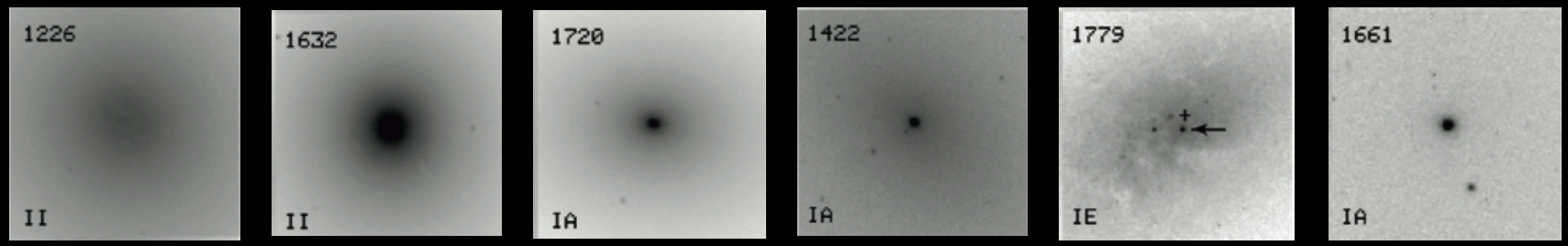
The Core (and Global) Structure of Galaxies from the ACSVCS, ACSFCS and NGVS



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"Central Massive Objects", ESO, Garching, June 22,-25 2010

https://www.astrosci.ca/**NGVS**/Home.html

Talk Outline

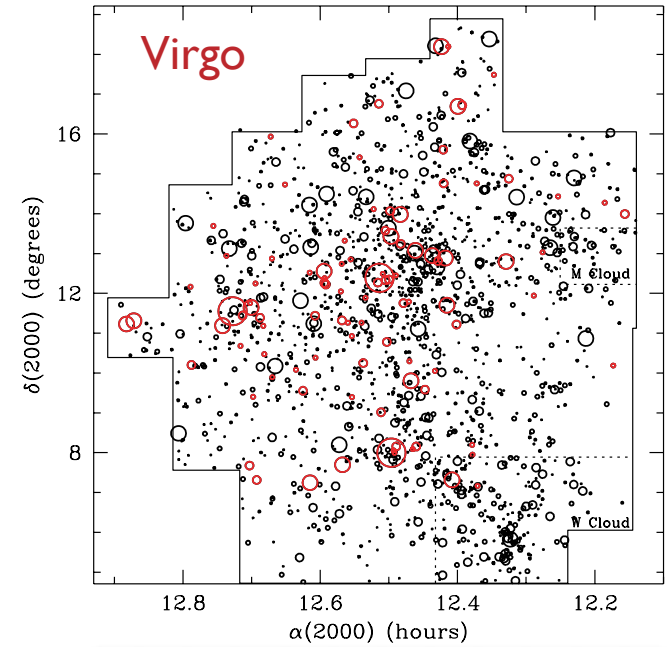
A mythological representation of the constellation Virgo, from Johannis Hevelius' 17th century Uranographicarum star atlas (credit: U.S. Naval Observatory and STScI.)

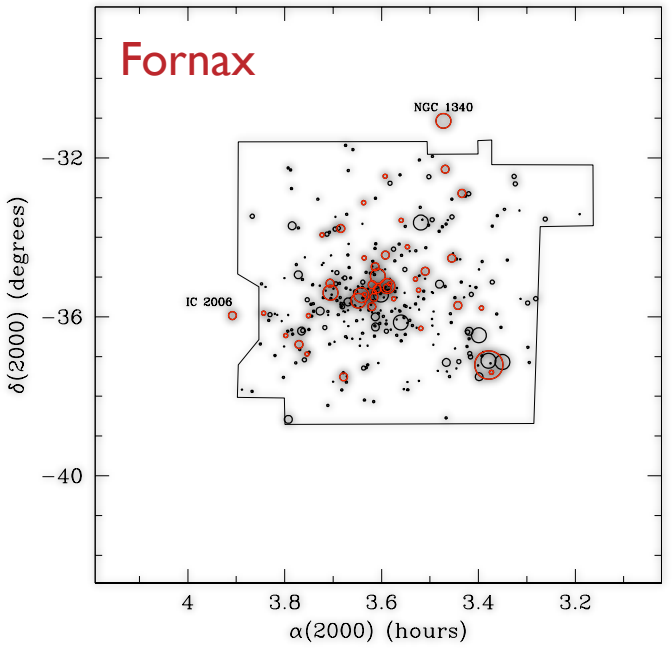
1. Stellar Nuclei in the context: the view from the ACS Virgo and Fornax Cluster Survey
2. Virgo and Fornax: nuclei in different environments
3. The Next Generation Virgo Cluster Survey
   - Overview of the survey
   - Demonstration of Capabilities

Stellar Nuclei and Galaxy Cores

The ACS Virgo and Fornax Cluster Surveys: Observing Strategy and Sample Selection

- Virgo and Fornax Clusters: the dominant mass concentrations in the Local Universe and the nearest large collections of early-type galaxies (at 16.5 and 20 Mpc, respectively).
- ACS/WFC observations of 100 (Virgo) + 43 (Fornax) = 143 member galaxies.
- $-22.3 < M_B < -15.1$ (range $\approx 10^3$ in L_B).
- Nearly complete census of early types = E, S0, dE, dE,N, dS0
- Each galaxy observed in F475W (*g*) and F850LP (*z*), 1 orbit per target.
- FOV = 3.4 × 3.4′ (= 16 × 16 kpc at Virgo, 20 × 20 kpc at Fornax)
- 0.05″ pixels (= 4/5 pc at Virgo/Fornax).

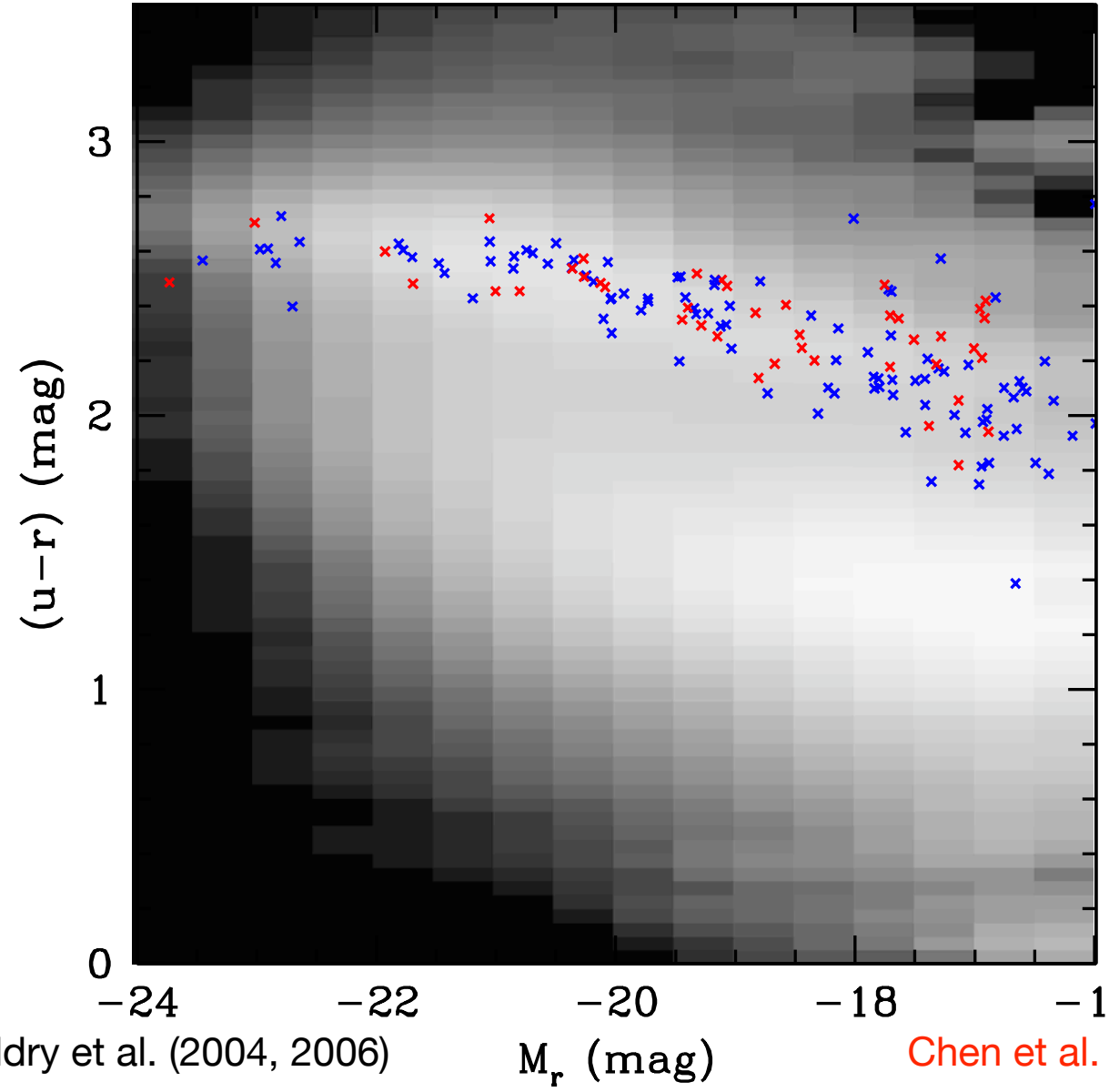




Côté et al. (2004), Jordán et al. (2007)

Core Properties Along the Red Sequence Luminosity Function

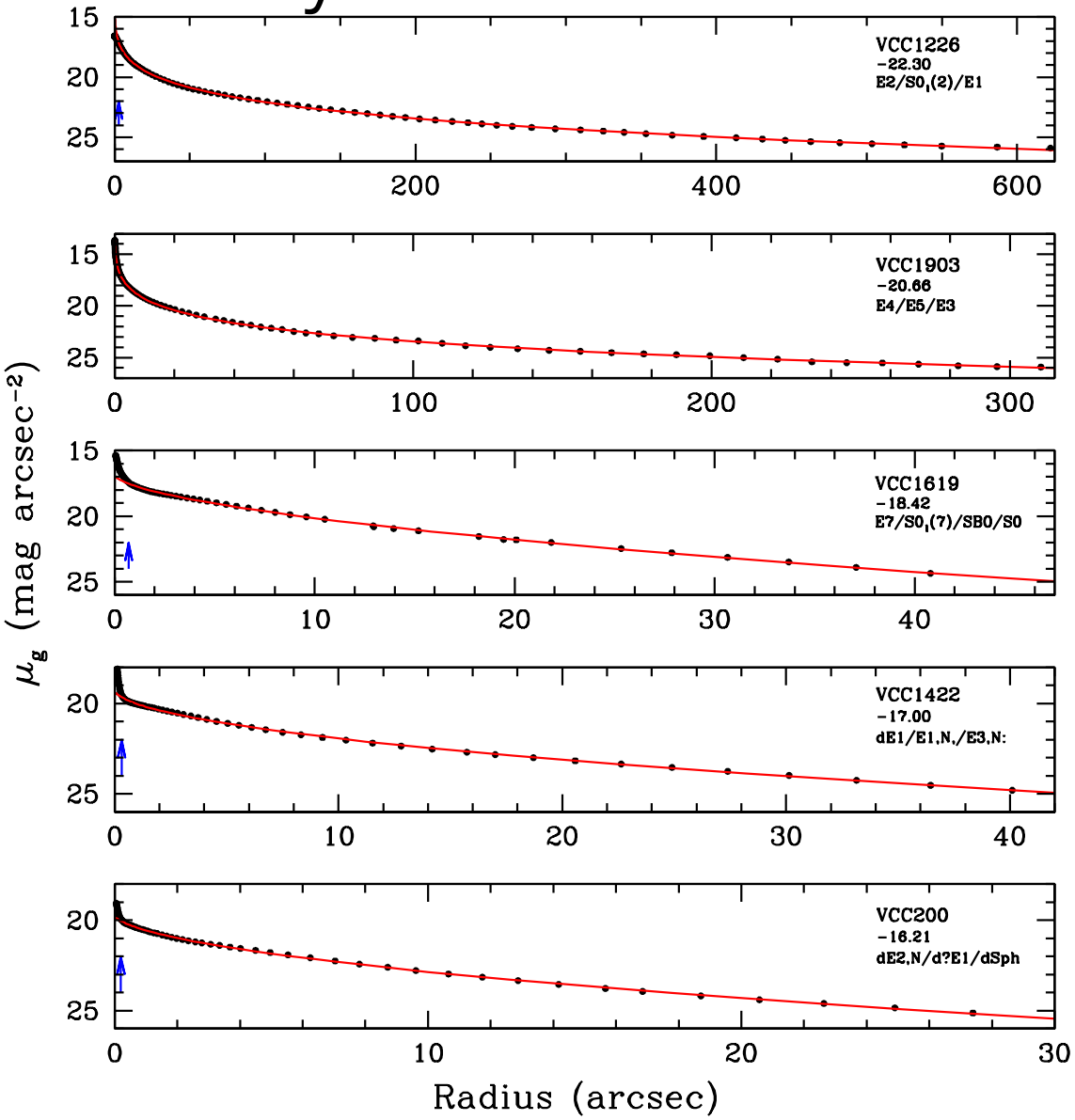
- Virgo early type
- Fornax early type



Baldry et al. (2004, 2006)

Chen et al. (2010)

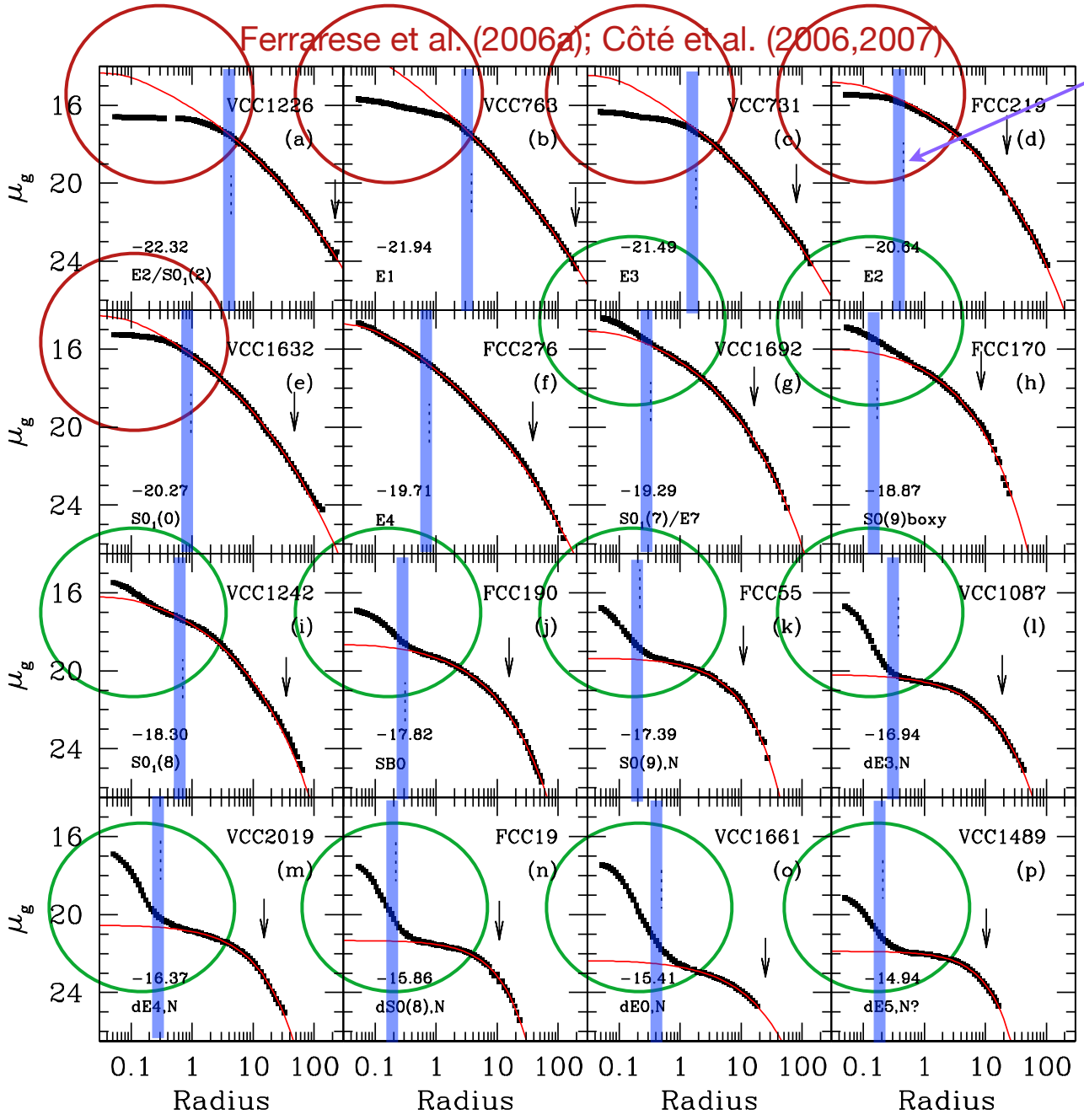
Systematics in Core Properties Along the Luminosity Function: the ACSVCS/FCS View



Ferrarese et al. (2006a); Côté et al. (2006,2007)

- **Beyond ~2% R_e, the profiles are well fitted by Sersic functions** (e.g. Jerjen & Binggeli '97; Caon et al. '93, '94; Graham et al. '03ab; Graham and Guzman '03; Gavazzi et al. '05; Grant et al. '05; Zibetti et al. '05; Misgeld et al. '08, '09; Kormendy et al. '09, etc...)

Systematics in Core Properties the ACSVCS/FCS View



2% R_e

- **Beyond ~2% R_e, the profiles are well fitted by Sersic functions** (e.g. Jerjen & Binggeli '97; Caon et al. '93, '94; Graham et al. '03ab; Graham and Guzman '03; Gavazzi et al. '05; Grant et al. '05; Zibetti et al. '05; Misgeld et al. '08, '09; Kormendy et al. '09, etc...)

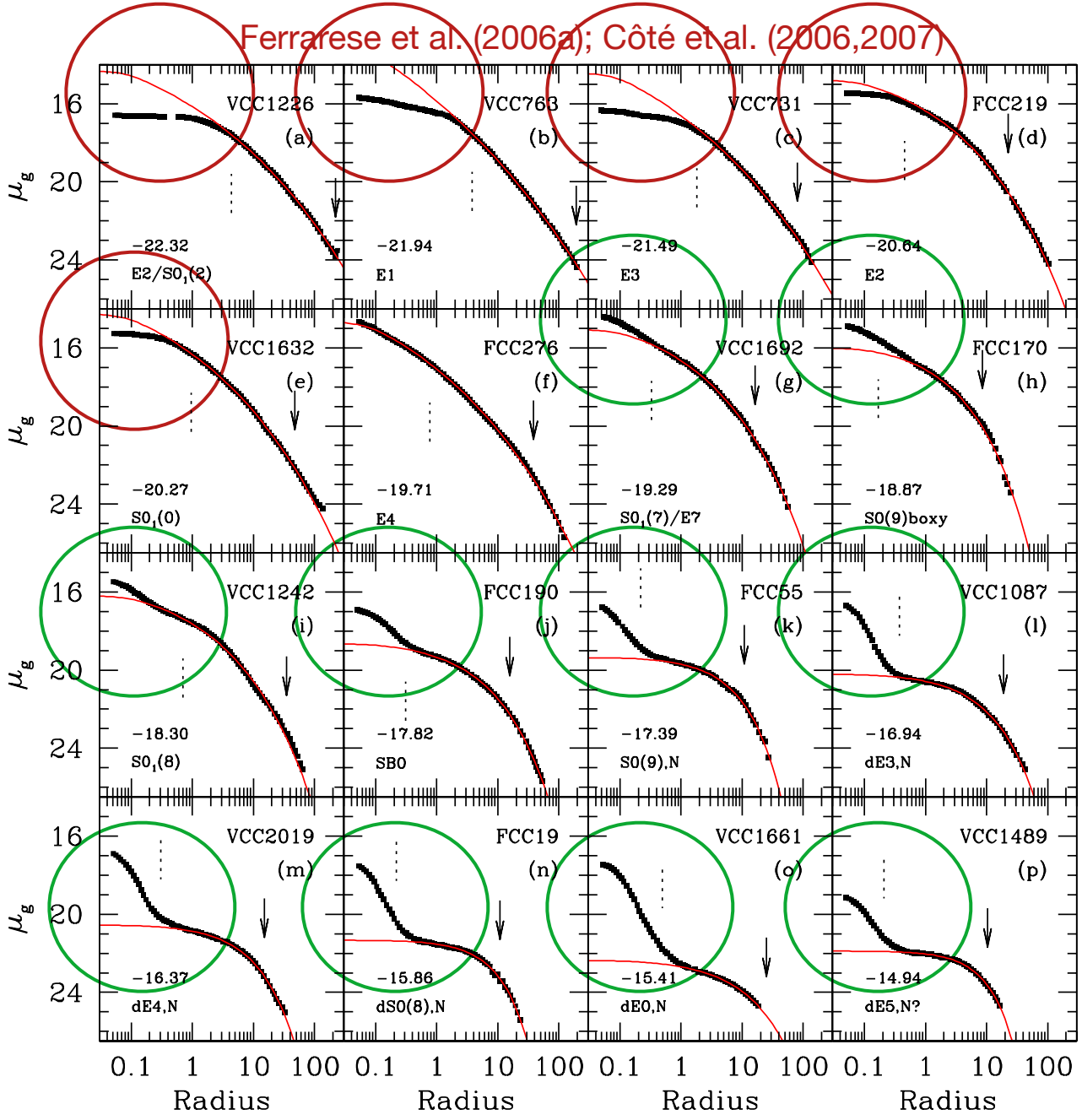
- **Systematic variations occur within ~2% R_e**. Relative to the inner extrapolation of the outer Sersic profile:

  - the brightest galaxies show **light "deficits"** (e.g. Graham 2004; Ferrarese et al. 2006ab)

  - In fainter galaxies, **stellar nuclei** are identified as **"excess" light** (Graham & Guzman 03; Grant, Kuipers & Phillips 05; Côté et al. 06, 07 -- latter results confirmed in Kormendy et al. 09)

Systematics in Core Properties the ACSVCS/FCS View

Ferrarese et al. (2006a); Côté et al. (2006,2007)



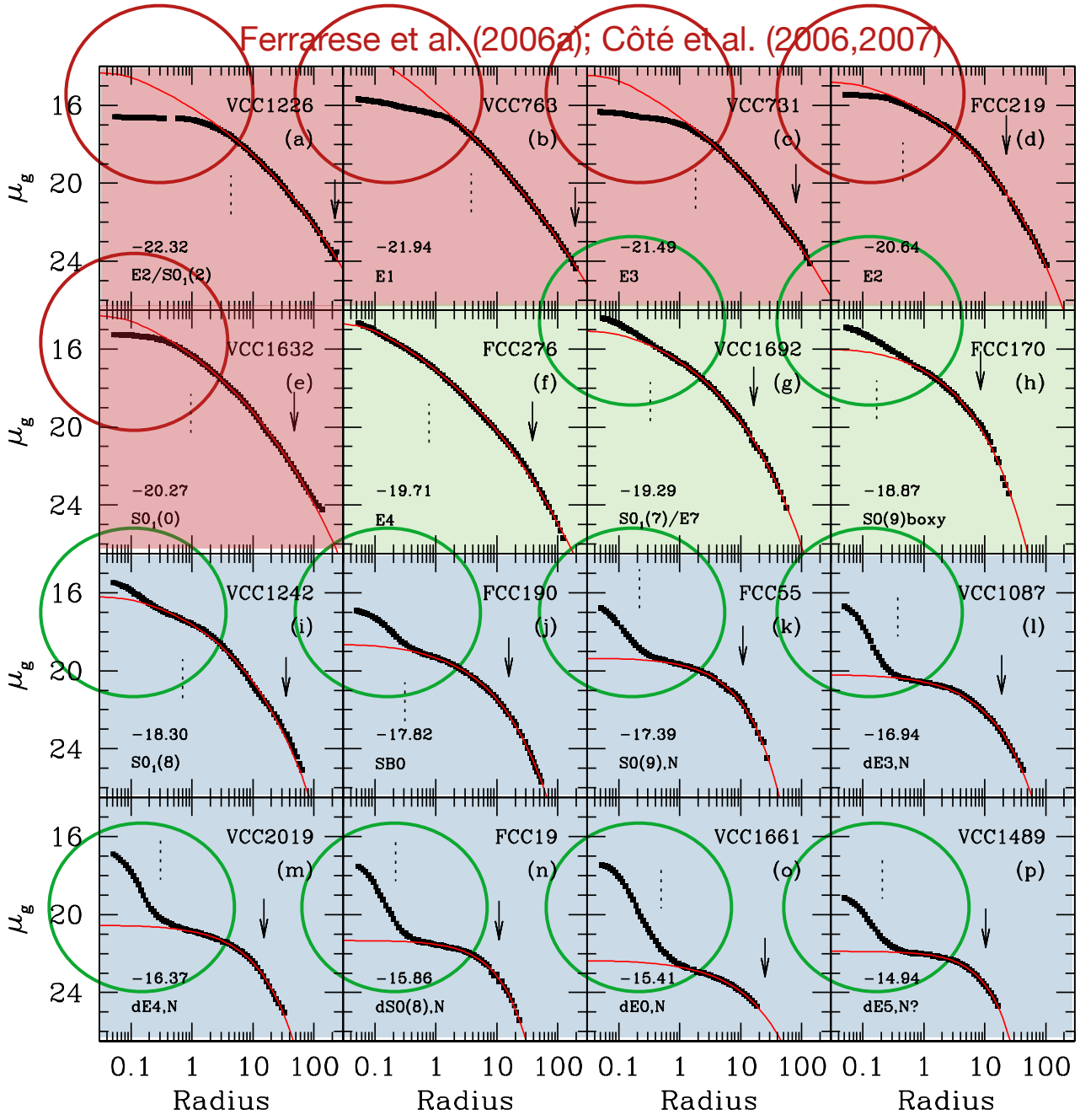
Luminosity "Deficit"

Transition from Central Luminosity Deficit to Excess: $M_B \approx -20$ mag

Luminosity "Excess"

Ferrarese et al. (2006a,b); Côté et al. (2006,2007)

Systematics in Core Properties the ACSVCS/FCS View



There is no evidence supporting a separation of early type galaxies in three different categories:

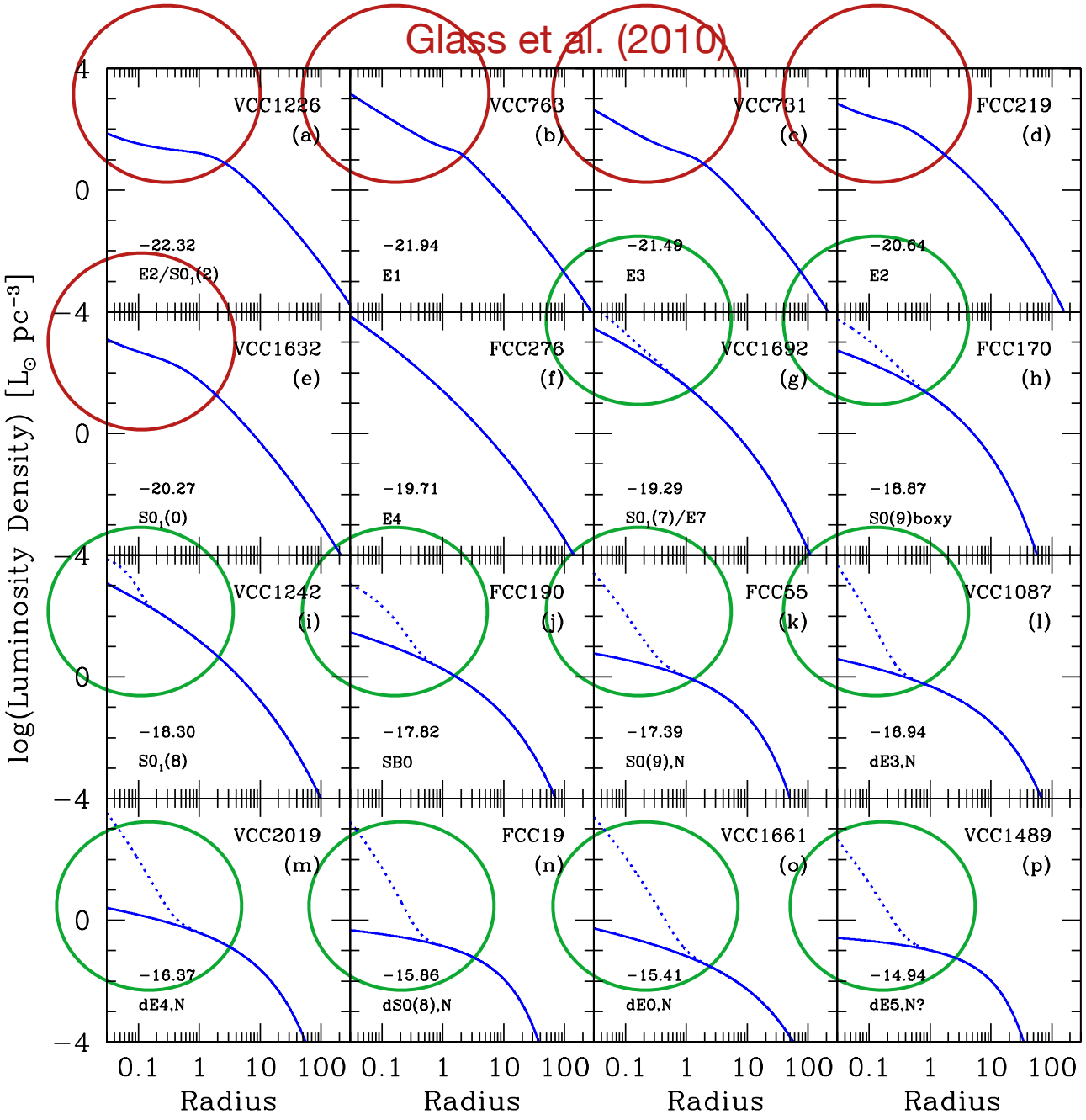
"Core"
(e.g. Lauer et al. '96, '07; Kormendy et al. '09)

"Power-law"
(e.g. Lauer et al. '96, '07)
or **"Coreless"**
(Kormendy et al. '09)

"Spheroidals"
(e.g. Kormendy et al. '85, '09)

Ferrarese et al. (2006a,b); Côté et al. (2006,2007)

Systematics in Core Properties: Deprojection

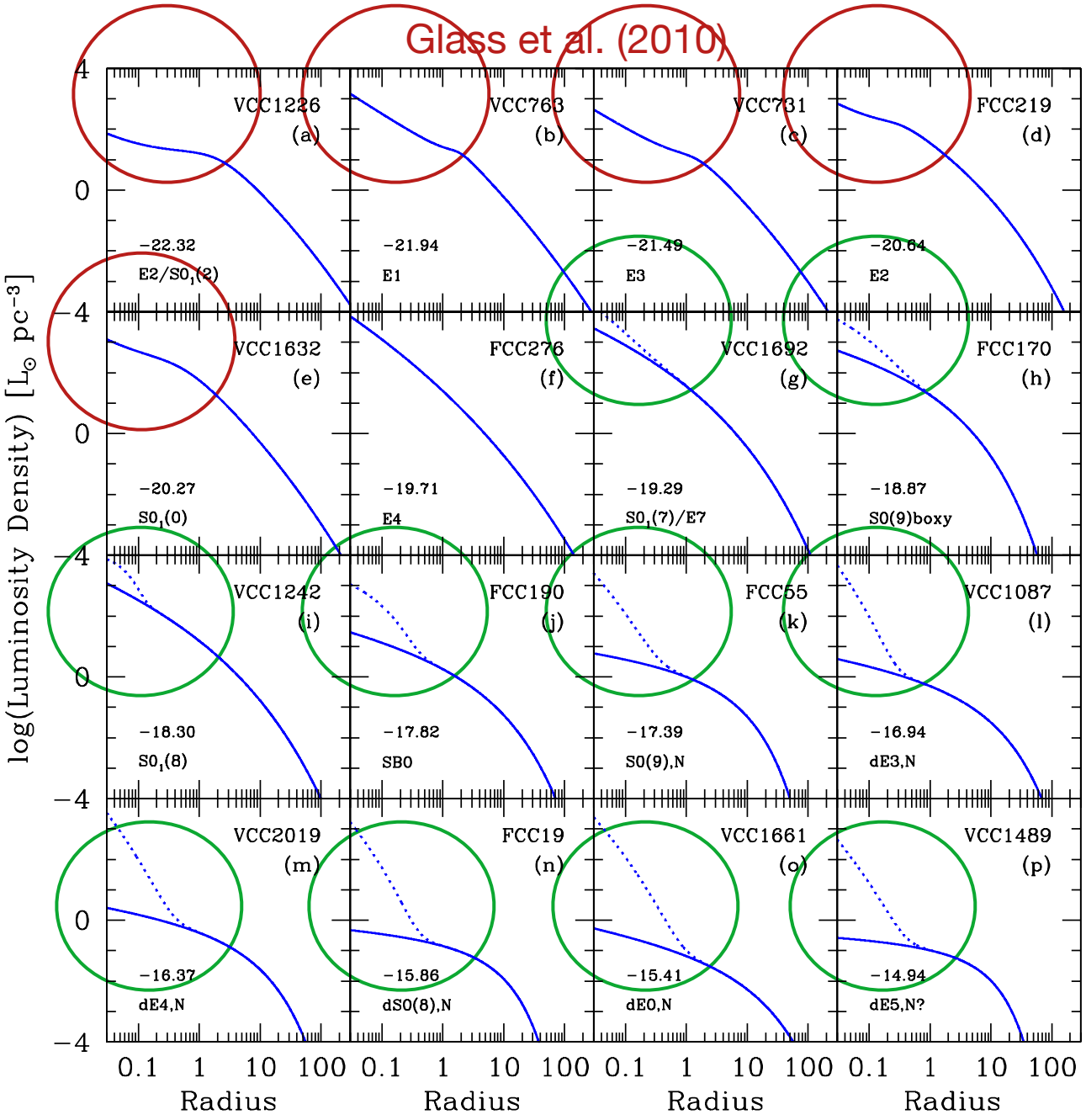


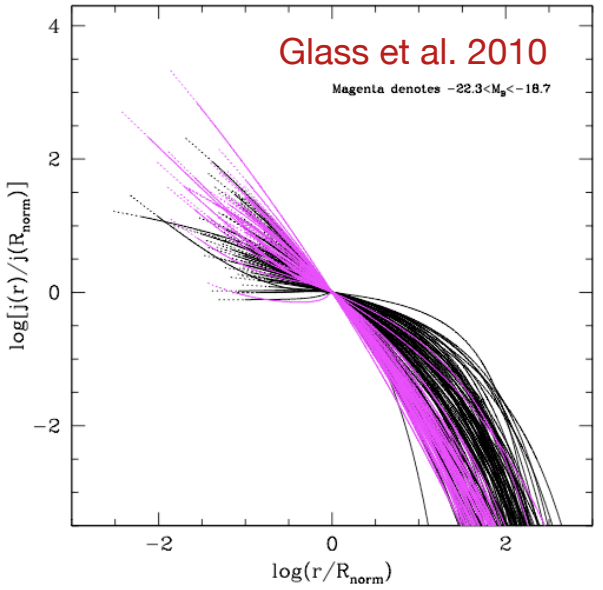
Luminosity "Deficit"

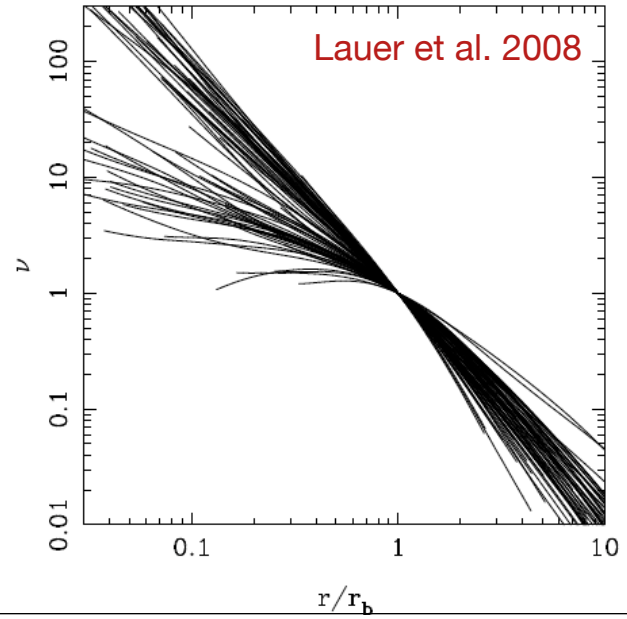
Transition from Central Luminosity Deficit to Excess: M_B ≈ -20 mag

Luminosity "Excess"

Systematics in Core Properties: Deprojection



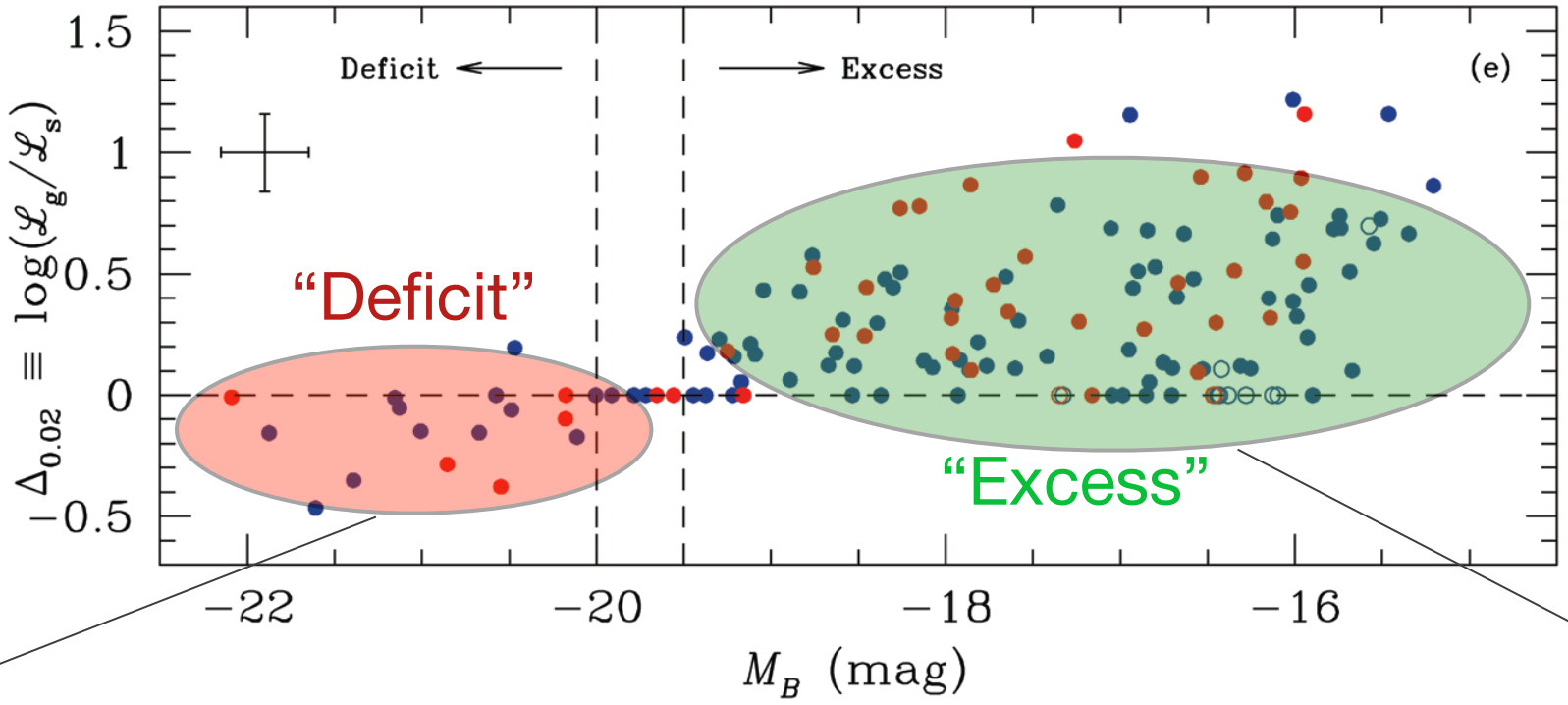




Systematics in Core Properties

- Define a parameter, $\Delta_{0.02}$, that measures the net luminosity deviation from the inward extrapolation of the outer Sersic component:

$$\Delta_{0.02} \equiv \log(\mathscr{L}_{galaxy}/\mathscr{L}_{sersic}) \qquad 0 < R/Re < 0.02$$



Coalescence of Supermassive Black Holes Binaries (e.g. Ebisuzaki,Makino, & Okumura 1991;Makino & Ebisuzaki 1996; Milosavljevic & Merritt 2001; Komossa et al. 2003)

Harmonic motions caused by periodic bipolar AGN outbursts (Peirani, Kay & Silk 2008) Core depletion by Supermassive Black Hole Binaries (Ebisuzaki et al. 1991, Faber et al. 1997, Milosavljevic & Merritt 2001)

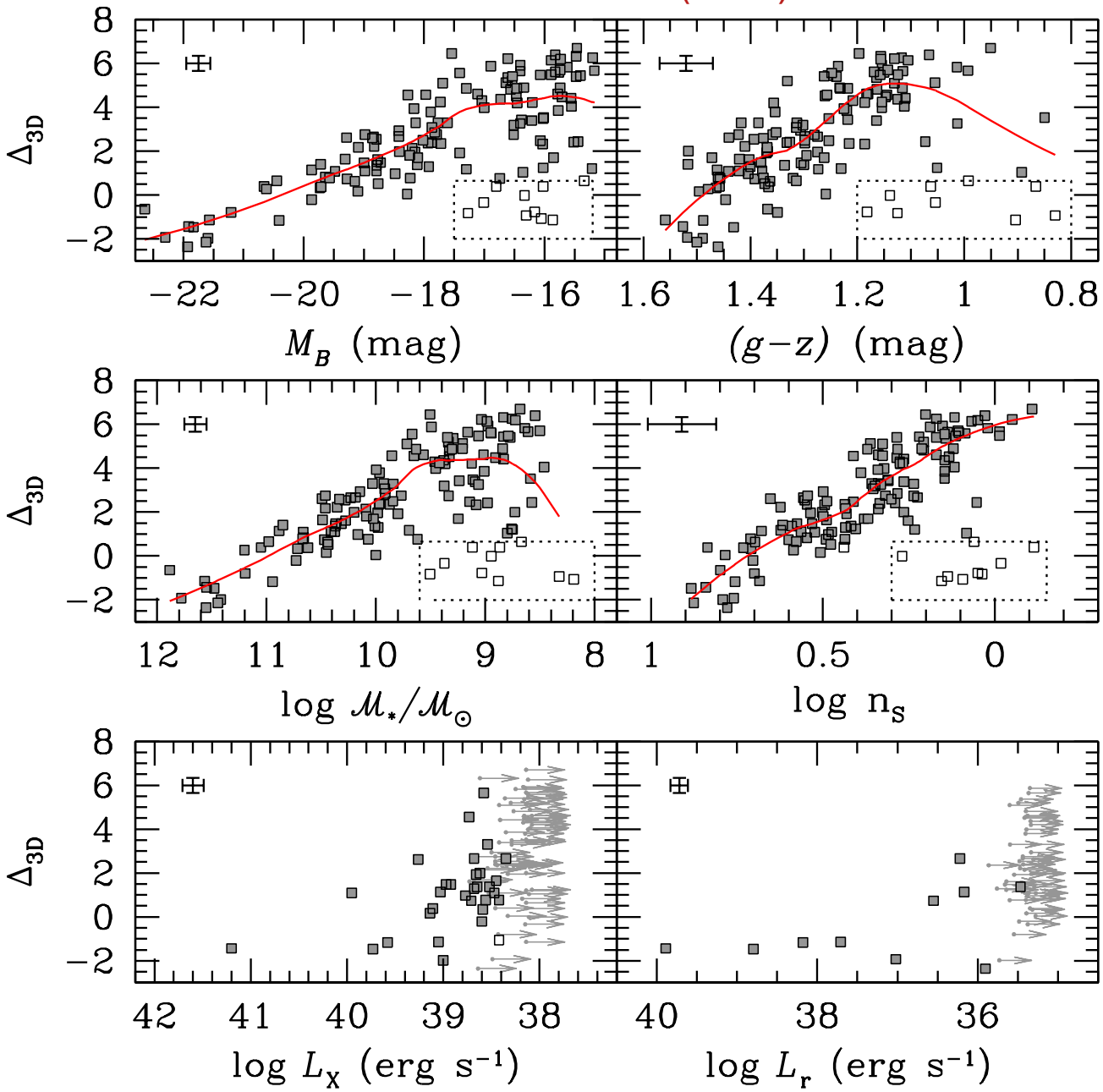
Gas Inflows (e.g. Barnes & Hernquist 1991; Mihos & Hernquist 1994, 1996)

Coalescence of Globular Clusters (e.g. Tremaine, Ostriker & Spitzer 1975; Capuzzo-Dolcetta 1993; Capuzzo-Dolcetta & Tesseri 1999; Capuzzo-Dolcetta & Miocchi 08; Bekki et al.04)

Observational Data: Walcher et al. (2005); Rossa et al. (2007); Seth et al. (2008, 2010)...

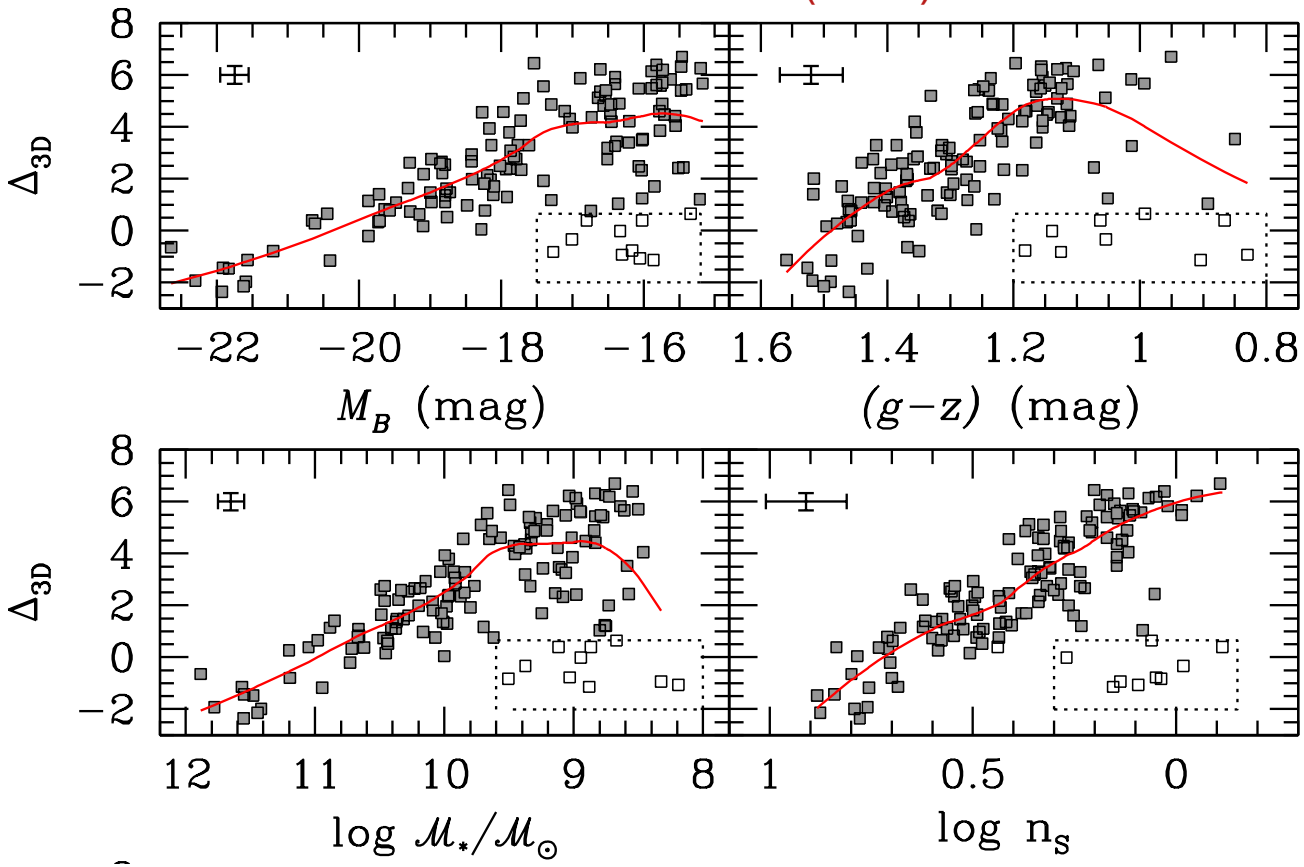
Systematics in Core Properties: Deprojection

Glass et al. (2010)

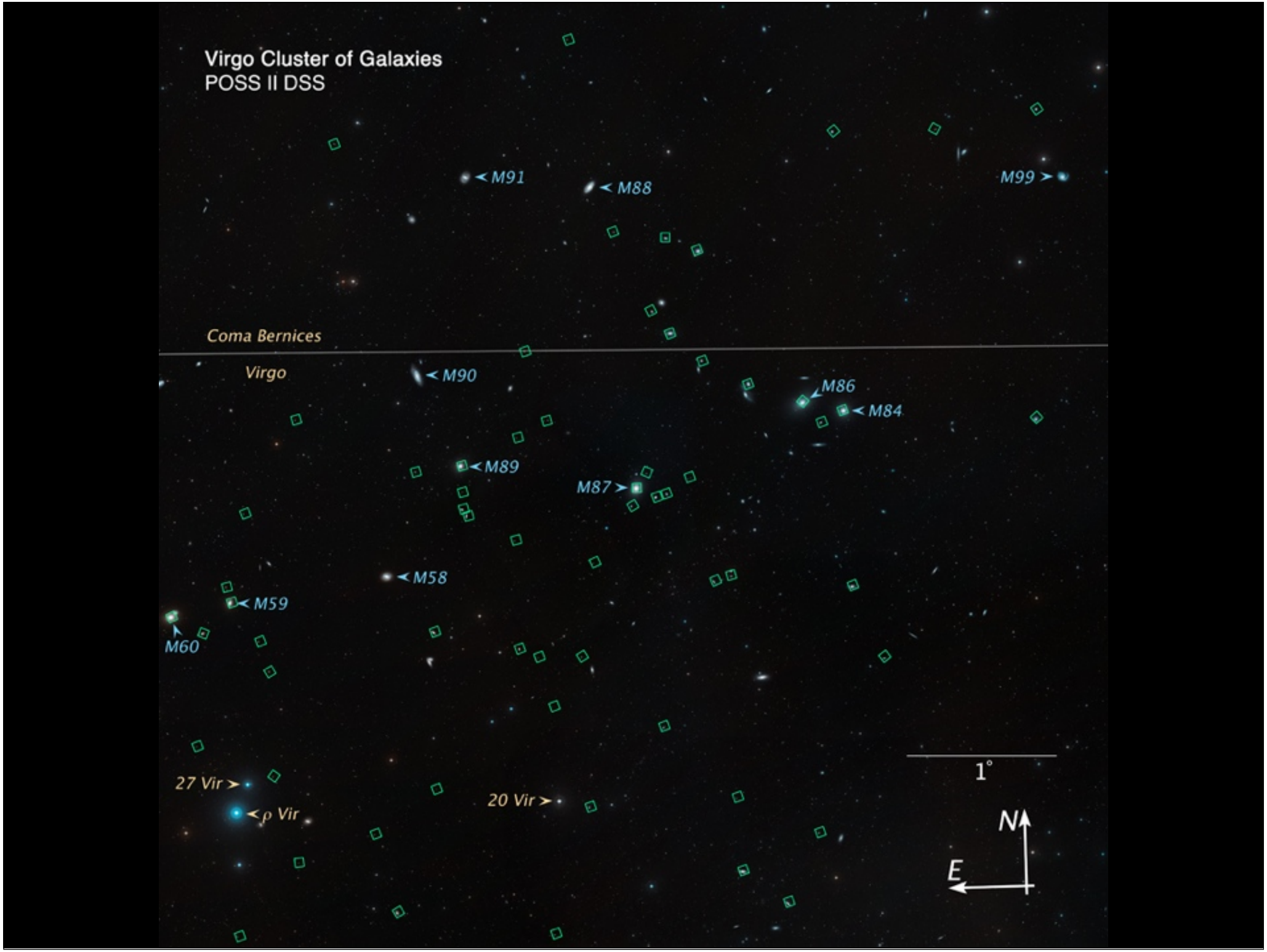


Systematics in Core Properties: Deprojection

Glass et al. (2010)



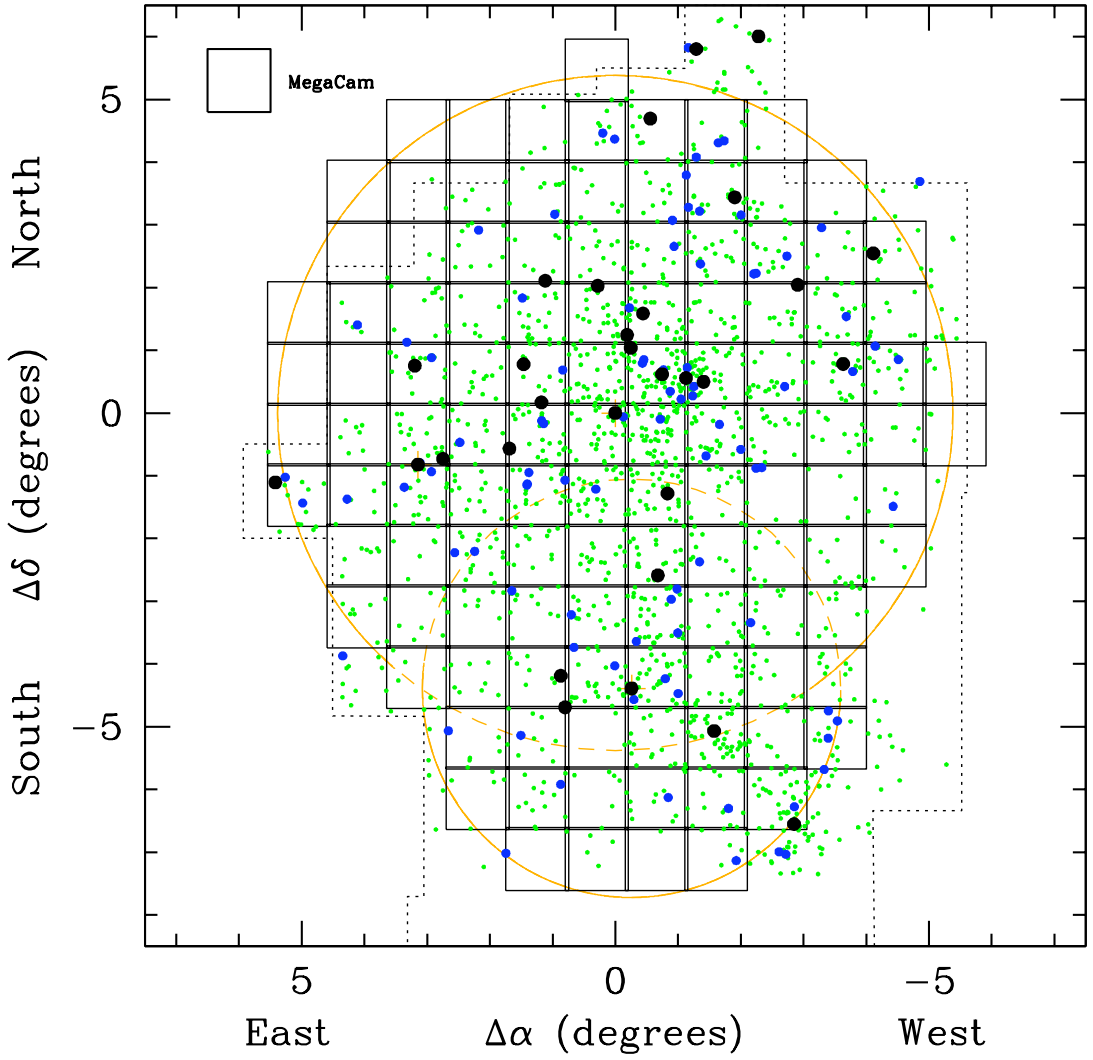
There is no discontinuity between galaxies with "deficits" and galaxies with "excess", rather a continuous progression from one to the other along the luminosity function (Cote et al. 2007). This implies that the same evolutionary processes are at play across the sequence (albeit with differing weights, e.g. Hopkins et al. 2008)


Virgo Cluster of Galaxies
POSS II DSS
M91
M88
M99
Coma Bernices
Virgo
M90
M86
M84
M89
M87
M58
M59
M60
27 Vir
ρ Vir
20 Vir
1°
N
E

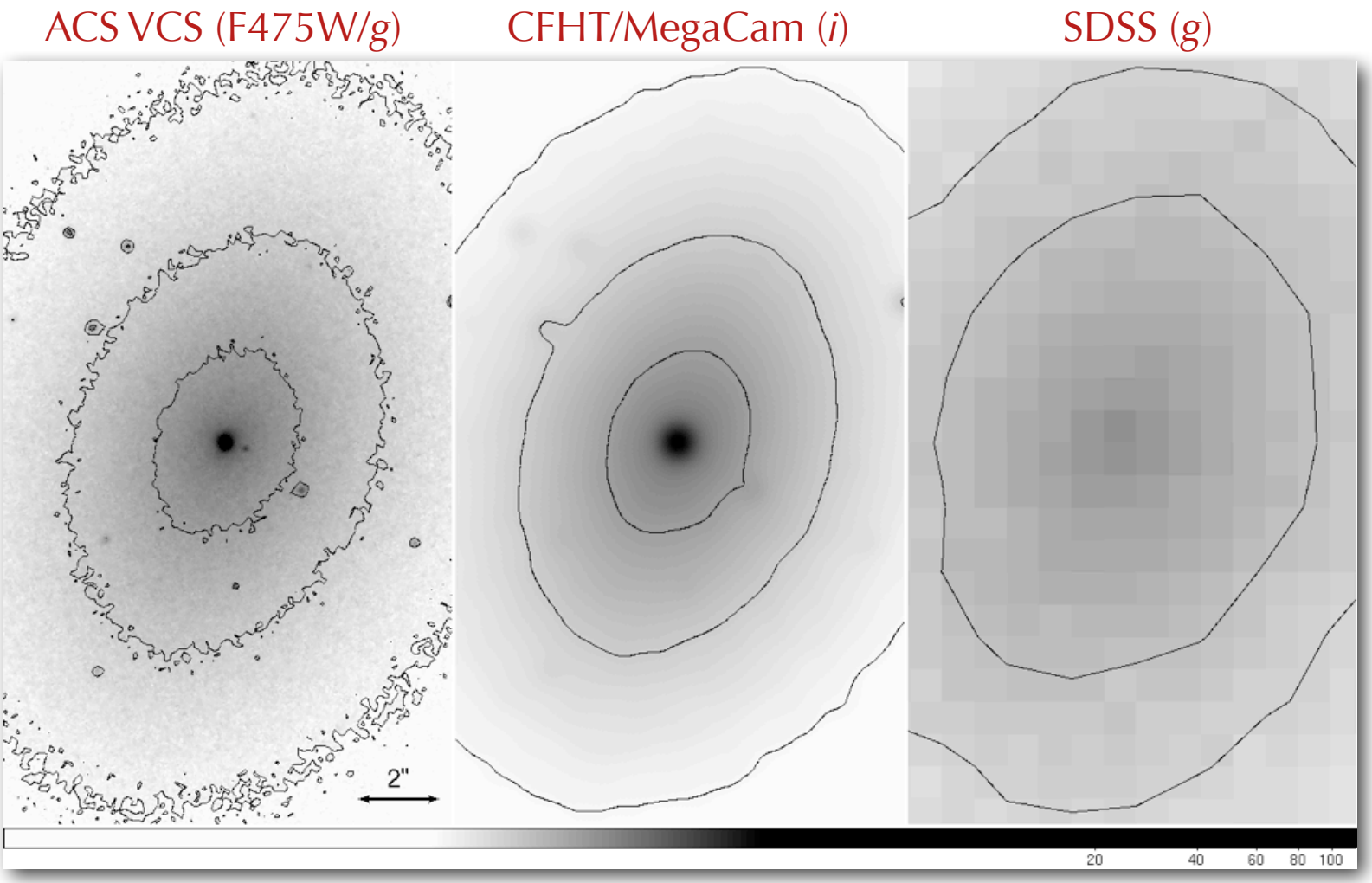
Looking Ahead:

The Next Generation Virgo Cluster Survey

- NGVS: CFHT/MegaCam Large Programme to survey the Virgo Cluster out to its virial radii (5.4 deg and 3.4 deg for the A and B sub-clusters, respectively) ➔ **104 square degrees.**
- ***u*g′r′i′z′***, to ***g′ ≈ 25.7 mag*** (10σ) and **$\mu_{g'} \approx 29$ mag arcsec^{-2}** (2σ).
- Image quality **≤ 1" (*u*g′r′z′*) ; ≤ 0.6" (*i′)***
- Awarded 771 hours (~**150 nights**) over four years (2009A - 2012A).
- Follow-up Programs: CFHT/WIRCam; Galex; MMT/Hectospec

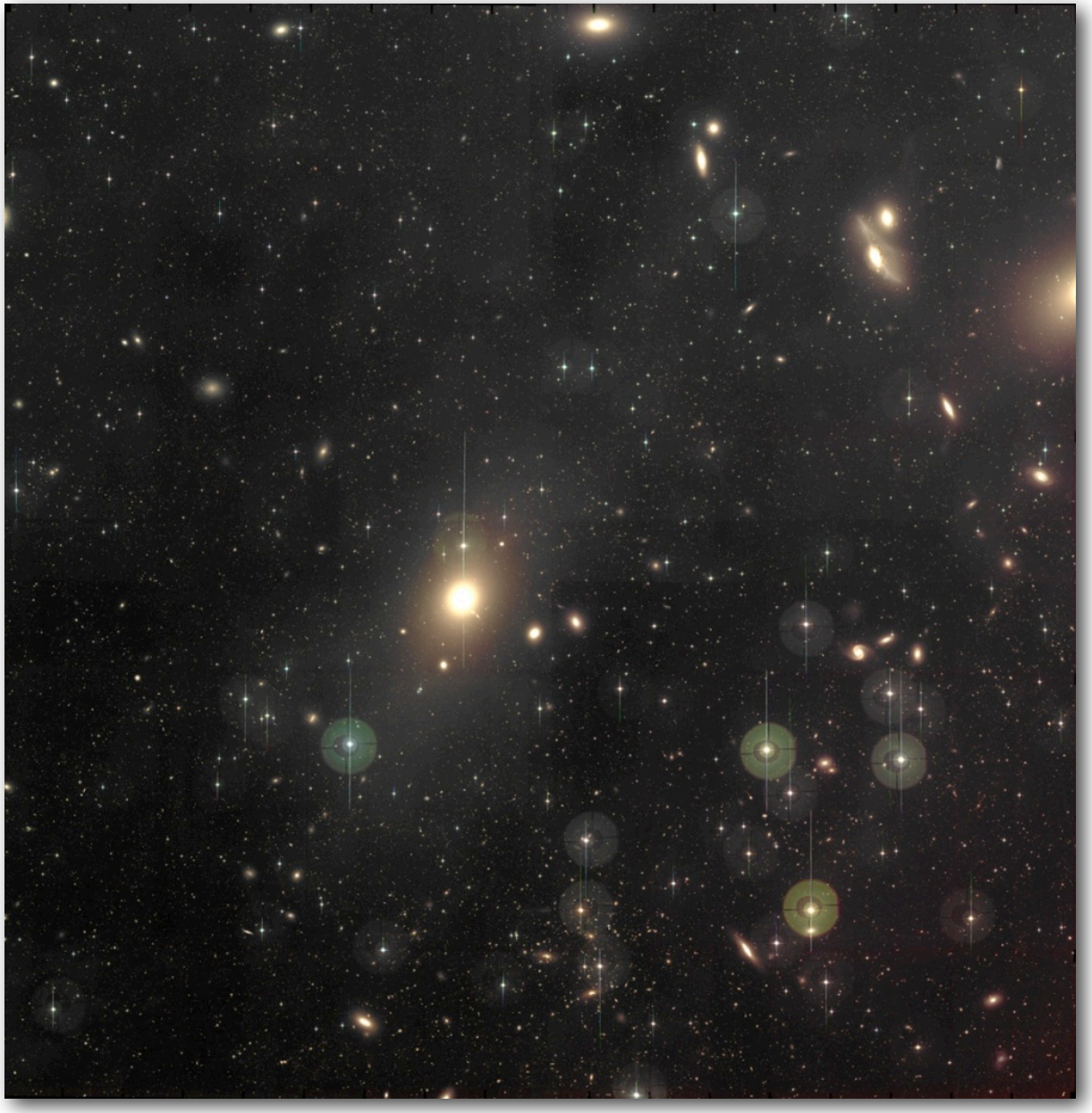


- Compared to VCC: 100× improvement in depth, 100× in surface brightness, >3× in spatial resolution, 5× in SED coverage. Plus, many synergistic opportunities with surveys at non-optical wavelengths.



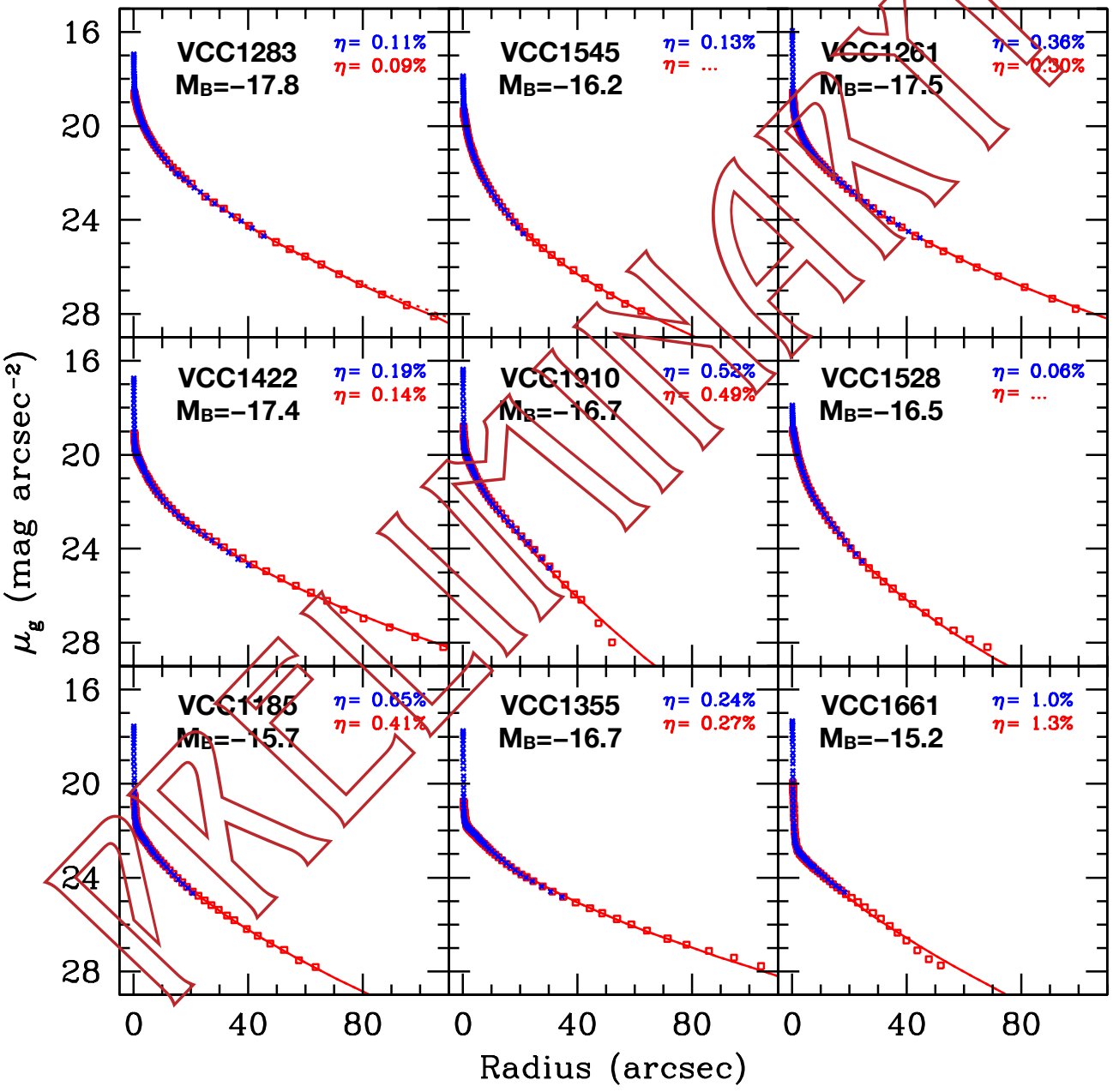
NGVS: Science Objectives

- Virgo Science
  - the faint end of the luminosity function
  - galaxy structural parameters
  - core properties and stellar nuclei
  - environmental effects
  - Intracluster light, tidal debris
  - globular clusters
- Background Science:
  - cosmic shear
  - intrinsic alignment
  - high-z clusters
- Foreground Science
  - the structure of the MW halo
  - Kuiper Belt Objects



ACSVCS vs NGVS Profiles and Nuclear Fractions

Blue: HST/ACS Profiles (from Ferrarese et al. 2006) **Red**: NGVS Profiles (*g'*)



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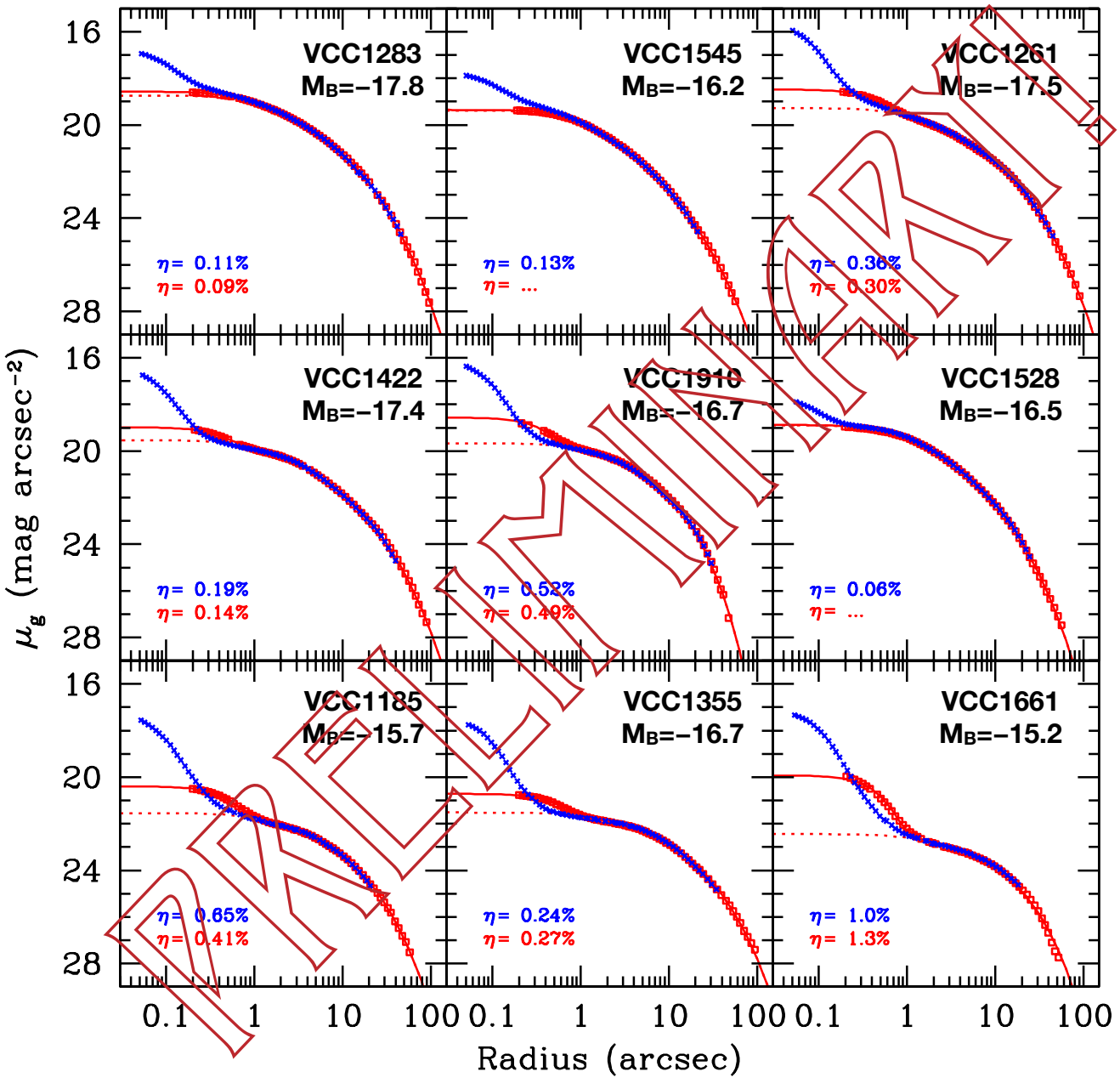
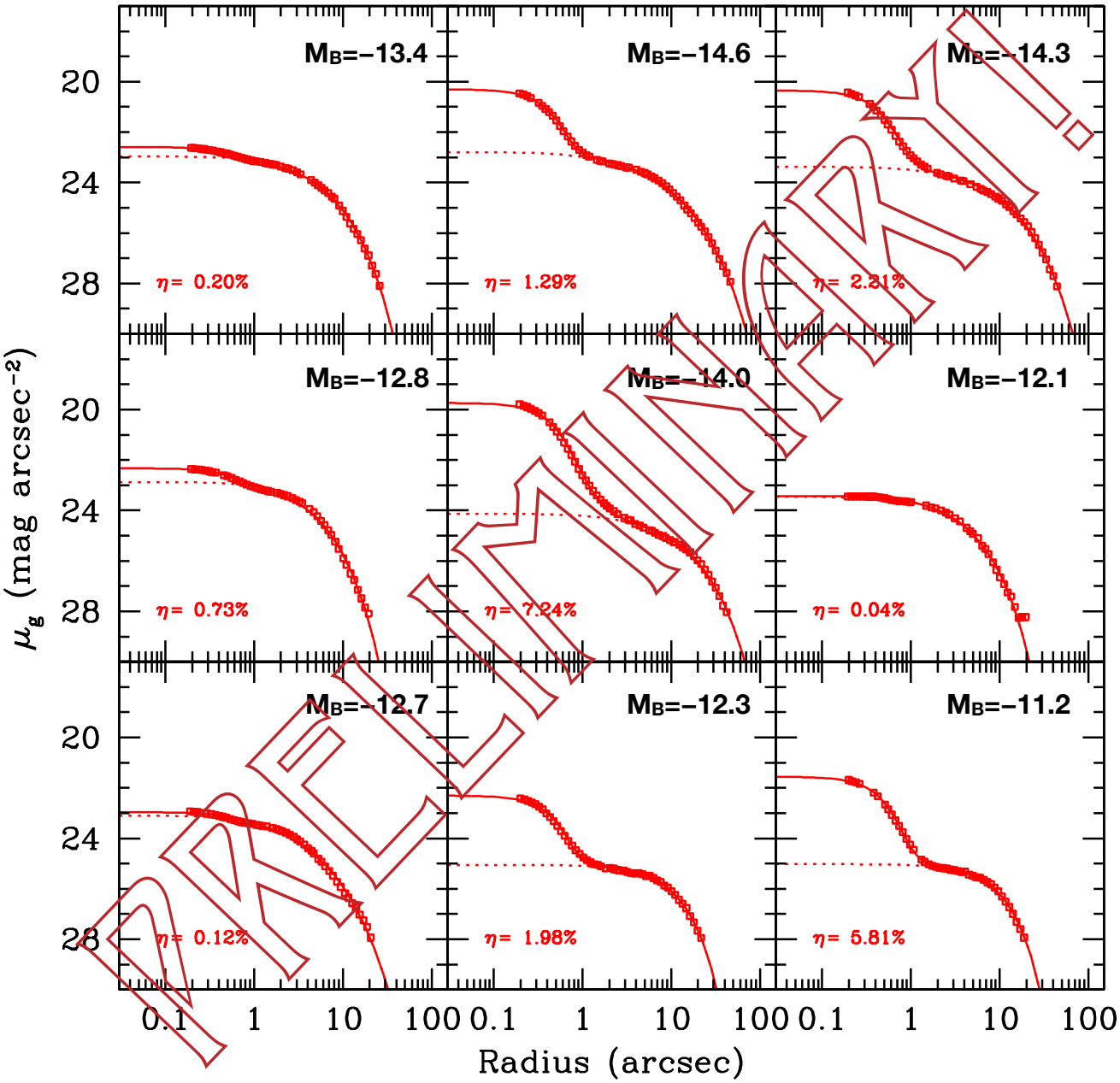
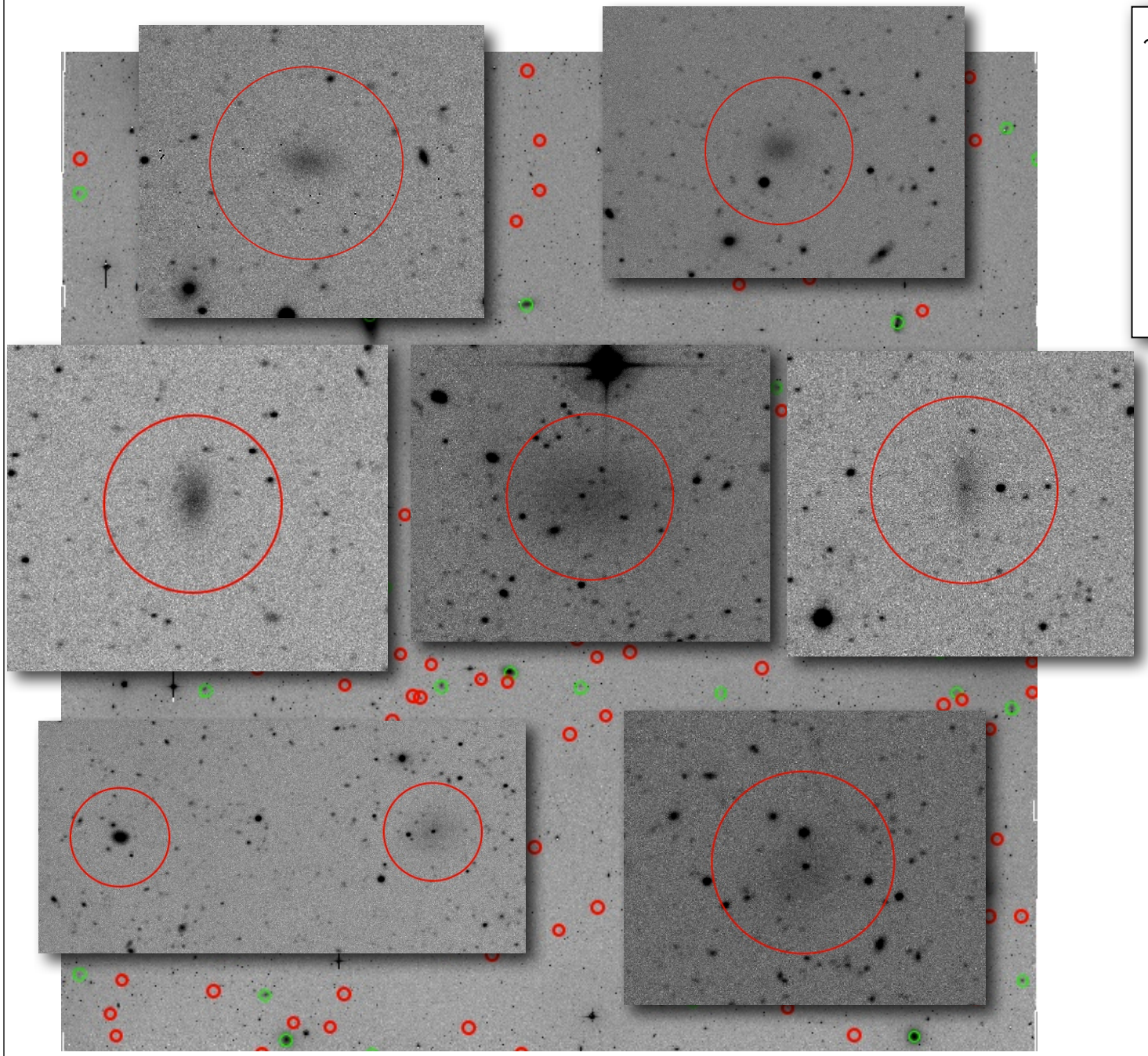


Extension to Fainter (VCC) Galaxies

Red: NGVS Profiles (*g'*)

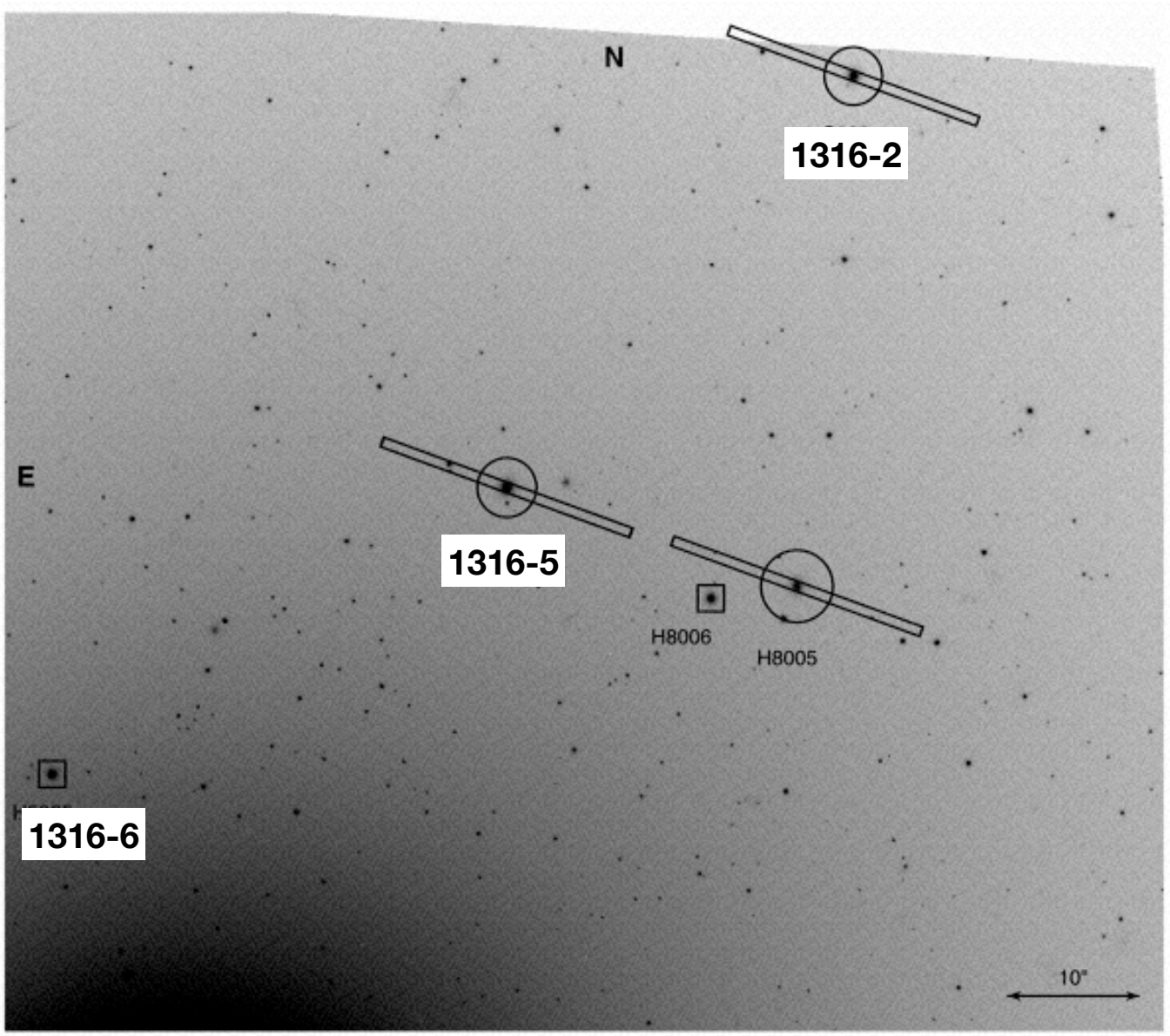


Extension to Fainter Galaxies



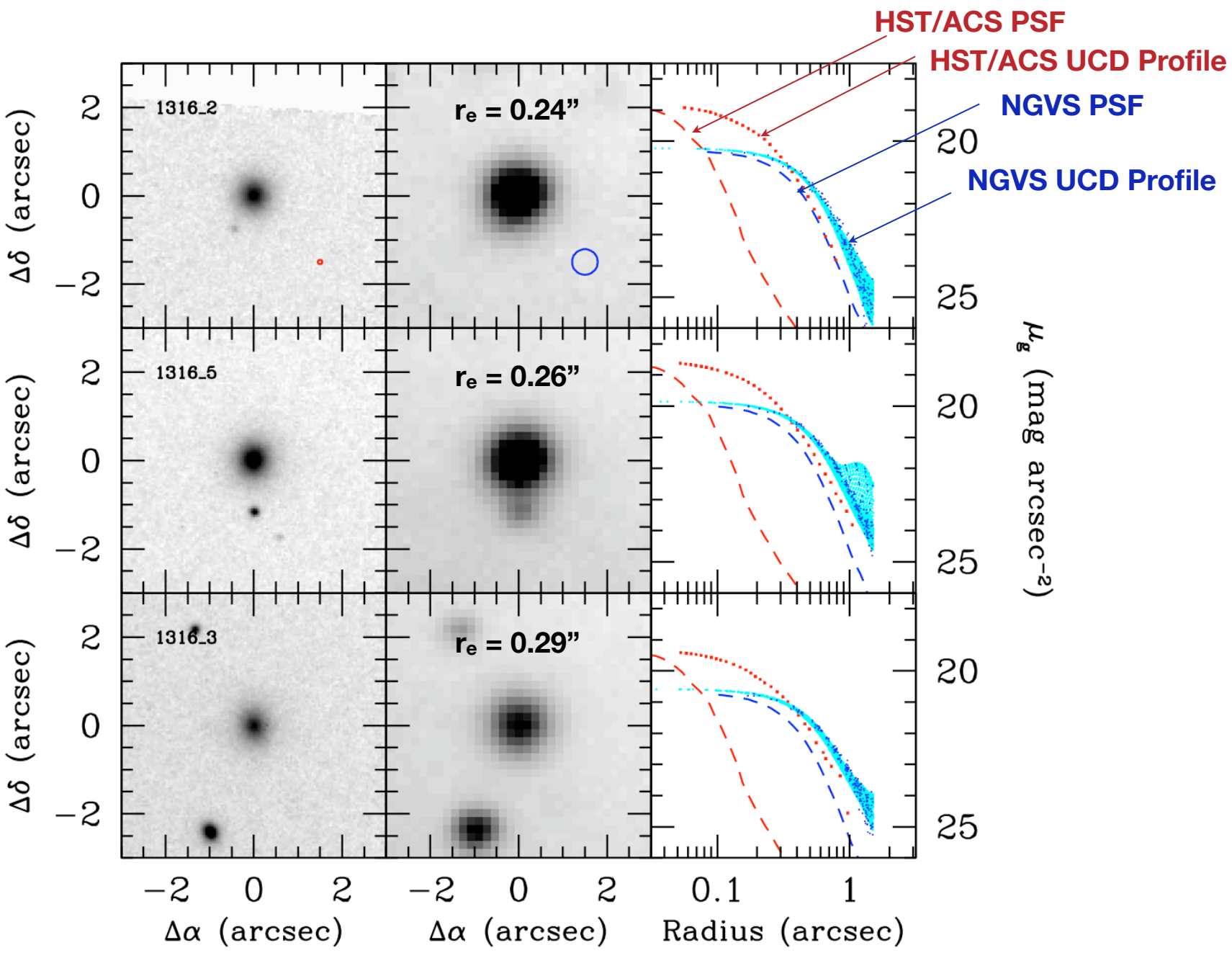
~600 **new** (likely) member galaxies visually identified in the 4 sq.degrees centered on M87. Close to 10,000 new members expected over the entire cluster.

Ultra Compact Dwarfs in the NGVS



From Hasegan et al. (2005)

Ultra Compact Dwarfs in the NGVS



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