Dark Matter Dominated Objects

Louie Strigari
Stanford

Milky Way Circa 2009

Satellite	Year Discovered
LMC	1519
SMC	1519
Sculptor	1937
Fornax	1938
Leo II	1950
Leo I	1950
Ursa Minor	1954
Draco	1954
Carina	1977
Sextans	1990
Sagittarius	1994
Ursa Major I	2005
Willman 1	2005
Ursa Major II	2006
Bootes I	2006
Canes Venatici I	2006
Canes Venatici II	2006
Coma Berenices	2006
Segue 1	2006
Leo IV	2006
Hercules	2006
Bootes II	2007
Leo V	2008

Segue 2 2009

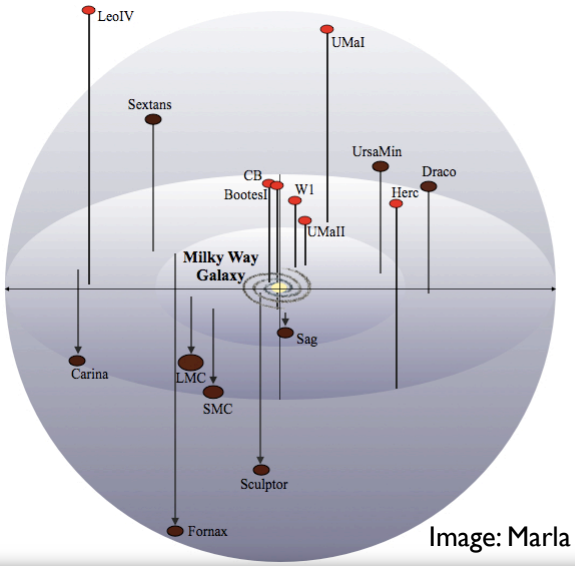
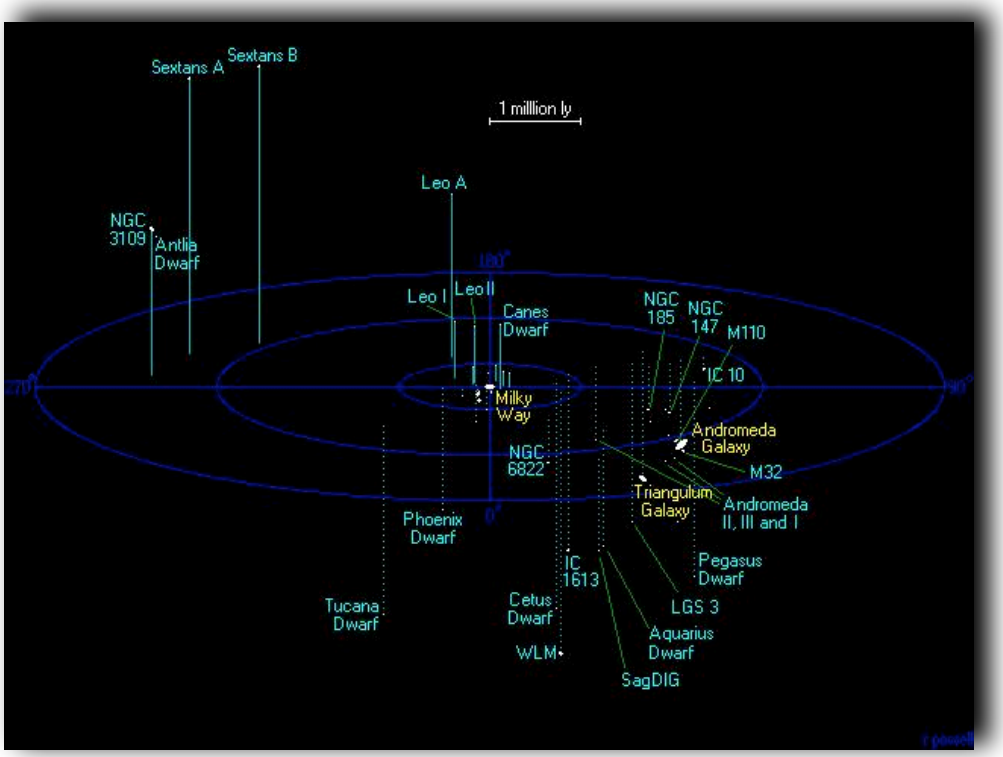
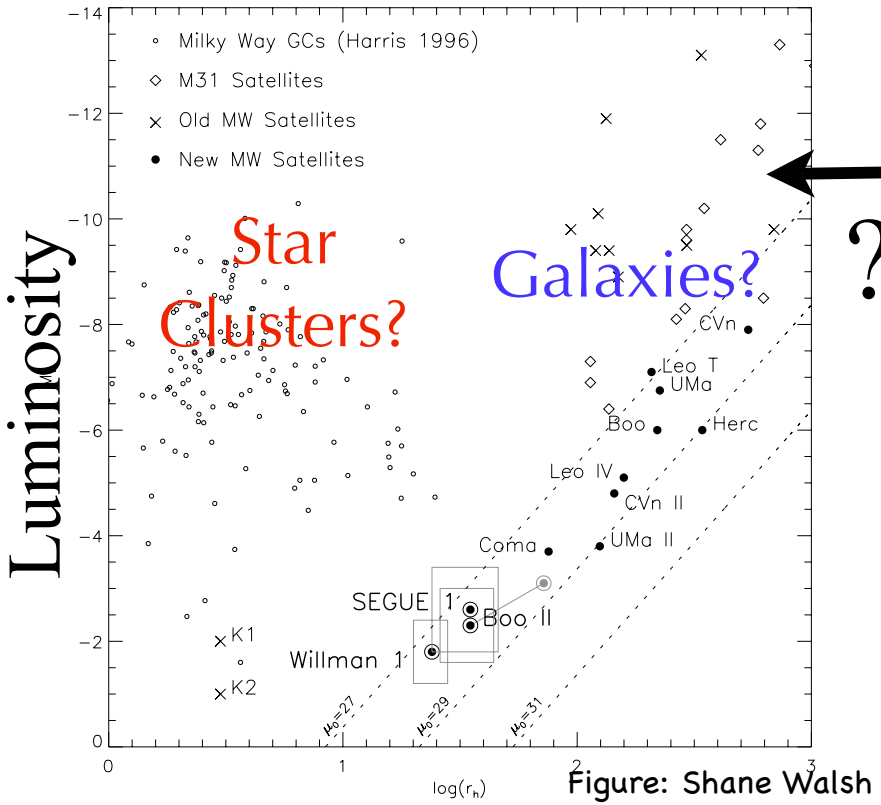


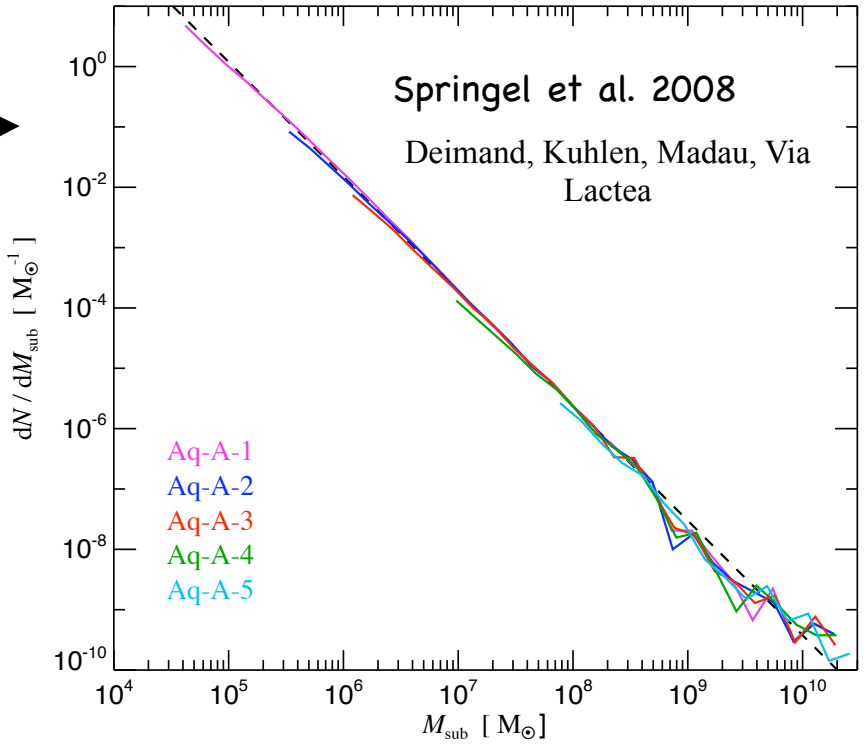
Image: Marla Geha



What is the minimum mass dark matter halo?
What is the minimum mass ``galaxy?"



?

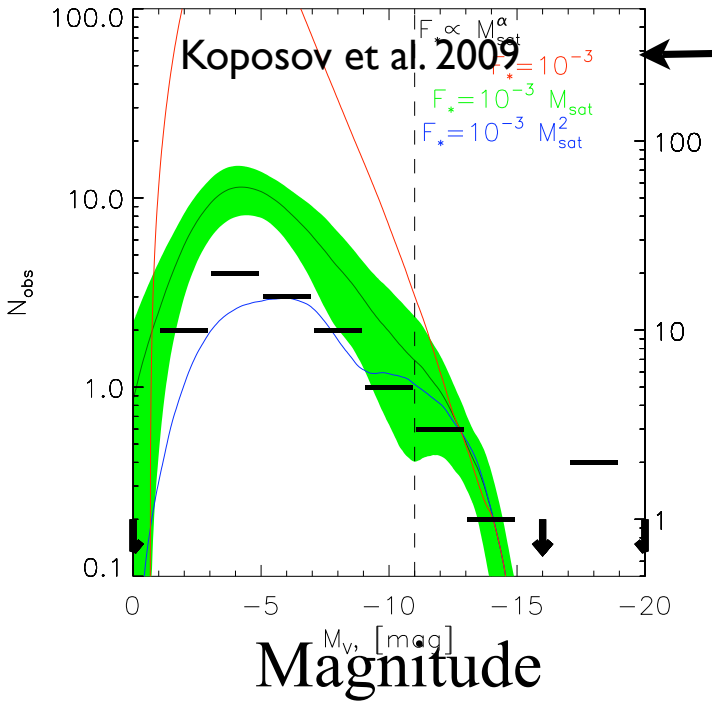


Half-light radius

Cold Dark Matter

Belokurov et al. 2006,
Gilmore et al. 2007

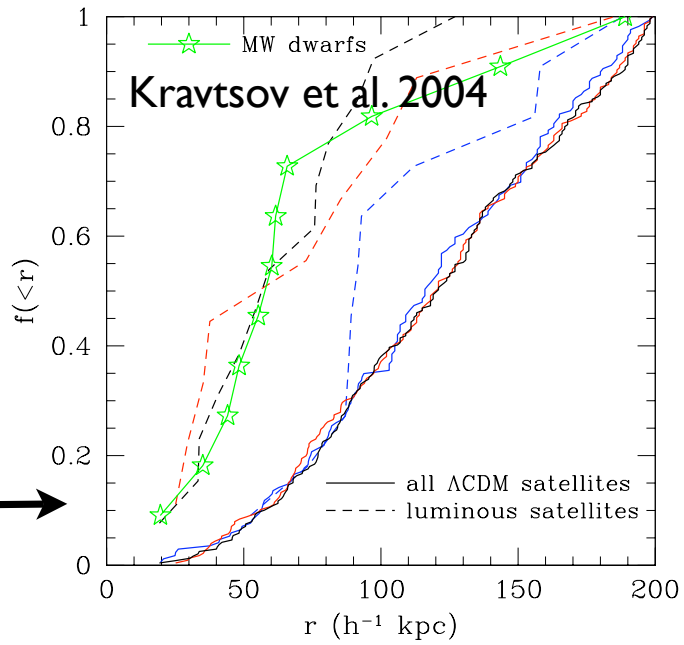
Mapping satellites onto CDM subhalos



Luminosity function [e.g. Bullock et al. 2001, Benson et al. 2002, Somerville et al. 2002, Kravtsov et al. 2004, Koposov et al. 2008, Tollerud et al. 2008, Busha et al. 2009, Bovill & Ricotti 2009, Koposov et al. 2009]

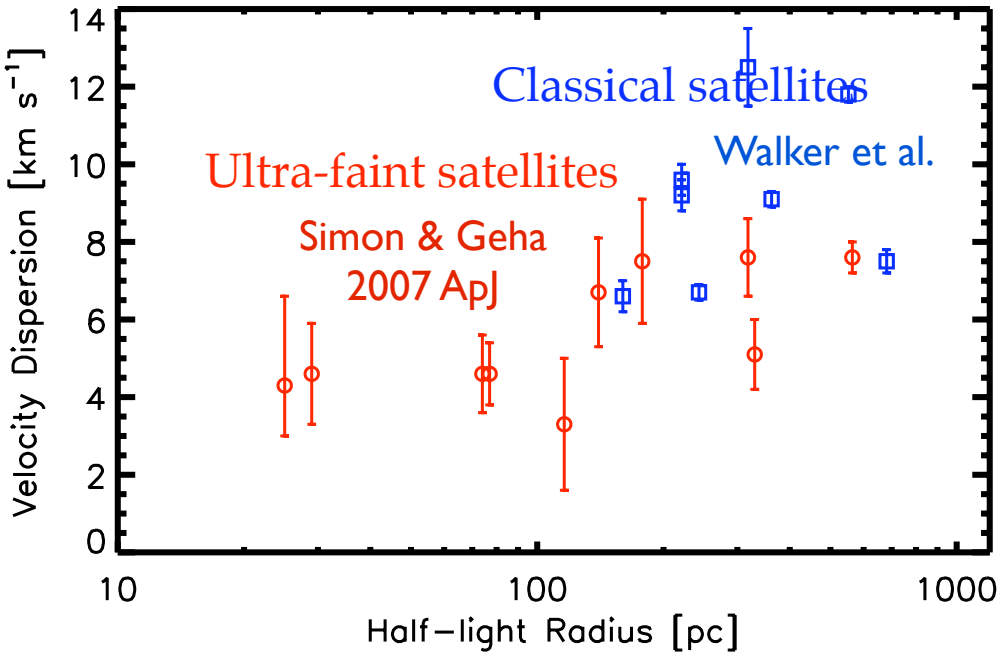
Radial/Velocity distribution

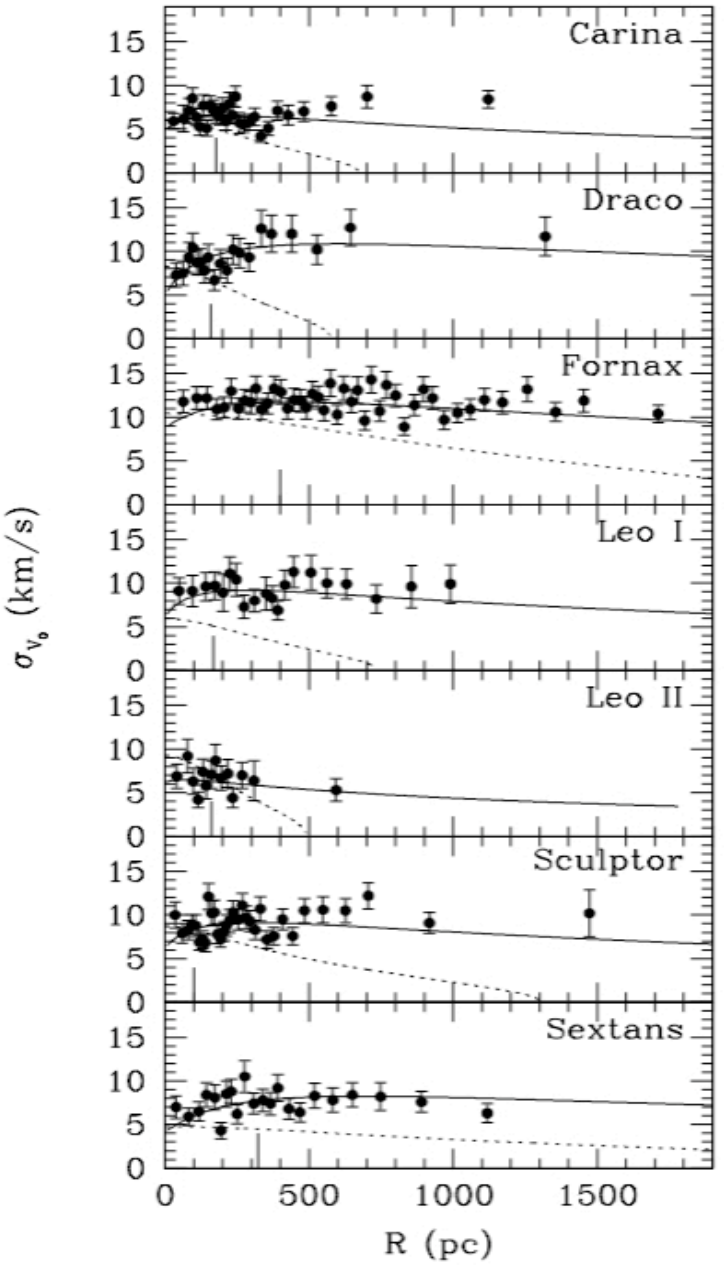
[e.g. Willman et al. 2004, Kravtsov et al. 2004]



Kinematics [e.g. Strigari et al. 2007, 2008, Li et al. 2008, Maccio et al. 2008]

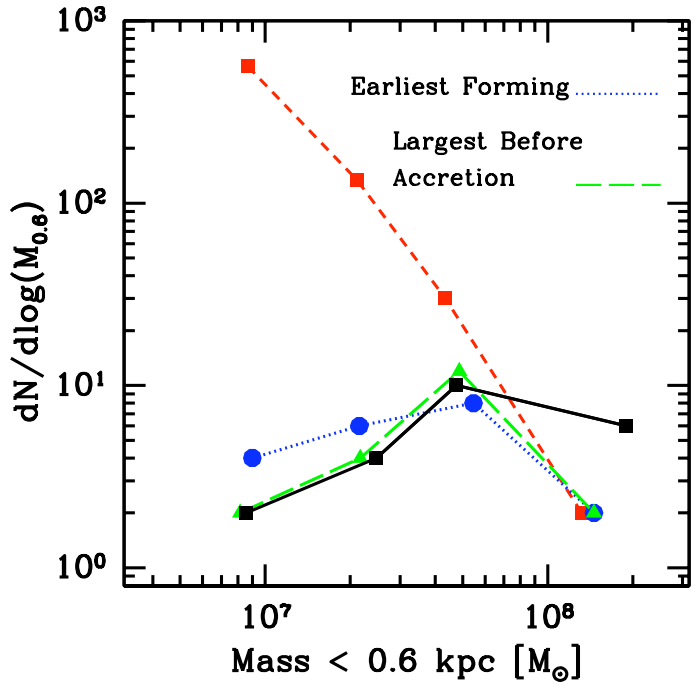
Dwarf halo kinematics



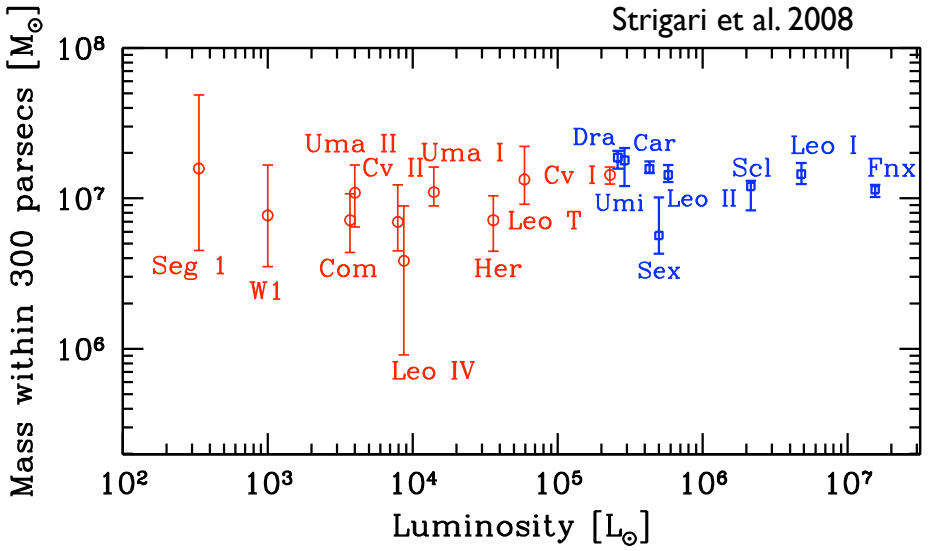


Walker et al ApJL 2008

Satellite Masses

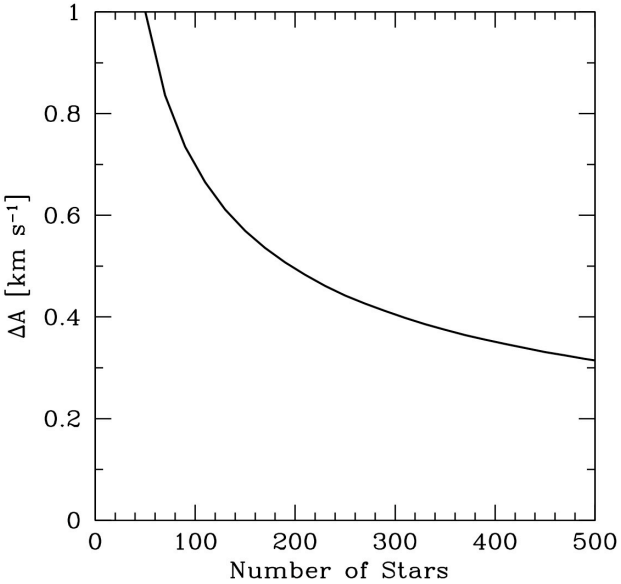


- Derived from spherical-symmetric analysis with variable velocity anisotropy
- Up to 8 parameters are free, though all not necessary for the faintest systems



- Estimated total mass-to-light ratios: 10-1000+
- Segue 1: Least luminous known galaxy (Geha et al. 2009)
- Tidal effects important, but not within stellar radius (Penarrubbia et al. 2008)

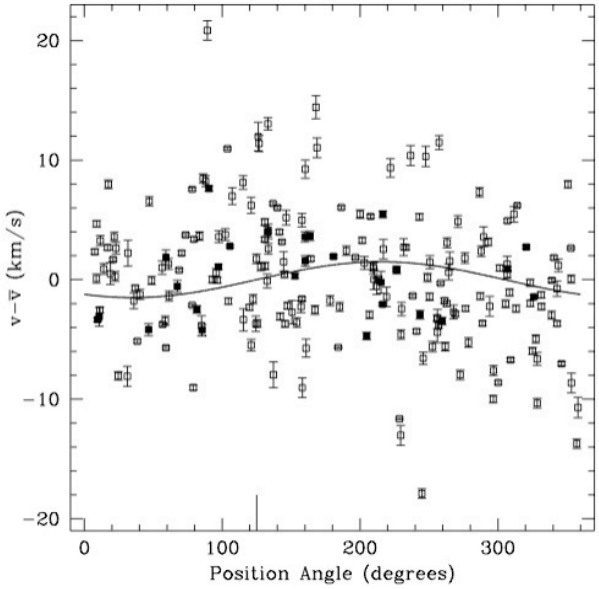
Tidal Disruption and Rotation

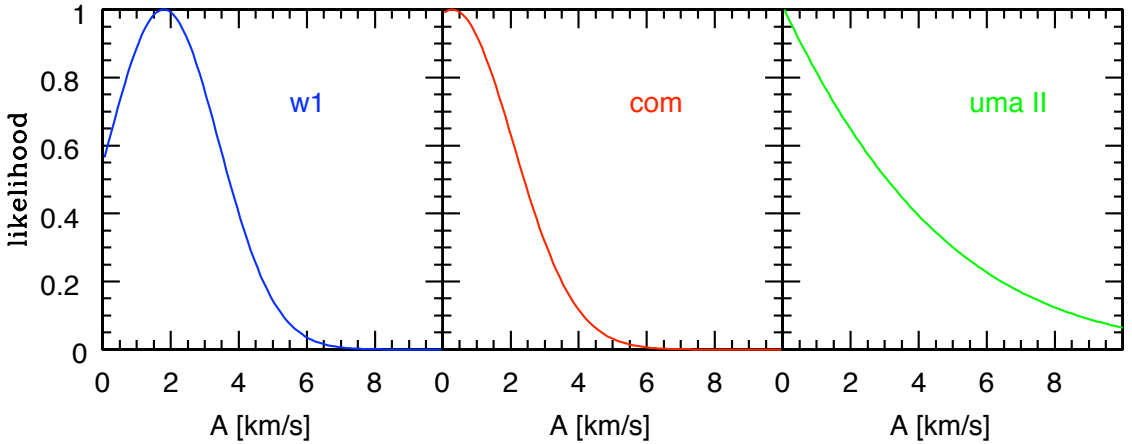


Error projections assuming 1 km/s rotation/gradient

- *Theoretical error modeling indicates that hundreds of stars needed for detection of a gradient*

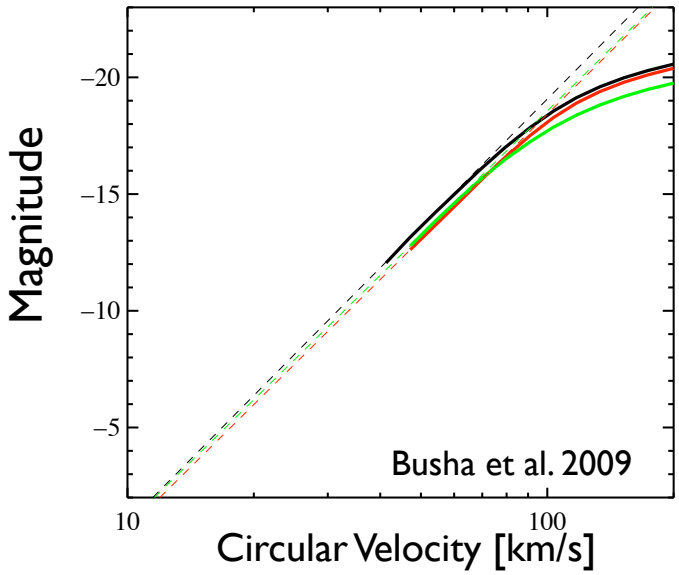
Rotation in this sense detected in M15 GC [Drukier et al. 1998]



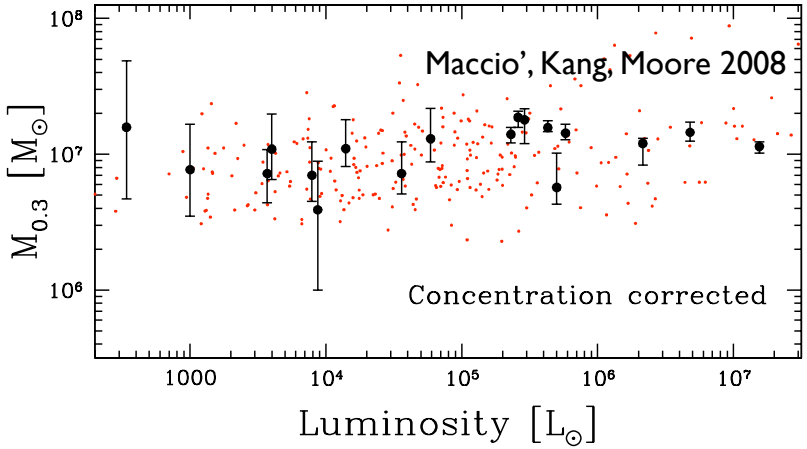


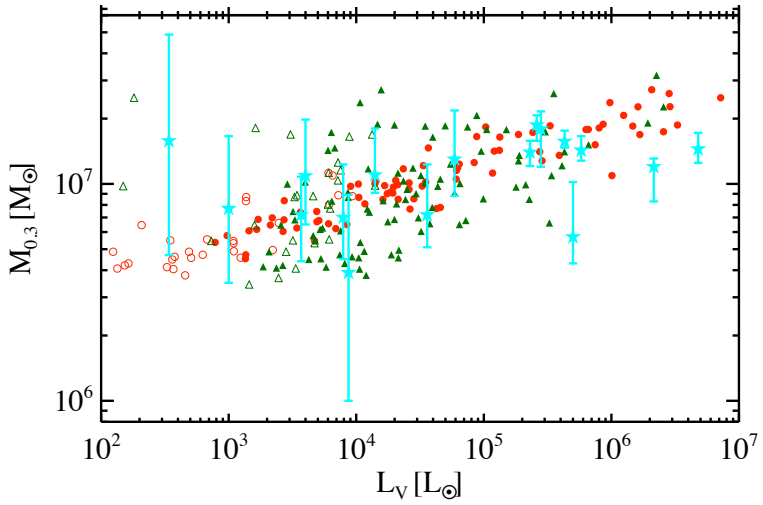
Rotation Amplitude

LCDM and the M_{300}/M_{600} relation



- Extrapolation of abundance matching technique [e.g. Kravtsov et al. 2004] implies the least luminous galaxies live in halos of about 10^8 Msun



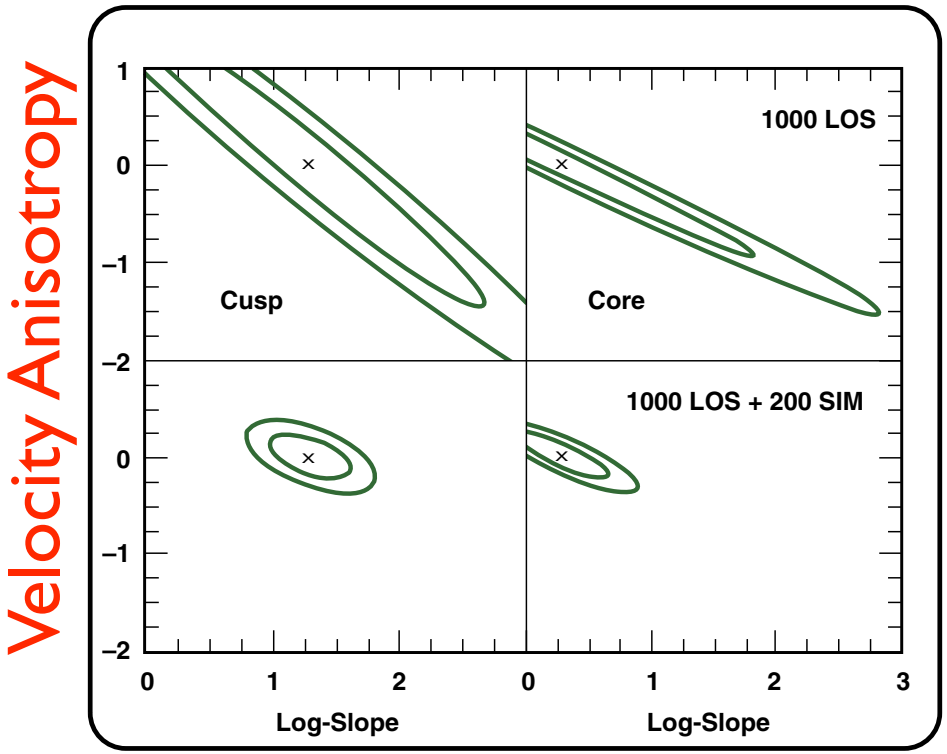


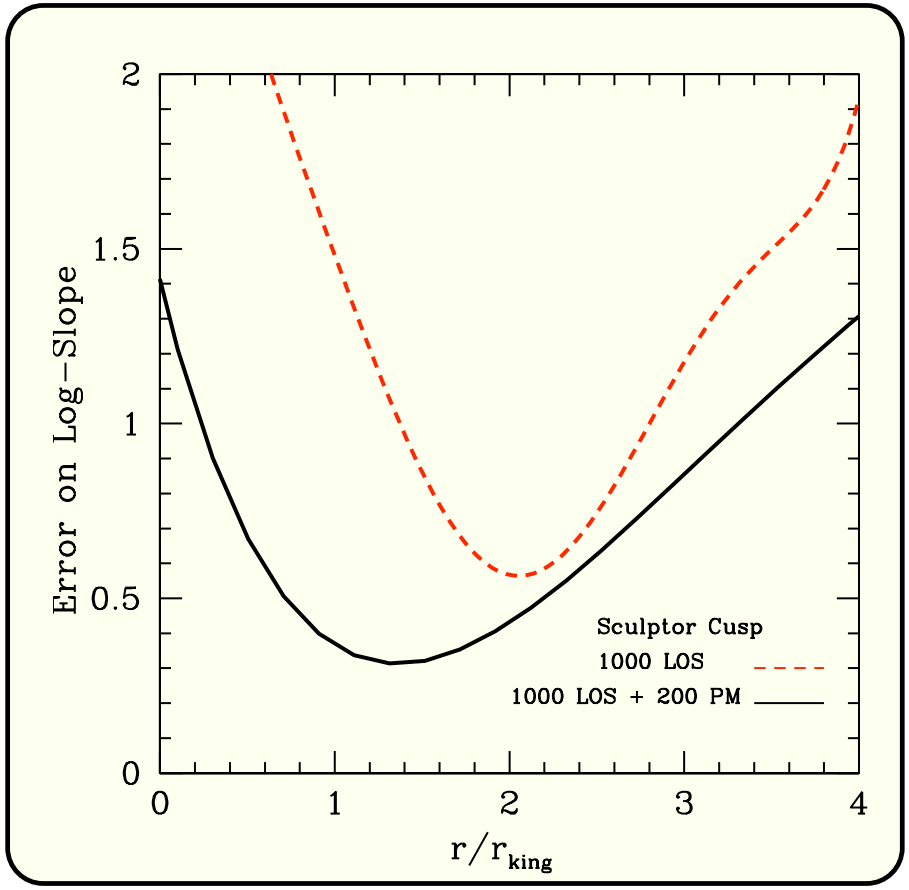
See also Li, Helmi, De Lucia, Stoehr 2008; Koposov et al. 2009

The core/cusp ``problem''

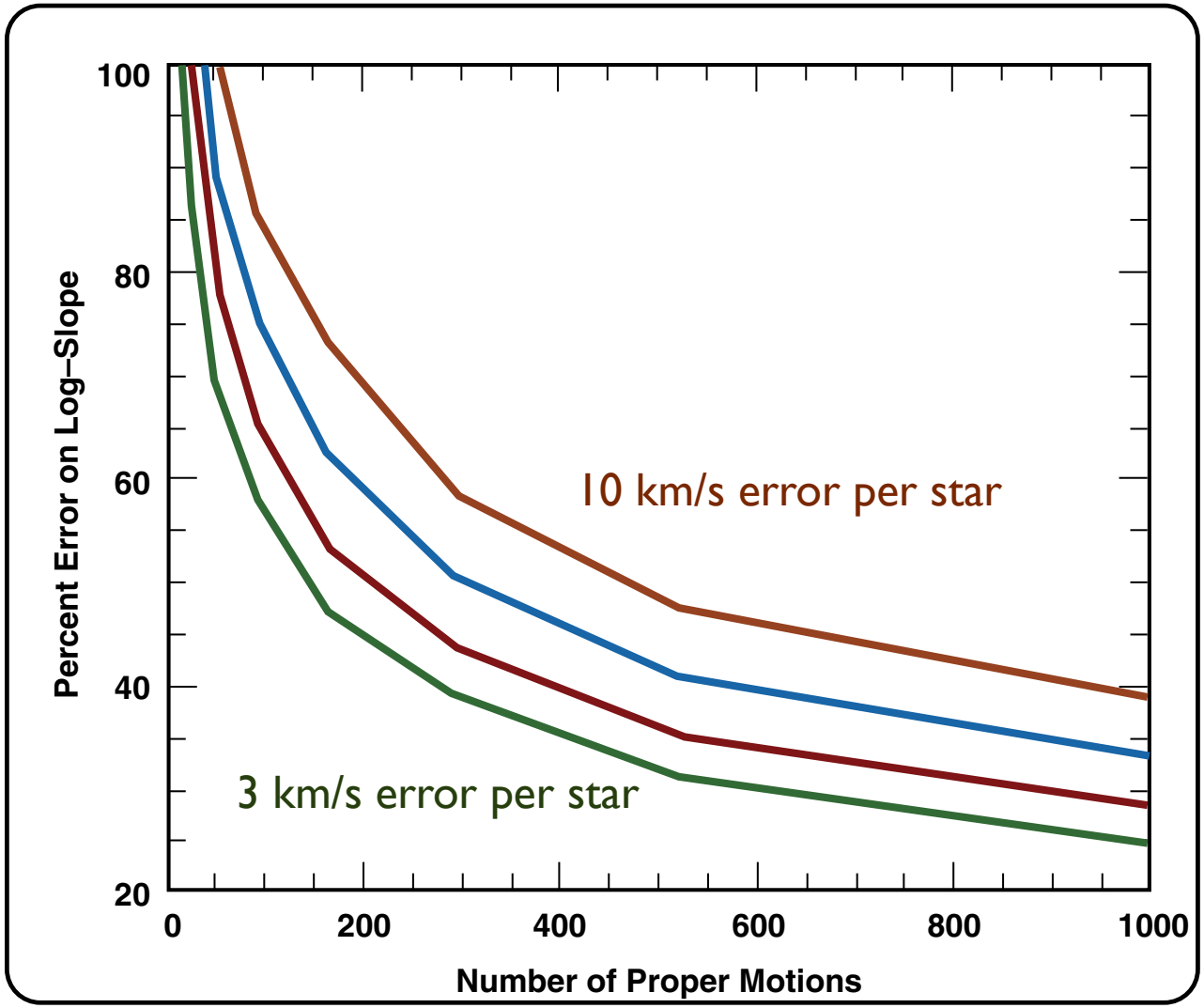
- CDM predicts NFW/Einasto cuspy profiles
- WDM or some alternatives predict shallower central densities
- Current data from MW dwarf spheroidals are unable to conclusively establish whether these galaxies have cores or cusps

Error projections

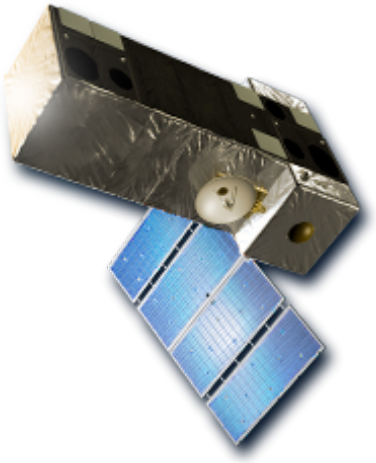


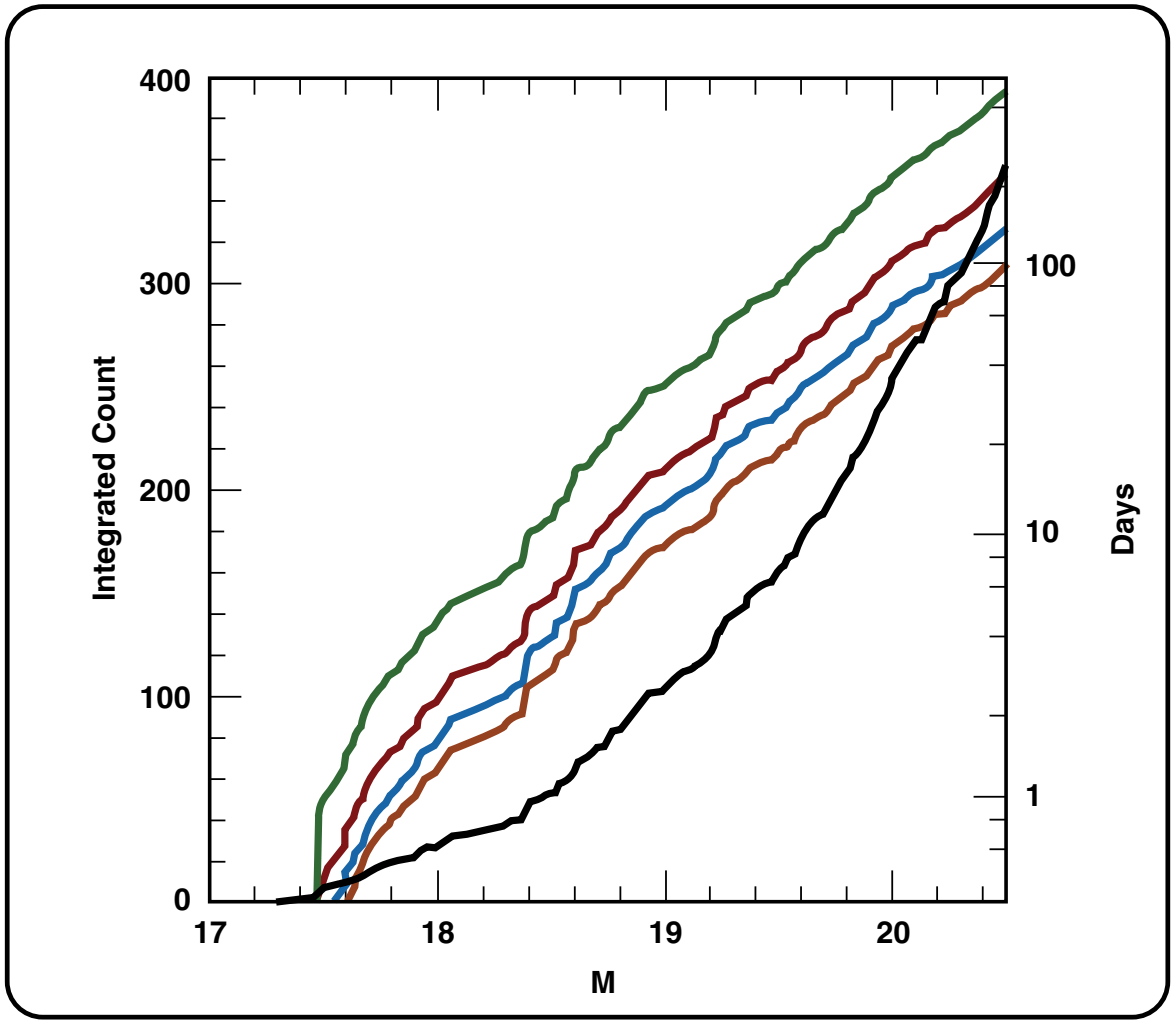


Error projections



Observational Estimates





SIM ASTROMETRIC OBSERVATORY