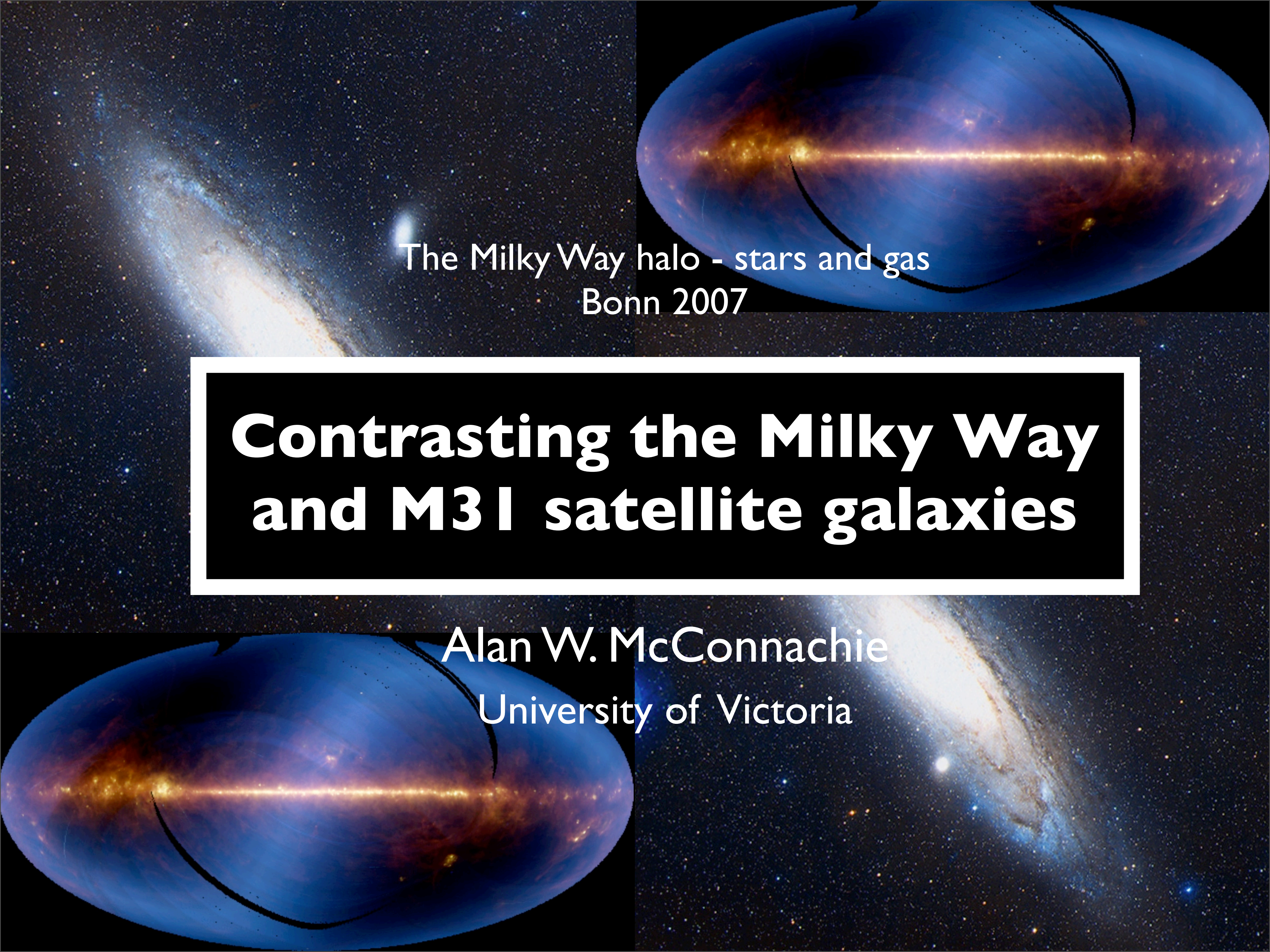


The Milky Way halo - stars and gas
Bonn 2007

Contrasting the Milky Way and M31 satellite galaxies

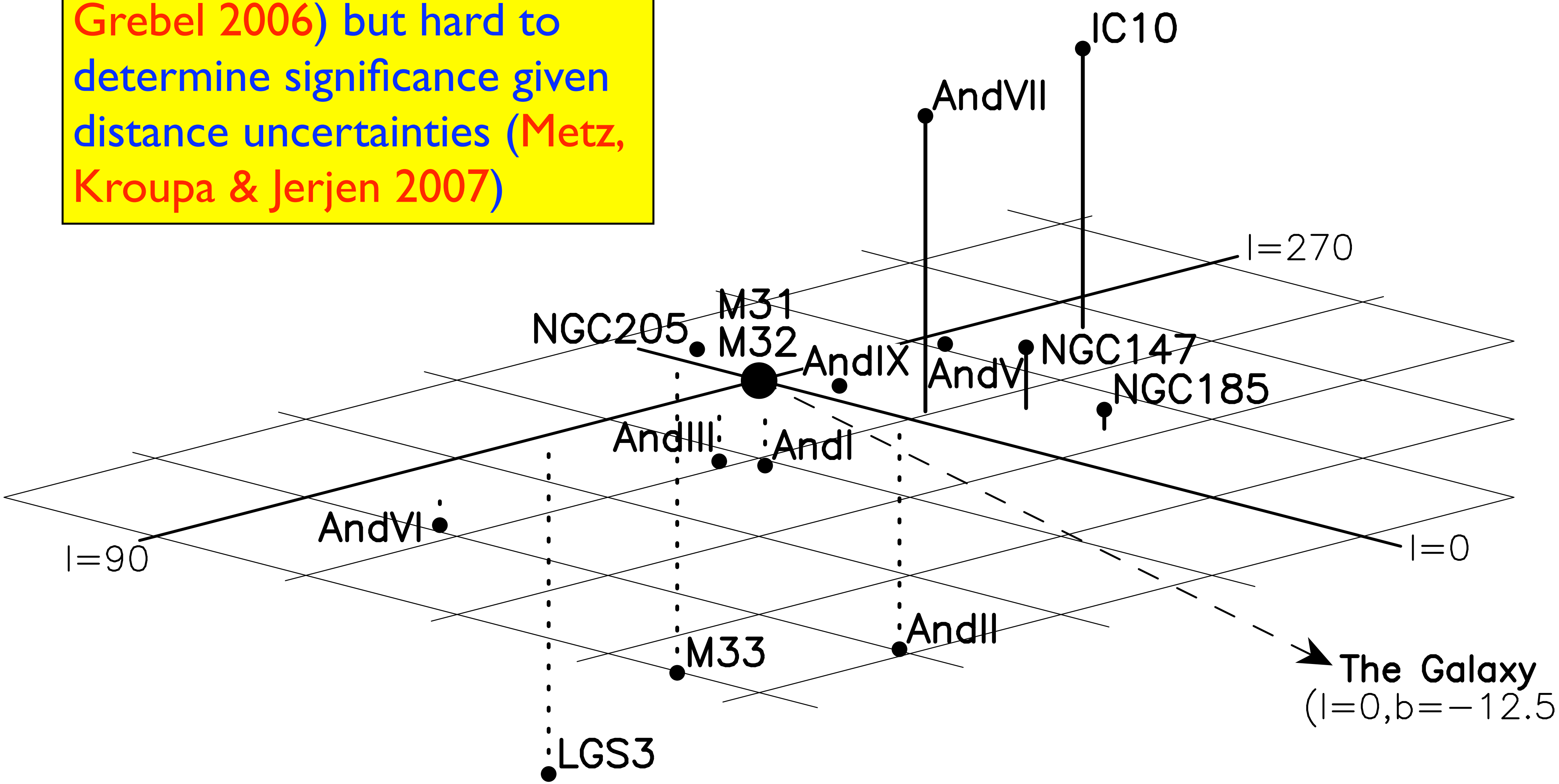
Alan W. McConnachie
University of Victoria

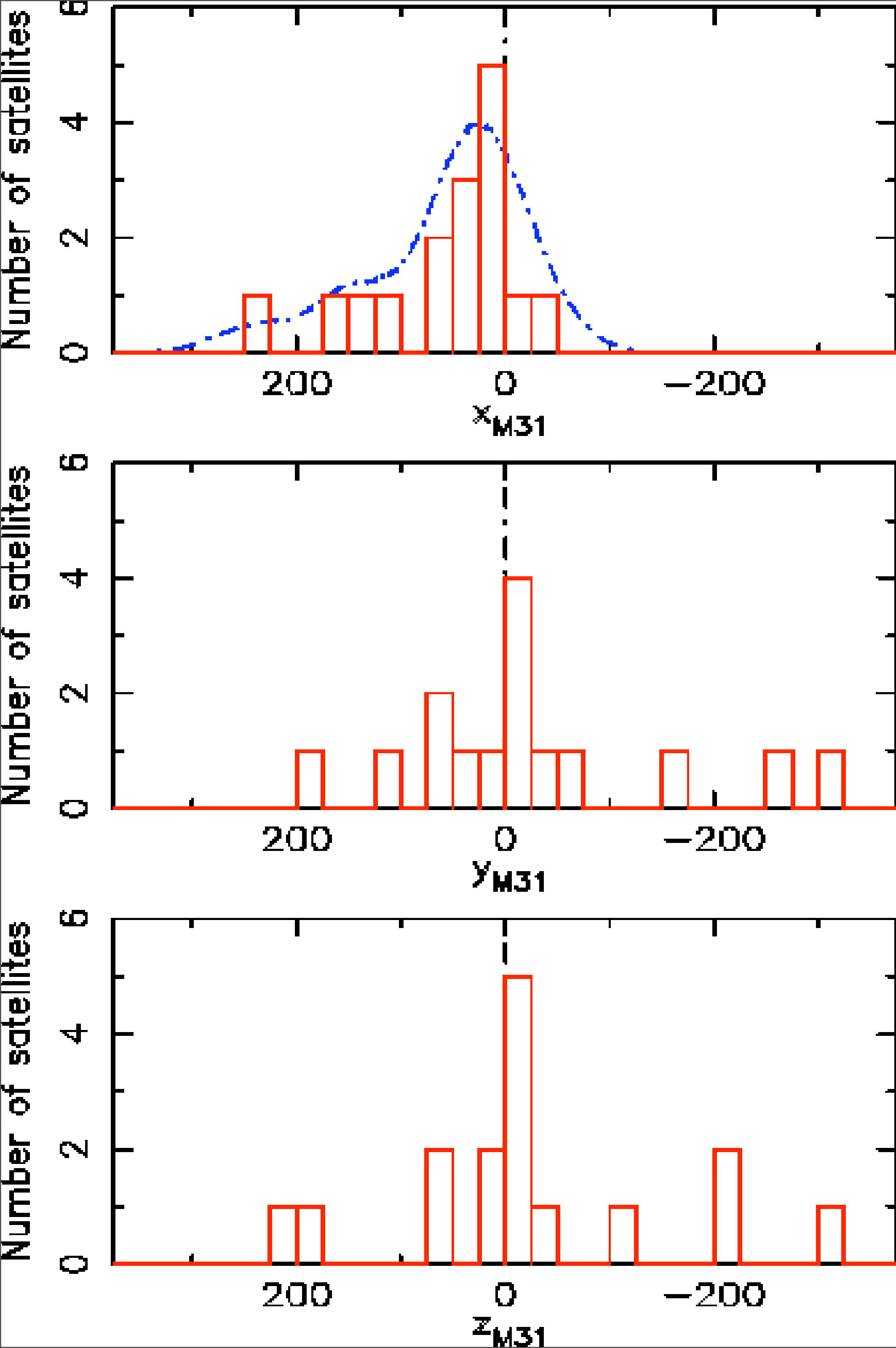
1. Satellite distributions

The M31 satellite system

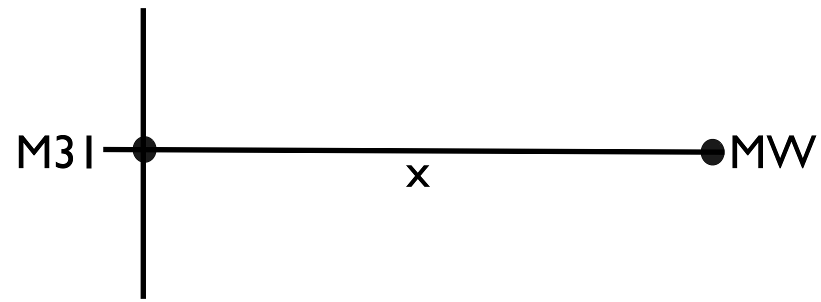
McConnachie & Irwin (2006a)
(distances from McConnachie et al. 2005)

Some evidence of alignments in streams (see Koch & Grebel 2006) but hard to determine significance given distance uncertainties (Metz, Kroupa & Jerjen 2007)

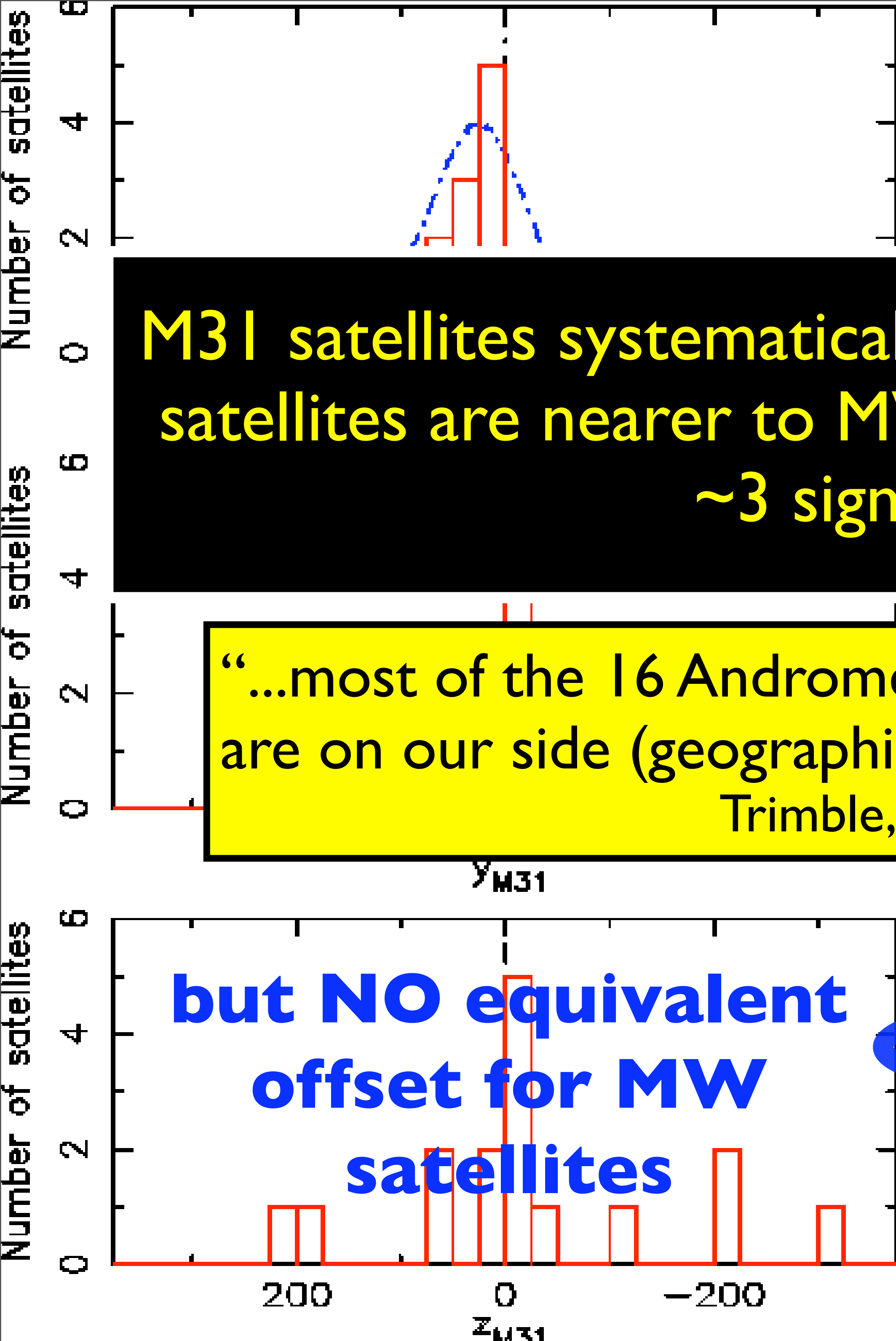




M31			
	mean	median	sigma
x	**58**	**45**	**13**
y	-55	-17	18
z	-25	-7	8



MW			
	mean	median	sigma
x	**19**	**-7**	**14**
y	3	8	26
z	-43	-17	28



M31			
	mean	median	sigma

M31 satellites systematically offset from host, so that satellites are nearer to MW than host. Significant at ~3 sigma level.

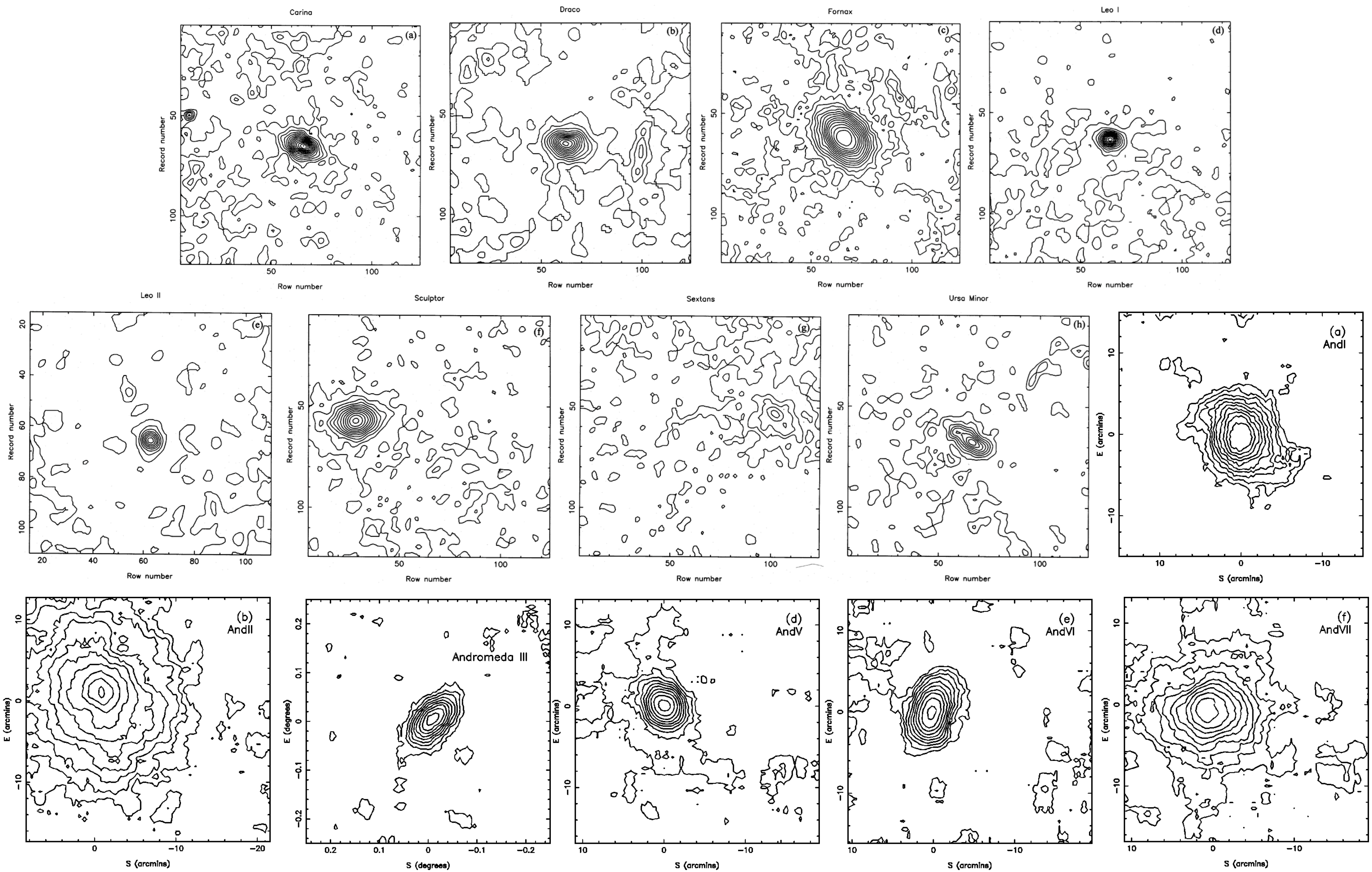
"...most of the 16 Andromeda satellites now known are on our side (geographically, not militarily..."

Trimble, Aschwanden & Hansen (2007)

but NO equivalent offset for MW satellites

MW			
	mean	median	sigma
x	**19**	**-7**	**14**
y	3	8	26
z	-43	-17	28

2. The structure of the dwarf spheroidal satellites



MW: Irwin & Hatzidimitriou (1995)

M31: McConnachie & Irwin (2006b)

MW dSph structural parameters

See more recent studies by

- Odenkirchen et al. (2001) [Draco]
- Palma et al. (2003) [UMi]
- Majewski et al. (2000, 2005), Muñoz et al. (2006) [Carina]
- Westfall et al. (2006) [Sculptor]
- Sohn et al. (2006) [Leo I]
- Koch et al. (2006) [Leo I, Leo II]

Galaxy	r_e (arcmin)	r_c (arcmin)	r_t (arcmin)	$r_{c,g}$ (pc)	$r_{t,g}$ (pc)	c	$r_{1/2,g}$ (pc)
Carina	5.5	8.8 ±1.2	28.8 ±3.6	177 ±28	581 ±86	0.51 ±0.08	137 ±22
Draco	4.5	9.0 ±0.7	28.3 ±2.4	158 ±14	498 ±47	0.50 ±0.05	120 ±11
Fornax	9.9	13.7 ±1.2	71.1 ±4.0	400 ±43	2078 ±177	0.72 ±0.05	339 ±36
Leo I	2.0	3.3 ±0.3	12.6 ±1.5	169 ±19	645 ±87	0.58 ±0.07	133 ±15
Leo II	1.5	2.9 ±0.6	8.7 ±0.9	162 ±35	487 ±60	0.48 ±0.10	123 ±27
Sculptor	6.8	5.8 ±1.6	76.5 ±5.0	101 ±28	1329 ±107	1.12 ±0.12	94 ±26
Sextans	15.5	16.6 ±1.2	160.0 ±50.0	322 ±42	3102 ±1028	0.98 ±0.14	294 ±38
Ursa Minor	10.1	15.8 ±1.2	50.6 ±3.6	196 ±24	628 ±74	0.51 ±0.05	150 ±18

M31 dSph structural parameters

Previously,

- Caldwell et al. (1992)
- Caldwell (1999)

	King profile					
	χ^2	r_c (arcmin)	r_t (arcmin)	r_c (kpc)	r_t (kpc)	$c = \log_{10}(r_t/r_c)$
Andromeda I	1.01	2.7 ± 0.3	10.4 ± 0.9	0.58 ± 0.06	2.3 ± 0.2	0.59 ± 0.06
Andromeda II	1.84	5.2 ± 0.2	22.0 ± 1.0	0.99 ± 0.04	4.2 ± 0.2	0.63 ± 0.03
Andromeda III	0.89	1.3 ± 0.2	7.2 ± 1.2	0.29 ± 0.04	1.5 ± 0.3	0.74 ± 0.10
Andromeda V	1.02	1.2 ± 0.2	5.3 ± 1.0	0.28 ± 0.04	1.2 ± 0.2	0.63 ± 0.11
Andromeda VI	0.96	2.1 ± 0.2	6.2 ± 0.4	0.48 ± 0.06	1.4 ± 0.1	0.46 ± 0.06
Andromeda VII	0.91	2.0 ± 0.1	19.3 ± 1.6	0.45 ± 0.02	4.3 ± 0.4	0.98 ± 0.04
Cetus	1.00	1.3 ± 0.1	32.0 ± 6.5	0.29 ± 0.02	7.1 ± 1.5	1.40 ± 0.10

MW dSph structural parameters

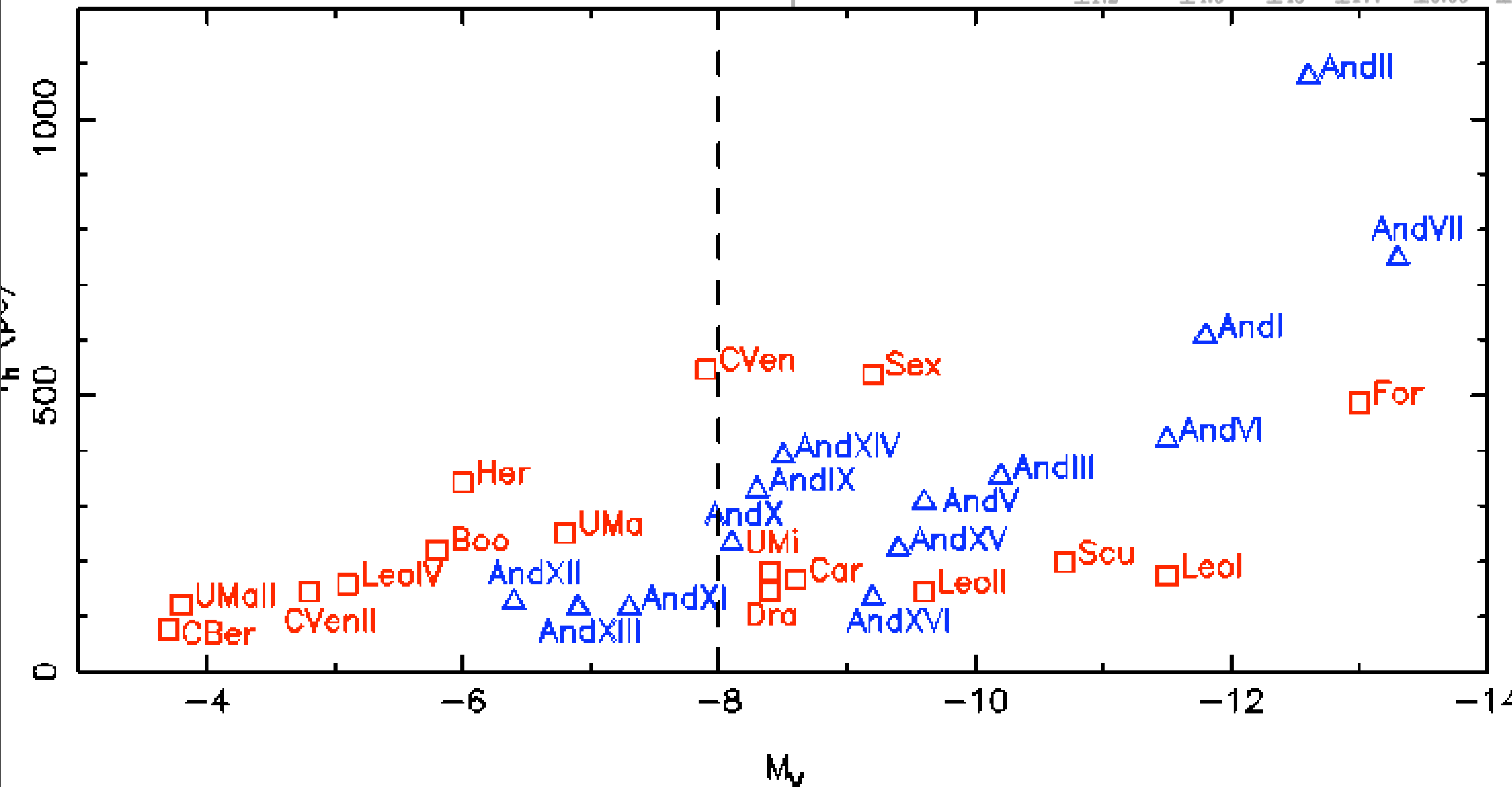
See more recent studies by

- Odenl
- Palma
- Majew

al. (2006) [Carina]

Galaxy	r_e (arcmin)	r_c (arcmin)	r_t (arcmin)	$r_{c,g}$ (pc)	$r_{t,g}$ (pc)	c	$r_{1/2,g}$ (pc)
							137 ±22
							120 ±11
Fornax	9.9	13.7 ±1.2	71.1 ±4.0	400 ±43	2078 ±177	0.72 ±0.05	339 ±36

M31 satellites are a factor of 2 - 3 larger in scale radi than MW counterparts



Peñarrubia, McConnachie & Navarro (2007)

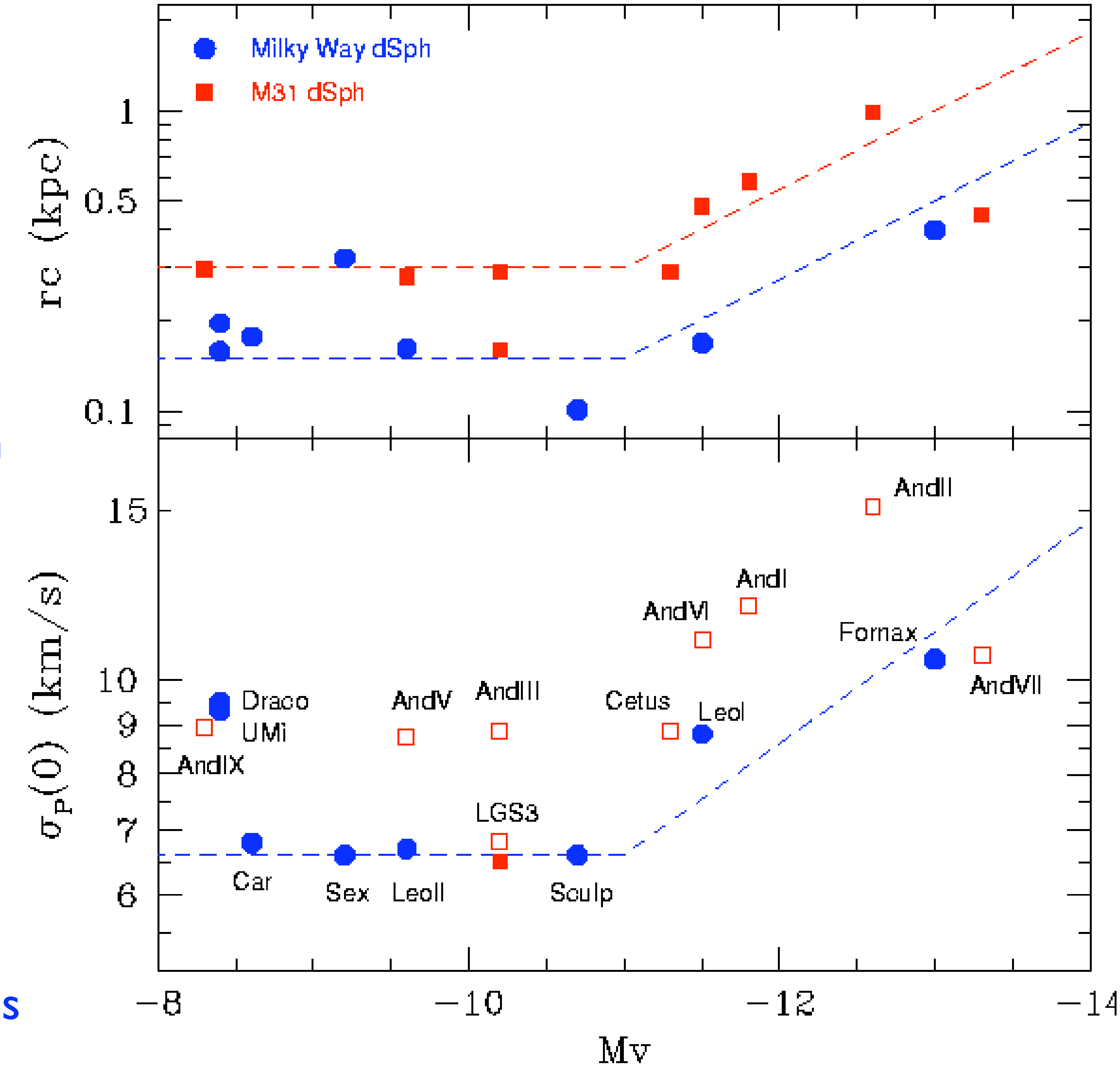
(Equilibrium)

1. MW and M31 satellites occupy similar haloes?

- expect difference in velocity dispersions

2. MW and M31 have similar velocity dispersions

- haloes would be less massive around M31

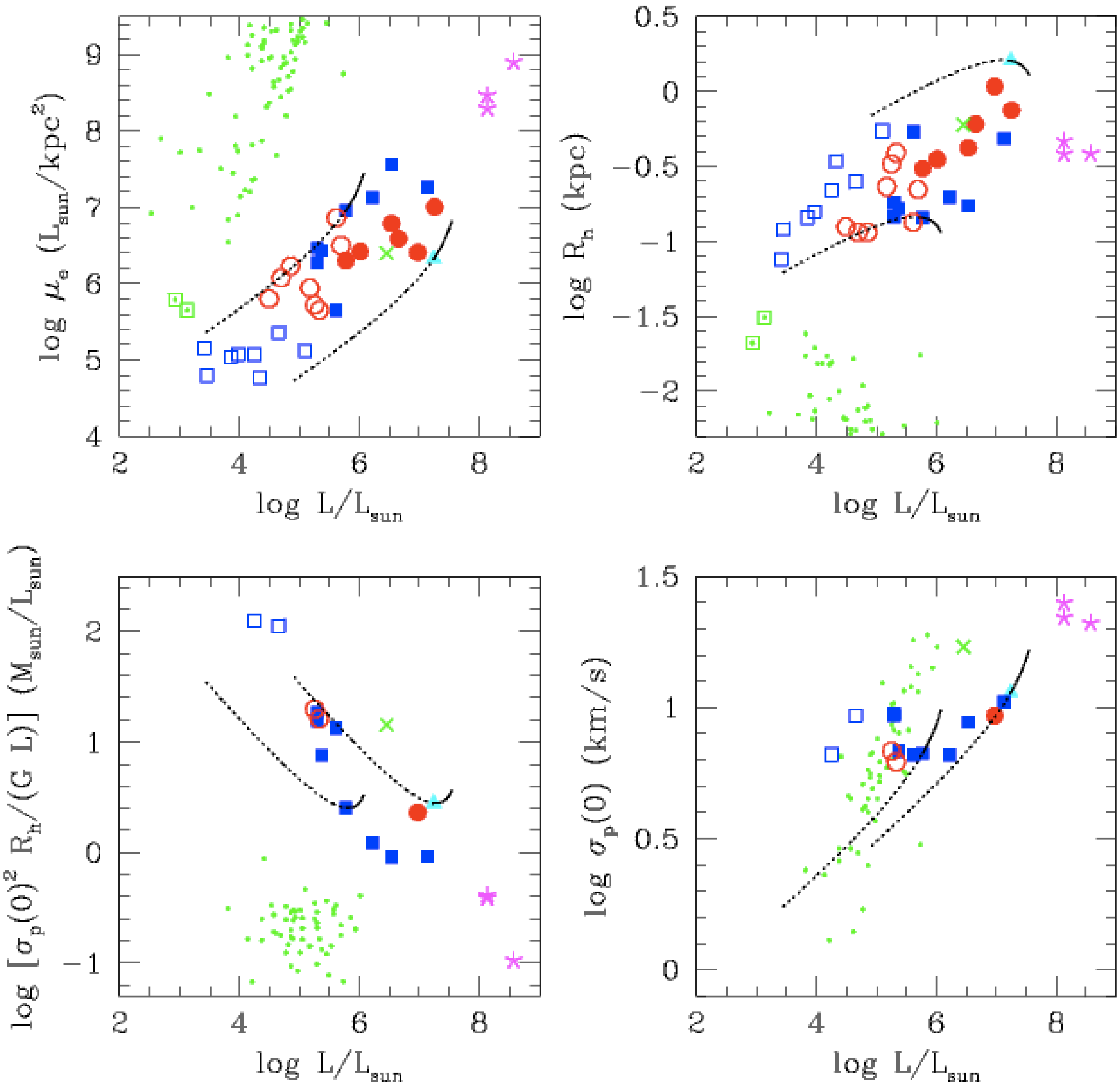


Peñarrubia, Navarro & McConnachie (2007)

(Tides)

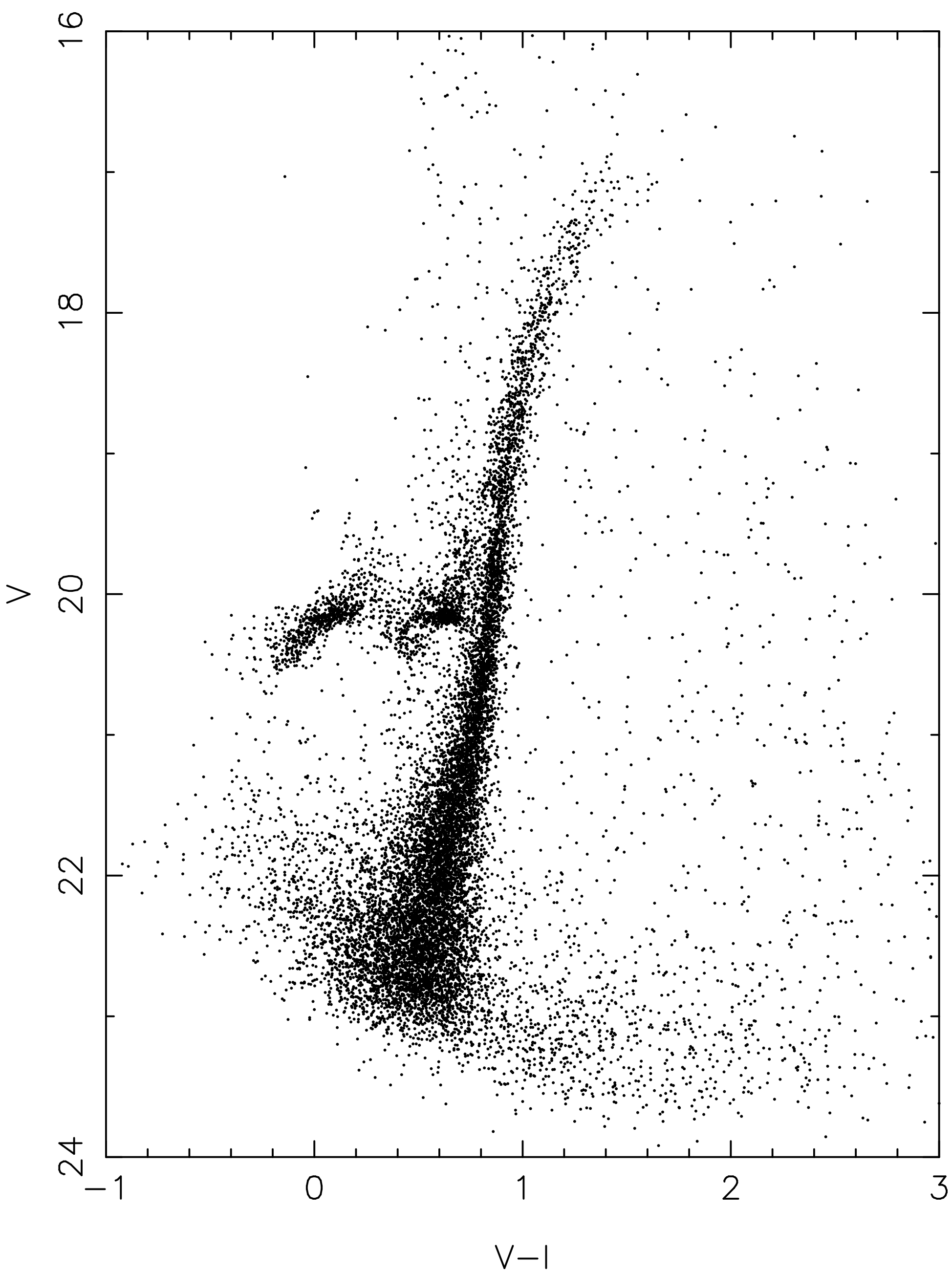
3. MW and M31 dSphs have been affected by different amounts due to tidal effects?

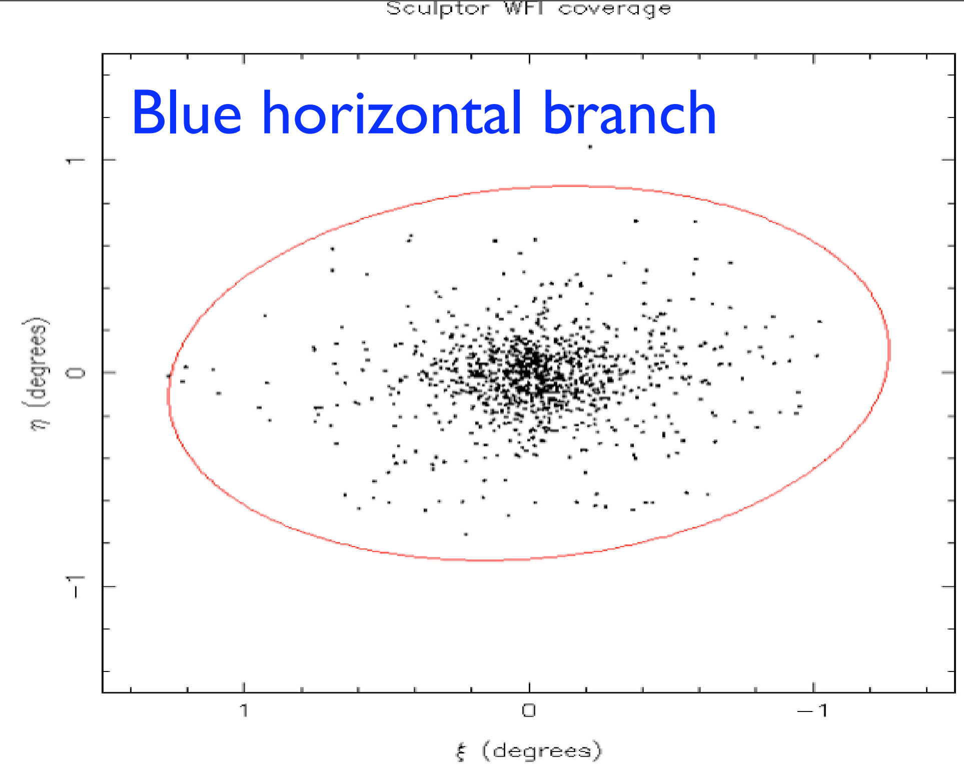
- cannot evolve a M31 satellite into an MW satellite, or vice-versa

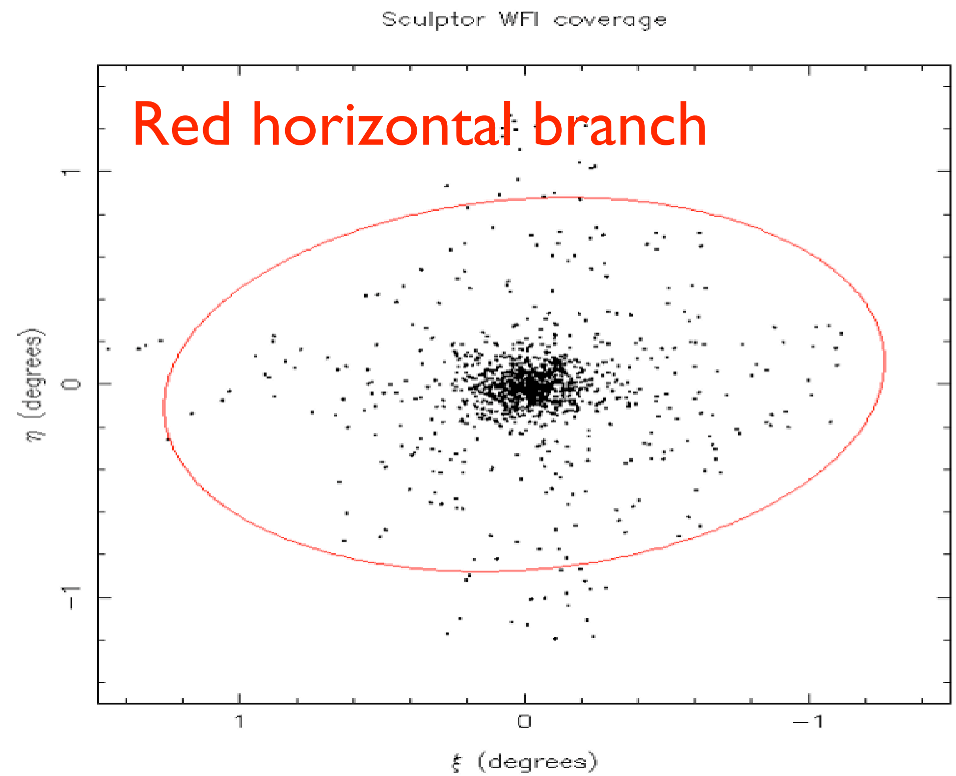


Tolstoy et al. (2004)

Dynamical structure of Sculptor



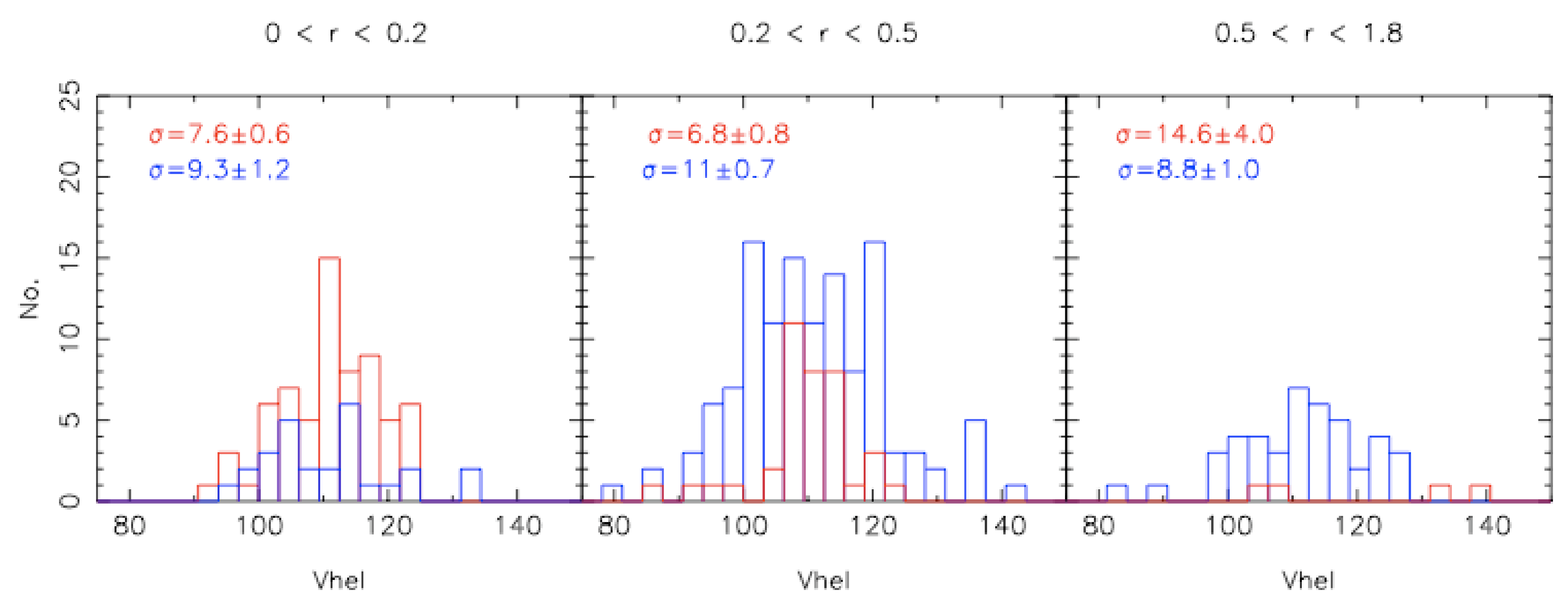




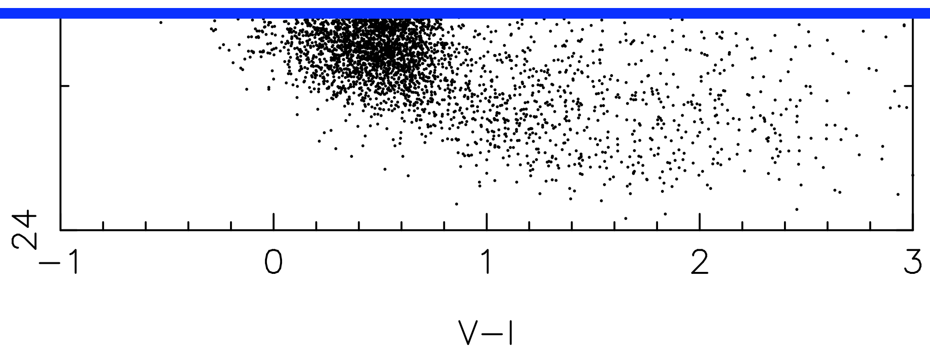
Tolsto

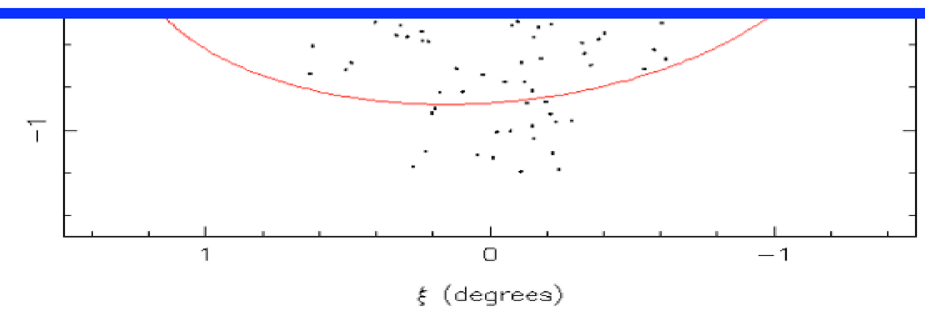
Dynam

- How common is this structure?
- Do the M31 dwarfs show anything similar?



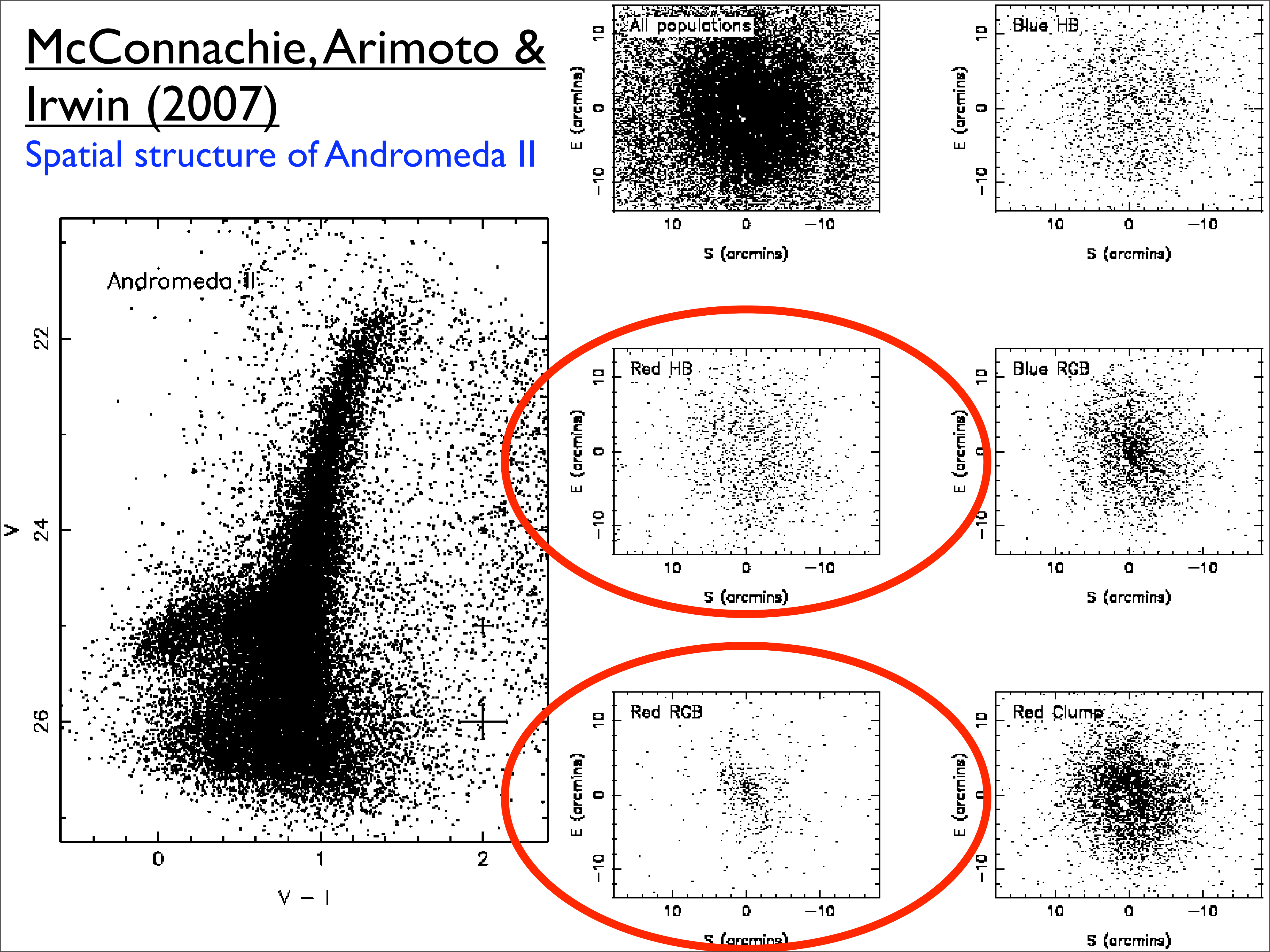
Distinct components spatially, kinematically and by metallicity

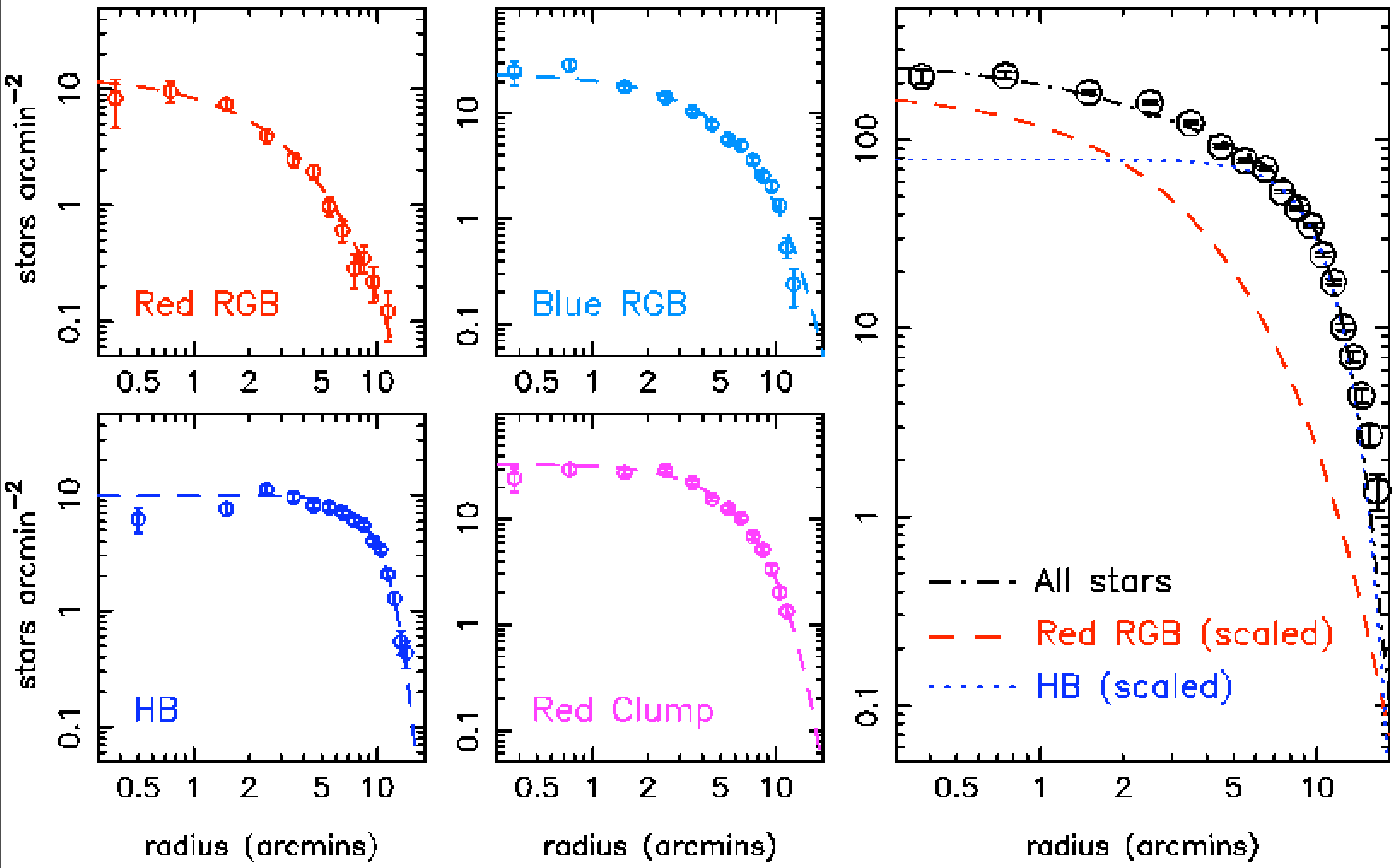




McConnachie, Arimoto & Irwin (2007)

Spatial structure of Andromeda II

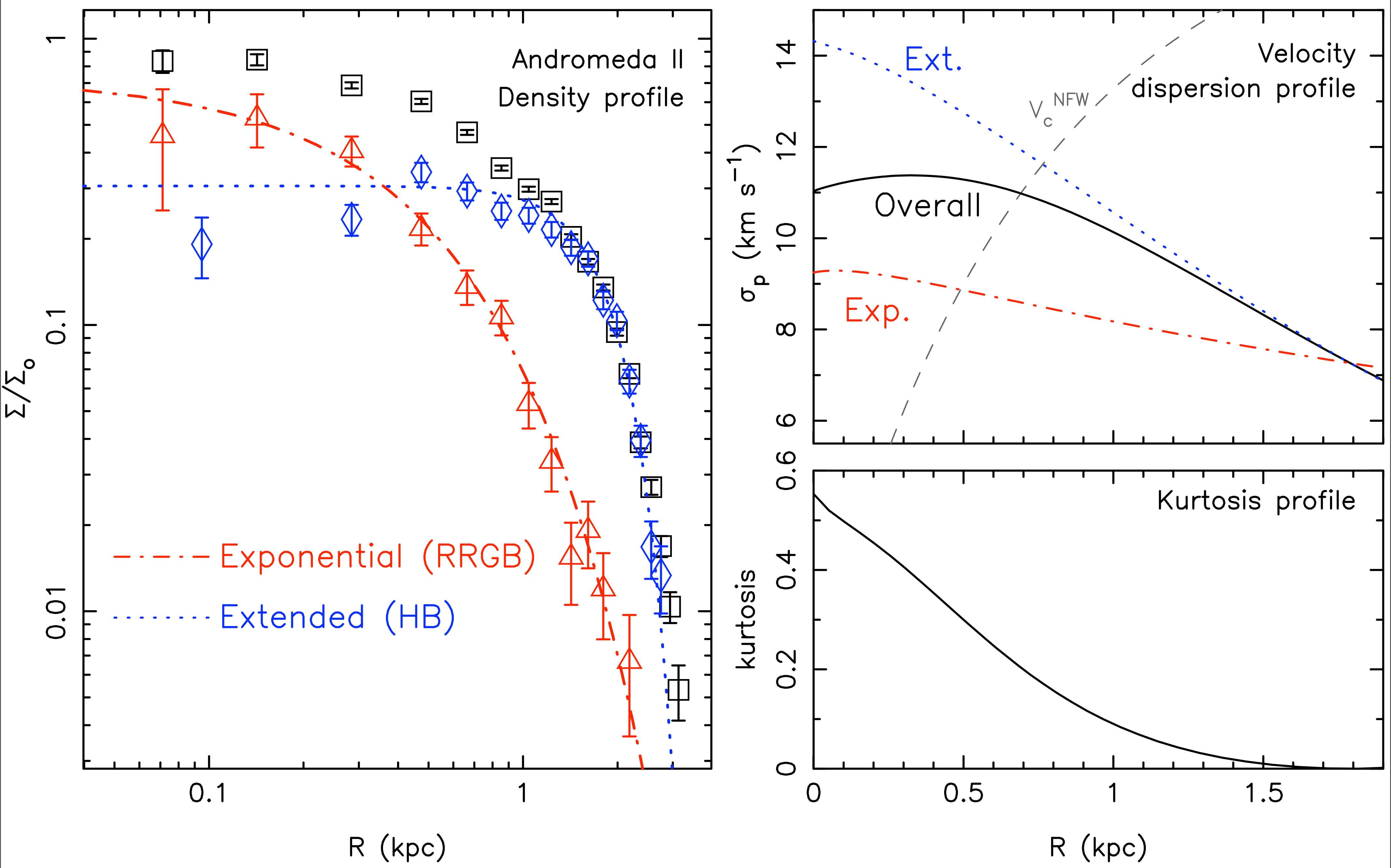




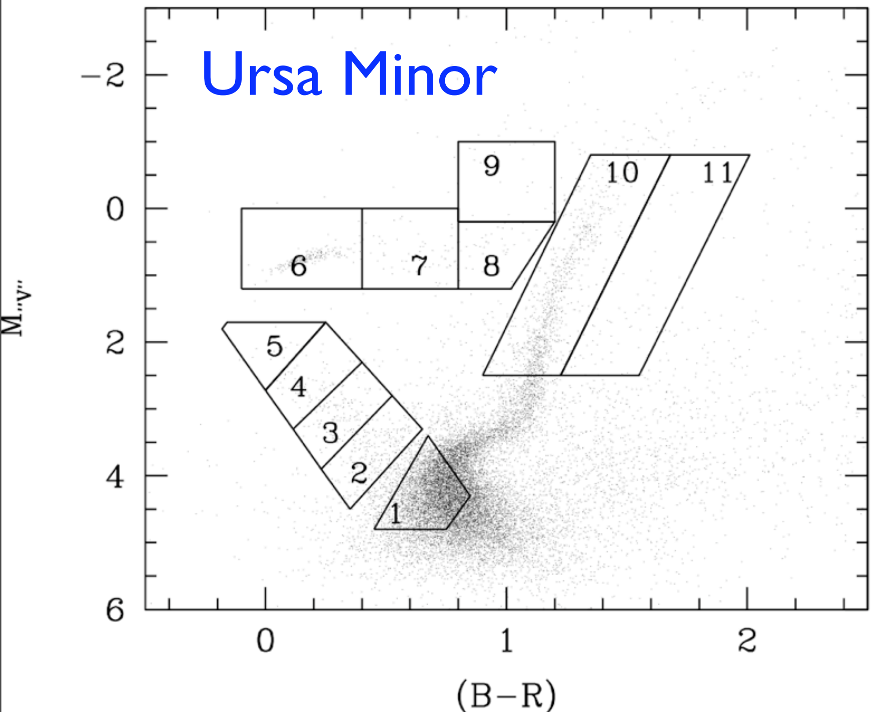
stars arcmin^{-2}
Red RGB
Blue RGB
HB
Red Clump
All stars
Red RGB (scaled)
HB (scaled)
radius (arcmins)

McConnachie, Penarrubia & Navarro (2007)

Dynamical structure of two stellar components

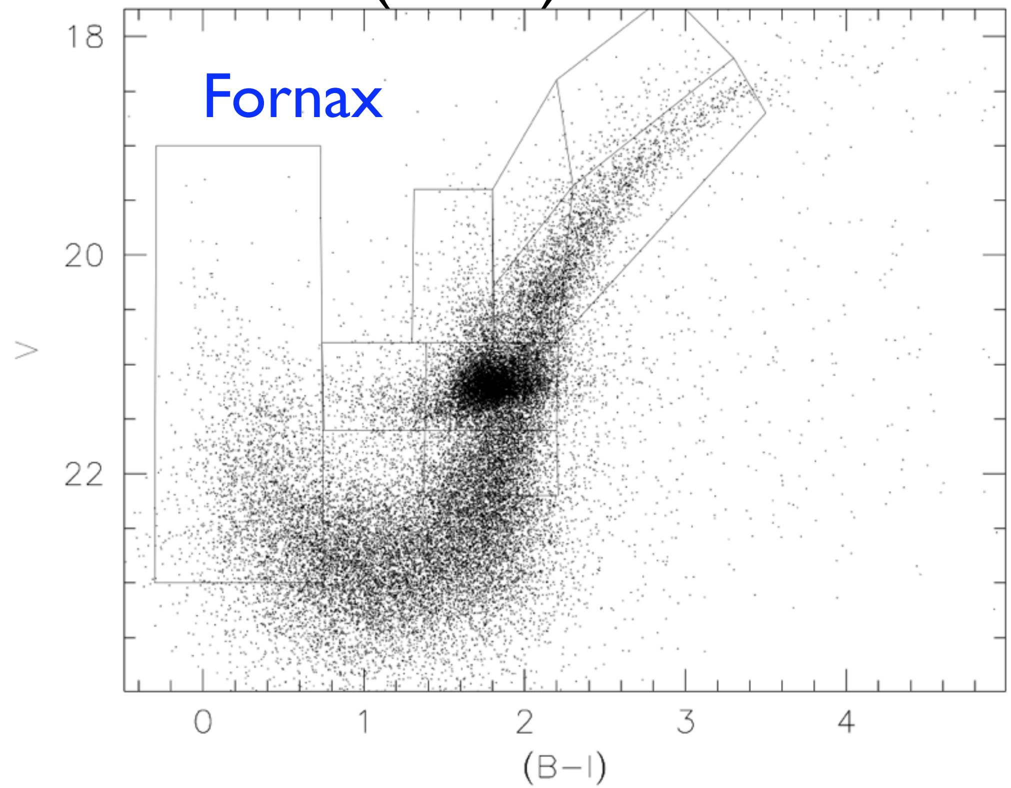


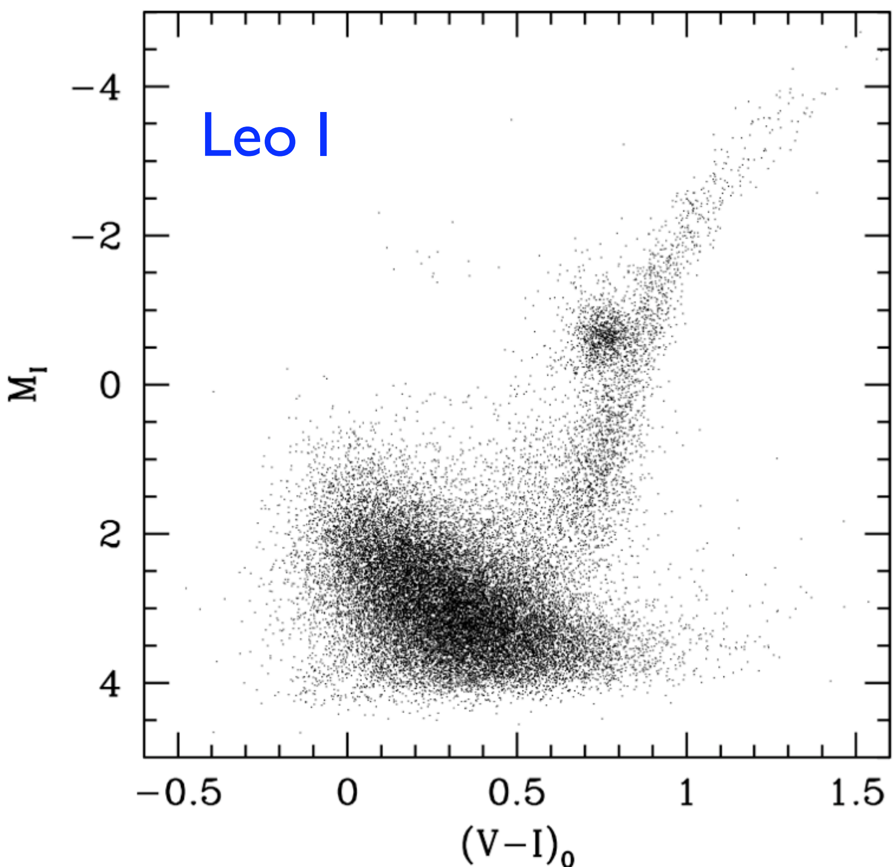
3. Star Formation Histories



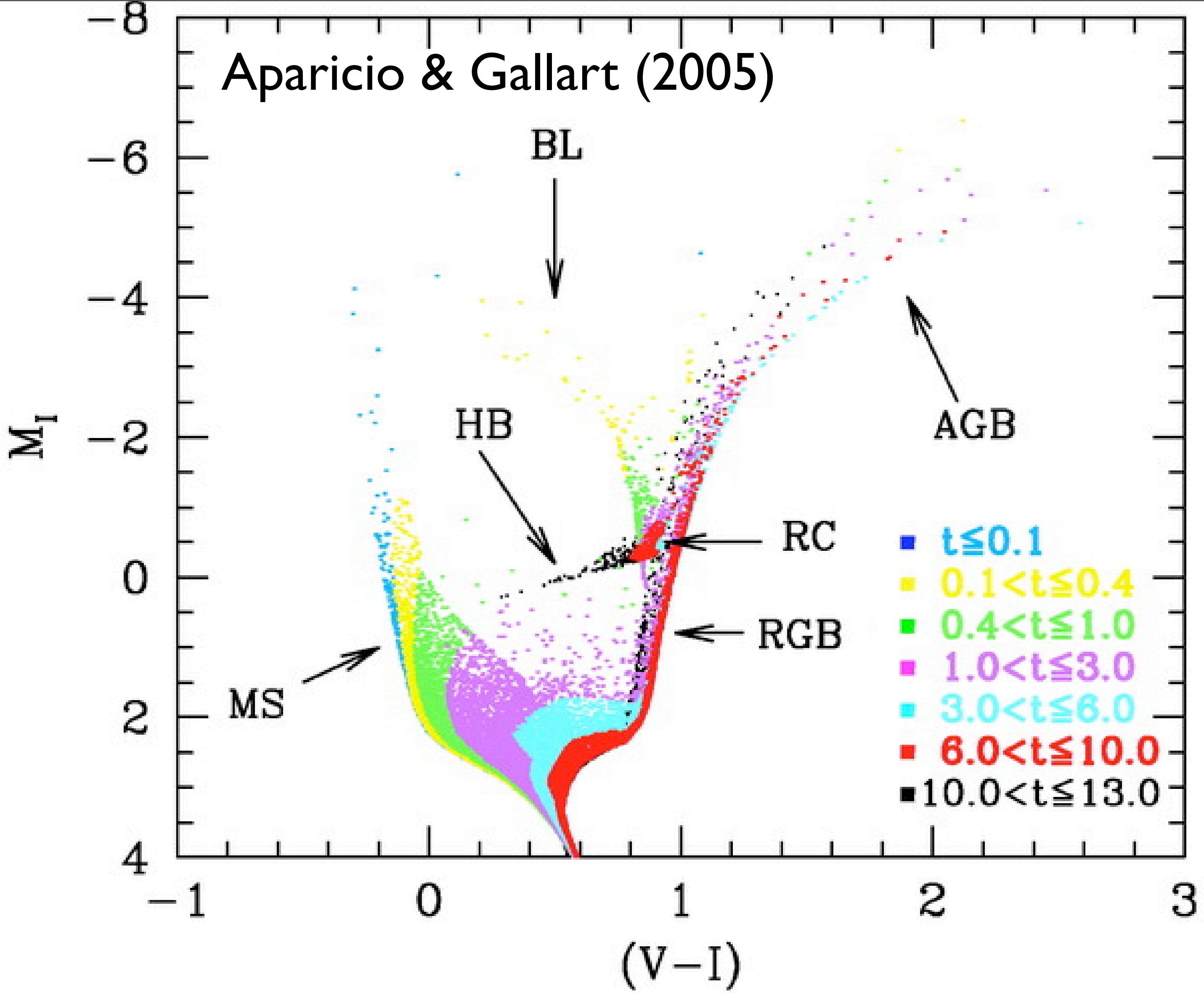
UMi: Carrera et al. (2002)

Fornax: Saviane, Held & Bertelli (2000)





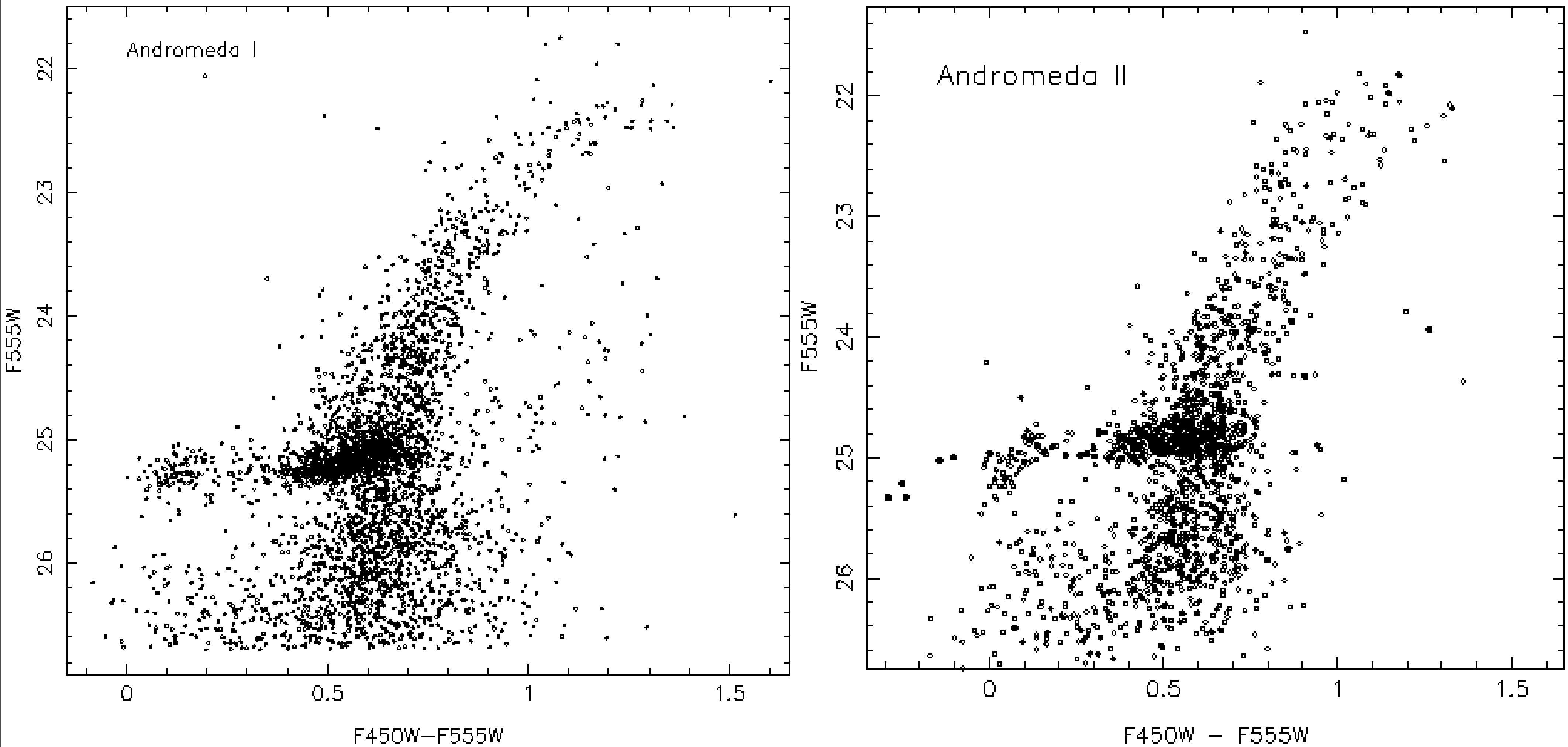
Leo I: Gallart et al. (1999)



MW satellites: photometry extending below the oldest main sequence turn-off. Good handle on age/metallicity degeneracy. Allows for detailed reconstruction of SFH based on monte-carlo simulations of stellar populations.

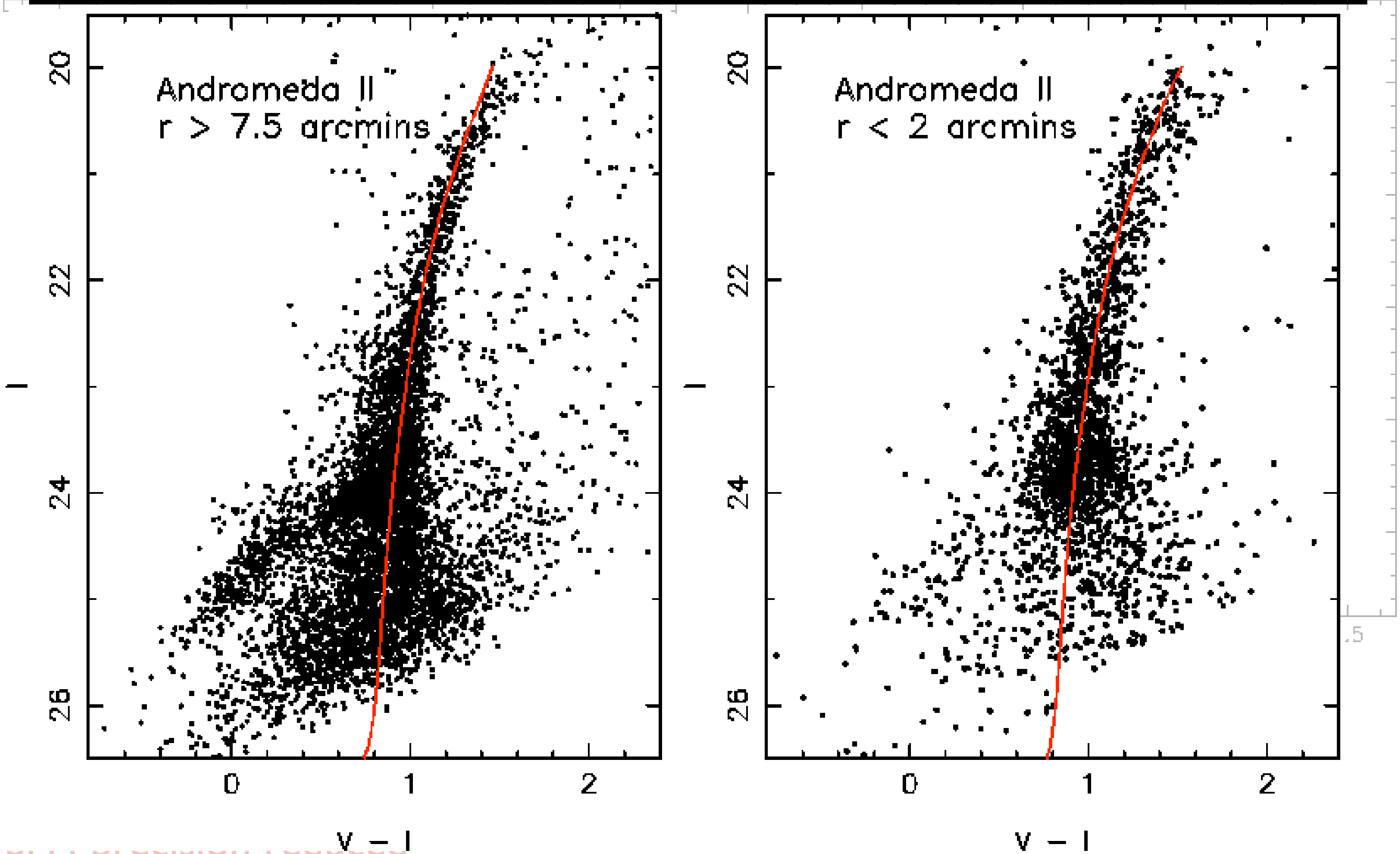
HST WFPC2 deep photometry

Da Costa, Armandroff: 1996, 2000, 2002



sub-horizontal branch imaging (red giant branch, horizontal branch, red clump, asymptotic giant branch). Vulnerable to age/metallicity degeneracies, SFH precision reduced

Difficult to distinguish between old and intermediate age populations without sub-MSTO imaging



Summary

- MW missing satellites at low latitude; M31 has isotropic distribution with latitude
- Radial distribution of M31 system twice as extended as MW
- 'Streams of satellites' might exist around M31, but they are not statistically significant given data quality
- M31 satellite distribution highly anisotropic. WHY?
- Some M31 satellites show evidence of tidal disruption
- M31 dSphs are 2 - 3 times more extended than for MW. Formation? Evolution? Tides do not appear to explain it
- SFHs of M31 dwarfs are not of same quality as for MW; no obvious strong young populations for M31 dSphs, intermediate ages are present. More data needed