M31 Satellites in the SPLASH Survey: Local Group dSph Scalings

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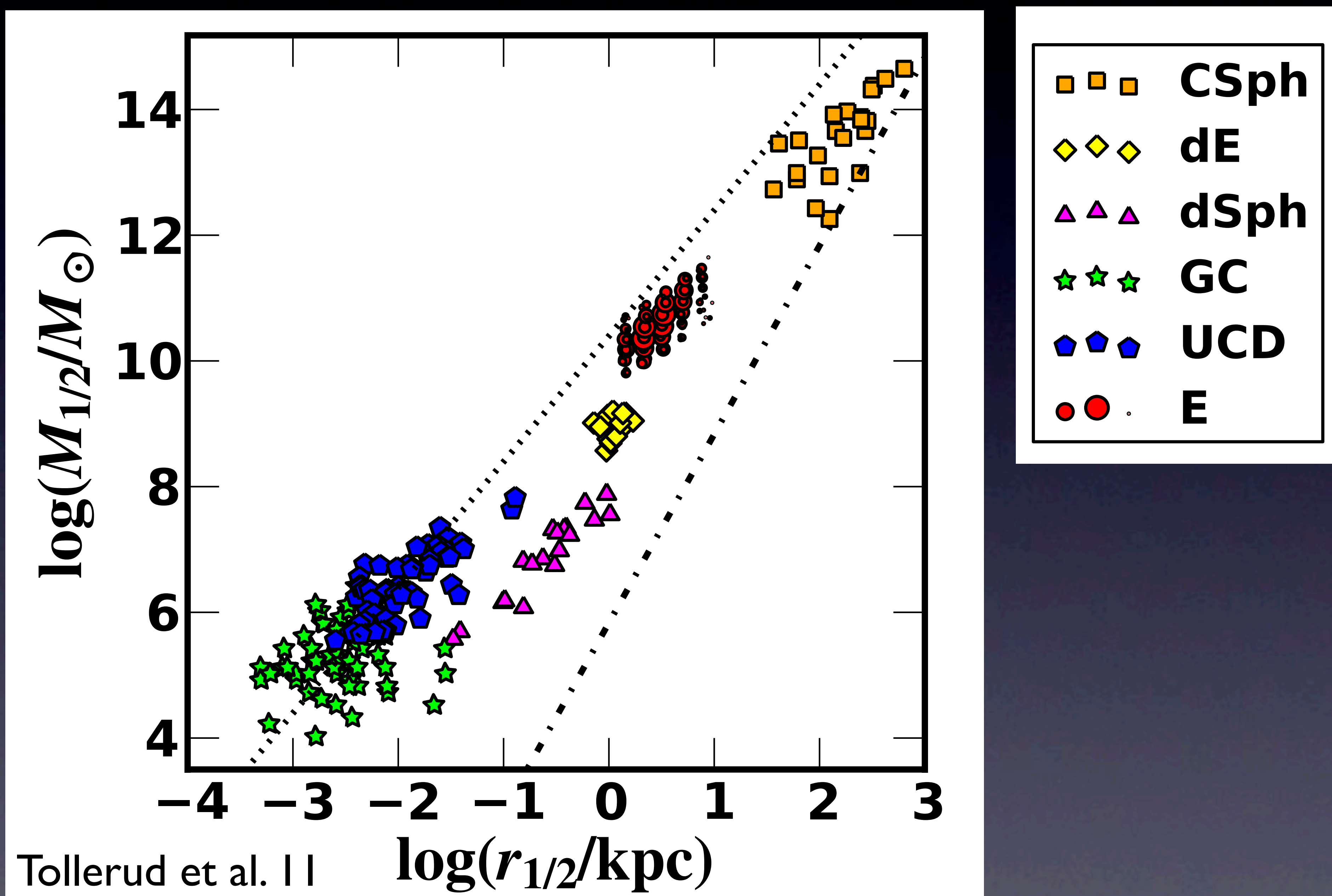
Why M31?/Outline

- MW may not be typical
- M31 dSphs may be different from MW (e.g. McConnachie+ 05)
- MRL Space Scaling Relations (Tollerud et al. 2011)
- SPLASH Survey: Kinematics of M31 dSphs

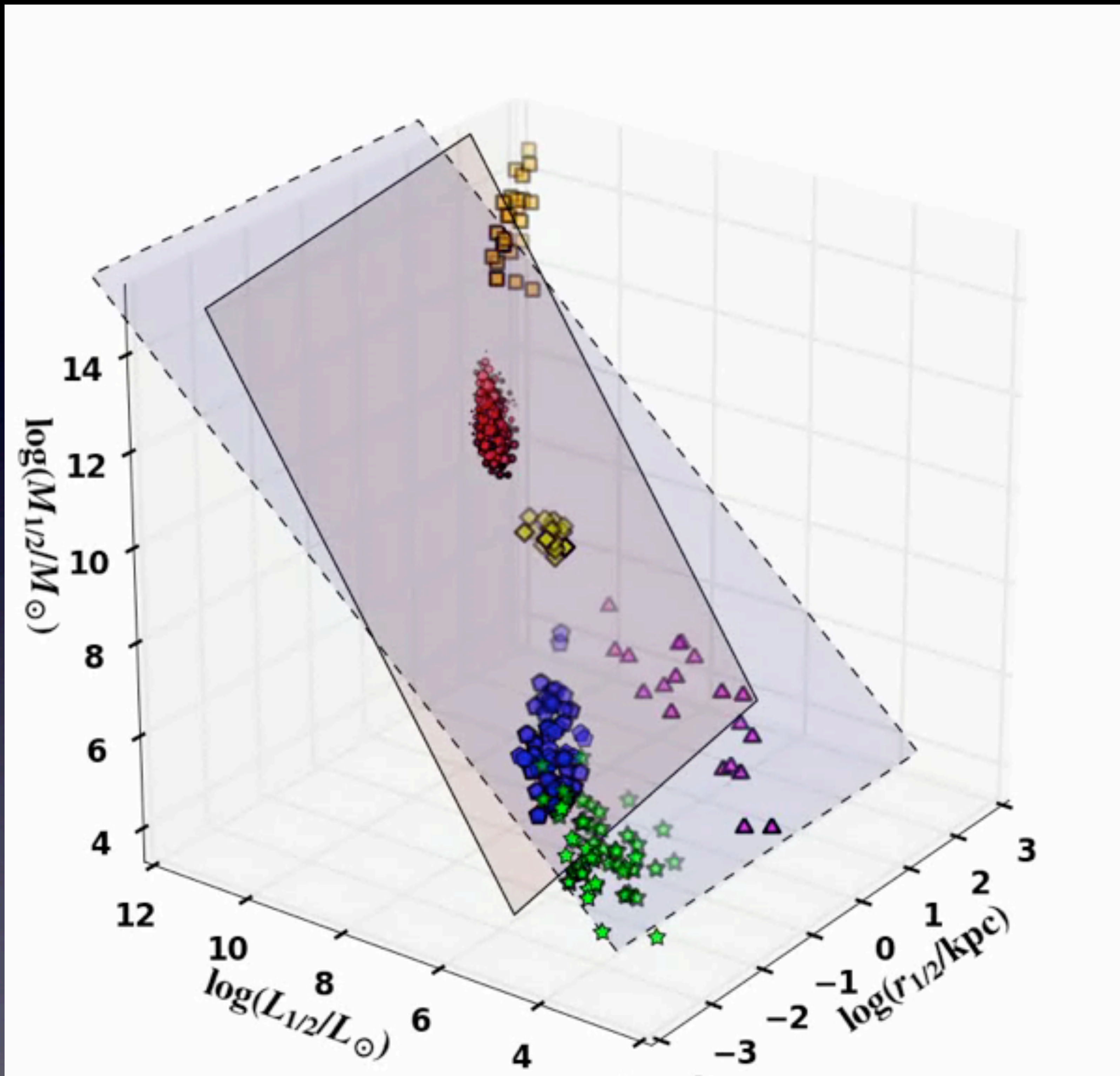
MRL Space



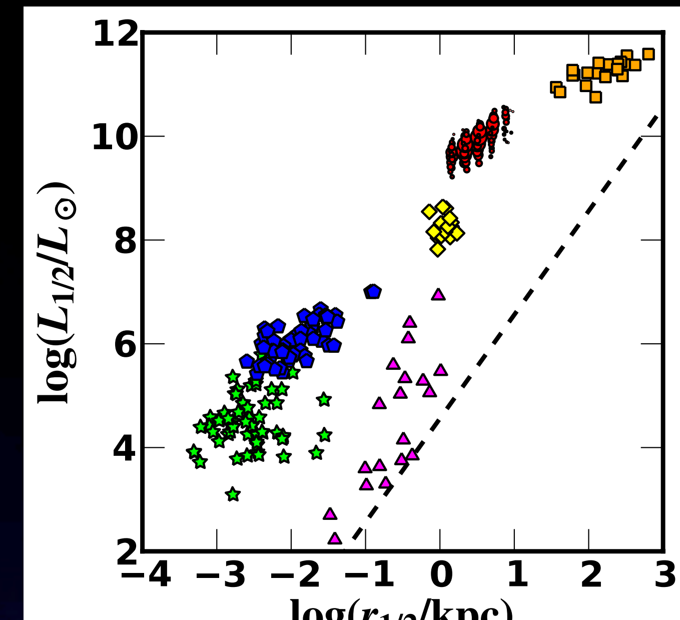
Zaritsky+ 06
Geha+ 03
Various, Wolf+ 10
Harris 03
Mieske 08
Graves+ 09

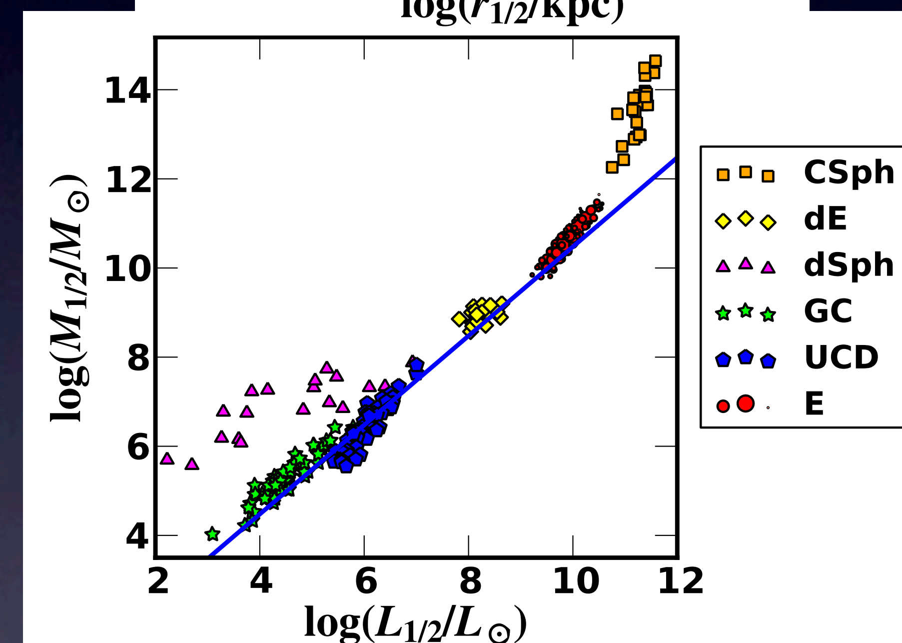
$$M_{1/2} = 3G^{-1}\sigma^2 r_{1/2}$$ Wolf+ 10

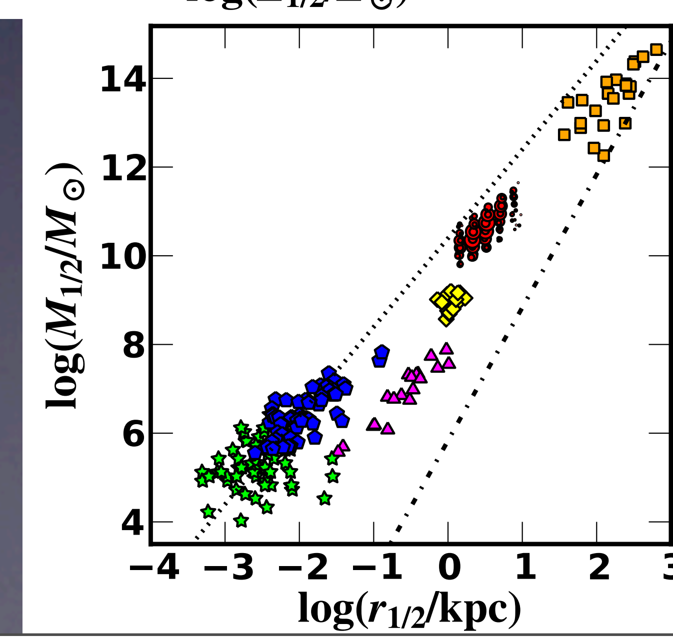
MRL Space



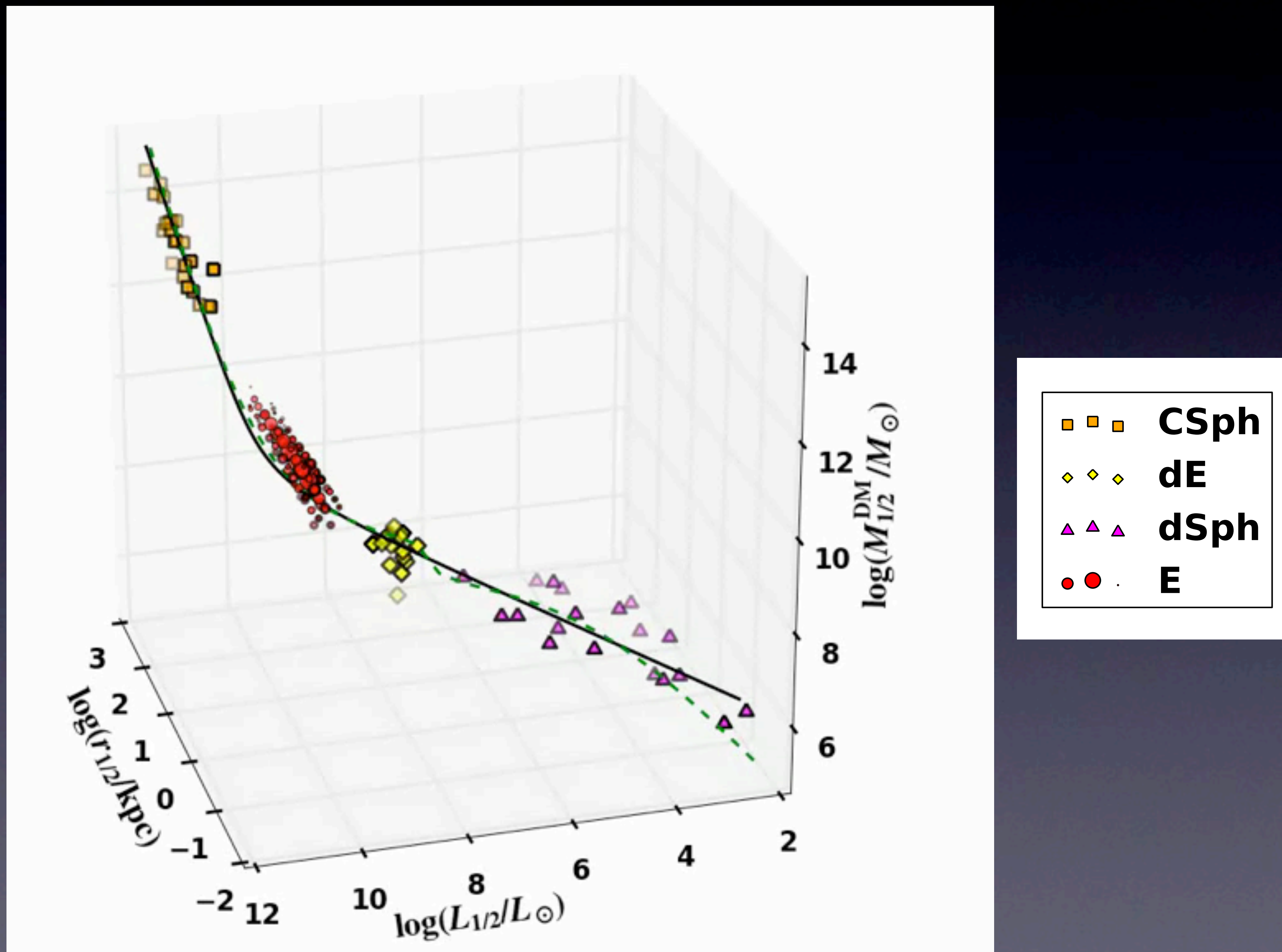
Tollerud et al. 11





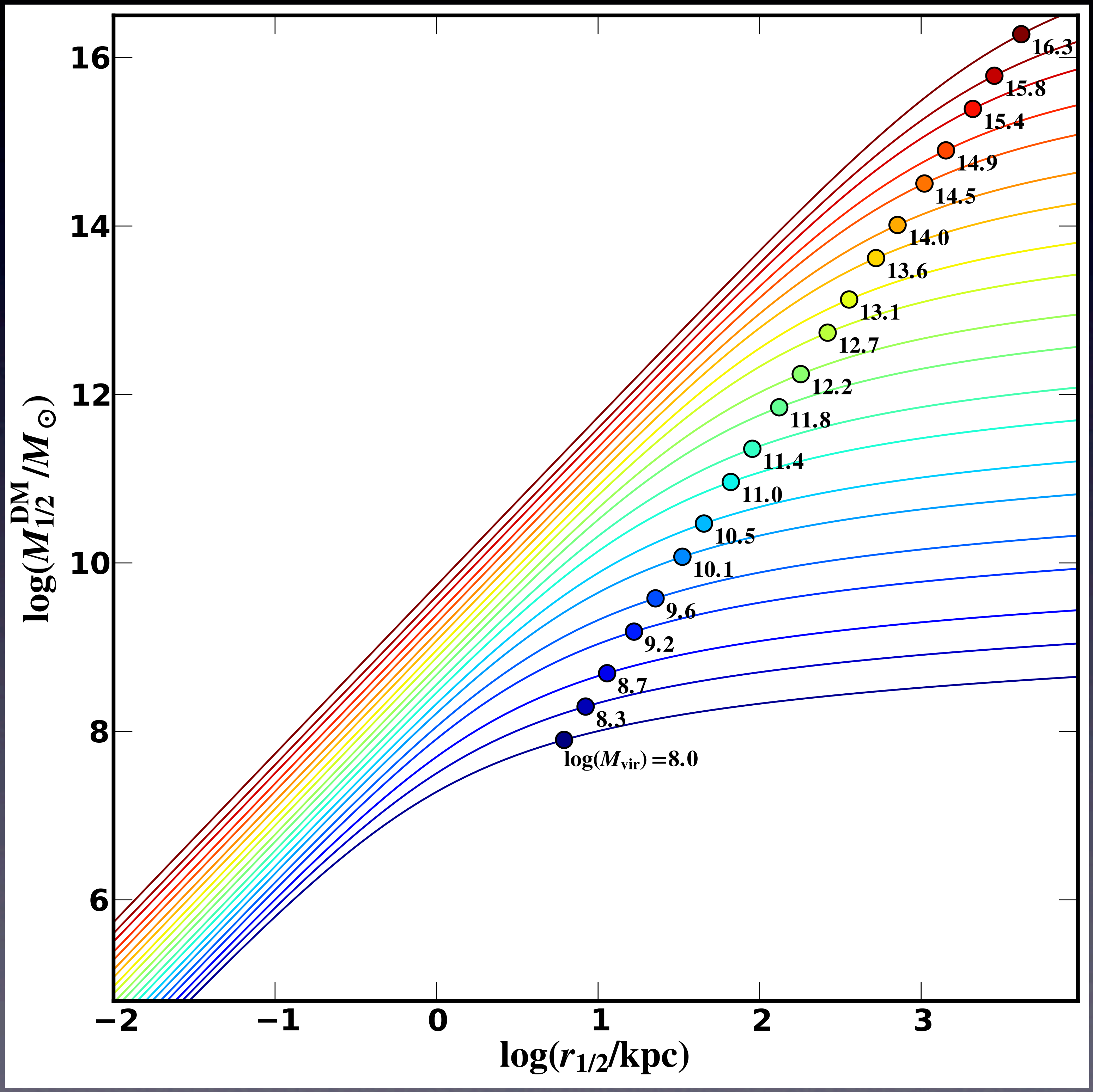


Fundamental Curve



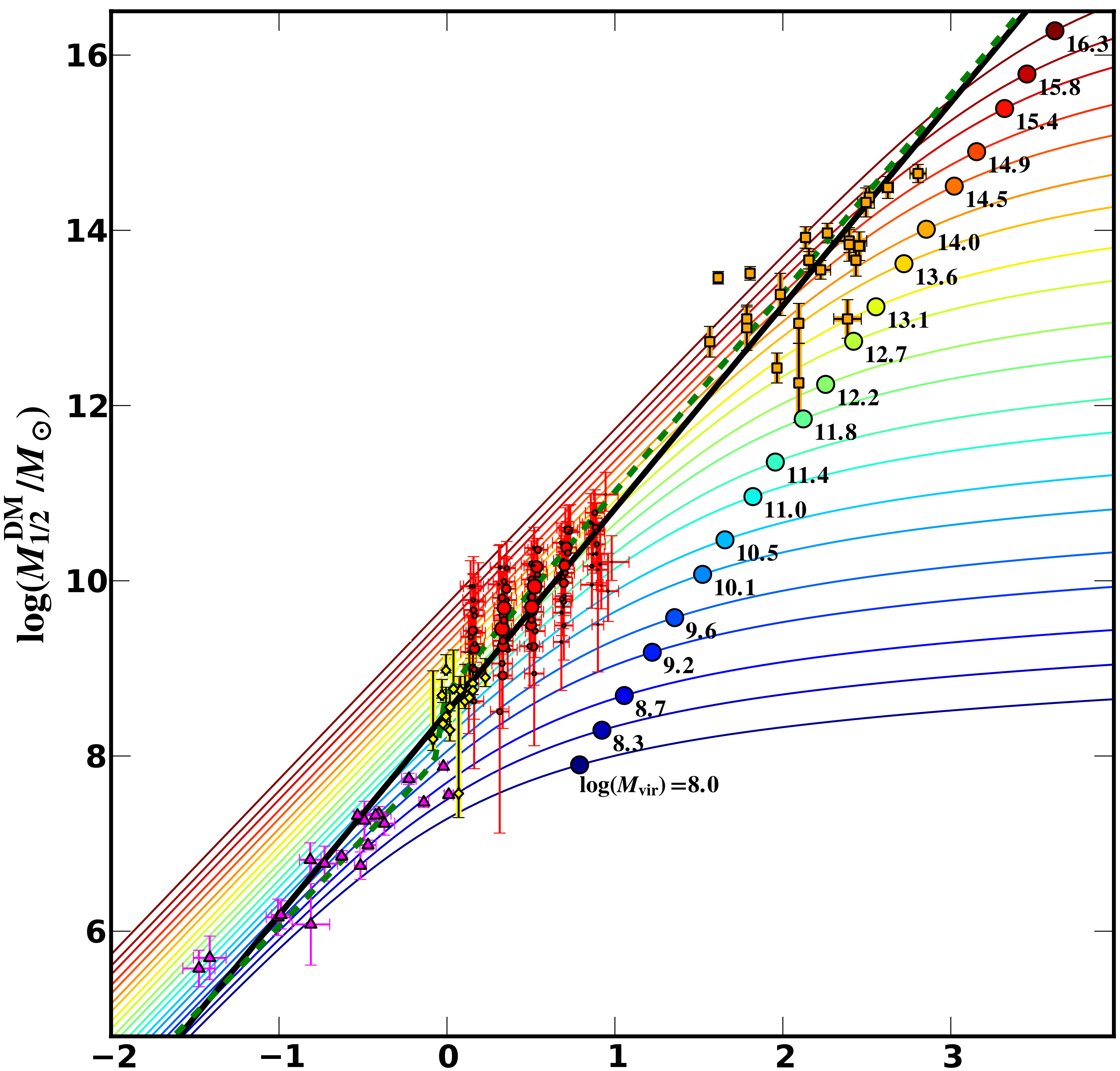
Tollerud et al. 11

DM Halo Scalings



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

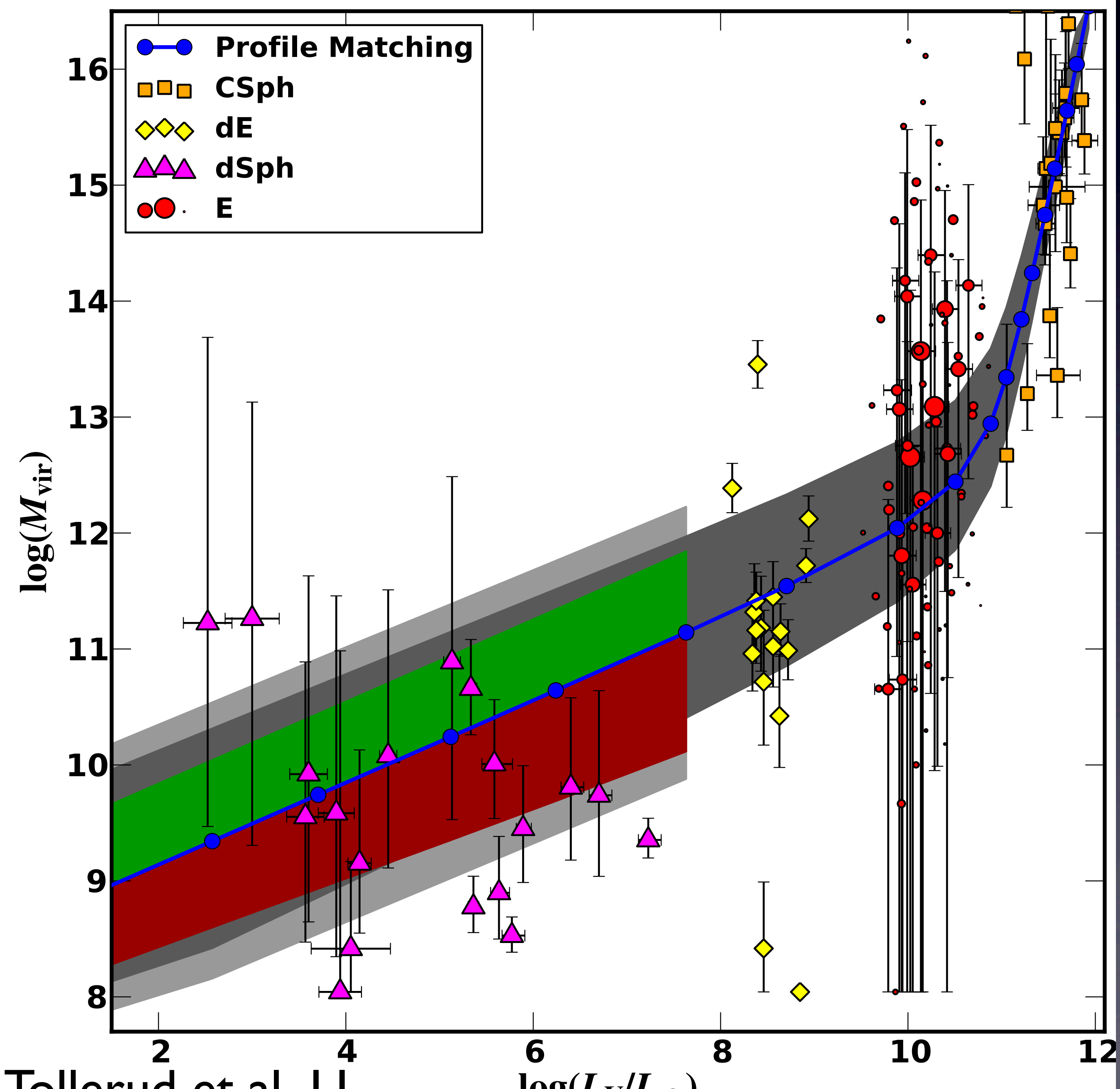
Profile Matching



Tollerud et al. 11

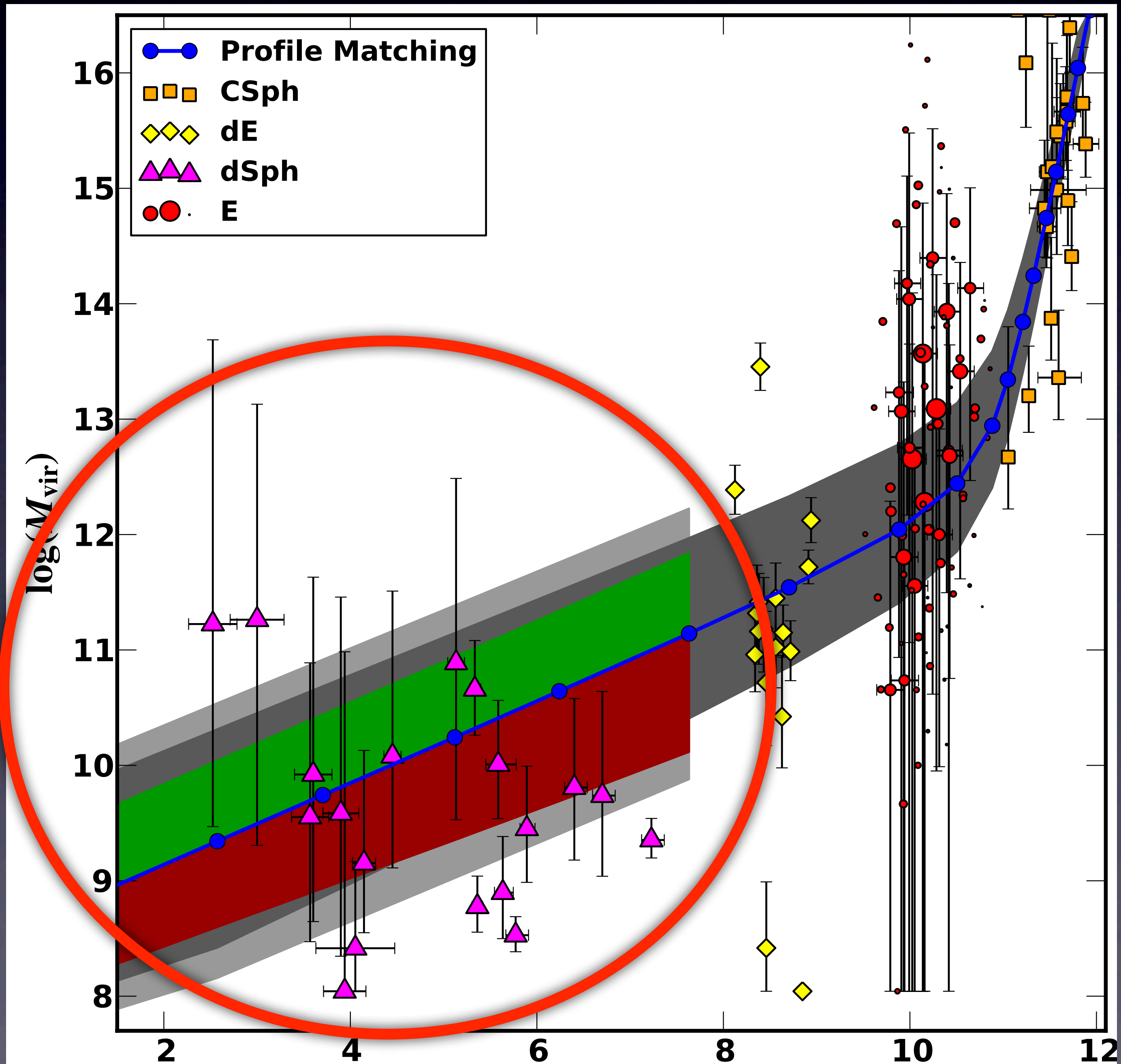
- Fundamental Curve Provides a 1-to-1 mapping from $r_{1/2}$ to $M_{1/2}$ or $L_{1/2}$
- M-r space then maps these galaxy scaling relations onto Halo scaling relations
- Abundance matching without abundances

Connecting Galaxies to Their Halos



Tollerud et al. 11

Connecting Galaxies to Their Halos



Tollerud et al. 11

Mass Scale?
(Strigari+ 08)

Spectroscopic and Photometric Landscape of Andromeda's Stellar Halo

SPLASH

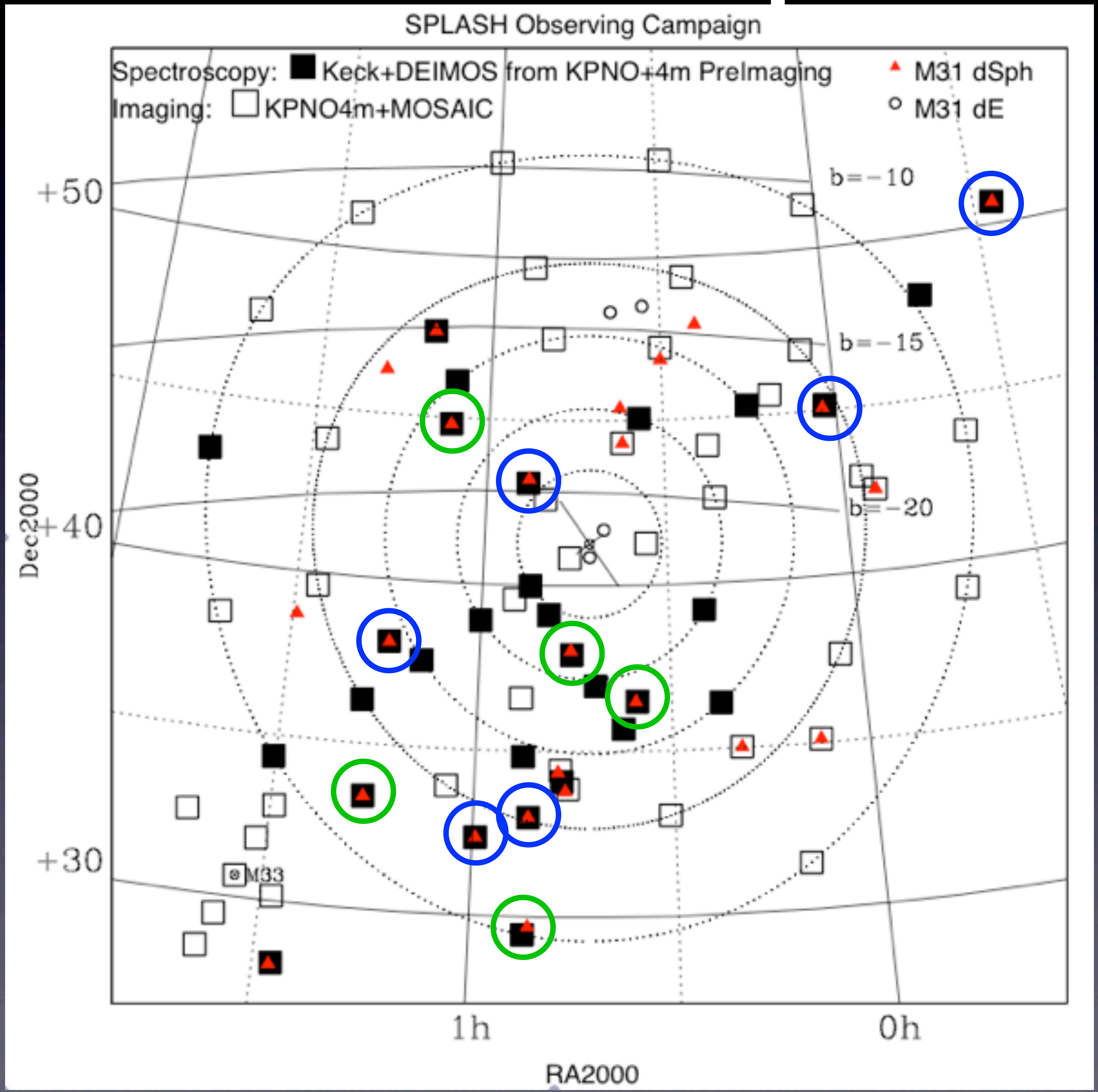
Photo credit: Dr. Andrew Davidhazy

- PI: **Raja Guhathakurta** (UCSC)
- Kirsten Howley, Claire Dorman (UCSC), Evan Kirby (Caltech), Karrie Gilbert (U Wash)
- **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

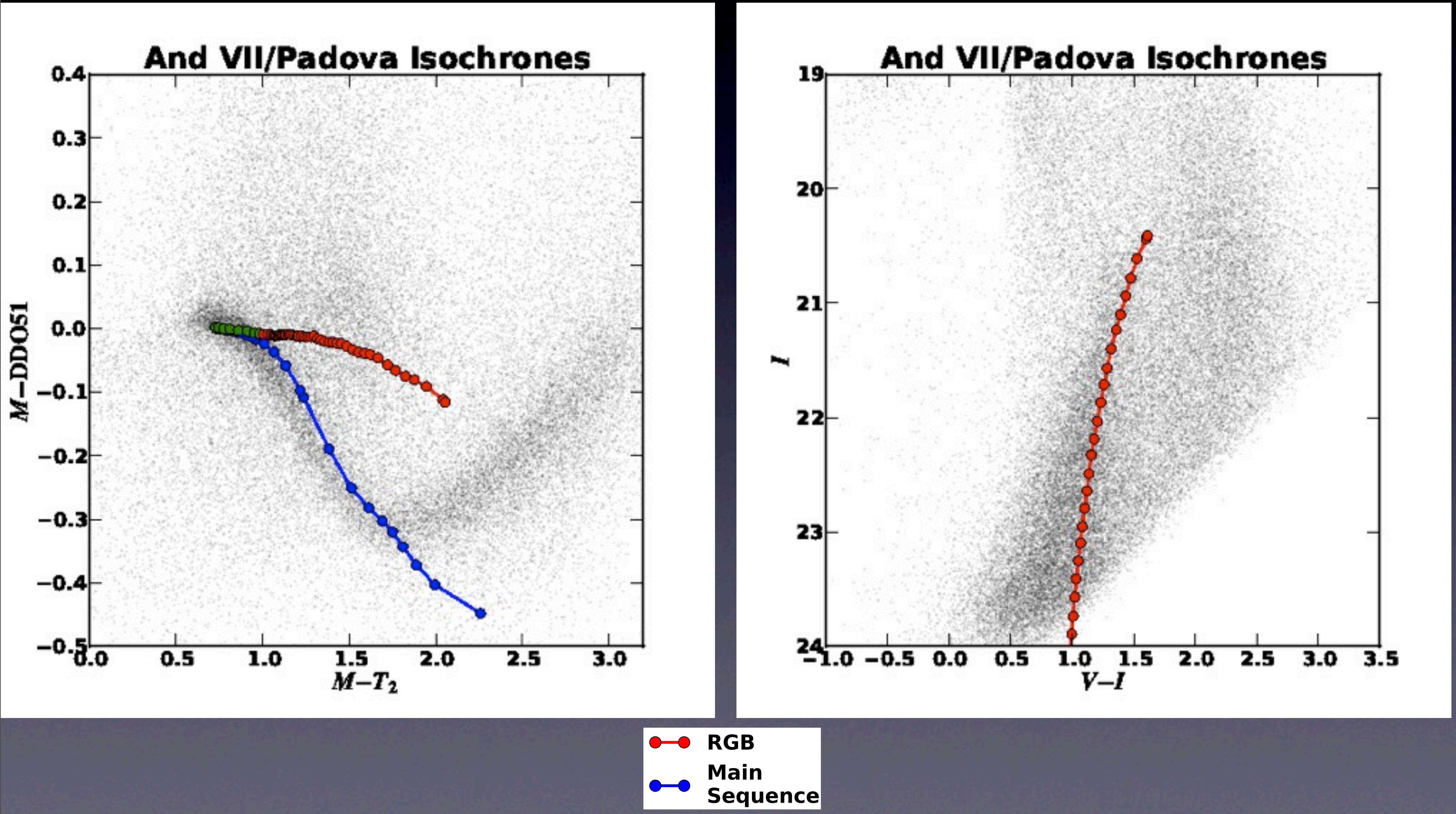
- And I
- And II
- And III
- And X
- And XIV



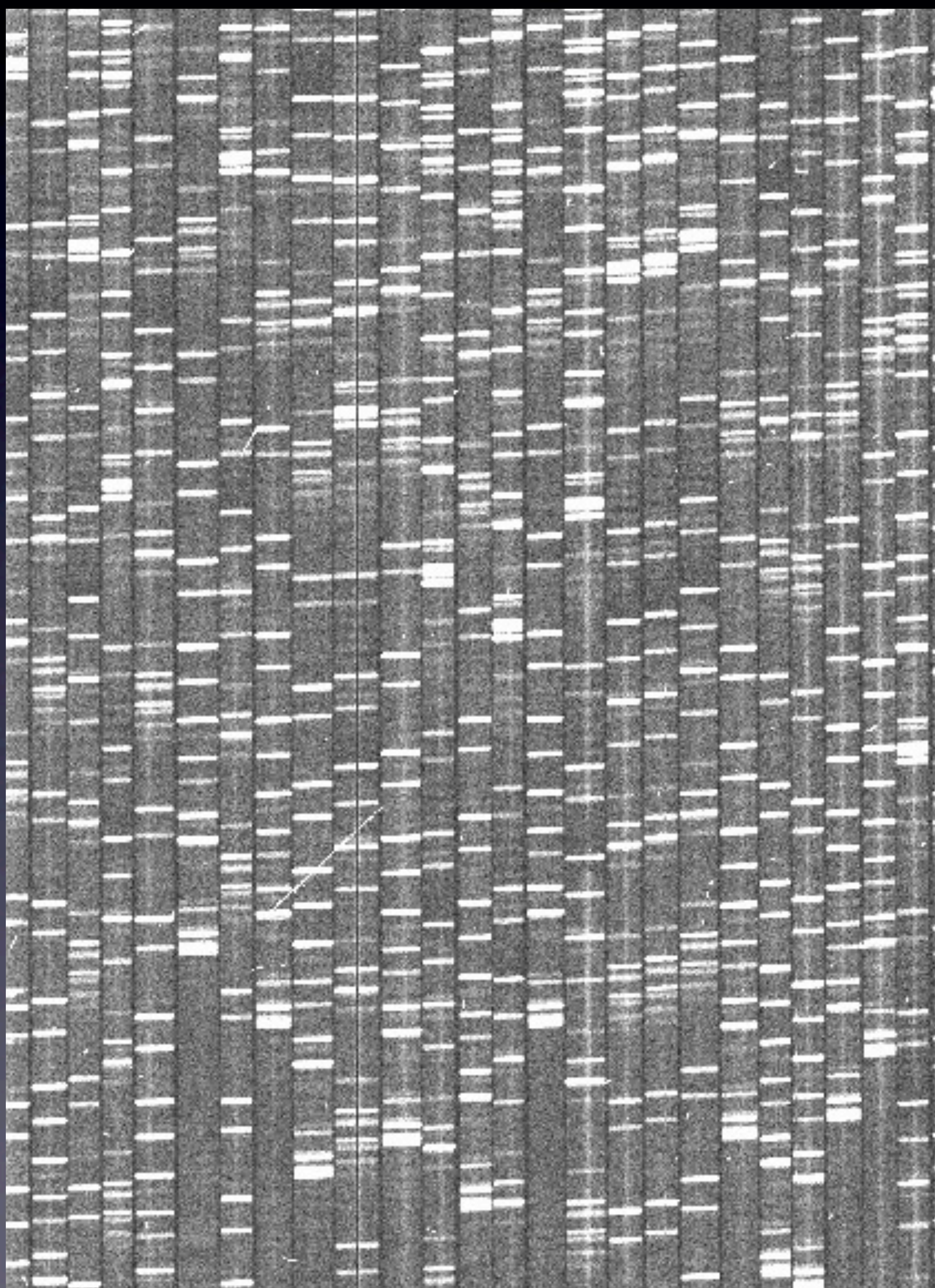
- And VII
- And IX
- And XIII
- And XV
- AndXVI
- And XVIII

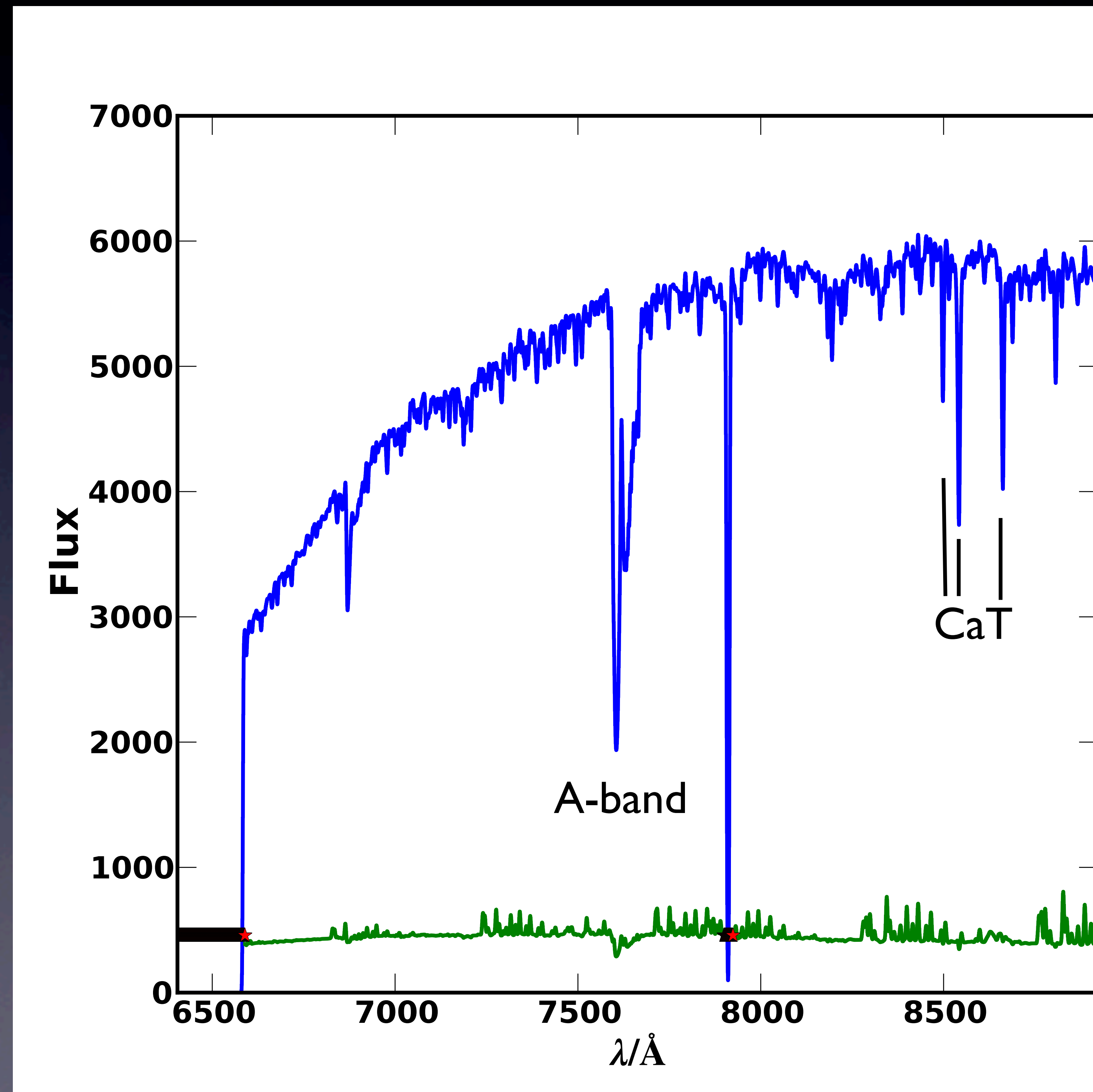
Monday, August 15, 2011

DDO51 Pre-Selection

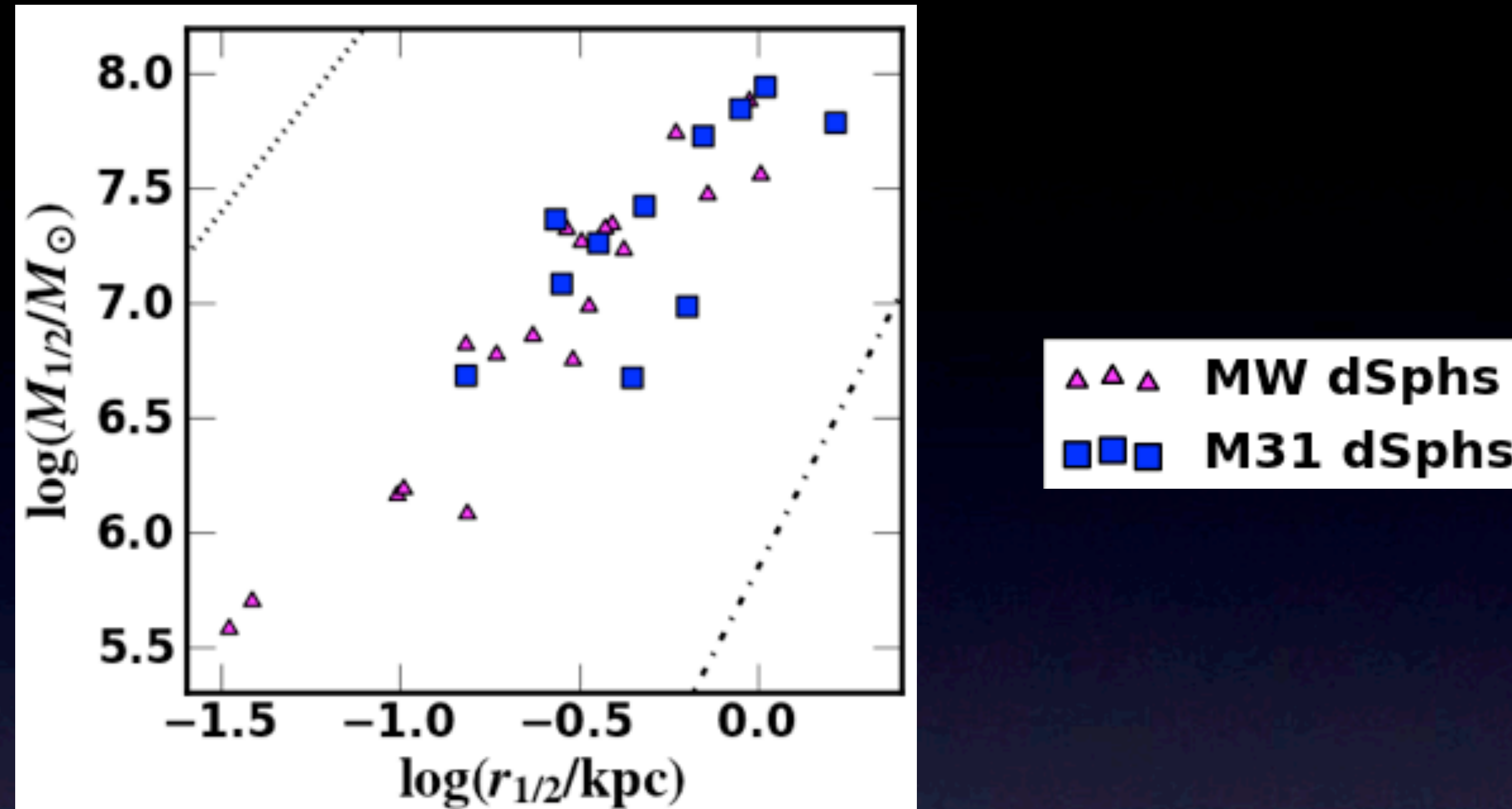


Keck/DEIMOS Spectroscopy



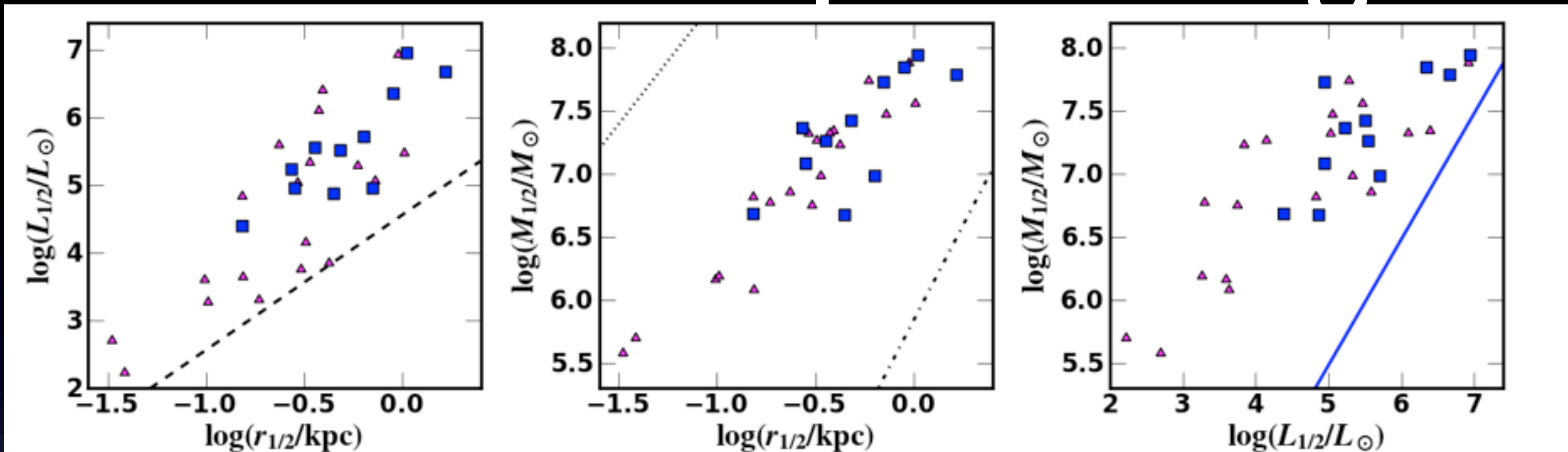


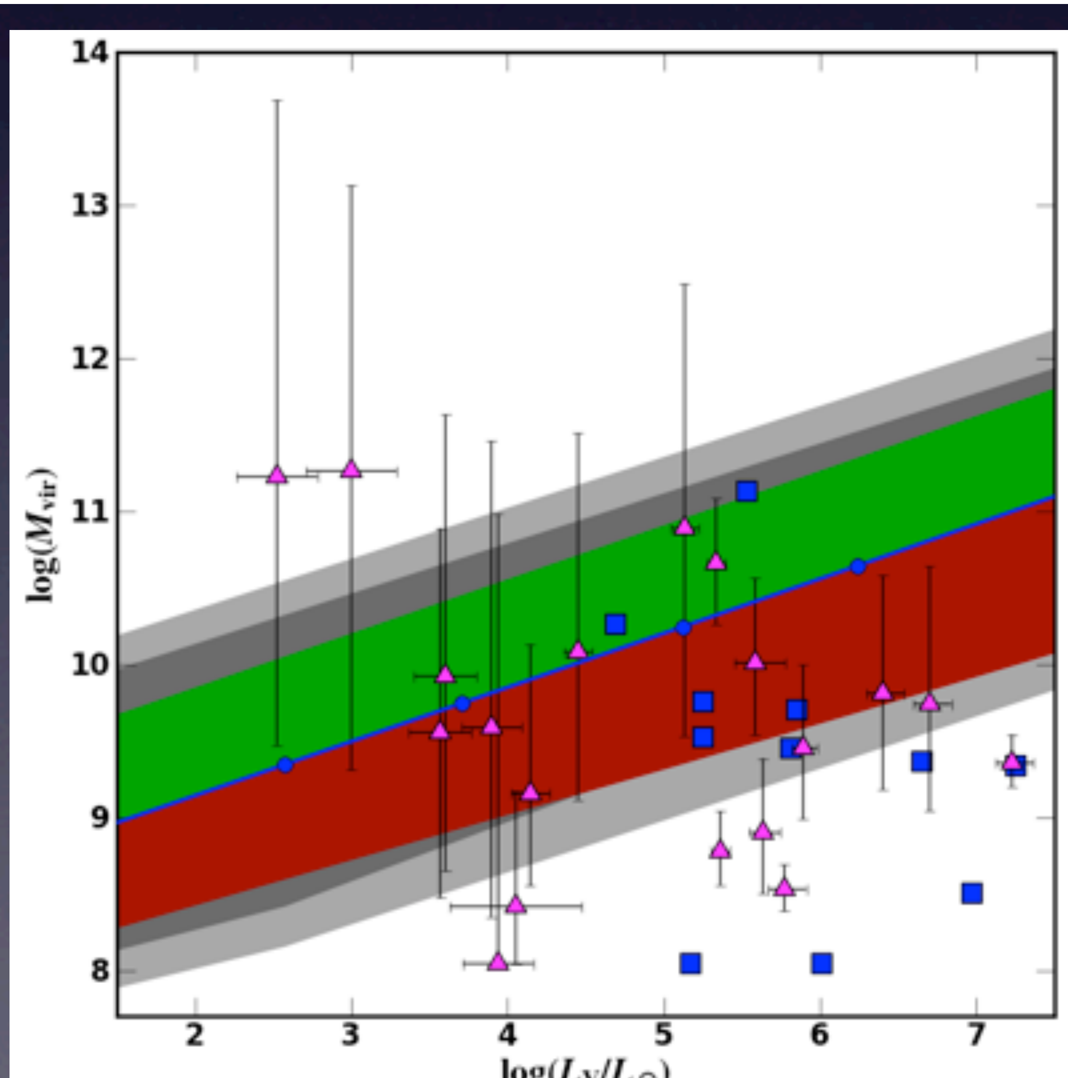
SPLASH dSph Kinematics



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

SPLASH dSph Scalings



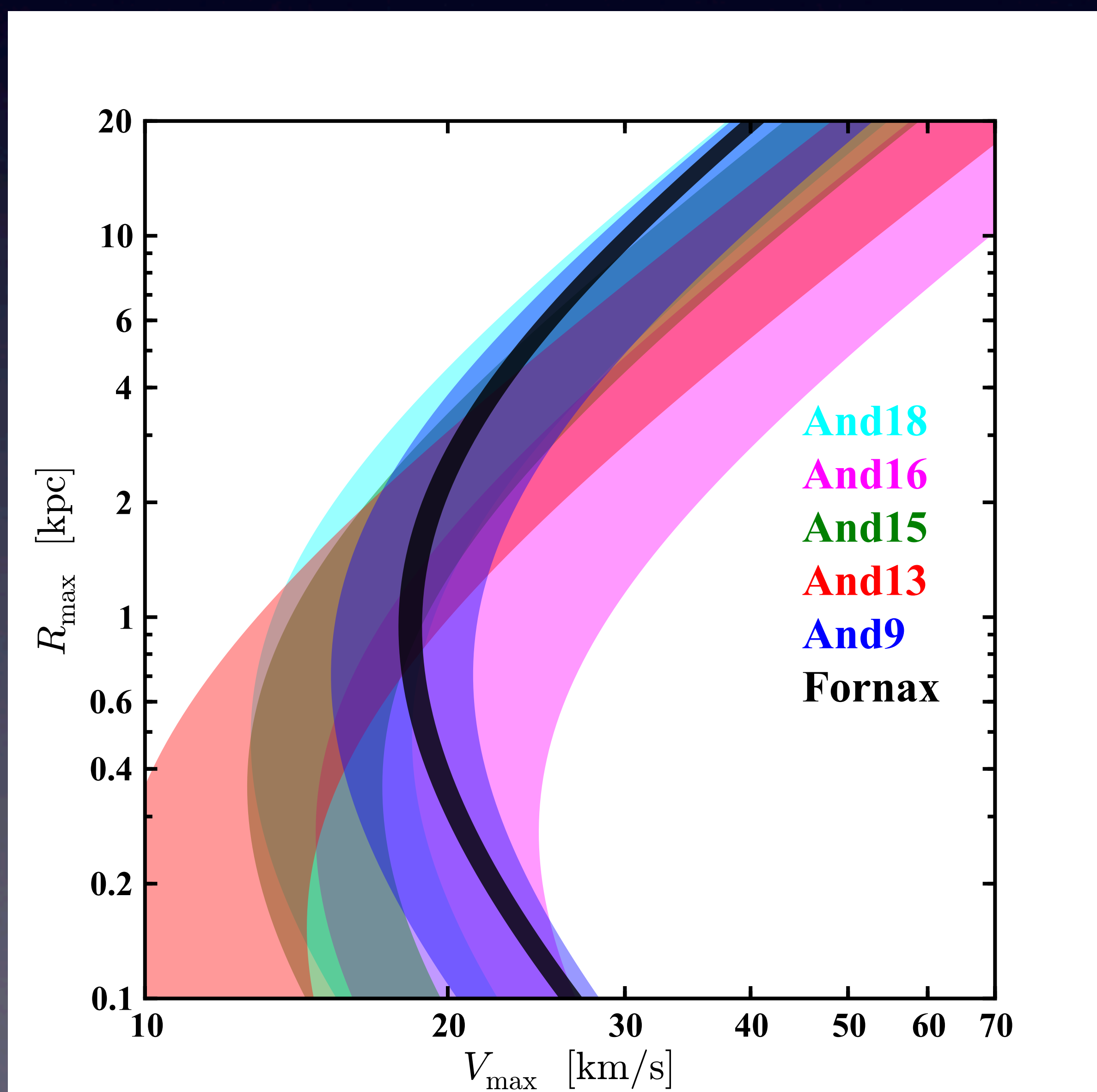


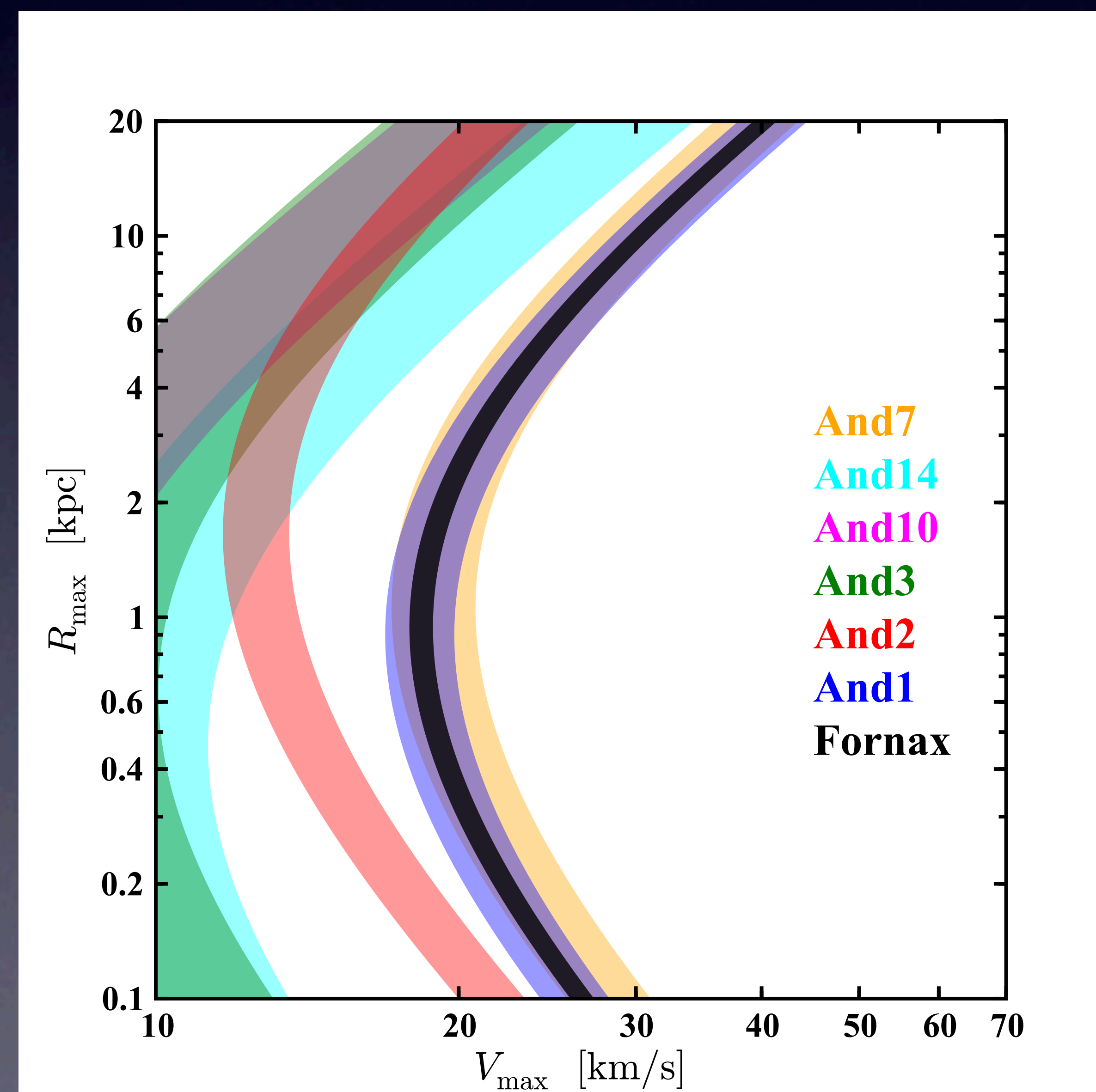
MW dSphs

M31 dSphs

- M31 dSphs have lower Mvir
- M31 dSph scatter similar to MW

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



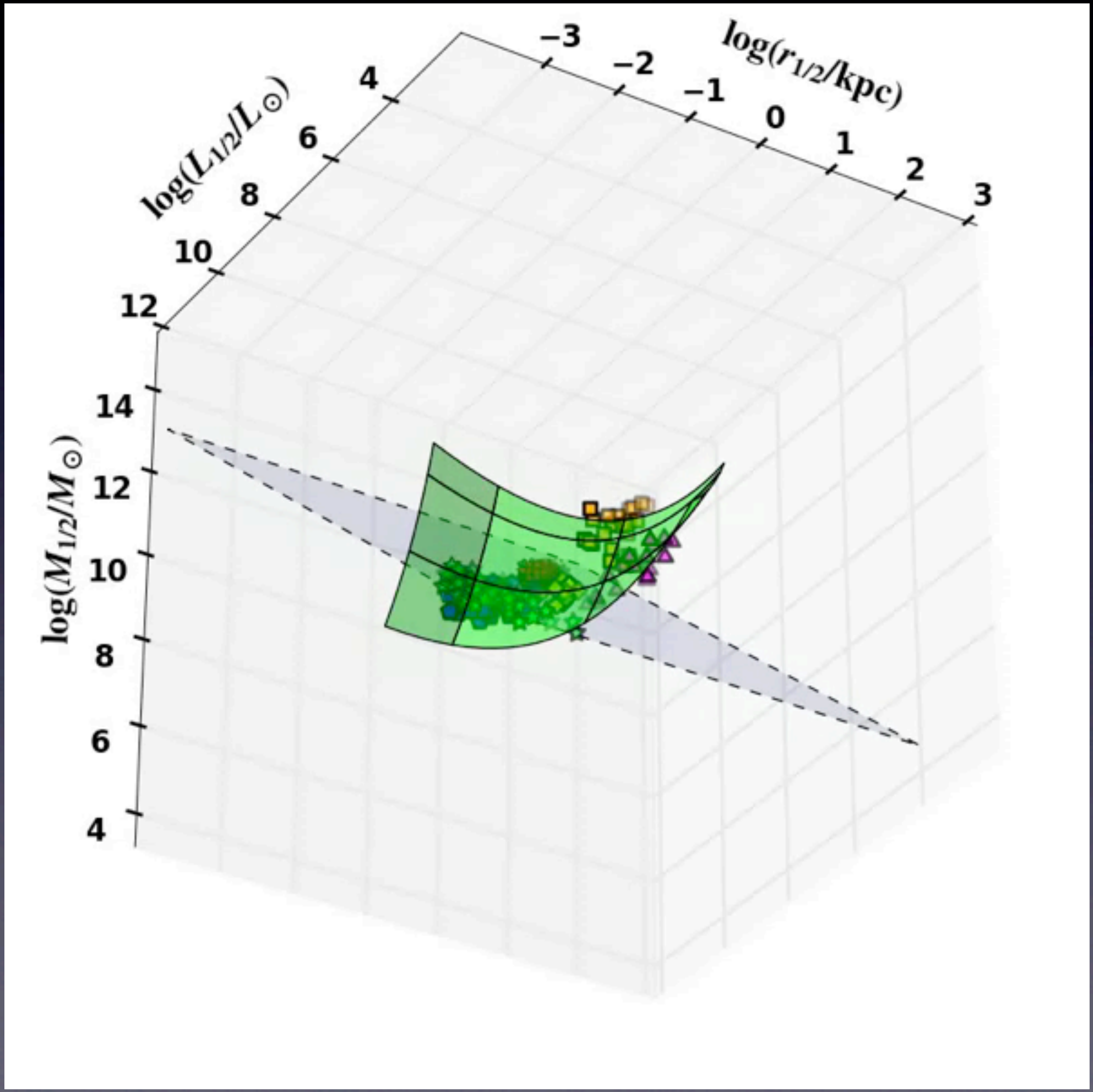


Conclusions

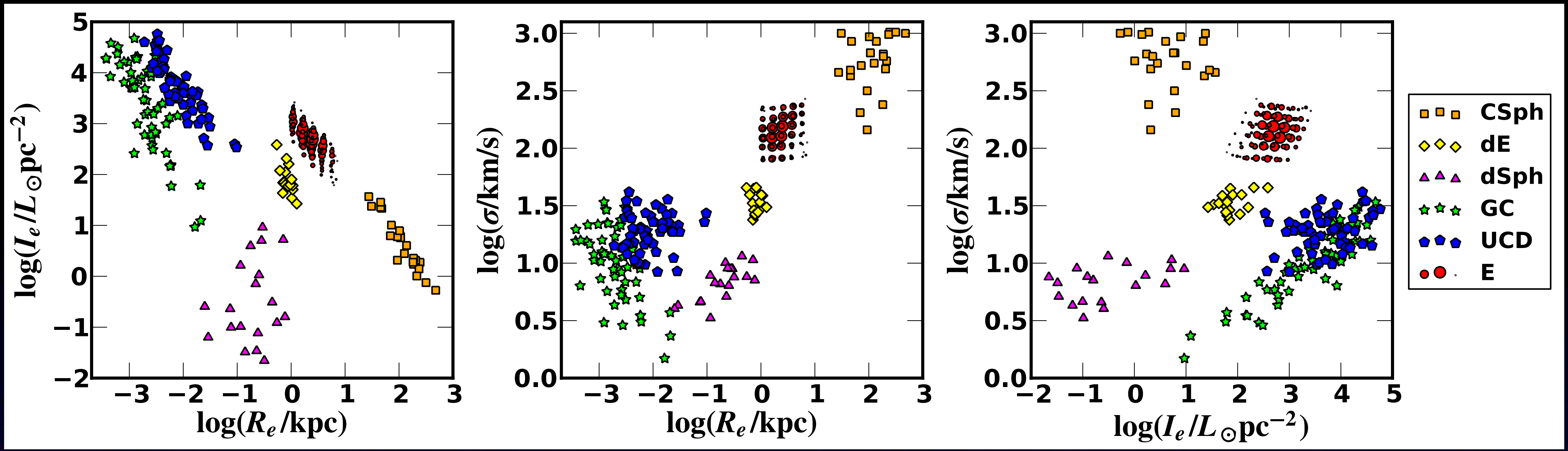
- Fundamental Curve+Profile Matching maps passive galaxy scaling relations to the associated dark halo scaling relations.
- MW dSphs scatter around this scaling and this is a constraint on formation models.
- M31 dSphs have similar scalings and similar scatter (with unusual outliers?).
- M31 also lacks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

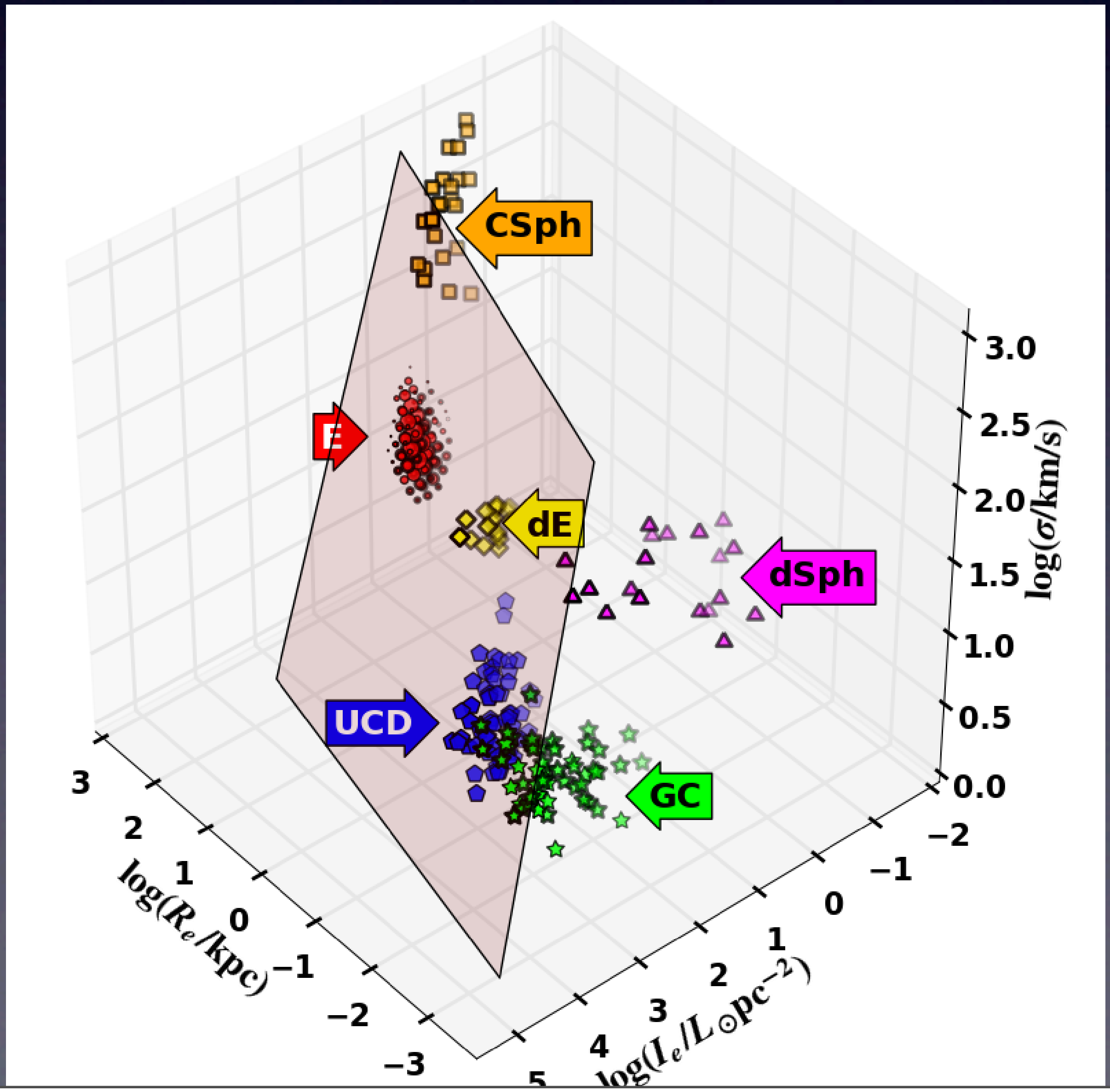
Backup Slides

Fundamental Manifold

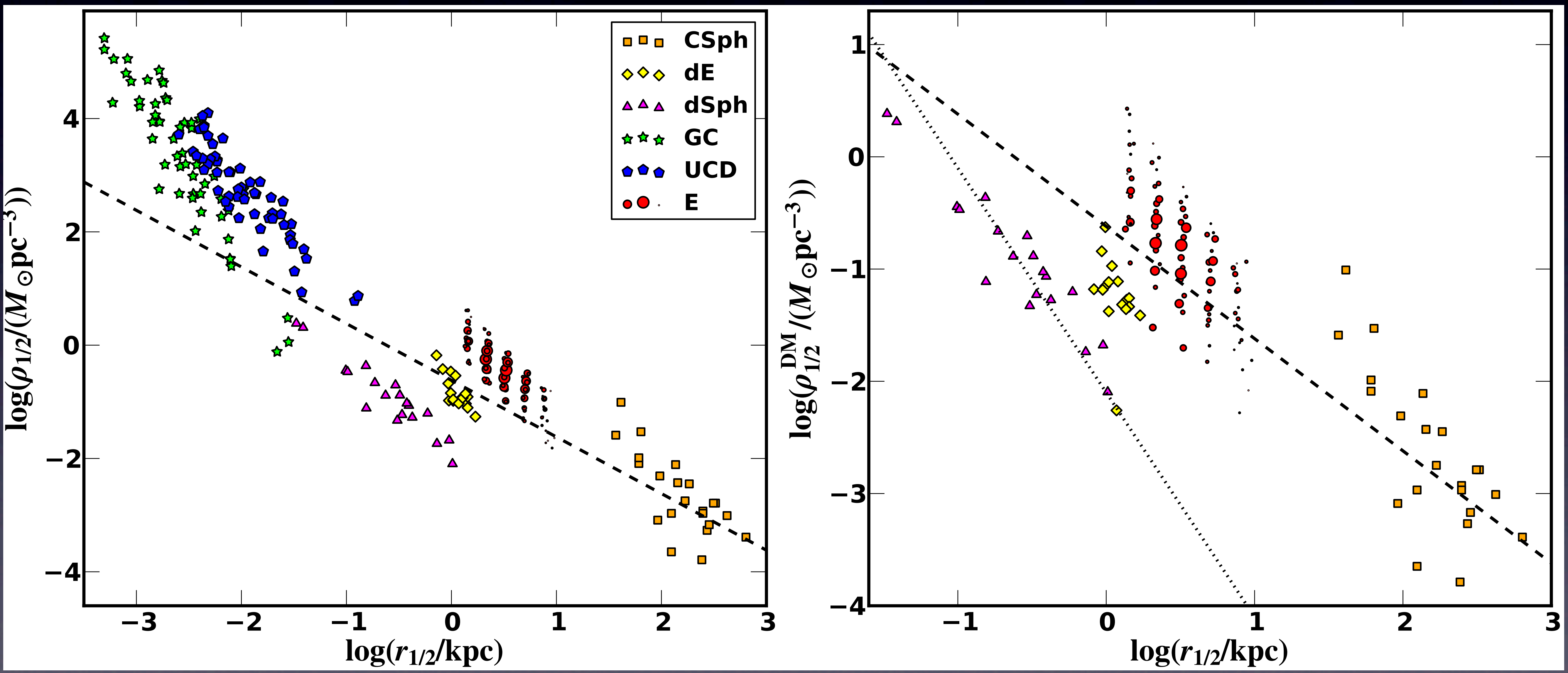


Fundamental Plane



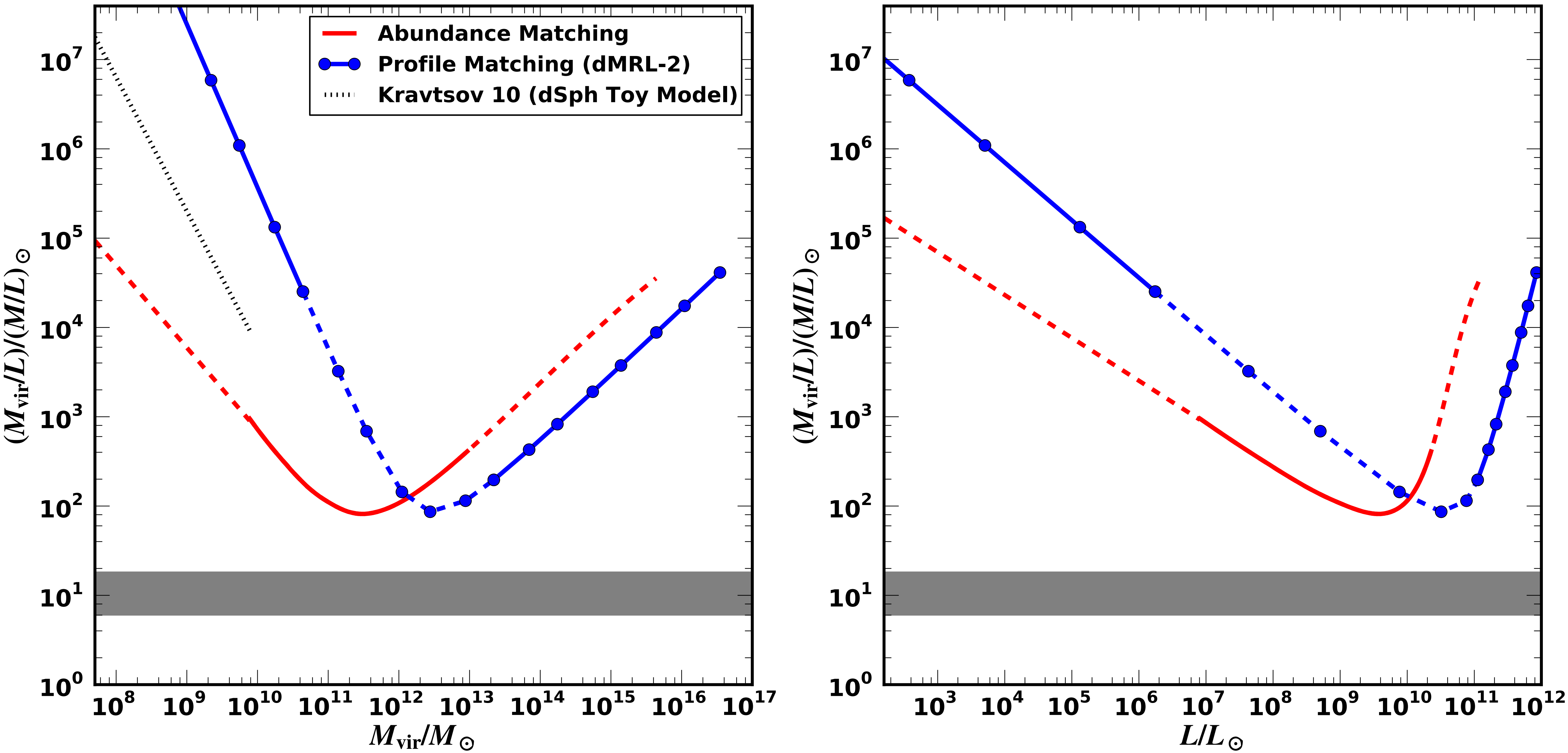


Density

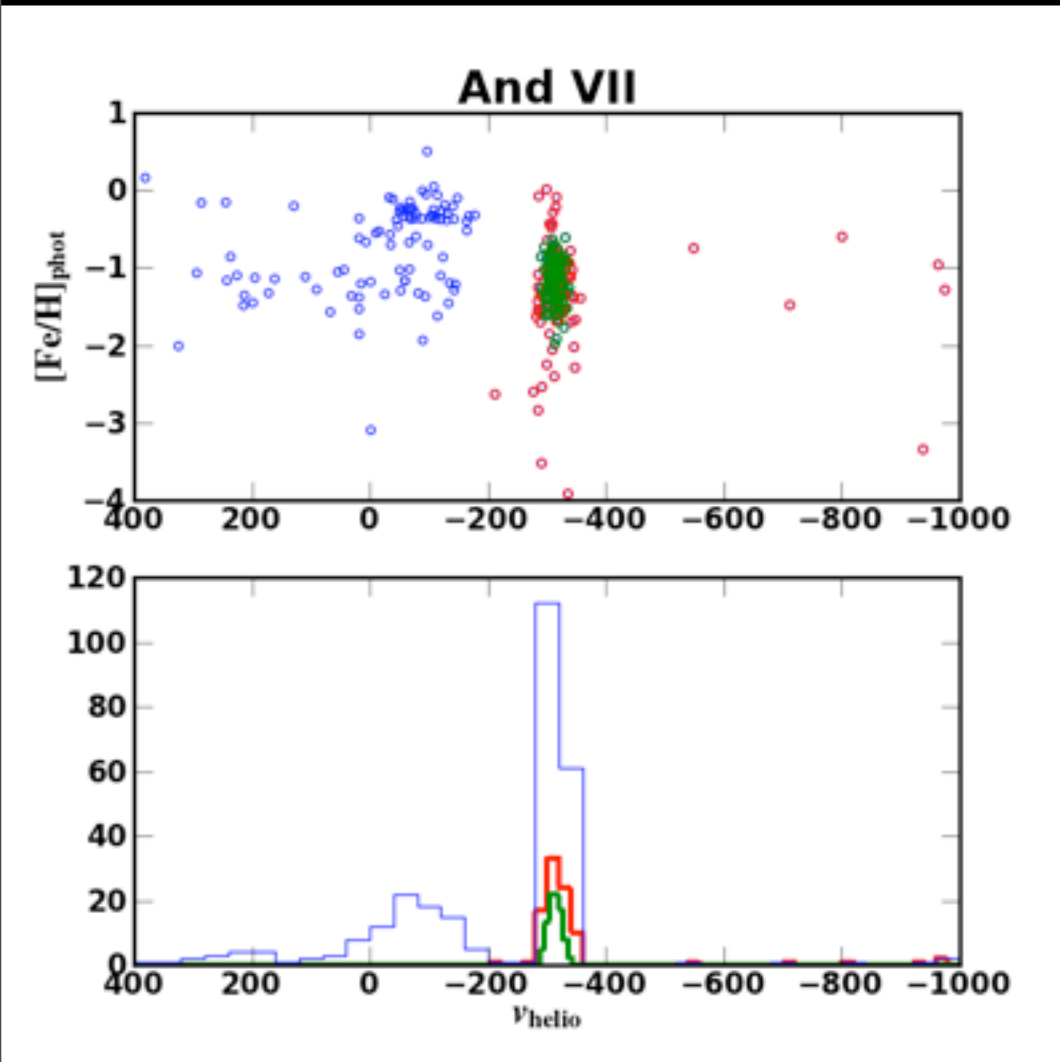


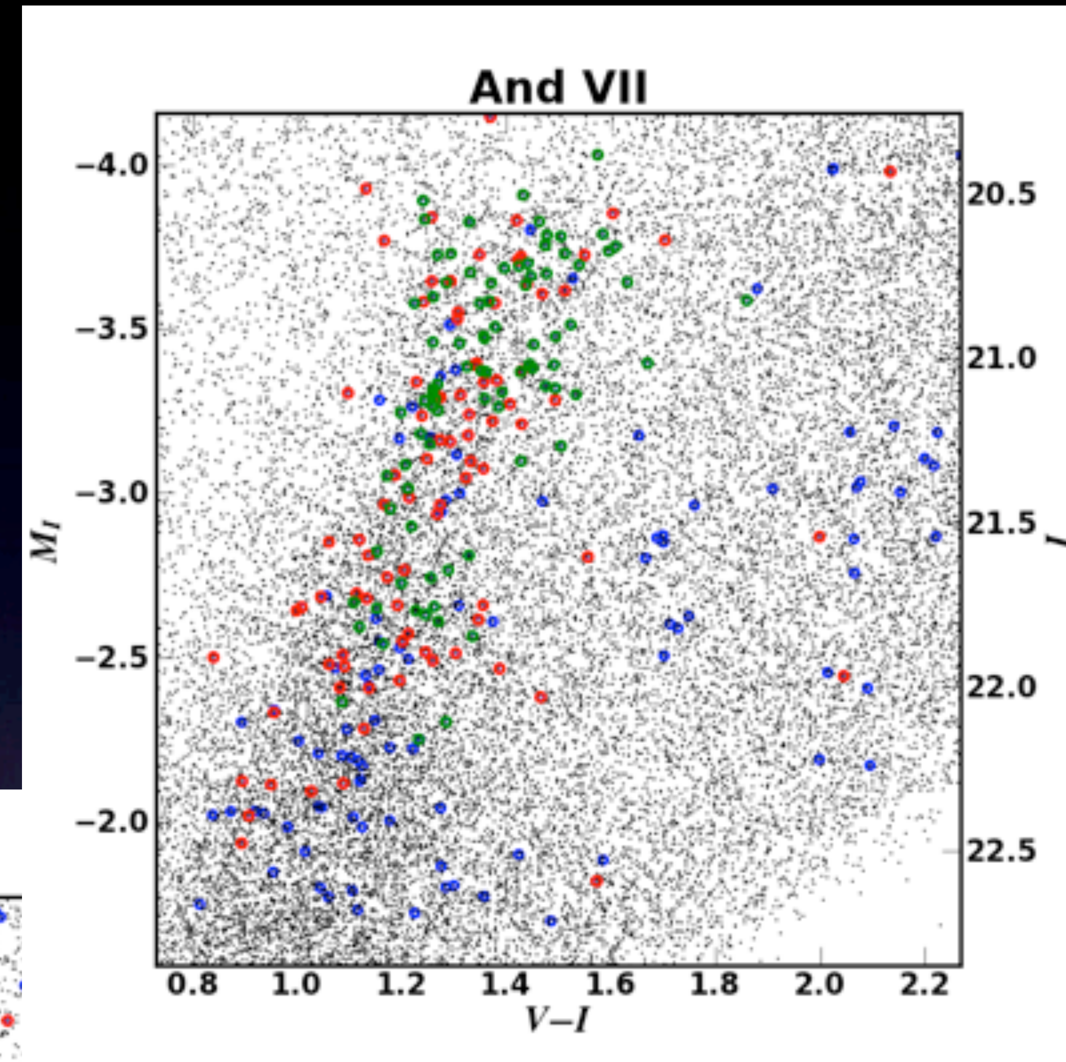
CSph
dE
dSph
GC
UCD
E
$\log(\rho_{1/2}/(M_\odot \mathrm{pc}^{-3}))$
$\log(r_{1/2}/\mathrm{kpc})$
$\log(\rho^{\mathrm{DM}}_{1/2}/(M_\odot \mathrm{pc}^{-3}))$
$\log(r_{1/2}/\mathrm{kpc})$

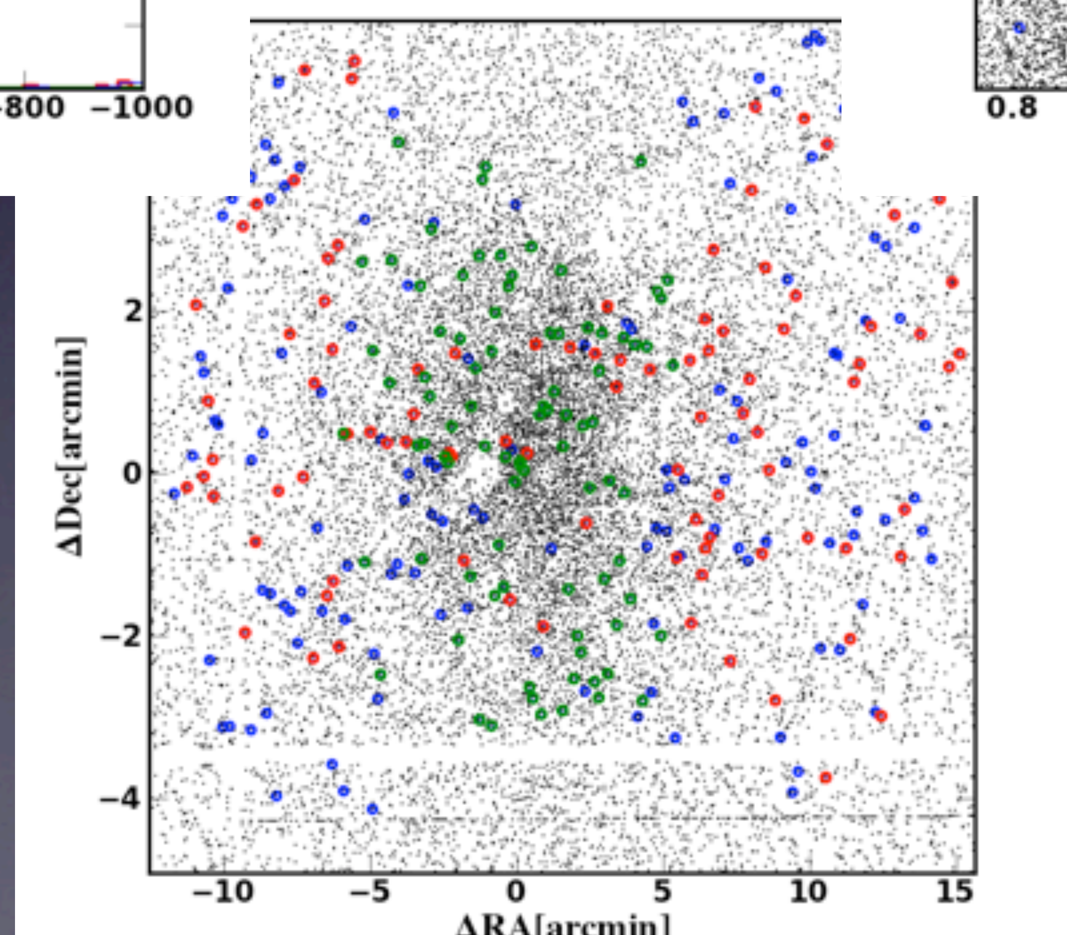
Abundance Matching



And VII



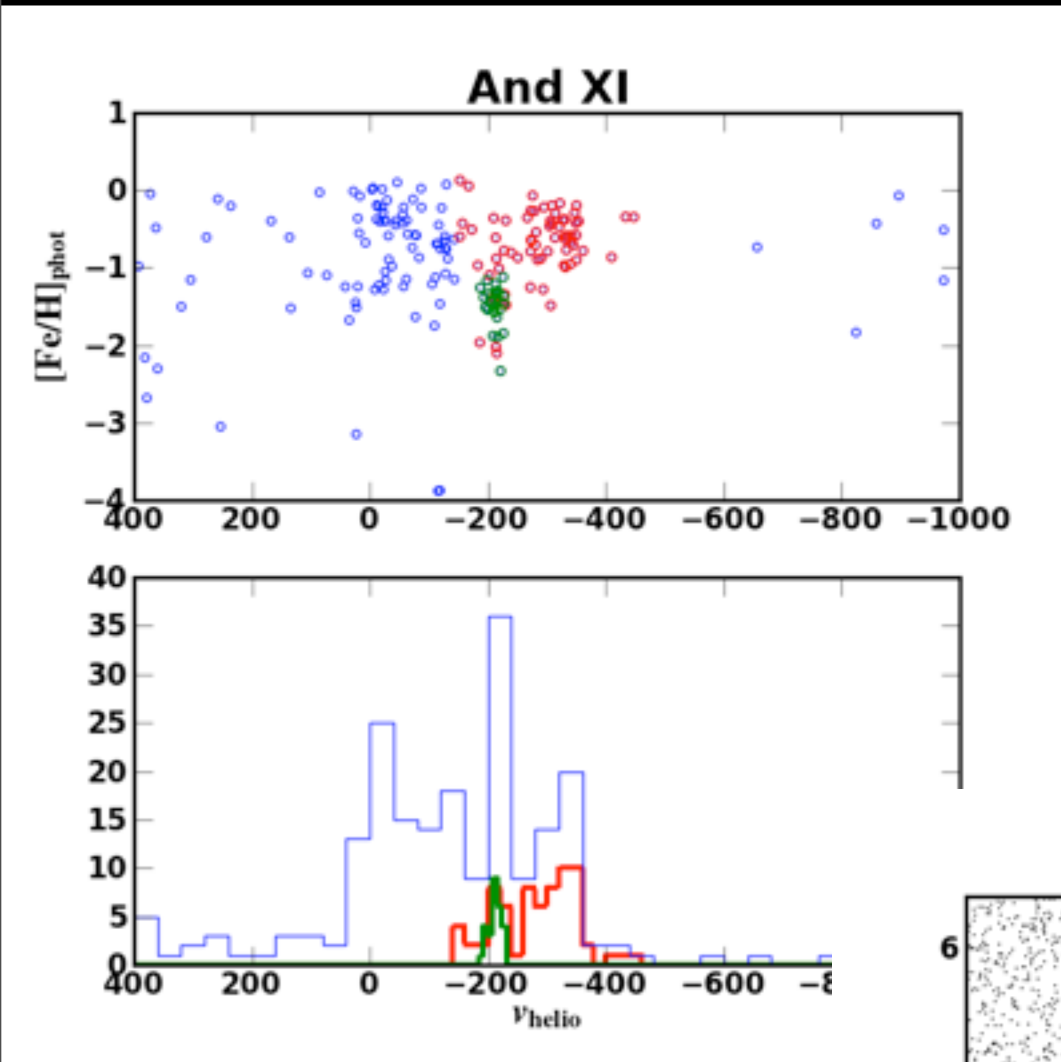


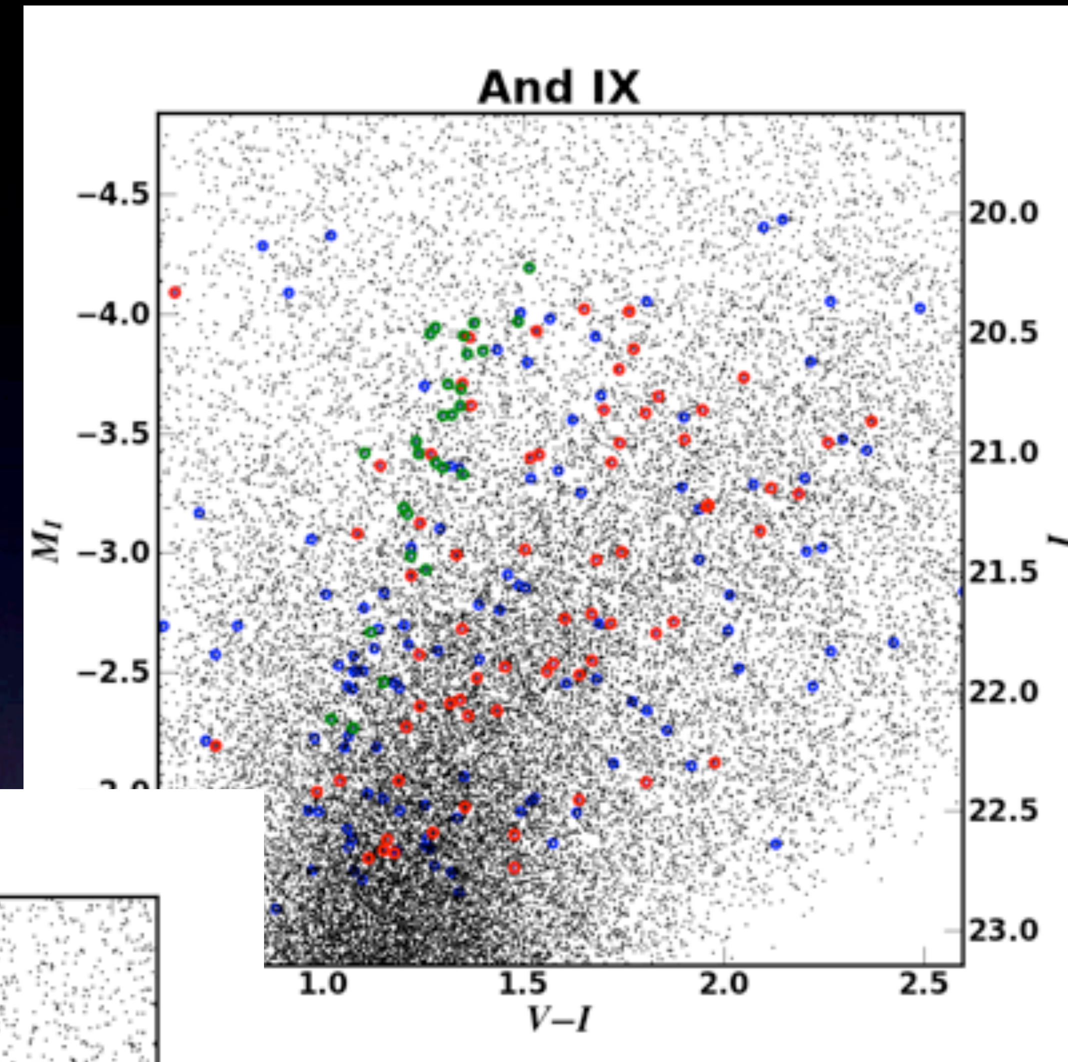


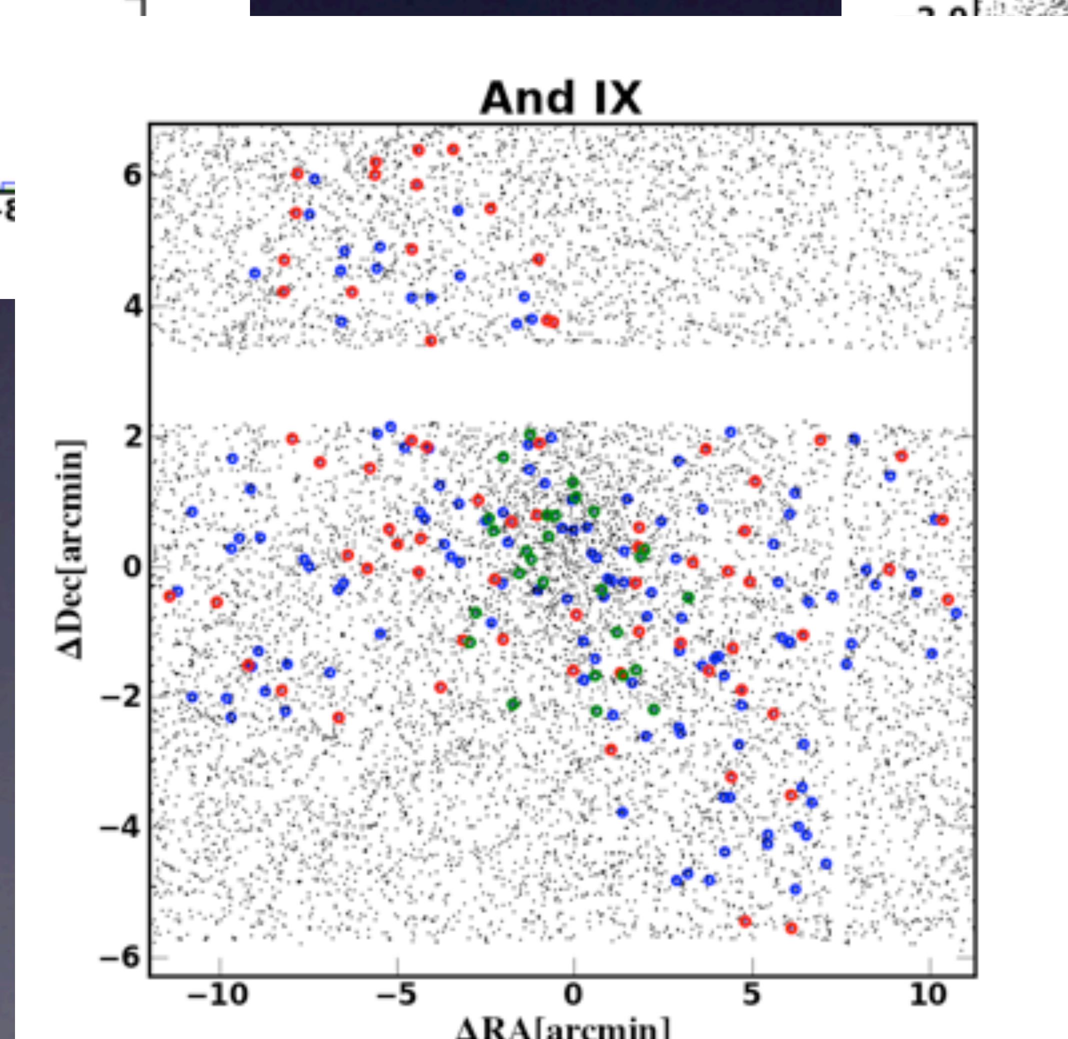
- M_V: -13.3
- L_V: 2 x10^7 $L_\odot$

- v_{helio}: -313 km/s
- σ: 10.9 km/s

And IX



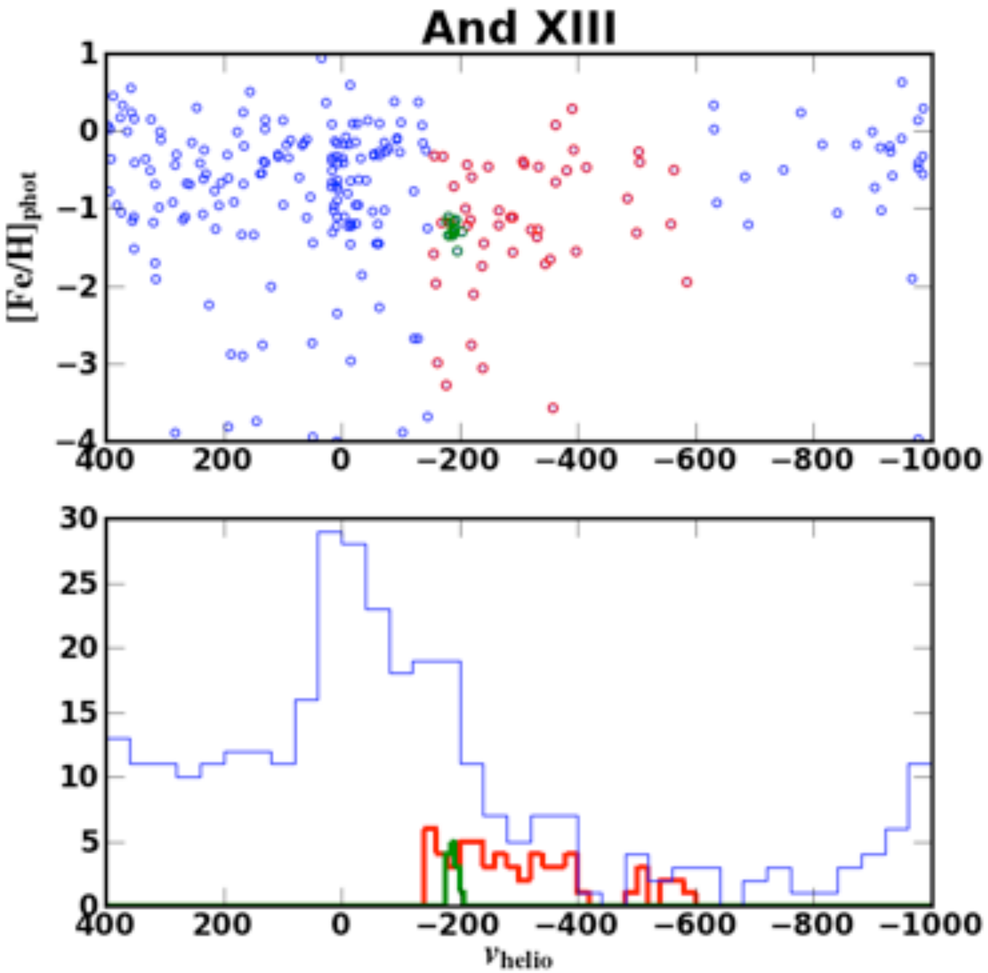


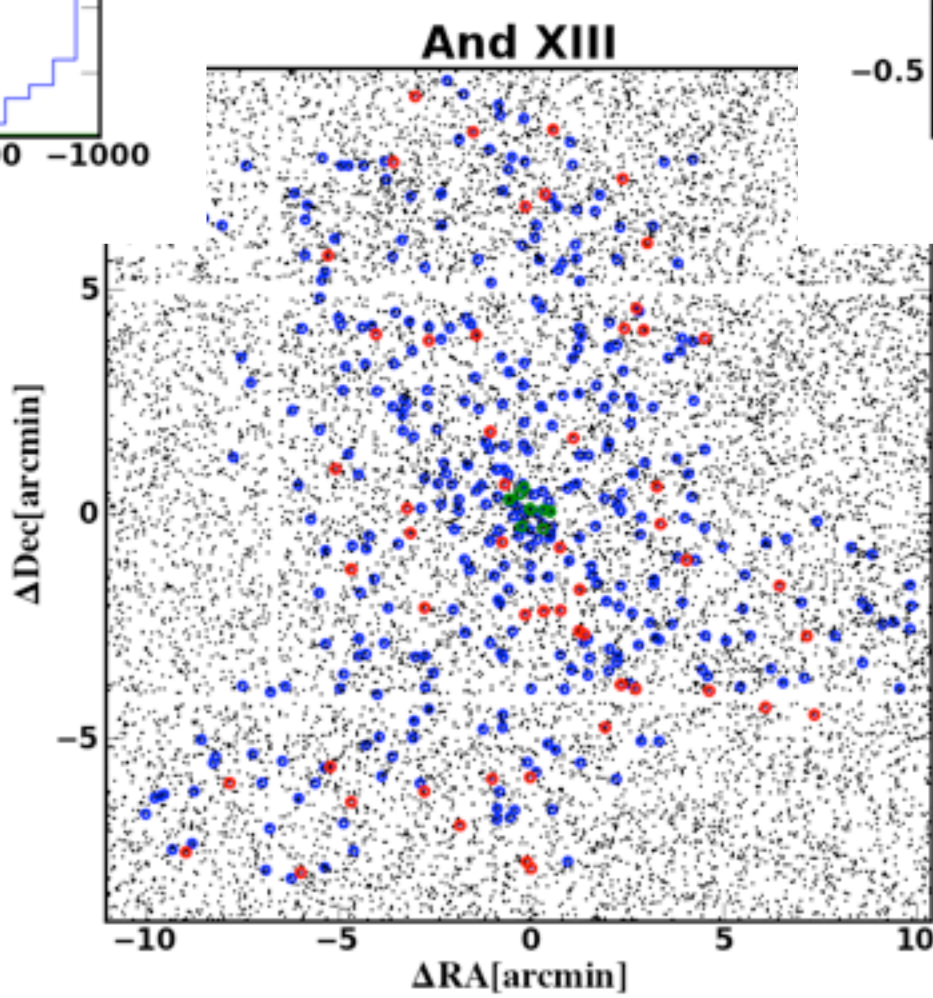


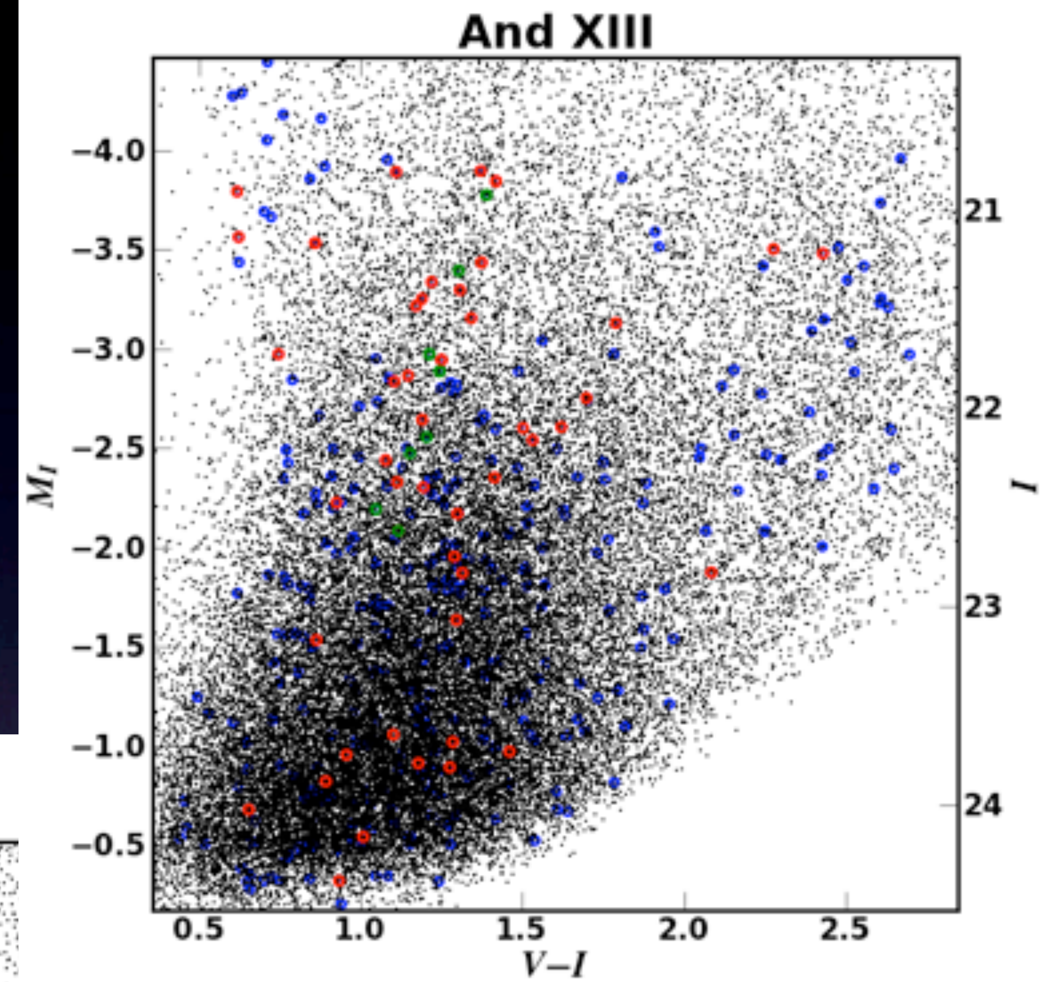
- M_V: -8.3
- L_V: 2 x10^5 $L_\odot$

- v_{helio}: -212 km/s
- σ: 10.4 km/s

And XIII



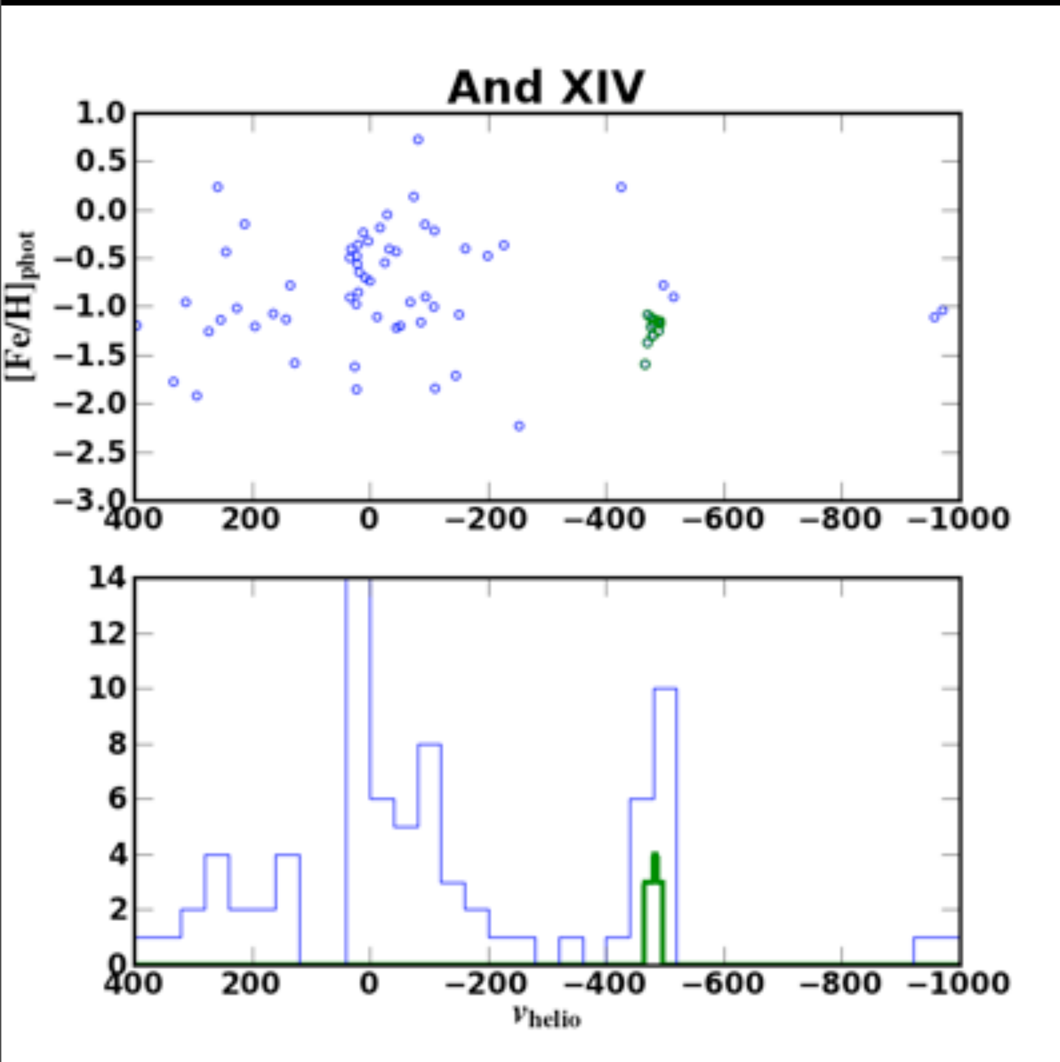


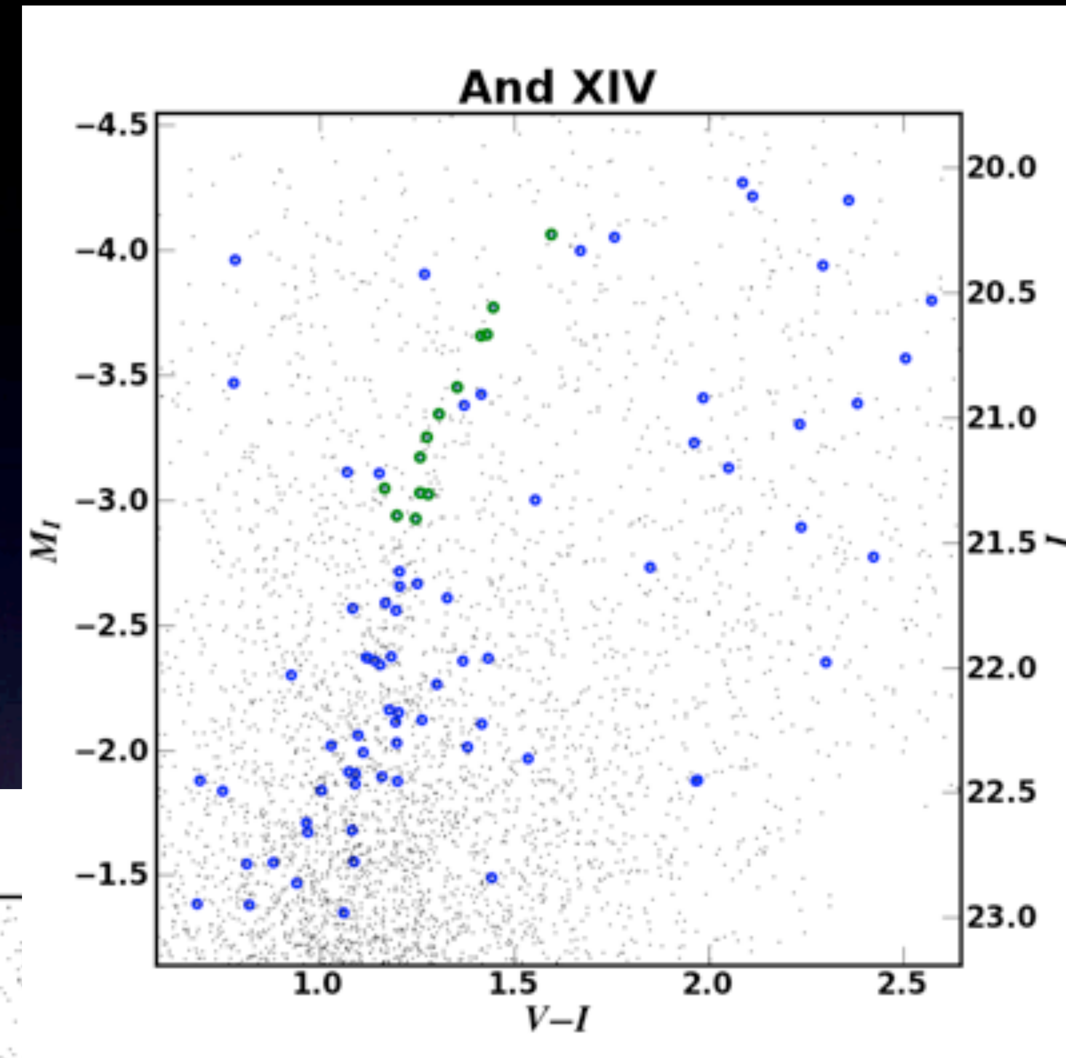


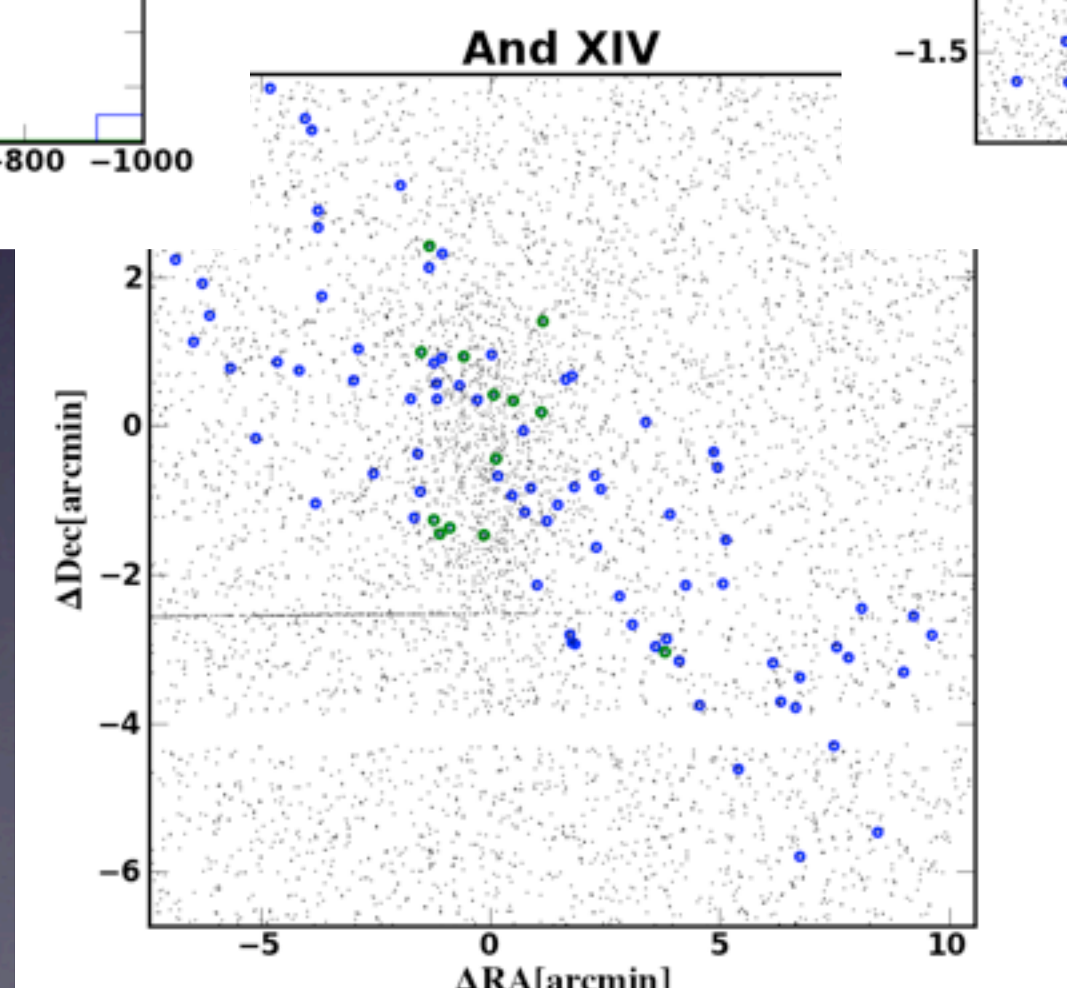
- M_V: -6.9
- L_V: 5 x10^4 $L_\odot$

- v_{helio}: -189 km/s
- σ: 6.7 km/s

And XIV



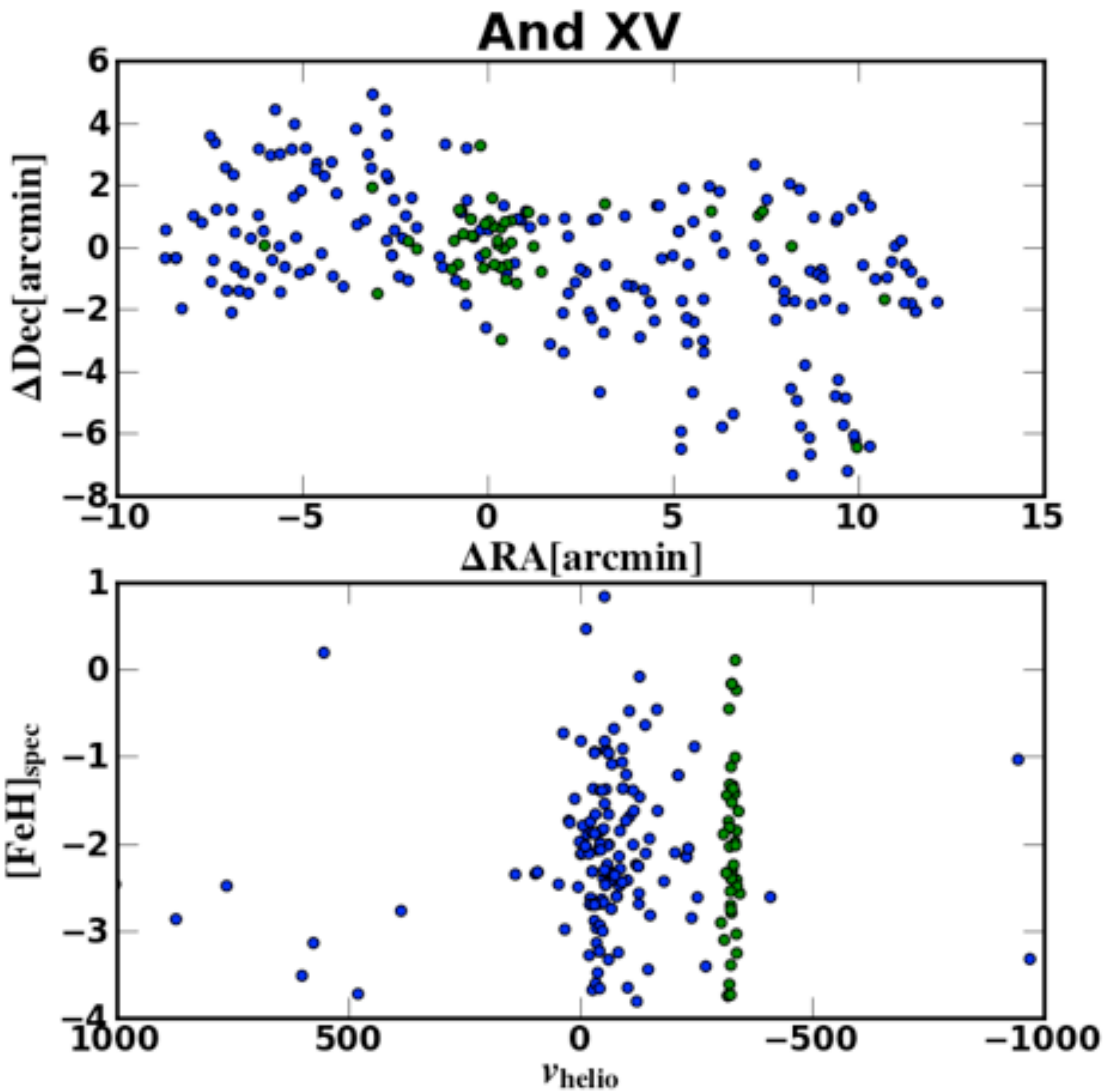


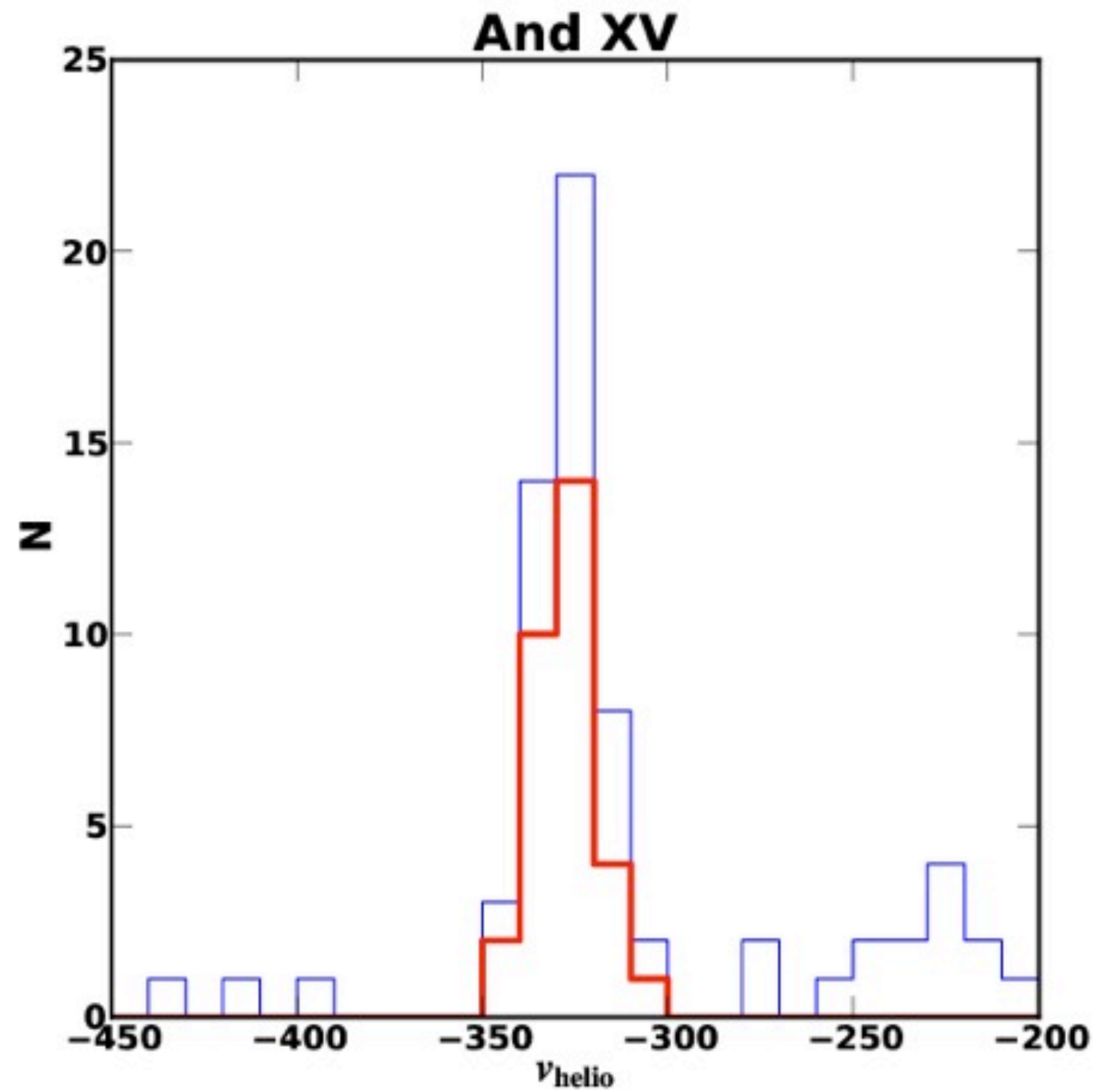


- M_V: -8.3
- L_V: 2 x10^5 $L_\odot$

- v_{helio}: -481 km/s
- σ: 7.8 km/s

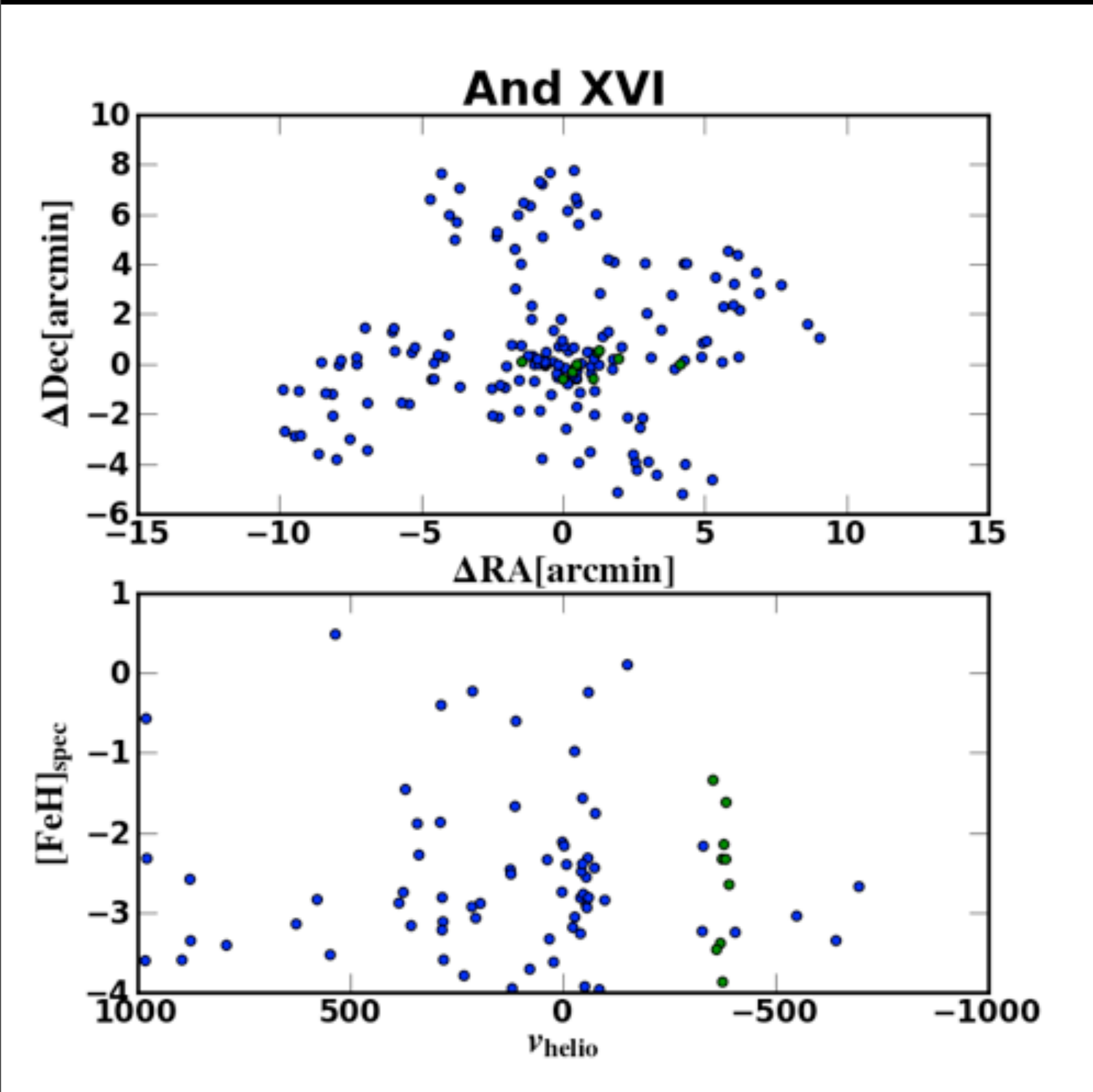
And XV

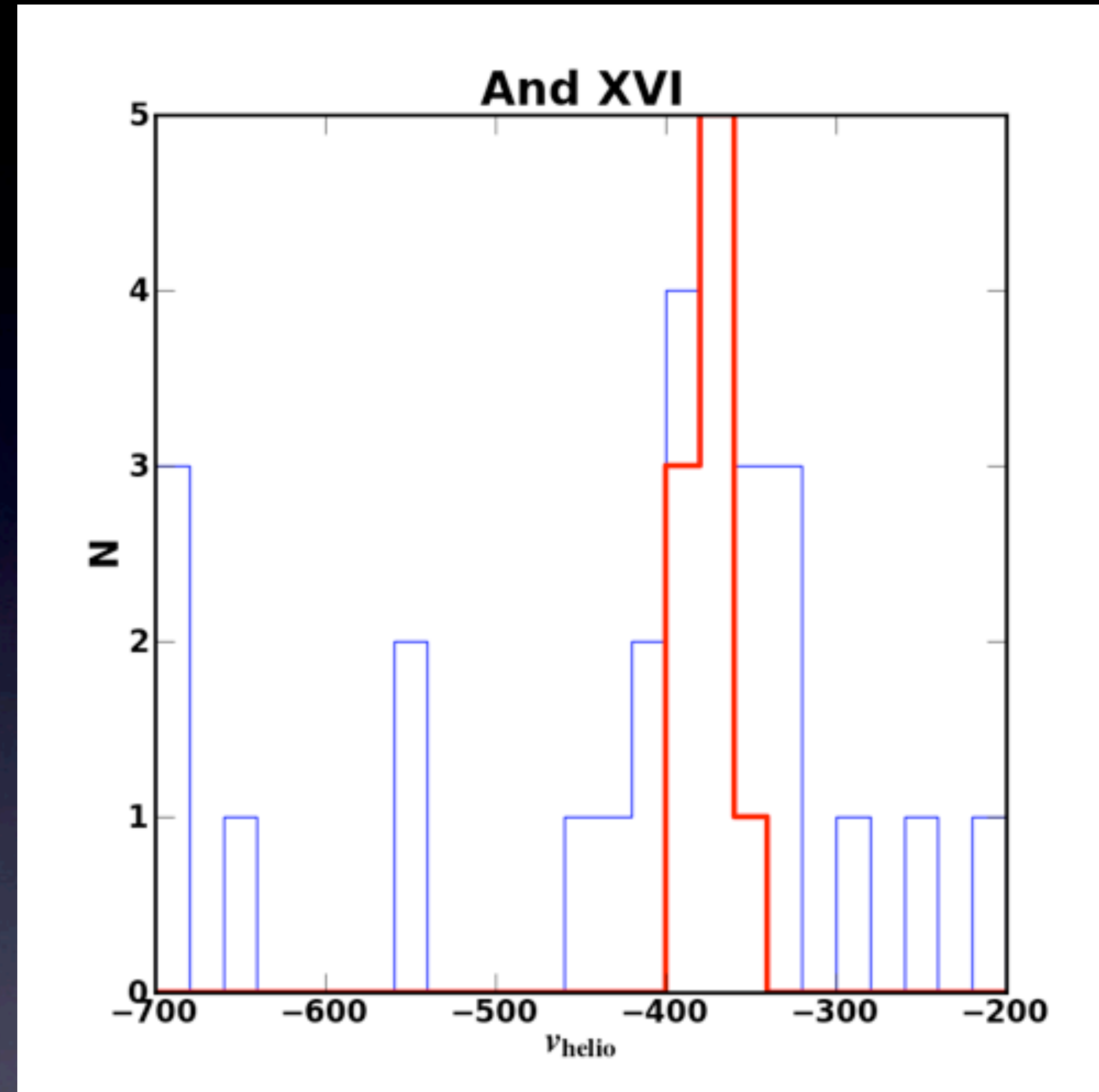




- M_V: -9.8
- L_V: 7 x10^5 $L_\odot$
- v_{helio}: -328 km/s
- σ: 8.5 km/s

And XVI

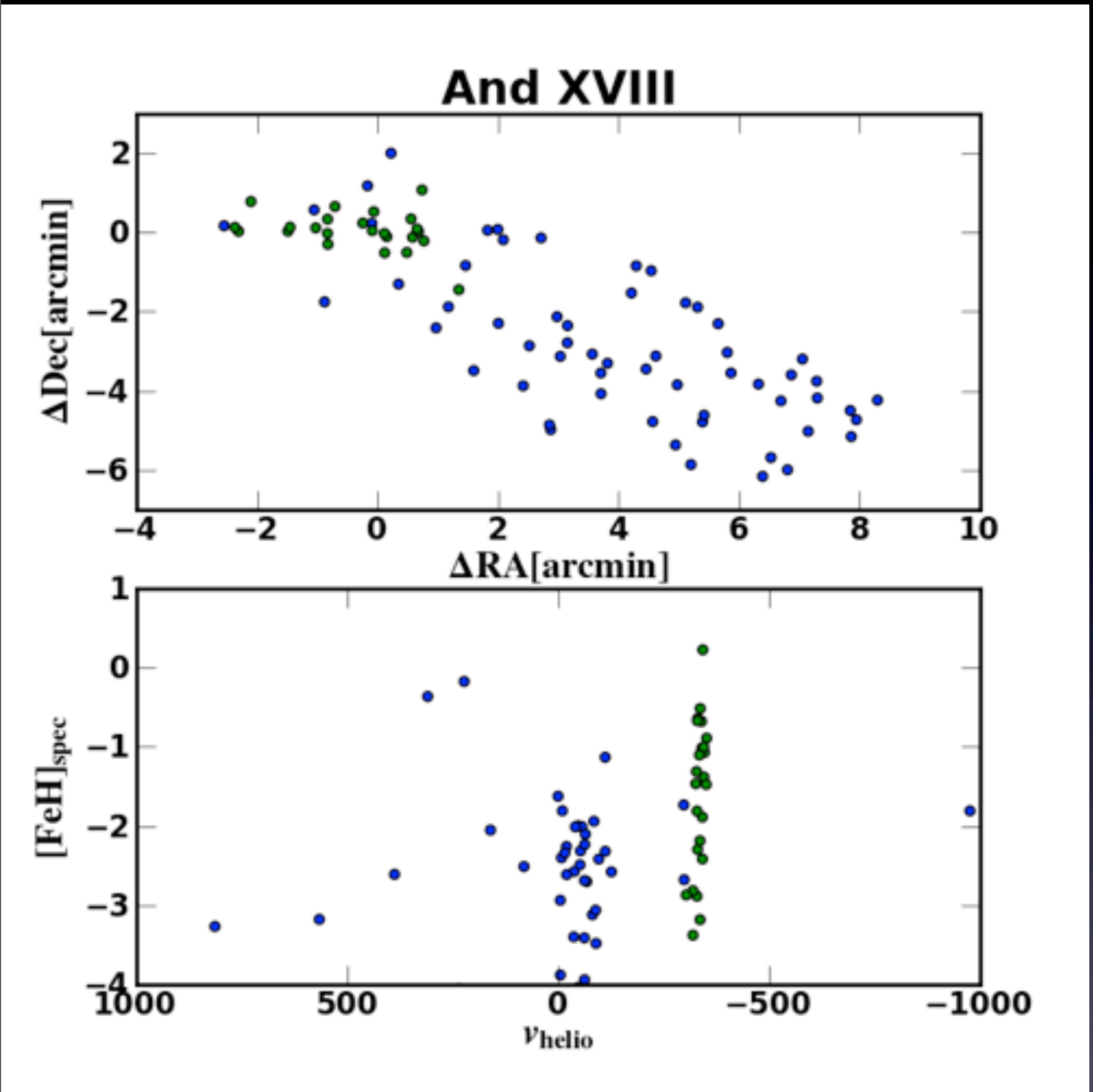


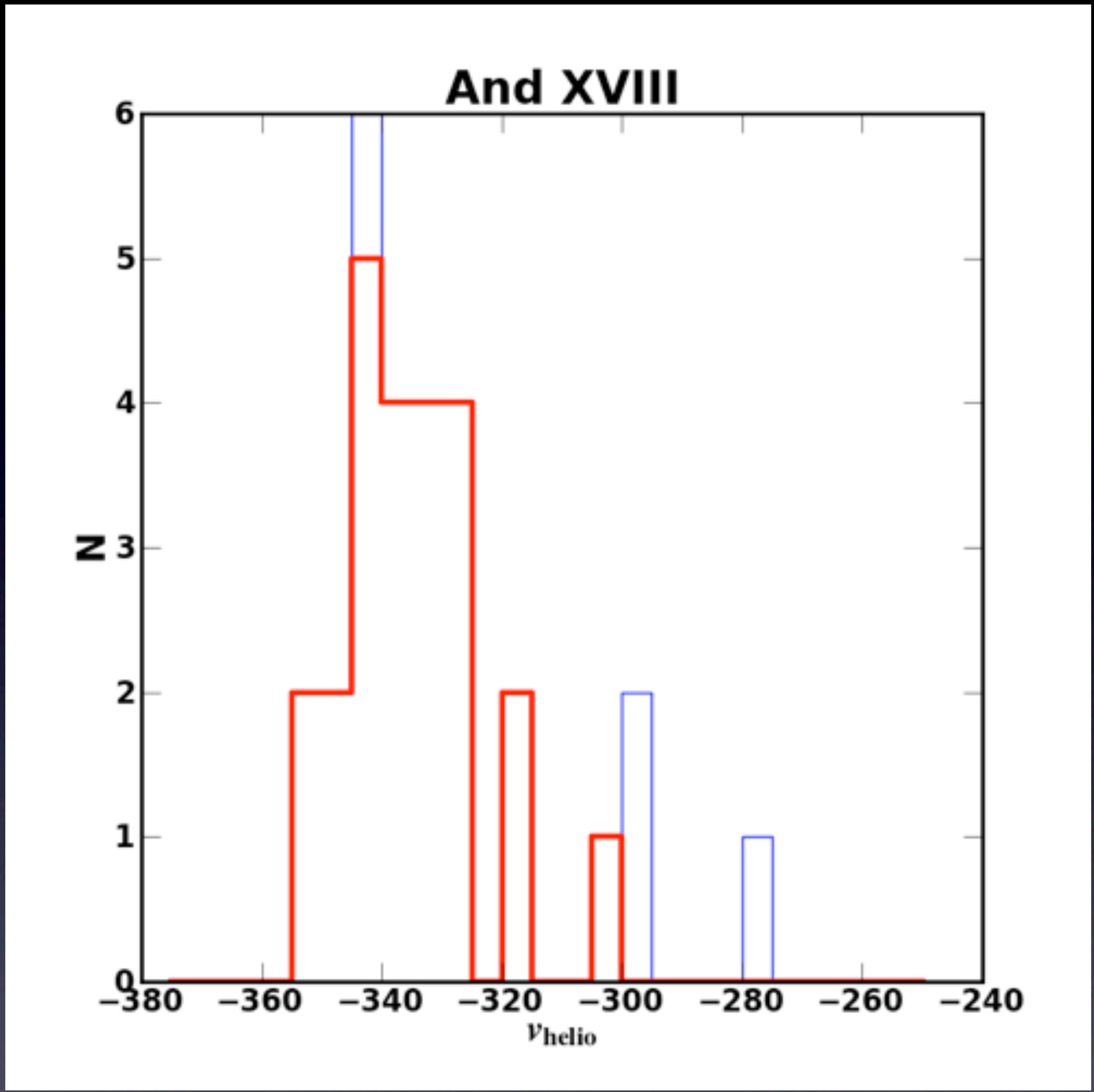


- M_v: -9.0
- L_v: 3 x10^5 $L_\odot$

- v_{helio}: -374 km/s
- σ: 11 km/s

And XVIII

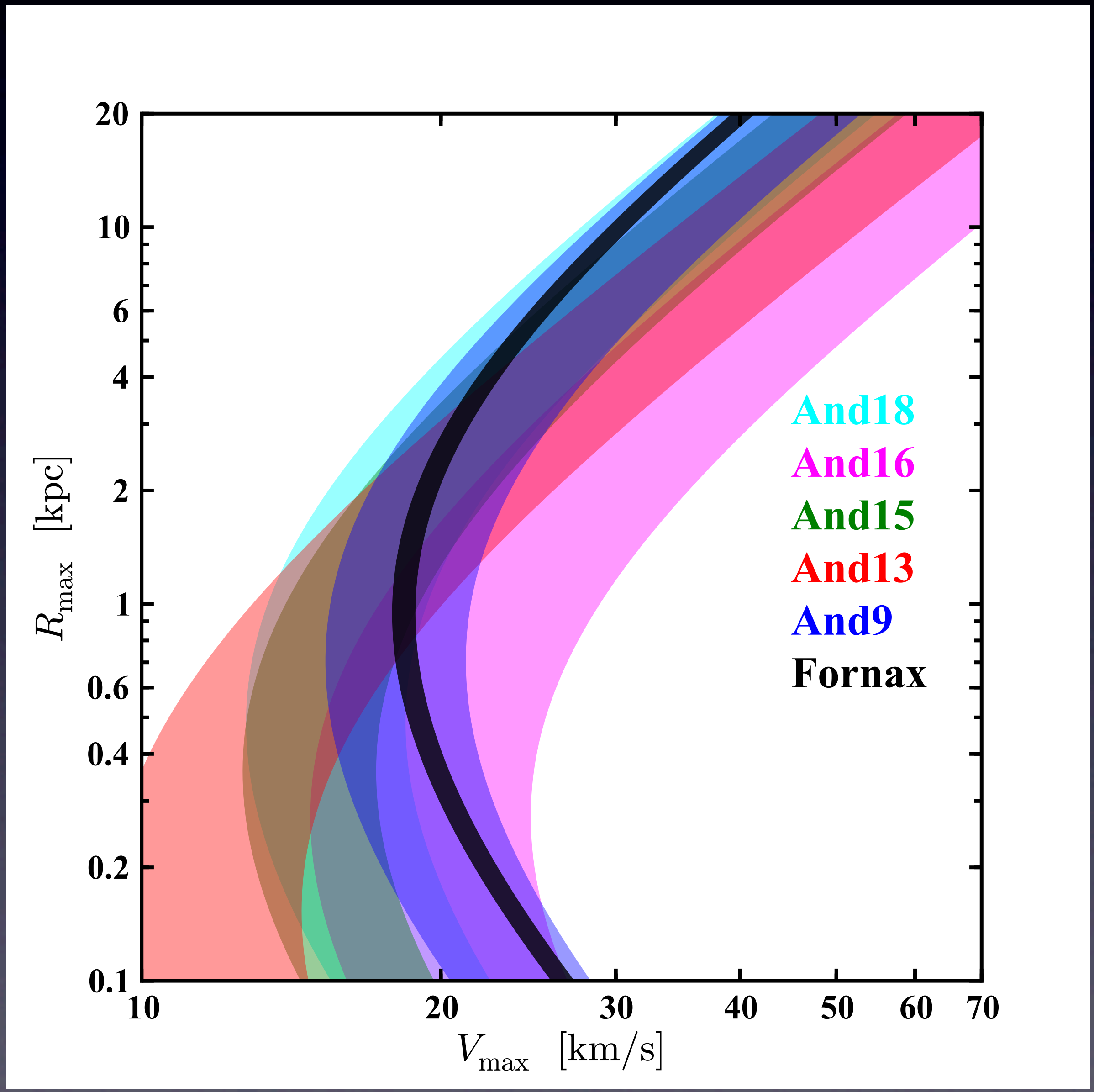




- M_V: -9.7
- L_V: 6 x10^5 $L_\odot$

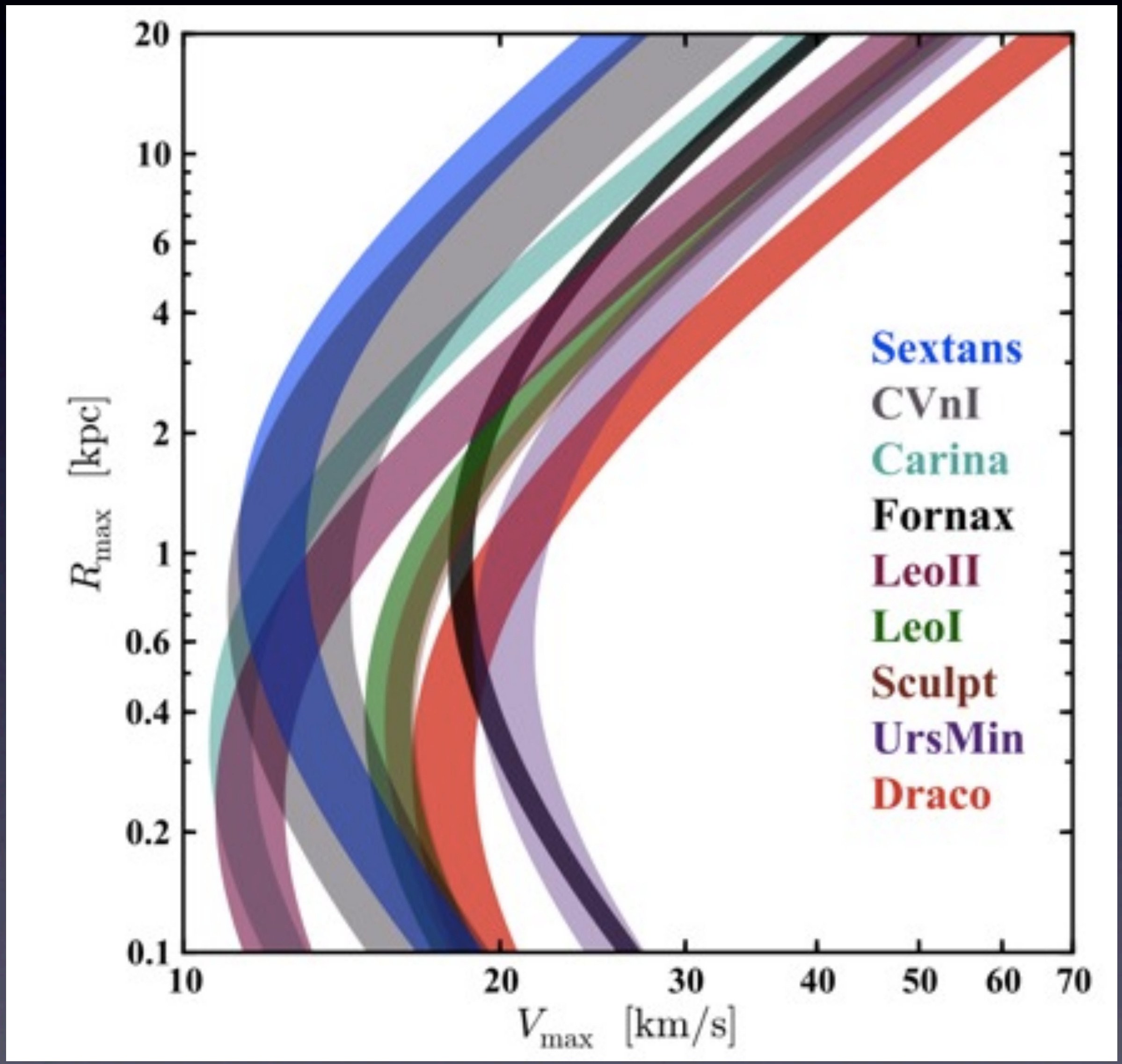
- v_{helio}: -336 km/s
- σ: 8.8 km/s

M31 dSphs



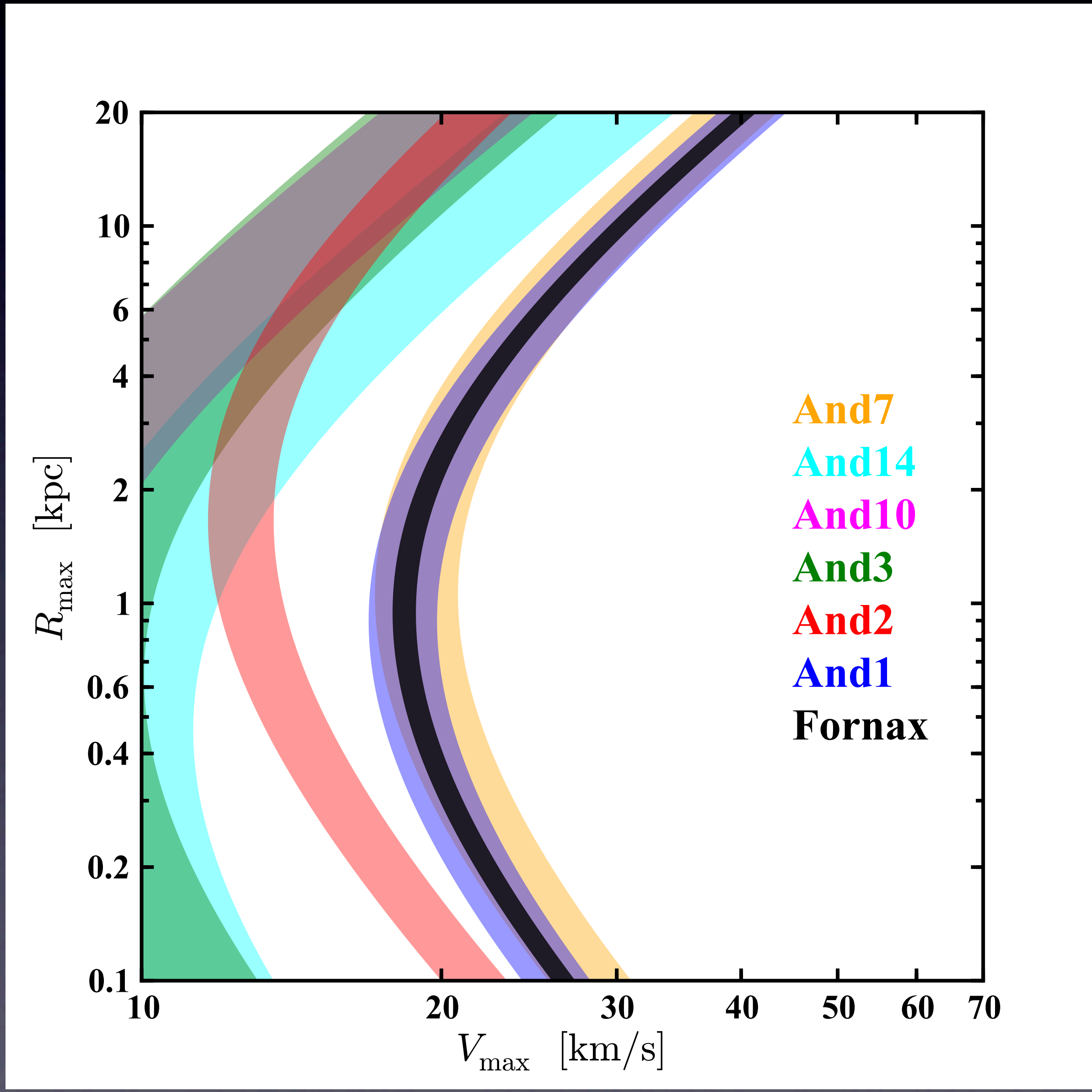
And18
And16
And15
And13
And9
Fornax
R_{max} [kpc]
V_{max} [km/s]
20
10
6
4
2
1
0.6
0.4
0.2
0.1
10
20
30
40
50
60
70

MW dSphs



Sextans
CVnI
Carina
Fornax
LeoII
LeoI
Sculpt
UrsMin
Draco
R_{max} [kpc]
V_{max} [km/s]
20
10
6
4
2
1
0.6
0.4
0.2
0.1
10
20
30
40
50
60
70

M31 dSphs (2)


20
10
6
4
2
1
0.6
0.4
0.2
0.1
R_{max} [kpc]
10
20
30
40
50
60
70
V_{max} [km/s]
And7
And14
And10
And3
And2
And1
Fornax