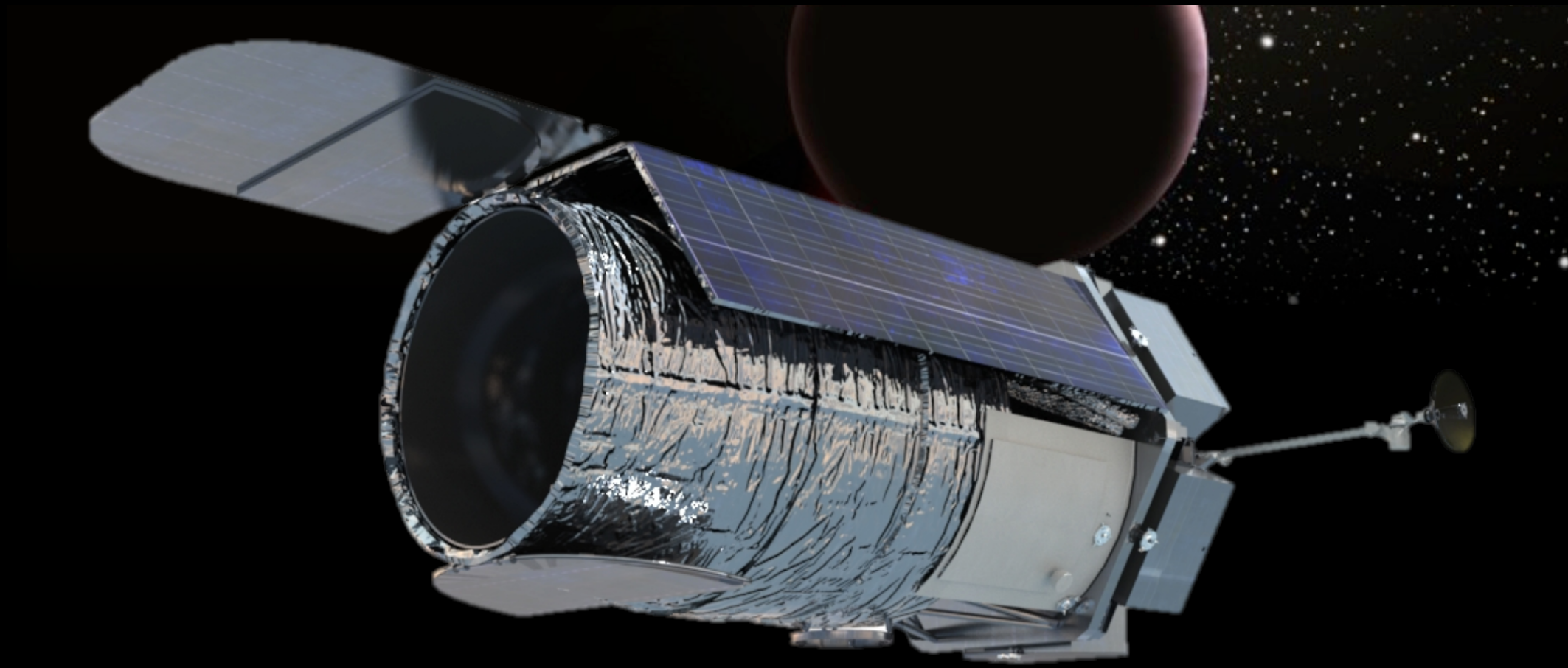
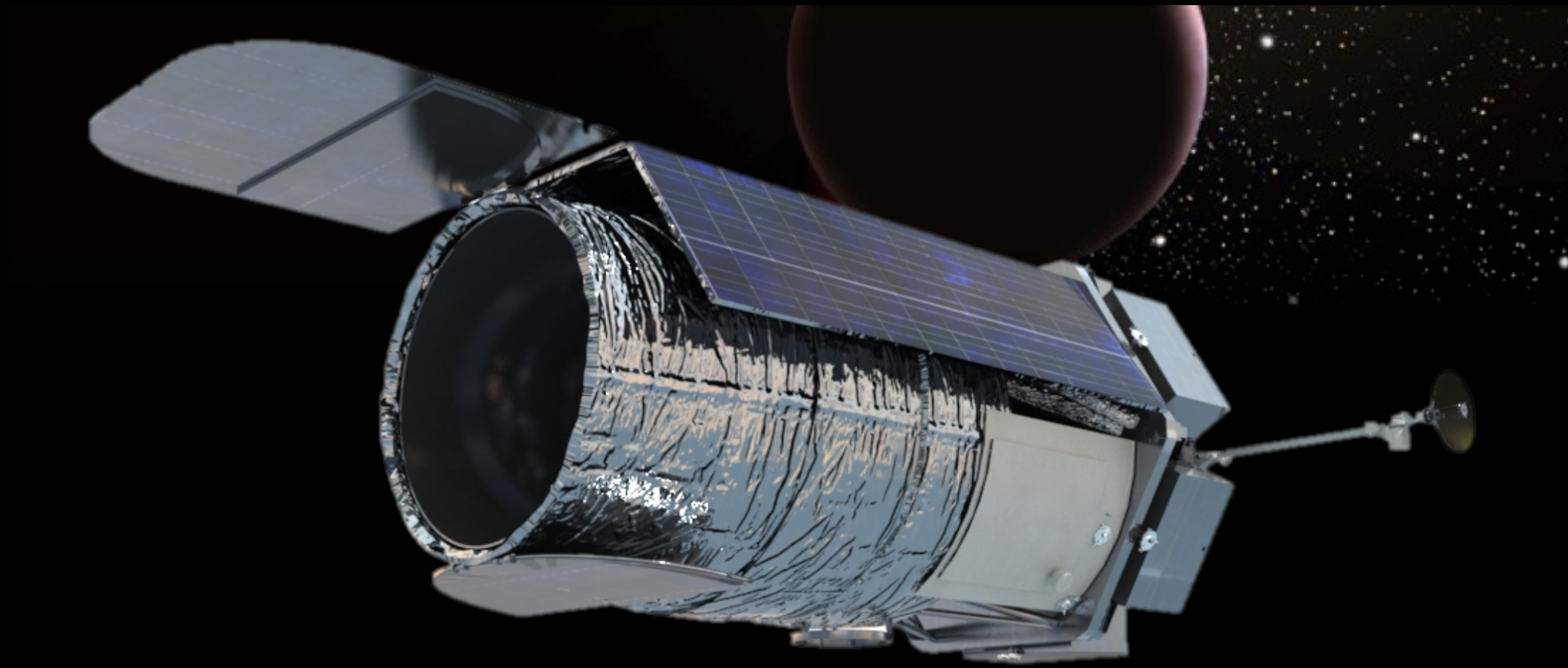
Galaxy Archaeology with WFIRST: Surveying the Local Volume at High-Resolution



Alan W. McConnachie
Dominion Astrophysical Observatory (NRC Herzberg)
January 10 2018

The Pandafication of the Local Volume



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With thanks to Ben Williams and the WINGS Team

PI: Williams (U. Wash.)

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

Postdoc: Khan (U.Wash.)

Photometry	Dolphin (Raytheon)
Stellar Halos	Bell (Mich.), *Johnston (Columbia),* Bullock (Irvine)
Dwarf Satellites	Sand (UA), Bullock (Irvine)
Small Scale Dark Matter	Walker (CMU), *Johnston (Columbia)*
Globular Clusters	Seth (Utah)
Star Formation Histories	Weisz (Berkeley)
Dust & ISM	*Gordon (STScI), Dalcanton (UW)*
Stellar Evolution	*Boyer (STScI)*

Collaborators:

Raja Guhathakurta (UCSC)
Denija Crnojevic (TTU)
Marina Rejkuba (ESO)
Antonela Monachesi (MPA)
Alan McConnachie (HIA)
Laura Sales (UCR)
Karin Sandstrom (UCSD)

Julia Roman-Duval (STScI)
Alberto Bolatto (Maryland)
Josh Peek (STScI)
Jay Anderson (STScI)
David Hendel (Columbia)
Meredith Durbin (UW)
Andrew Graus (Irvine)
Tyler Kelley (Irvine)

Anna Yu (Irvine)
Sol Courtney (Columbia)
Amy Secunda (Columbia)
Beth Willman (LSST)
Phil Rosenfield (CfA)
Margaret Meixner (STScI)
Leo Girardi (Padova)
Nicolas Martin (MPIA)

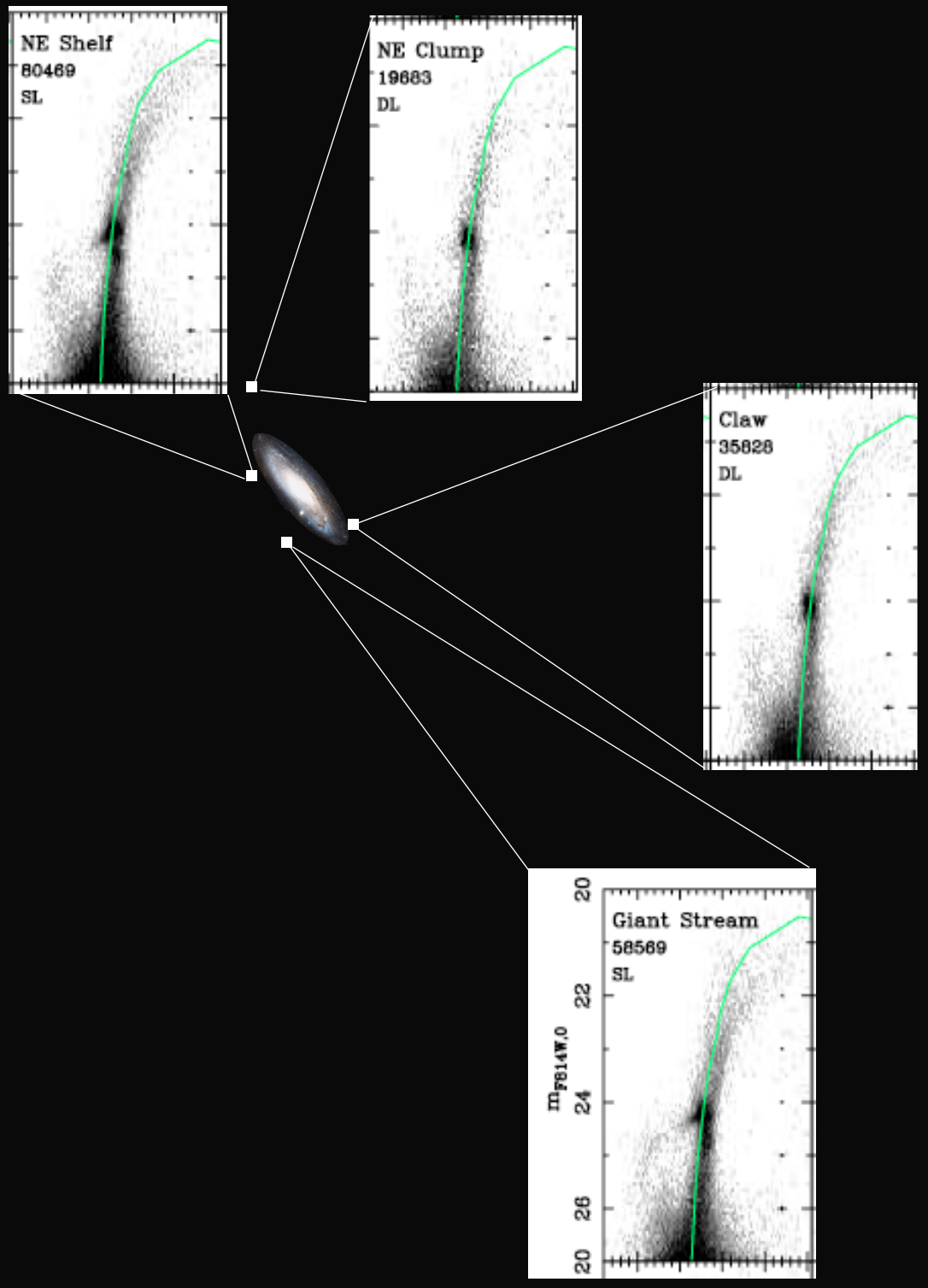
Cliff Johnson (UCSD)
Jay Strader (MSU)
Robyn Sanderson (Caltech)
Adrian Price-Whelan (Columbia)
Sergey Koposov (Cambridge)
Julio Chaname (Catolica)
Jorge Penarrubia (Edinburgh)
Coral Rose Wheeler (Caltech)

Mosaic of 411 HST pointings (7398 exposures)

Andromeda Galaxy ▪ M31 ▪ Panchromatic Hubble Andromeda Treasury (PHAT)
Hubble Space Telescope ▪ Advanced Camera for Surveys

NASA and ESA

STScI-PRC15-02a


NE Shelf
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Giant Stream
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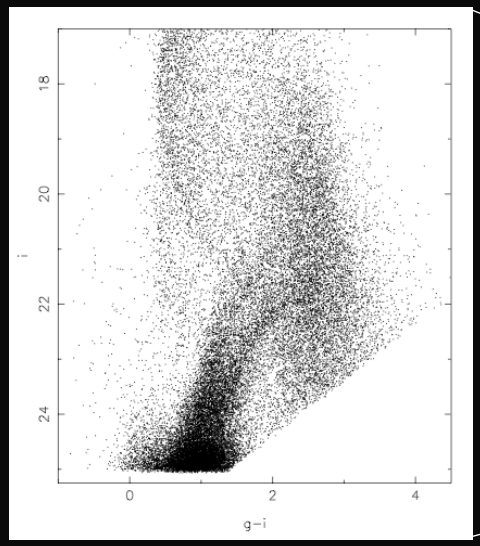
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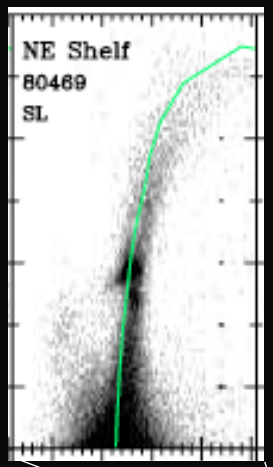
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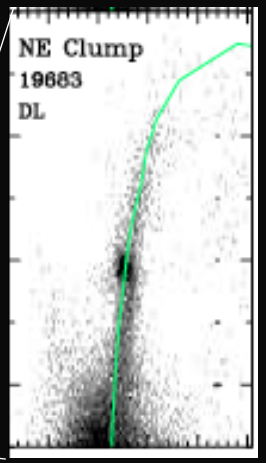
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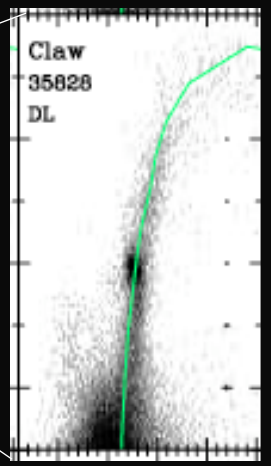
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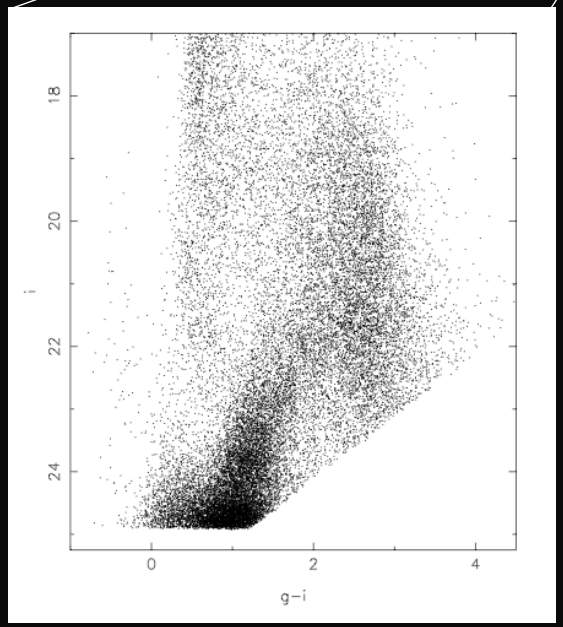
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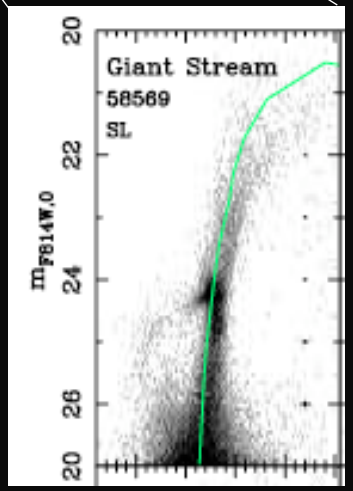
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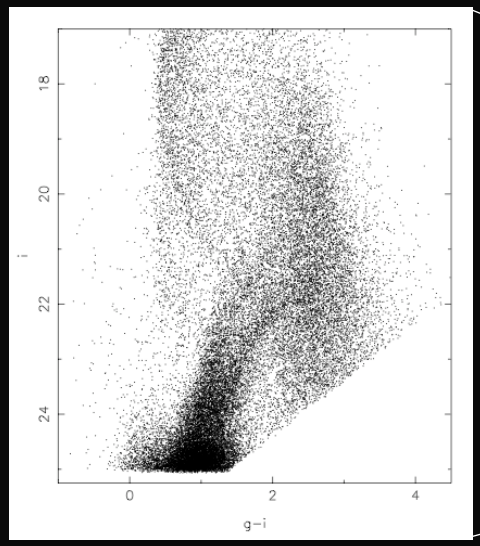
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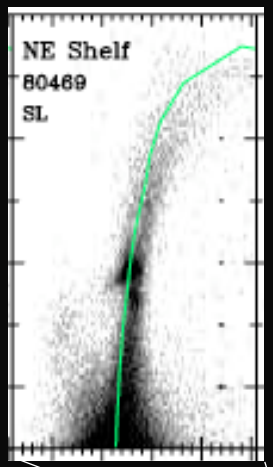
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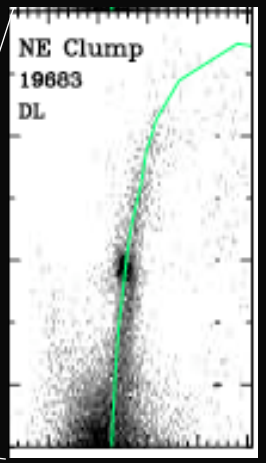
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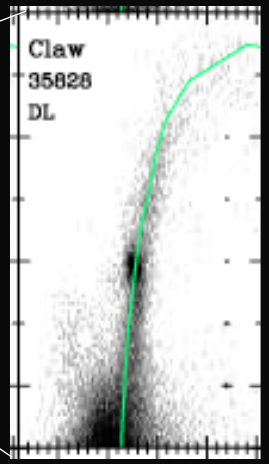
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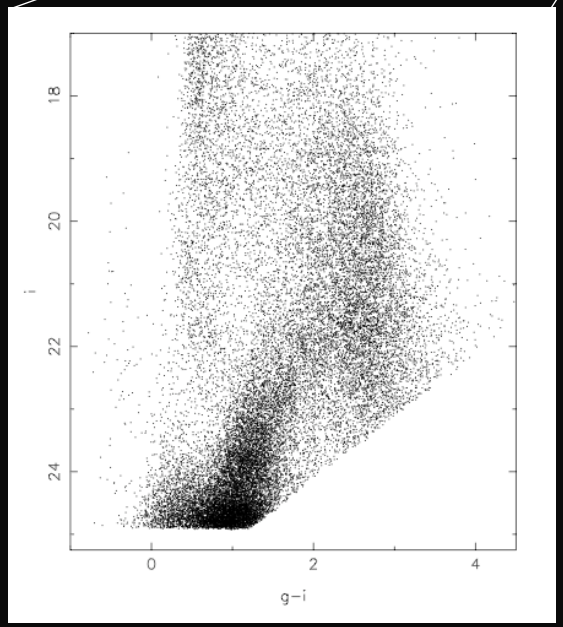
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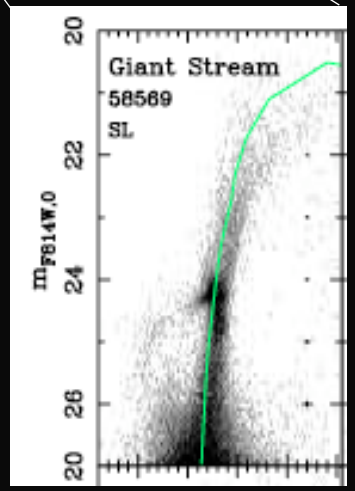
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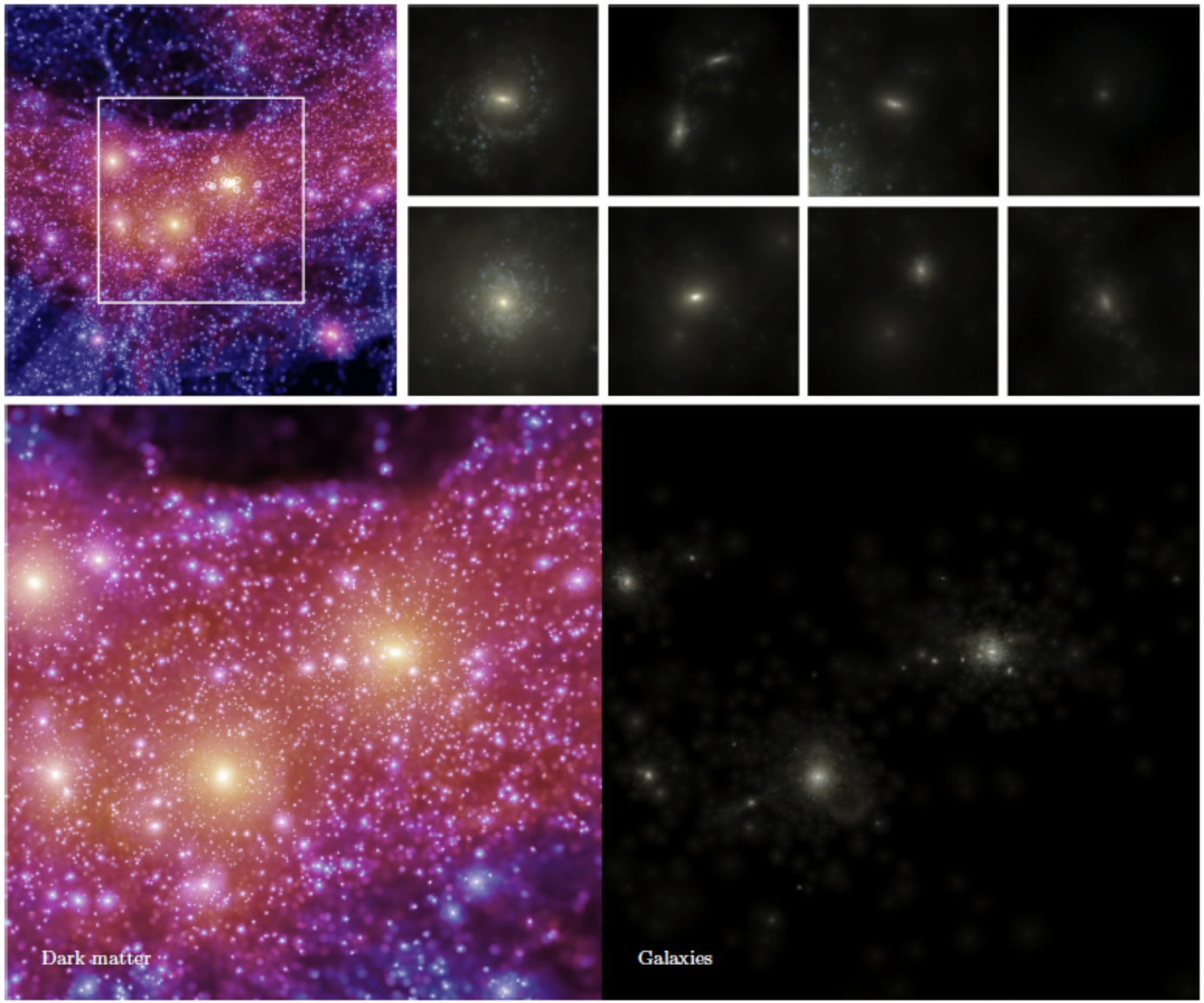
The haloes of MW-like galaxies



APOSTLE Simulations, Sawala et al. 2016

Johnston & Bullock 2005

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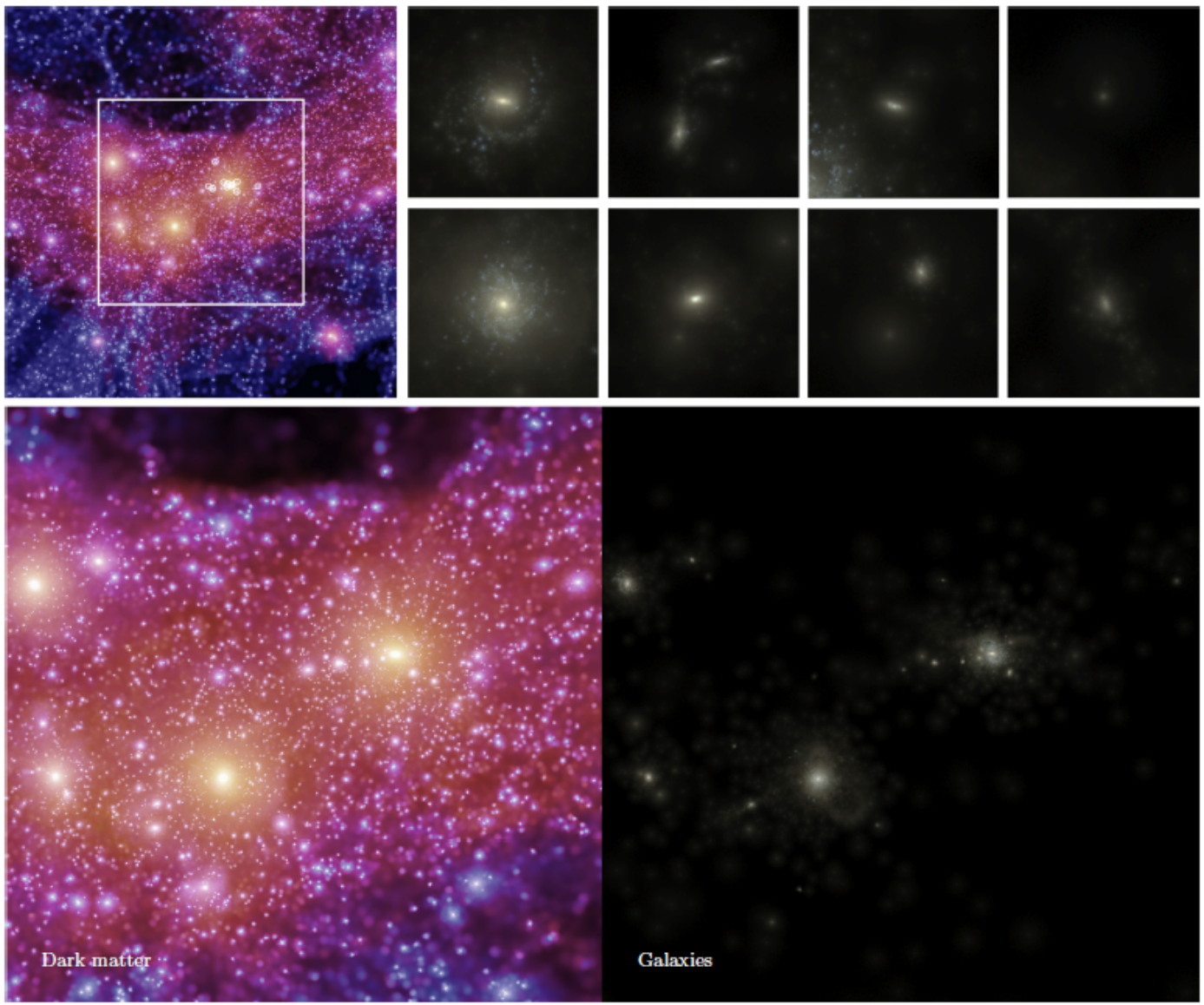

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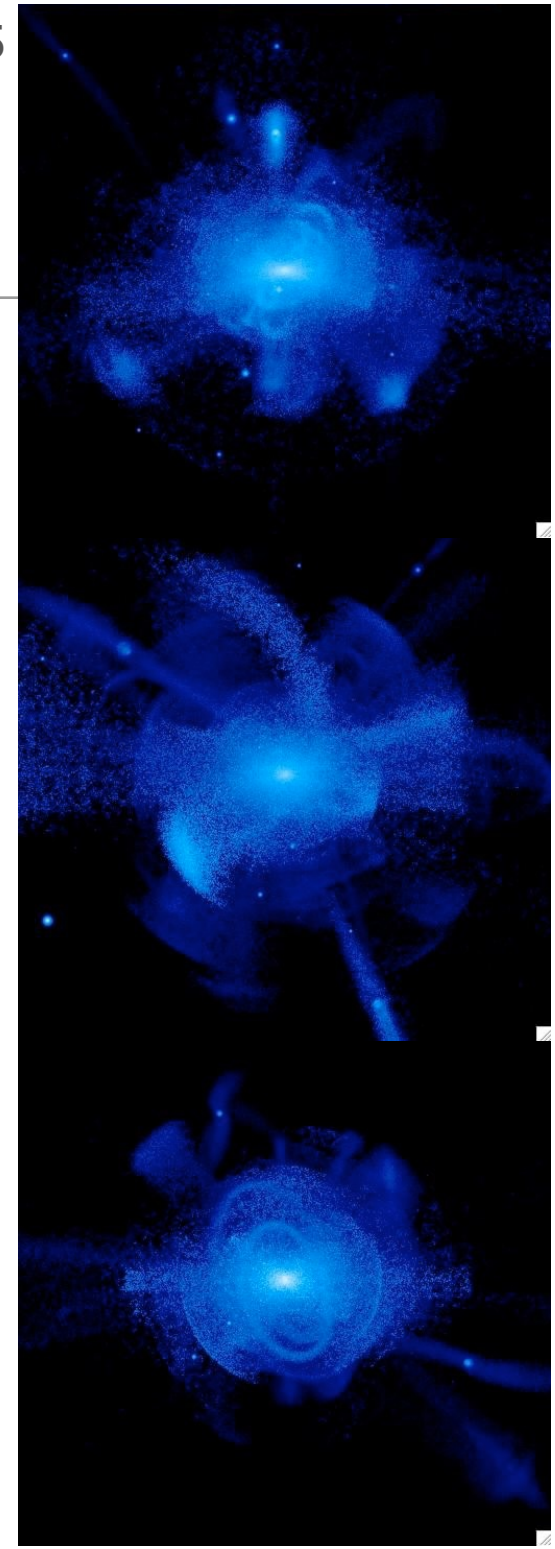
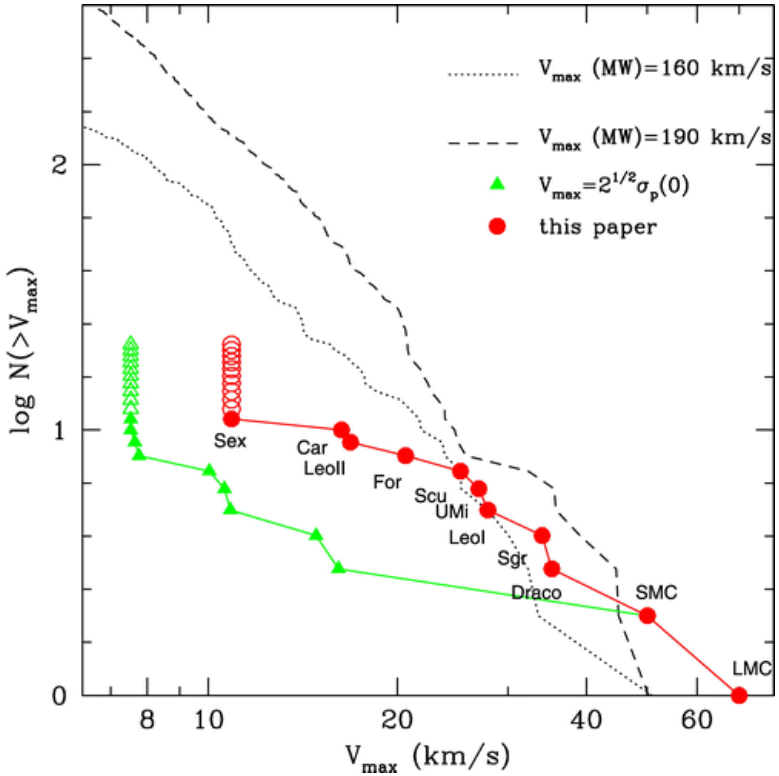
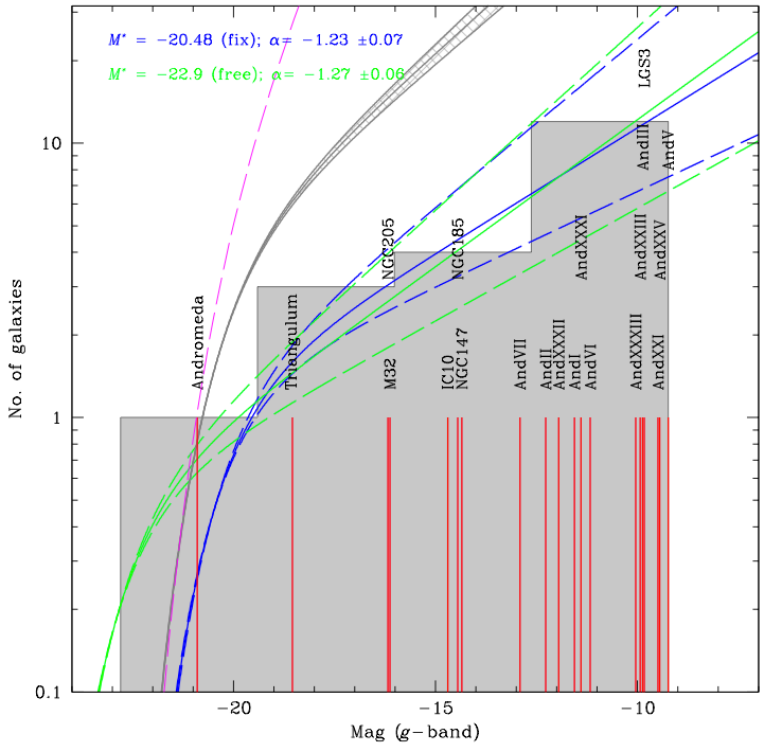


The extreme faint end of the luminosity function



Penarrubia et al. 2008



Ferrarese et al. 2015

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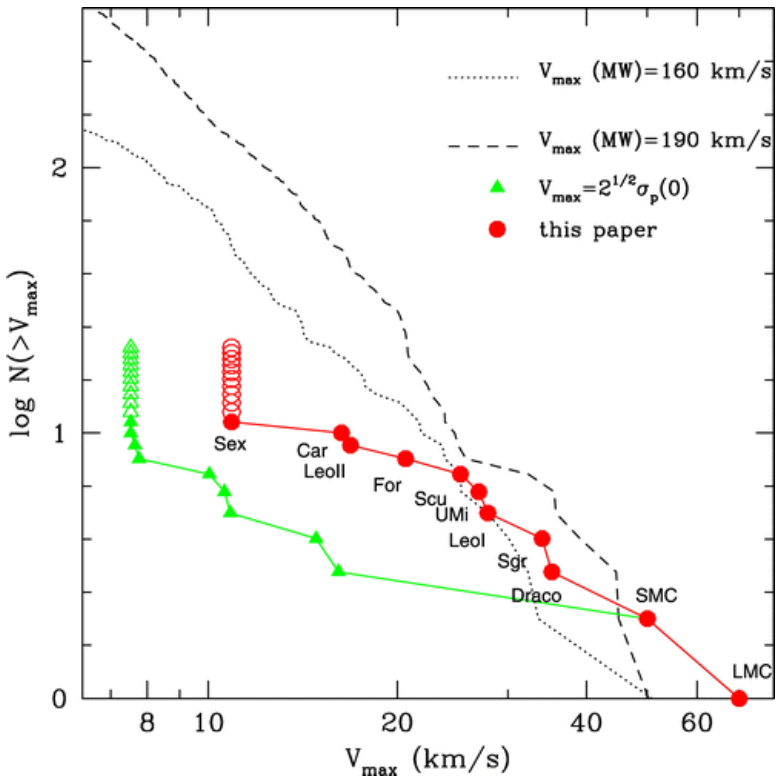

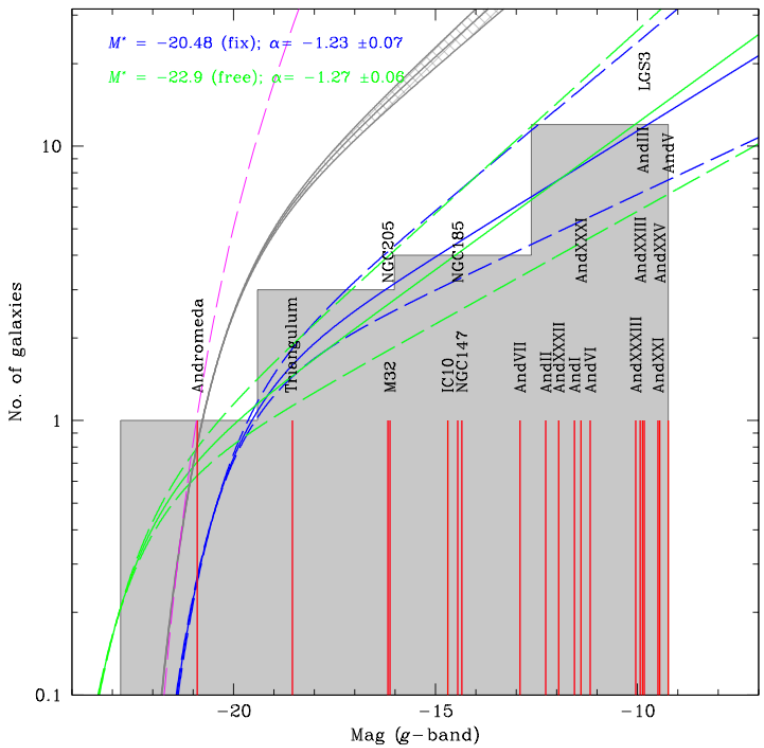

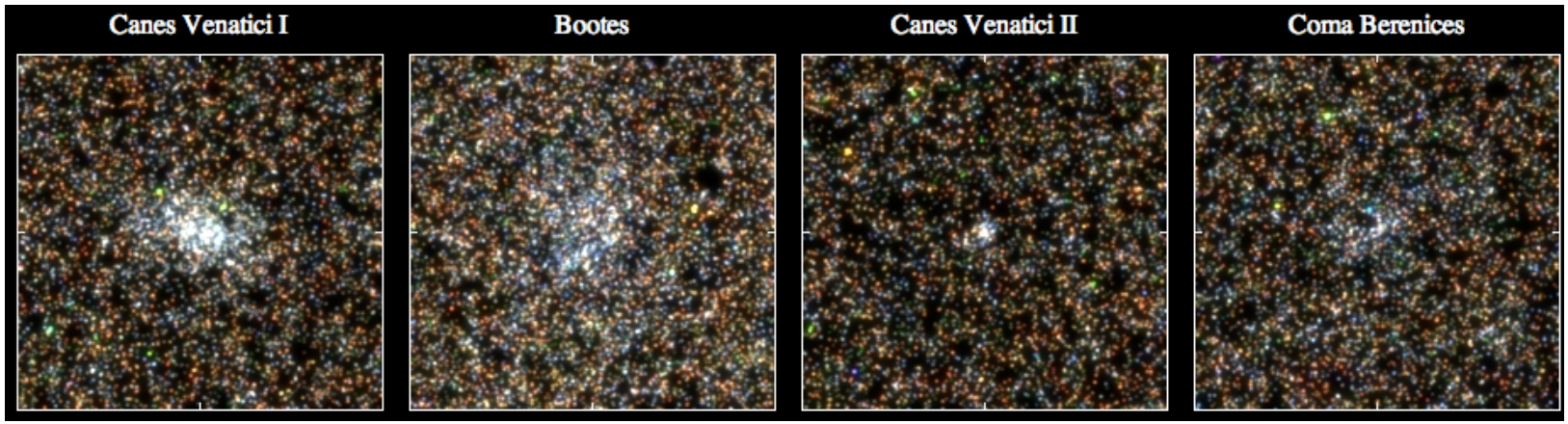

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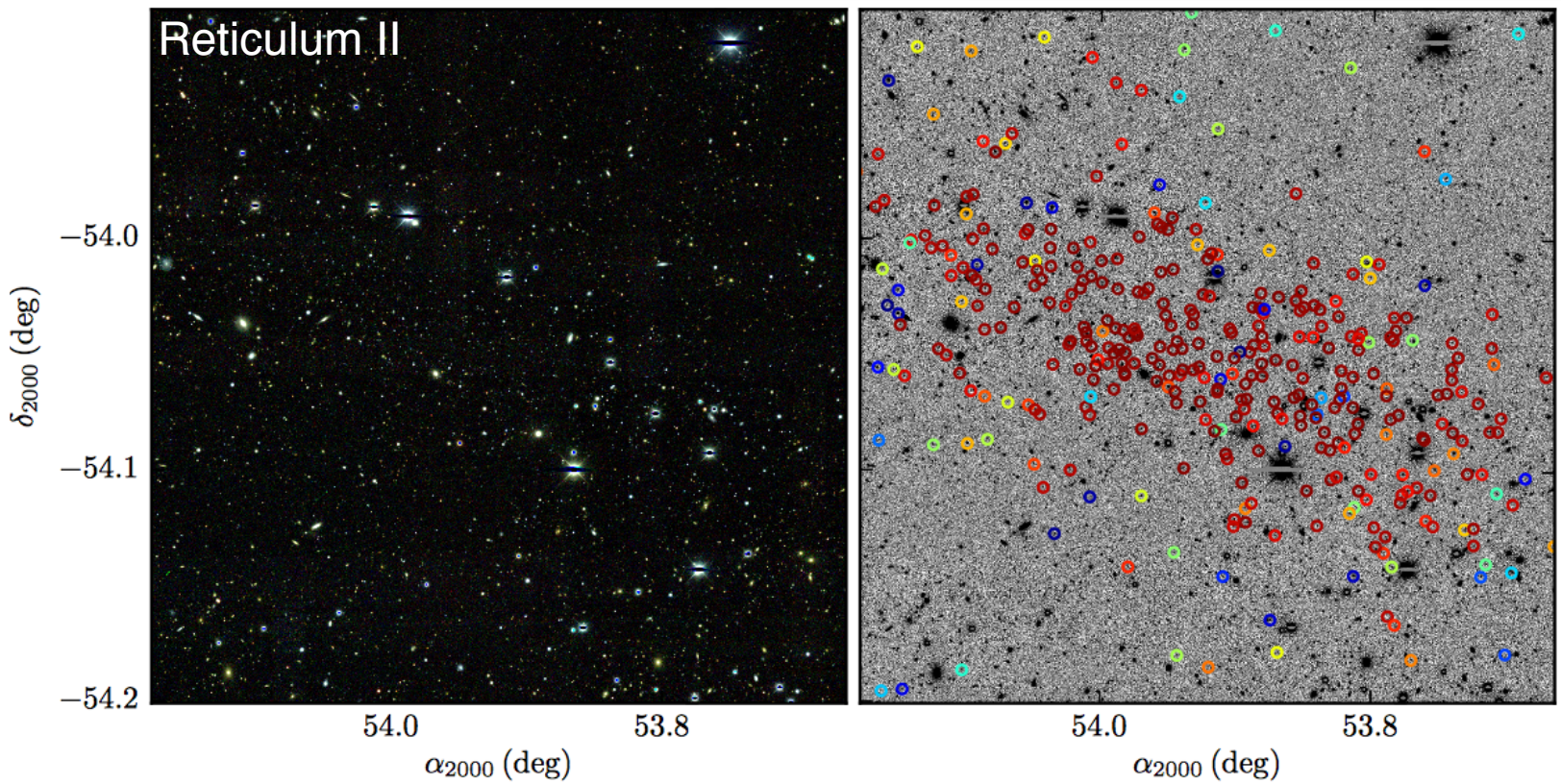

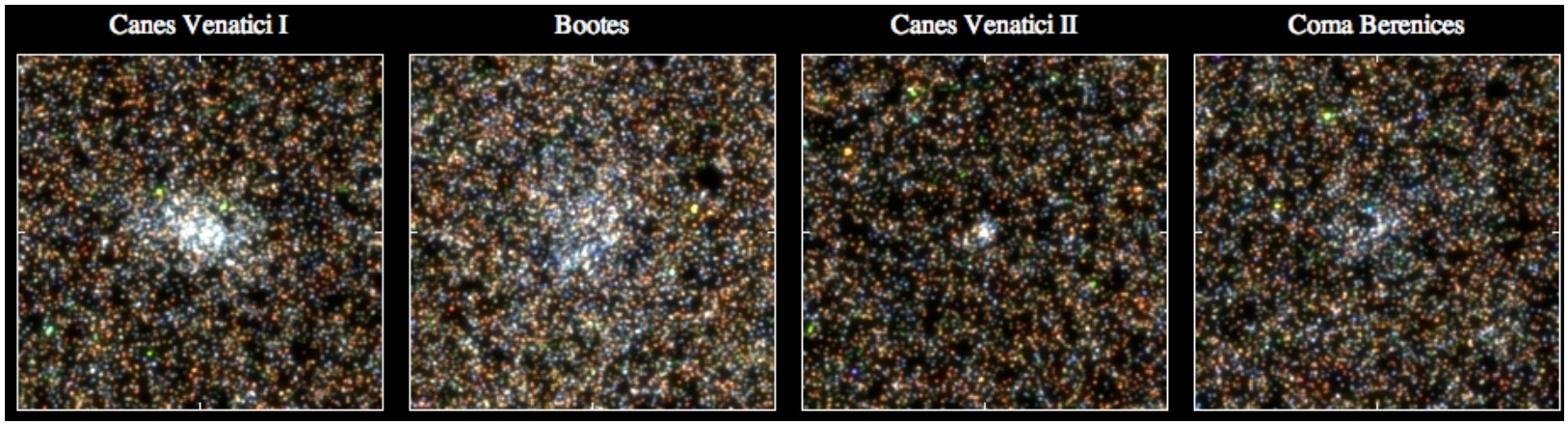

Setting the context: science in stellar halos

- Key science drivers:
  - What is the overall shape of the stellar halo of a large galaxy?
    - What is the degree and morphology of substructure in the stellar halo? How is t stellar halo distributed between surviving dwarfs, substructure and the “smooth component?
    - What is the relation between globular clusters and halo stars?
    - ***Probing the recent accretion/formation history of galaxies***

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  - What is the luminosity function of an entire galaxy sub-group, down to extremely faint magnitudes?
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    - ***Probing galaxy formation and dark matter at smallest scales***

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    - ***Probing galaxy formation and dark matter at smallest scales***
- Basic requirements / strategy
  - Haloes expected to extend out to beyond 100kpc - large area survey
    - ***wide field instruments essential***
  - Low surface brightness - use stars as tracers of light
    - ***deep point source photometry, high spatial resolution essential***

The surrounding of the nearest L* galaxy

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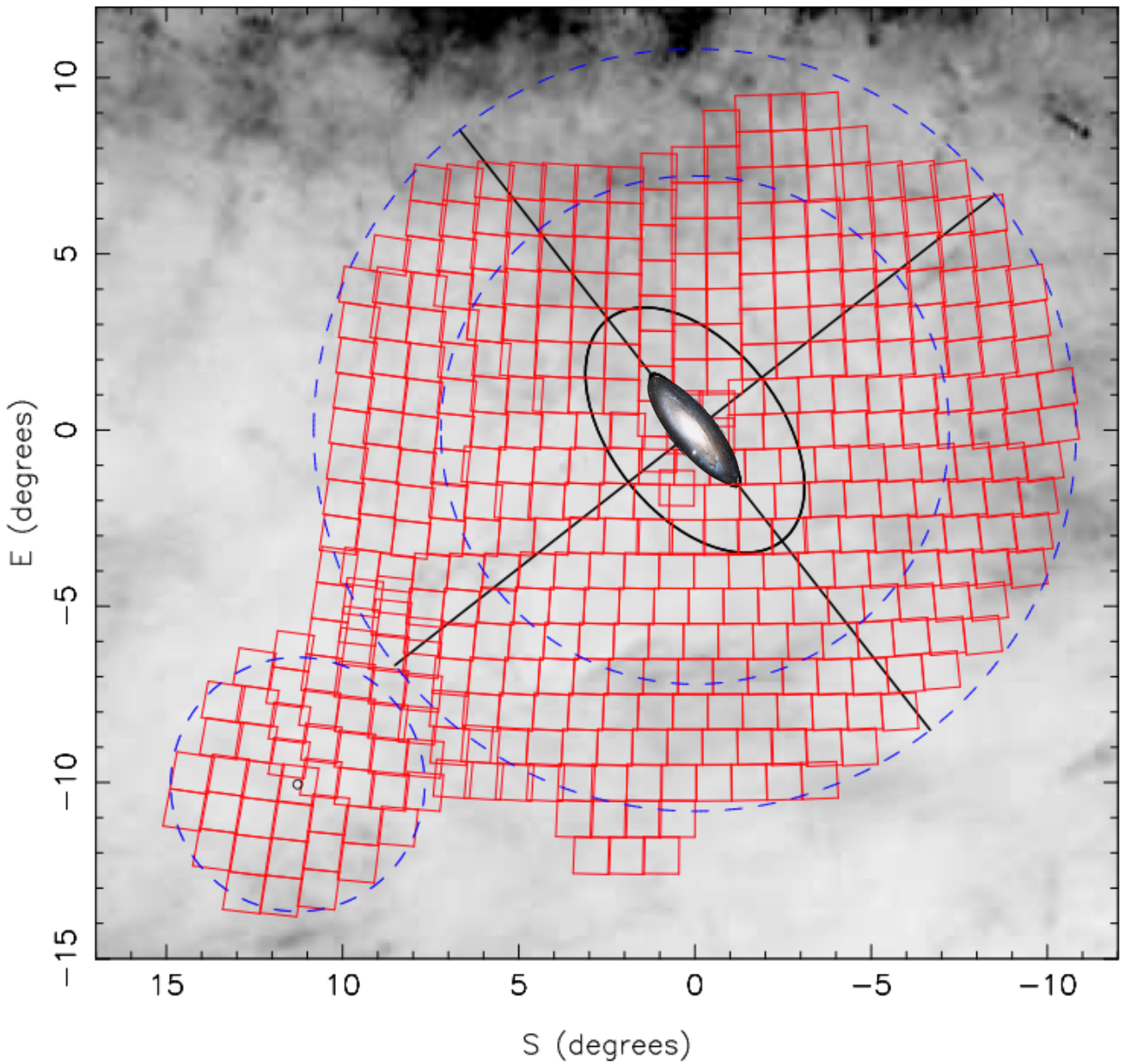


·The Pan-Andromeda Archaeological Survey

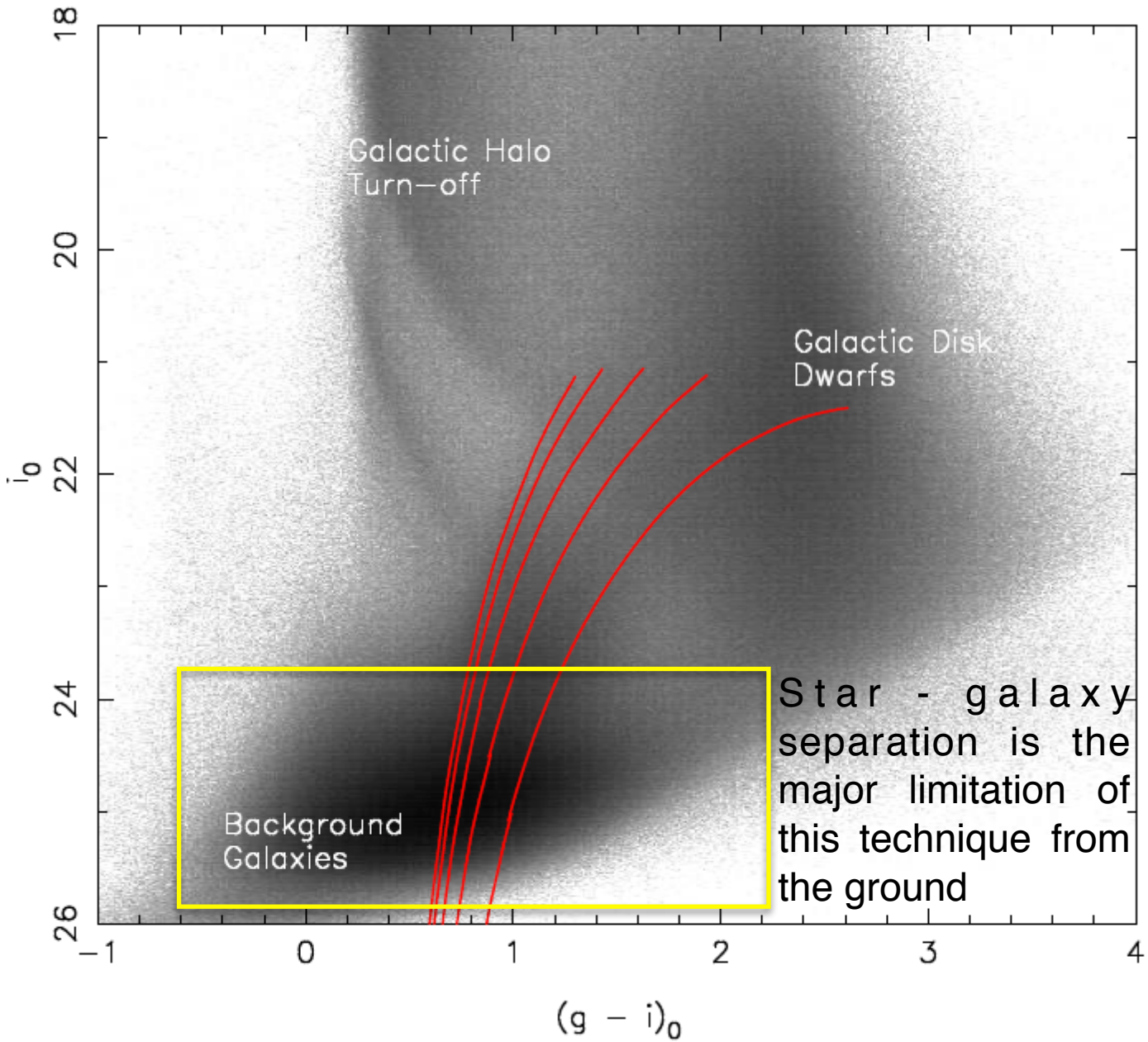
·S08B - S10B: 226 hours (41 nights) (B semesters only) on MegaCam in g and i bands

·Builds upon earlier P.I. programs by Ibata (S02B - S06B) and McConnachie (S06B - S07B)

·Ultimately, builds upon INT WFC survey of M31 (S00B - S05B)

·Total area of ~400 square degrees (~15 million cupic kpc of halo of M31/M33)

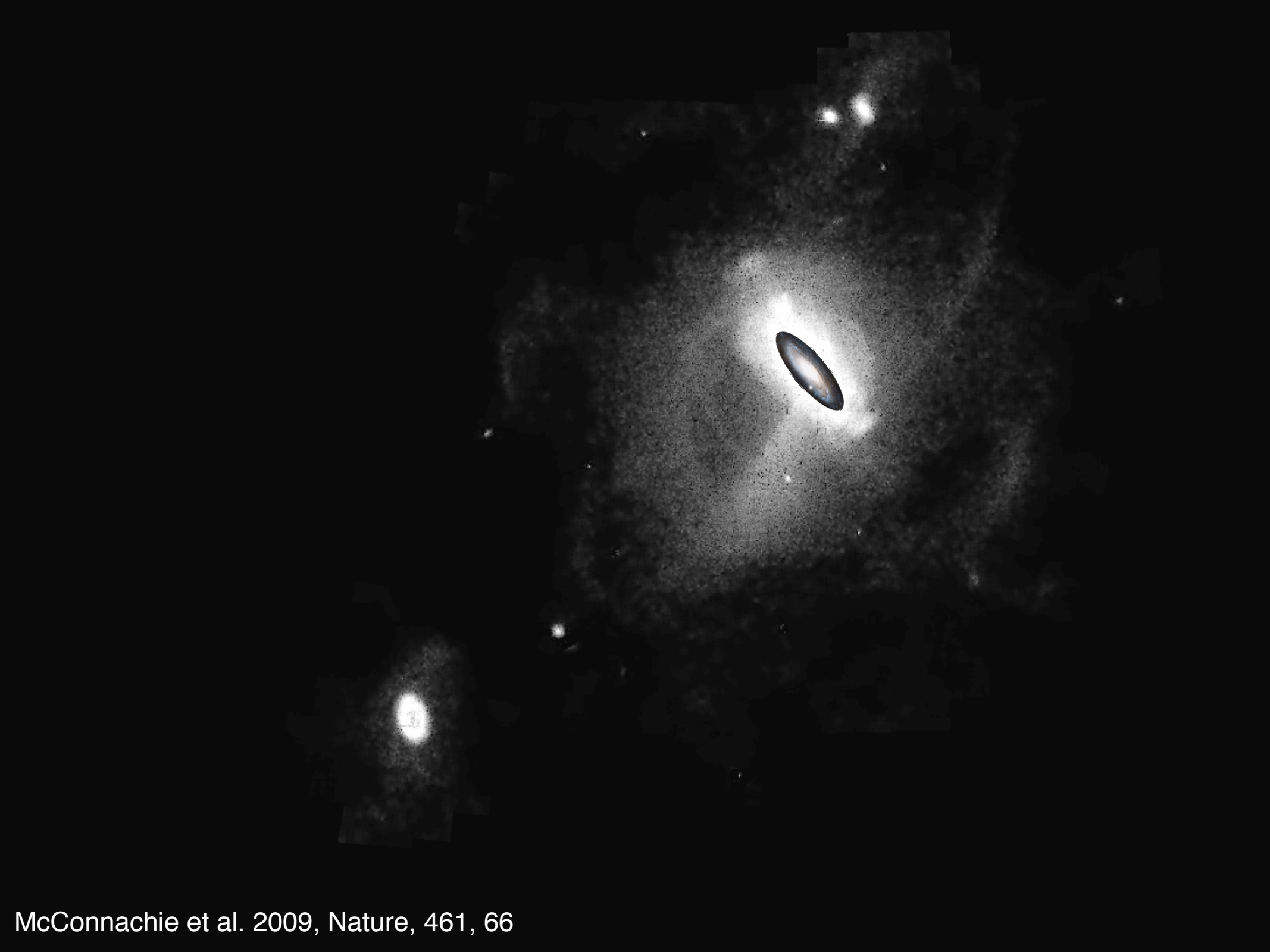
Colour - magnitude diagrams



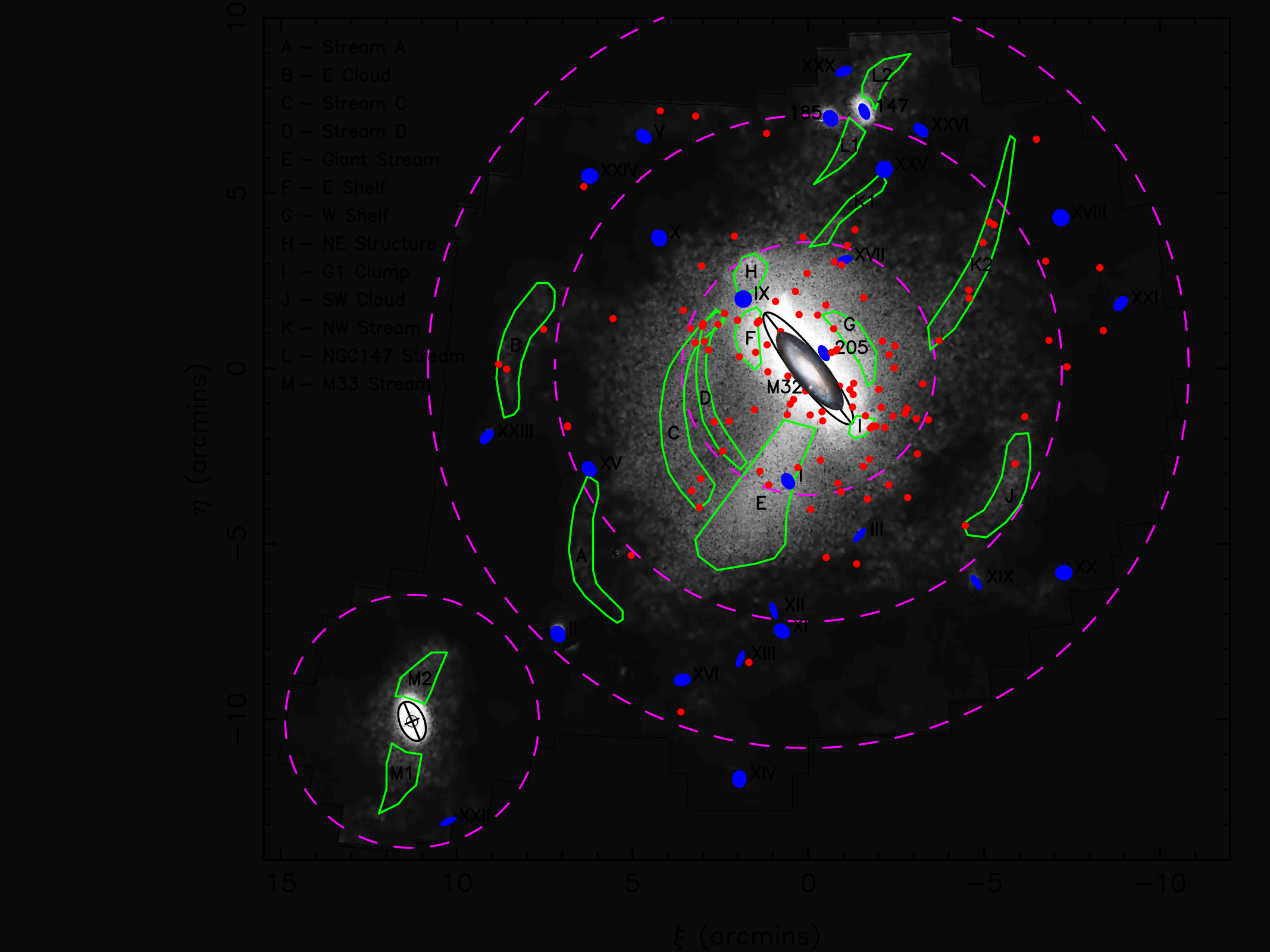
- Approx 15 million stellar objects

- Approx 10 million stellar objects consistent with red giant branch stars at the distance of M31

- S/N =10 for point sources at g = 25.5, i = 24.5



McConnachie et al. 2009, Nature, 461, 66


A – Stream A
B – E Cloud
C – Stream C
D – Stream D
E – Giant Stream
F – E Shelf
G – W Shelf
H – NE Structure
I – G1 Clump
J – SW Cloud
K – NW Stream
L – NGC147 Stream
M – M33 Stream
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XVIII
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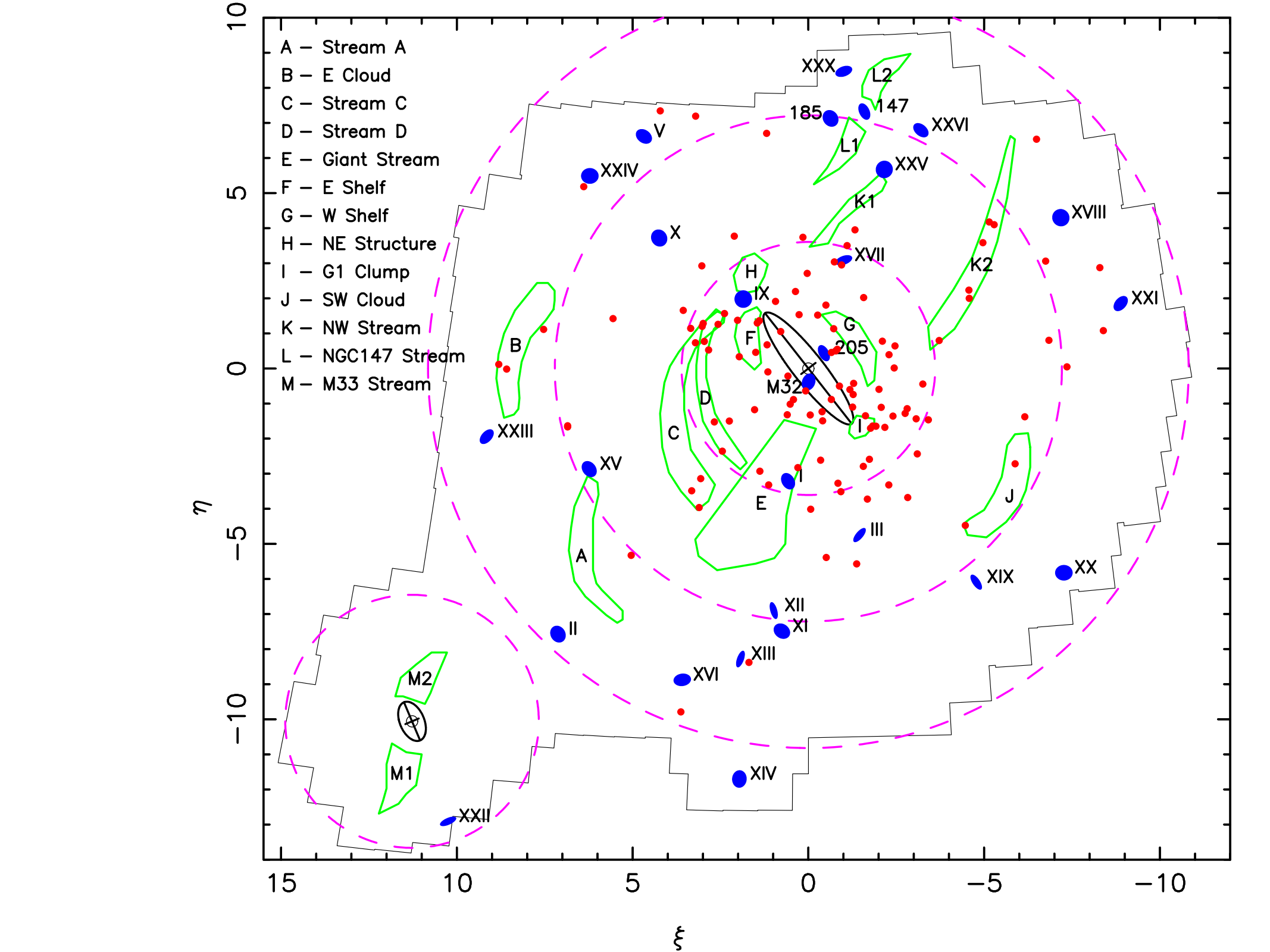
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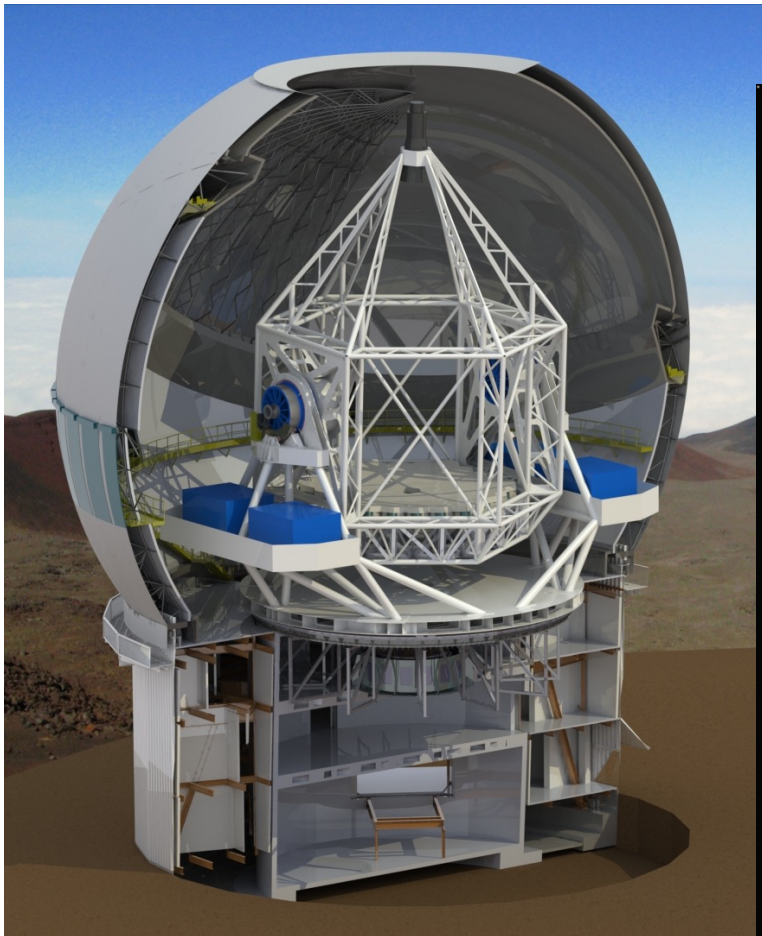
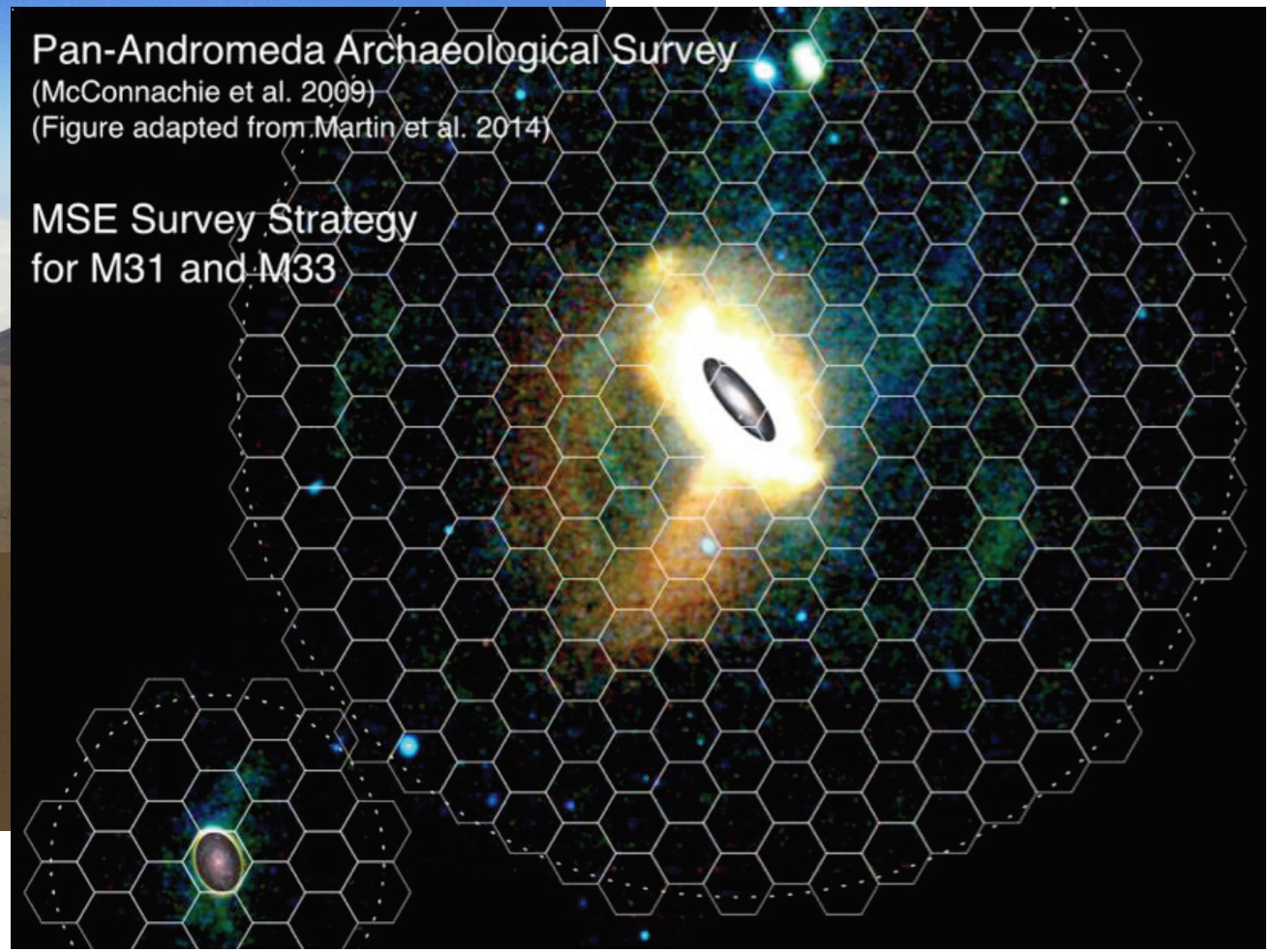
So what's next?

- Two obvious avenues:

  (1) Wide field spectroscopy to follow-up on wide field imaging (e.g., MSE)

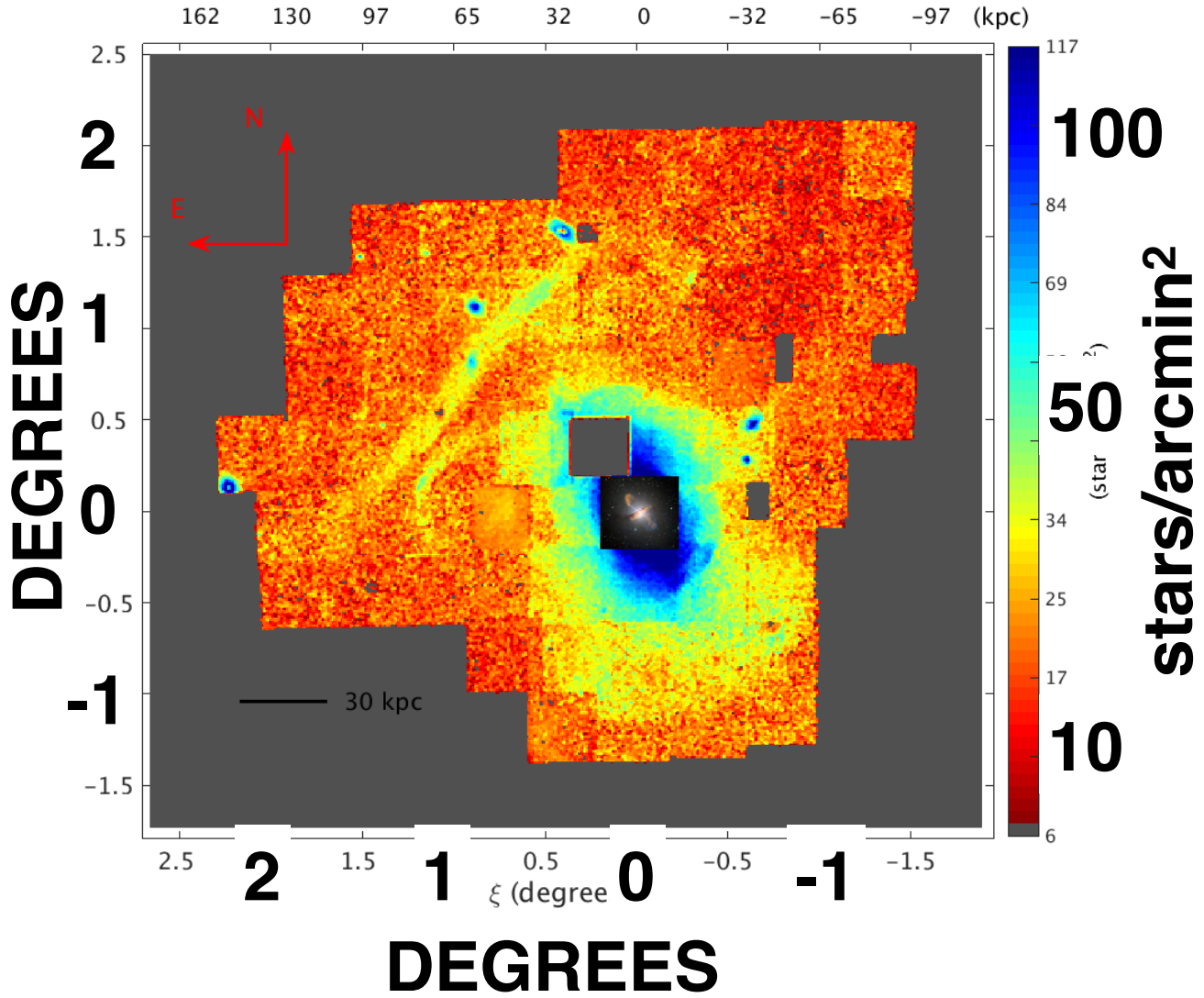




So what's next?

- Two obvious avenues:

  (2) Statistics for galaxies across a range of mass and morphological type



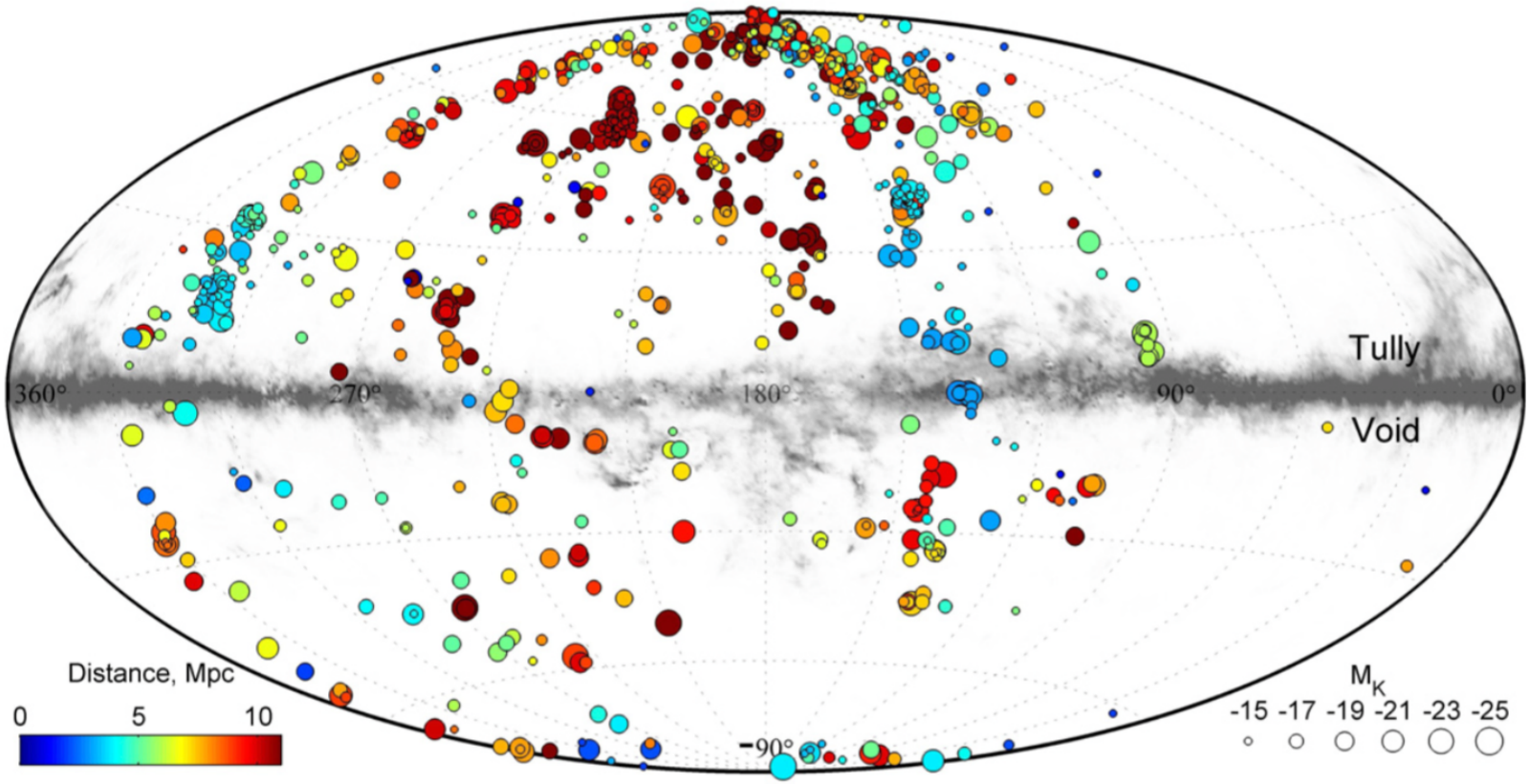
From the ground, deep photometry with good IQ (for star - galaxy seperation) is difficult for all but the Local Group

Centaurus A, 3.6Mpc
Crnojevic et al. 2015

From the Local Group to the Local Volume…

·Ultimate aim to get meaningful statistics for galaxies of all masses, morphologies…

- Nearest giant elliptical is M87 at ~15Mpc
- Essentially all other morphological types present within ~10Mpc (869 galaxies within 11Mpc or V_{LG}<600km/s; Karachentsev et al. 2013)



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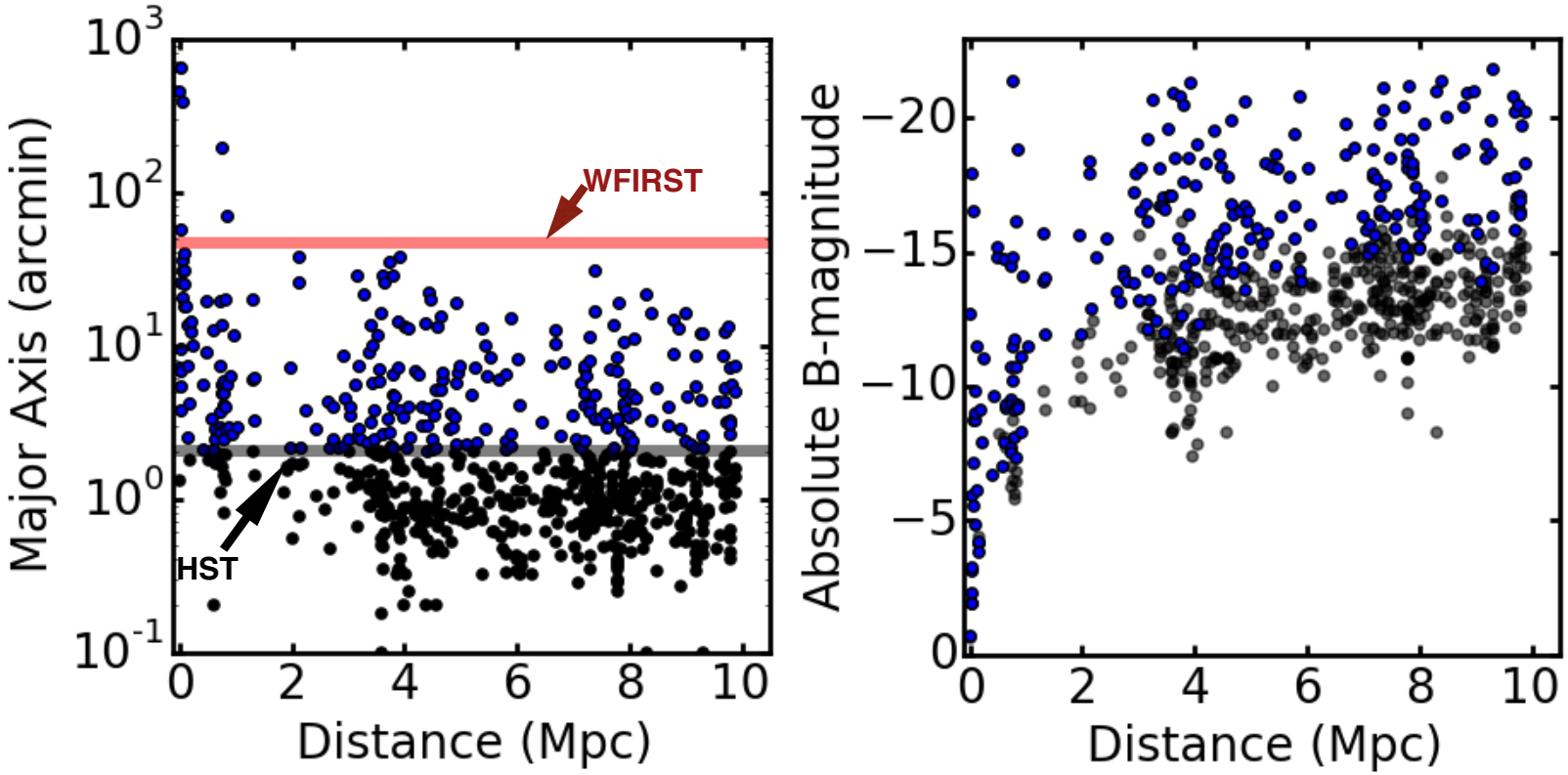
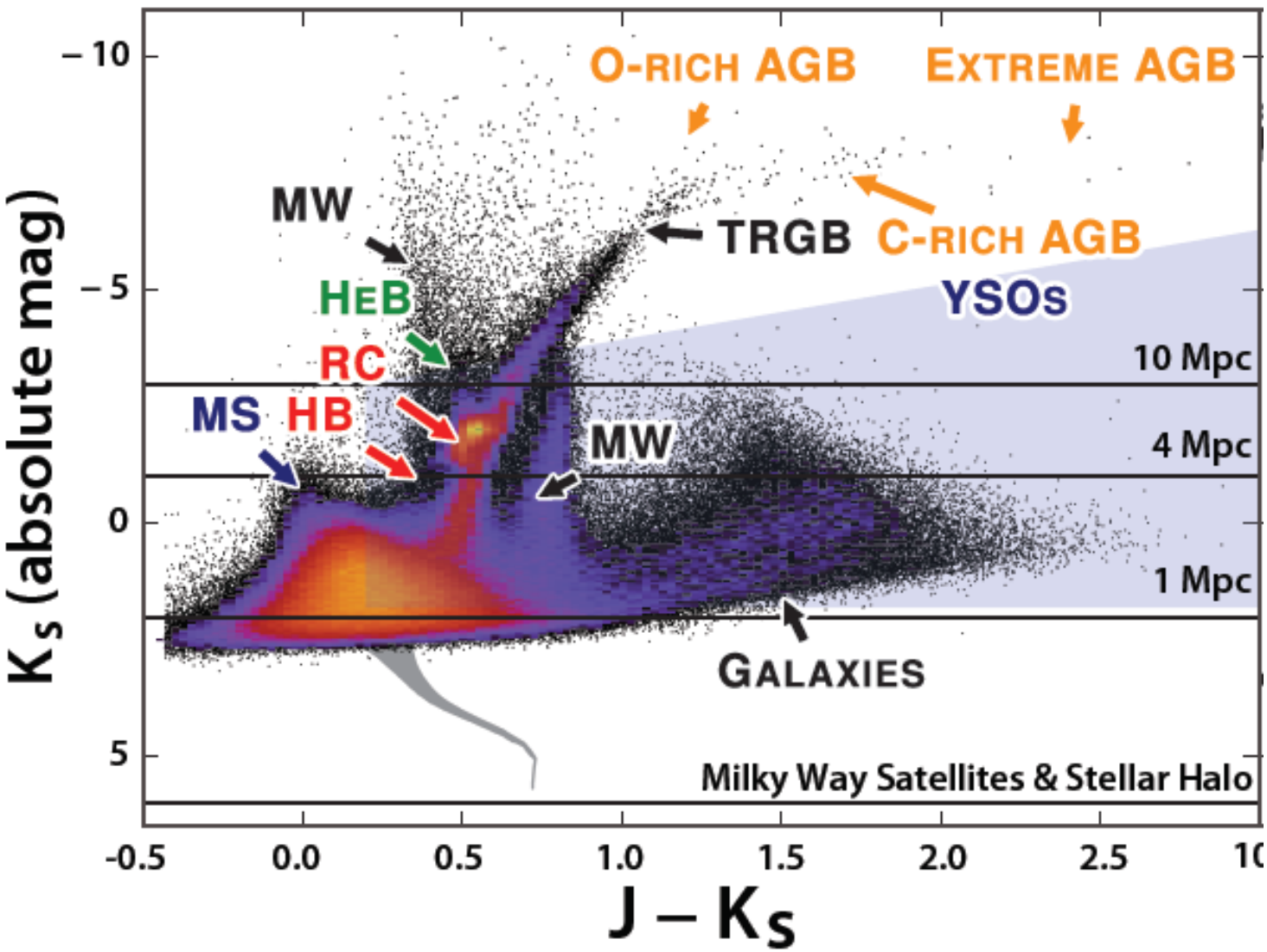


Going further with WFIRST



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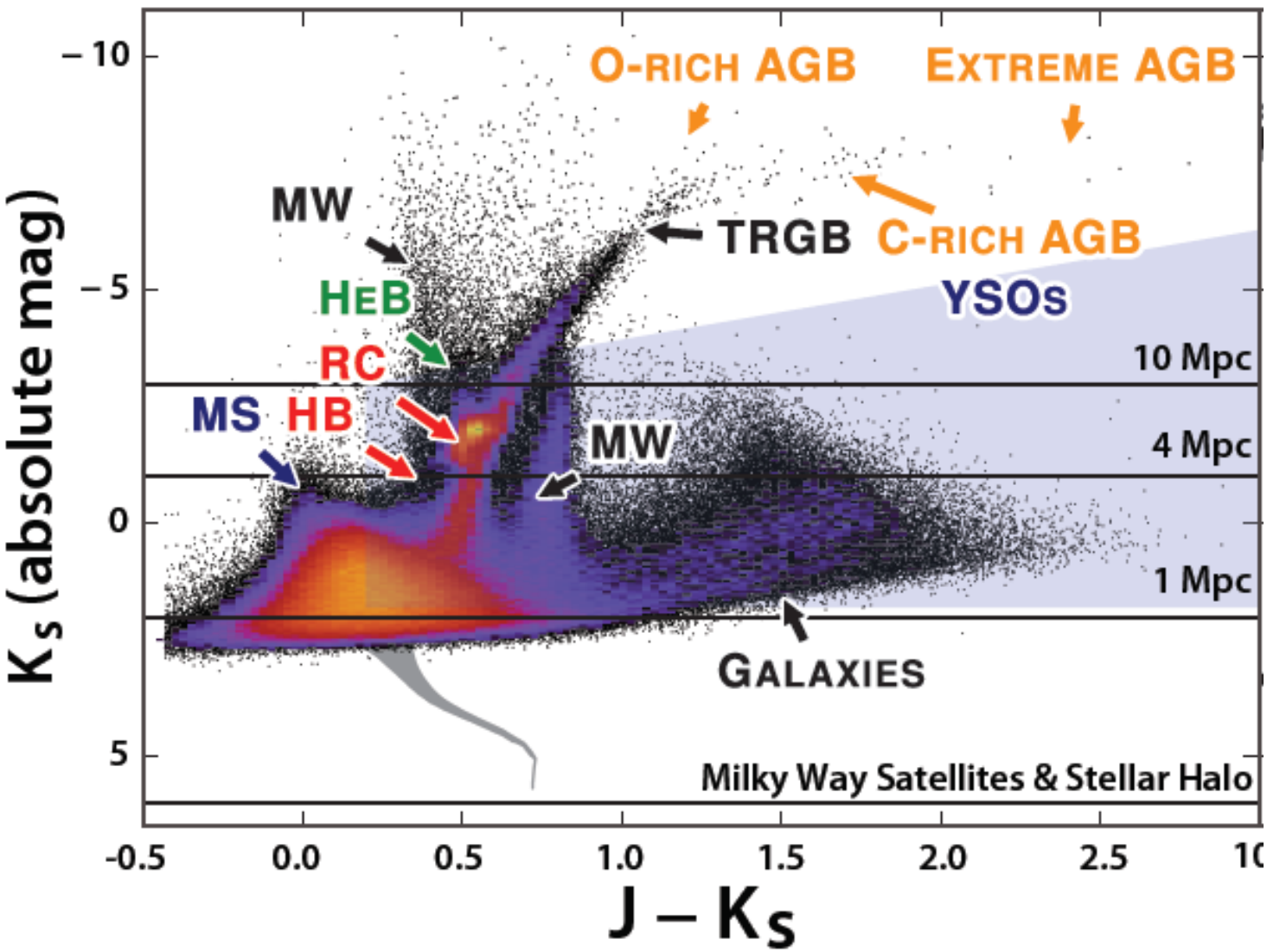
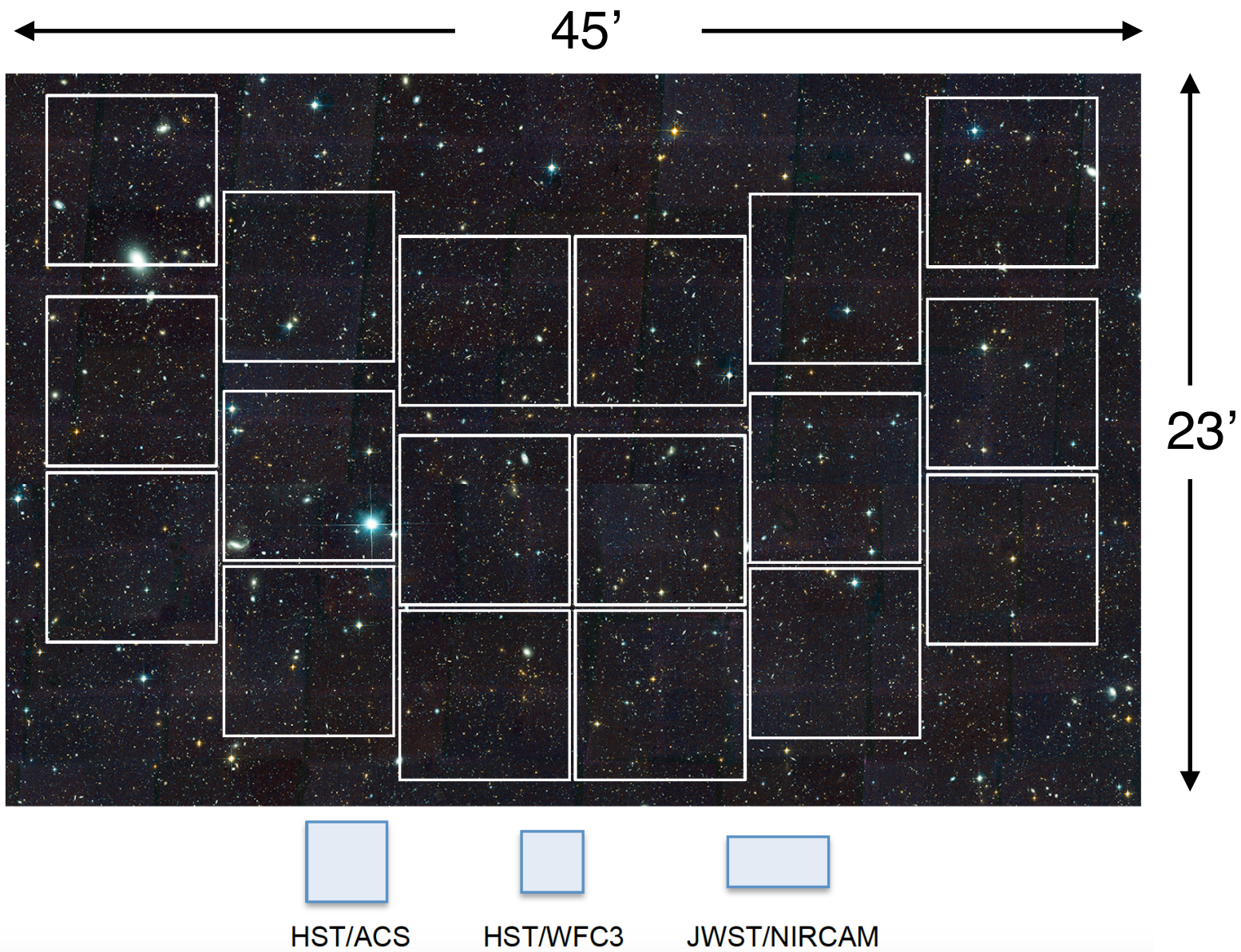


Hundreds of targets at PAndAS depth

Nearest galaxy groups (inc. L* galaxies)

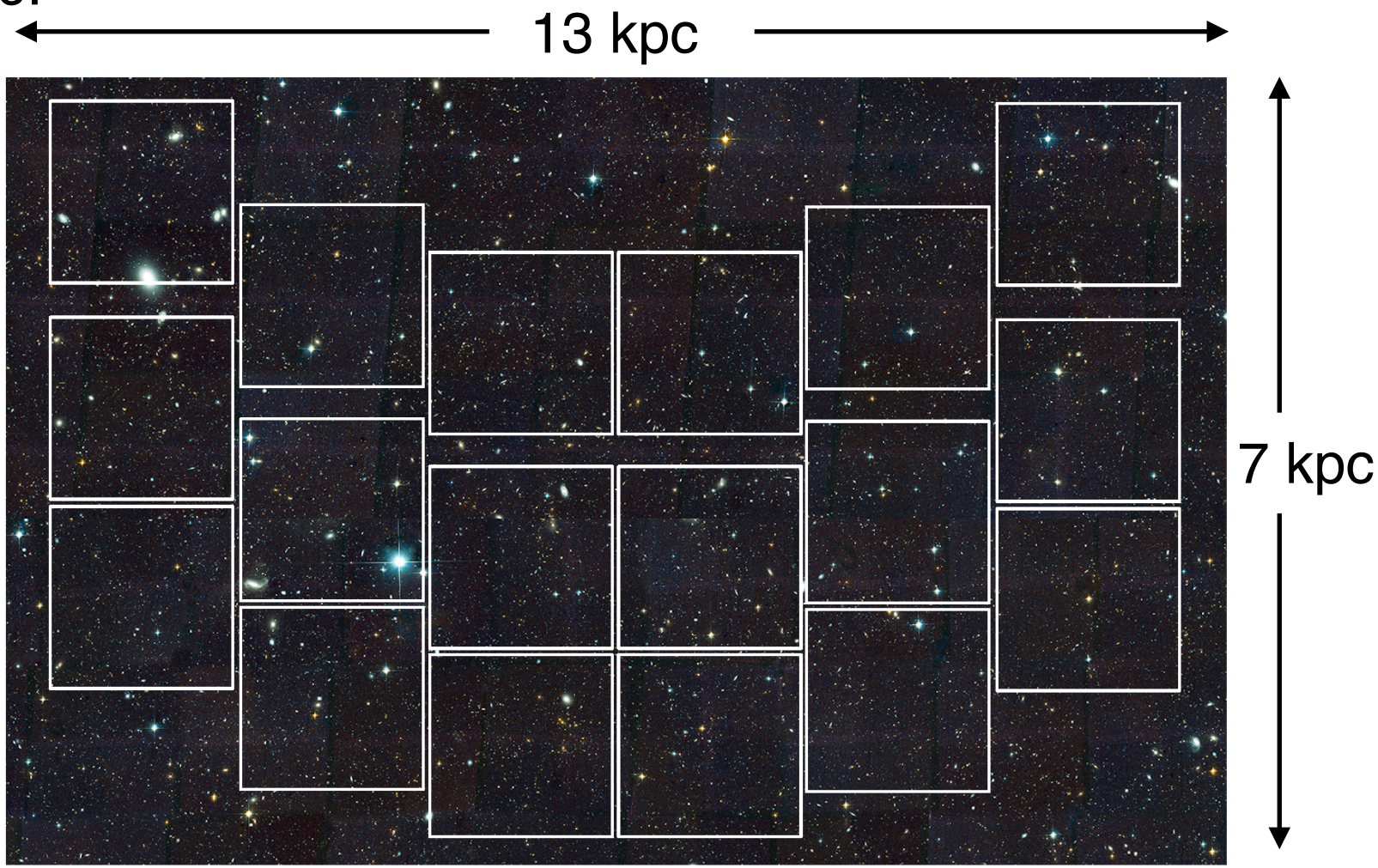
Local Group / M31

Go big or go home



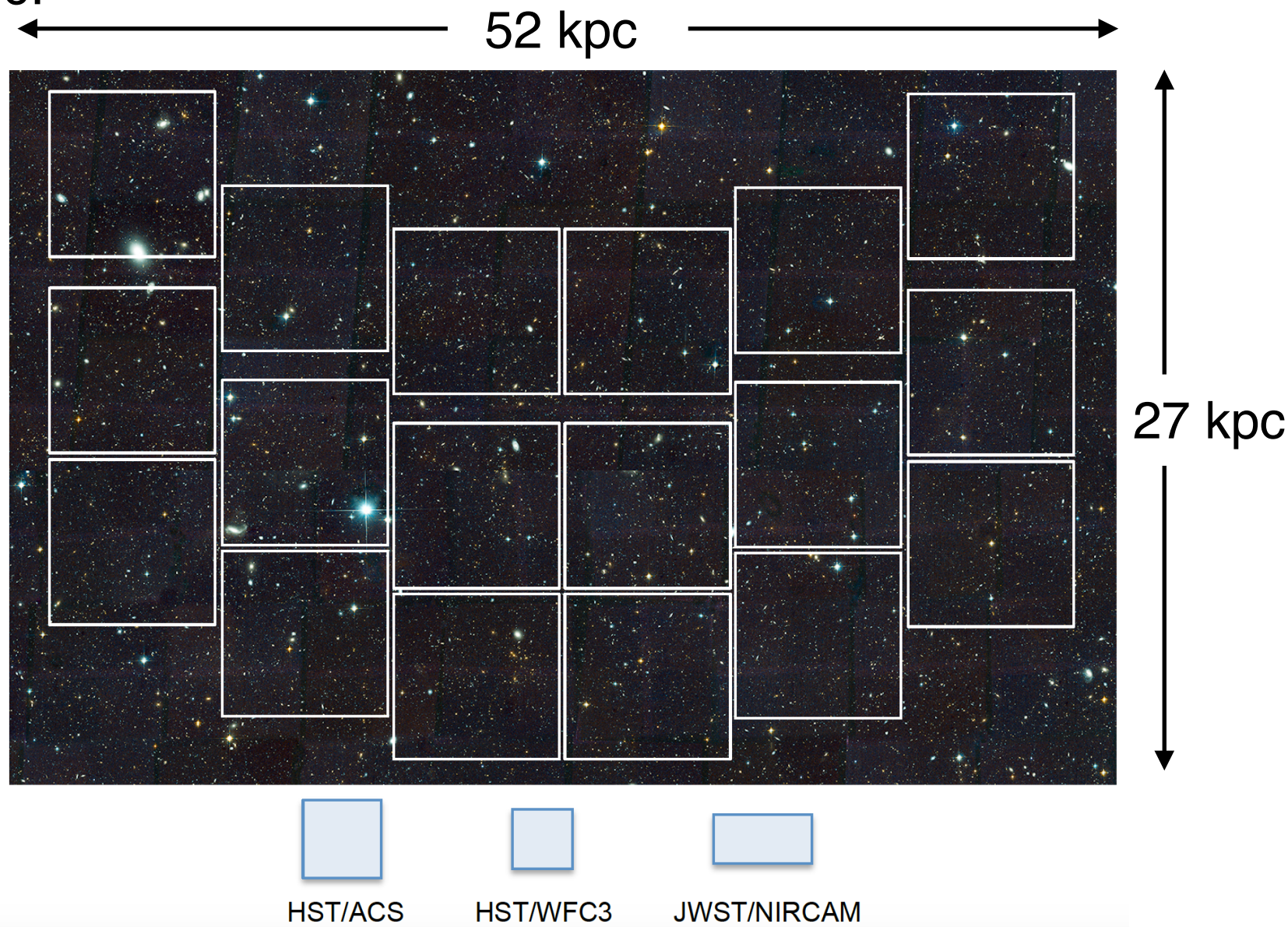
Go big or go home

At 1Mpc:



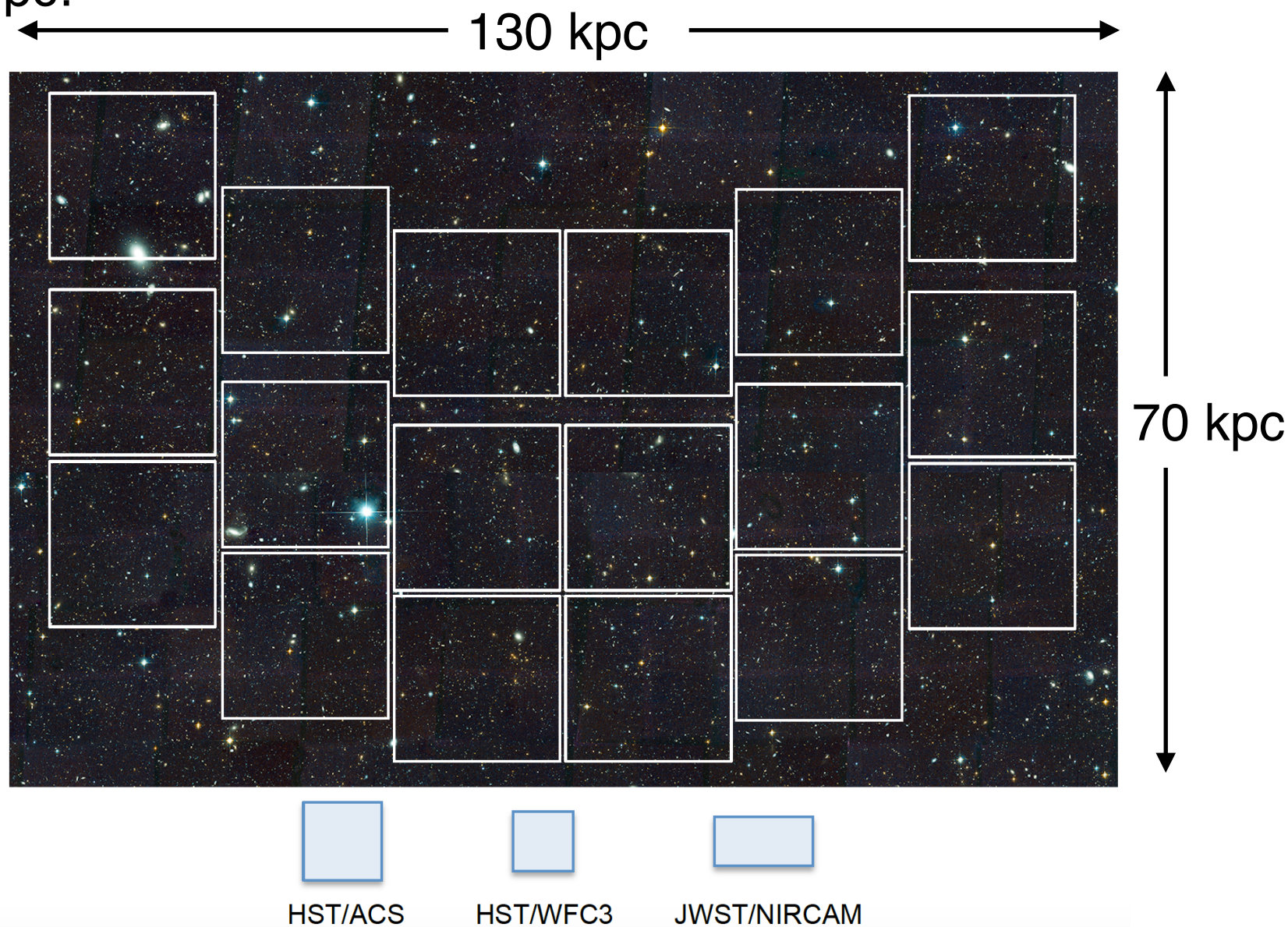
Go big or go home

At 4Mpc:



Go big or go home

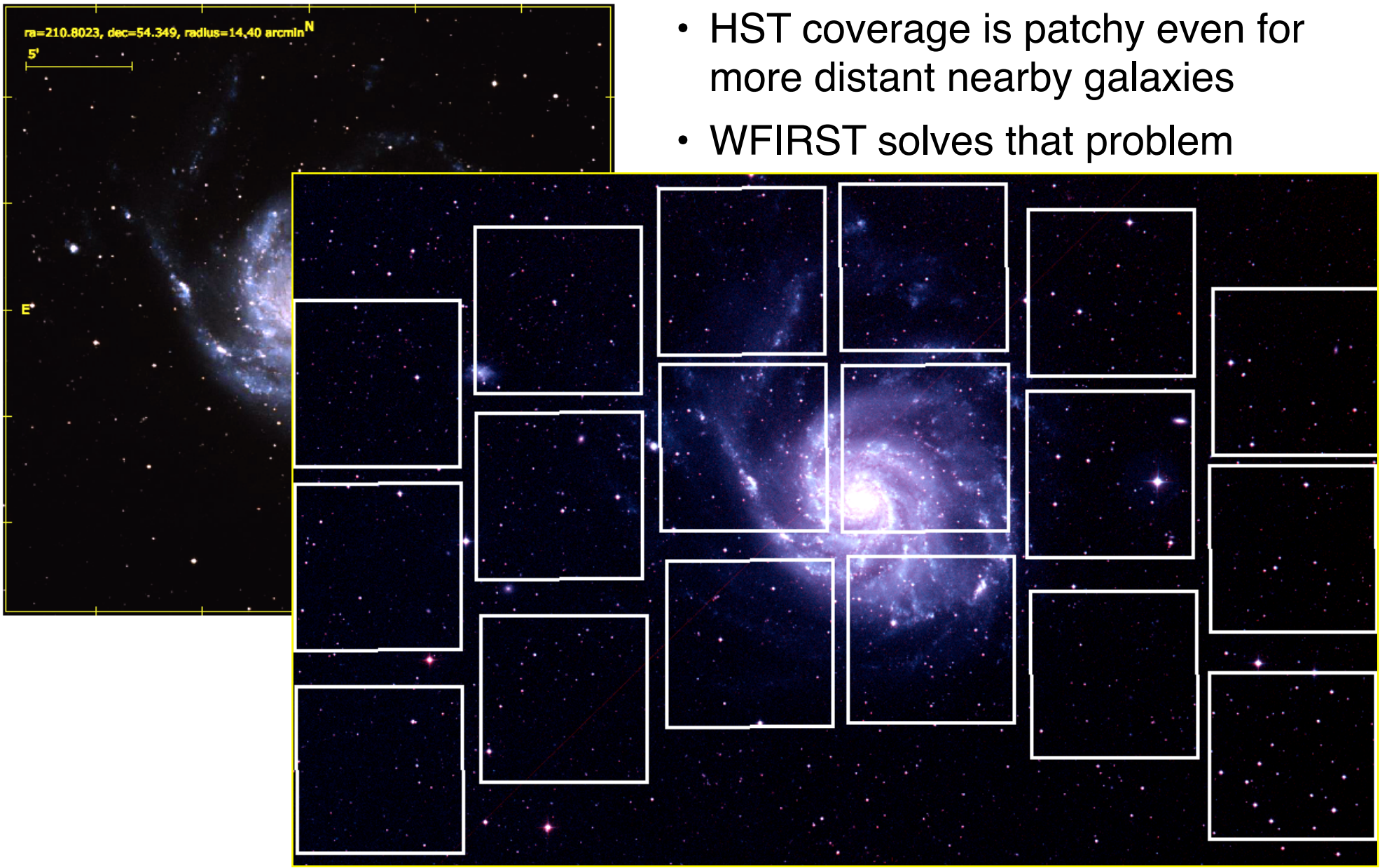
At 10Mpc:



M101 (7.4Mpc)

- HST coverage is patchy even for more distant nearby galaxies

M101 (7.4Mpc)



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- WFIRST solves that problem

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- WFIRST combines field of view with HST-esque resolution - an unprecedented tool for galaxy archaeology in the Local Volume