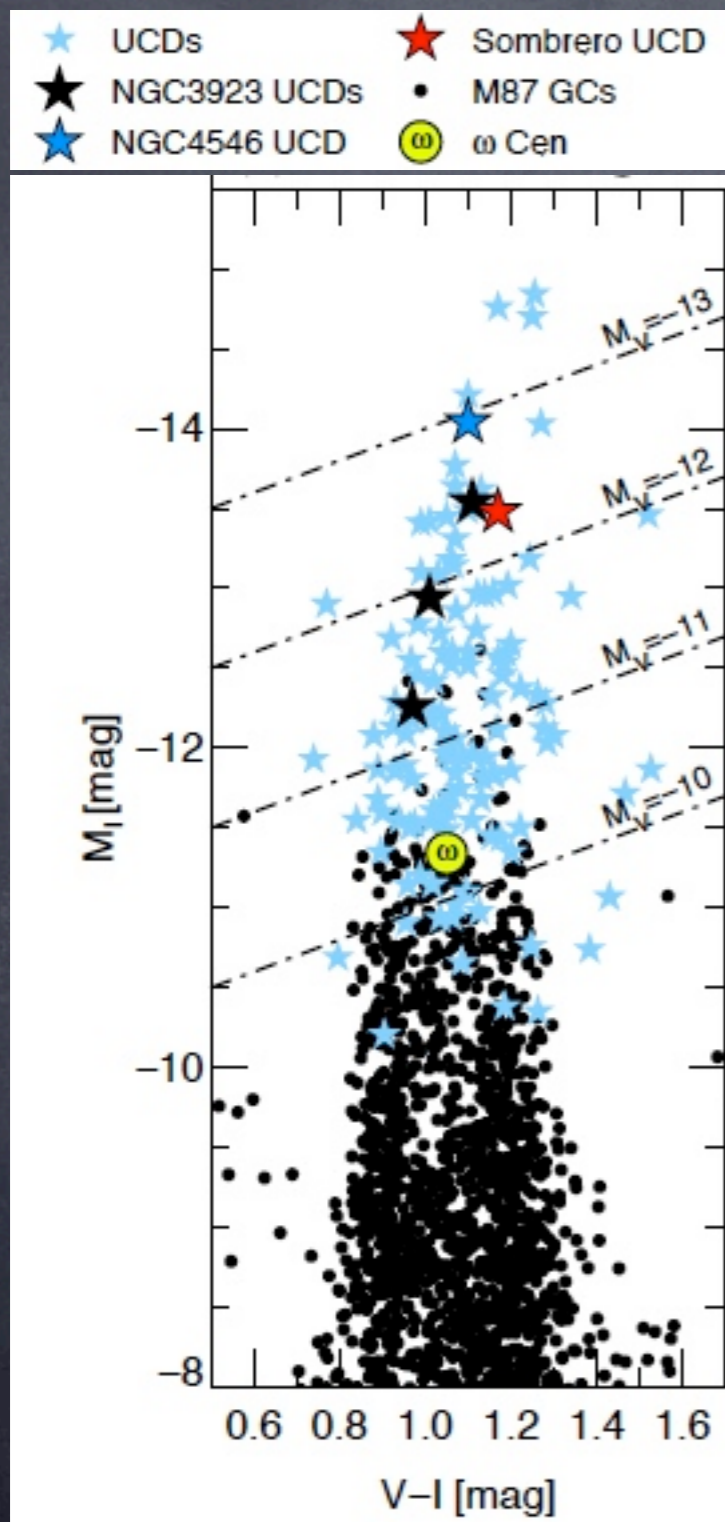# Early-type stellar systems in nearby clusters:
from star clusters to galaxies

Ingo Misgeld (USM/ESO),

Michael Hilker, Steffen Mieske, Tom Richtler, Iskren Georgiev, Ylva Schuberth
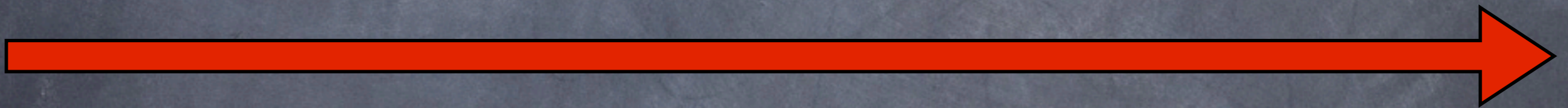
Ultra-compact dwarf galaxies (UCDs) vs. globular clusters (GCs)

Norris & Kannappan 2011

- typical UCD luminosities: $-13.5 < M_V < -11.0$ mag

- UCD half-light radii: $10 < r_h < 100$ pc

- UCD masses: $2 \times 10^6 < m < 10^8$ M_{sol}

- size-luminosity relation

UCDs in local galaxy clusters

Distance

UCDs in local galaxy clusters

e.g. Hilker+ 99, Drinkwater+ 00,
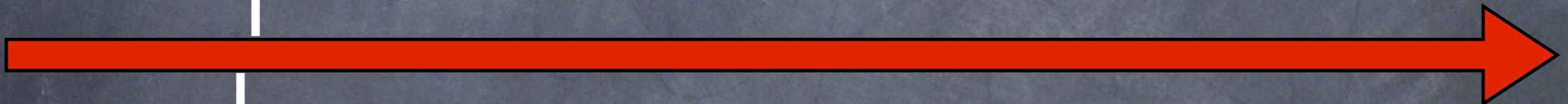Phillipps+ 00, Mieske+ 04,
Gregg+ 09

Fornax

17 Mpc

Distance

Virgo

14 Mpc

e.g. Hasegan+ 05, Jones+ 06

UCDs in local galaxy clusters

e.g. Hilker+ 99, Drinkwater+ 00, Phillipps+ 00, Mieske+ 04, Gregg+ 09

e.g. Mieske+ 07, Mieske+ 09

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Antlia
35 Mpc

Caso et al. (POSTER)

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Caso et al. (POSTER)

Coma
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Hydra I
42 Mpc

Coma
95 Mpc

e.g. Price+ 09, Chiboucas+ 10, Madrid+ 10 (POSTER)

Antlia
35 Mpc

Caso et al. (POSTER)

The Hydra I cluster
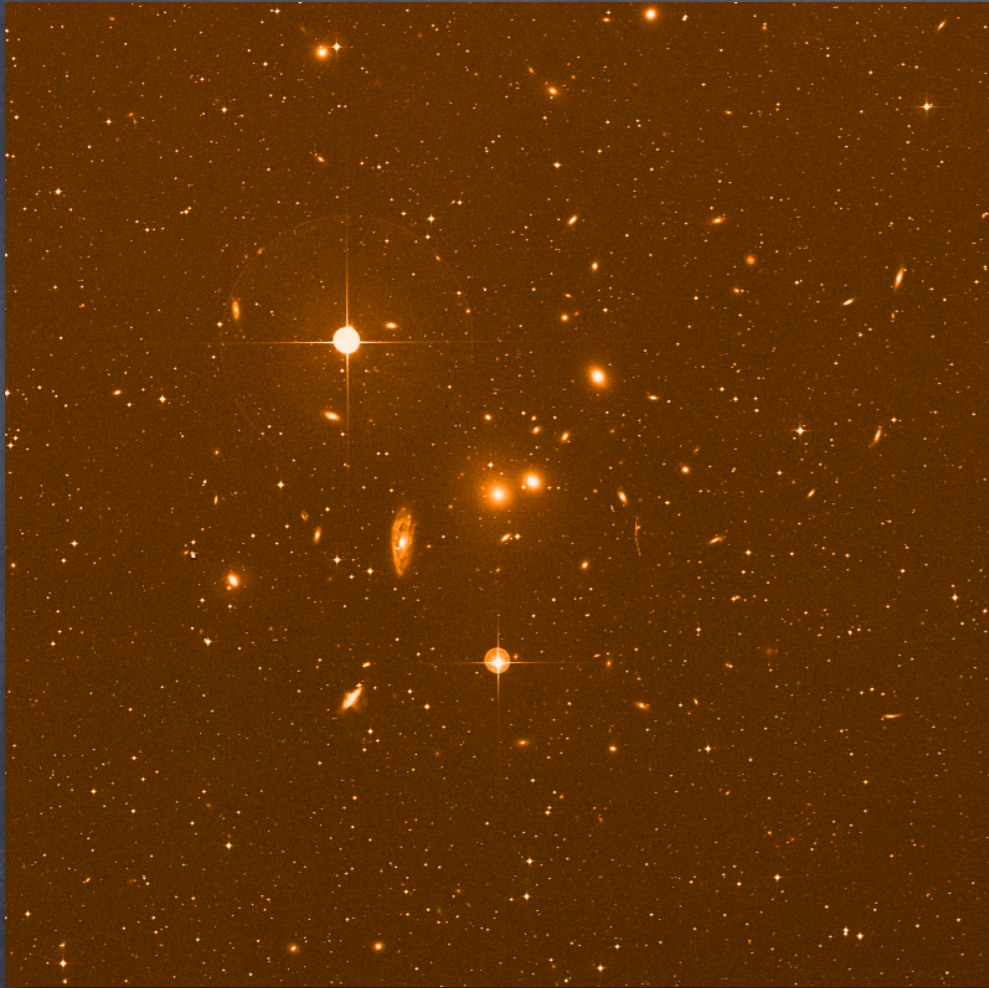
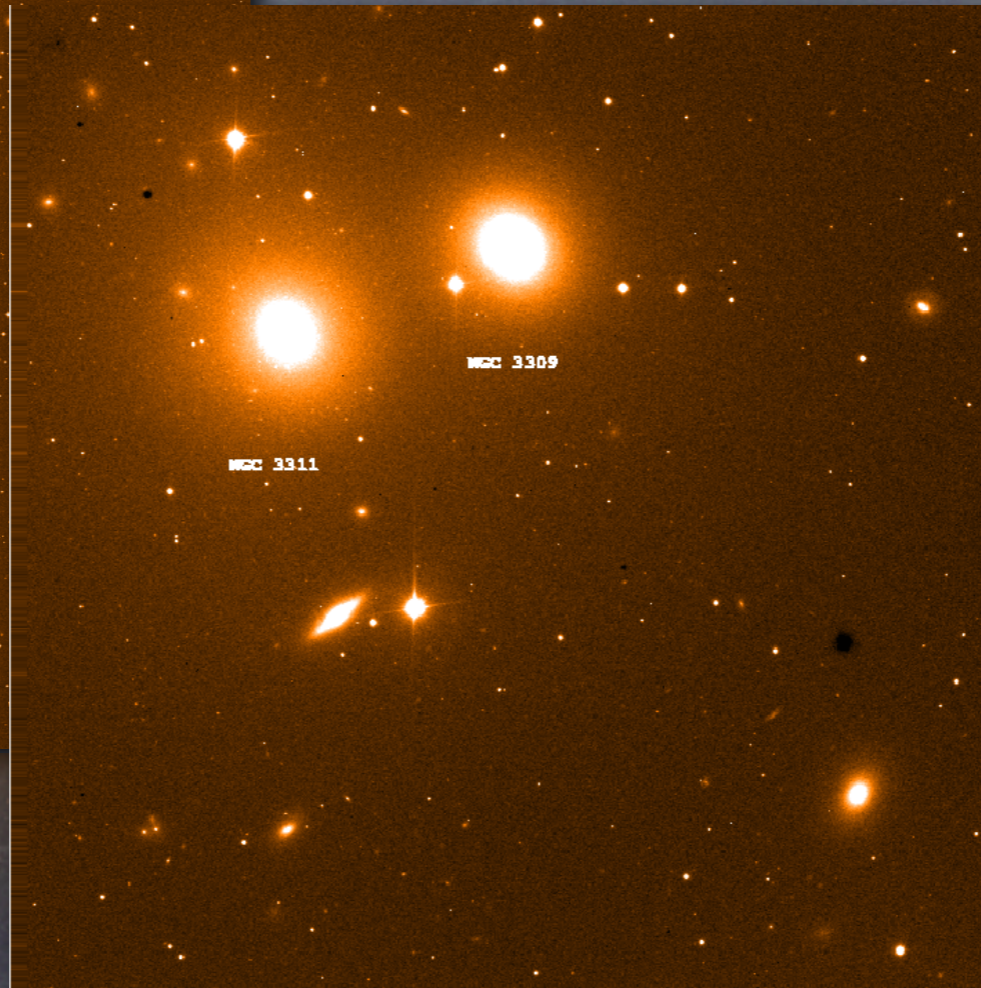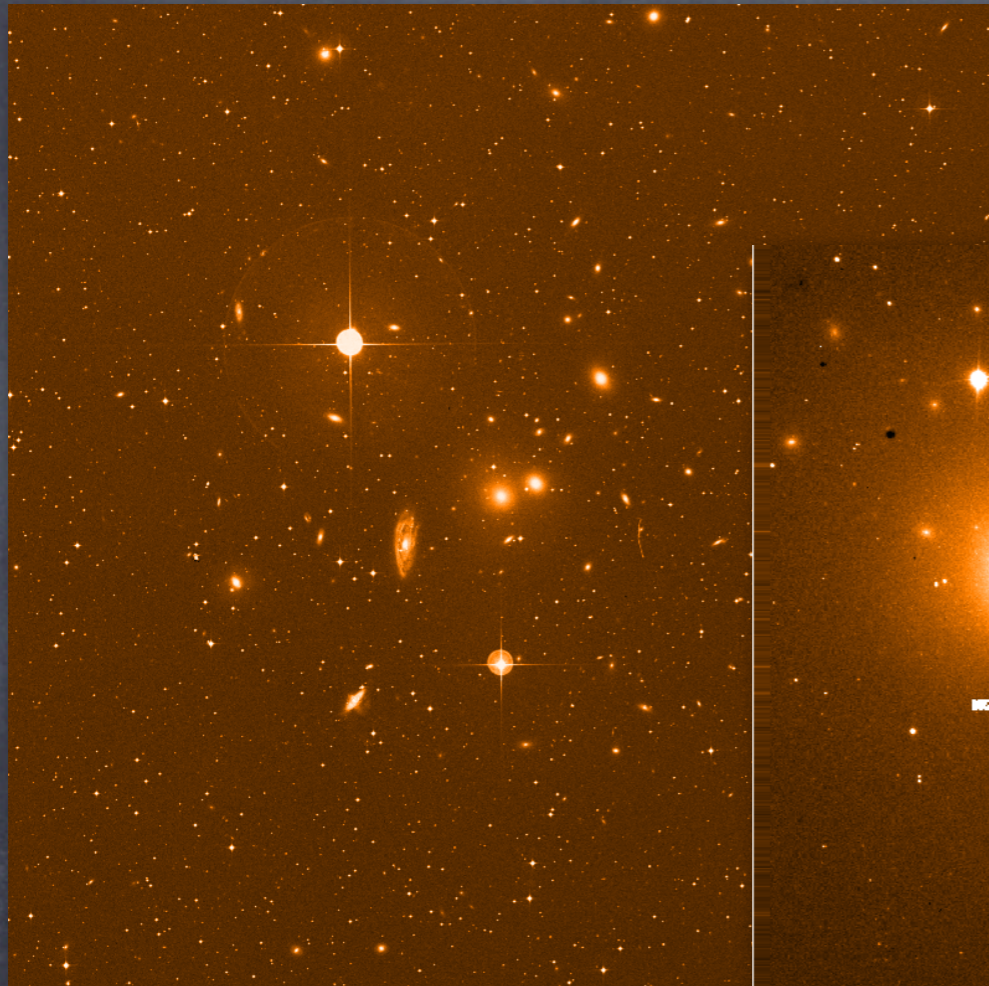# The Hydra I cluster
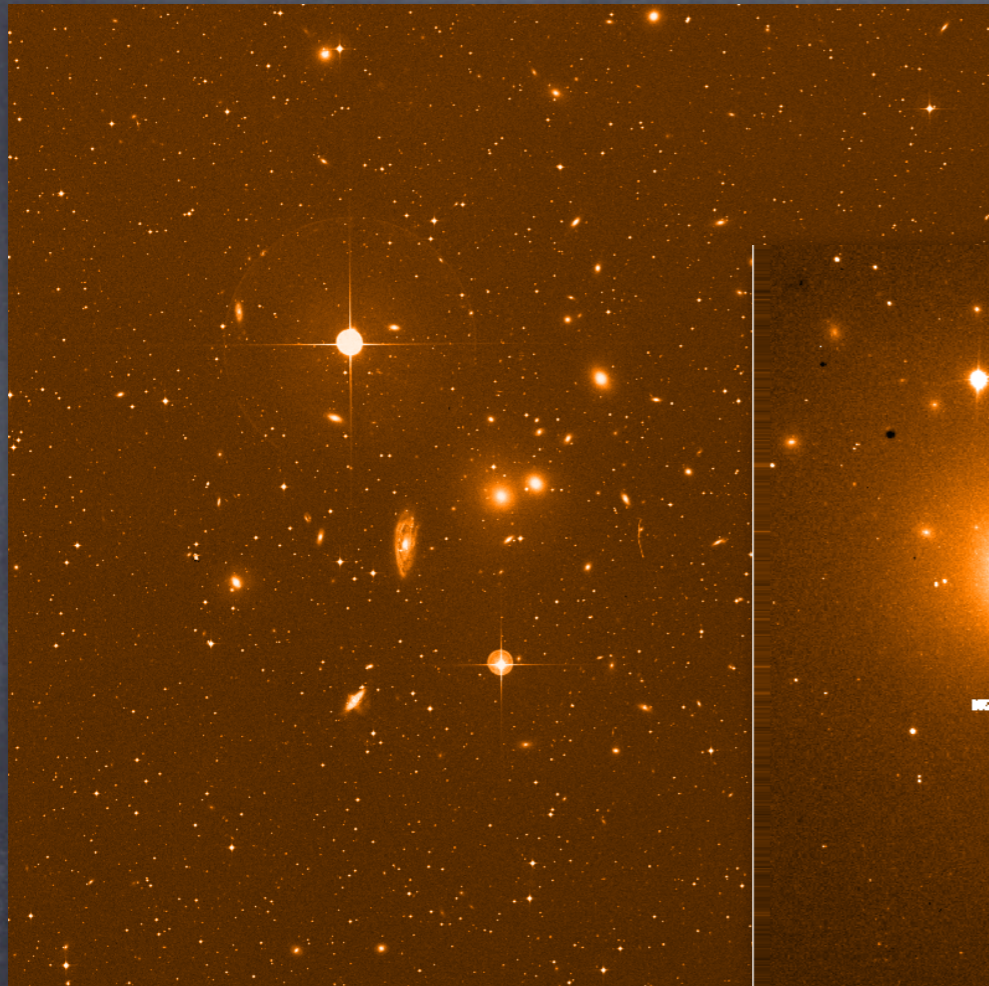
pronounced diffuse light component

extremely rich GC system

(van den Bergh 1977, McLaughlin et al. 1995, Mieske et al. 2005, Wehner et al. 2008)

NGC 3309

NGC 3311

dominated by cD galaxy
NGC 3311

The Hydra I cluster

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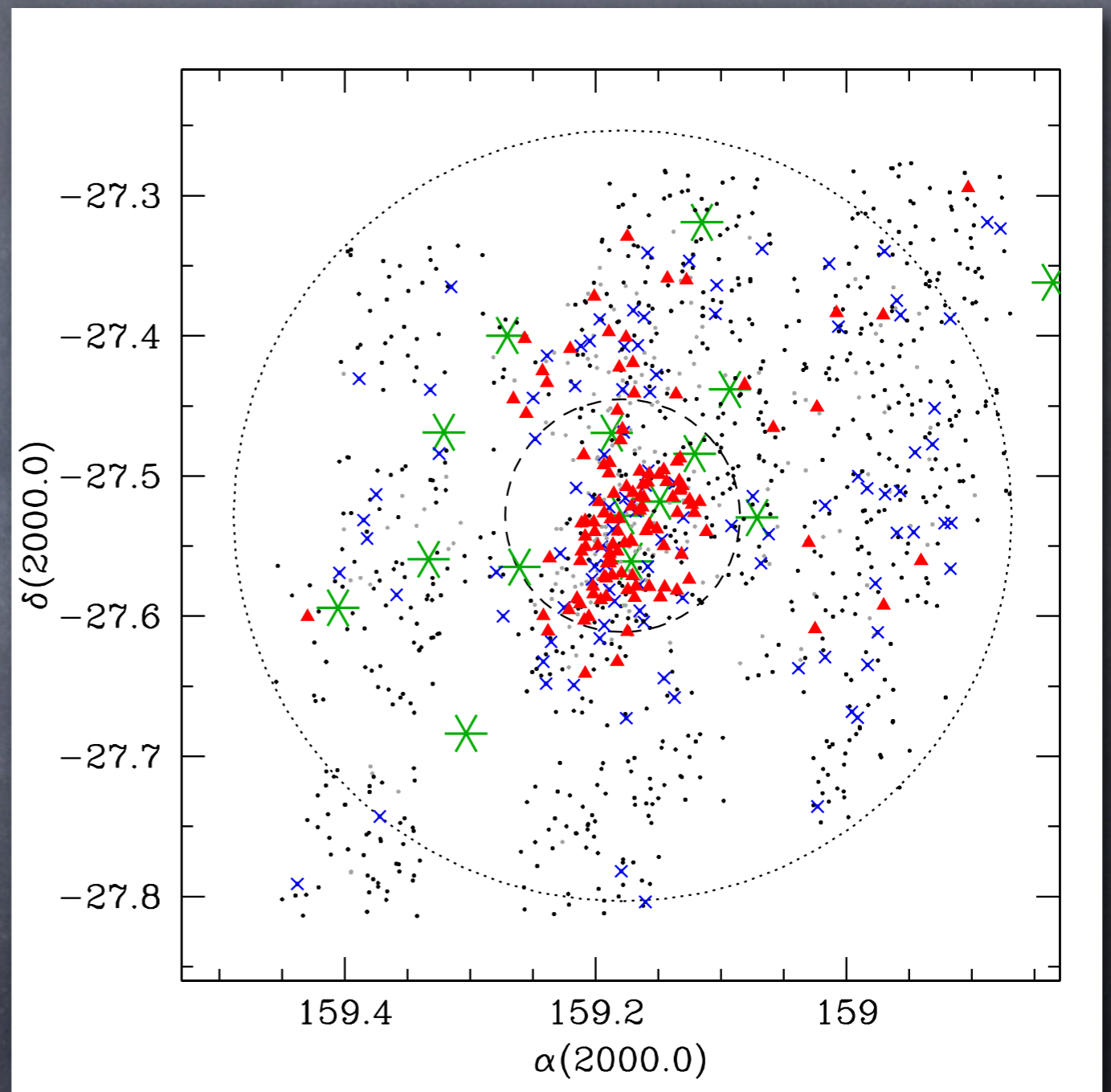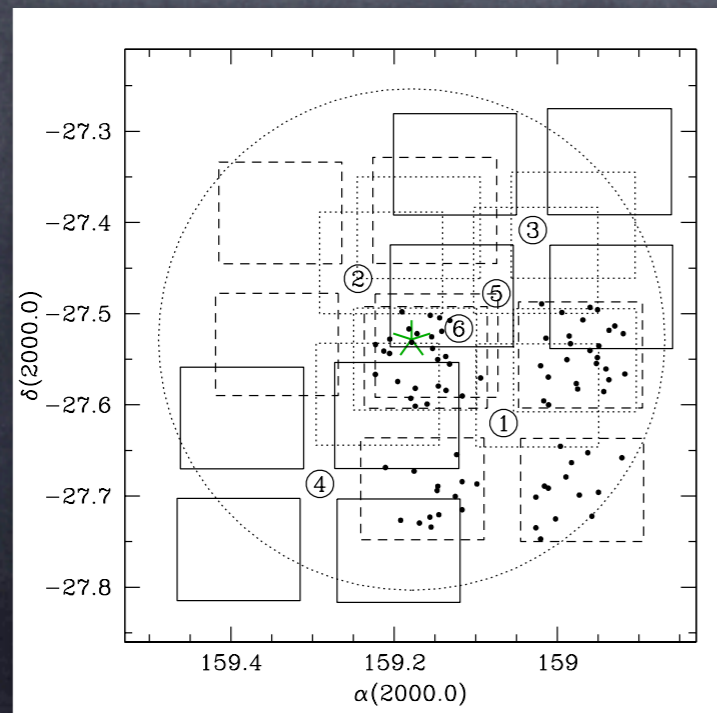(van den Bergh 1977, McLaughlin et al. 1995, Mieske et al. 2005, Wehner et al. 2008)

NGC 3309

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dust structure in the core of NGC 3311
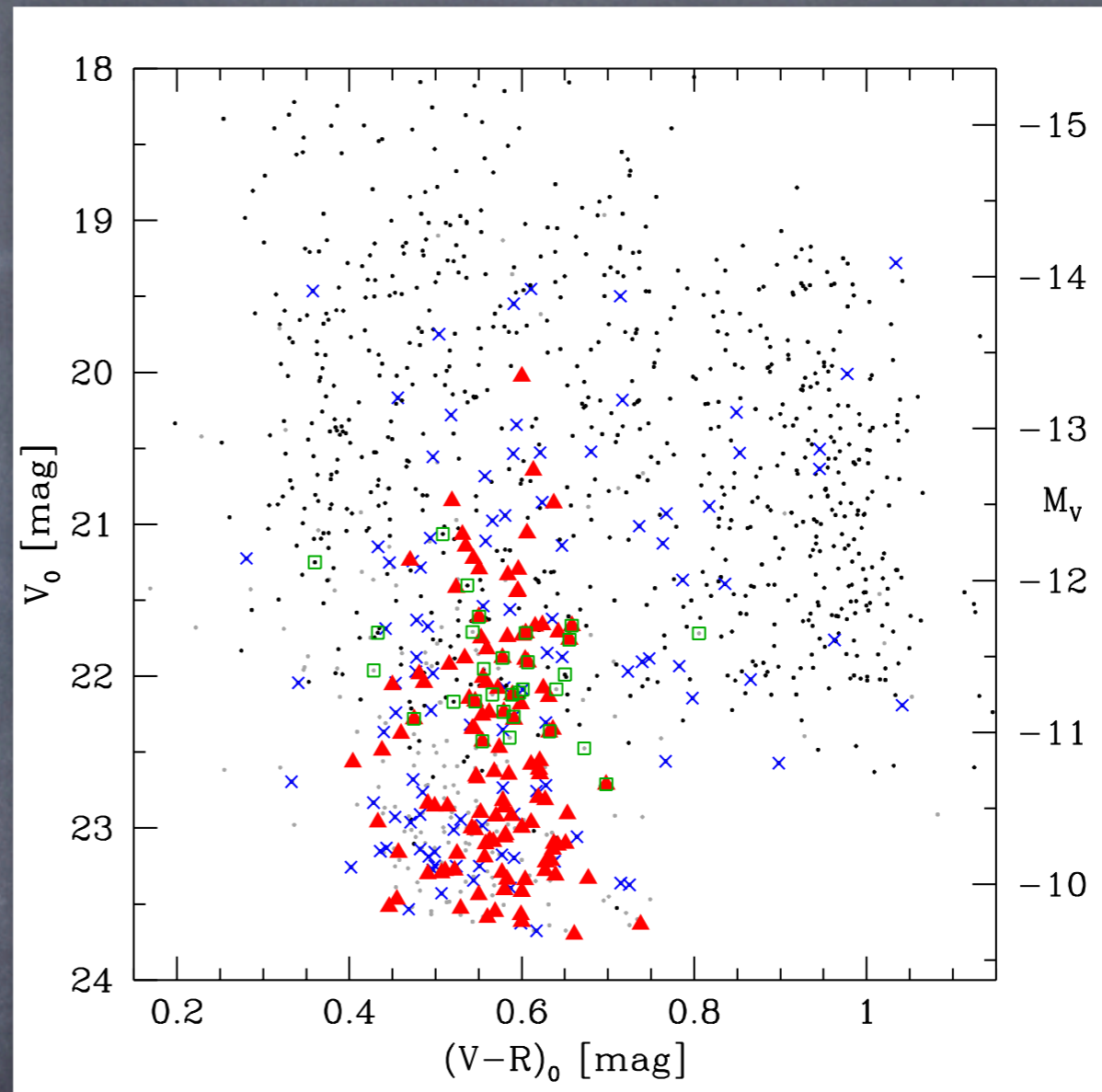
A spectroscopic search for UCDs in Hydra I

- 6 VIMOS pointings in the cluster core region
  (PIs: I. Misgeld, T. Richtler)

- ~1200 medium resolution spectra of GC/UCD candidates

- ~1000 radial velocities (>80%)

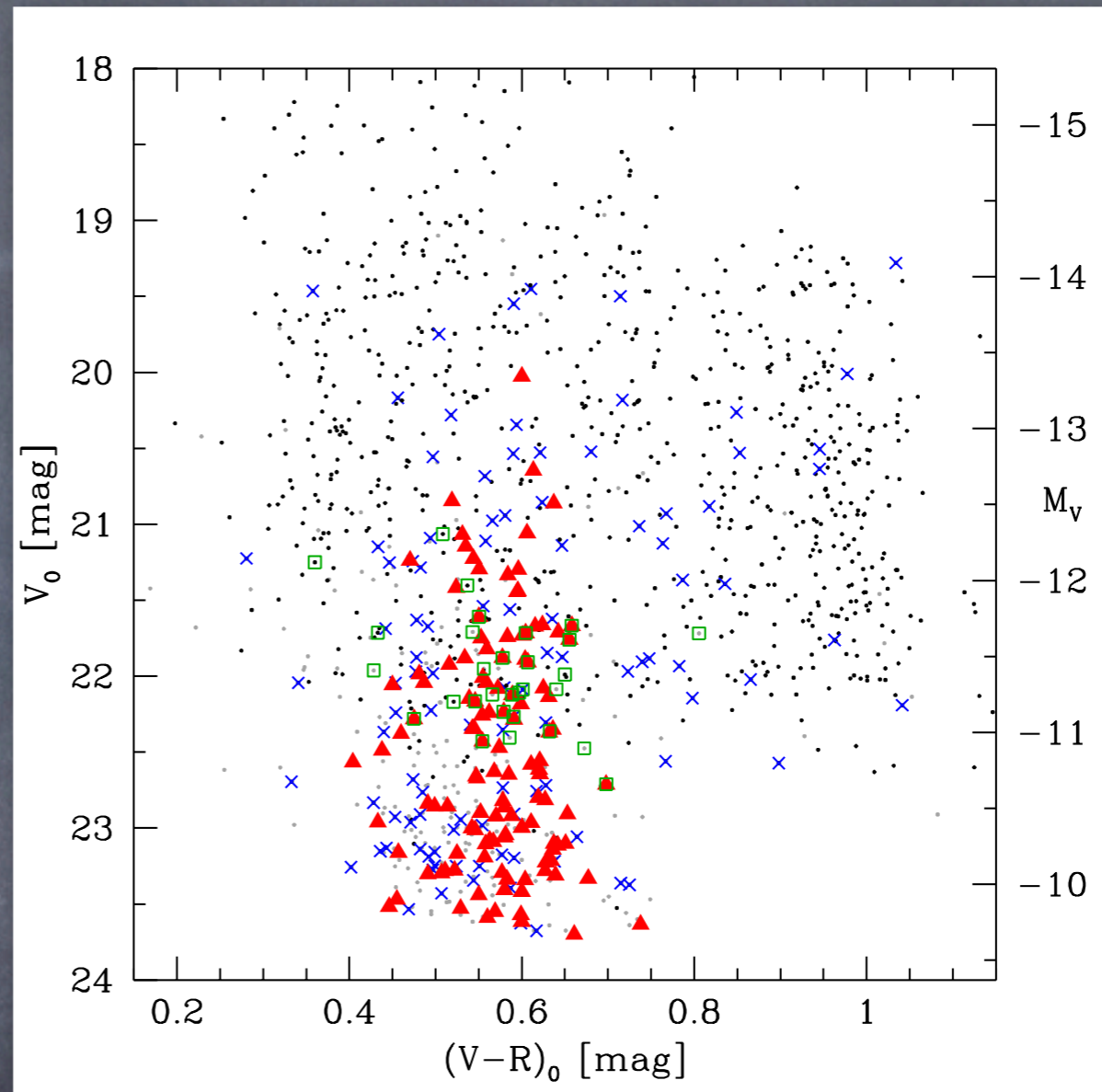Misgeld et al. 2011, arXiv:1103.5463

Photometry I (VIMOS)

118 cluster GCs/UCDs
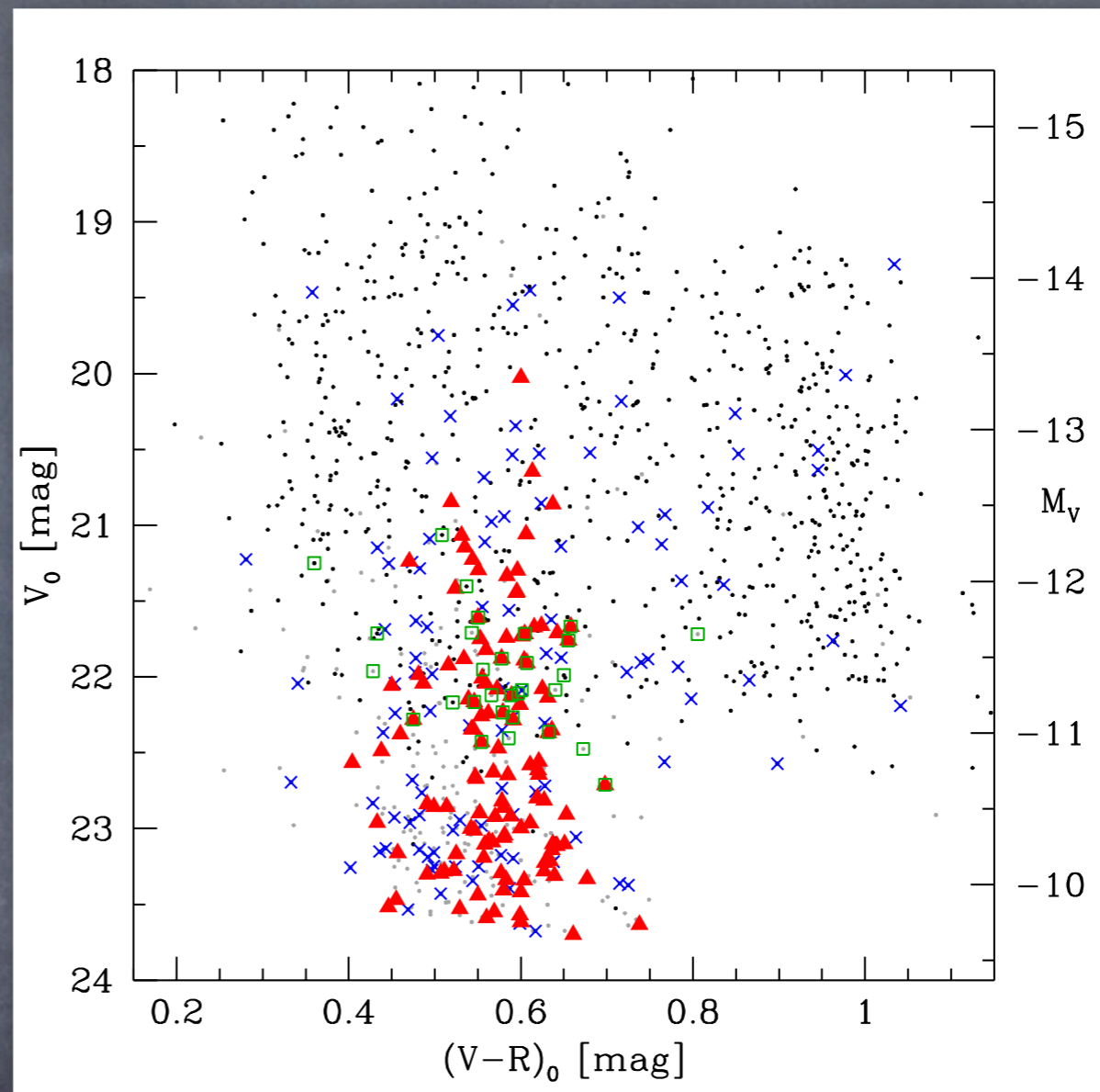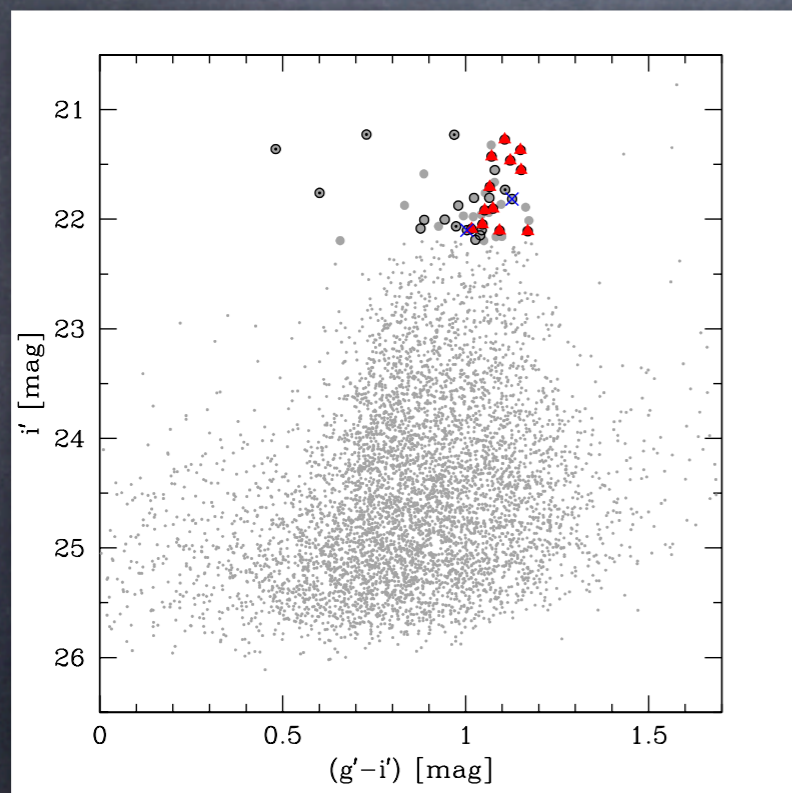
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(mass > 6.5 × 10^6 M$_{sol}$,
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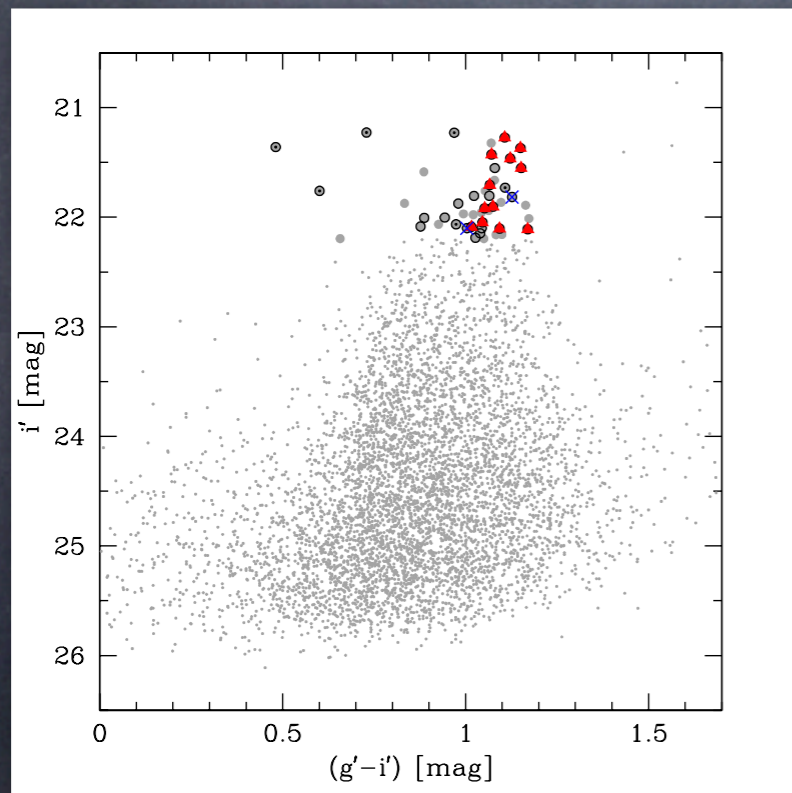assuming M/L = 3)

NGC 3311 GC CMD after Wehner & Harris 2007,
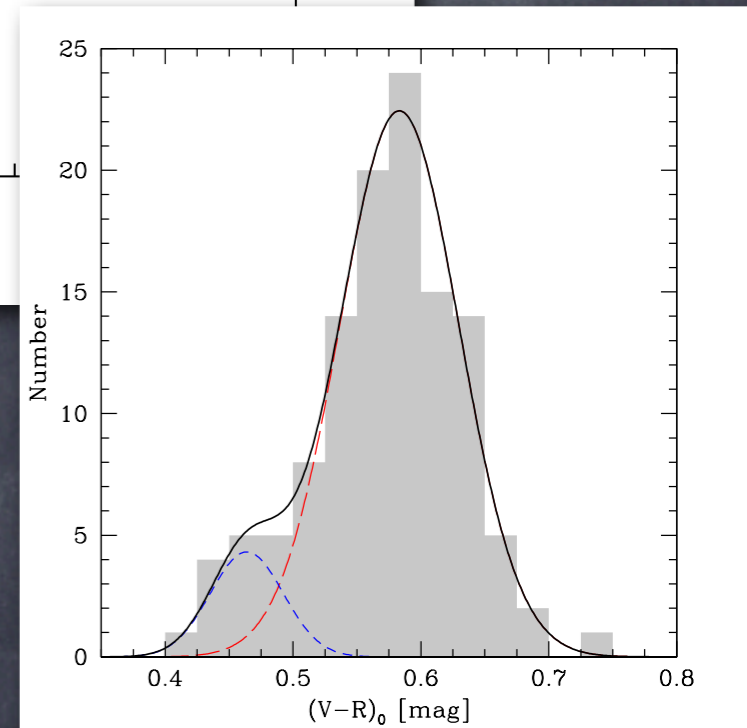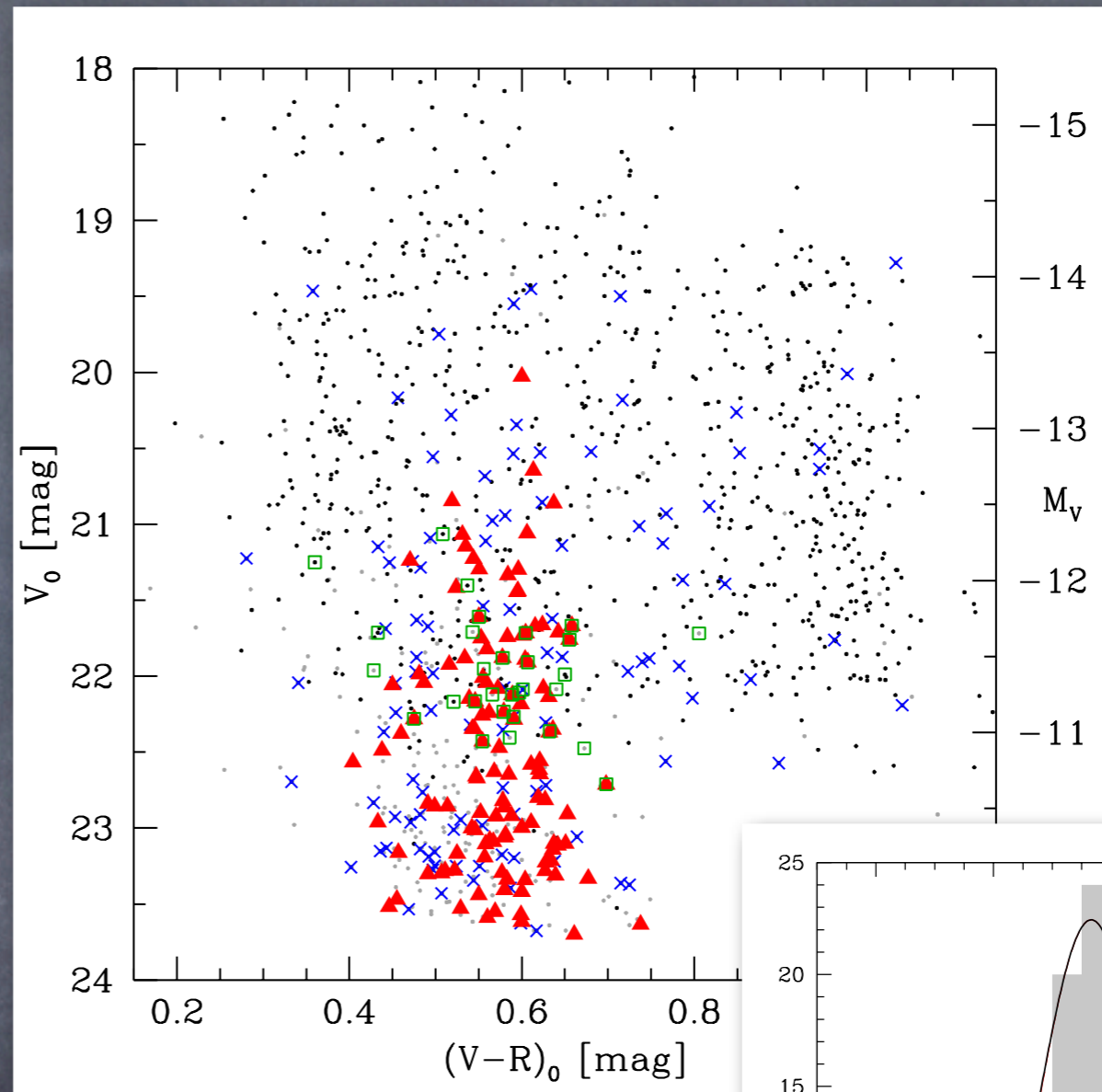Wehner et al. 2008

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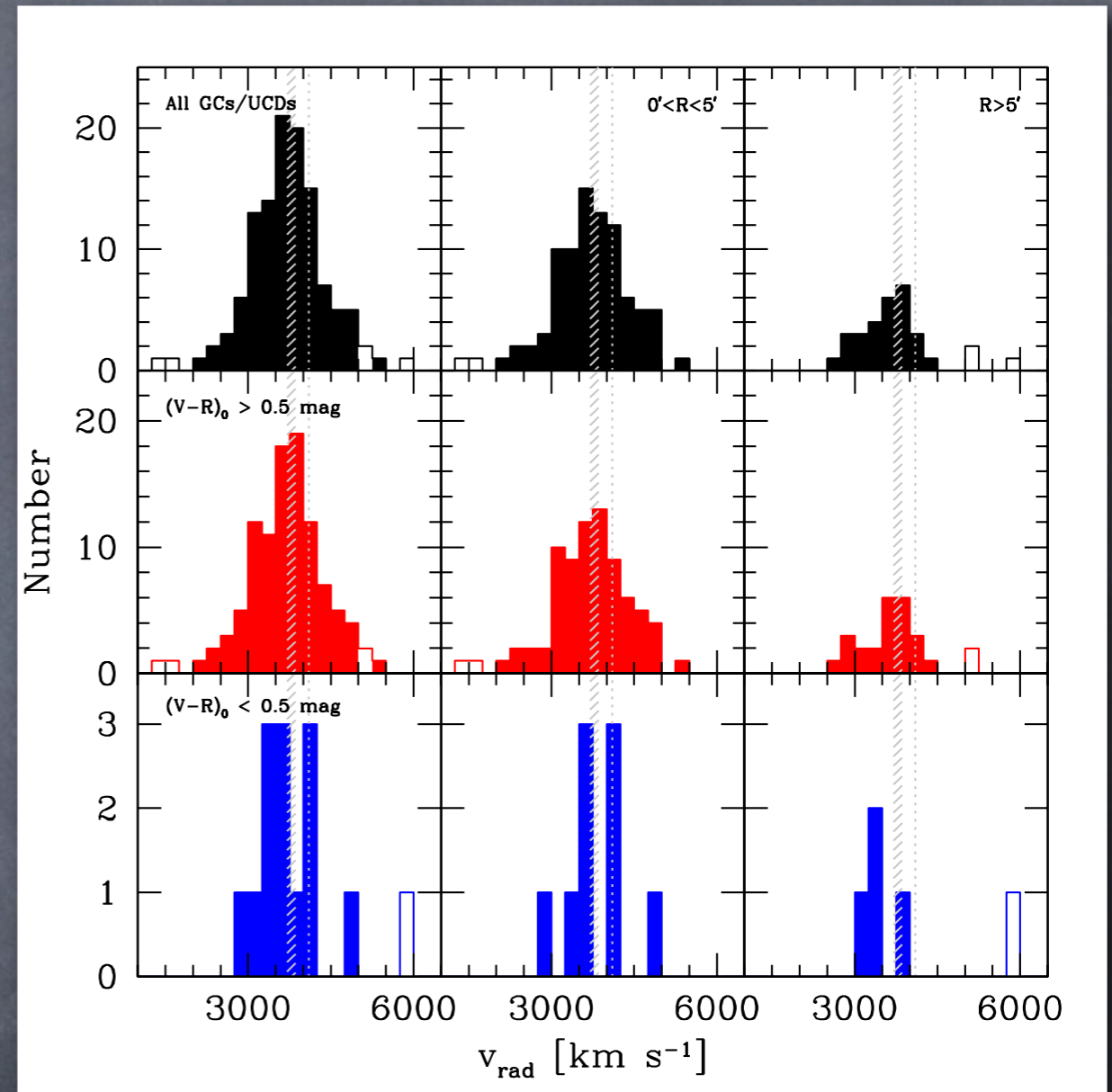
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Kinematics I
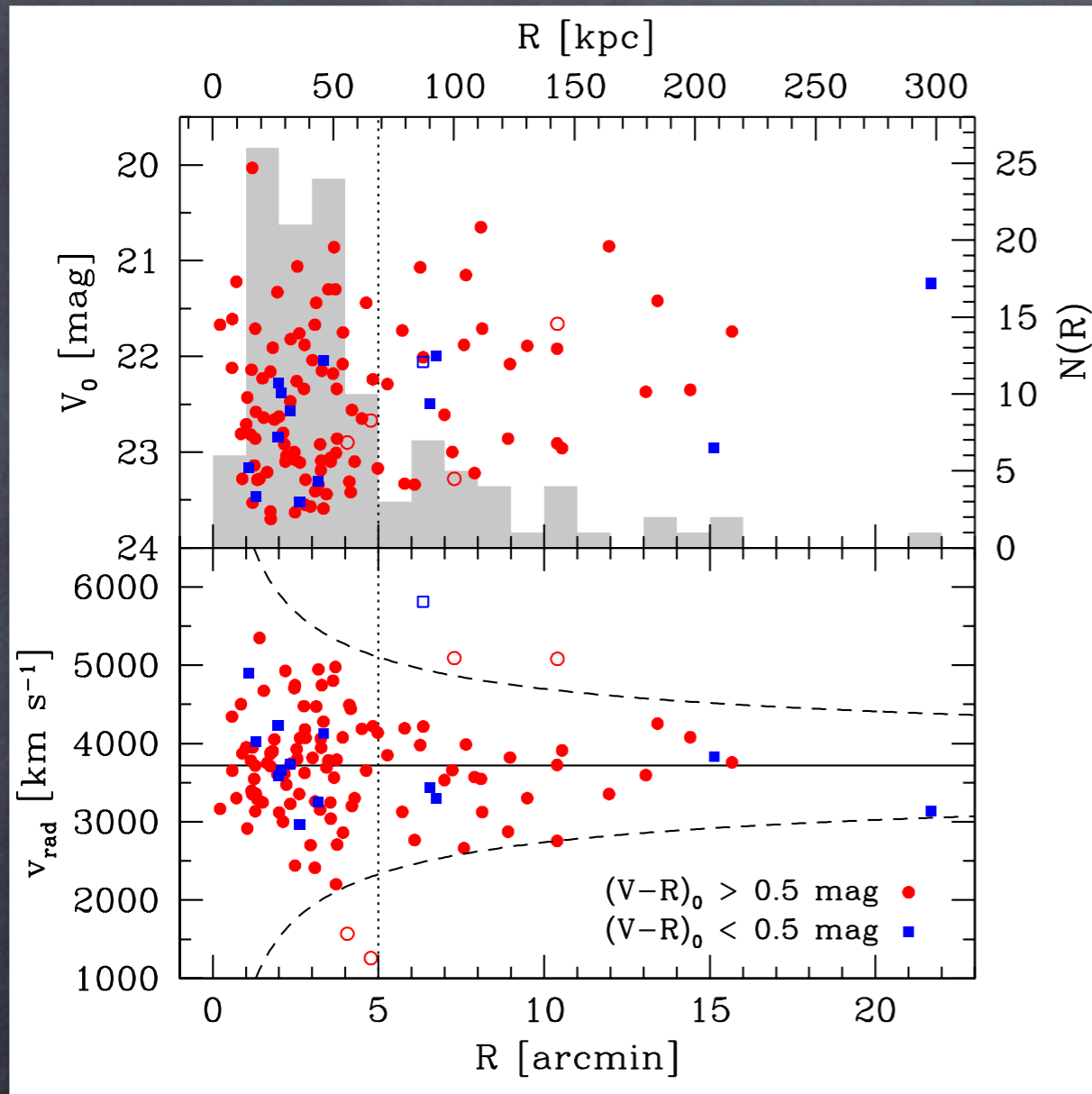
- mean $v_{rad} = 3717 \pm 65$ km/s, consistent with systemic velocity of NGC 3311 (NGC 3309 @ ~4100 km/s)

- $\sigma = 706 \pm 46$ km/s, comparable to galaxy velocity dispersion

- most objects are spatially and dynamically associated to the central cD galaxy

Kinematics II
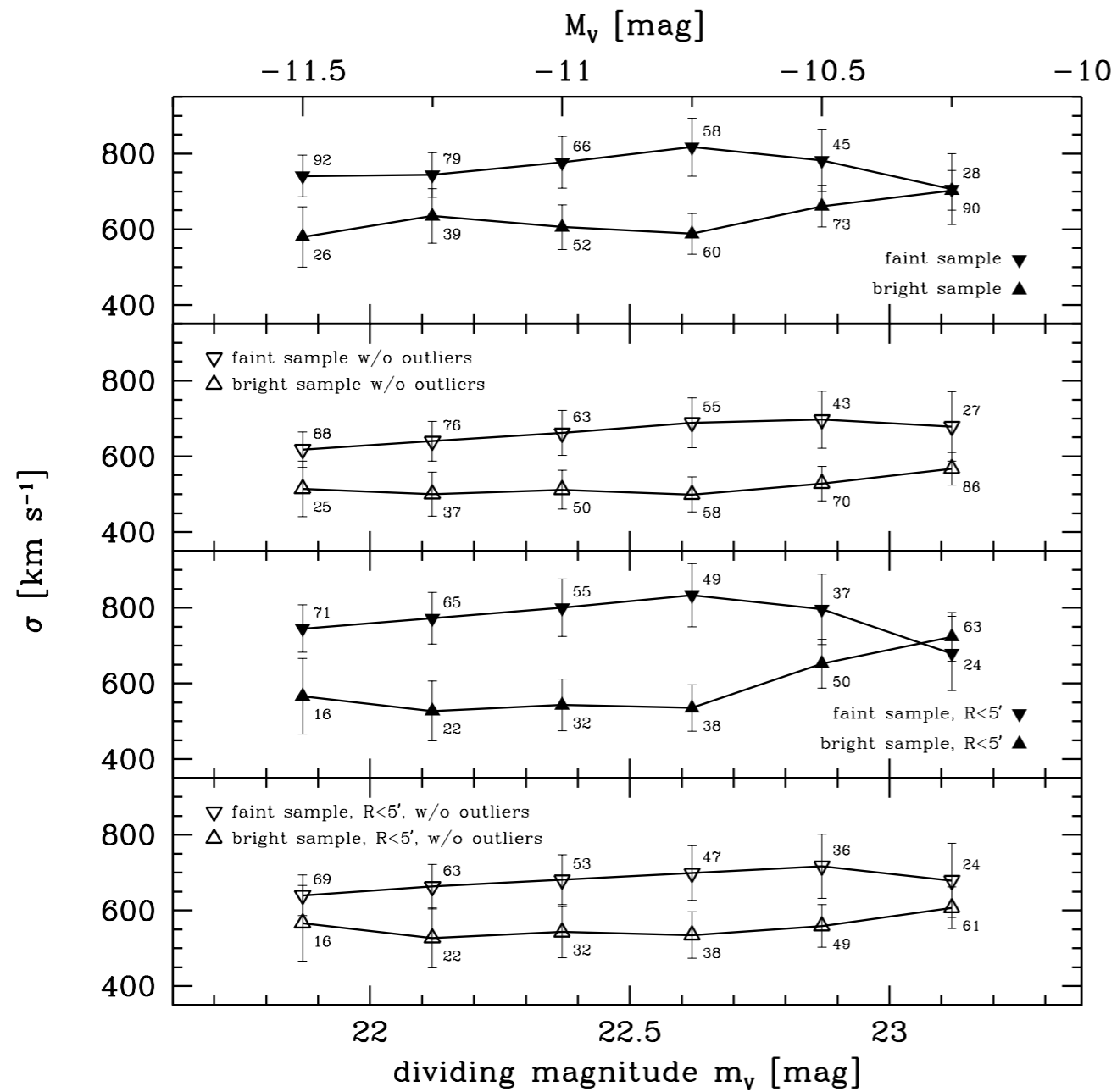
Kinematics II

- brighter GCs/UCDs have lower velocity dispersions
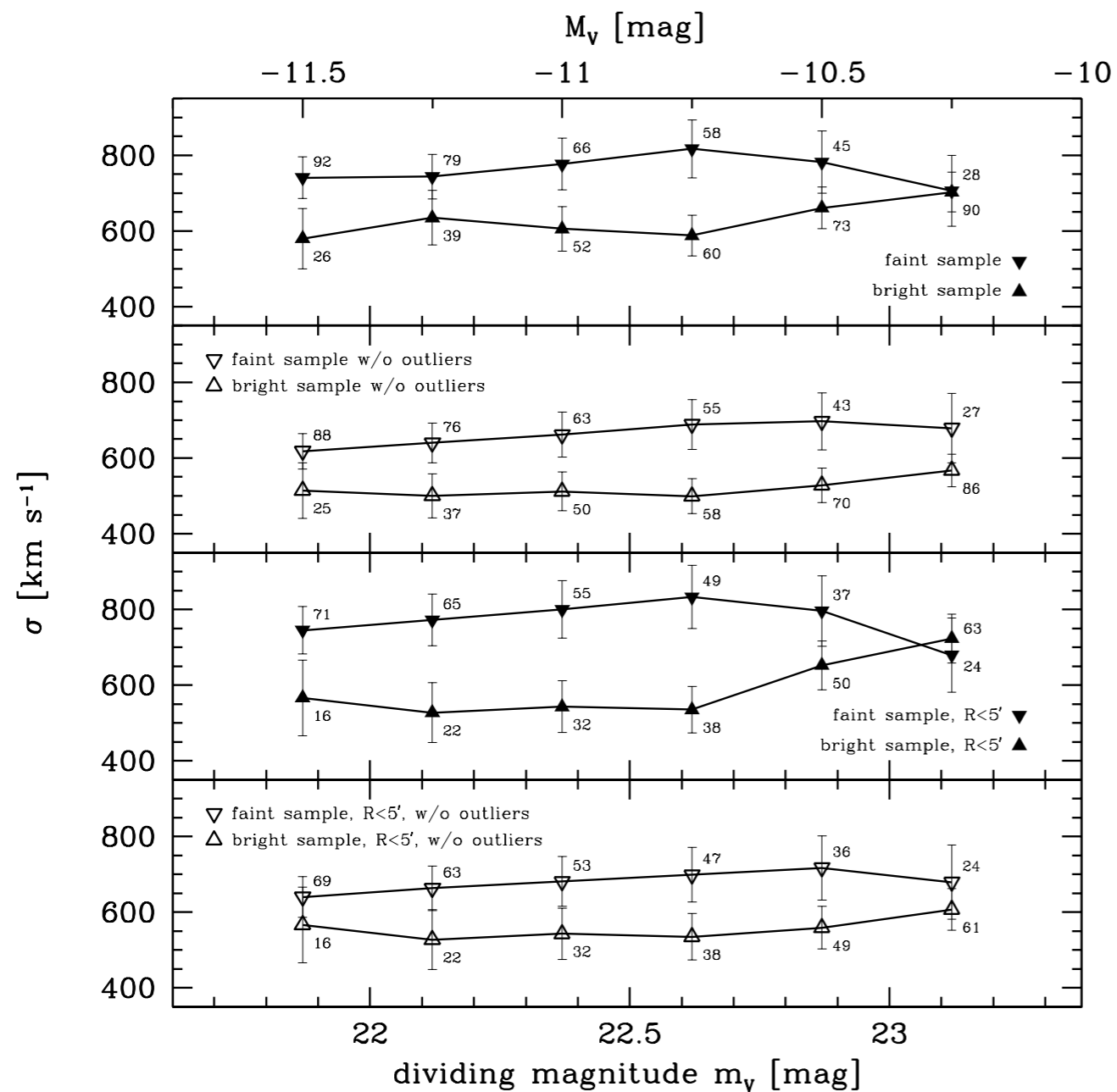
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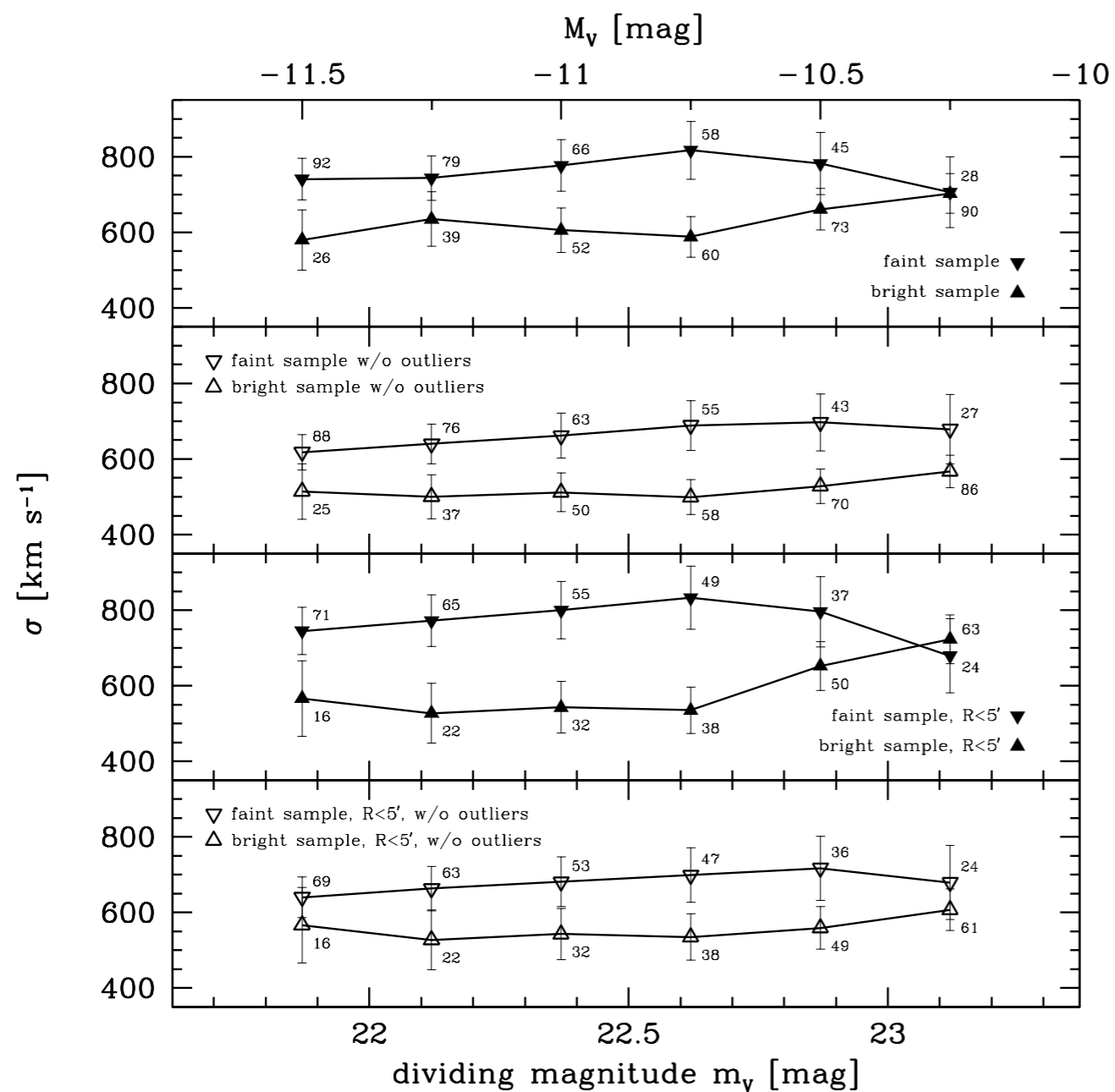
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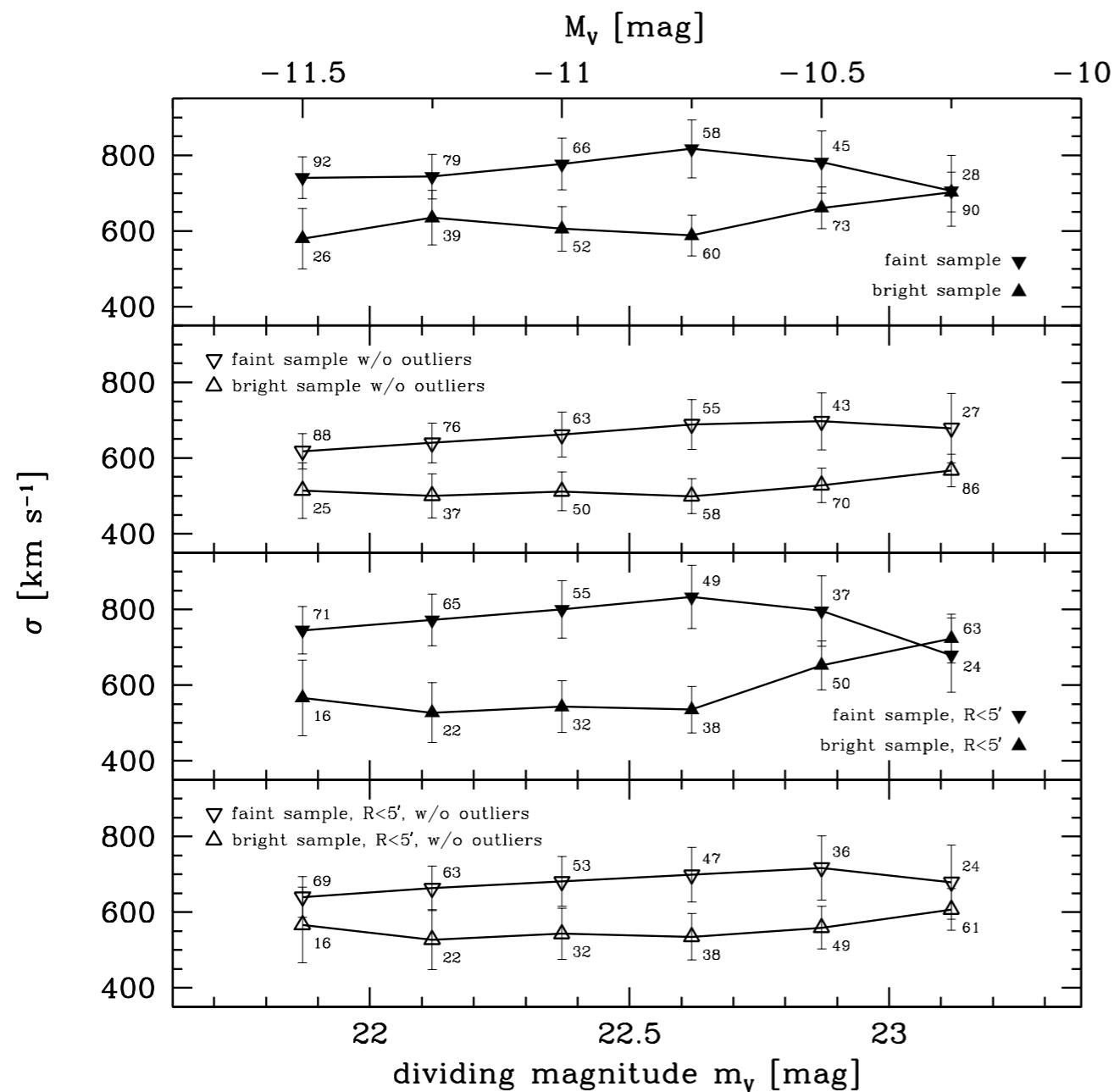
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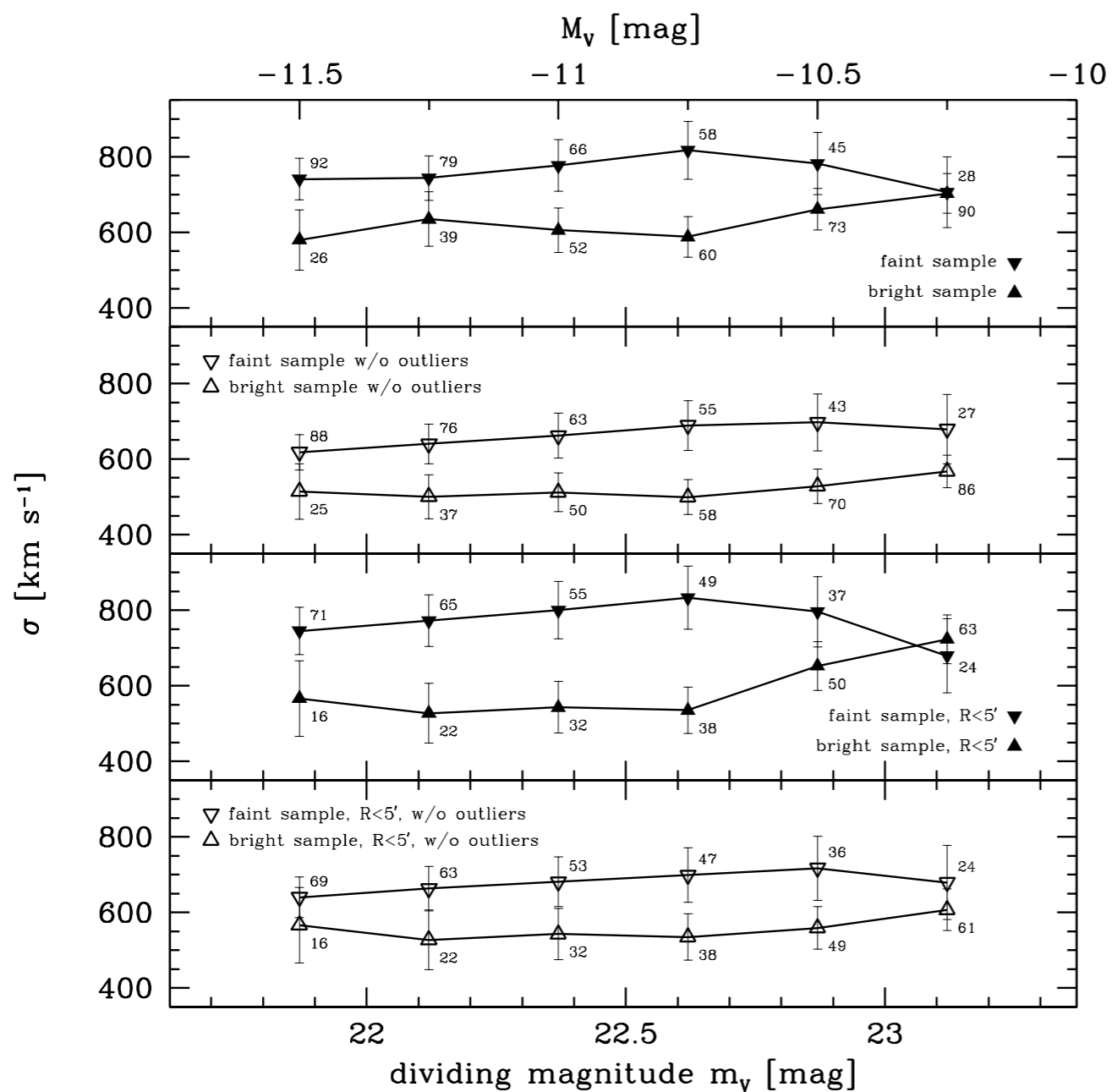- plausible in a scenario, where the brightest objects formed in violent starbursts

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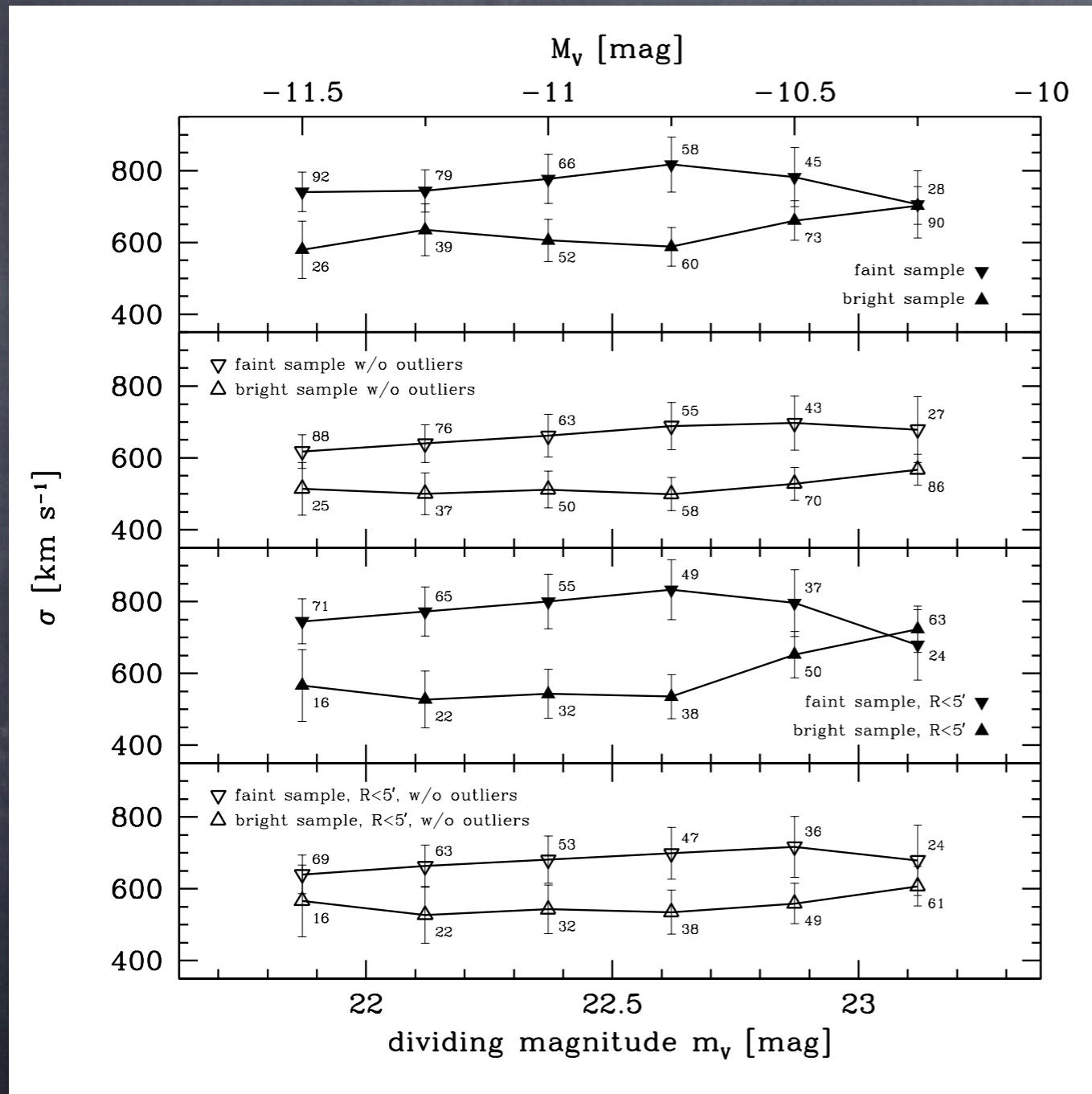

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- complete photometric sample over larger radial range required

Photometry II (HST)
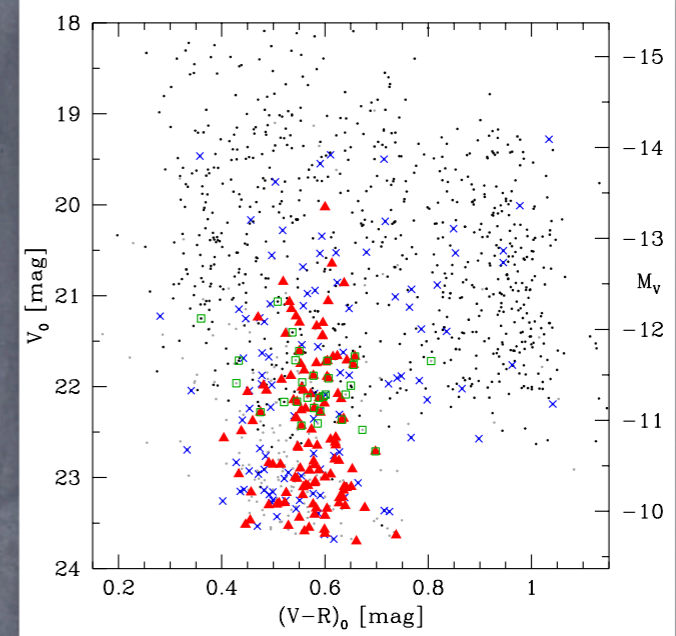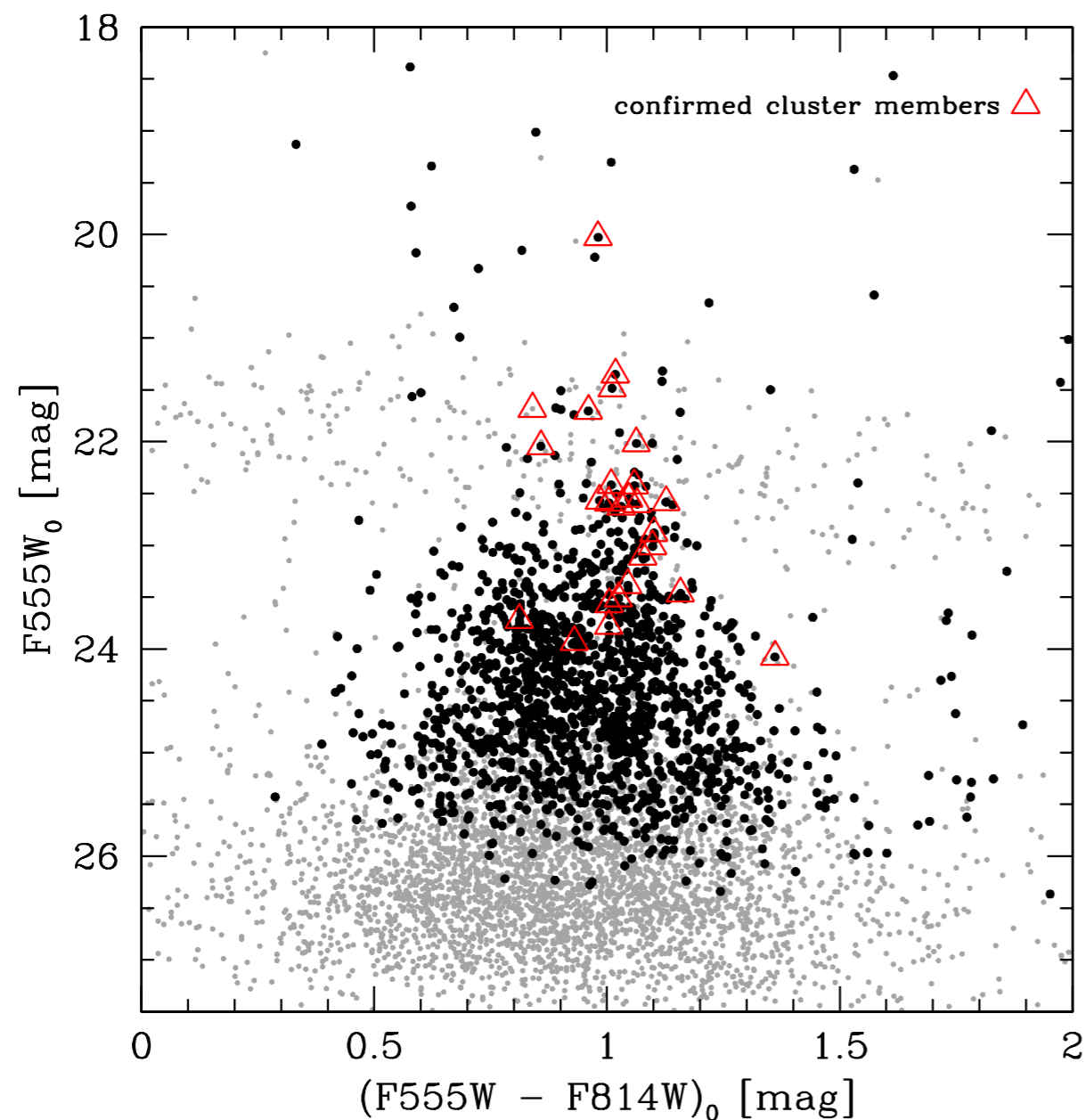
- 26 cluster GCs/UCDs with HST imaging

- brightest UCDs tend to extend the red GC population towards higher luminosities
(see also Wehner et al. 2008)

UCD sizes
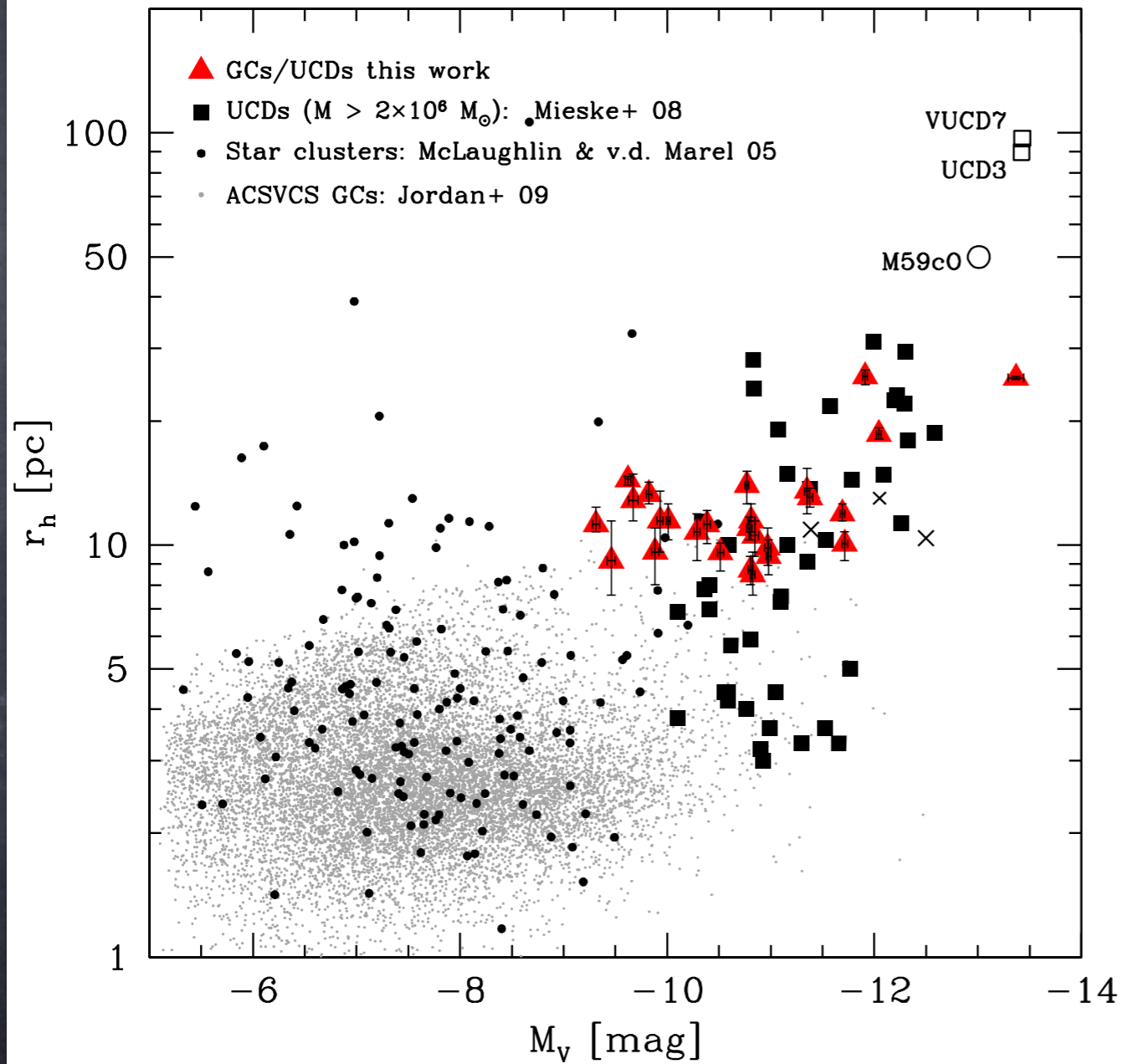
UCD sizes
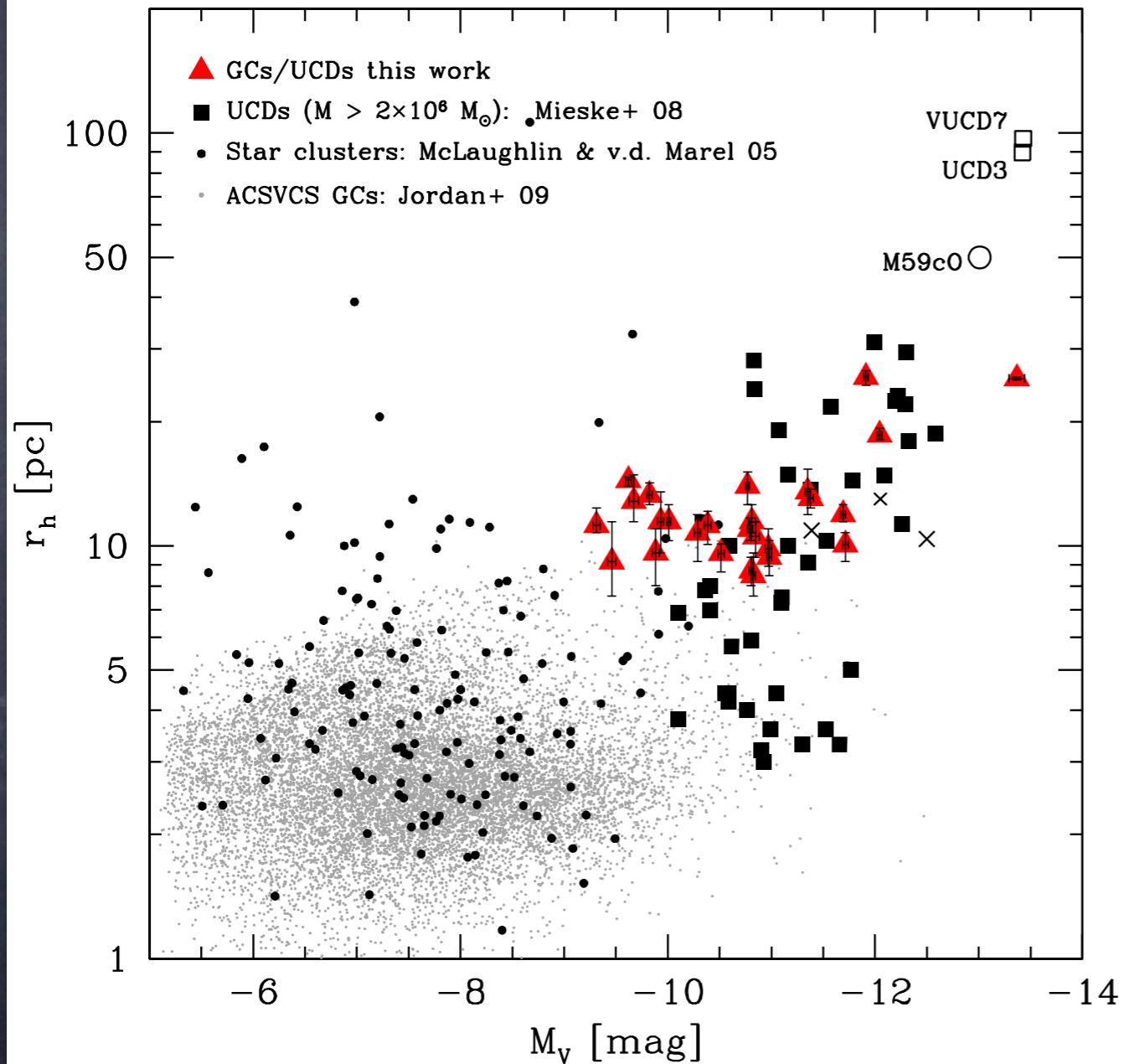
with M_V = −13.4 mag and r_{eff} = 25.4 pc, HUCD1 belongs to the most luminous and most massive UCDs ever discovered

$M_{HUCD1} \approx 5 \times 10^7$ M_{sol} (M/L = 3)
$M_{HUCD1} \geq 1 \times 10^8$ M_{sol} (M/L ≥ 5)

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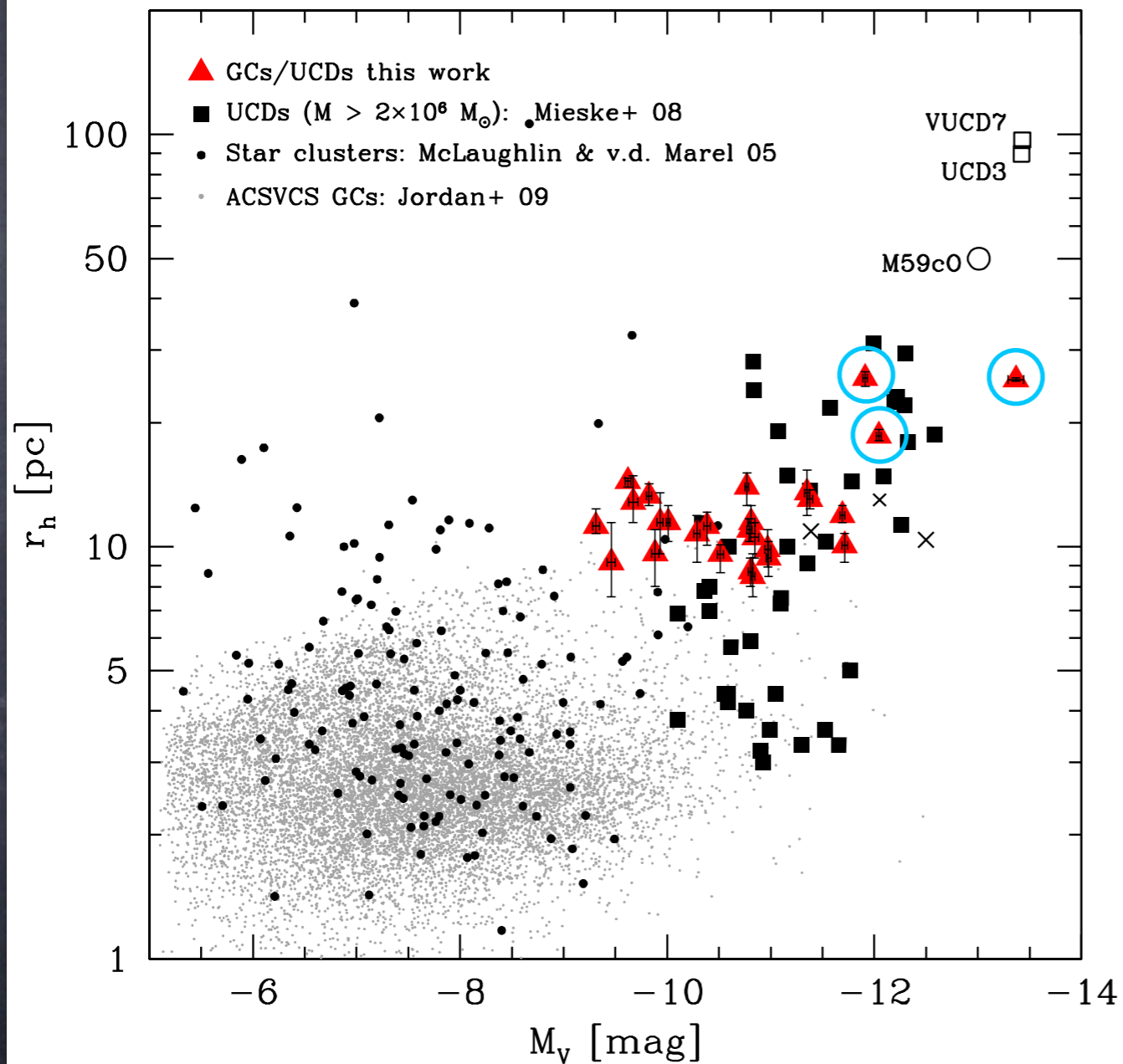
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- HUCD1 is rather compact, but faint envelope?

Families of dynamically hot stellar systems...
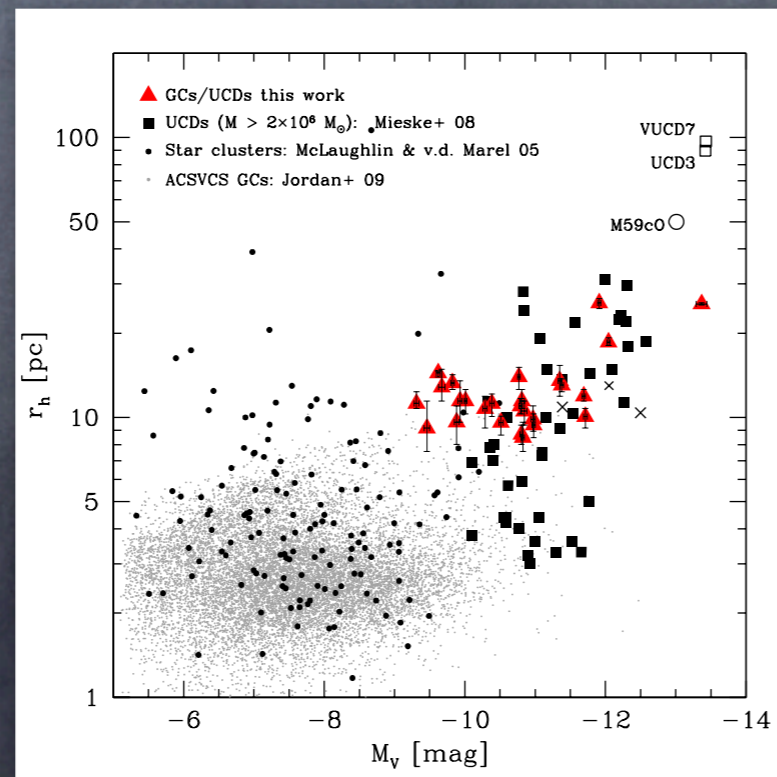
Families of interesting stellar systems...
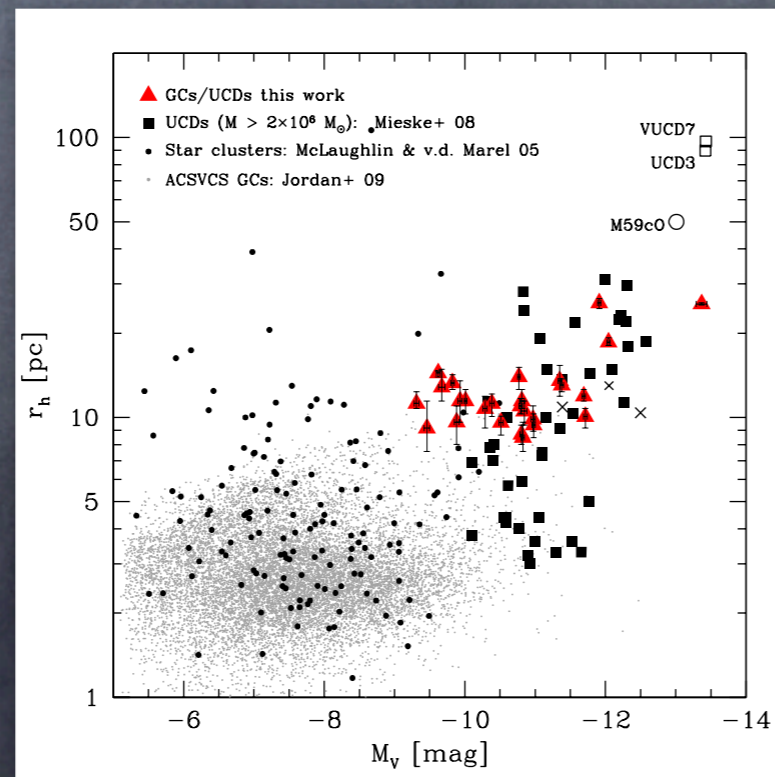
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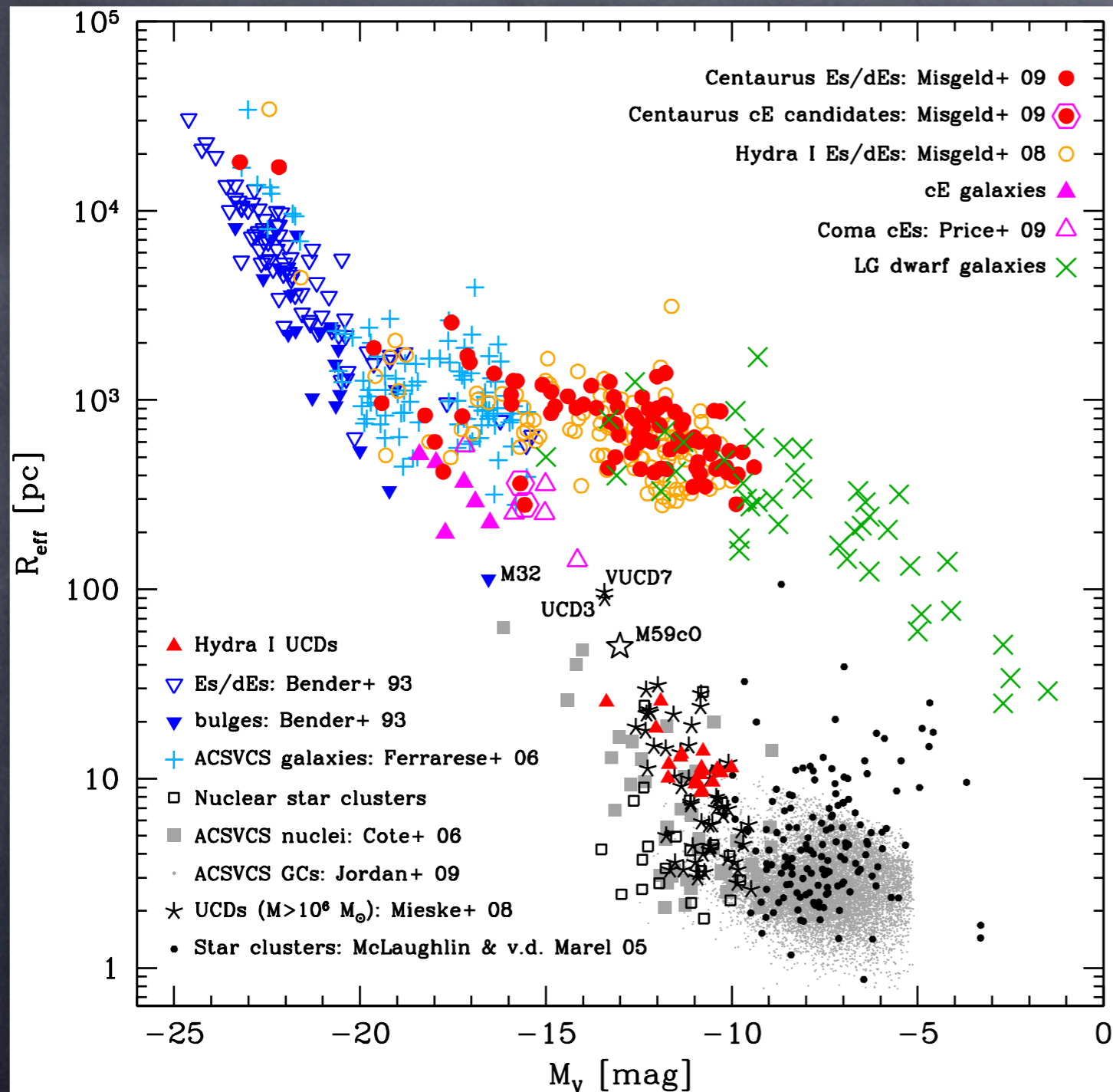
Misgeld & Hilker 2011, arXiv:1103.1628

Families of interesting stellar systems...

Centaurus Es/dEs: Misgeld+ 09 ●
Centaurus cE candidates: Misgeld+ 09 ⬡
Hydra I Es/dEs: Misgeld+ 08 ○
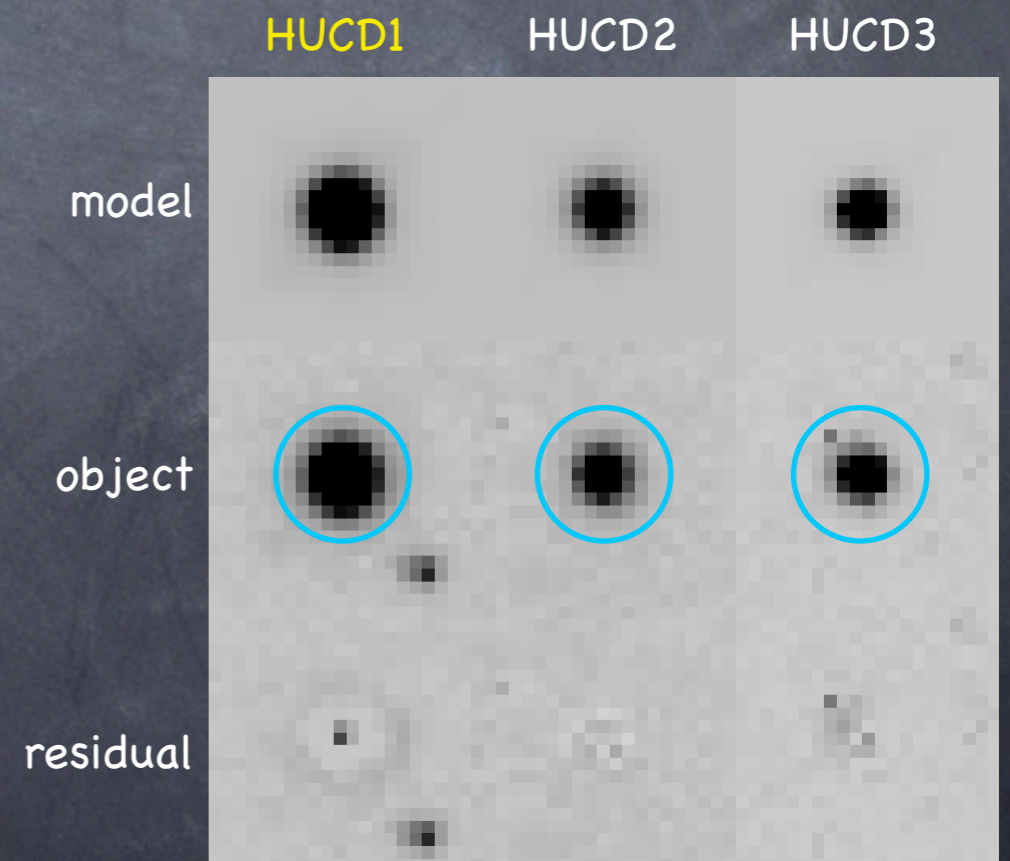cE galaxies ▲
Coma cEs: Price+ 09 △
LG dwarf galaxies ✕

Hydra I UCDs ▲
Es/dEs: Bender+ 93 ▽
bulges: Bender+ 93 ▼
ACSVCS galaxies: Ferrarese+ 06 +
Nuclear star clusters □
ACSVCS nuclei: Cote+ 06 ▪
ACSVCS GCs: Jordan+ 09 ·
UCDs (M>10⁶ M⊙): Mieske+ 08 ✳
Star clusters: McLaughlin & v.d. Marel 05 •

M32
VUCD7
UCD3
M59cO

R_{eff} [pc]
M_V [mag]

Misgeld & Hilker 2011, arXiv:1103.1628
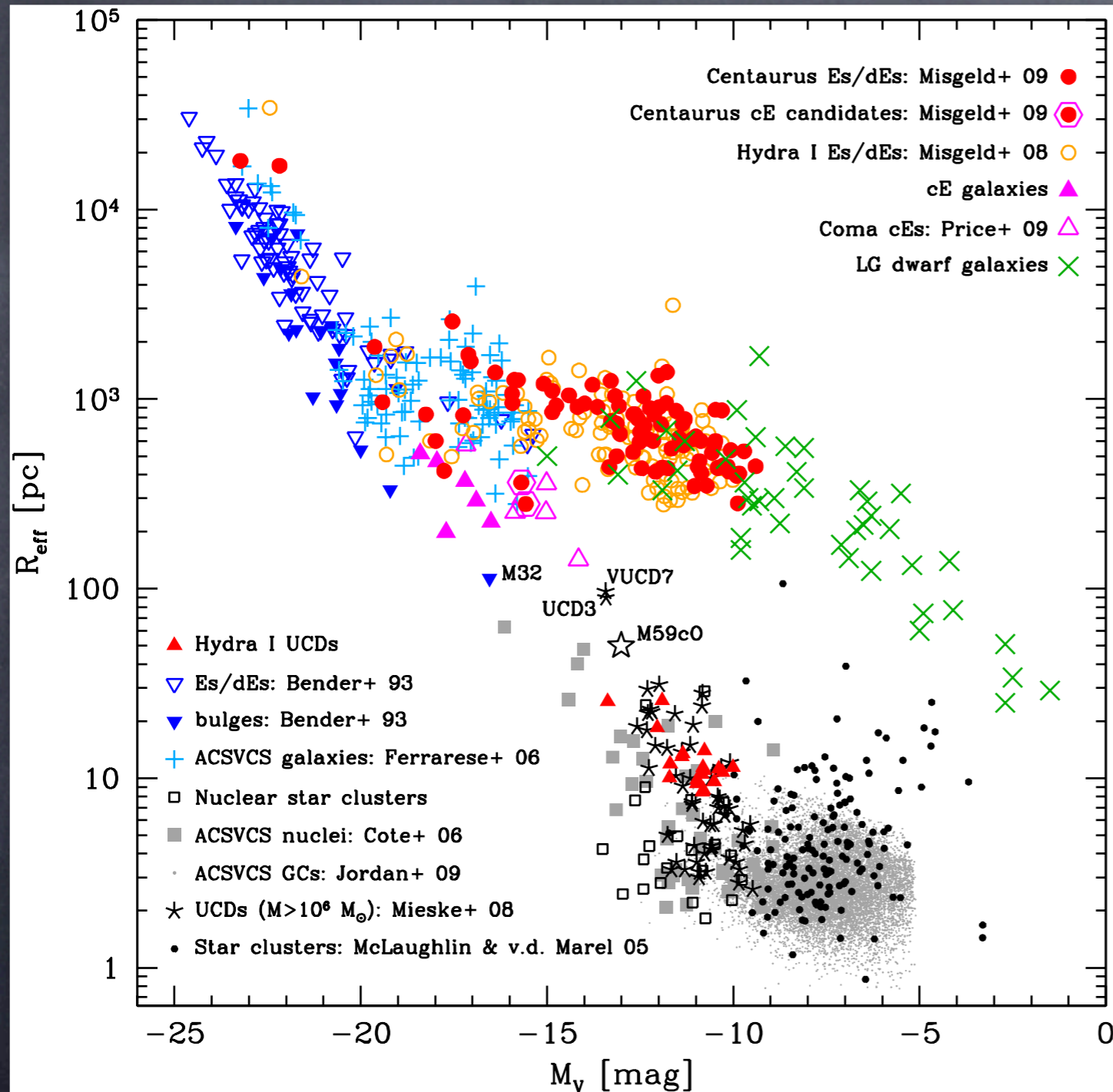
- two distinct families of objects:

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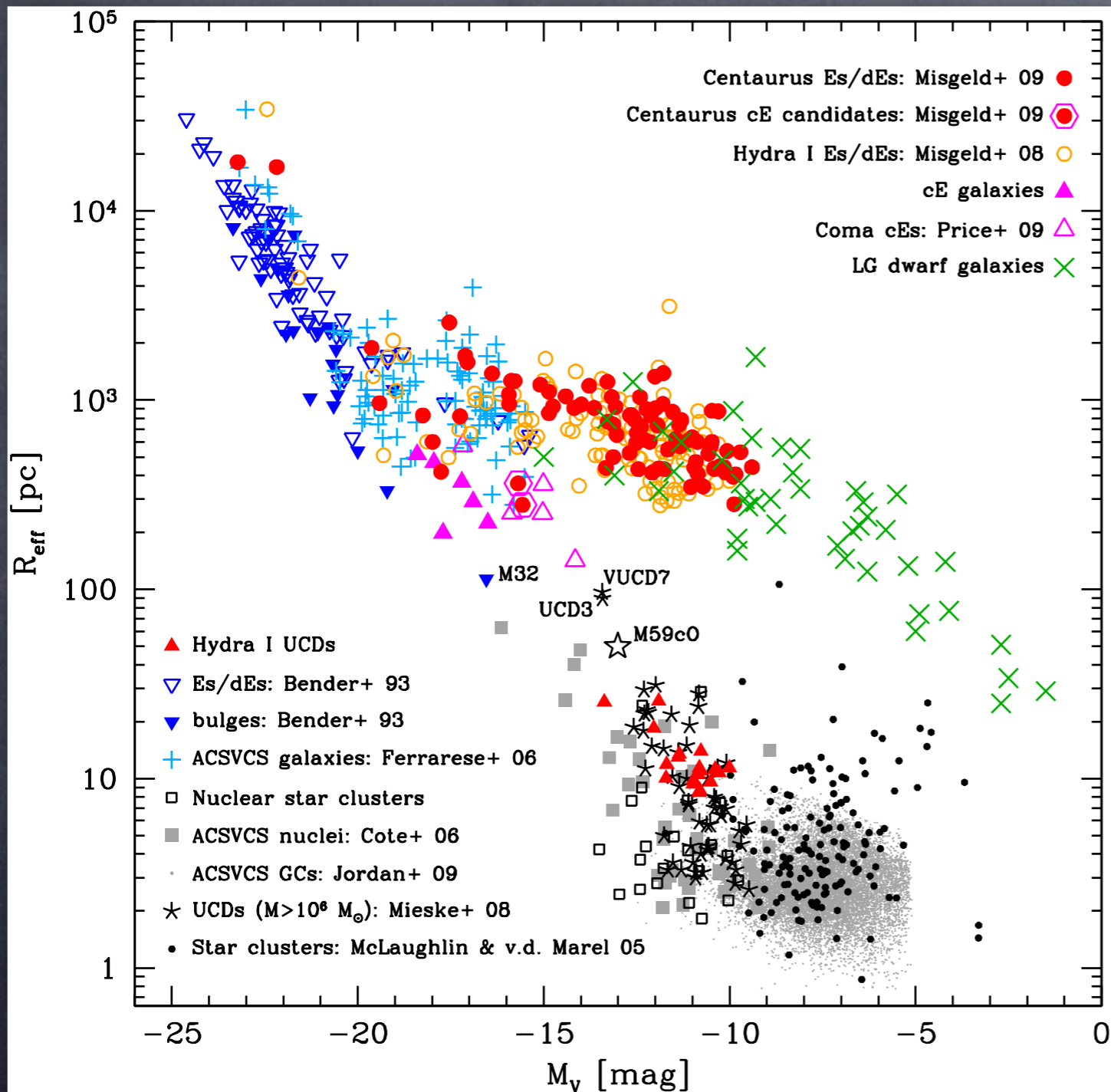
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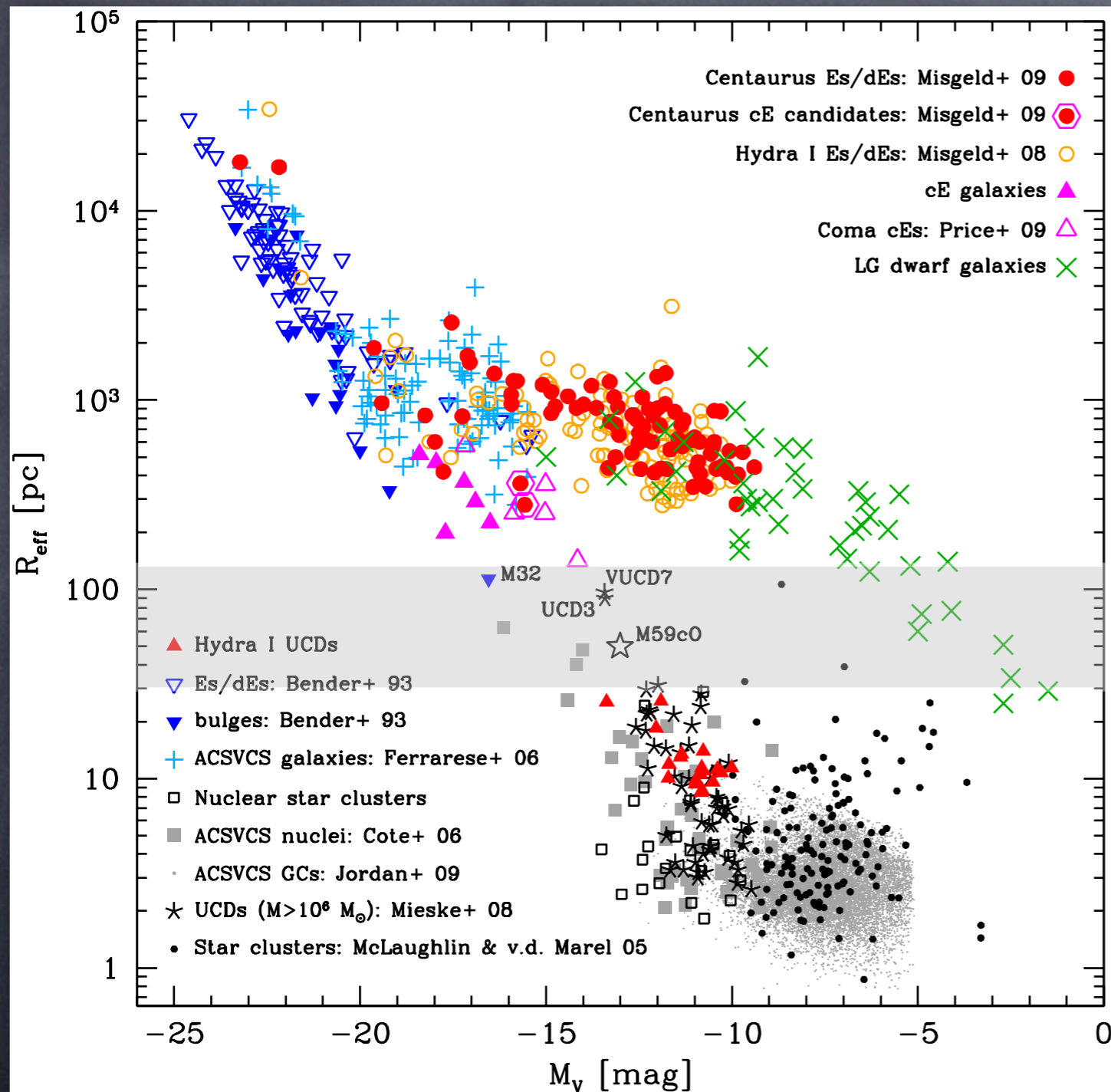
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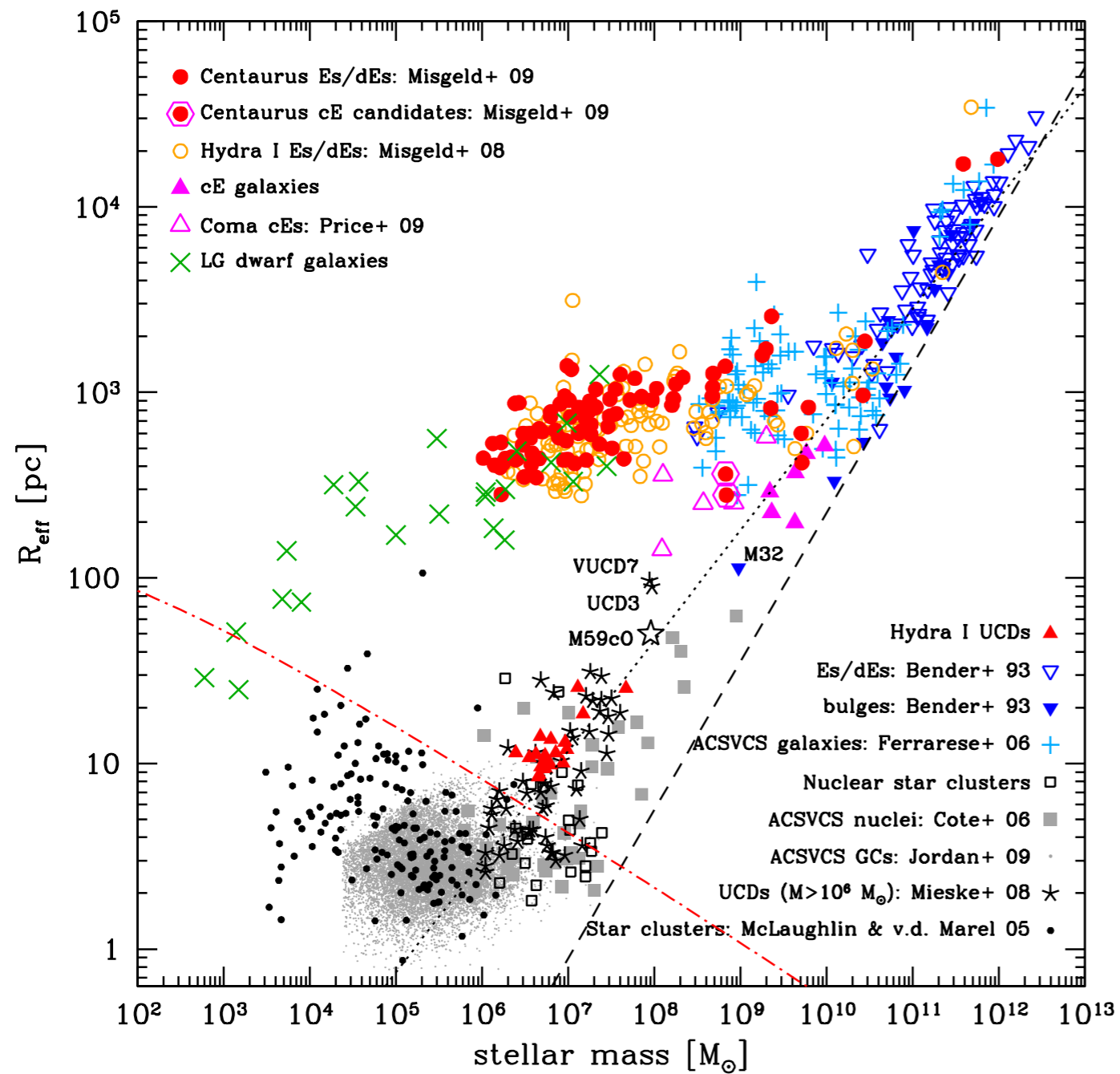
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- is there really a size gap between ~30 pc and ~120 pc? (Gilmore et al. 2007)

...over 10 orders of magnitude in mass

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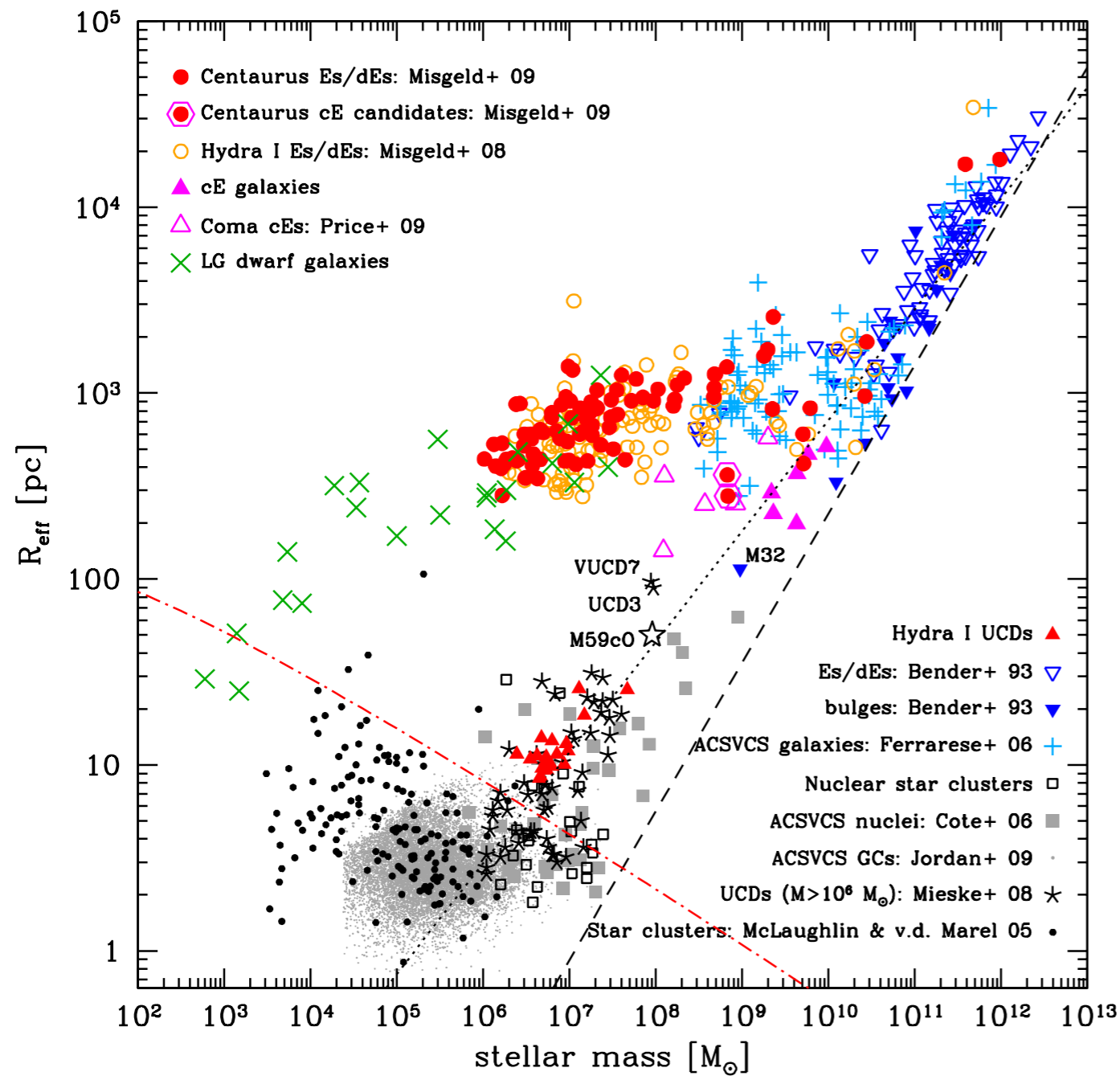
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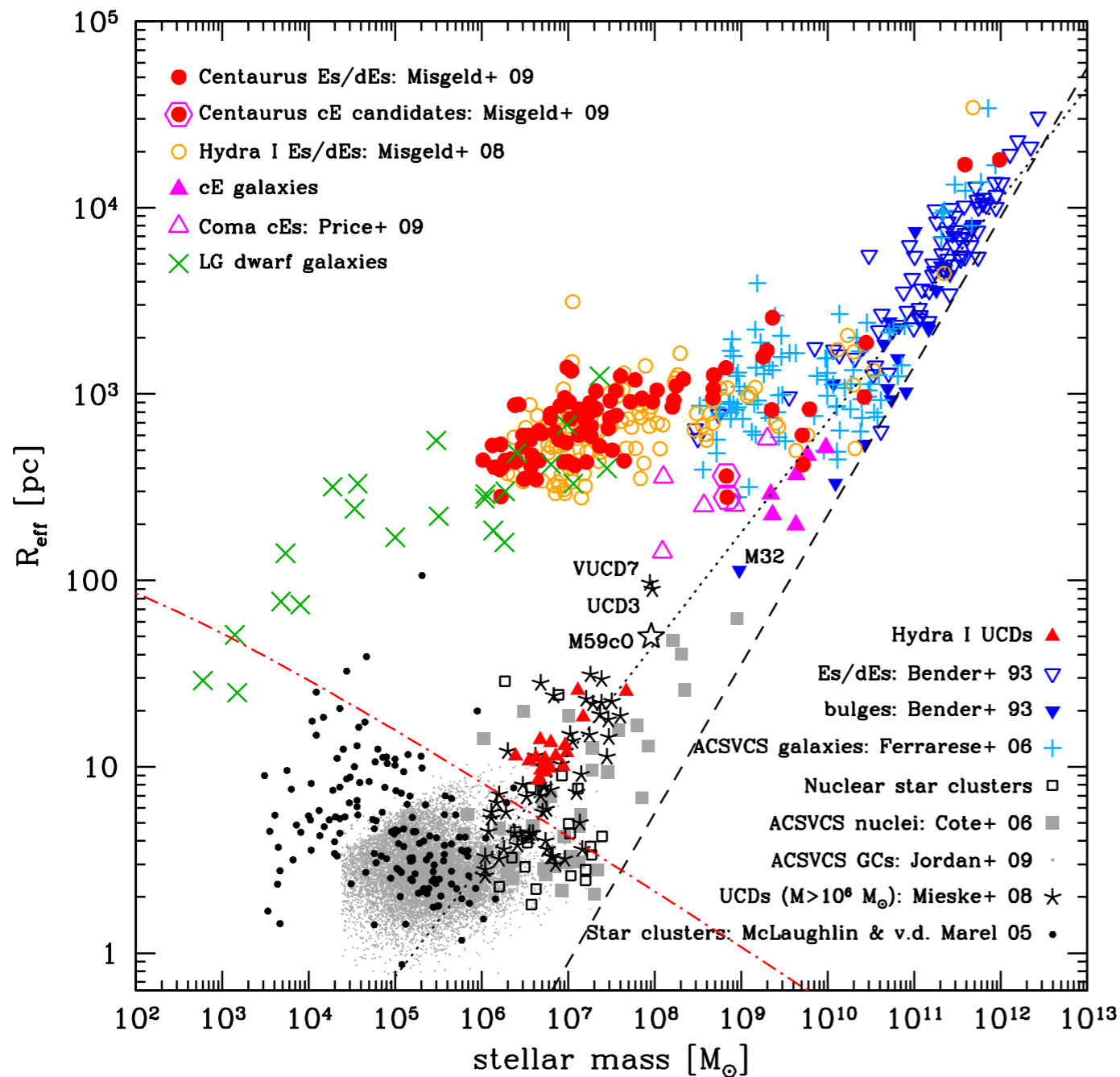
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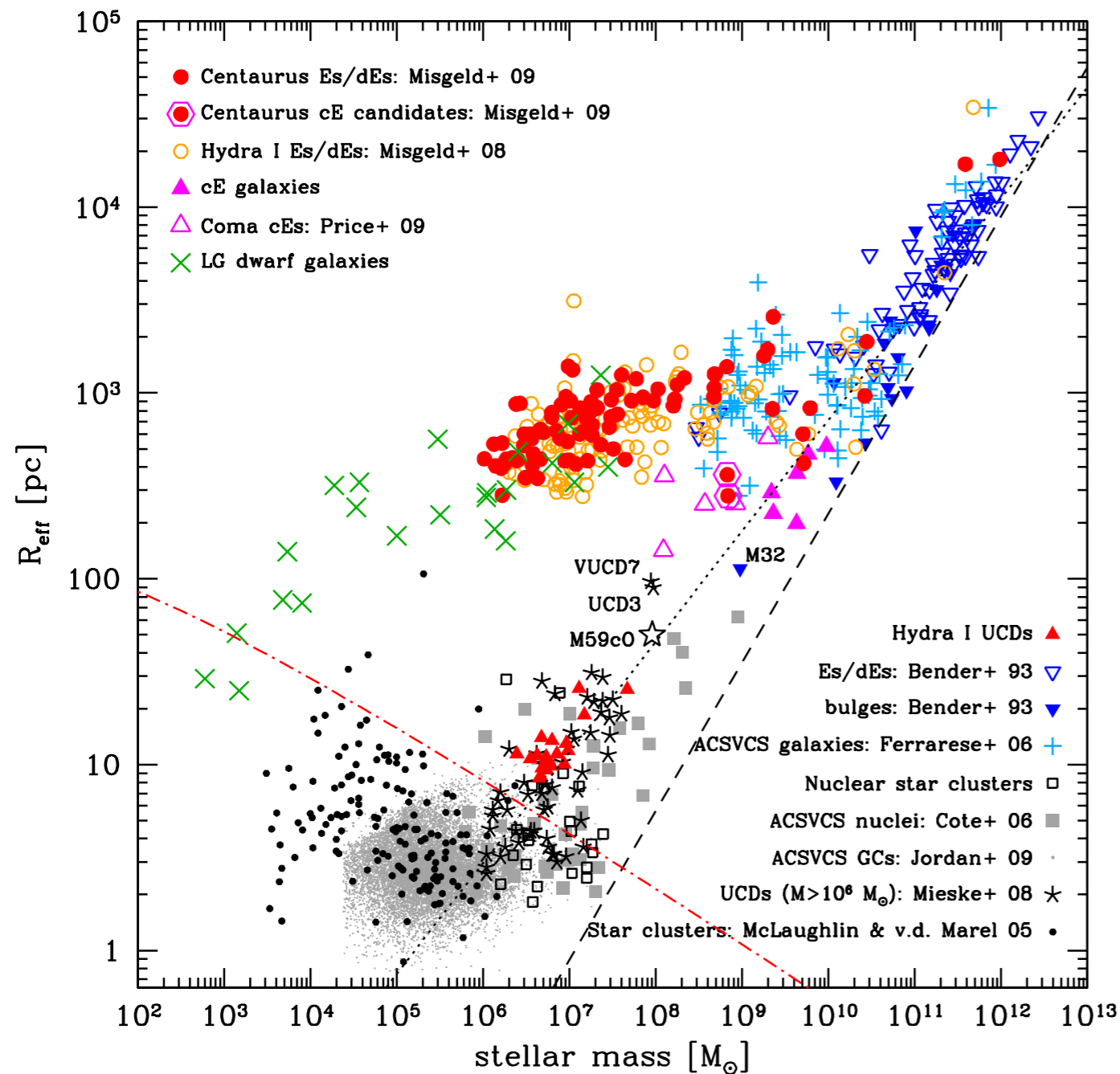
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$$R_{\rm eff} = 2.24 \cdot 10^{-6} \cdot M_\star^{4/5}\,{\rm pc}$$

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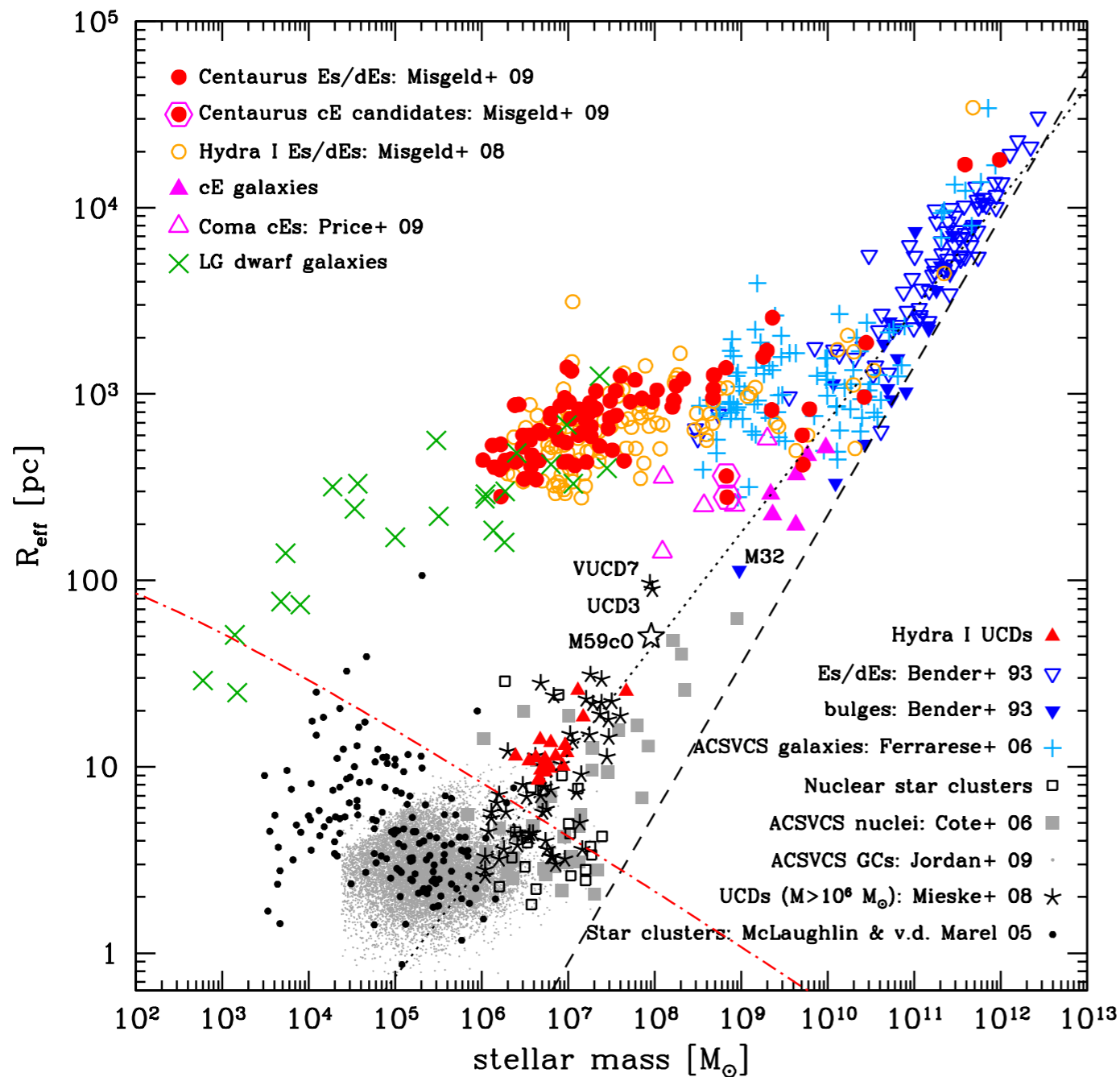
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- connection between UCDs and nuclei of dE,Ns?
  (--> talks by Michael Hilker and Mark Norris)

Galaxies and their star cluster mates
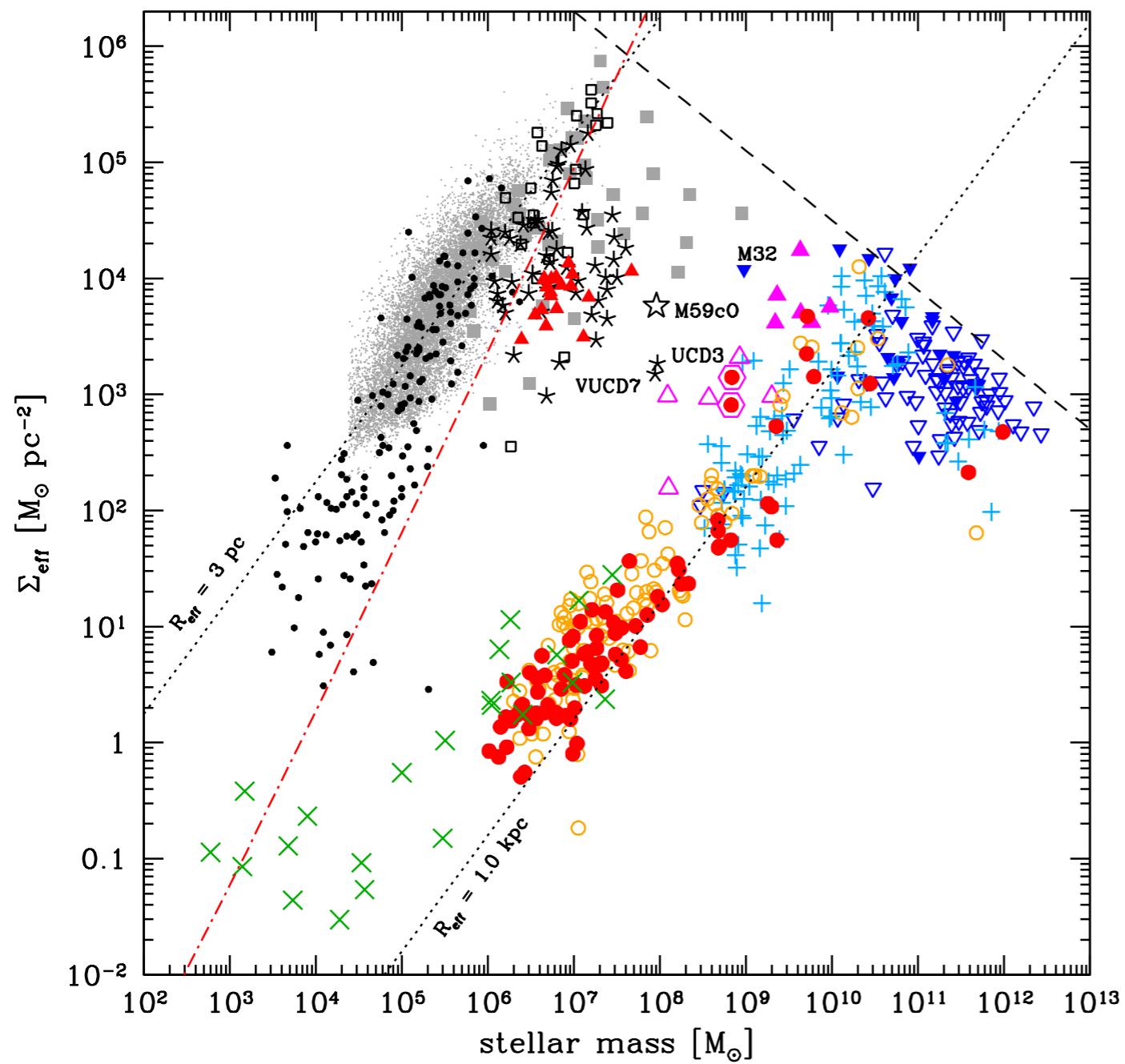
Galaxies and their star cluster mates
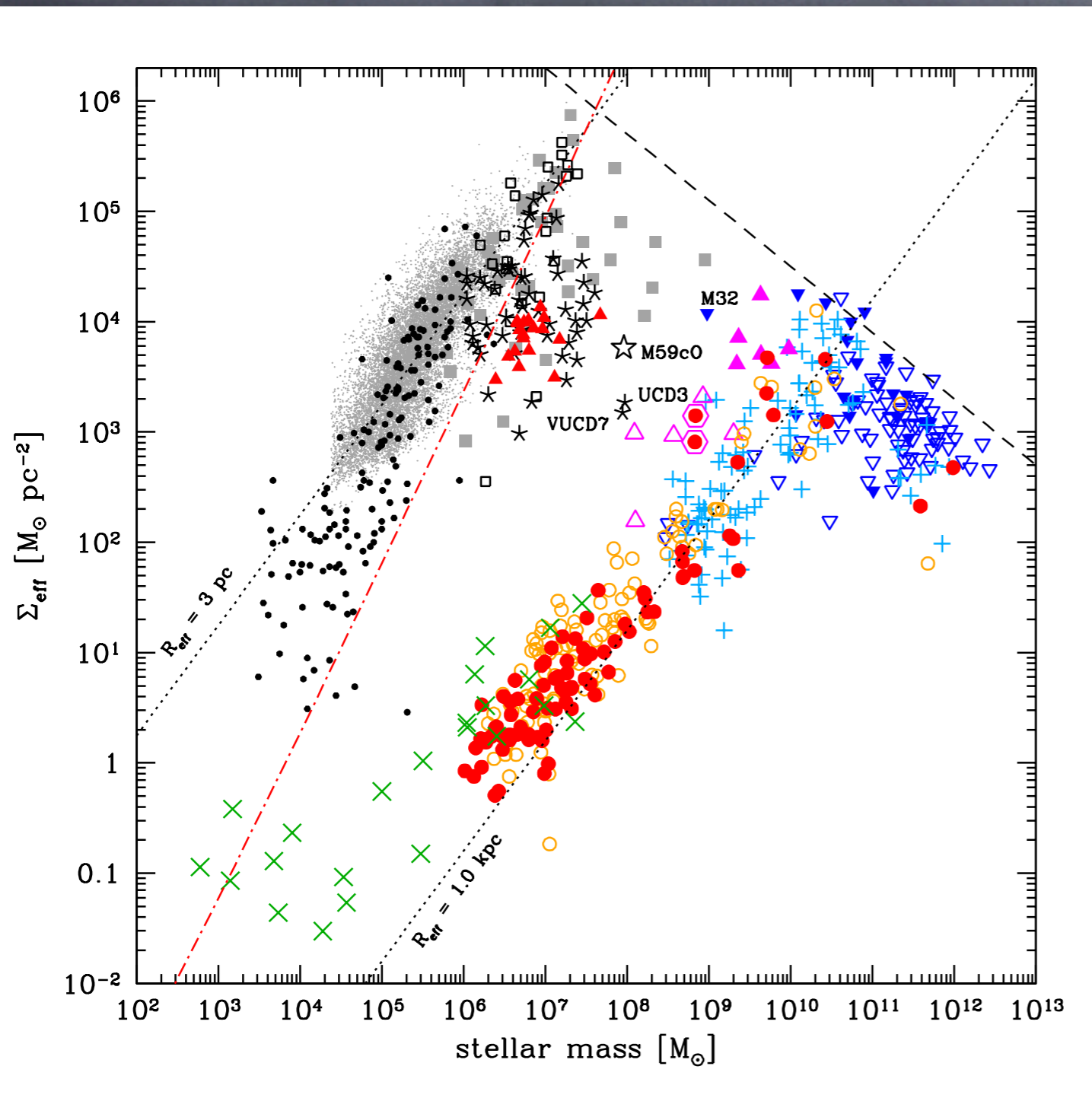
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Galaxies and their star cluster mates

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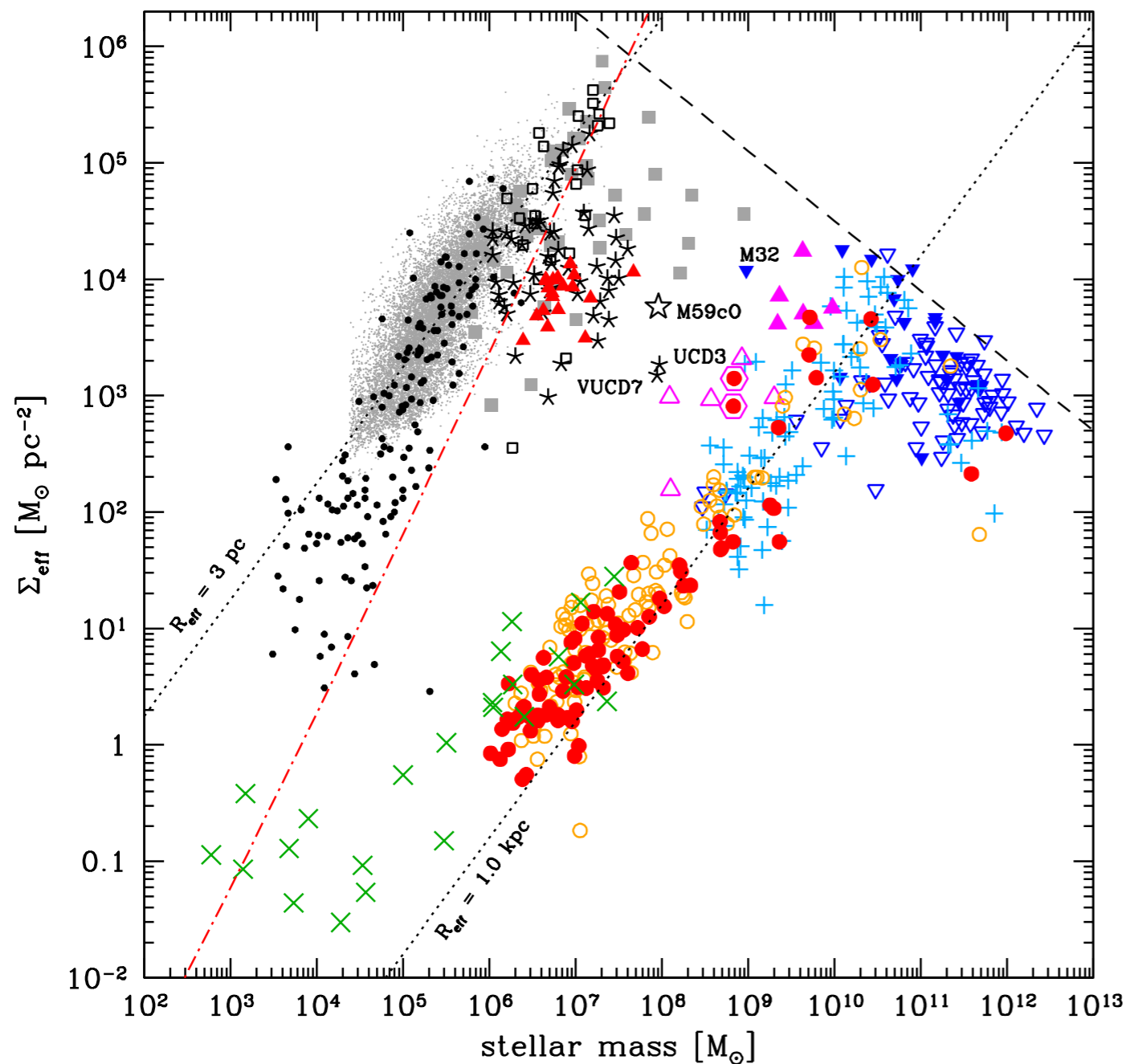
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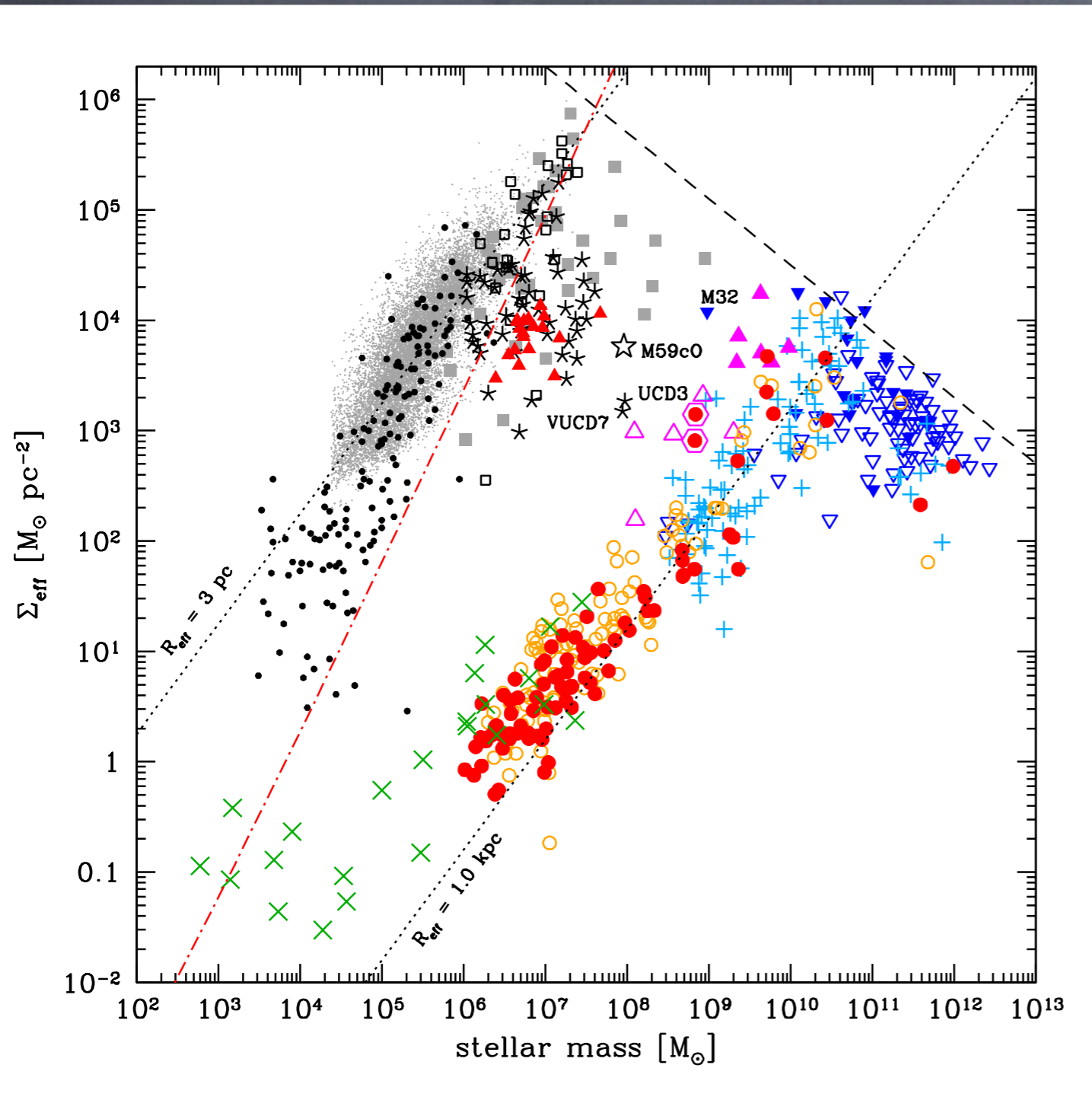
- above a certain stellar mass, almost orthogonal sequence
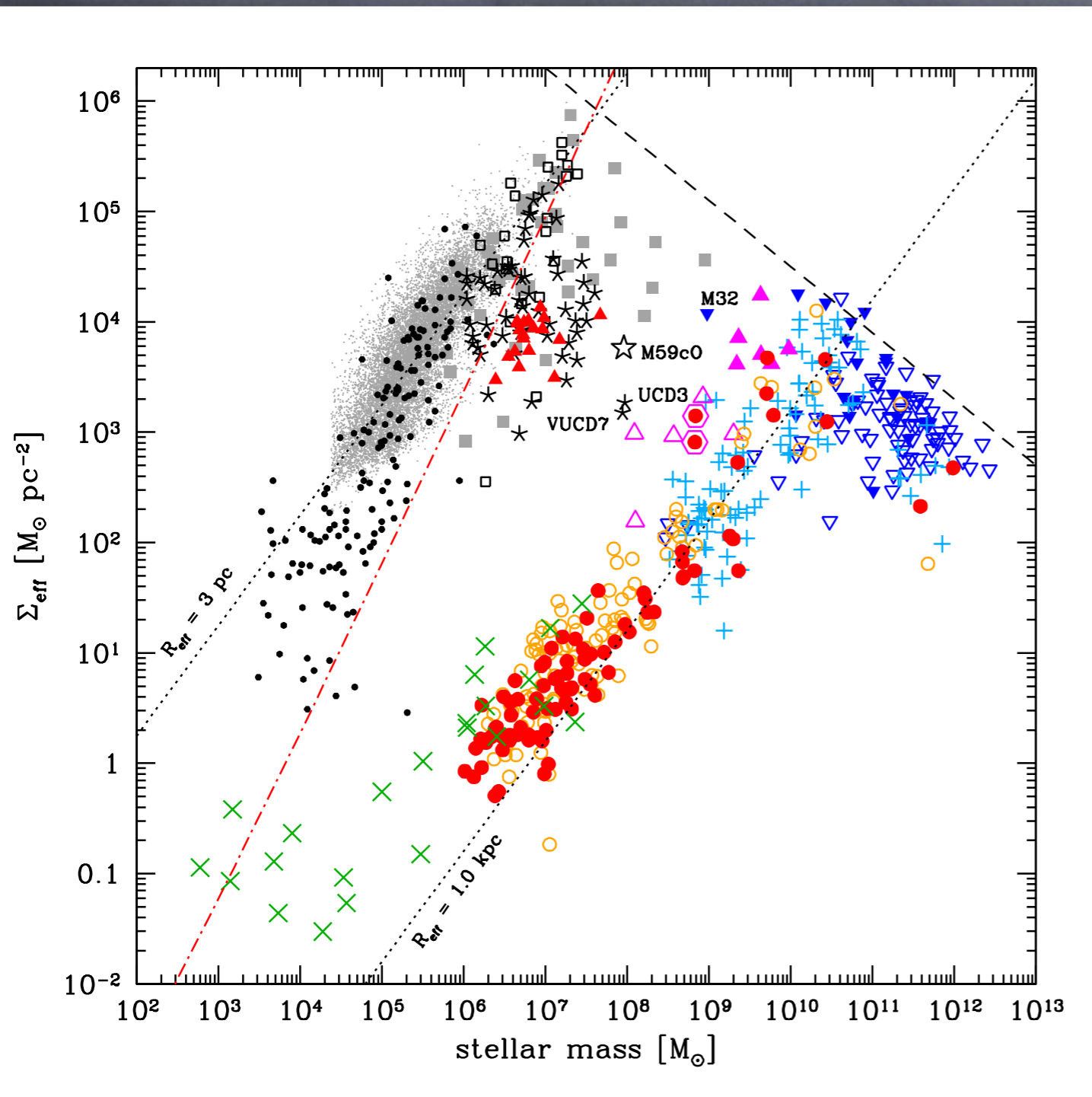
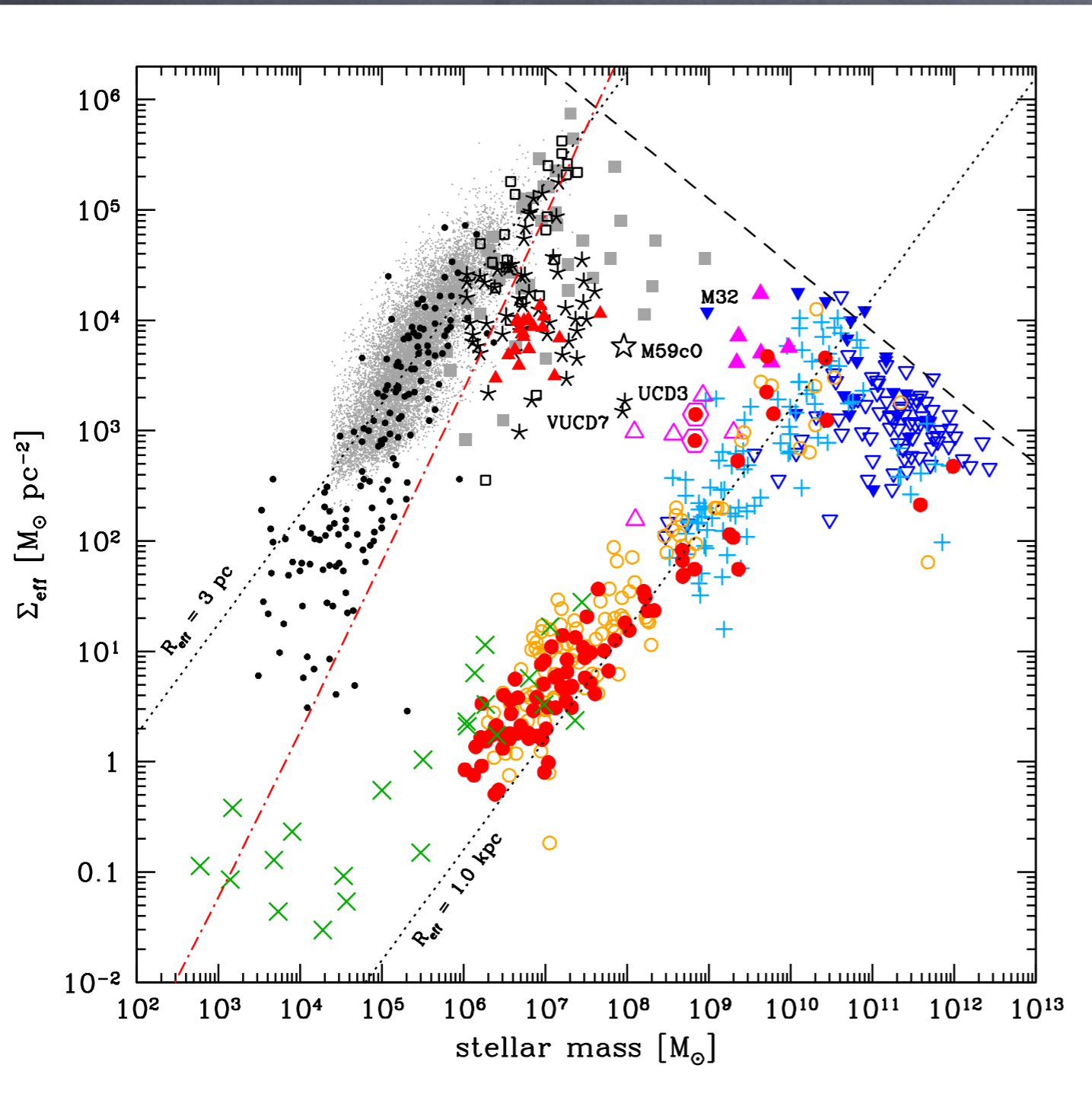# Galaxies and their star cluster mates

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- maximum mass surface density:
$$\Sigma_{\mathrm{eff}}(M) \le 3.17 \cdot 10^{10} \cdot M_\star^{-3/5} \; \mathrm{M}_\odot \; \mathrm{pc}^{-2}$$

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- with large samples of star clusters and galaxies, fundamental scaling relations now traceable over many orders of magnitude