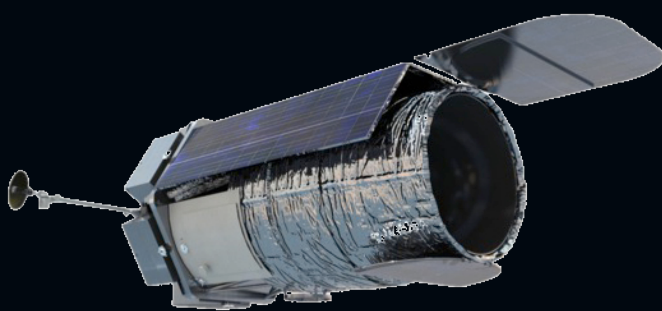
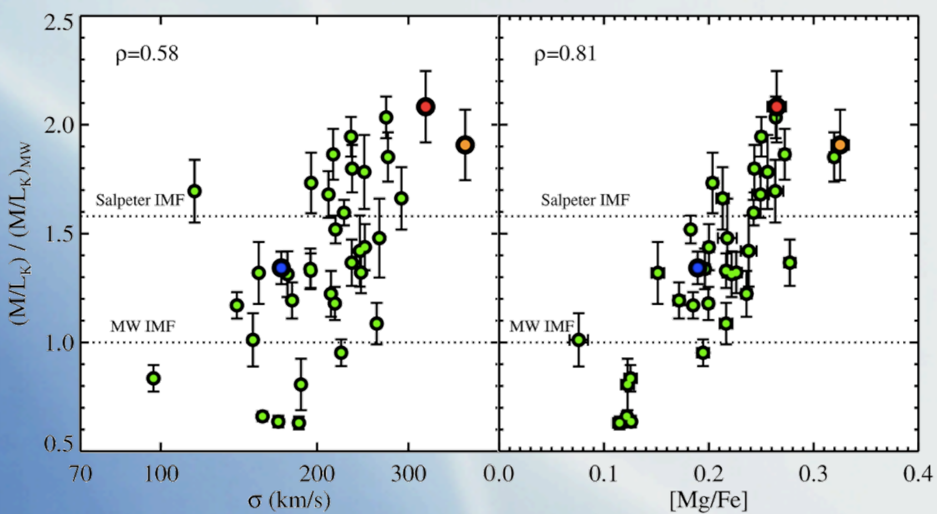
WFIRST Observations of Milky Way Satellites

Josh Simon
Carnegie Observatories

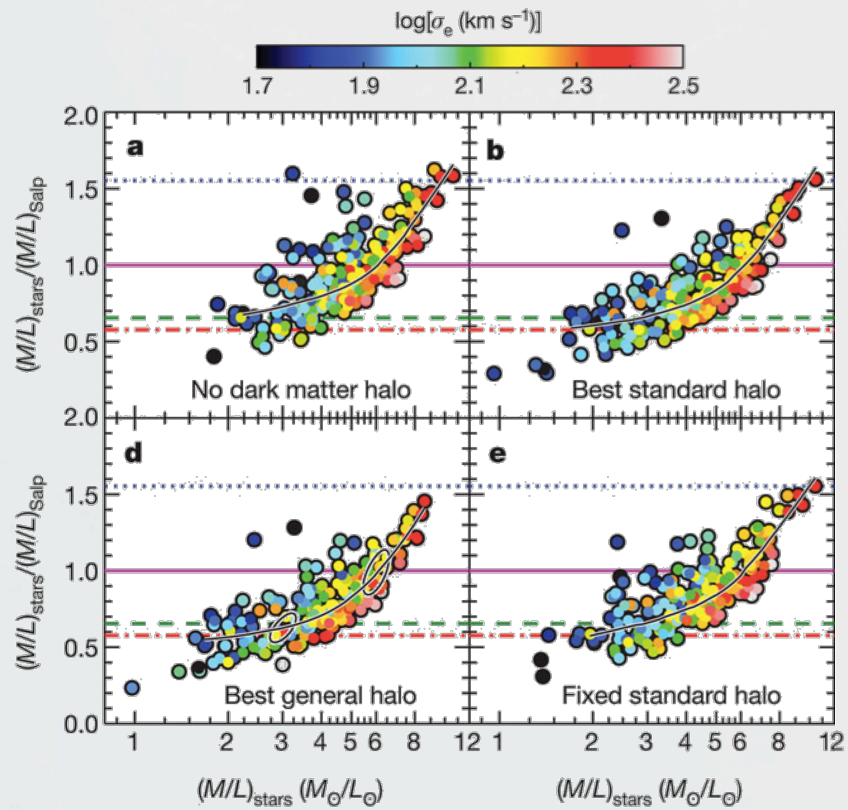


1. IMF Variations with Galactic Environment

- Observations now provide compelling evidence for a varying IMF



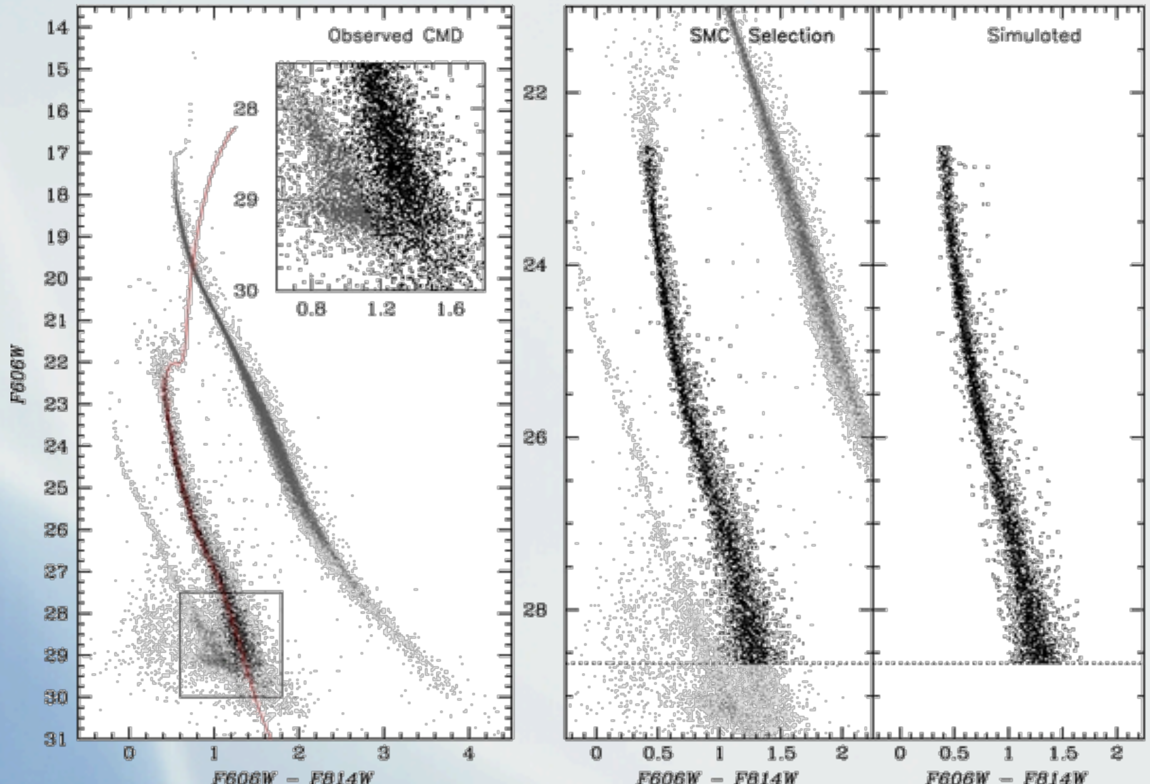
Conroy & van Dokkum (2012)



Cappellari et al. (2012)

But: Existing Evidence is Indirect

- From space, <u>direct</u> measurements are possible for nearby galaxies



Kalirai et al. (2012)

The IMF at Low Metallicity

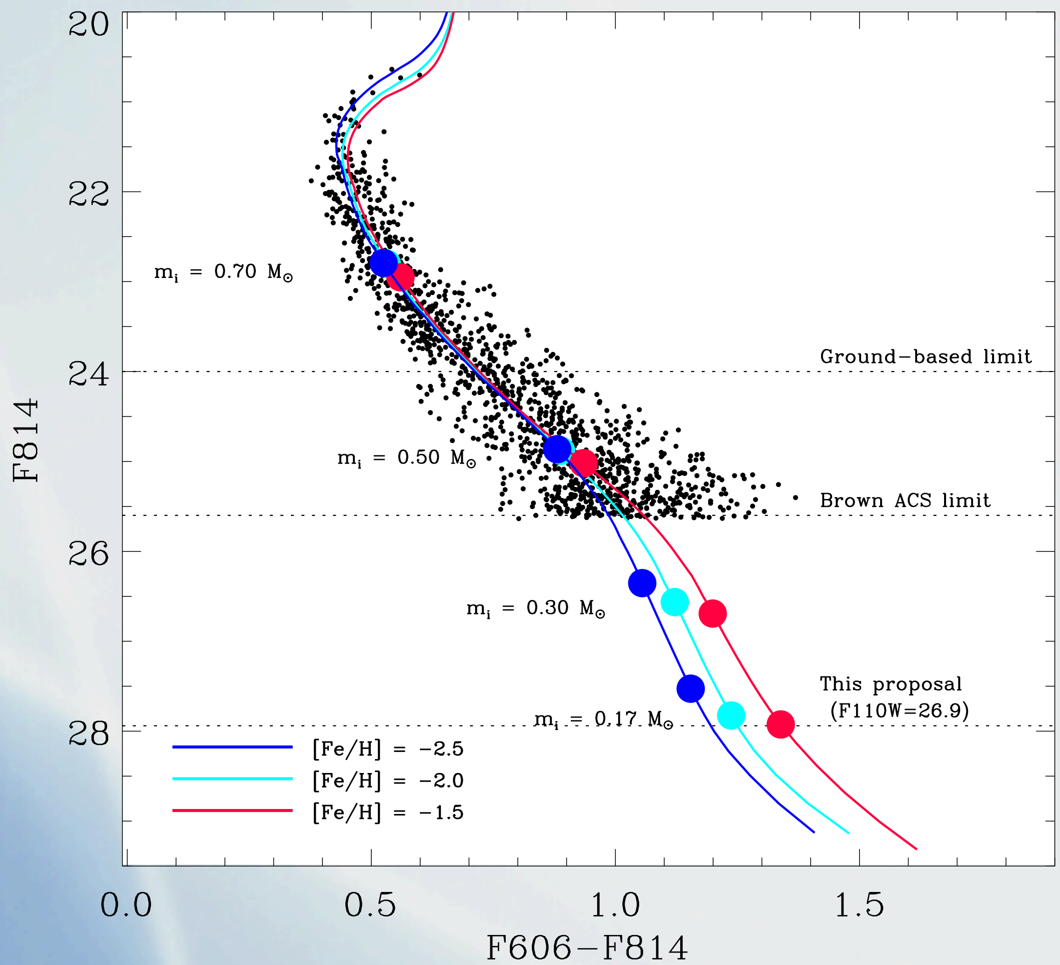
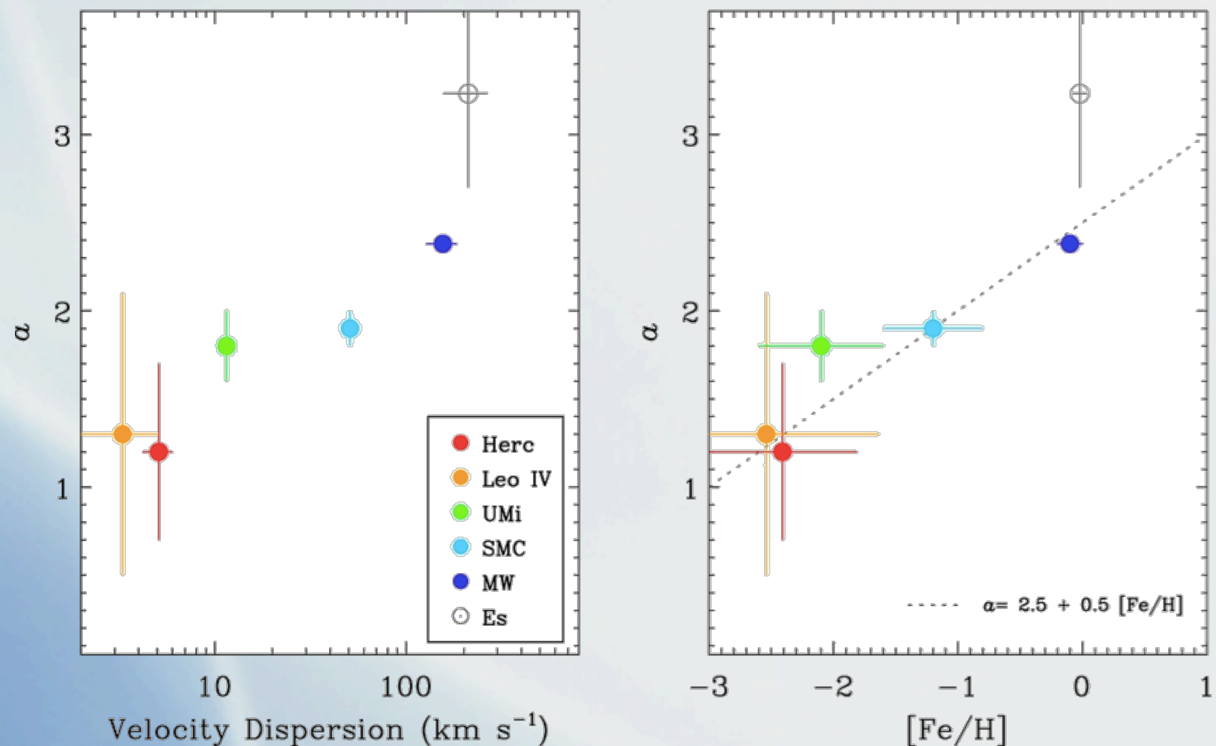


Figure courtesy of Marla Geha

What Is the Physics Driving the IMF?

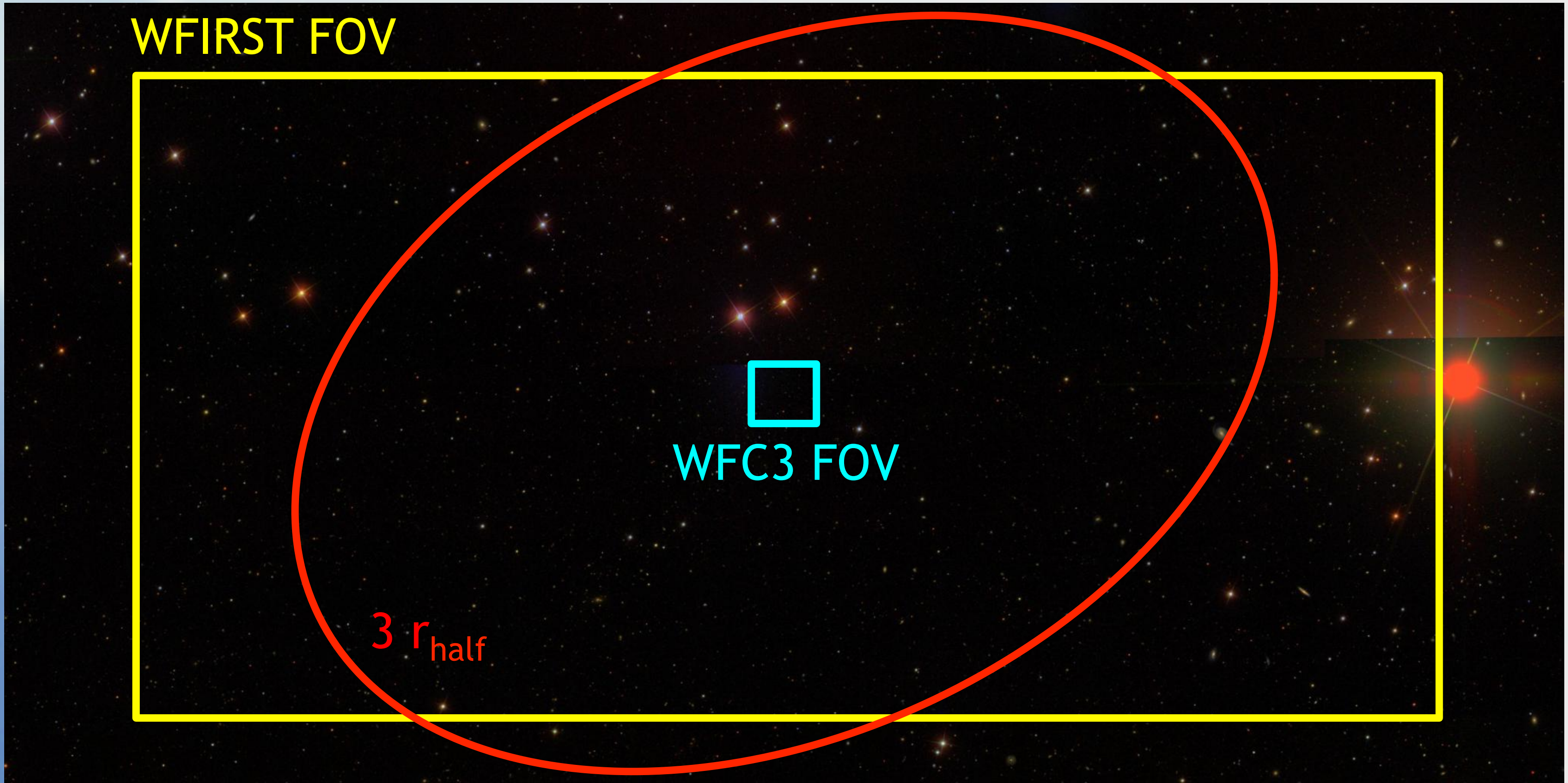
- Galaxy parameter space is very sparsely sampled so far



Geha et al. (2013)

The IMF with WFIRST

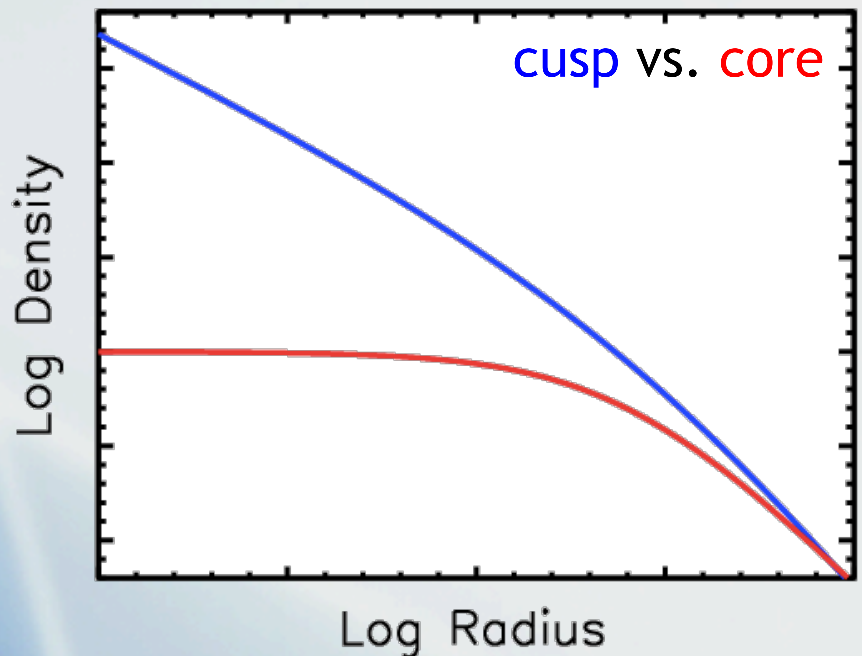
- Efficiency is ~10× Hubble from near-IR wavelengths plus field of view



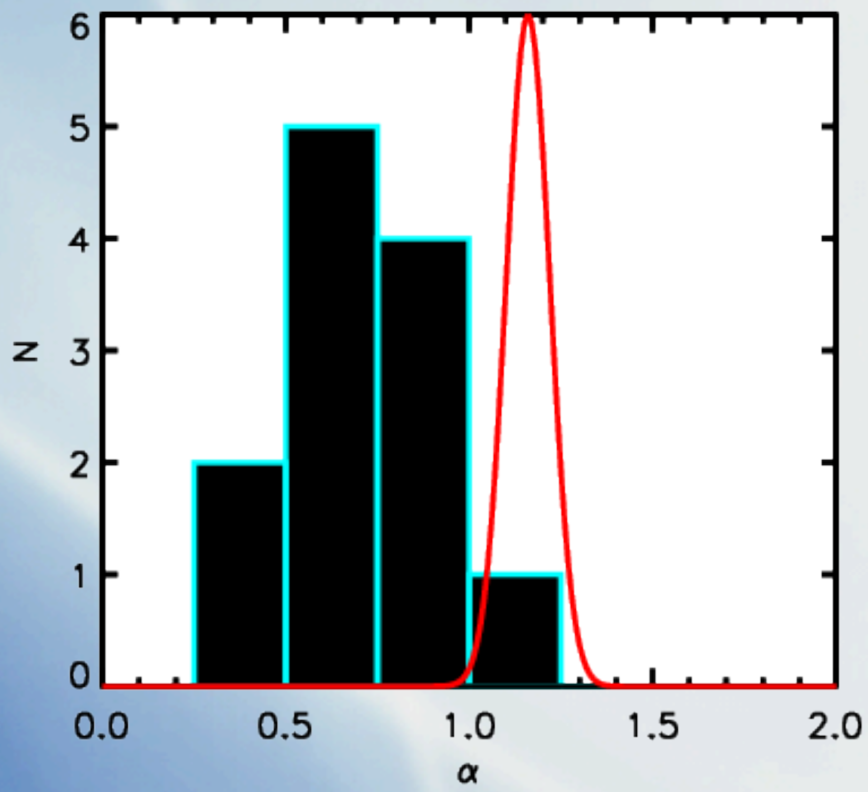
2. The Nature of Dark Matter

- Navarro, Frenk, & White (1996) profile

$$\rho(r) \propto \frac{1}{(r/r_s)(1 + r/r_s)^2}$$



Observed Distribution of Dark Matter Central Slopes



Galaxy sample: Adams et al. (2014) + Simon et al. (2005) + Oh et al. (2011)

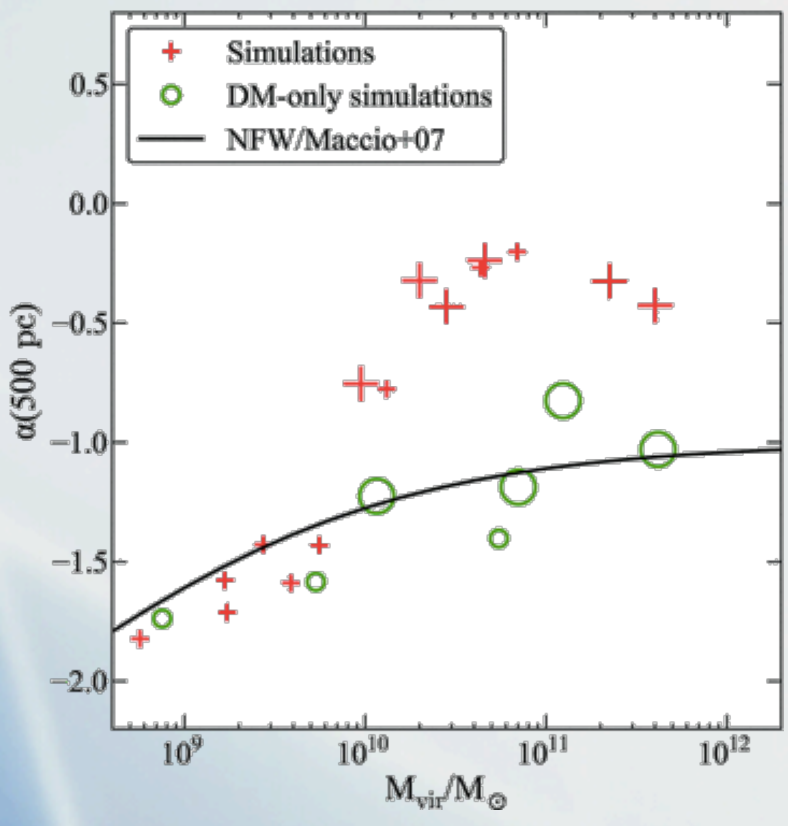
Simulations: Diemand et al. (2004)

Average DM profile has $\alpha = 0.63 \pm 0.28$

Adams et al. (2014)

Lower Mass Galaxies Are the Key

- Galaxies with $M_{vir} \leq 10^{10}\ M_{\odot}$ ($M_* \leq 10^7\ M_{\odot}$) should be unaffected by feedback

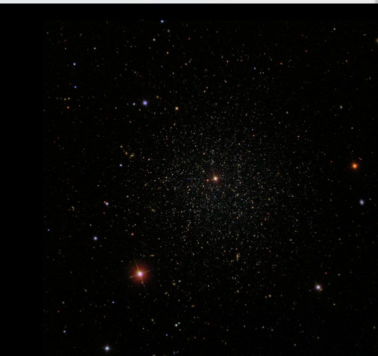


Governato et al. (2012)

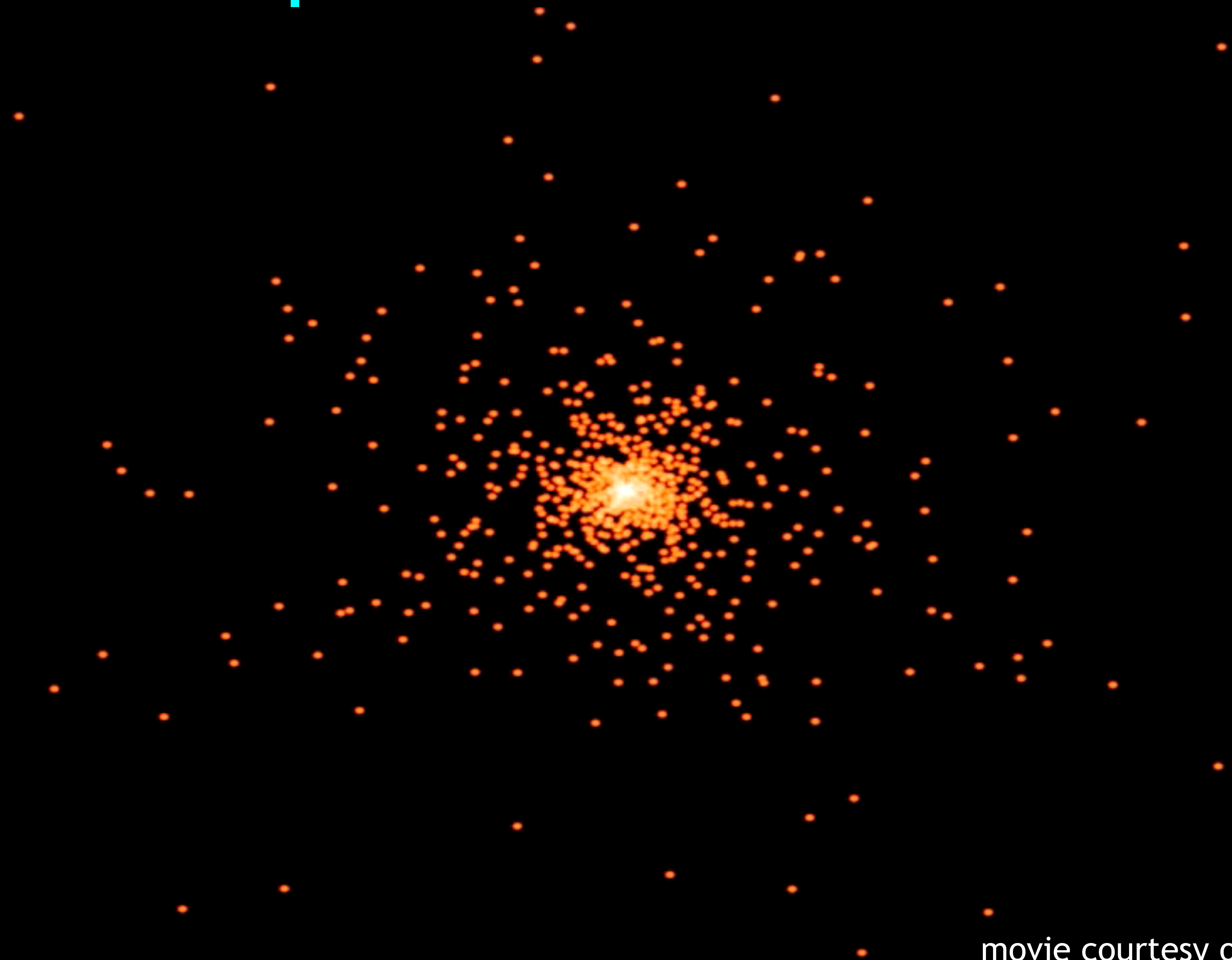
Dwarf Spheroidals as DM Probes

- Closest and most dark matter-dominated galaxies known
  - luminosities from 10^3 to 10^7 $L_\odot$
  - sizes from 30 to 1000 pc
  - masses of ~10^9 $M_\odot$
- But: radial velocities provide only one component of the 3D motion of each star



Dwarf Spheroidals as DM Probes



movie courtesy of TJ Cox

dSph Density Profile Results

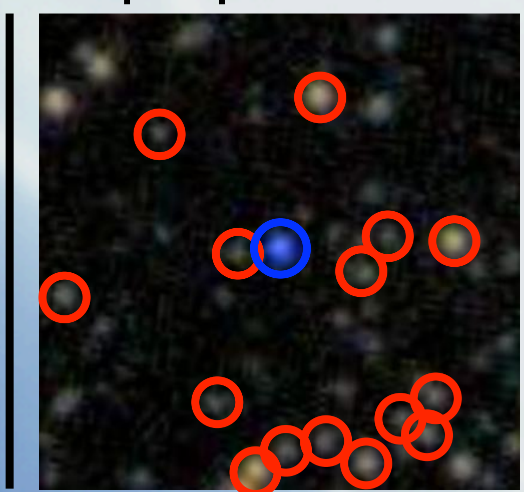
- Fornax
  - $\gamma = 0.39^{+0.37}_{-0.43}$ (Walker & Penarrubia 2011)
  - core (Jardel & Gebhardt 2012)
  - core or cusp (Breddels & Helmi 2013)
- Sculptor
  - core or cusp (Battaglia et al. 2008)
  - $\gamma = 0.05^{+0.39}_{-0.51}$ (Walker & Penarrubia 2011)
  - core (Amorisco & Evans 2012)
  - $\gamma = 0 \pm 1.2$ (Breddels et al. 2013)
  - core or cusp (Breddels & Helmi 2013)
  - $\gamma = 0$ or 1.2 (Richardson & Fairbairn 2014)

dSph Proper Motions with WFIRST

- Combining radial velocities with proper motions measures orbital anisotropy
  - 5 km s^{-1} ~ 16 μas yr^{-1} (measurable in 5 years)

ELT proper motions

40”



QSO

Leo II members

WFIRST proper motions

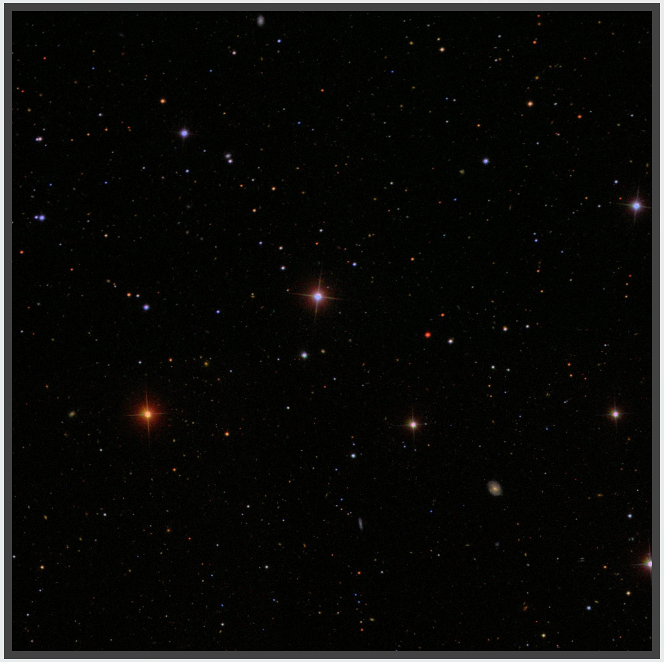
40’

3. Formation of the Faintest Dwarfs

- SDSS revealed a new population of incredibly faint dwarf galaxies

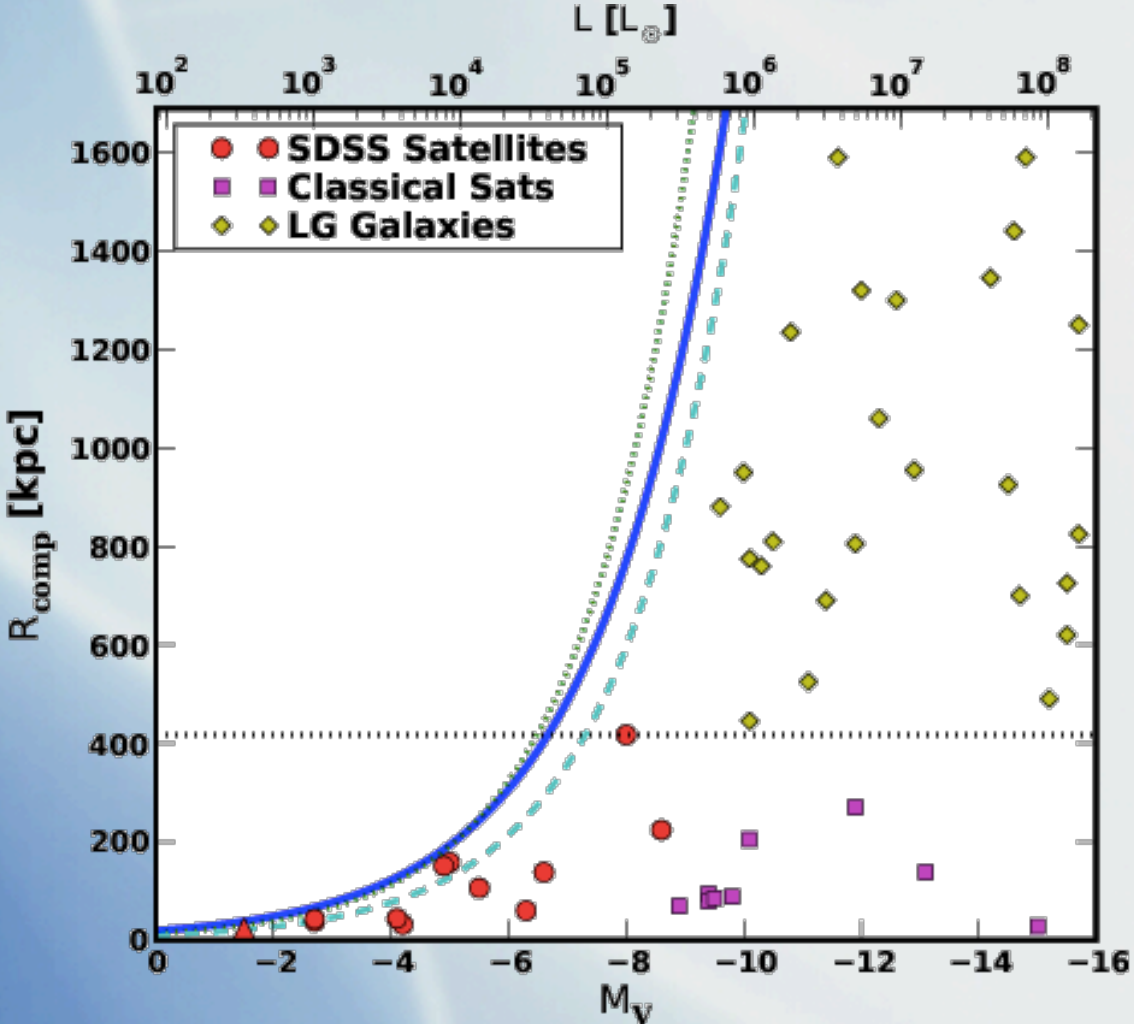
Pre-SDSS dwarf

SDSS dwarf



Belokurov et al. (2006b)

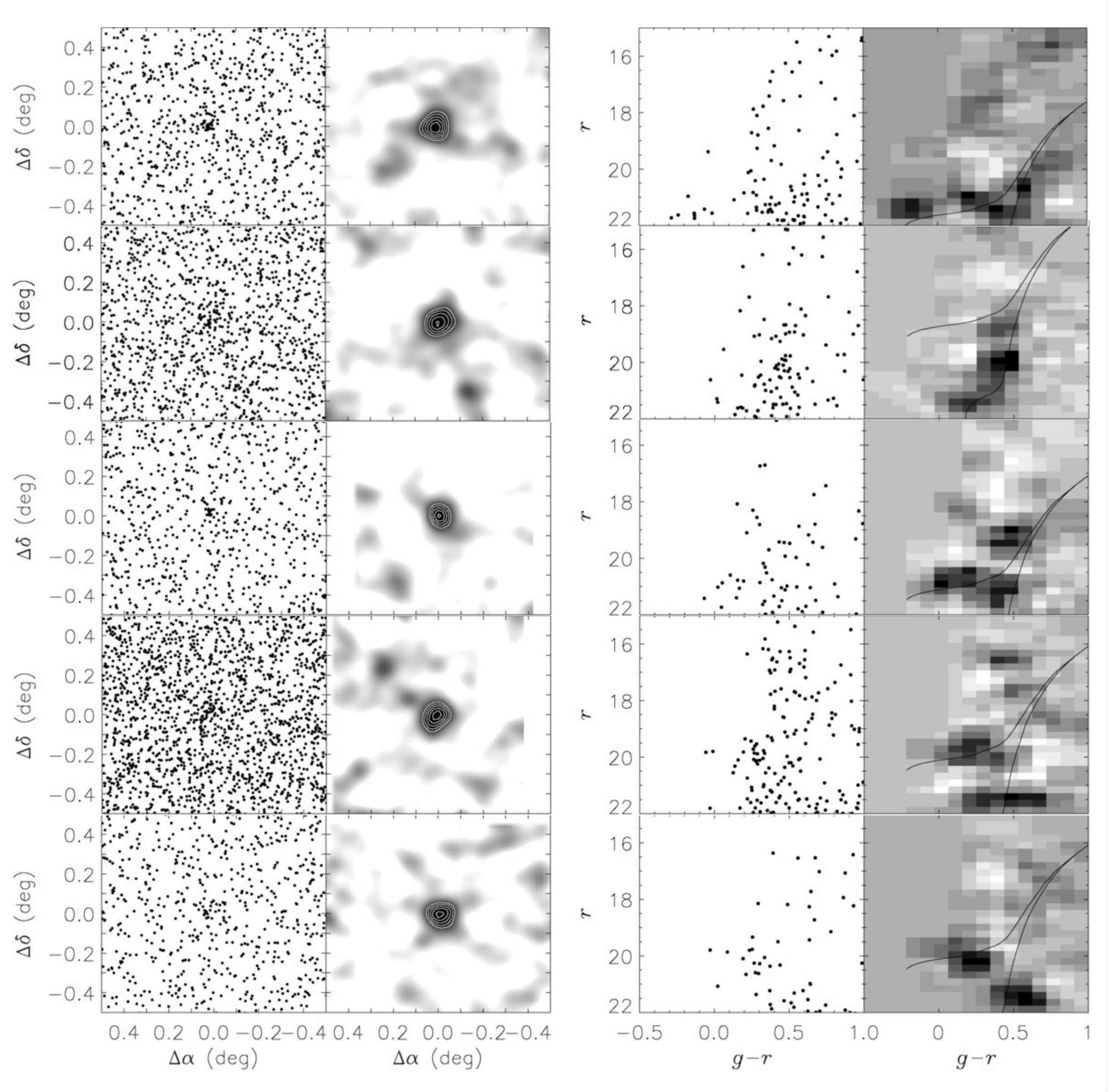
Do L < 10^3 $L_\odot$ Dwarfs Exist Beyond 50 kpc?



Ultra-faint dwarfs only detectable in SDSS if they are very nearby

Tollerud et al. (2008)

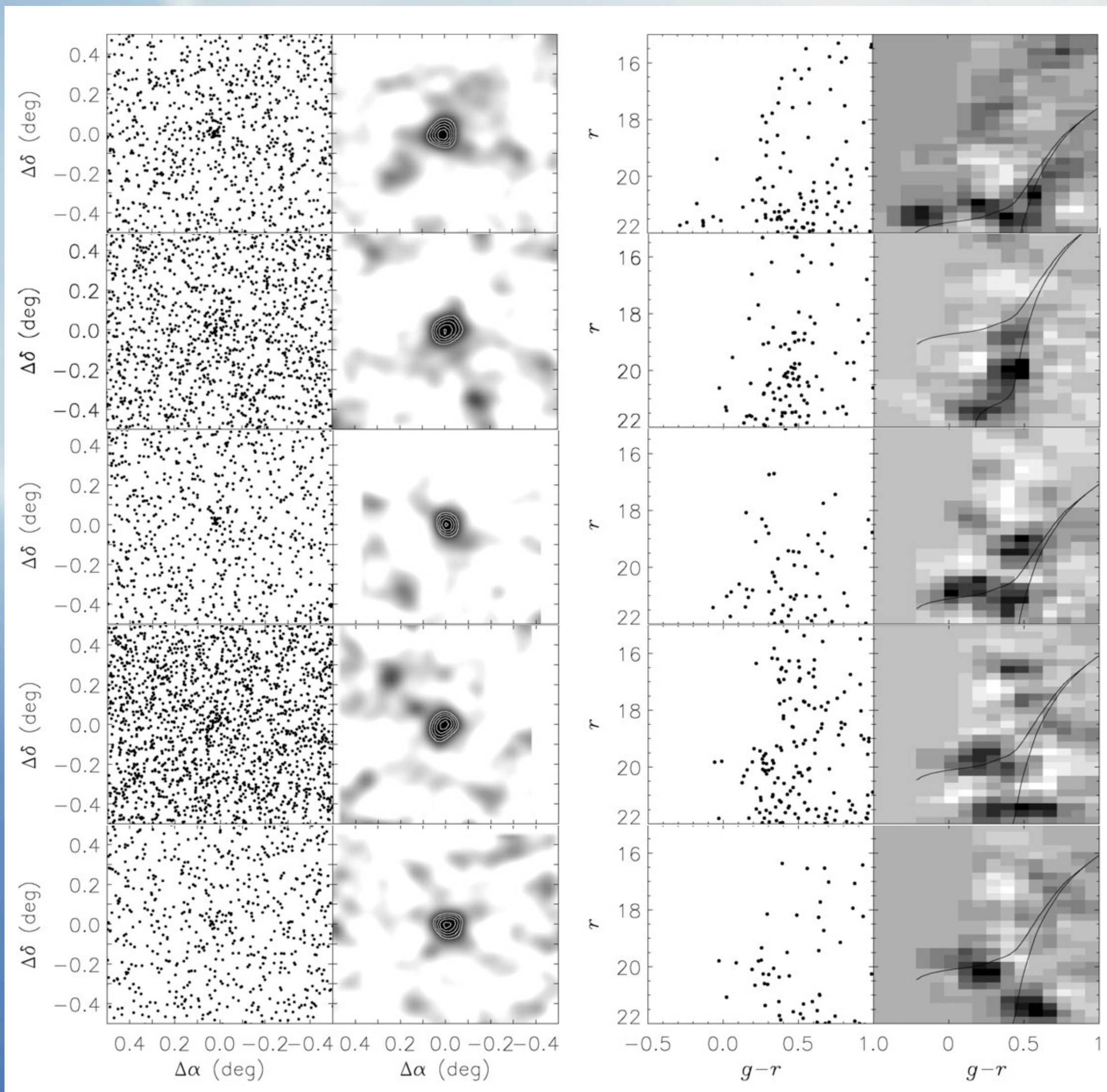
Deep Ground-Based Surveys Require Intensive Follow-up



LSST will find hundreds of objects like these - which ones are dwarfs?

Walsh et al. (2009)

Deep Ground-Based Surveys Require Intensive Follow-up



Dwarf

Dwarf

Asterism?

Asterism?

Asterism?

Walsh et al. (2009)

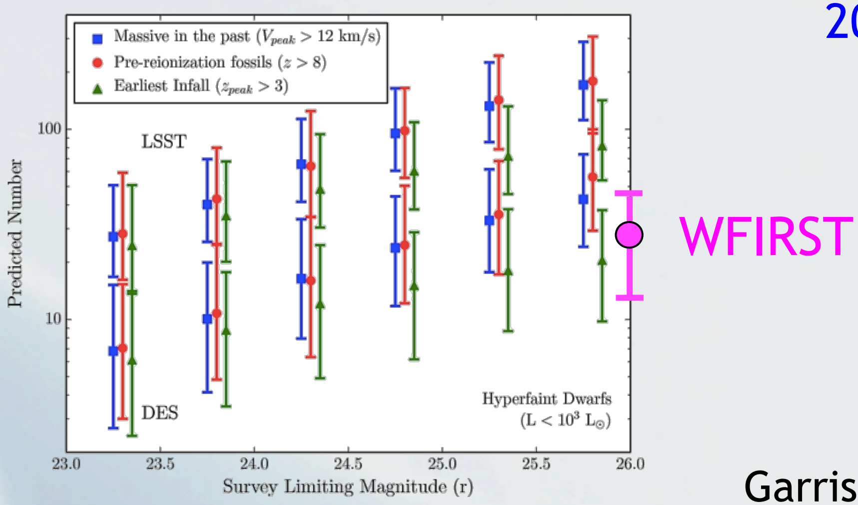
Ultra-Faint Dwarfs in WFIRST HLS

- WFIRST will provide a clean sample of dwarfs out to ~2.5 Mpc without follow-up
  - Estimated discoveries:

    5 ± 2 L > 10^3 $L_\odot$ Milky Way satellites (Hargis et al. 2014)

    28 ± 15 L < 10^3 $L_\odot$ Milky Way satellites (Hargis et al. 2014)

    58 L > 10^3 $L_\odot$ dwarfs beyond 300 kpc (Garrison-Kimmel et al. 2014)



Garrison-Kimmel et al. (2014)

Local Group Science with WFIRST

- Direct measurements of the IMF
  - Efficient determination of IMF variation with [Fe/H] and mass
  - Robust GO and/or Local Group Legacy program
- Internal proper motions in dSphs
  - Will provide cleanest possible cusp/core measurements
  - Requires maximizing WFIRST astrometric performance
- Census of the faintest dwarfs
  - Do dwarfs become ultra-faint via nature or nurture?
  - The bigger the High Latitude Survey, the better