The smallest* galaxies

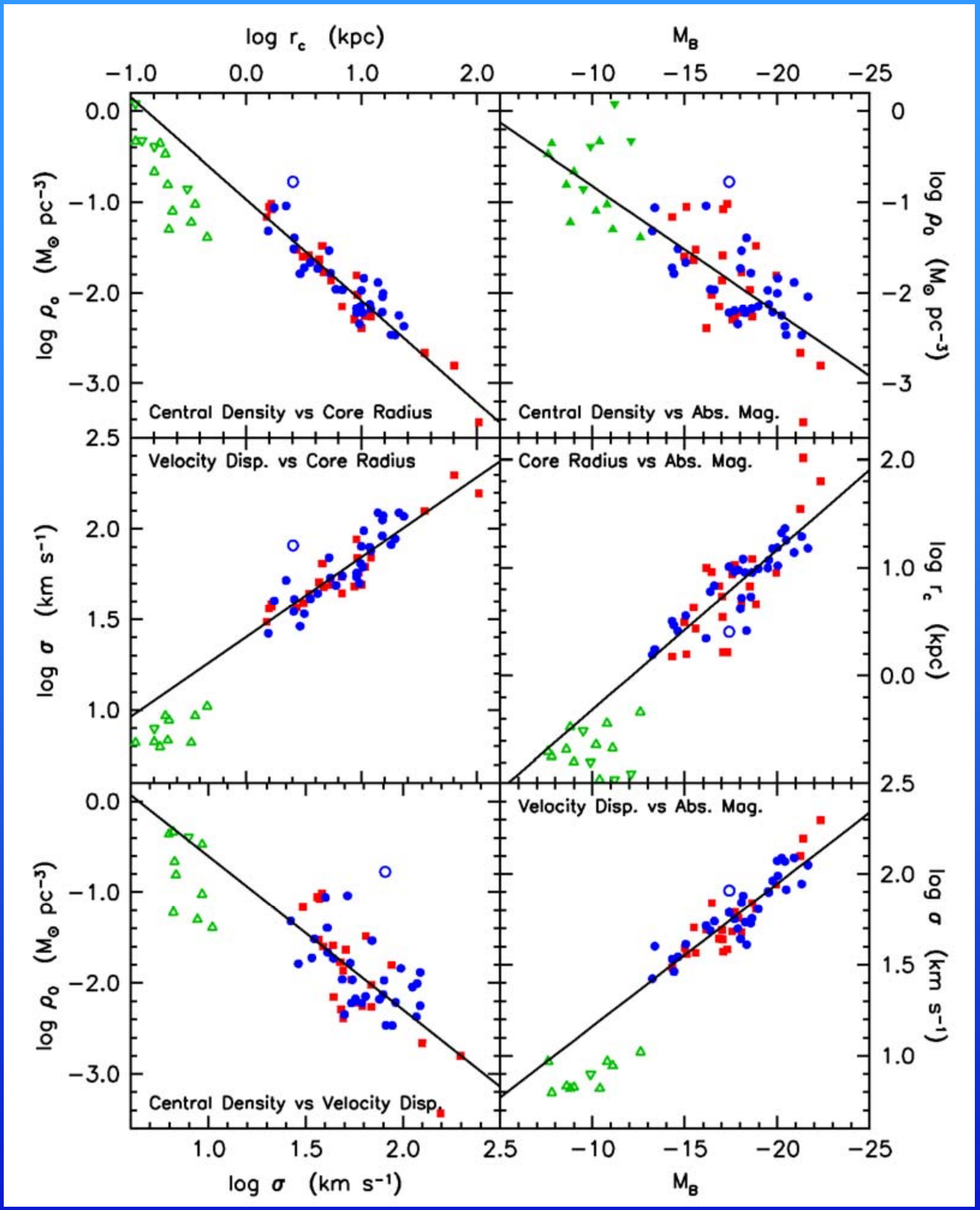
Gerry Gilmore
IoA Cambridge

- *smallest=oldest=faintest=building block???
- = direct test of small scale fluctuation spectrum
- = test of uv divergence in extrapolation
- = scale on which astroparticle physics might be seen

Kormendy & Freeman 04

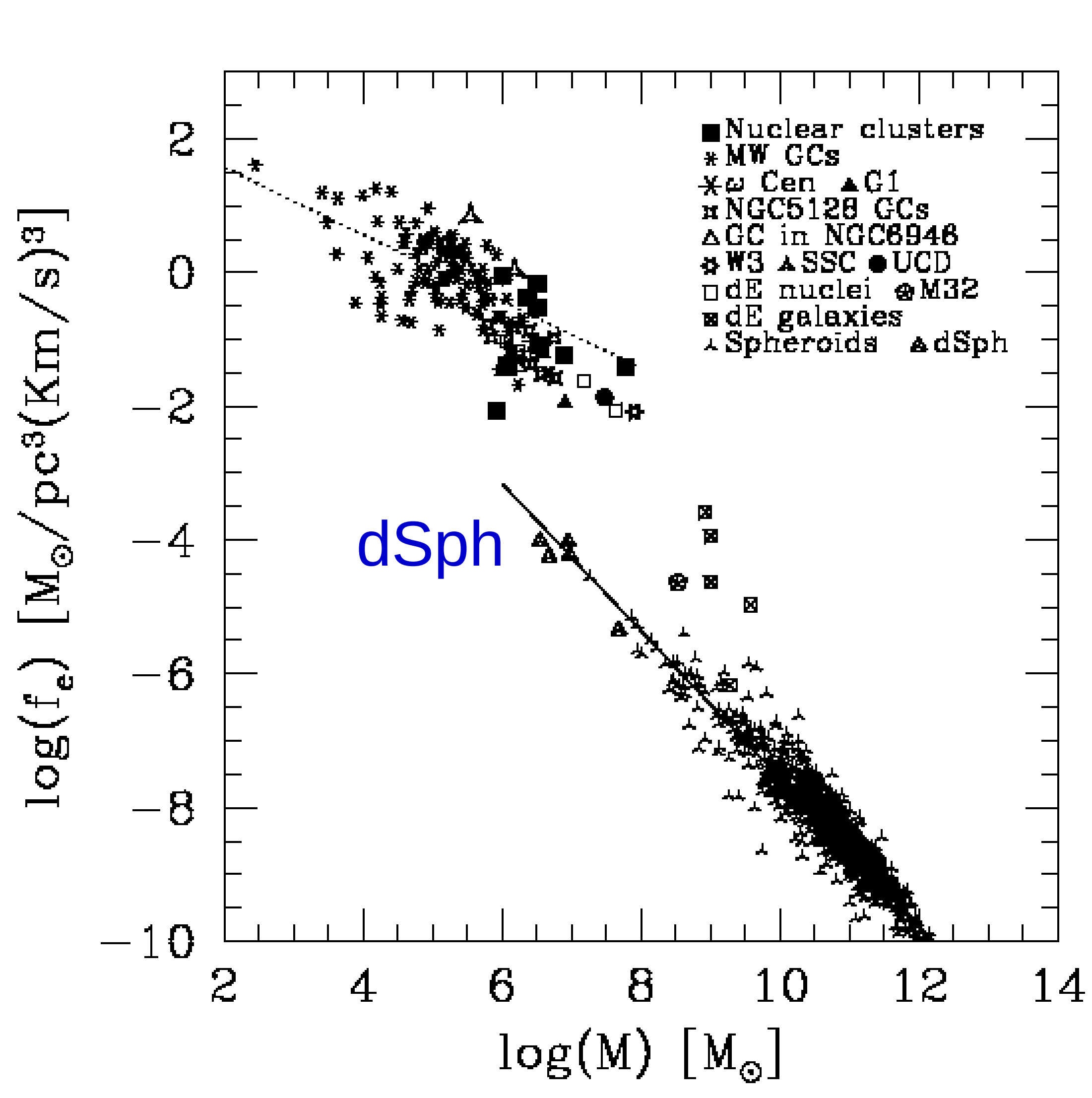
galaxy scaling relations are well-established

The dSph-larger galaxy link is a long-standing puzzle



Walcher et al 2005

Dotted line is virial theorem for stars, no DM



There is a discontinuity in (stellar) phase-space density between small galaxies and star clusters.

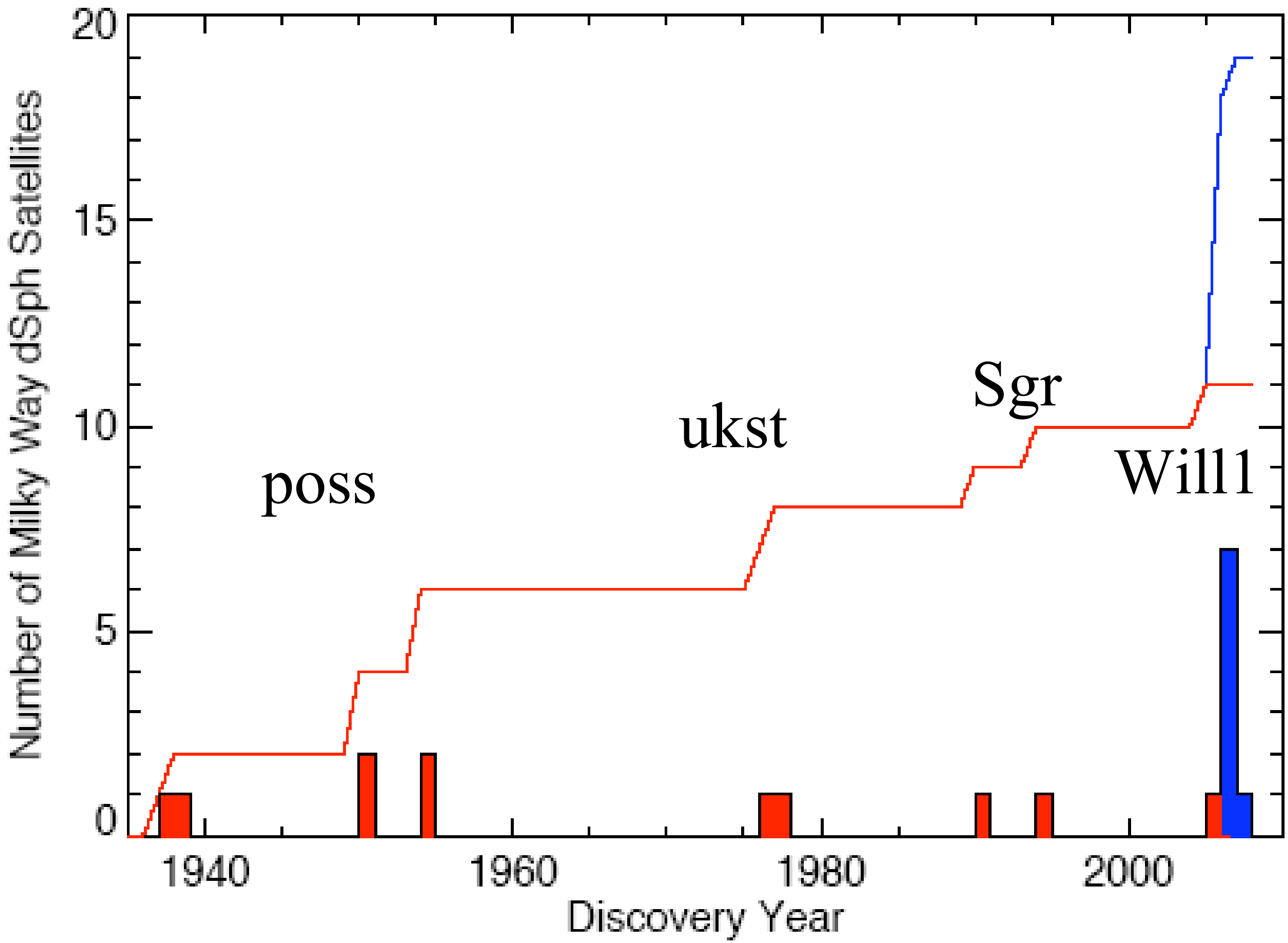
Why?

➔ Dark Matter

and

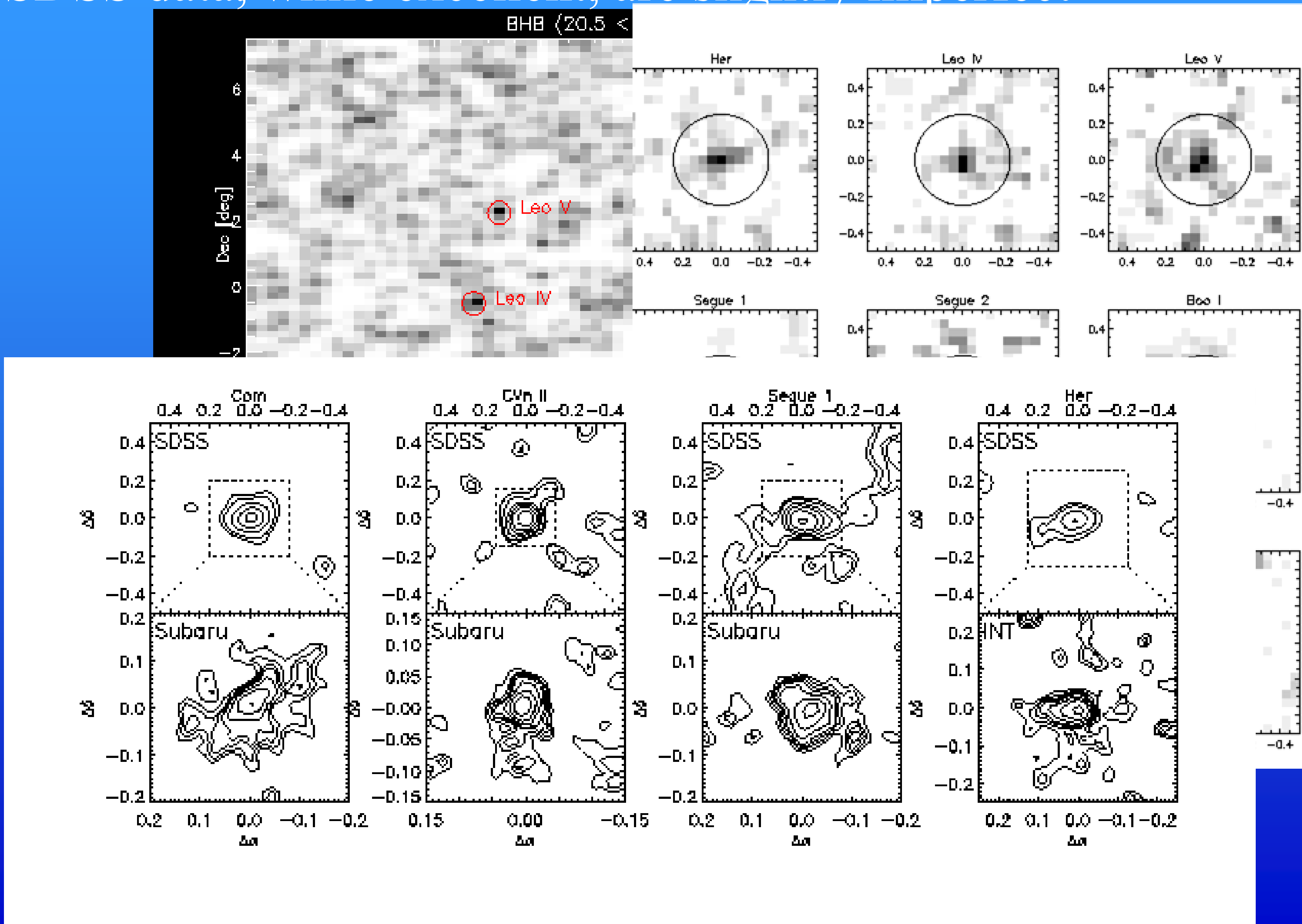
➔ sizes

Phase space density ($\sim \rho/\sigma^3$) $\sim 1/(\sigma^2 r_h)$

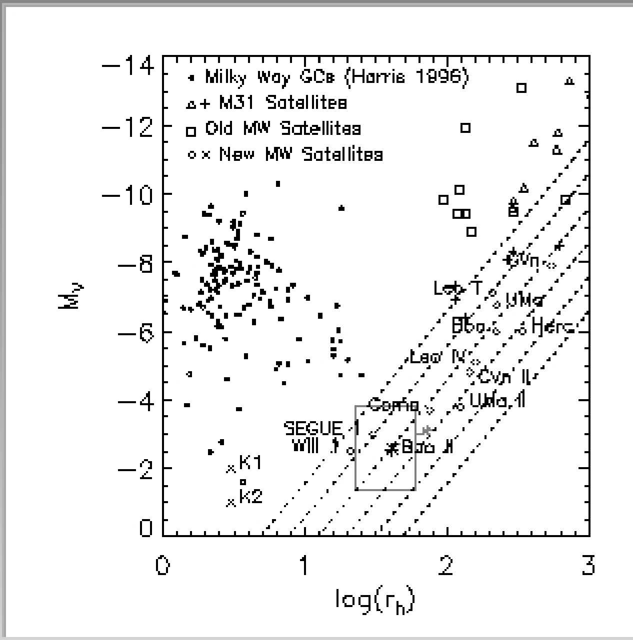


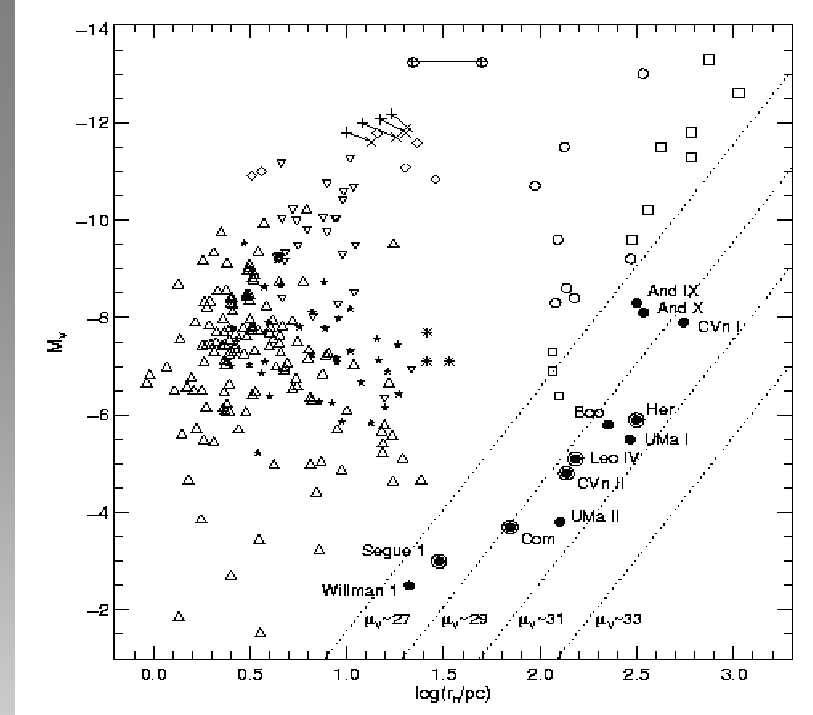
Number of Milky Way dSph Satellites
Discovery Year
0
5
10
15
20
1940
1960
1980
2000
poss
ukst
Sgr
Will1

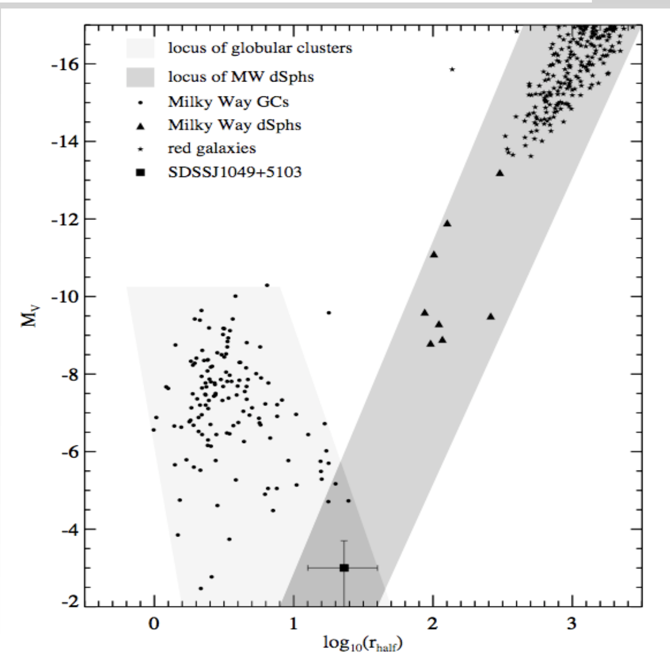
Finding dSph – discoveries all require confirmation: SDSS data, while excellent, are slightly imperfect

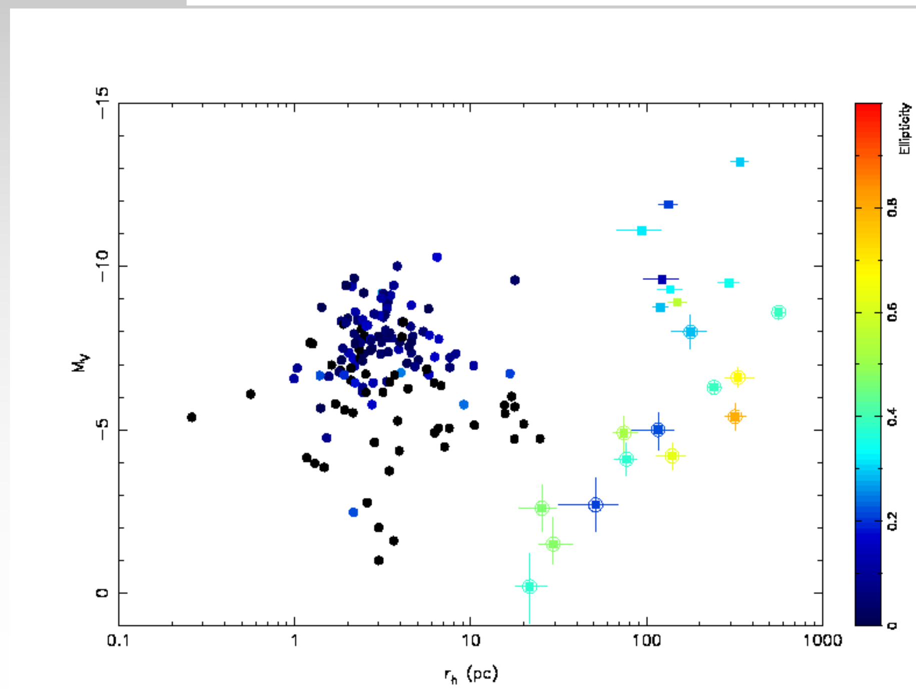


Size-luminosity relations







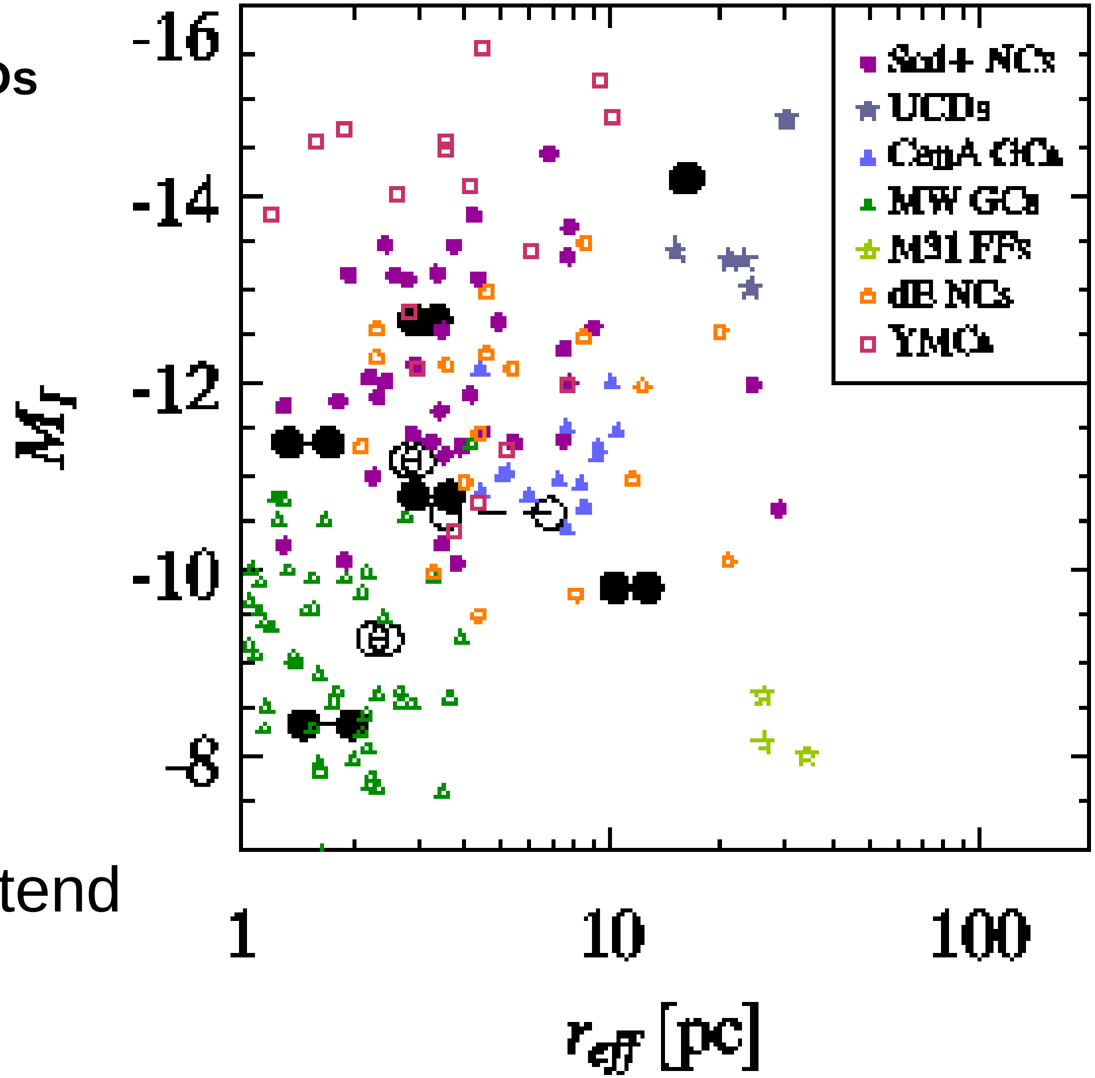


New photometric and kinematic studies of UCDs, nuclear clusters, etc → ALL the small things are purely stellar systems, M/L~1-4

cf Seth etal 0801.0439 re nuclei

Virgo & Fornax UCDs have stellar M/L –

Hilker etal, A&A 463 119 2007



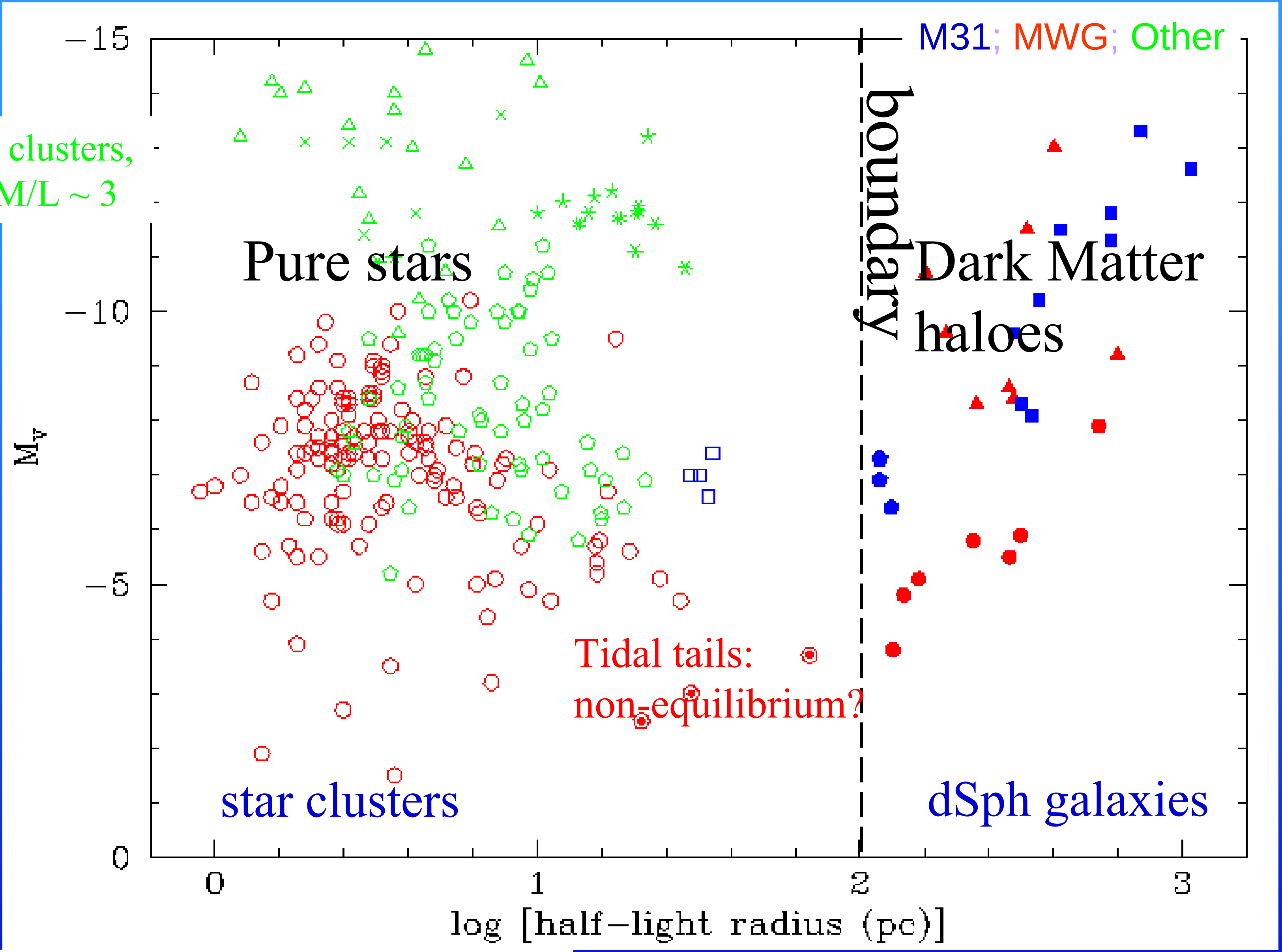
N5128 GC; Rejkuba etal A+A 469 2007

MWG GCs extend down to M~-2

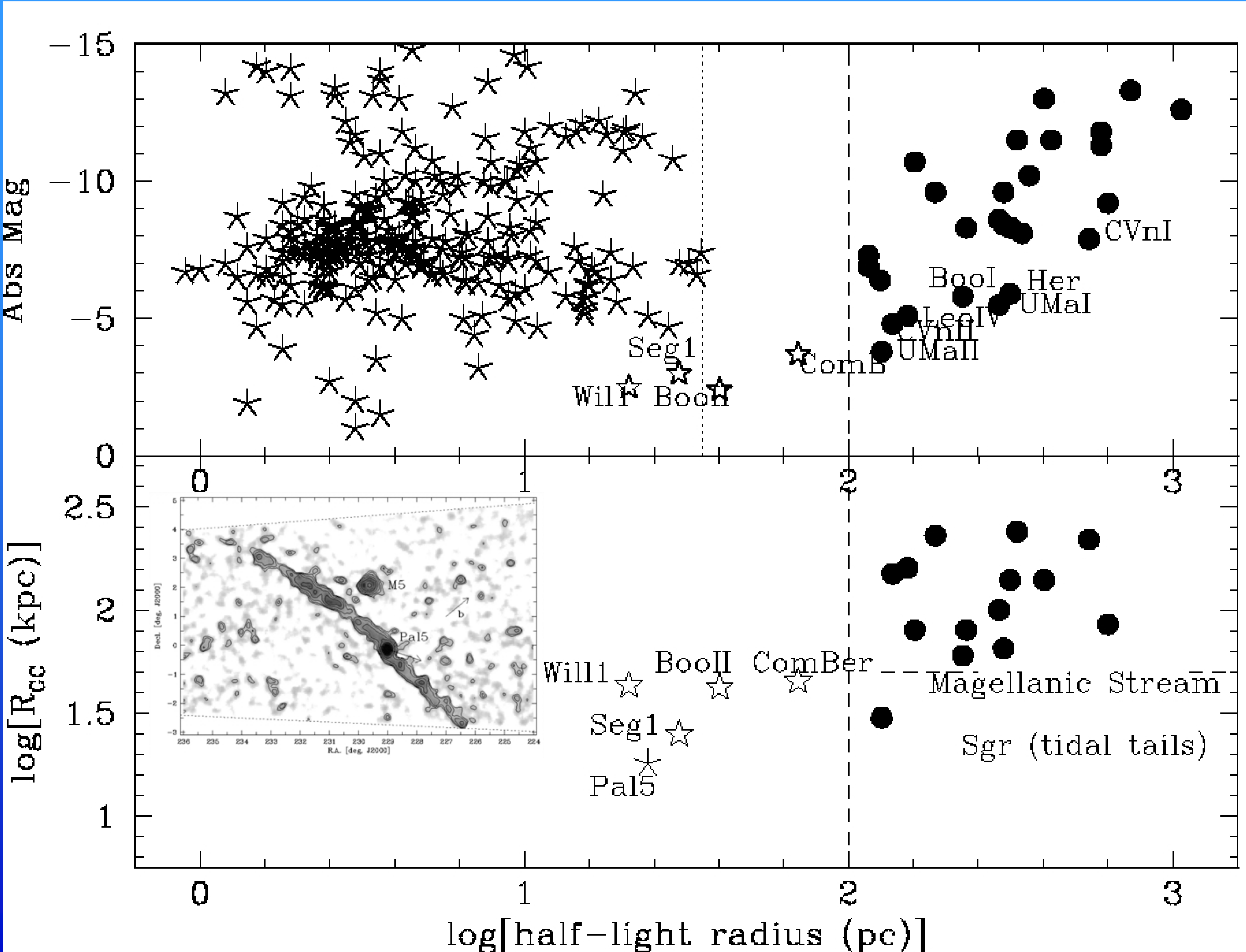
MWG nuclear cluster has size ~5pc, mass 10^6Msun Schodel etal A+A 469 125

Slightly different perspective… (updated data)

Nuclear clusters, UCDs, M/L ~ 3



GG, Wilkinson, Wyse et al 2007



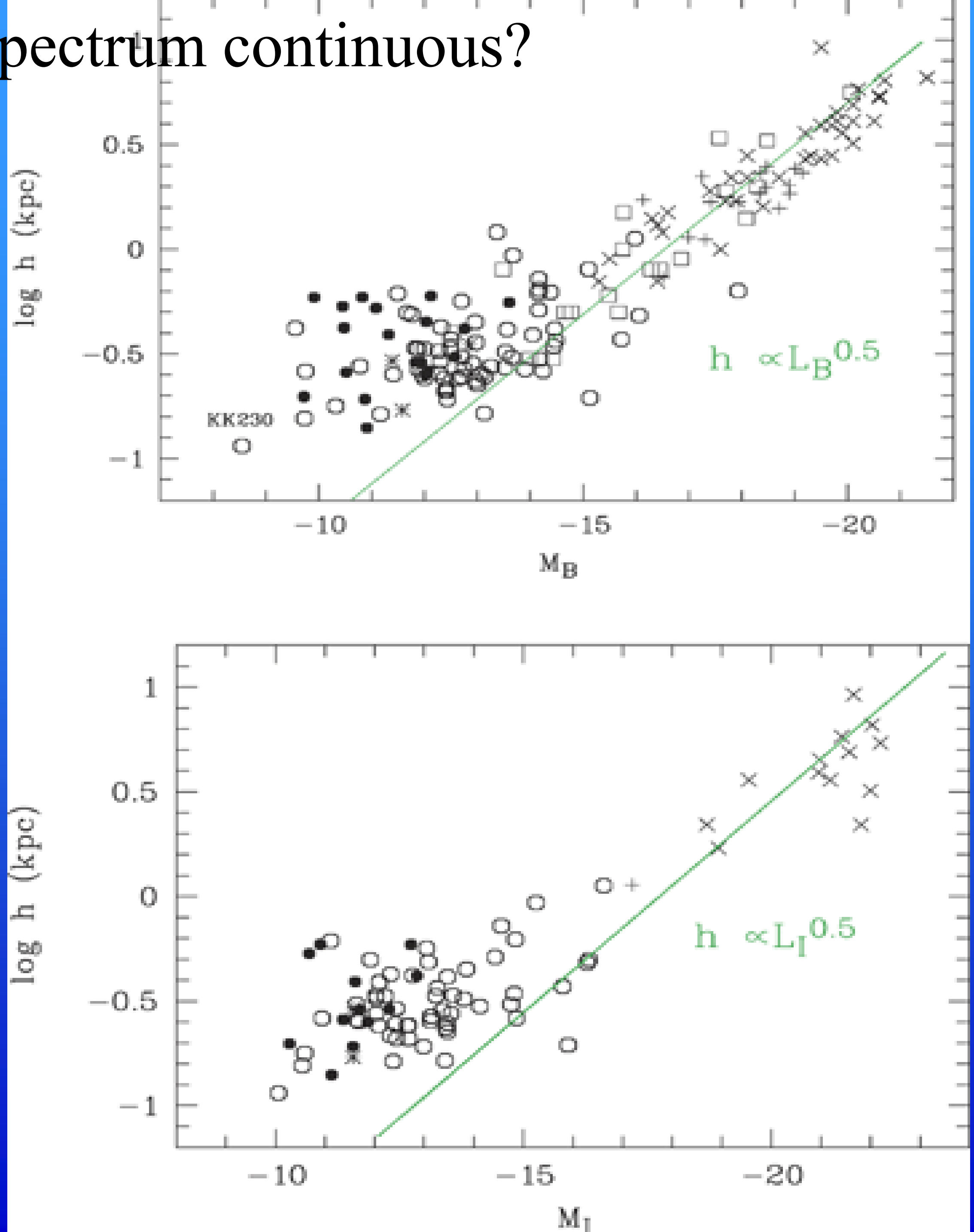
Abs Mag
−15
−10
−5
0
CVnI
BooI
Her
UMaI
LeoIV
CVnII
UMaII
Seg1
ComB
Will
BooII
log[R_{GC} (kpc)]
2.5
2
1.5
1
M5
Pal5
Will1
BooII
ComBer
Seg1
Pal5
Magellanic Stream
Sgr (tidal tails)
0
1
2
3
log[half−light radius (pc)]

Is the galaxy size spectrum continuous? ACS studies

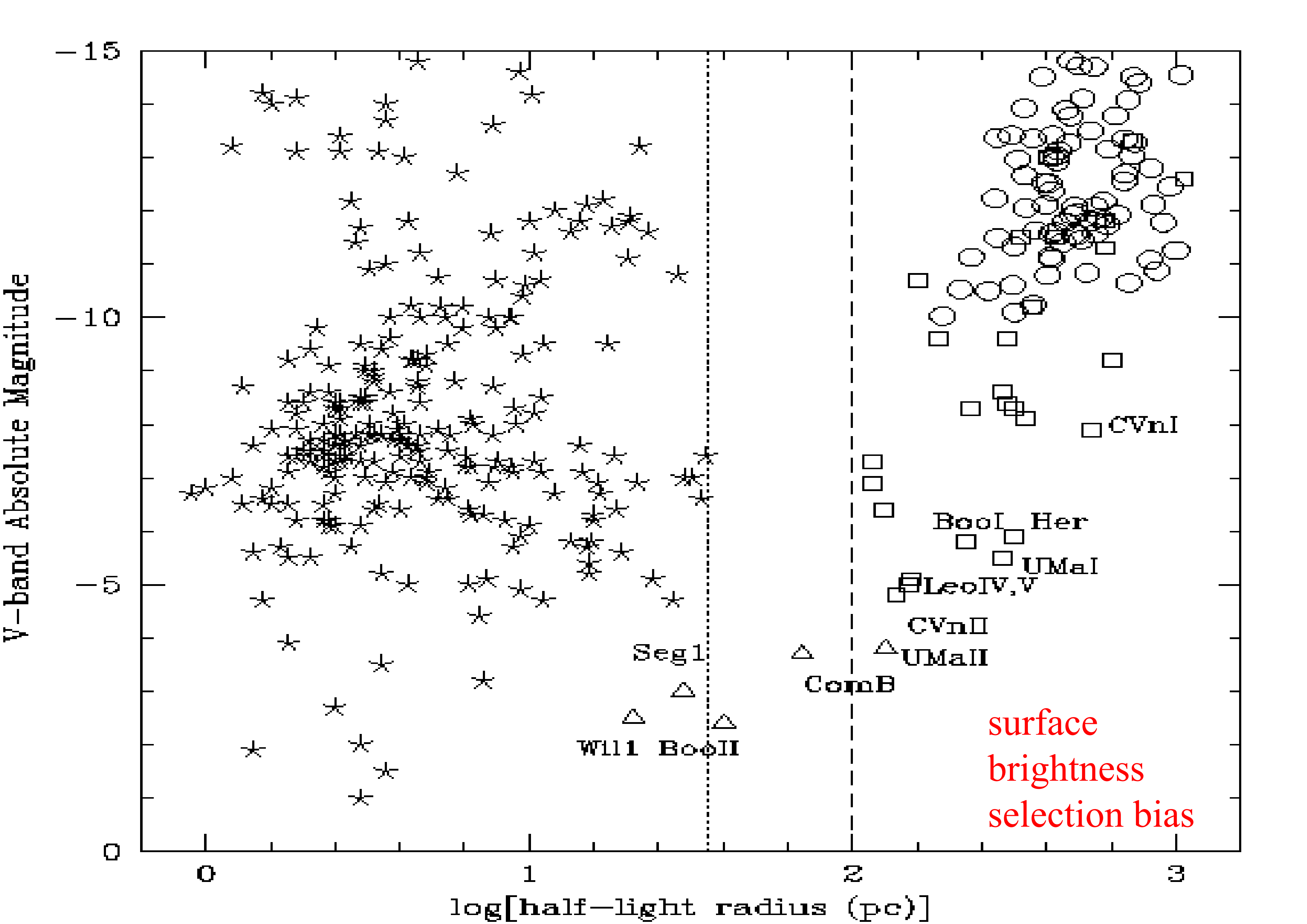
Very recent support that galaxies break from the lum-size scaling relation at dSph luminosities

Gilmore etal 2007

Sharina etal 2008 MN 384 1544



Gilmore etal 2007, plus Sharina etal mnras 384, 1544 2008

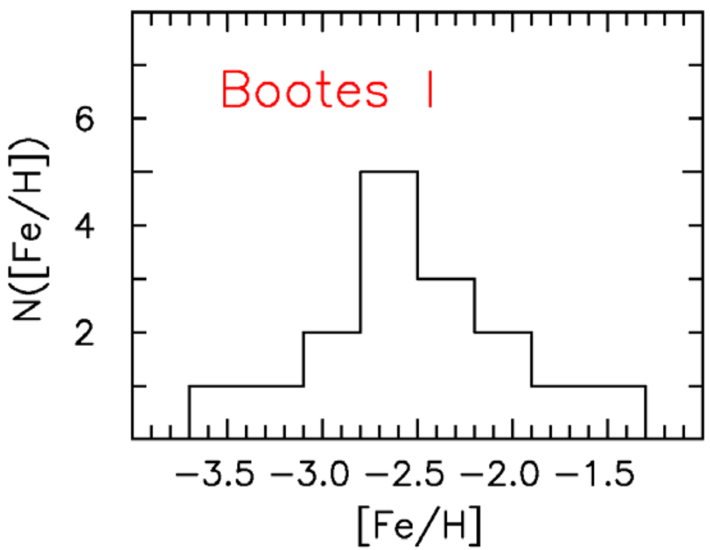


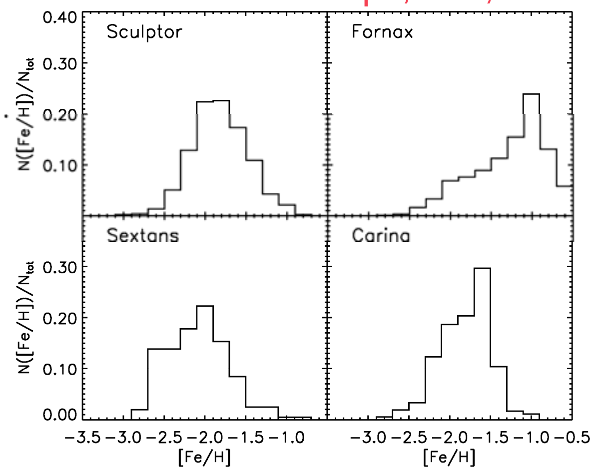
The very low luminosity objects have too few stars to allow robust dynamical masses: can we determine if they are/were star clusters or more massive dSph galaxies?

- Normal globular clusters have small or no internal chemical abundance dispersion
- Star clusters form from pre-enriched material
- dSph galaxies, and massive star clusters, self-enrich

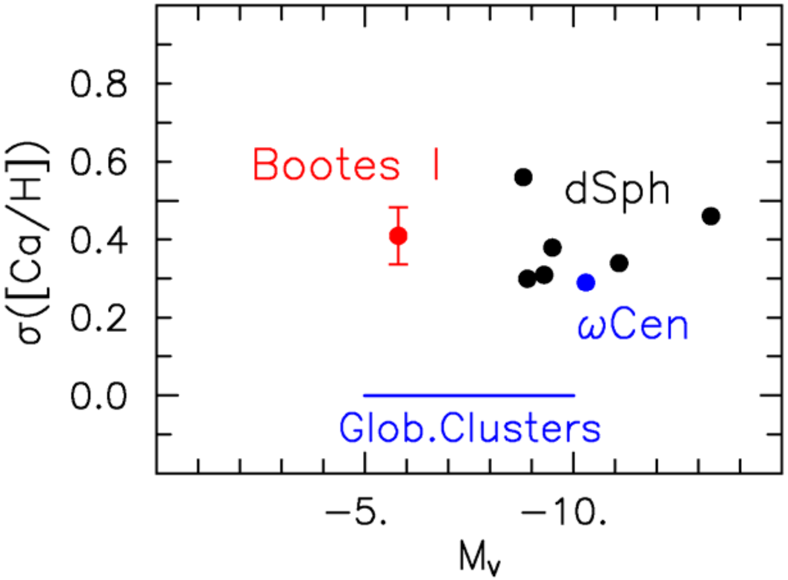
- Mass threshold is about $10^8 M_{sun}$ to see internal abundance scatter
- So use internal abundance scatter as a proxy for initial mass

Abundance mean and dispersion is a mass proxy, and a direct test of the minimum length scale hypothesis





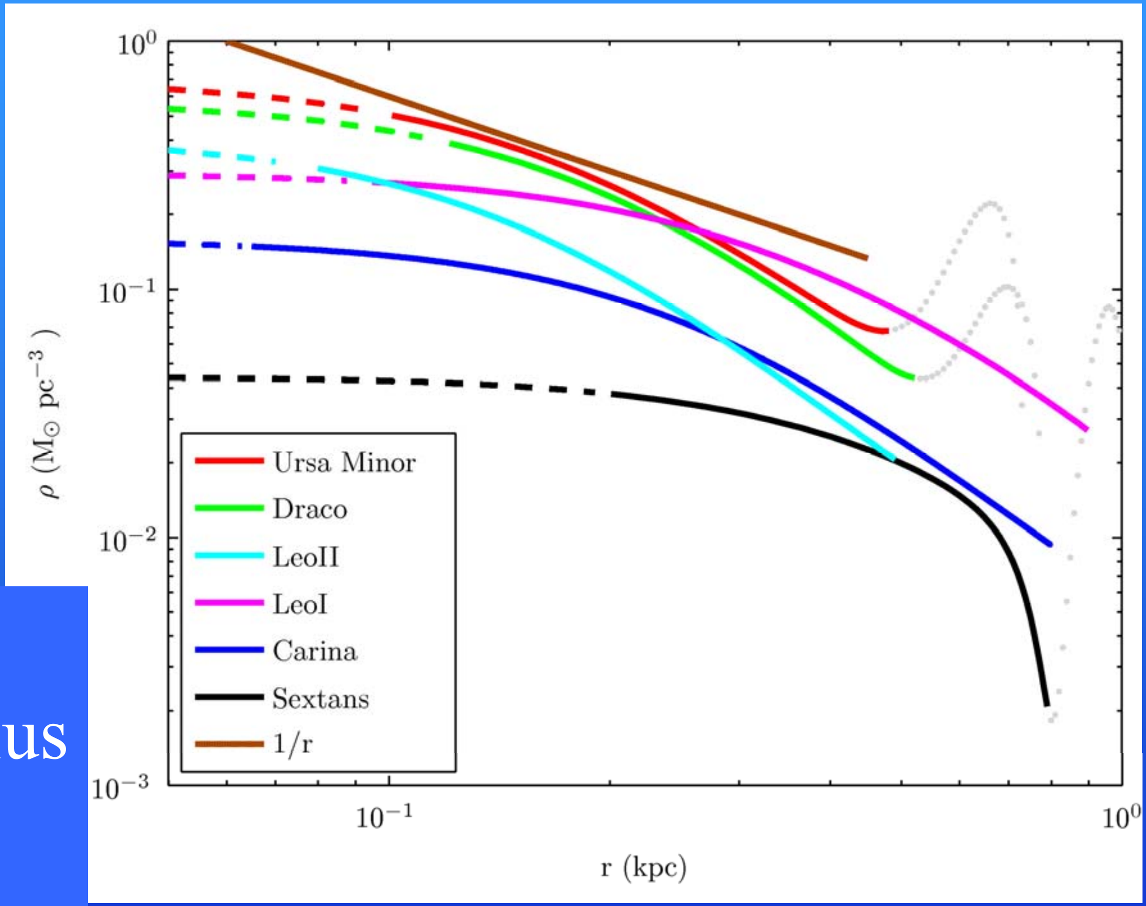
Norris, GG, Wyse etal 2008 – submitted
cf Kirby etal



NB: self-enrichment on these scales requires low SFR, and weak feedback

Derived mass density profiles: scale of ~100pc

Jeans' equation with ***assumed isotropic*** velocity dispersion: all consistent with cores.



CDM predicts slope of -1.3 at 1% of virial radius and asymptotes to -1 (Diemand et al. 04)

NB these Jeans' models are to provide the most objective sample comparison – DF fitted models agree with these

Conclusion :

- There is a well-established size bi-modality:
  - all systems with size < 30pc are purely stellar
  - $-16 < M_v < 0$ (!!) M/L ~ 3;
  - all systems with size greater than ~100pc have a dark-matter halo, and self-enrich
- There are no known (virial equilibrium) systems with half-light radius 30 < r < 100pc
- 100pc seems a physical scale imprinted on, or by, Dark Matter