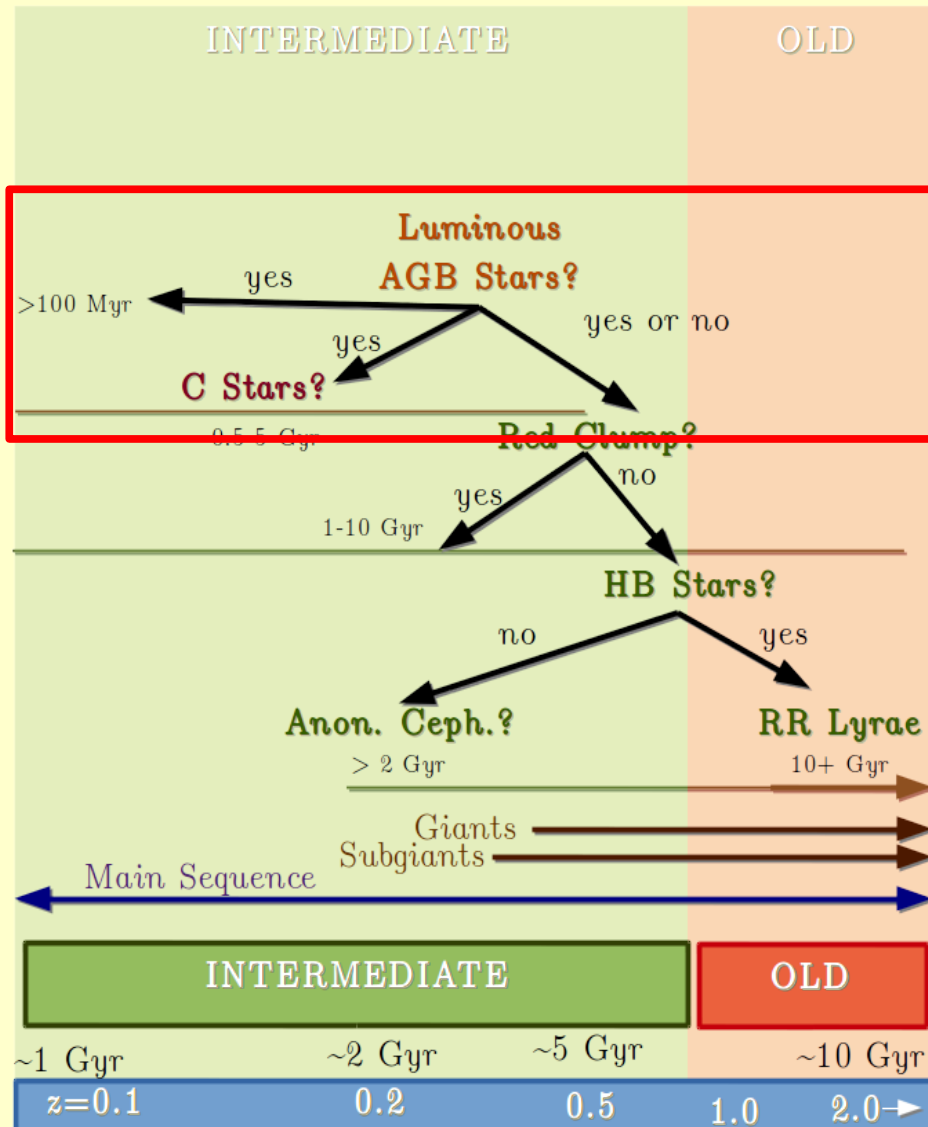
Luminosity
of tracer in
NIR



Canonical avenues to
age stellar populations in the
optical.

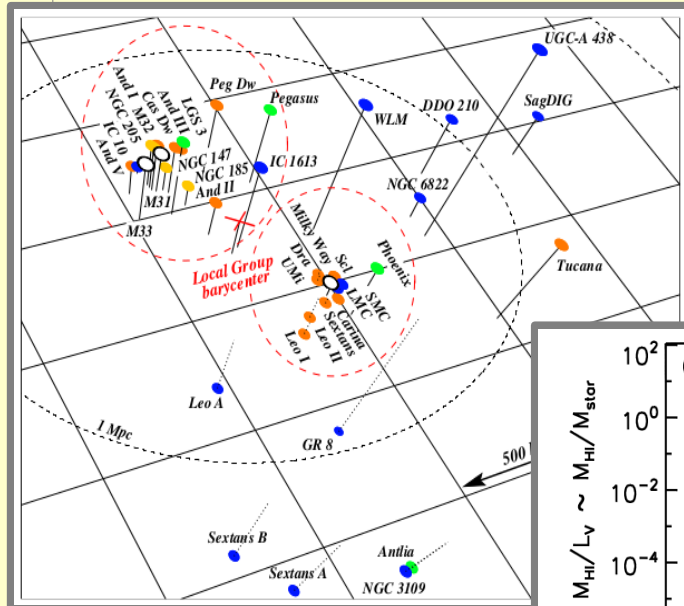
IR Stellar Populations

A
Luminosity
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NIR



Youngest Age $\sim t_{acr}$

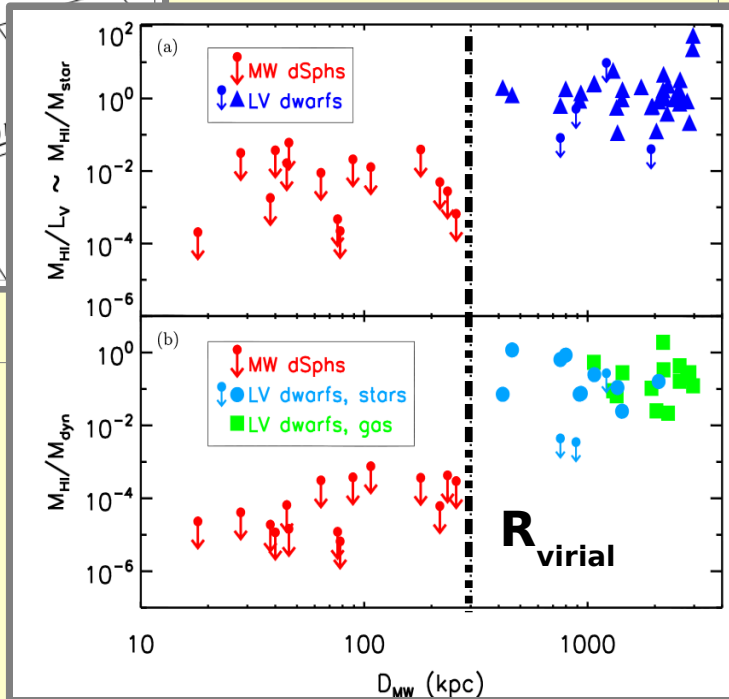
Density-Morphology Relationship in Local Group



Grebel 1999; Mateo 1998

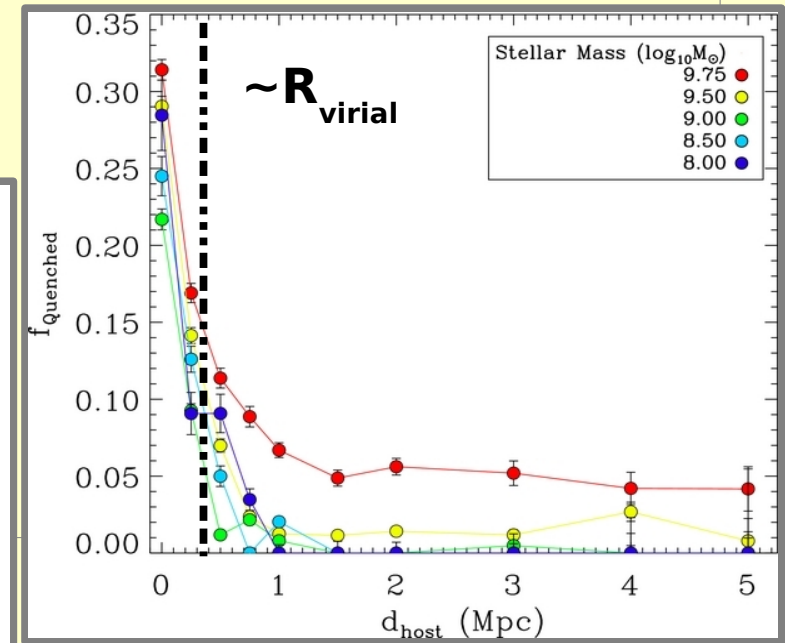
Star Forming Satellites
only
Found $> R_{virial}$ in
Local Group

Satellites with Atomic Gas only
Found $> R_{virial}$ in Local
Group



Spekkens et al. 2014; Greveich & Putman 2009

Higher Quenching for Dwarfs Near Hosts in SDSS Volume



Geha et al. 2012

Halo Formation Mechanisms

- **Accreted from Dwarf Satellites**

- Star formation ceases $\sim t_{\text{acr}} \Rightarrow$ range of ages, metallicities, range of radii
- Stripped from dwarf with orbits depending on original orbital properties
(Johnston et al. 2001, Johnston et al. 2008)

- **Kicked Up Disk/Bulge**

- Metal rich, α -enhanced, $R < 10$ s kpc
- Formed in main galaxy and kicked out onto high energy orbits
(Purcell et al. 2010, McCarthy et al. 2010, Zolotov et al. 2009)

- **In-situ halo stars**

- Ancient, metal poor, α -rich, all radii
- Form during primordial collapse
(Samland & Gerhard 2003; Eggen, Lynden-Bell & Sandage 1962)

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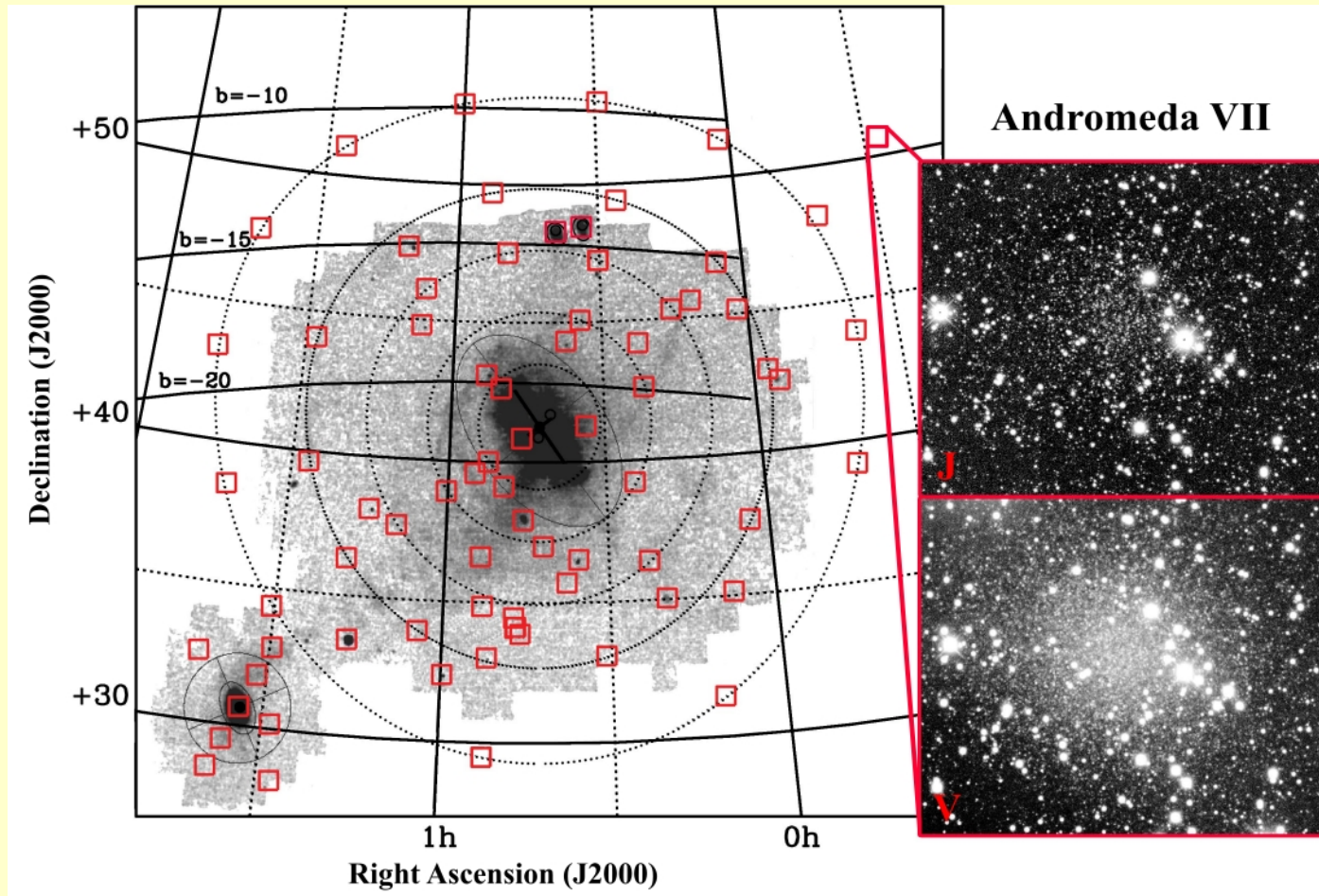
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****Only disentangled with age information**

Is it feasible?

M31 Asymptotic Giant Extended Survey

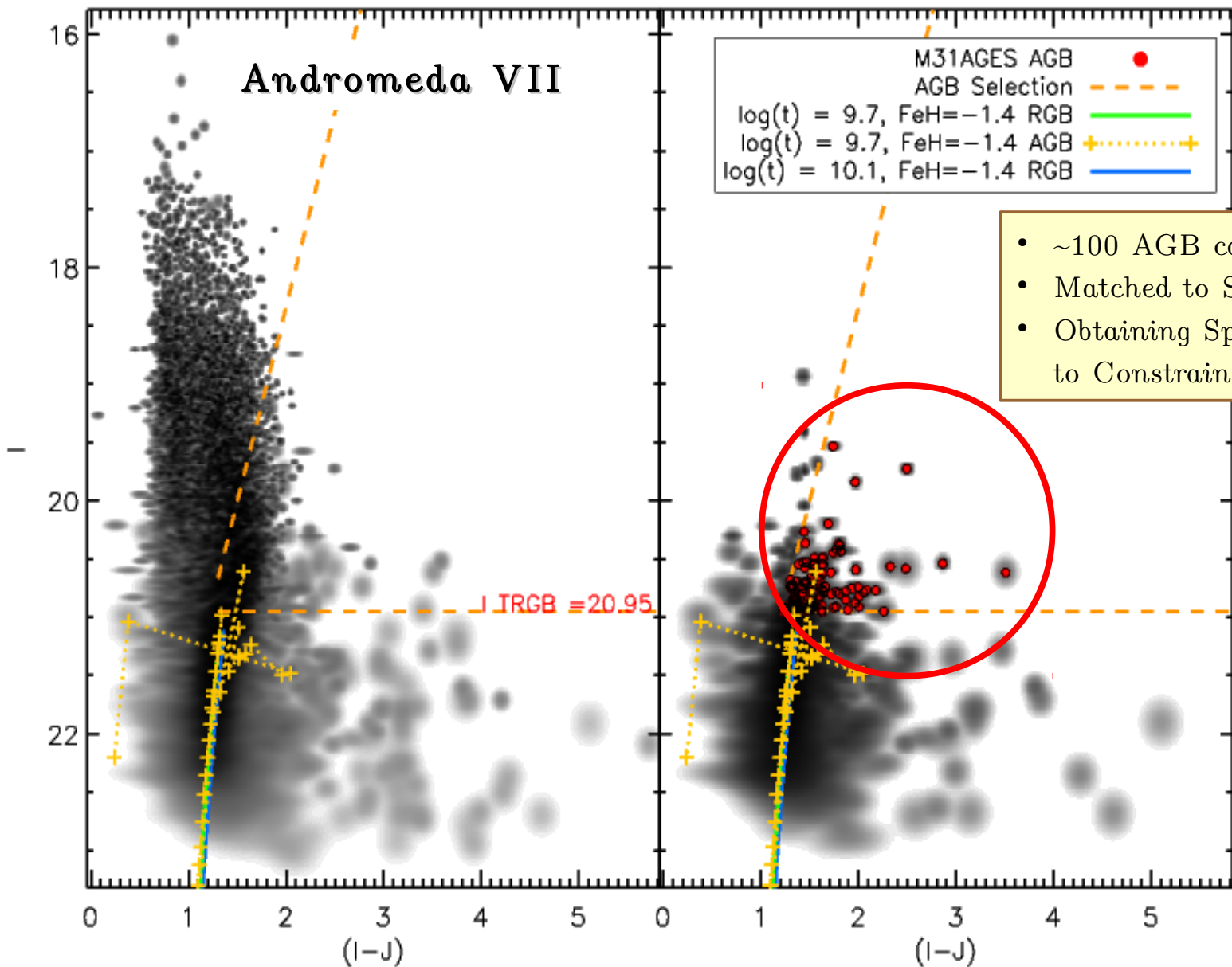


Co-PI's Guhathakurta & Beaton; NOAO 3 Year Survey Program
36 nights KPNO4m+NEWFIRM
72 0.21 deg² fields

Is it feasible?

(preliminary)

NIR CMD for Andromeda VII – 3 Hours of observations to J,K~23

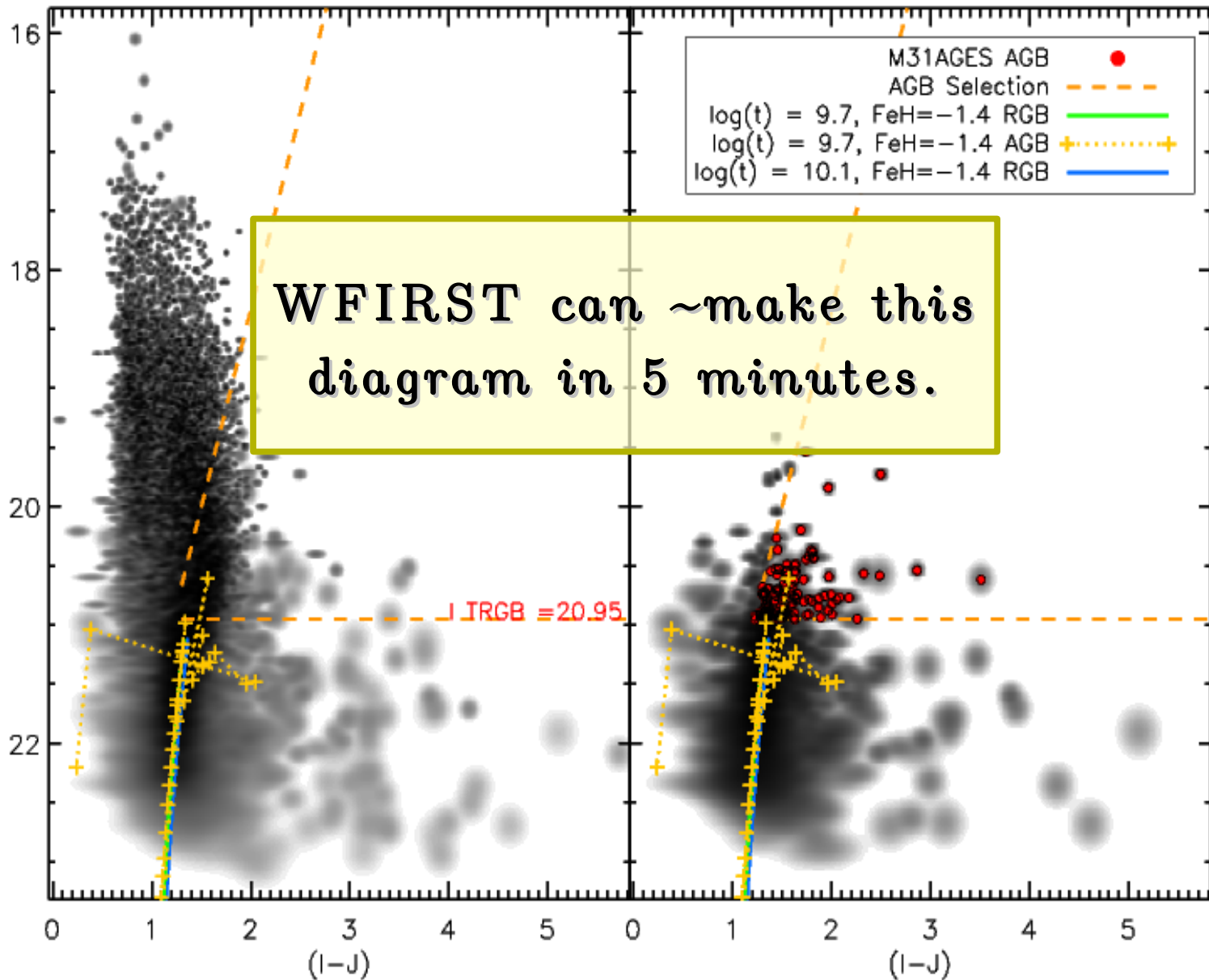


- ~100 AGB candidates
- Matched to Spitzer (Boyer, in prep.)
- Obtaining Spectroscopic Follow Up to Constrain MW dwarf foreground

AGB Selection following Cioni et al. 2000

Is it feasible?

NIR CMD for Andromeda VII – 3 Hours of observations to J,K~23



AGB Selection
following
Cioni et al. 2000

Summary:

- Build the first statistical sample of stellar halos probed for basic properties.
 - Missing Satellites? & All that jazz
 - Cosmic Variance
- In integrated light tie recent accretion histories to disk, bulge, etc. properties.
- Use age distributions to resolve halos into phase space.
 - Build \sim Gyr level accretion histories
 - Constrain the roles of 3 formation mechanisms

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ONLY FEASIBLE (en masse) WITH WFIRST

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ONLY FEASIBLE (en masse) WITH WFIRST

** Can use old populations in stellar halos to get distances to SN1a hosts!

