

# M31 Satellites in the SPLASH Survey: Local Group dSph Scalings

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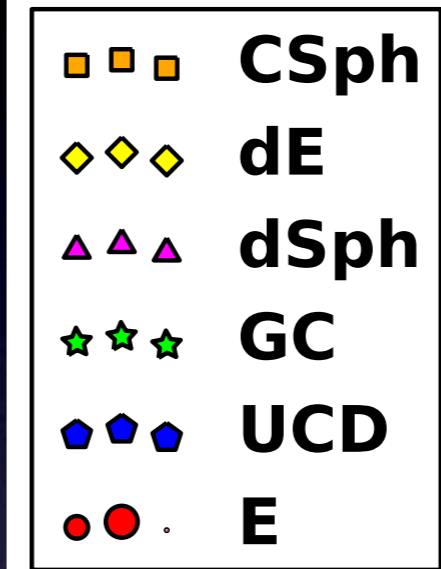
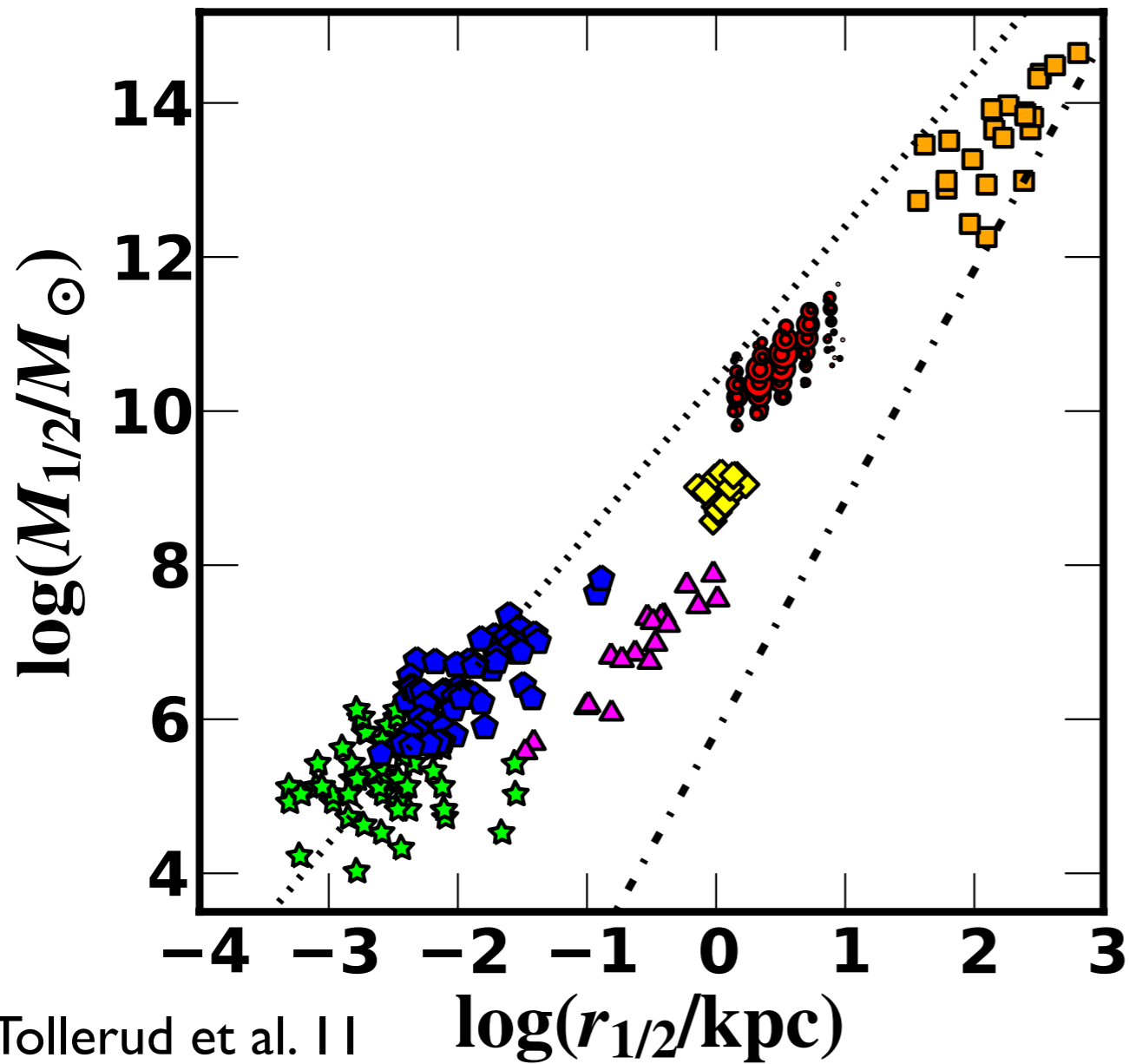
James Bullock<sup>1</sup>, Raja Guhathakurta<sup>2</sup>, Rachael Beaton<sup>3</sup>, Genevieve Graves<sup>4</sup>, Joe Wolf<sup>1</sup>,  
Steve Majewski<sup>3</sup>

<sup>1</sup>University of California Irvine, <sup>2</sup>University of California Santa Cruz <sup>3</sup>University of  
Virginia, <sup>4</sup>University of California Berkeley

# Why M3 I?/Outline

- MW may not be typical
- M3 I dSphs may be different from MW (e.g. McConnachie+ 05)
- MRL Space Scaling Relations (Tollerud et al. 2011)
- SPLASH Survey: Kinematics of M3 I dSphs

# MRL Space

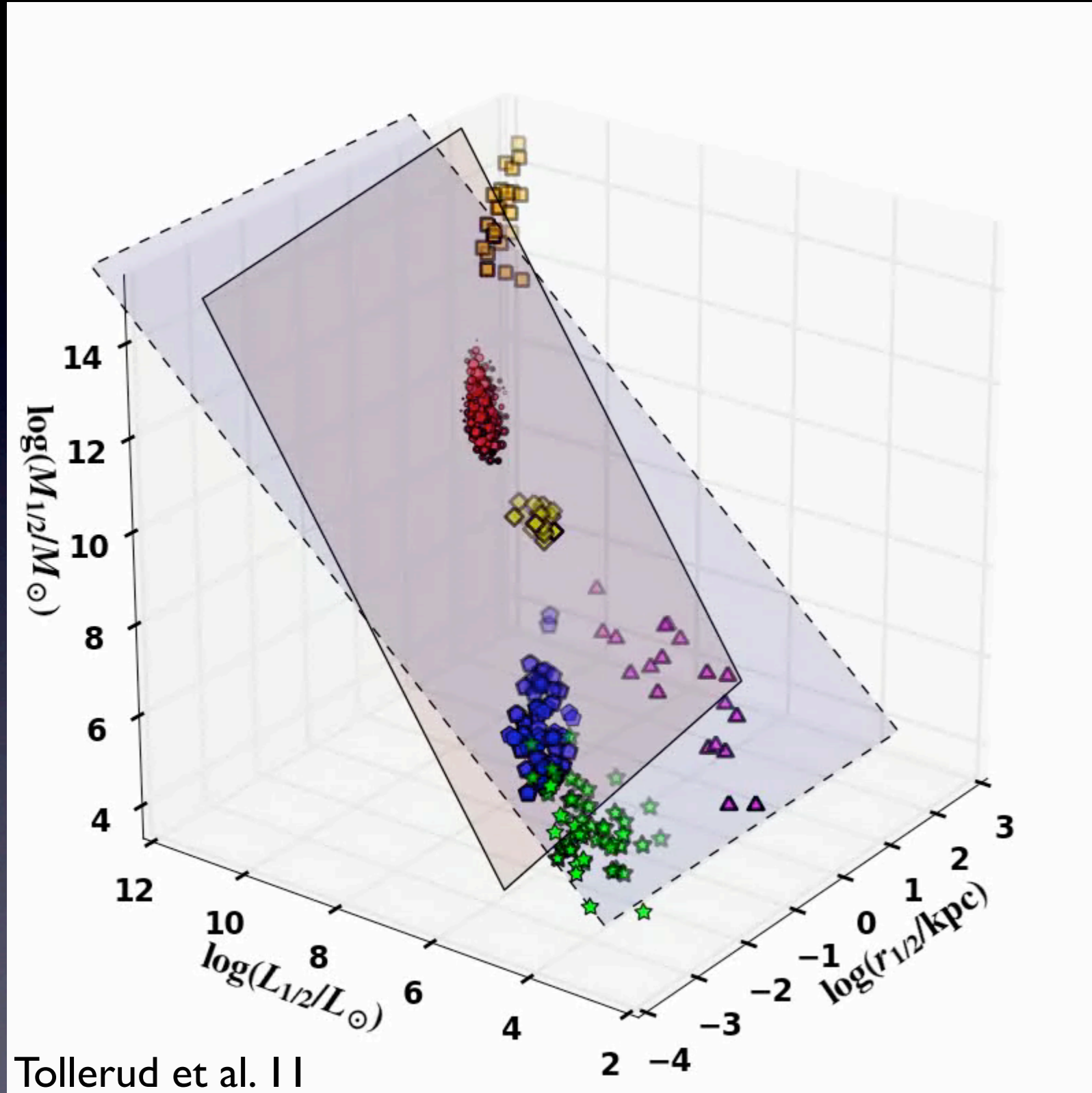


Zaritsky+ 06  
Geha+ 03  
Various, Wolf+ 10  
Harris 03  
Mieske+ 08  
Graves+ 09

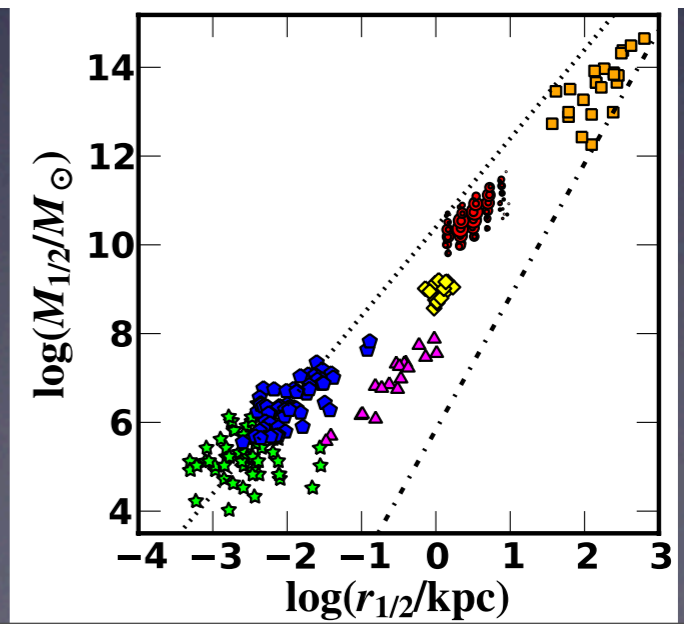
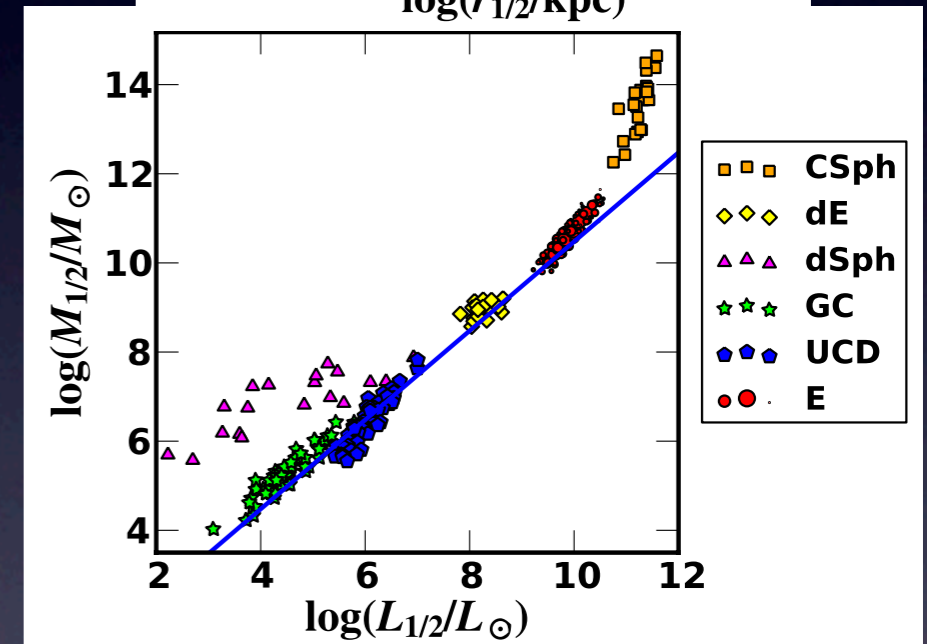
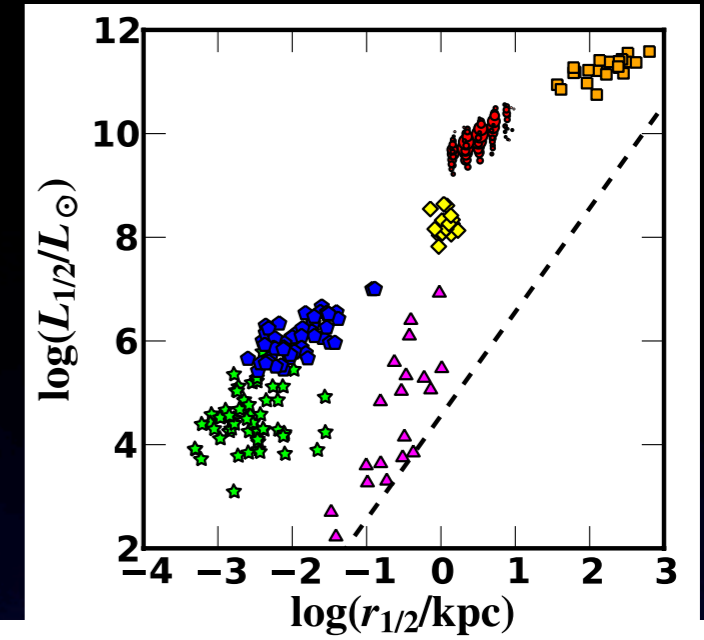
Tollerud et al. 11

$$M_{1/2} = 3G^{-1}\sigma^2 r_{1/2} \quad \text{Wolf+ 10}$$

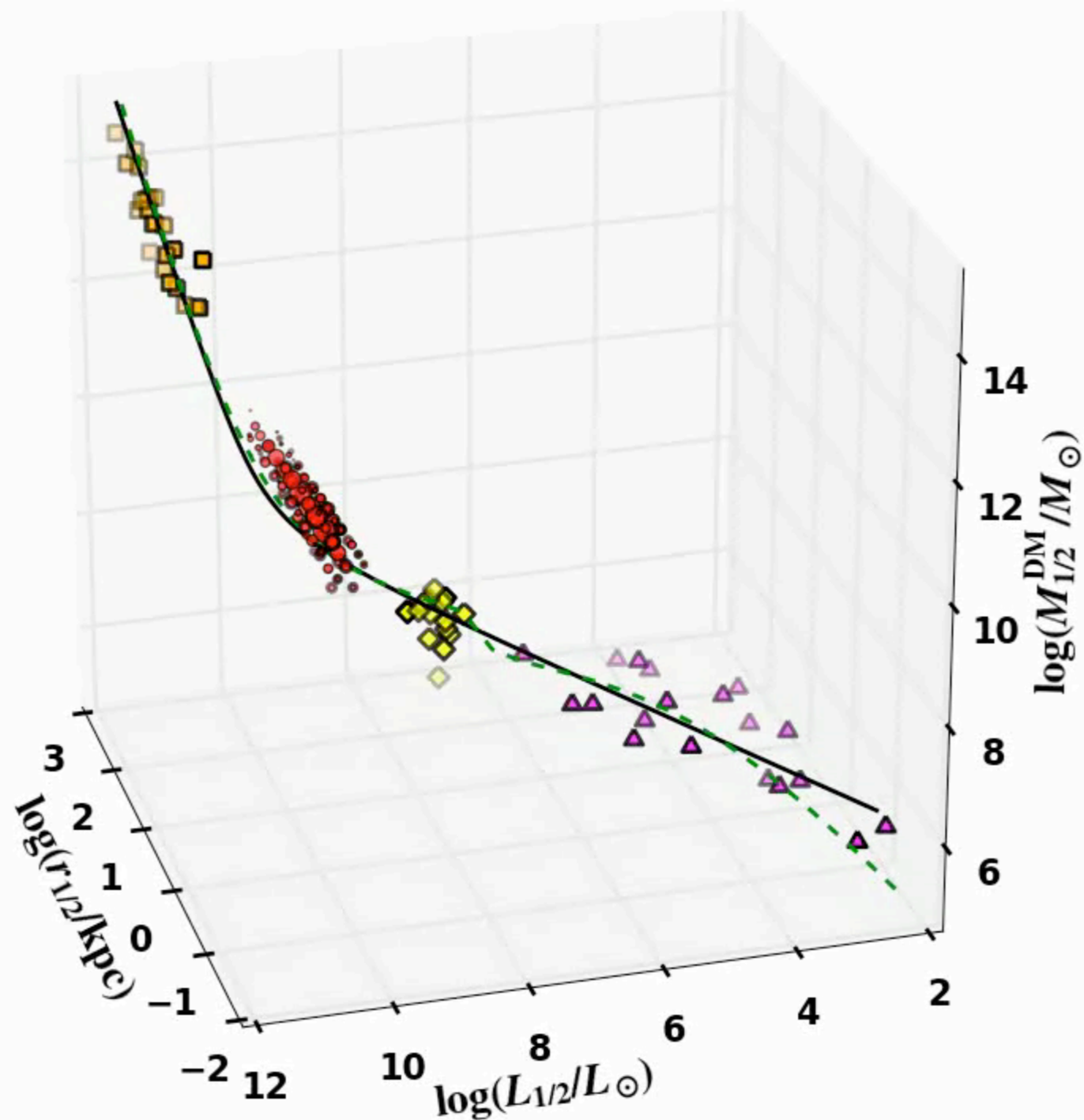
# MRL Space



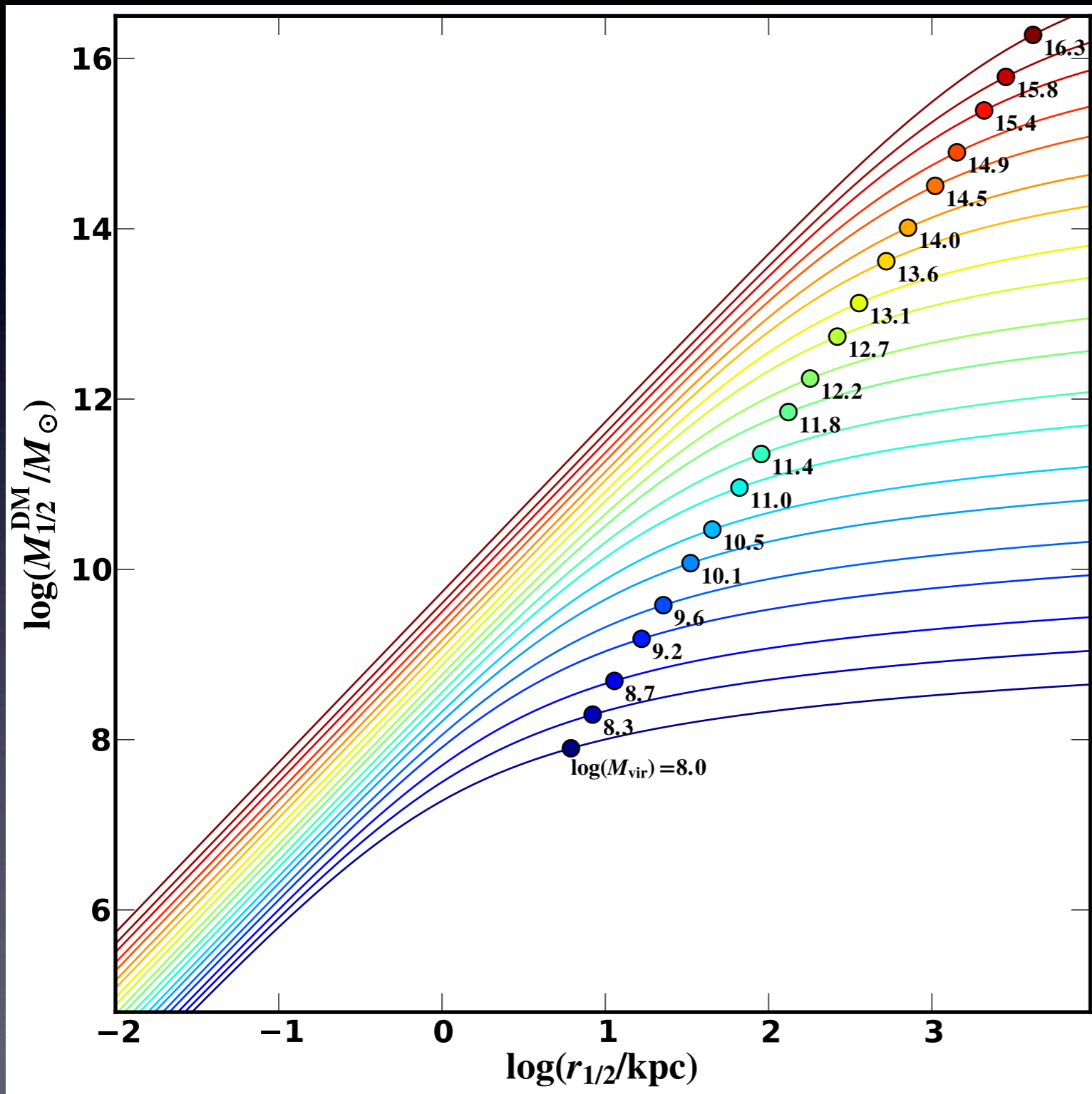
Tollerud et al. II



# Fundamental Curve

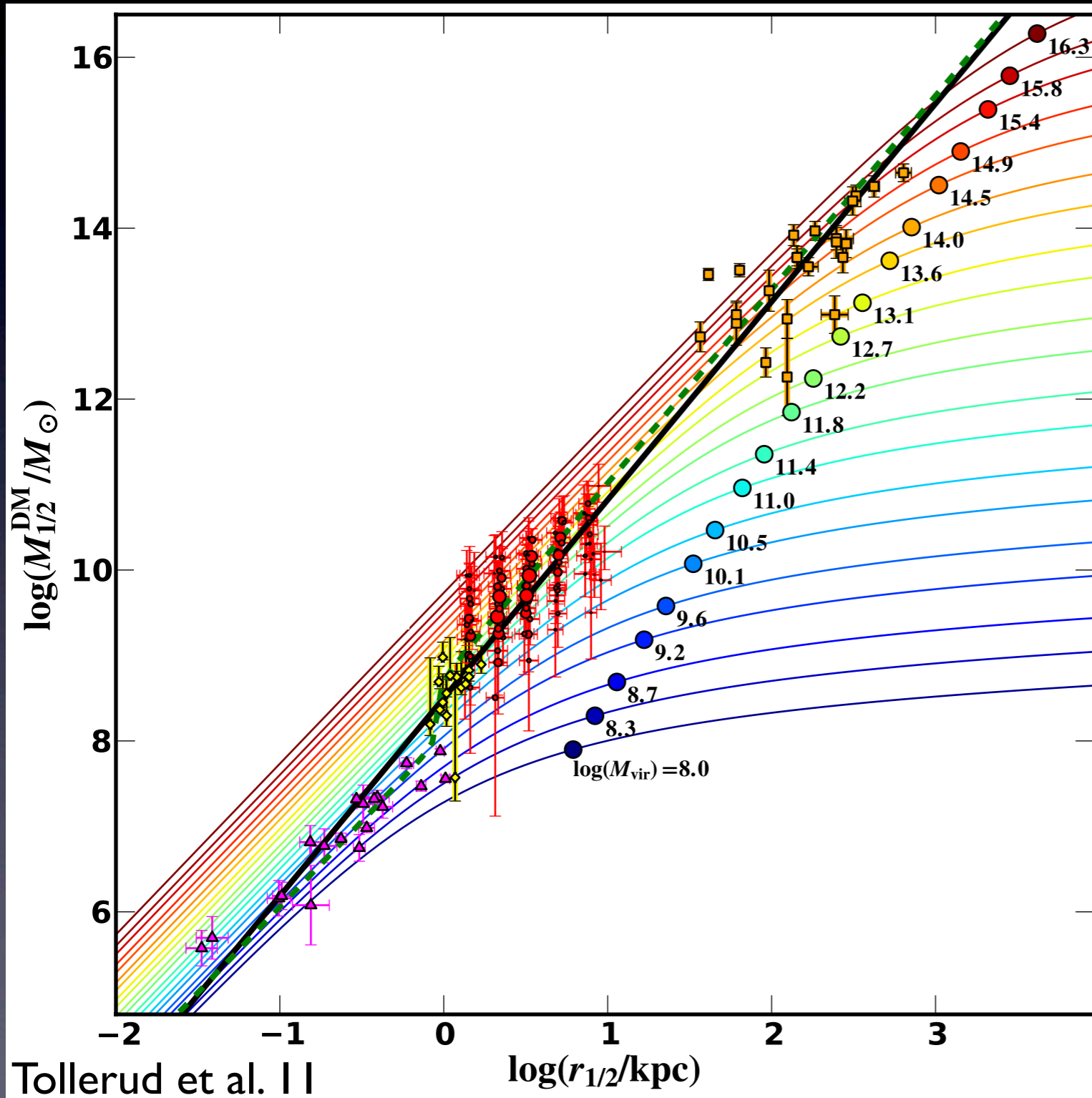


# DM Halo Scalings



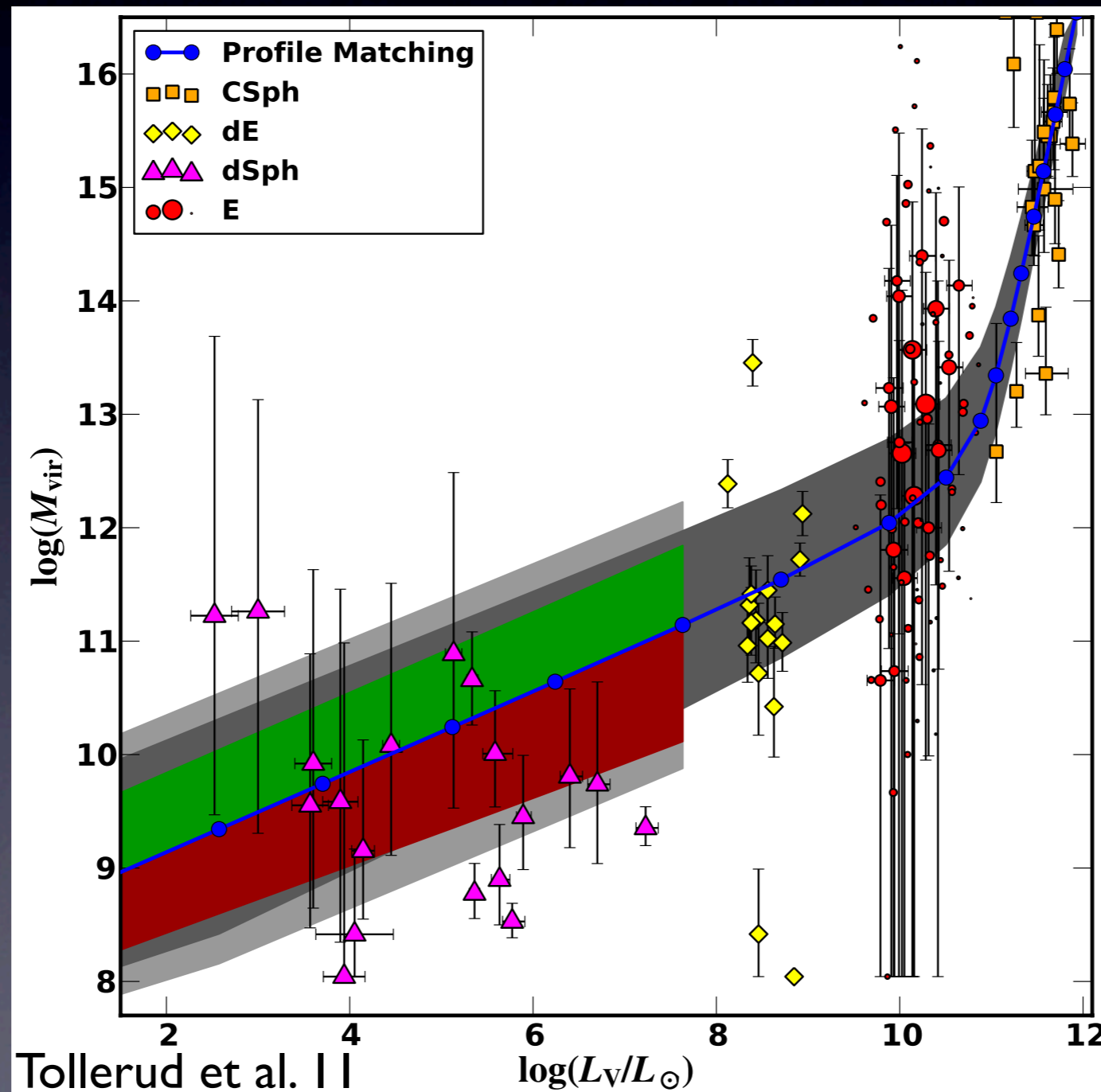
- For NFW Halos, there is a unique halo mass for any point in  $r_{1/2}$ - $M_{1/2}$  plane

# Profile Matching



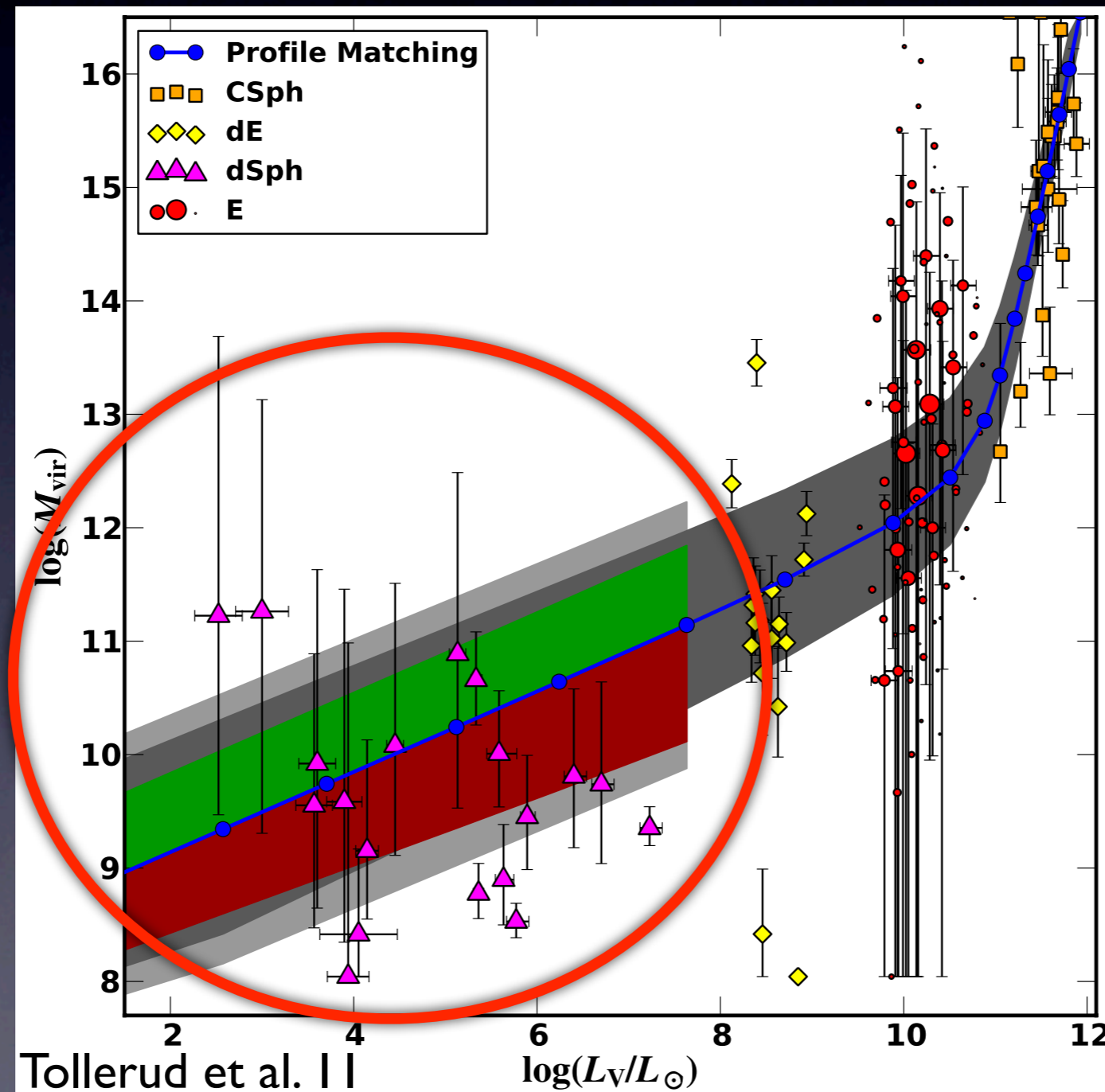
- Fundamental Curve Provides a 1-to-1 mapping from  $r_{1/2}$  to  $M_{1/2}$  or  $L_{1/2}$
- M-r space then maps these galaxy scaling relations onto Halo scaling relations
- Abundance matching without abundances

# Connecting Galaxies to Their Halos





# Connecting Galaxies to Their Halos



Mass Scale?  
(Strigari+ 08)

Spectroscopic and Photometric Landscape  
of Andromeda's Stellar Halo

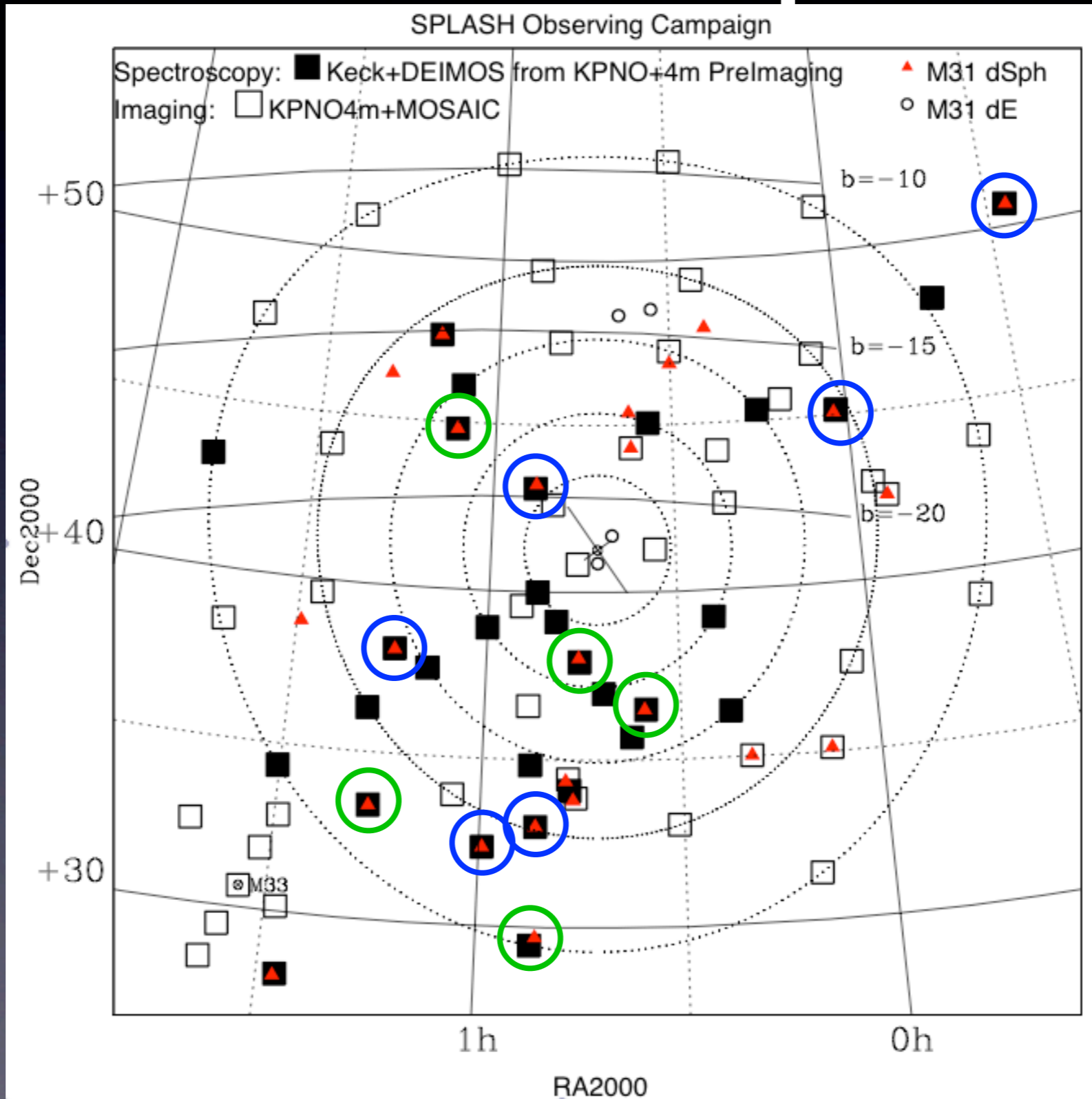


- PI: **Raja Guhathakurta** (UCSC)
- Kirsten Howley, Claire Dorman (UCSC), Evan Kirby (Caltech), Karrie Gilbert (UWash)
- **James Bullock**, Joe Wolf, **Erik Tollerud**, Basilio Yniguez (UC Irvine)
- Roeland van der Marel, **Jason Kalirai**, Tom Brown (STScI), Chris Sneden (UT Austin)
- Steve Majewski, **Rachael Beaton**, Ricky Patterson (U Virginia)
- Marla Geha (Yale), Phil Choi (Pomona), David Reitzel (Griffith Obs)
- Jennifer Consiglio (UCSC)
- Mikito Tanaka (U Tokyo), Masashi Chiba (Tohoku U), Jean-Charles Cuillandre (CFHT)
- Stephane Courteau, Larry Widrow (Queens U), Anahí Caldu Primo (UNAM/UCSC)
- Andreea Font (Durham), Kathryn Johnston (Columbia U), Mark Fardal (U Mass)
- Arif Babul (U Victoria), Alyson Brooks (Caltech), Adi Zolotov (NYU)
- Piero Madau, Juerg Diemand, Val Rashkov (UCSC)

# SPLASH dSphs

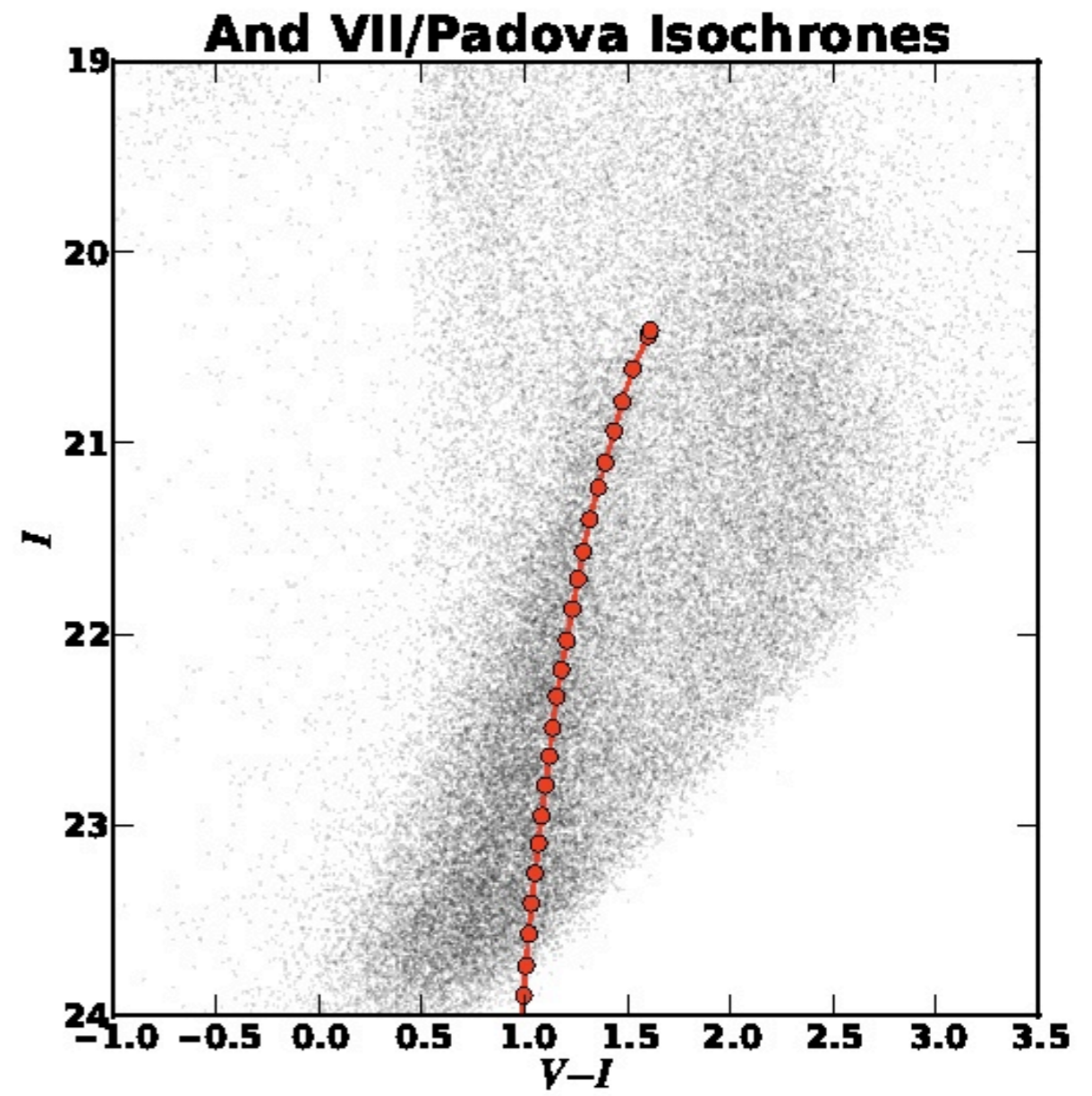
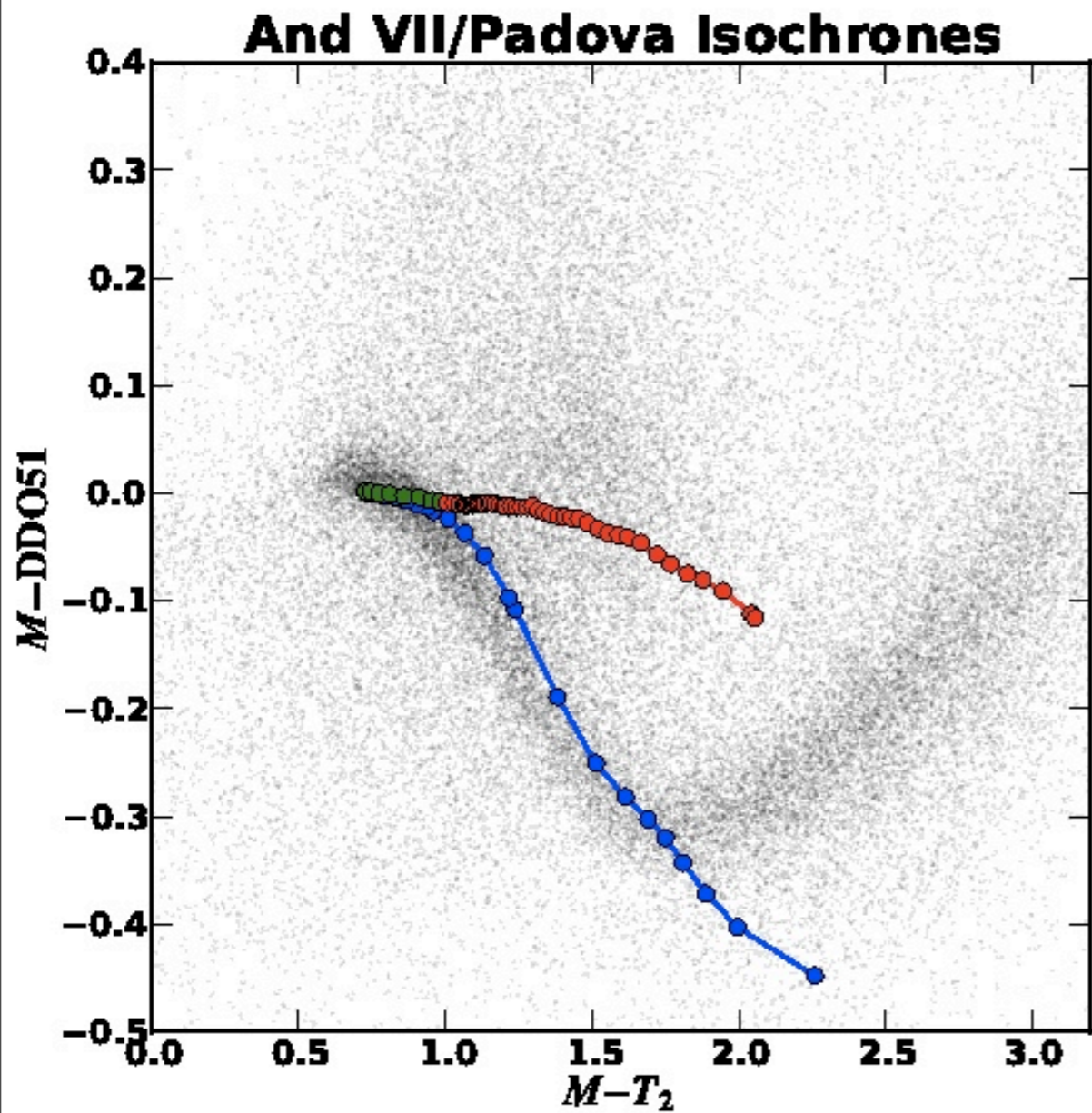
Kalirai+ 2010

- And I
- And II
- And III
- And X
- And XIV

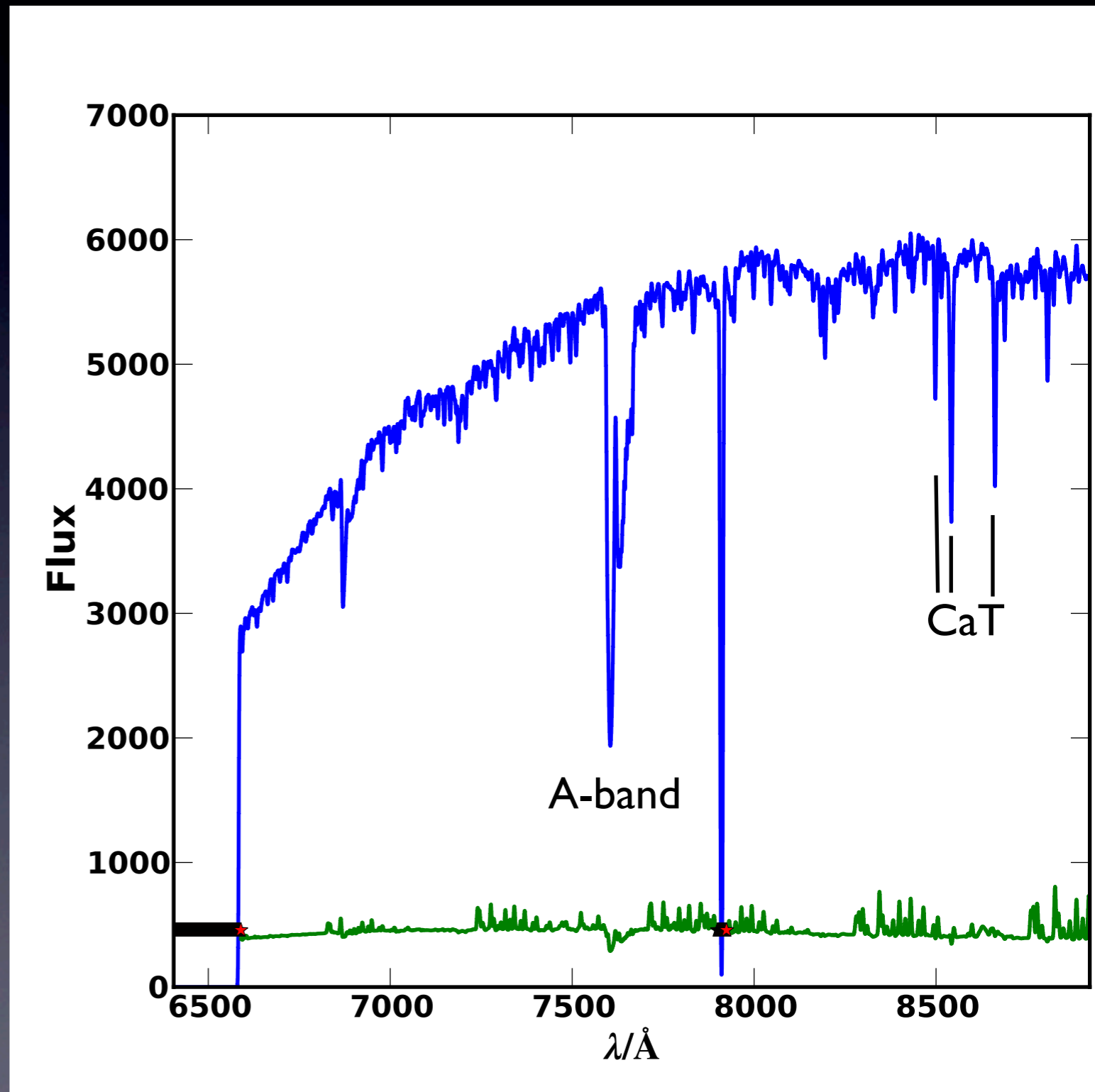
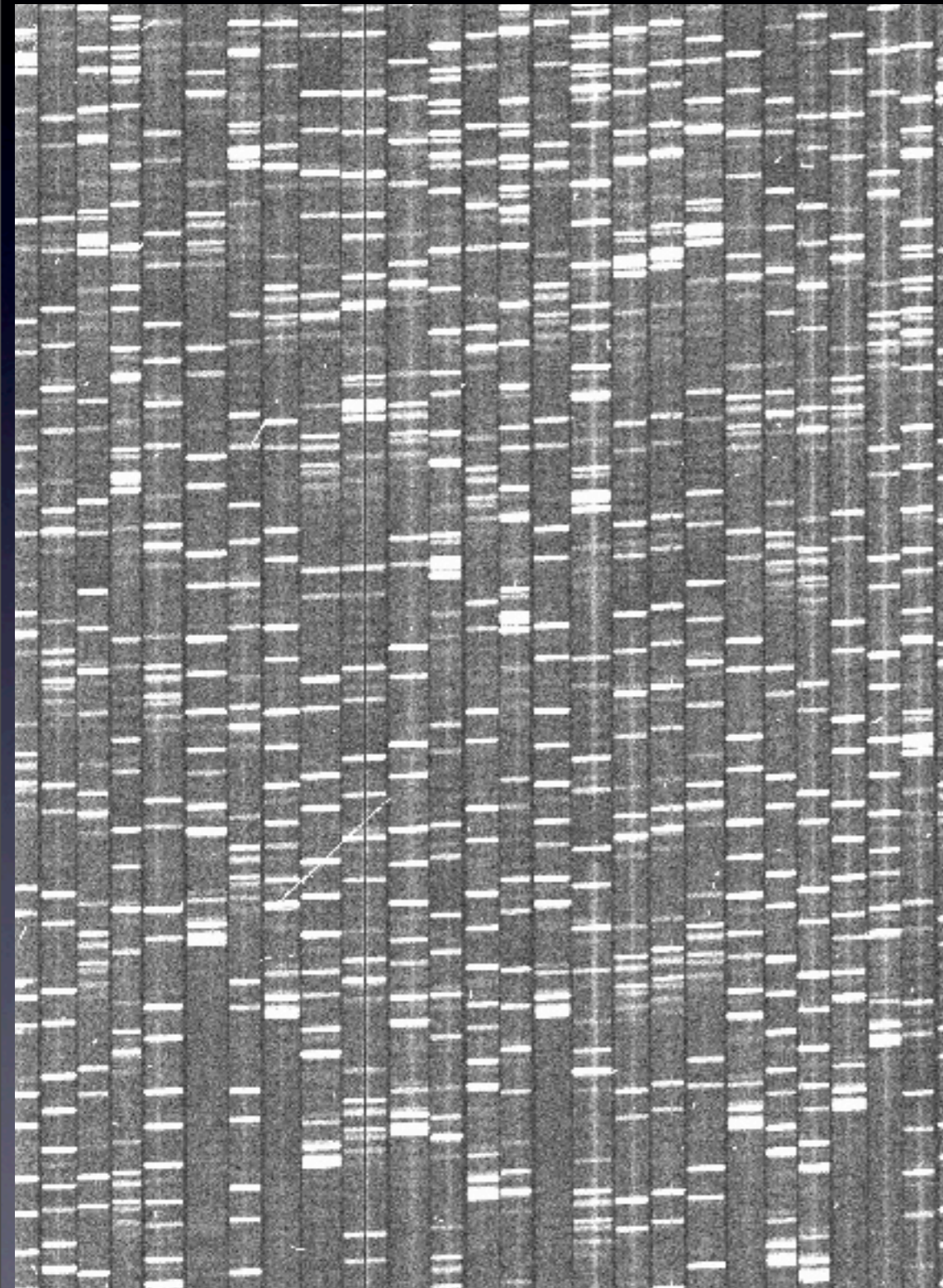


- And VII
- And IX
- And XIII
- And XV
- And XVI
- And XVIII

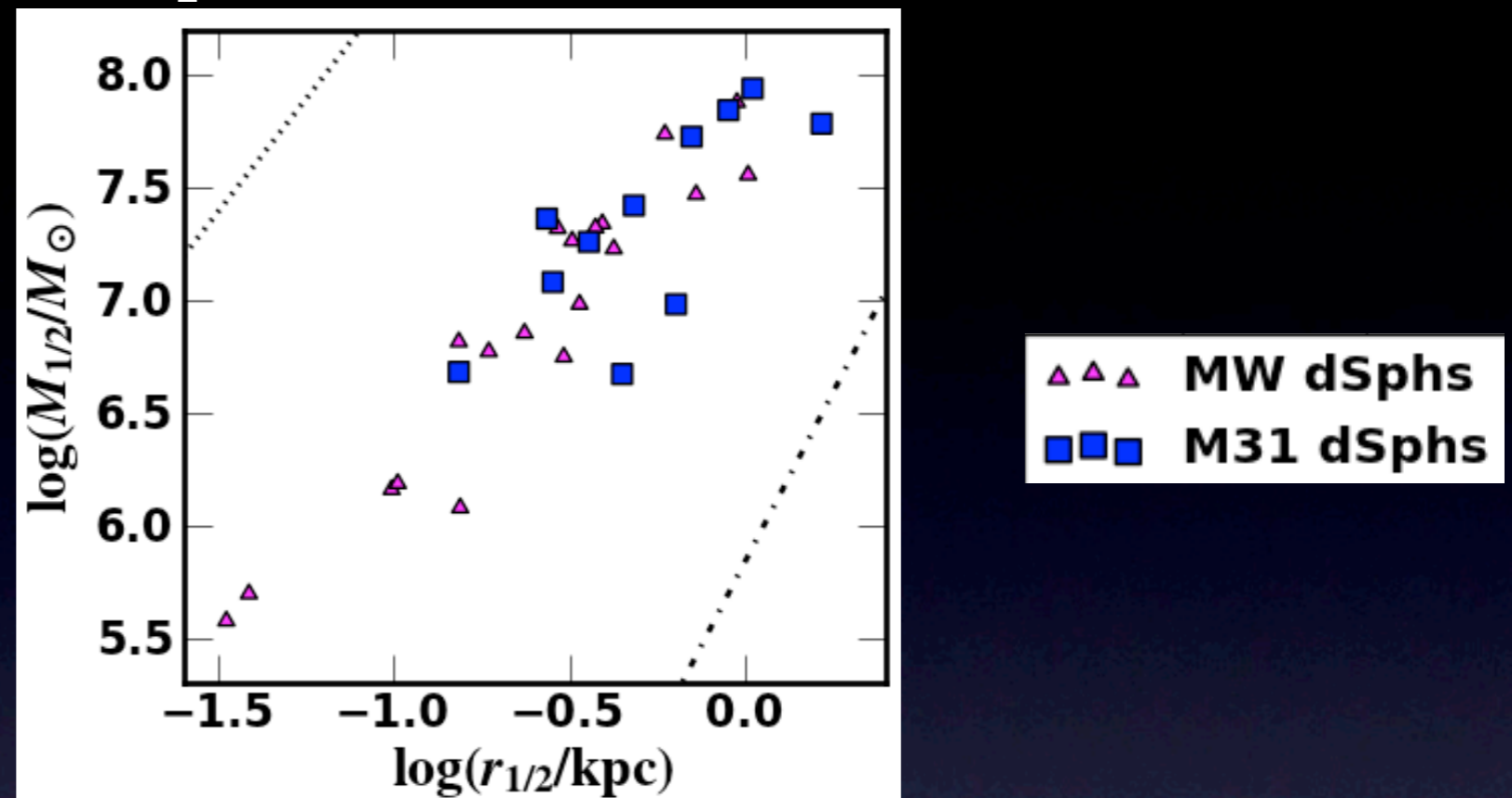
# DDO51 Pre-Selection



# Keck/DEIMOS Spectroscopy

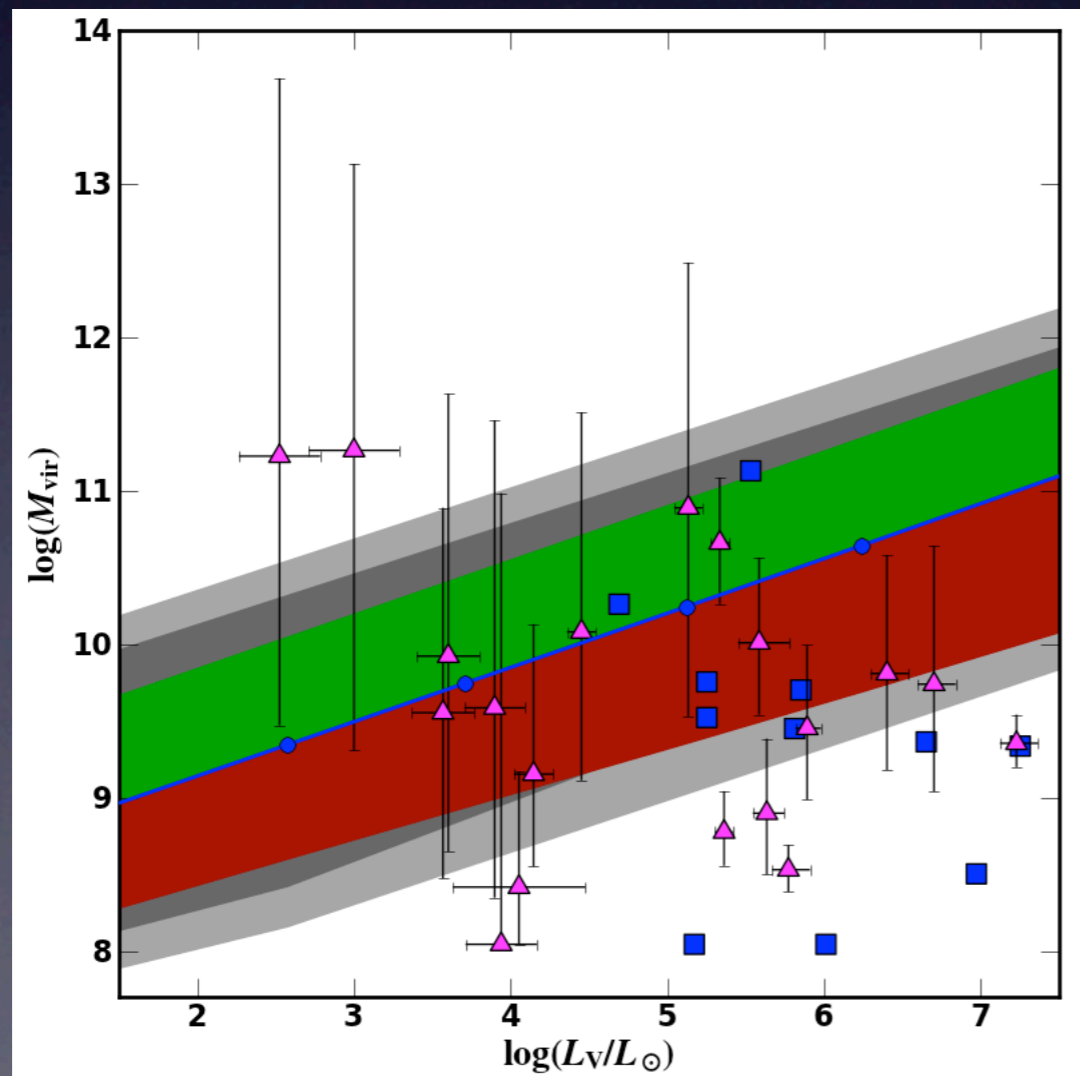
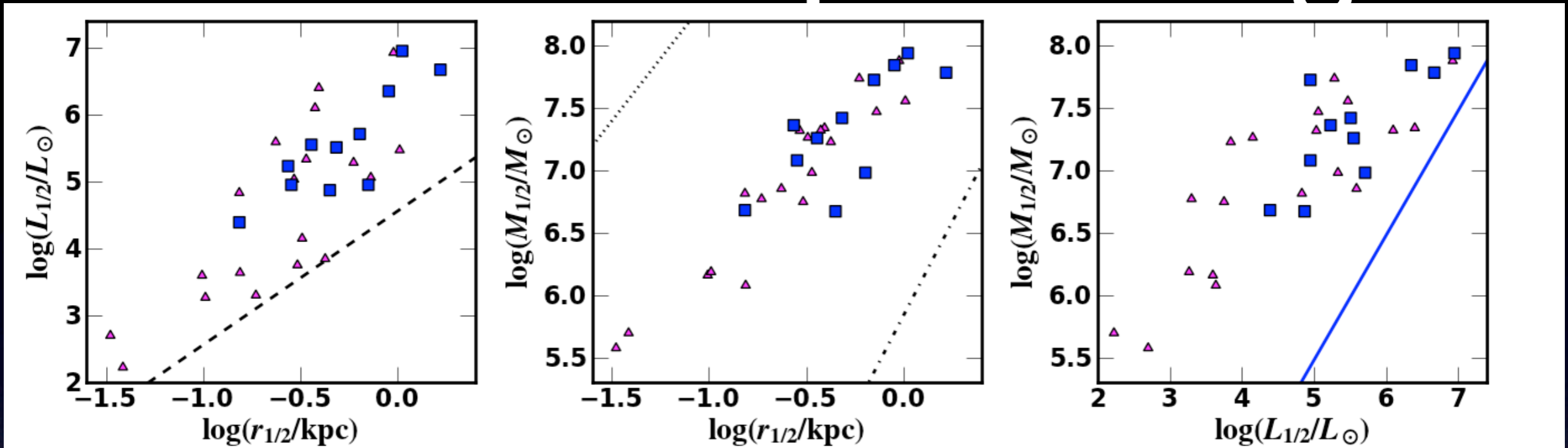


# SPLASH dSph Kinematics



- And VII ( $M_V = -13.3$ )  $\sigma = 10.9$  km/s,  $v_{\text{sys}} = -313$  km/s
- And IX ( $M_V = -8.3$ )  $\sigma = 10.4$  km/s,  $v_{\text{sys}} = -212$  km/s
- And XIII ( $M_V = -6.9$ )  $\sigma = 6.7$  km/s,  $v_{\text{sys}} = -189$  km/s
- And XV ( $M_V = -9.8$ )  $\sigma = 8.5$  km/s,  $v_{\text{sys}} = -328$  km/s
- And XVI ( $M_V = -9.0$ )  $\sigma = 11.0$  km/s,  $v_{\text{sys}} = -374$  km/s
- And XVIII ( $M_V = -9.7$ )  $\sigma = 8.8$  km/s,  $v_{\text{sys}} = -336$  km/s

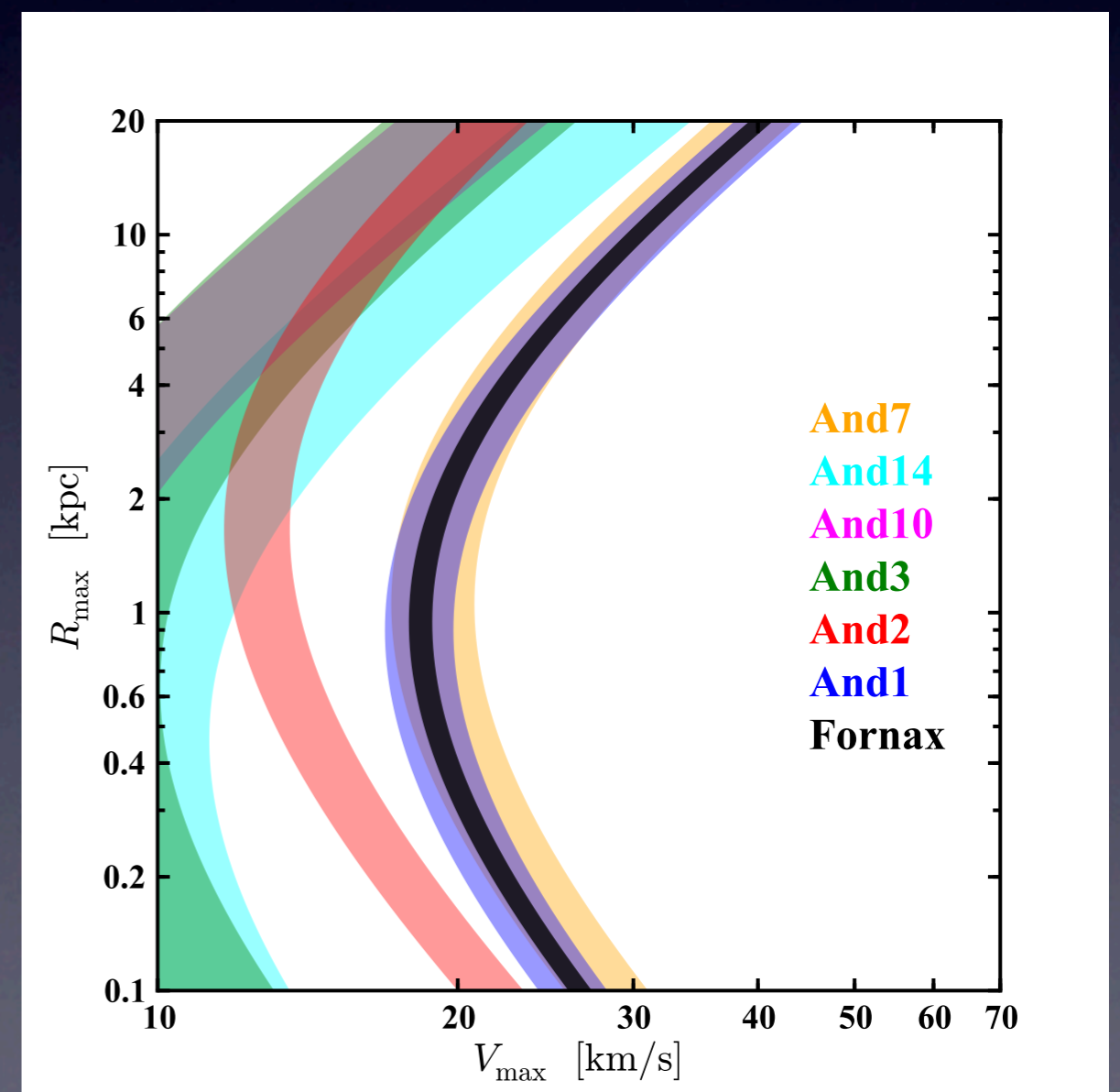
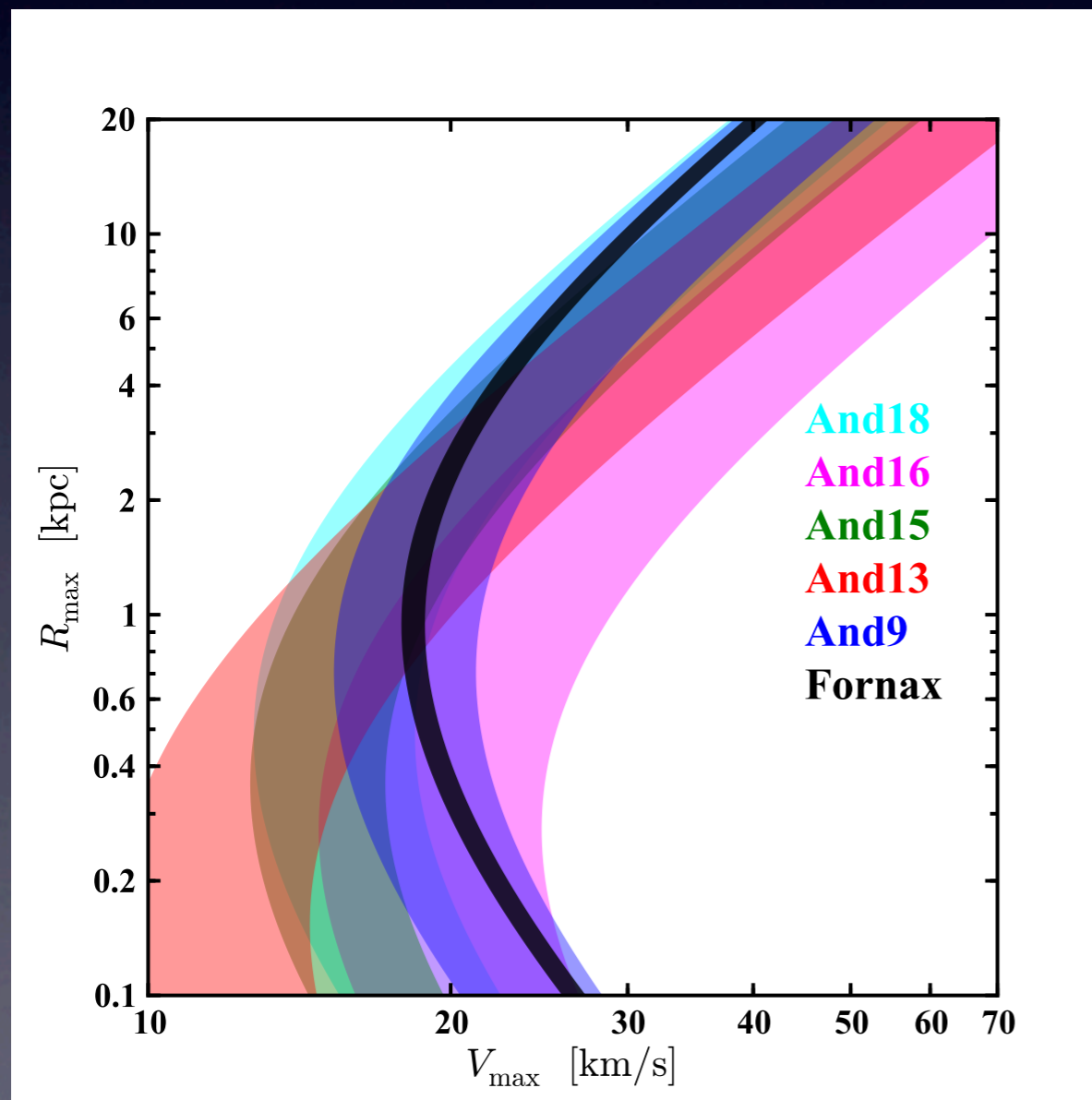
# SPLASH dSph Scalings



▲▲▲ MW dSphs  
■ ■ ■ M31 dSphs

- M31 dSphs have lower  $M_{\text{vir}}$
- M31 dSph scatter similar to MW

# M31 Also Has Too Big To Fail (Outsourcing Won't Help)



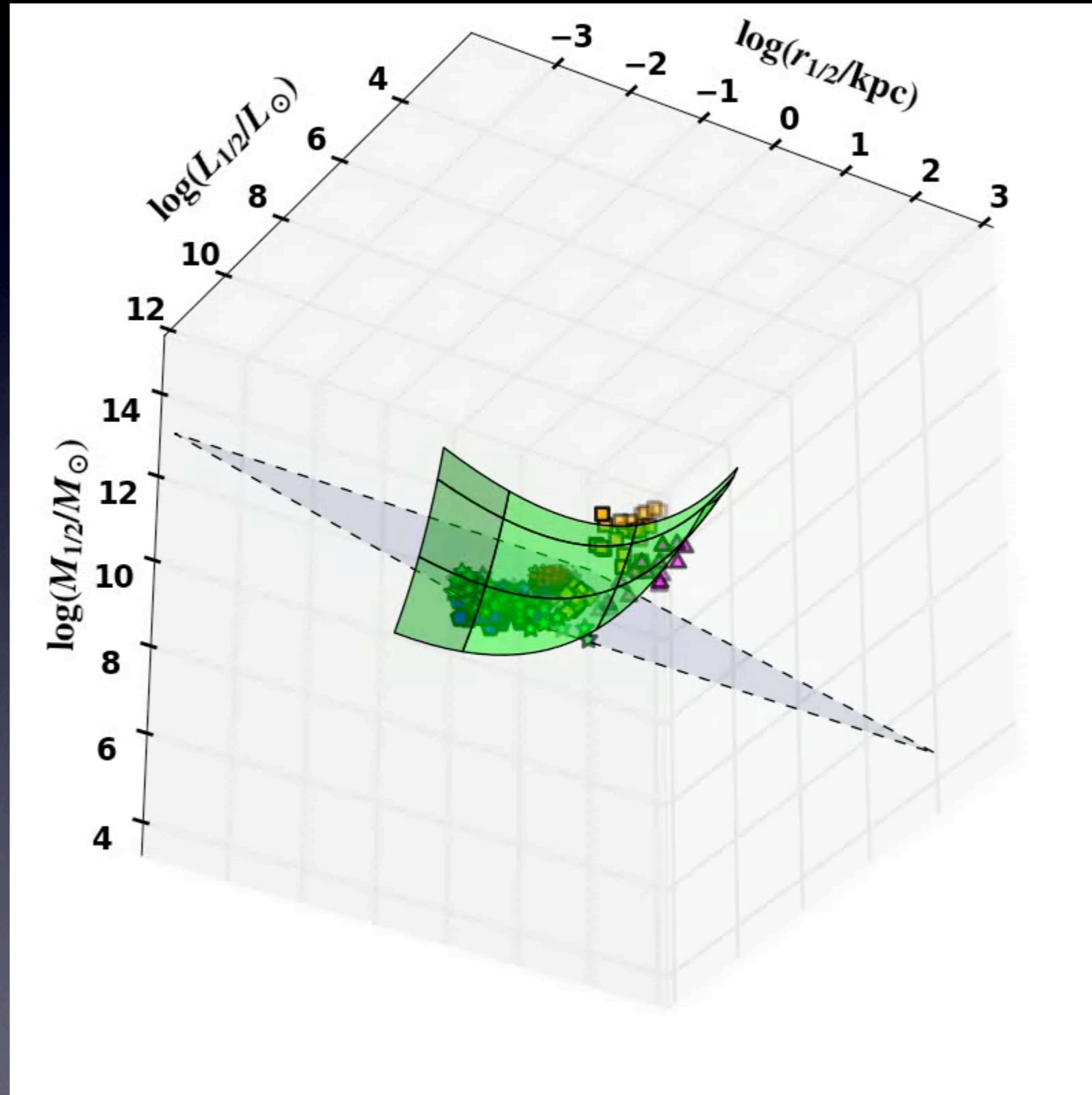


# Conclusions

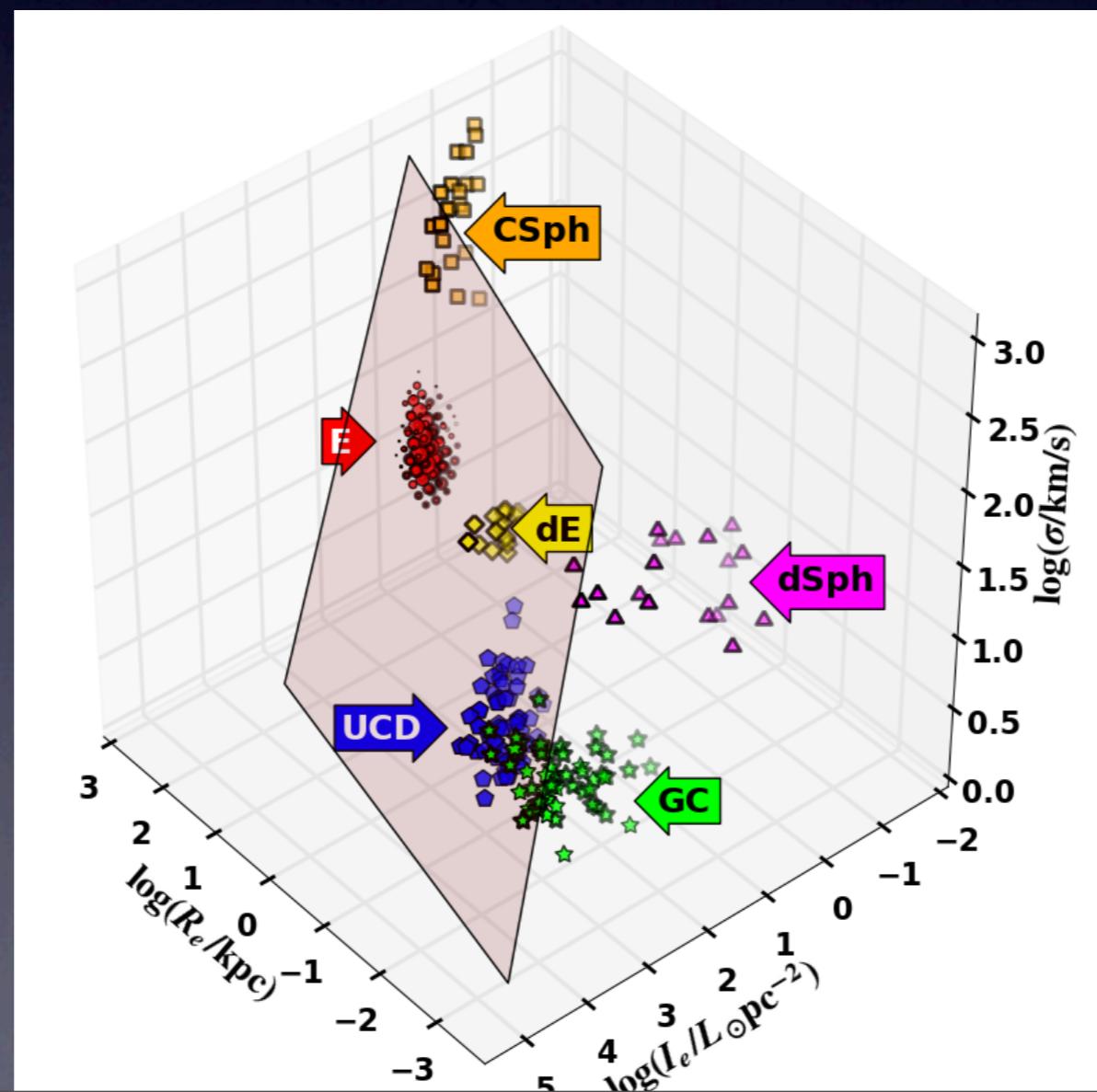
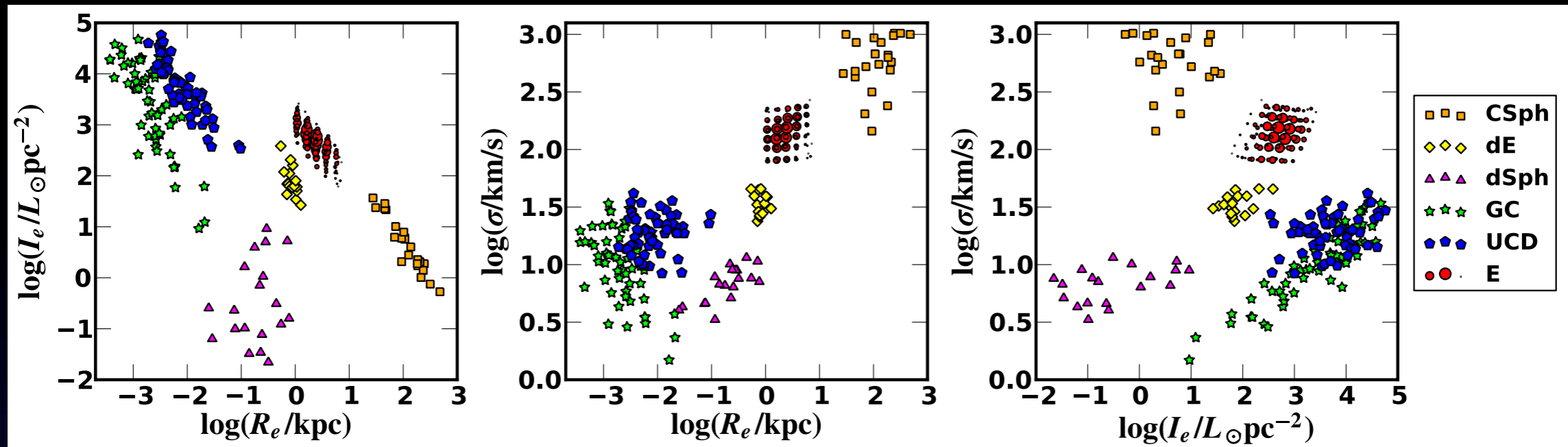
- Fundamental Curve+Profile Matching maps passive galaxy scaling relations to the associated dark halo scaling relations.
- MW dSphs scatter around this scaling and this is a constraint on formation models.
- M31 dSphs have similar scalings and similar scatter (with unusual outliers?).
- M31 also lacks satellites for massive subhalos.

# Backup Slides

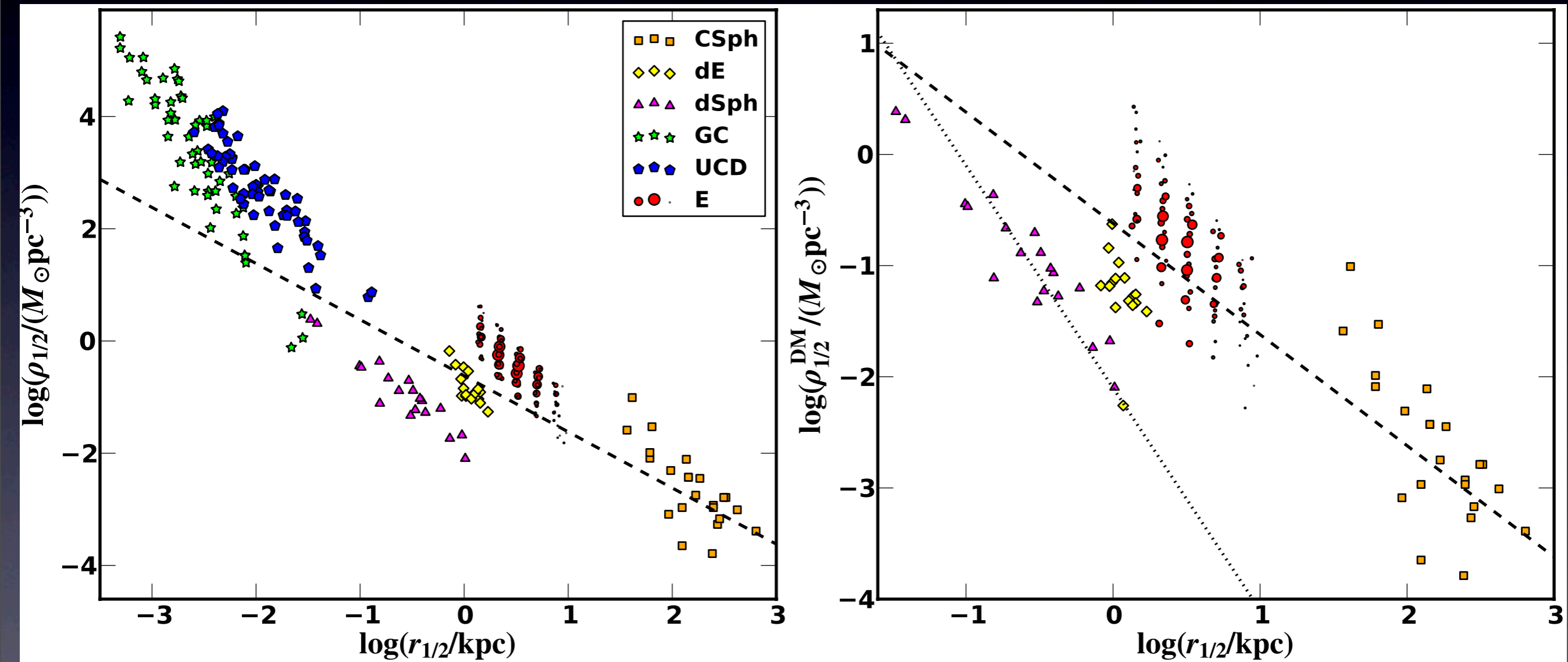
# Fundamental Manifold



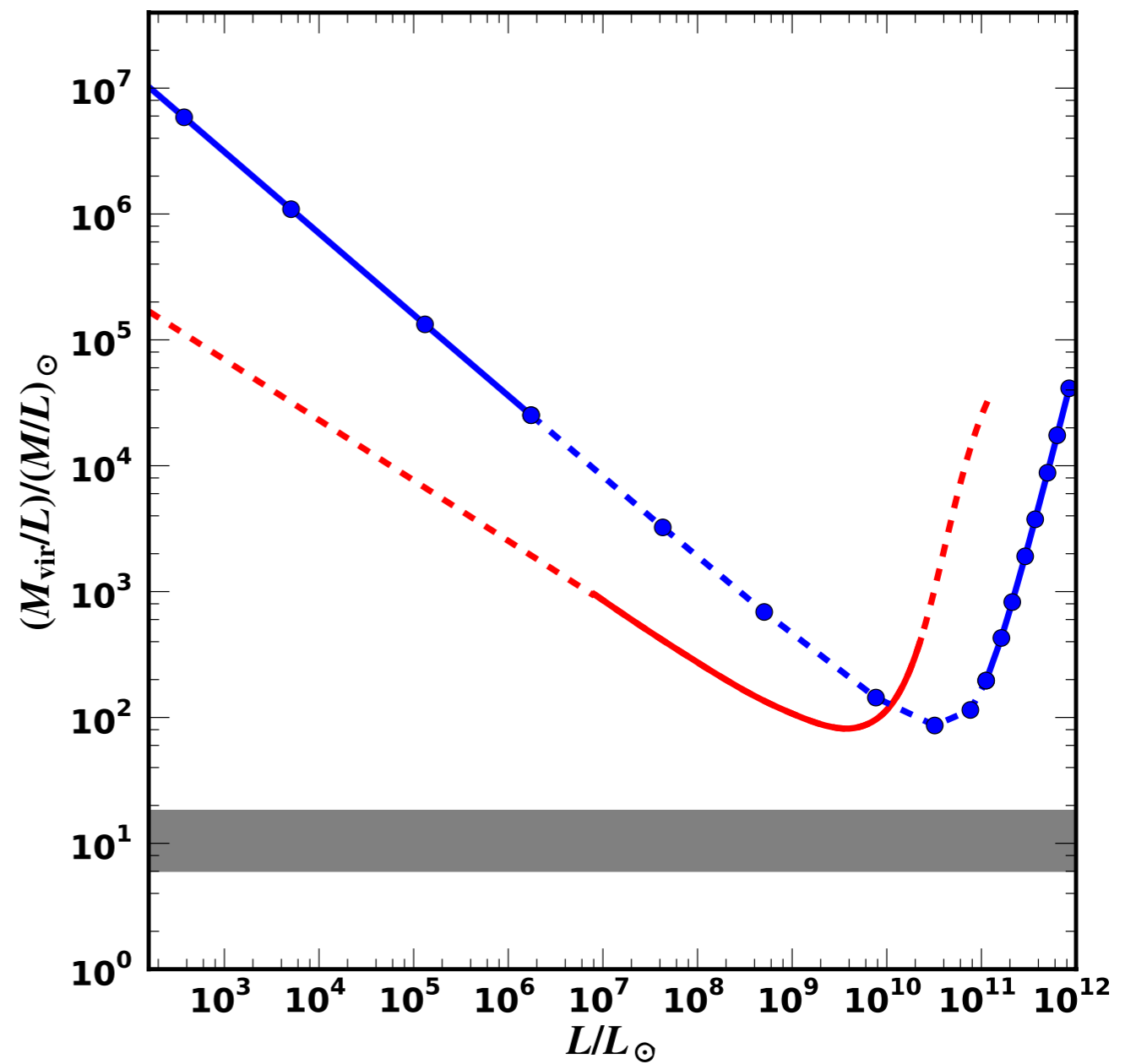
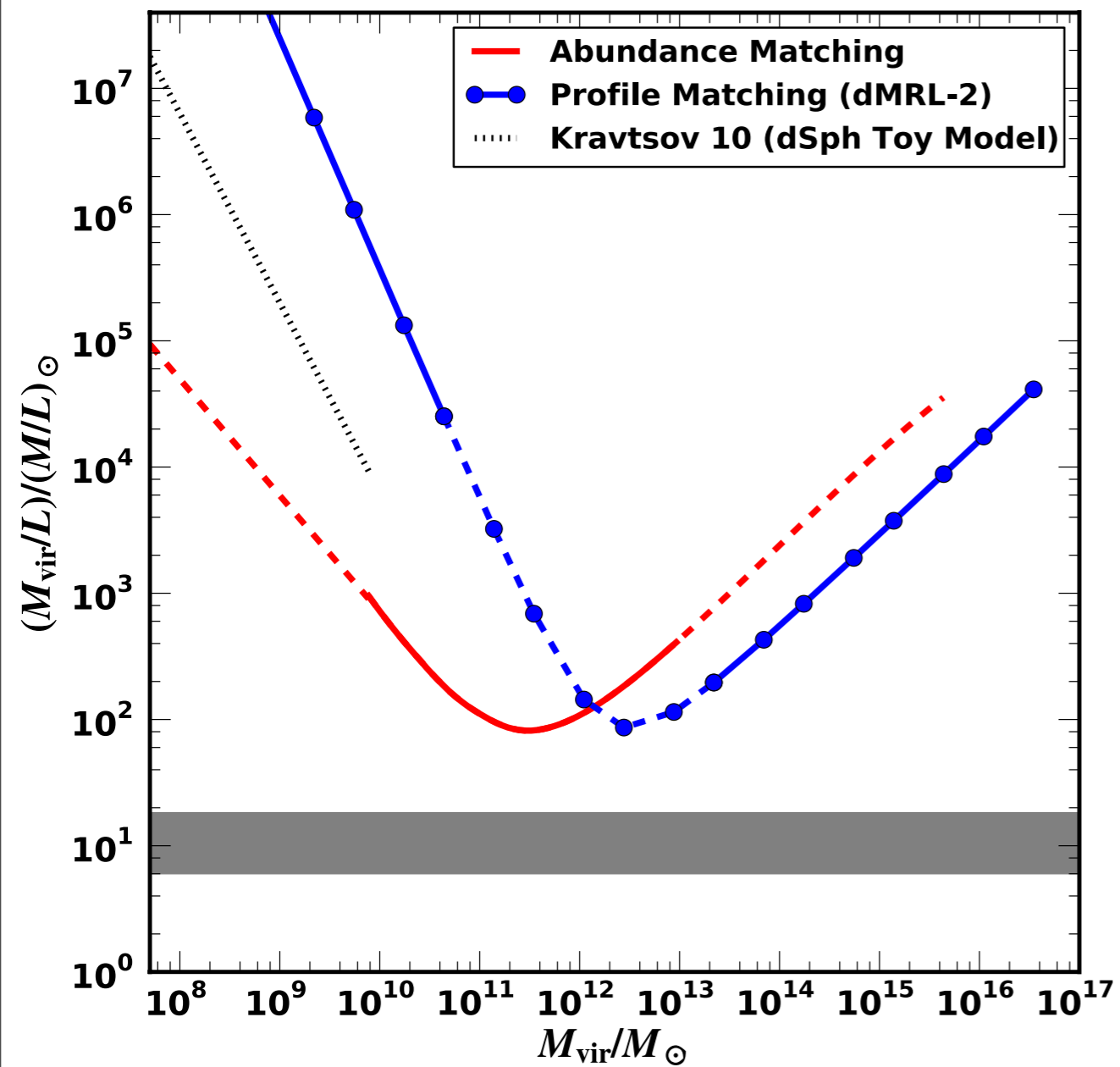
# Fundamental Plane



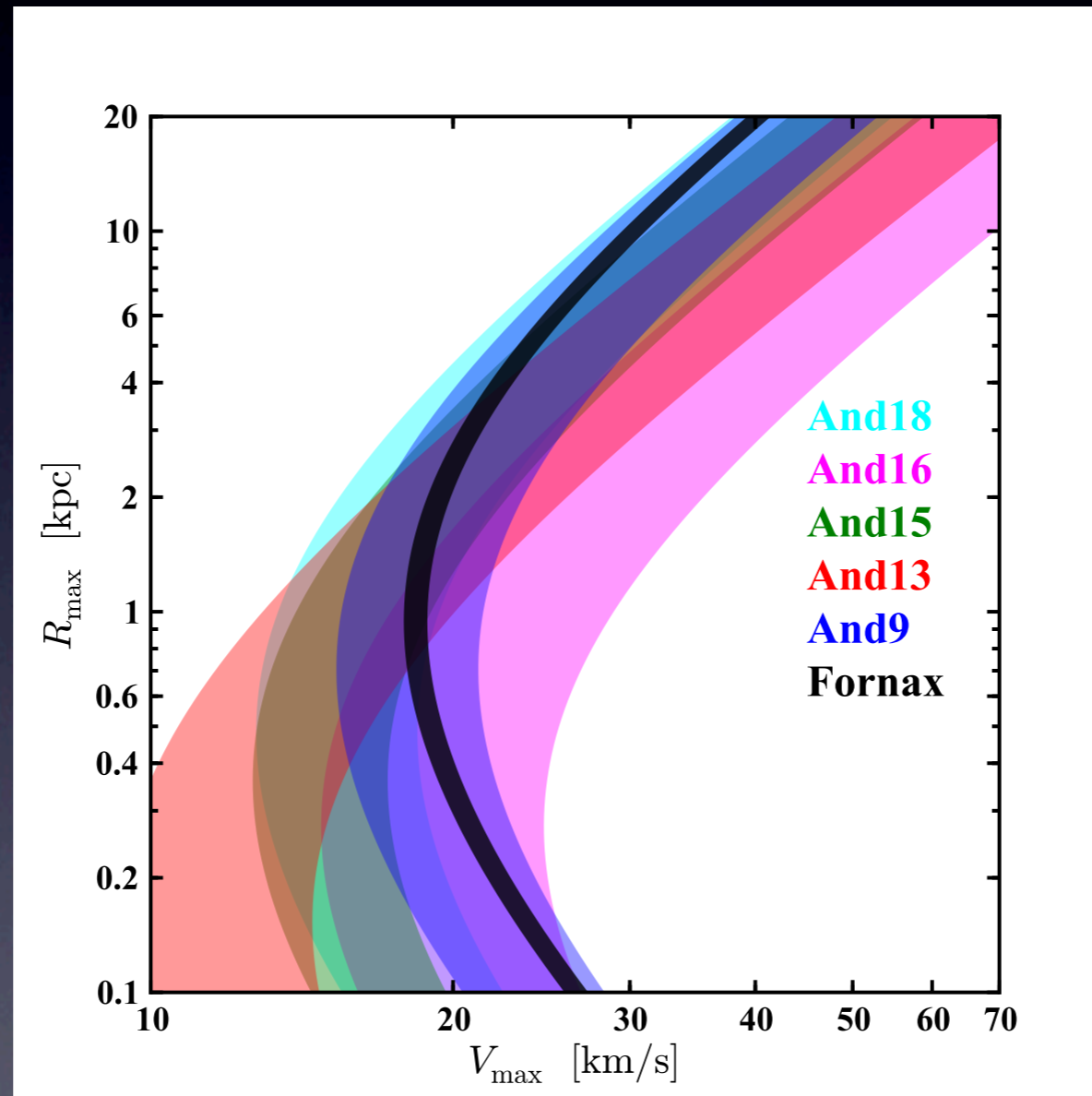
# Density



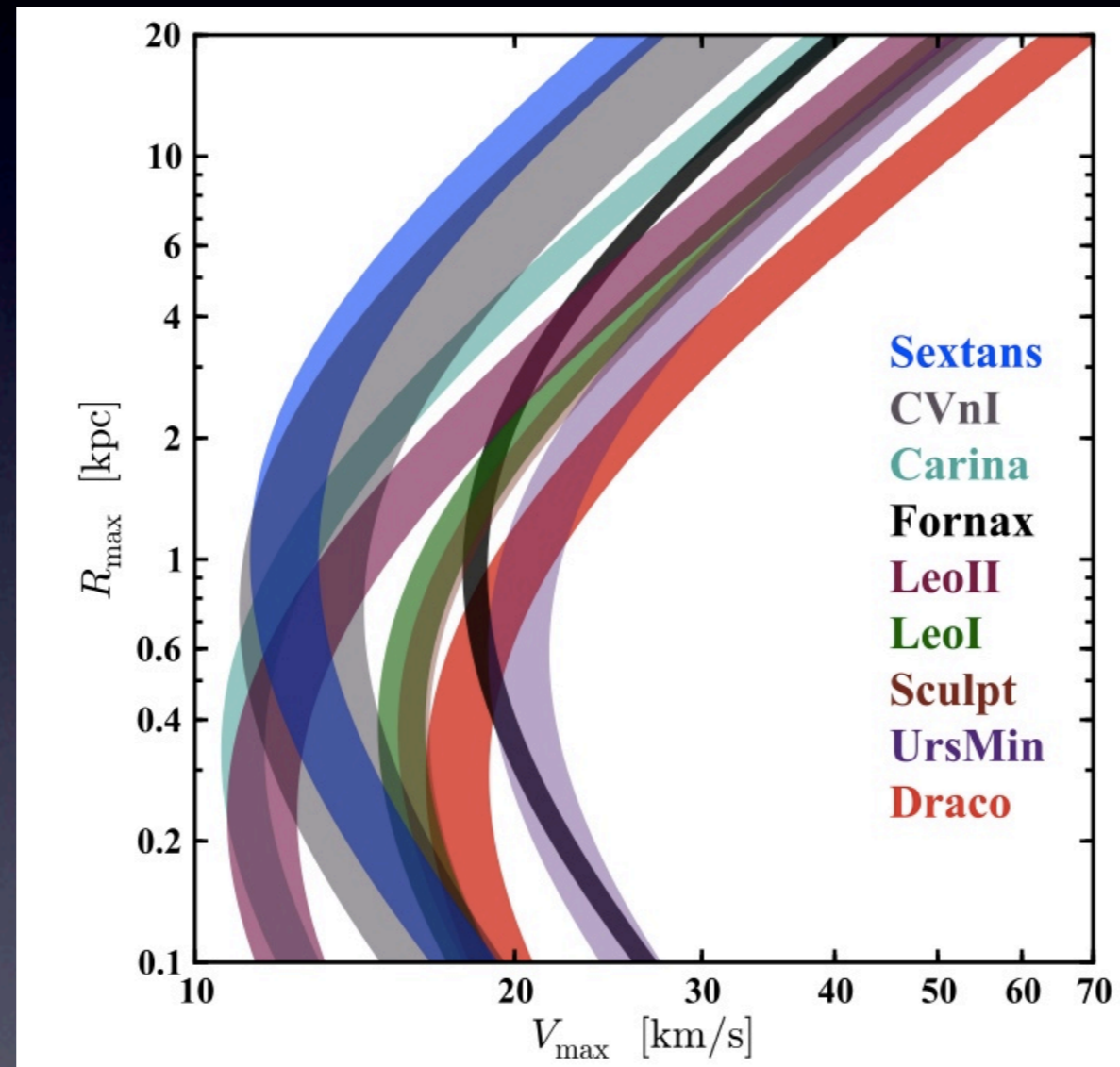
# Abundance Matching



# M31 dSphs



# MW dSphs





# M3 I dSphs (2)

