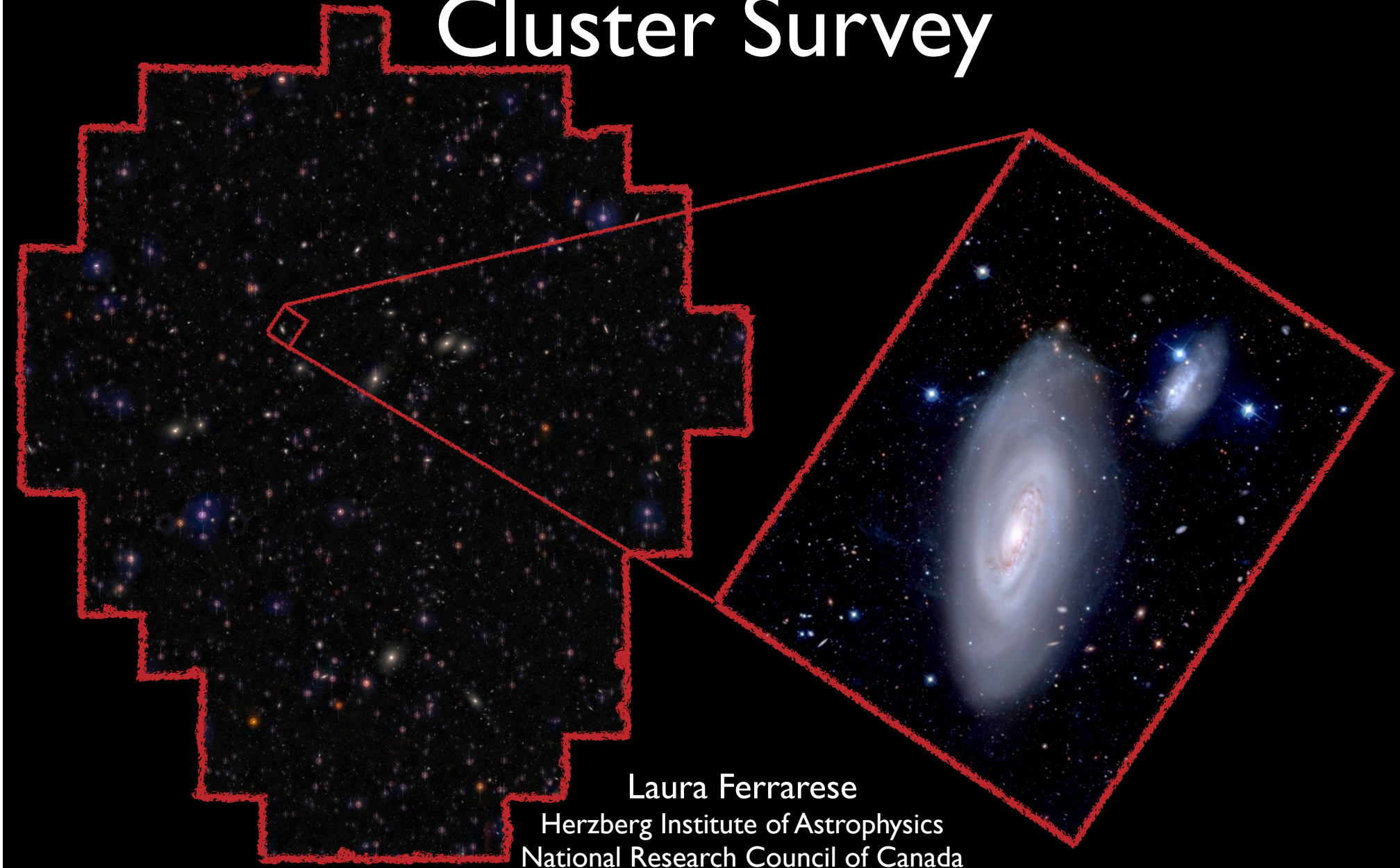
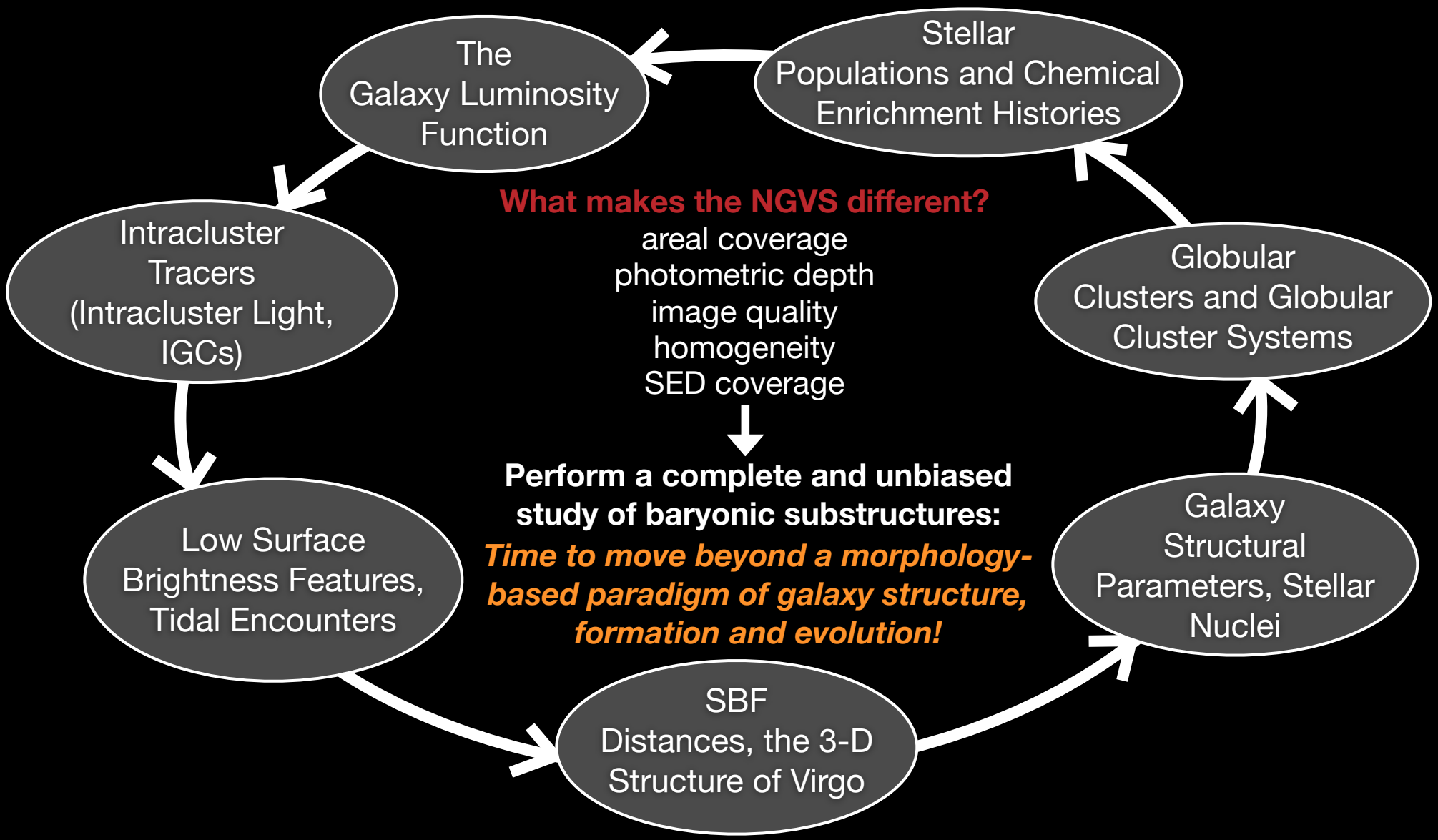
The Next Generation Virgo Cluster Survey



Laura Ferrarese
Herzberg Institute of Astrophysics
National Research Council of Canada

NGVS: Motivation



- Existing optical surveys of Virgo fall short at achieving these goals: VCC (Binggeli, Sandage & Tammann) is now nearly a quarter century old (≈1983-1987); SDSS did not significantly improve upon the VCC's point-source and surface brightness detection limits.

NGVS: More than Virgo

Virgo Cluster Science

- Galaxy Luminosity and Mass Functions
- Colour-Magnitude Relation vs. Morphology
- Photometric, Structural and Dynamical Scaling Relations
- Compact Stellar Systems
- Galactic Nuclei and AGNs
- The Extragalactic Distance Scale and Structure of Virgo
- Diffuse Intracluster Light
- Galaxy Interactions and Evolution
- Extragalactic Star Clusters

Foreground Science

- The Kuiper Belt and the Outer Solar System
- The Structure of the Galactic Halo

Background Science

- Cosmic Shear and Galaxy-Galaxy Lensing
- High-z Galaxy Clusters
- Strong Lensing Events
- Intrinsic Alignment

NGC 4435 and NGC4438 @ NGVS

The NGVS at a Glance

- **NGVS**: CFHT/MegaCam Large Programme to survey the Virgo Cluster from the cores to the virial radii of its two main sub-clusters (5.4 deg and 3.4 deg for the A and B sub-clusters, respectively)

- 104 square degrees, tiled with 117 slightly overlapping pointings.

- 4 background fields to estimate background/foreground contamination.

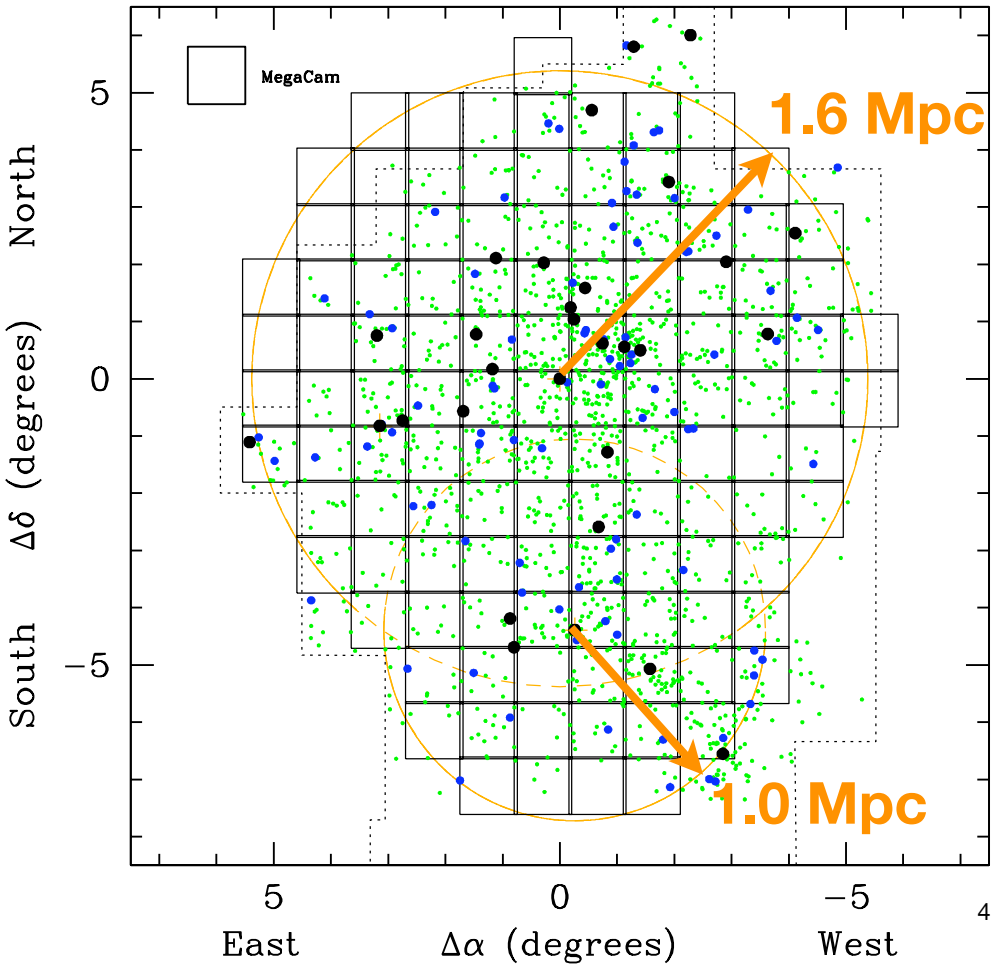
- *u*g′r′i′z′*, to $g' \approx 25.7$ mag (10σ)
  $\mu_{g'} \approx 29$ mag arcsec^{-2} (2σ).

- Awarded 900 hours (~180 nights) over five years (2009A - 2013A).

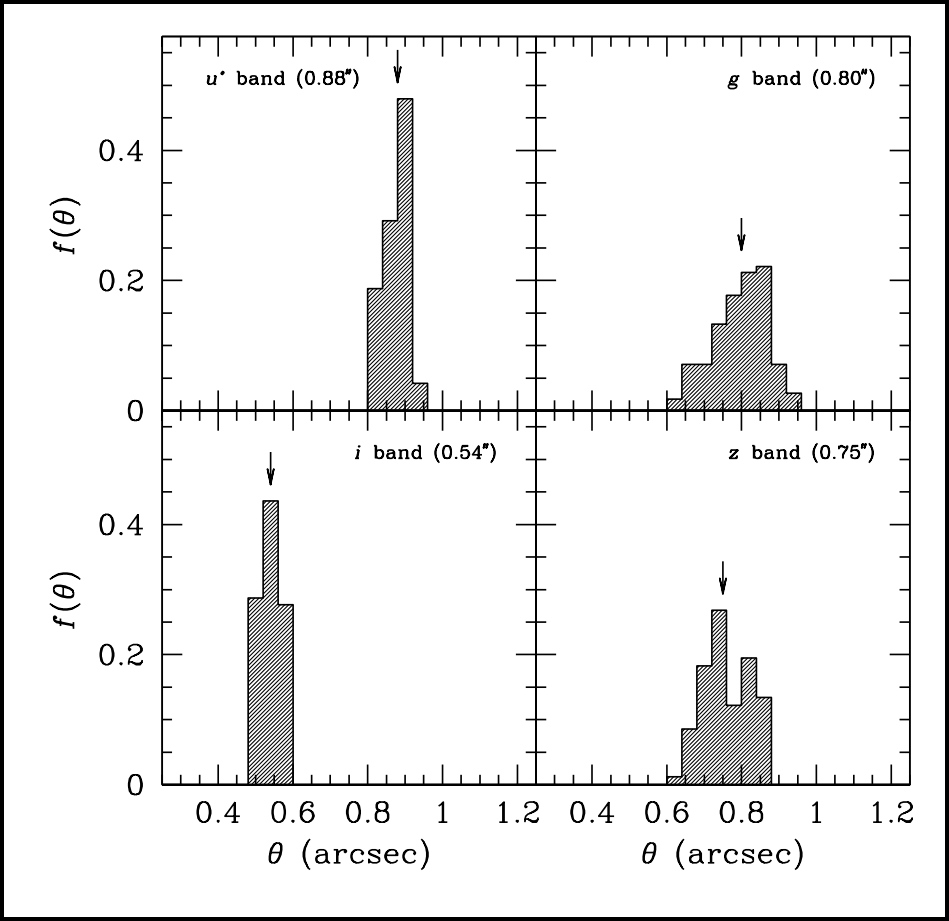
- 15 TB of data (beginning of year 5)

- Extensive spectroscopic (~250hr) and NIR imaging (~80hr) followup.

- Additional details: *Ferrarese et al. 2012, ApJS, 200,4*



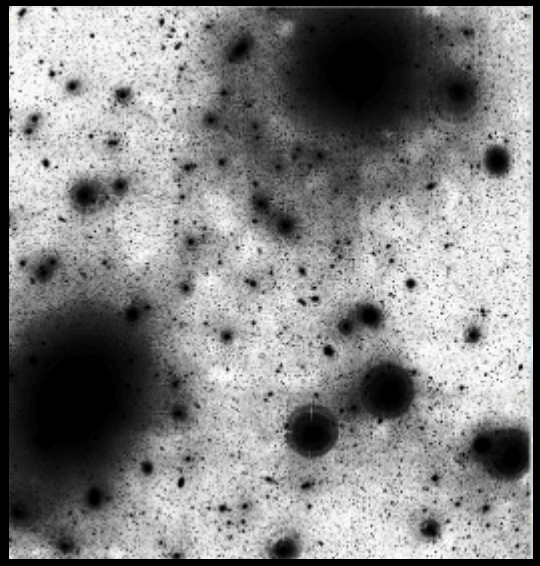
NGVS Data Quality: Spatial Resolution



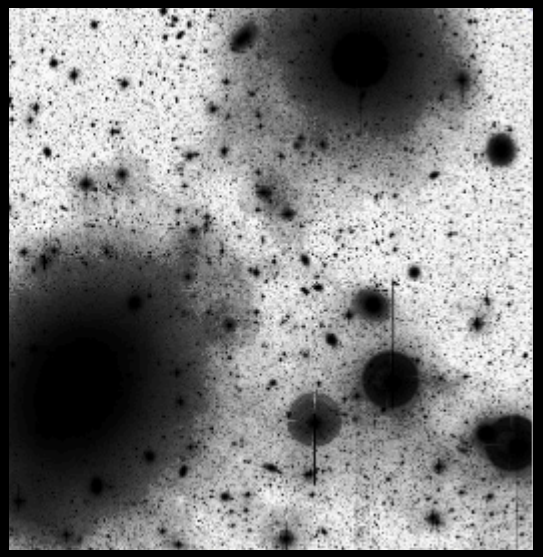
- Ultra Compact Dwarfs are easily resolved
- Virtually all globular clusters brighter than $g = 23$ mag and with $r_h > 5$ pc are spatially resolved
- Stellar nuclei are easily detected and (in many cases) spatially resolved.

NGVS Data Quality: Surface Brightness Limits

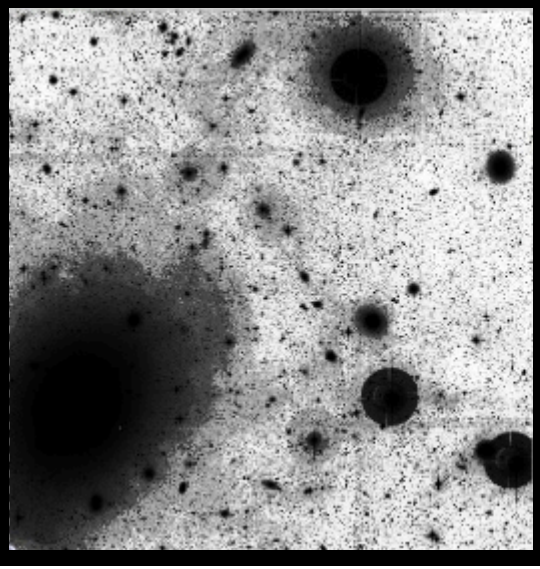
- Dedicated data acquisition strategy that allows a real-time background estimate.
- Dedicated data reduction (Elixir-LSB, J.C. Cuillandre) and stacking pipelines (S. Gwyn, Y. Mellier, P. Hudelot, T. Erben).



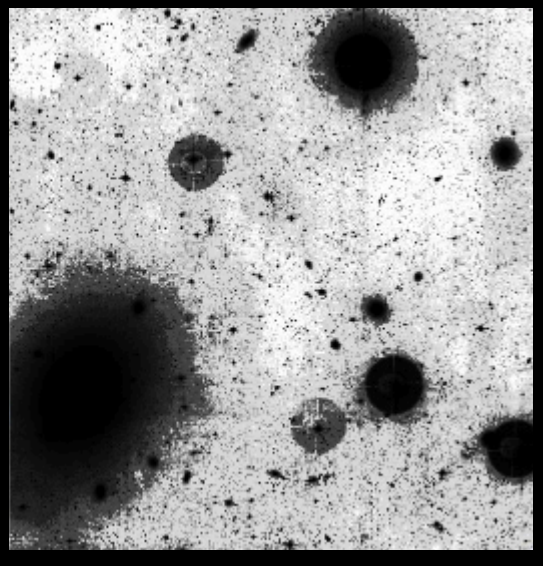
*u**
- Res = 0.2%
- Sky = 22.6 mag/sq.”
- Lim = 29.3 mag/sq.”
- Max = 0.5%



*g**
- Res = 0.2%
- Sky = 22.2 mag/sq.”
- Lim = 29.0 mag/sq.”
- Max = 0.5% (rare)



i’
- Res = 0.2%
- Sky = 20.7 mag/sq.”
- Lim = 27.4 mag/sq.”
- Max = 0.5% (rare)
- Significantly reduced fringing

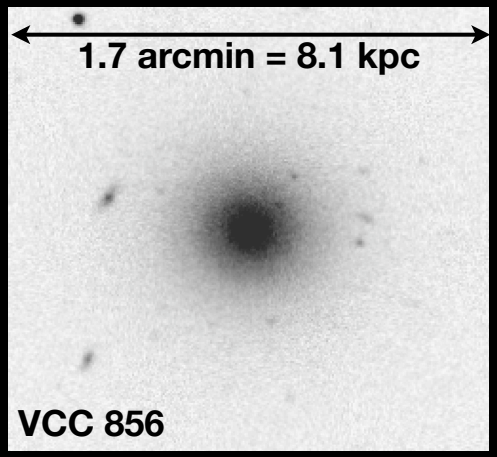


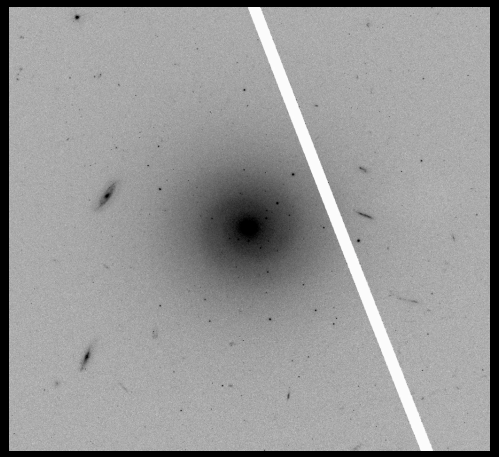
z’
- Res = 0.2%
- Sky = 19.3 mag/sq.”
- Lim = 26.0 mag/sq.”
- Max = 0.5%
- Significantly reduced fringing

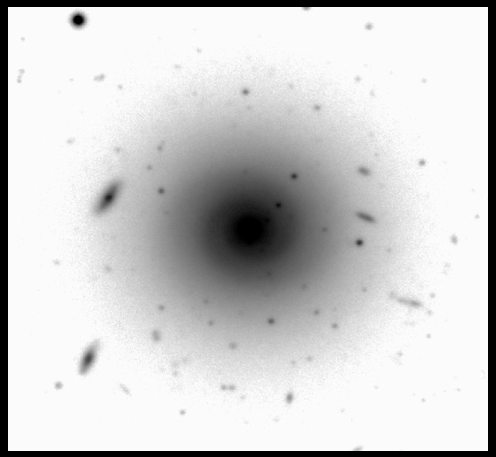
NGVS Data Quality: Surface Brightness Limits

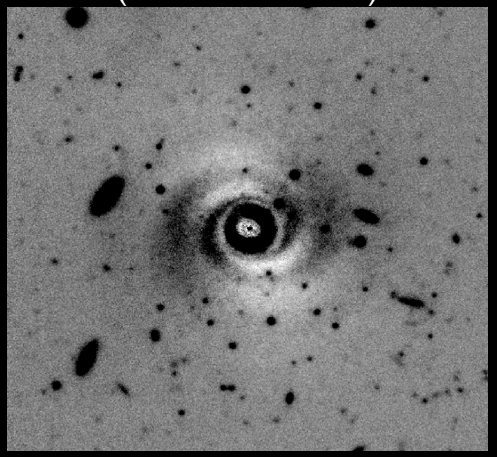
- Dedicated data acquisition strategy that allows a real-time background estimate.
- Dedicated data reduction (Elixir-LSB, J.C. Cuillandre) and stacking pipelines (S. Gwyn, Y. Mellier, P. Hudelot, T. Erben).

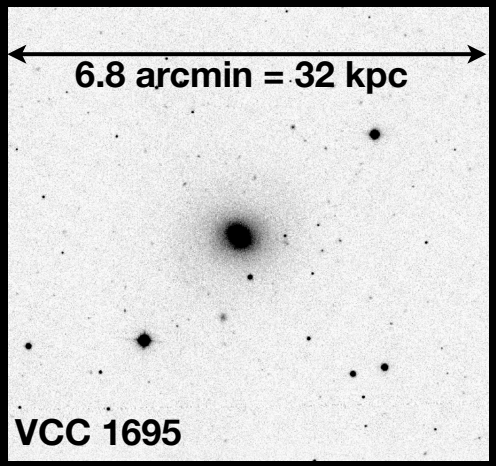
SDSS | HST/ACS | NGVS | NGVS (model subtracted)

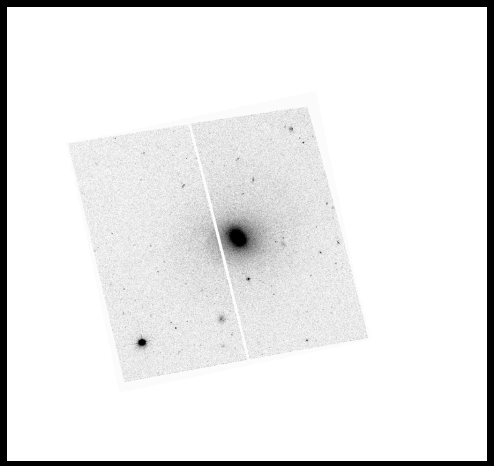


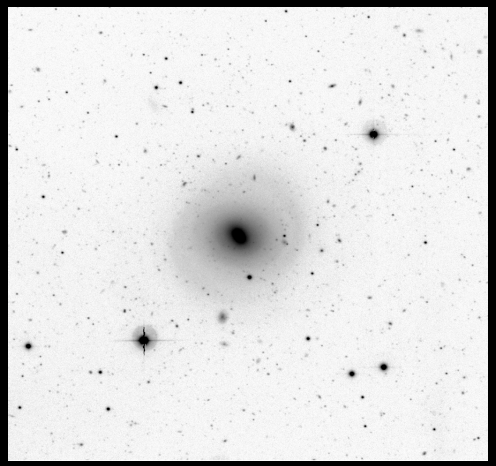


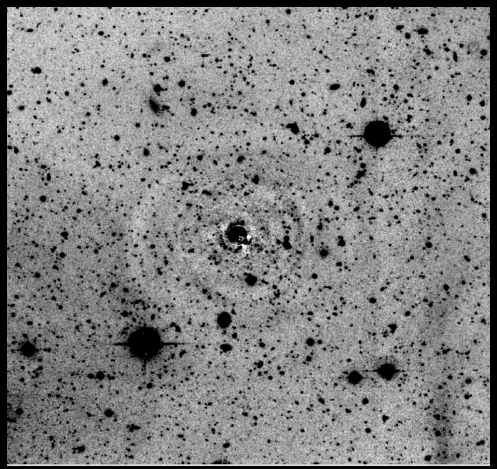




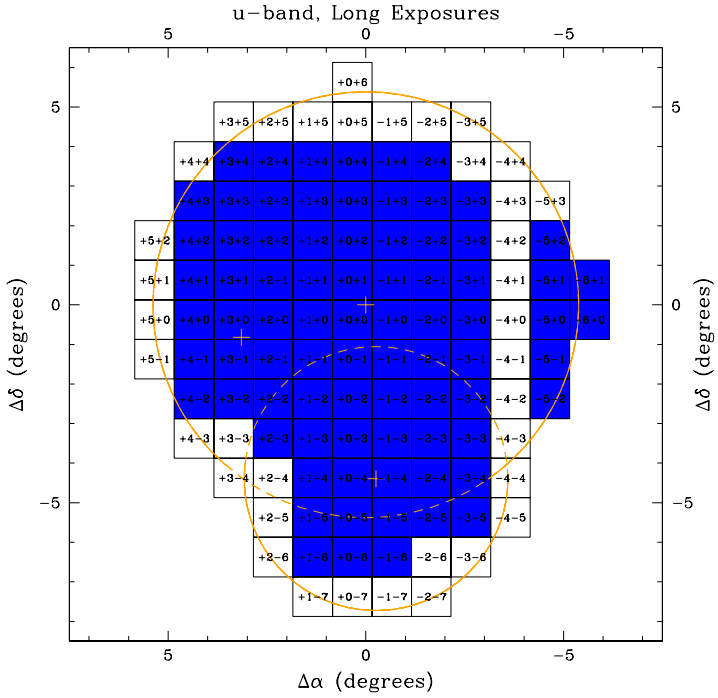


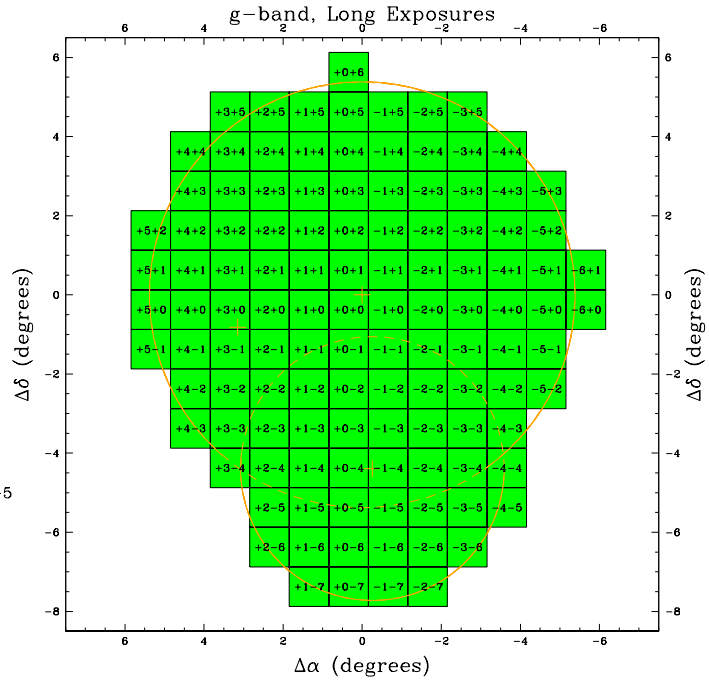


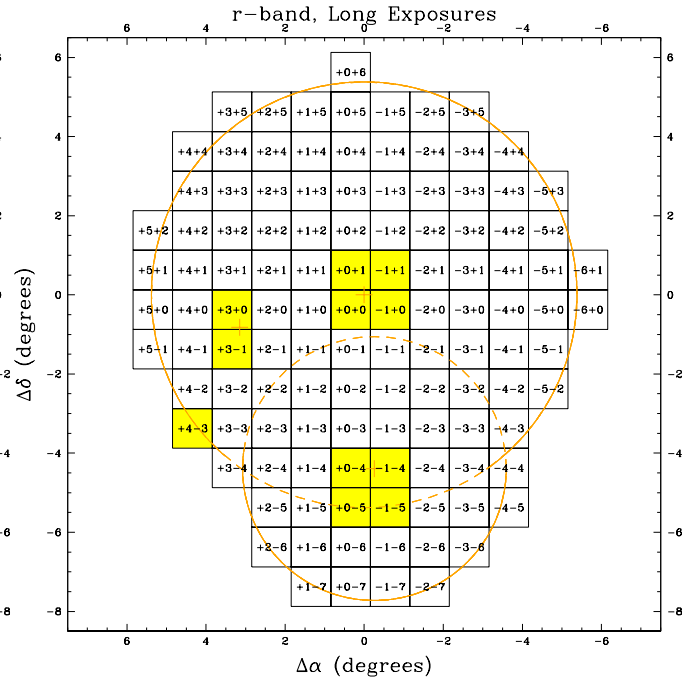


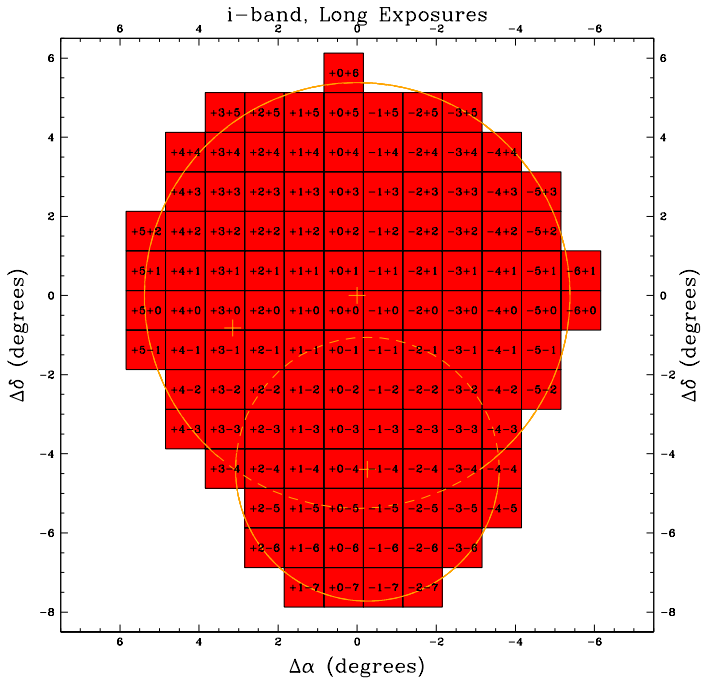


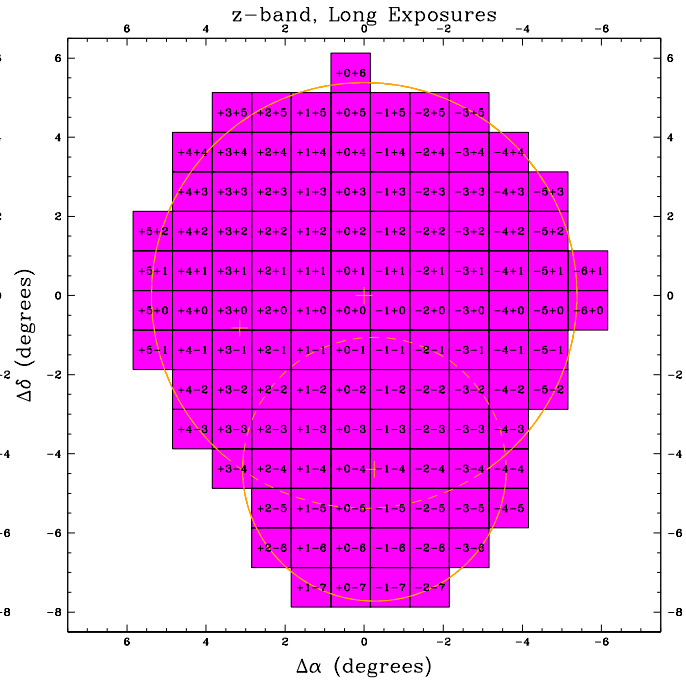
NGVS: Observing Status











u: **68% (71 sq. deg)**

g: **100% (104 sq. deg)**

r: **9% (10 sq. deg)**

i: **100% (104 sq. deg)**

z: **100% (104 sq. deg)**

The NGVS view of the Virgo Core

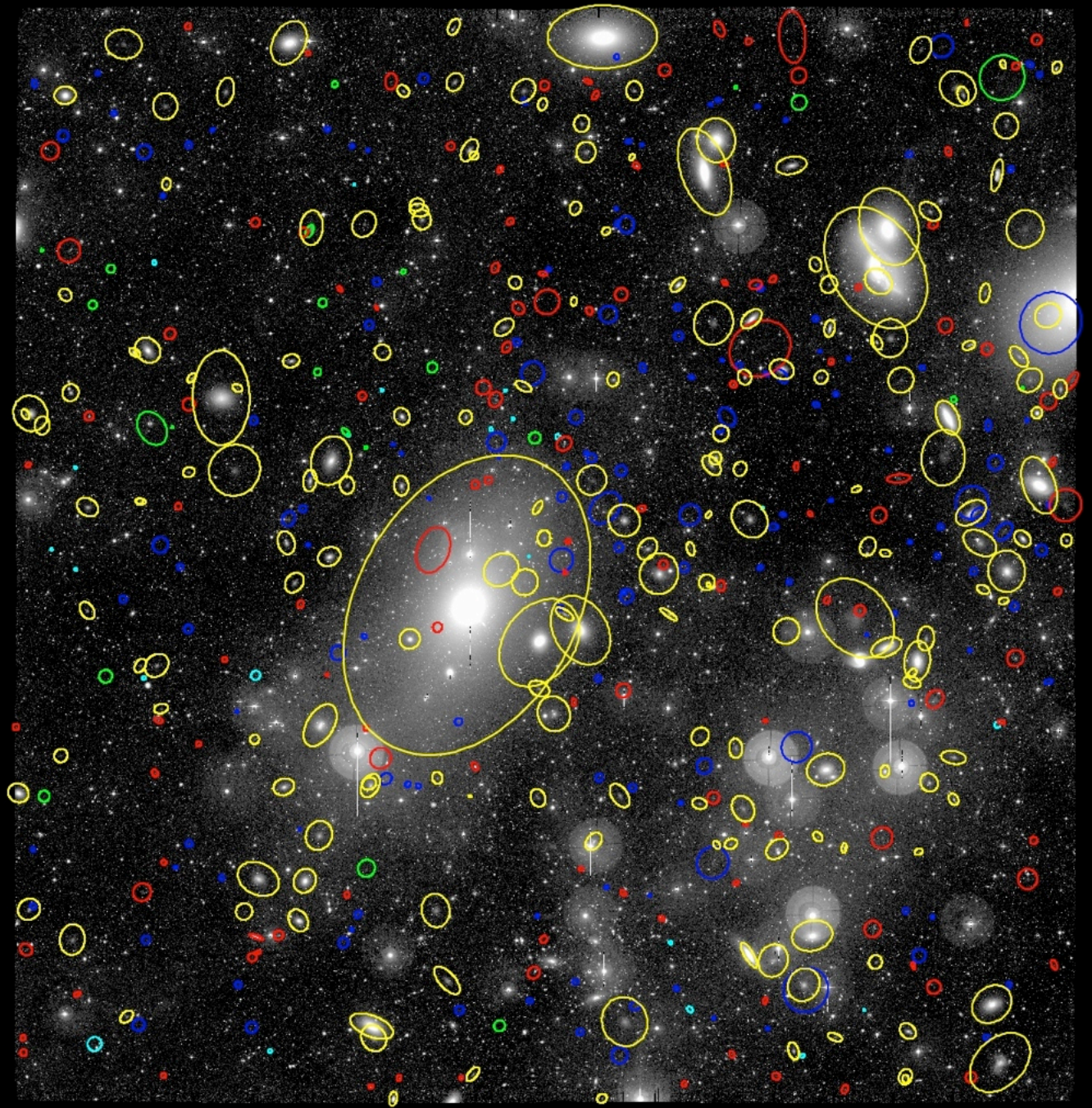
2×2 deg, roughly centred on M87.

Catalogued members:

- VCC: 184 galaxies, M_g<-11.5
- Trentham & Tully: 17 galaxies, M_g<-7.8

NGVS:

- 308 NEW galaxies -13.5 < M_g< -6.5. Membership probability based on a number of diagnostics (scaling relations, photo-zs, smoothness, MacArthur et al. 2013).

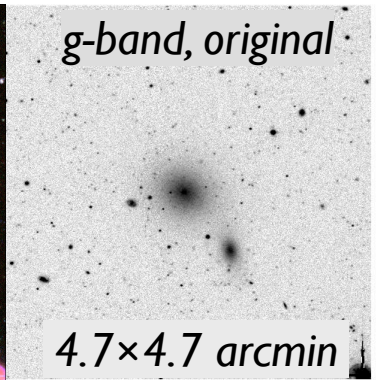


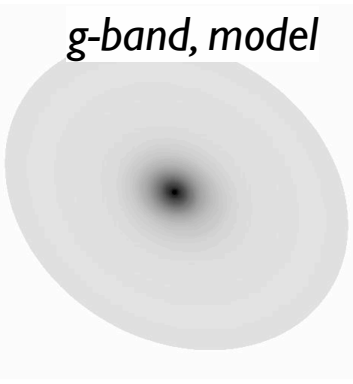
GALAXY STRUCTURAL PARAMETERS

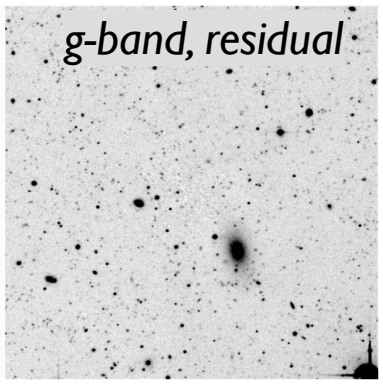
&

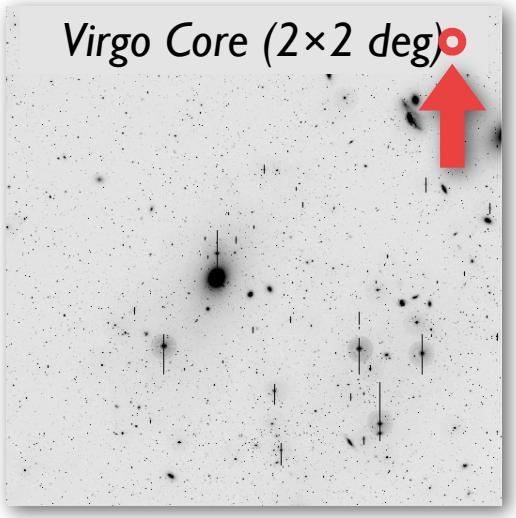
SCALING RELATIONS IN THE VIRGO CORE

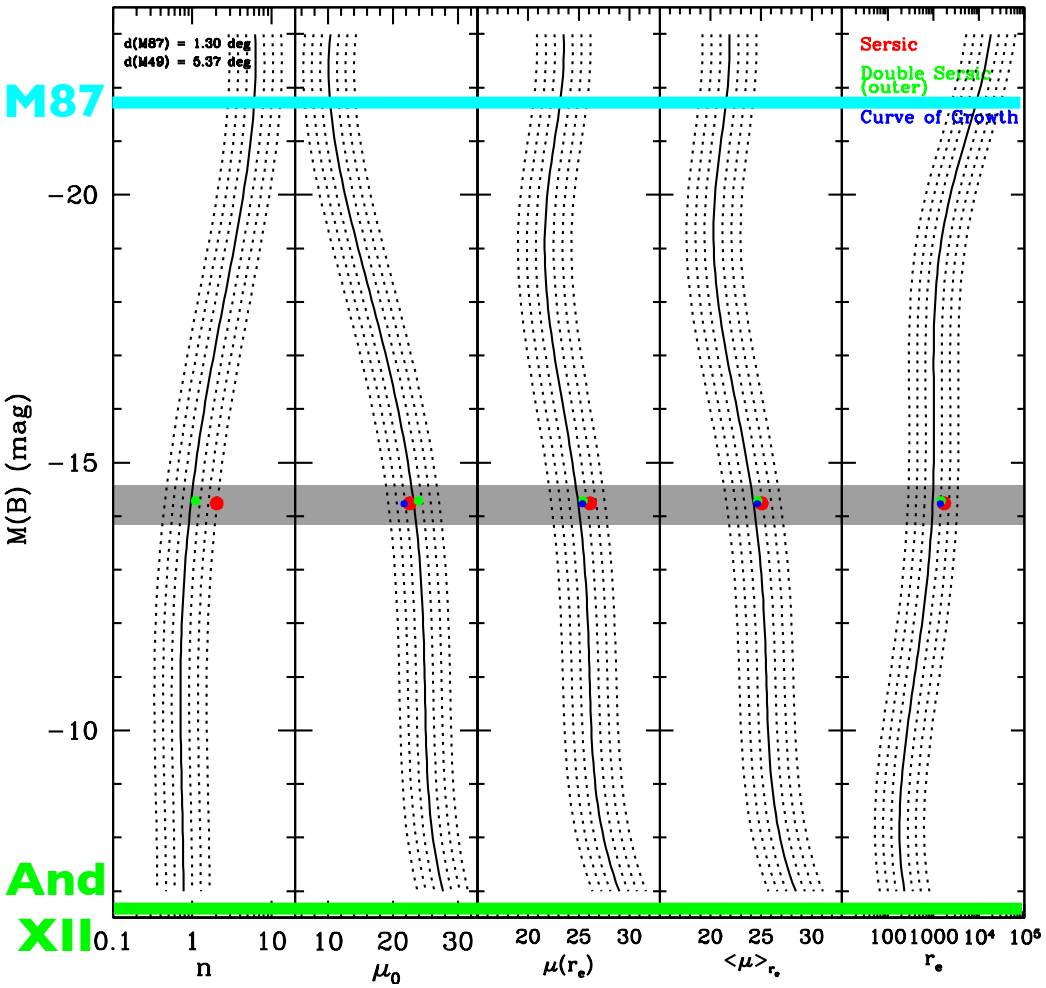
NGVS12:27:08.417+13:20:08.64 VCC972 M(g) = −14.69 mag

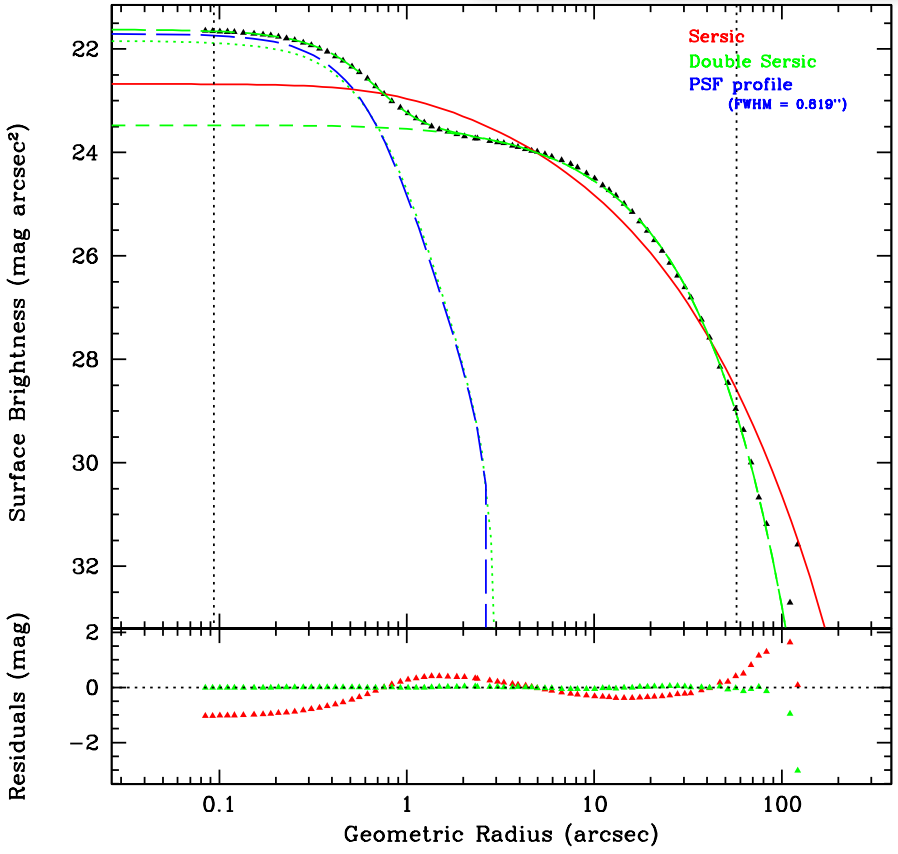




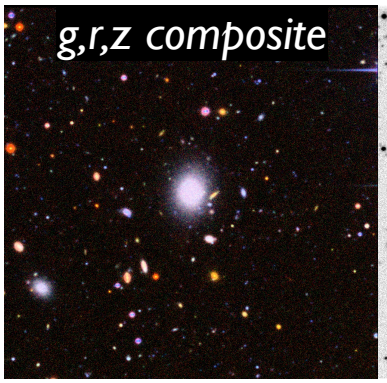


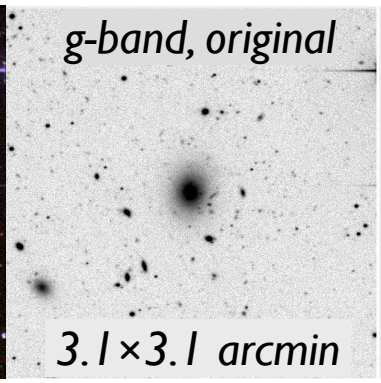


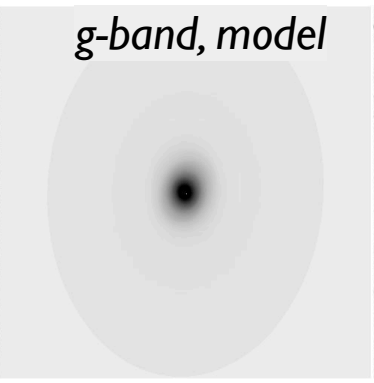


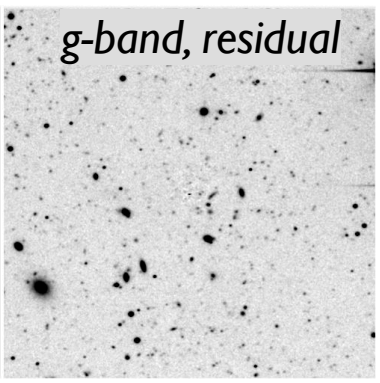


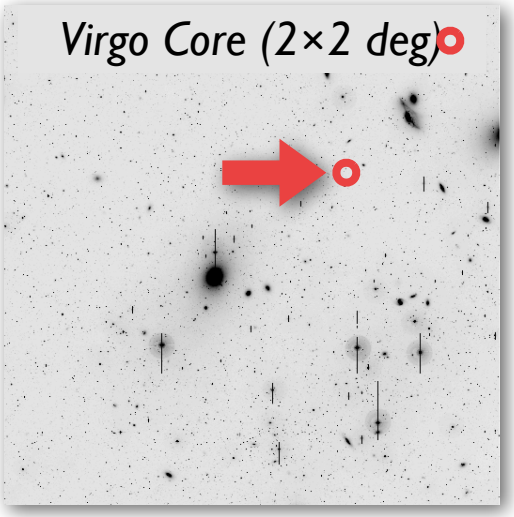
NGVS12:28:44.894+12:48:33.35 VCC1129 M(g) = −13.49 mag

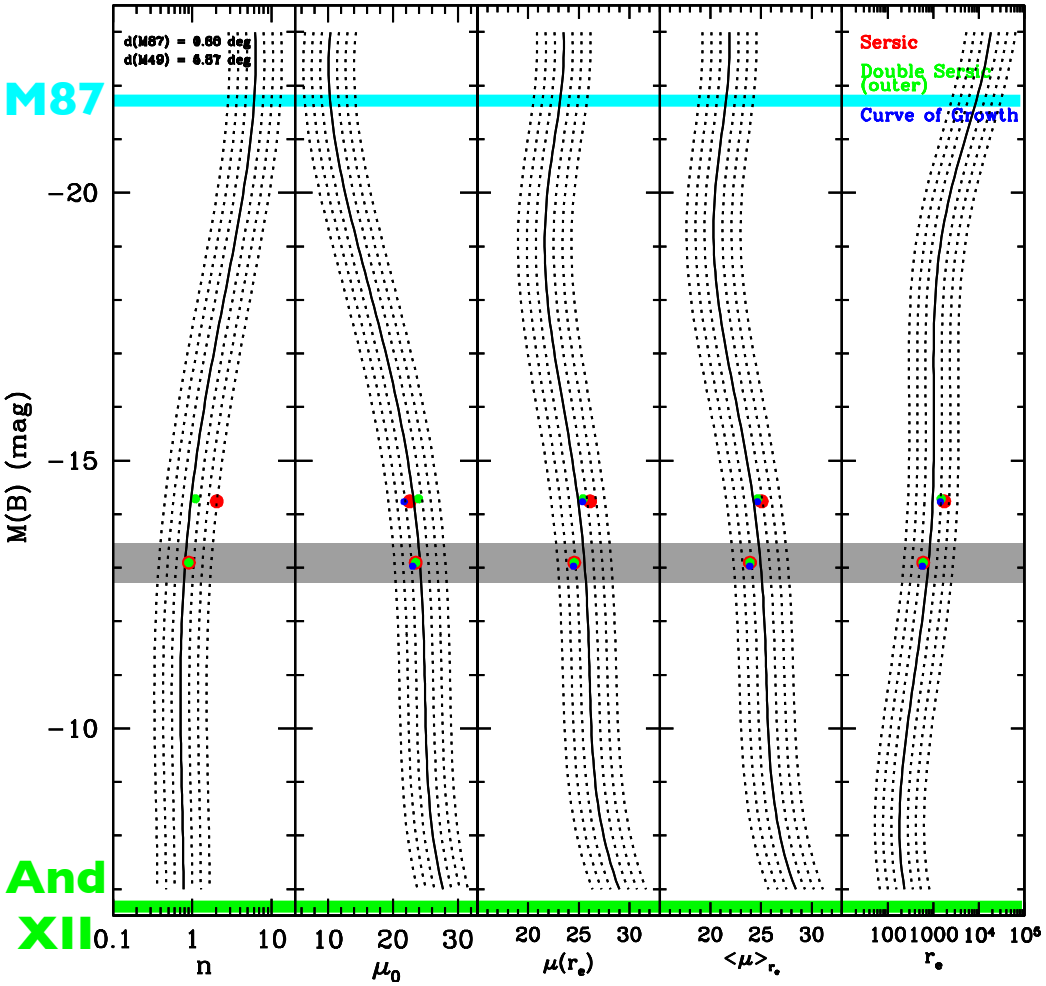


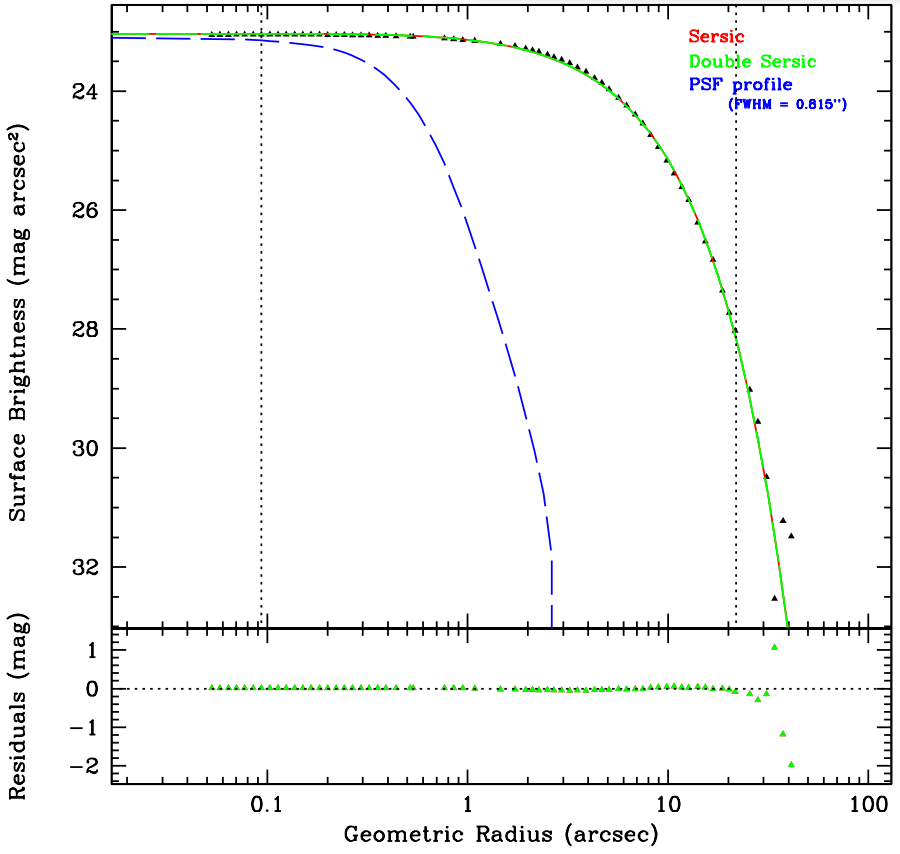




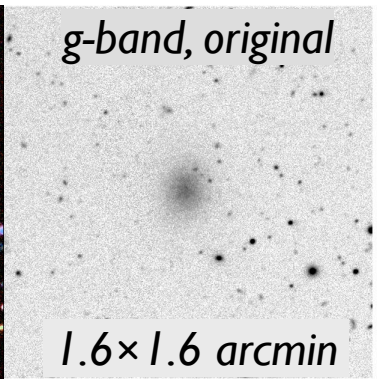


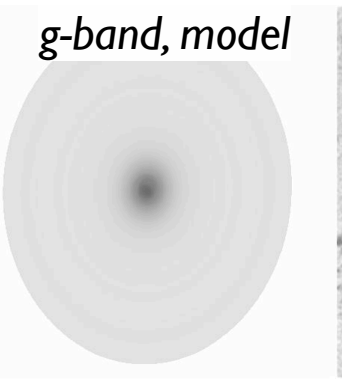


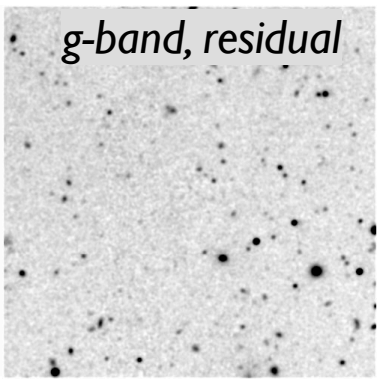


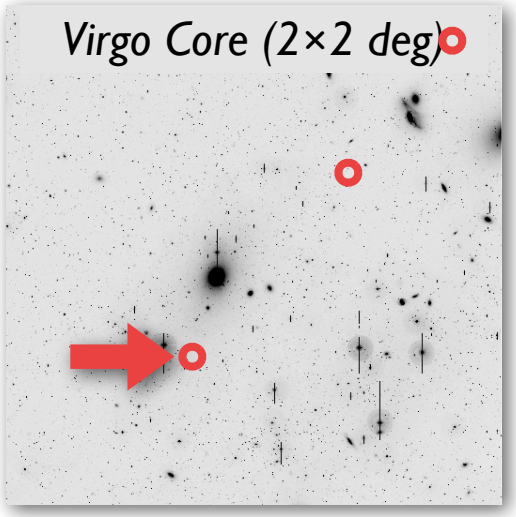


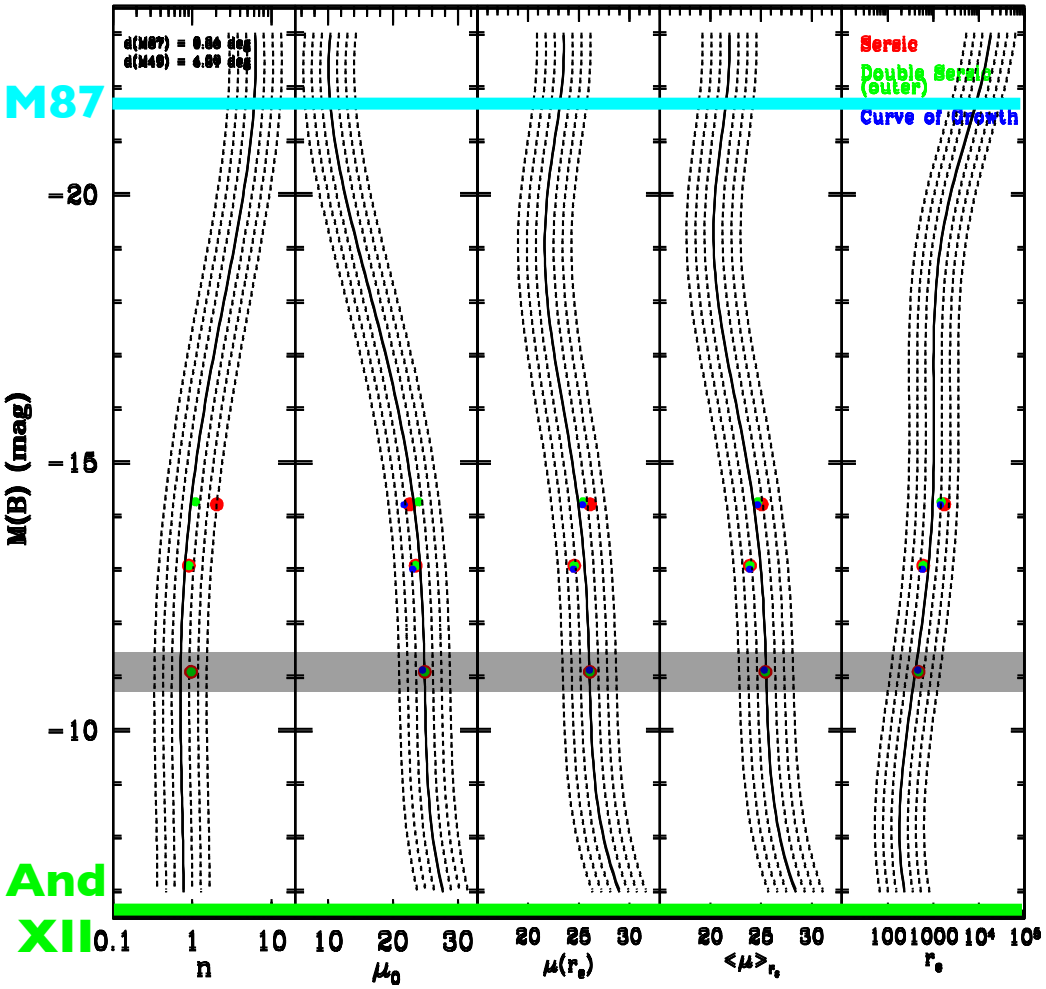
NGVS12:31:03.259+12:04:40.37 VCC1335 M(g) = −11.59 mag

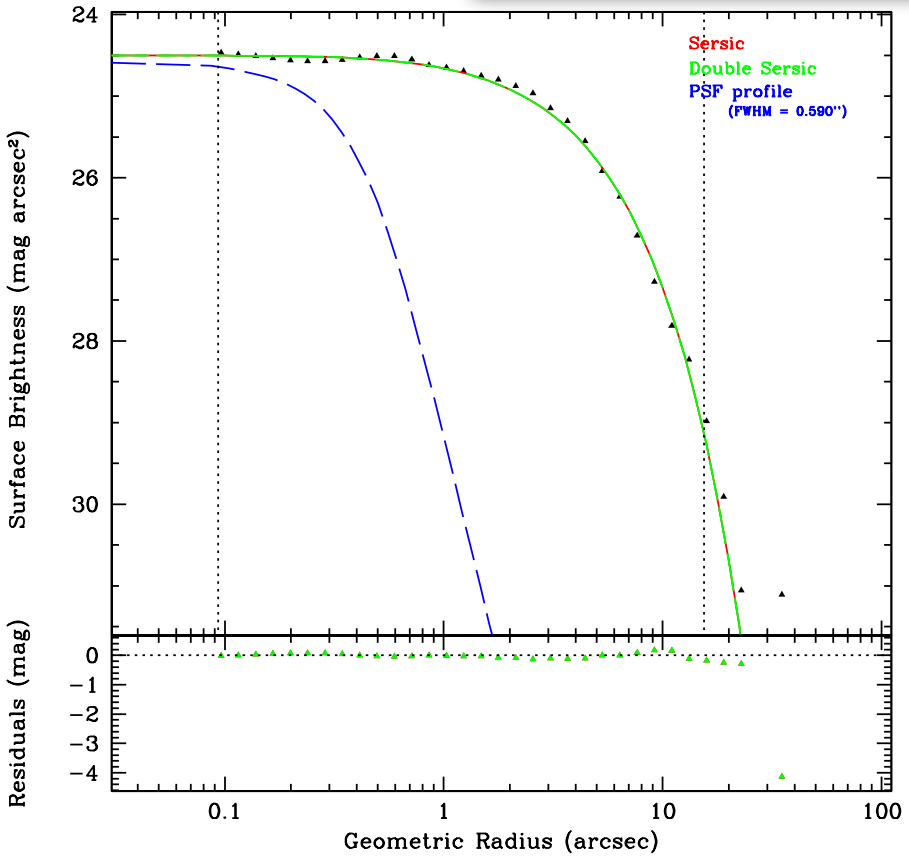




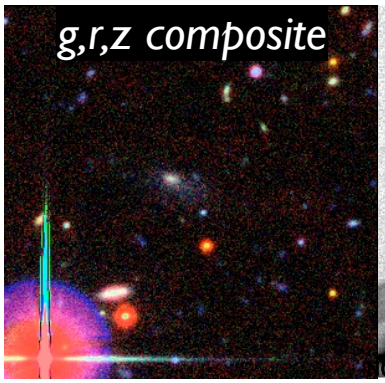


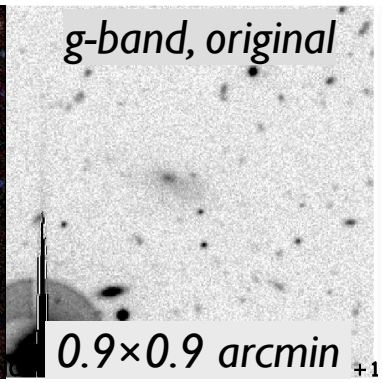


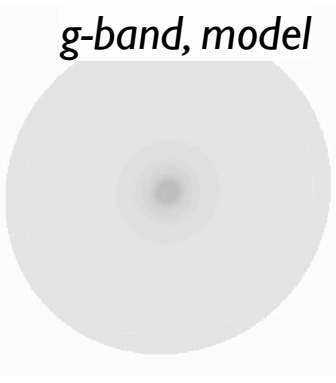


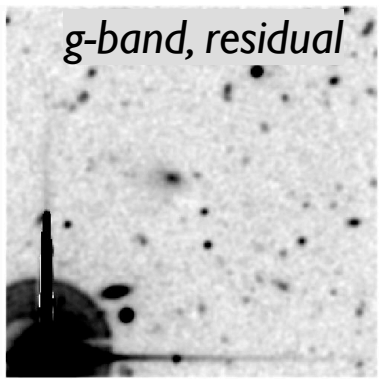


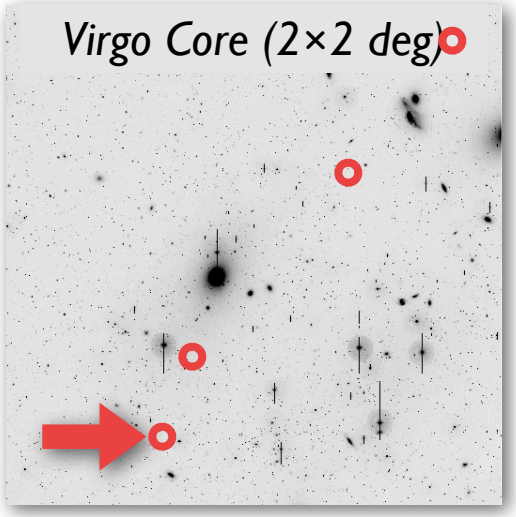
NGVS12:31:41.501+11:48:04.82 Unclass. M(g) = −8.39 mag

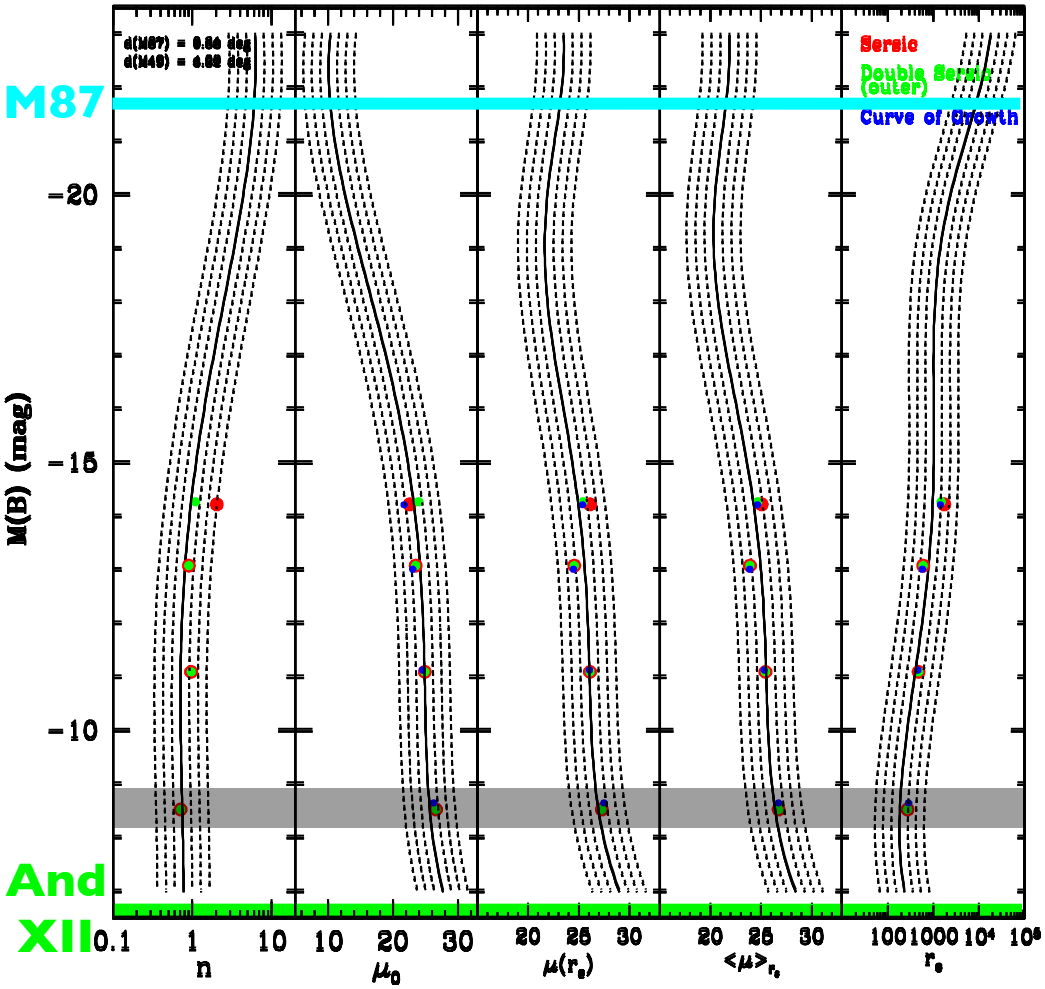


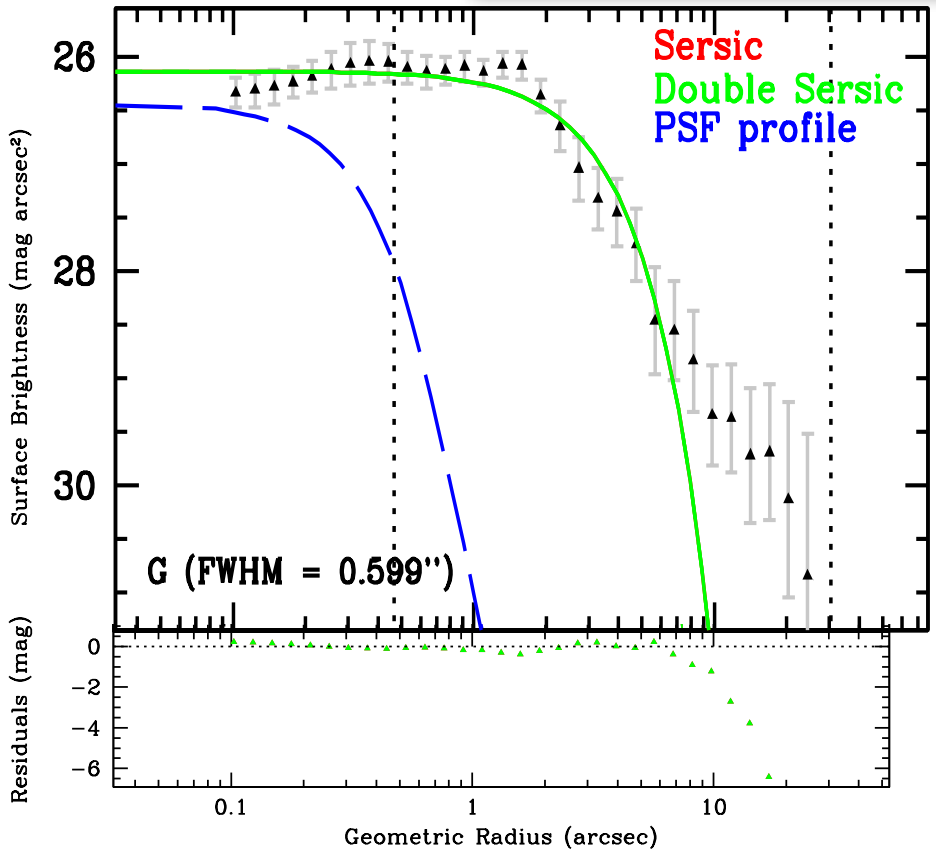




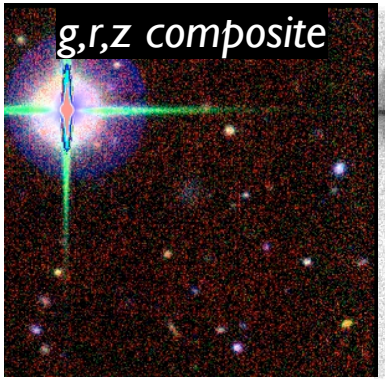


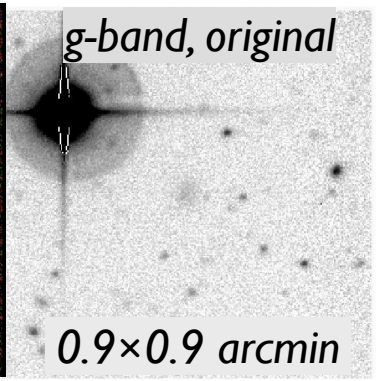


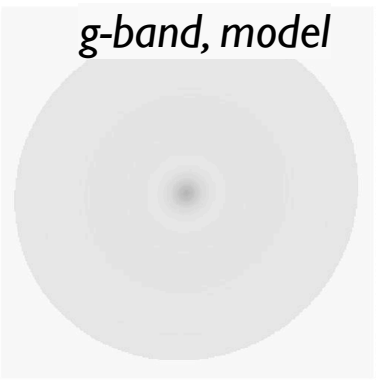


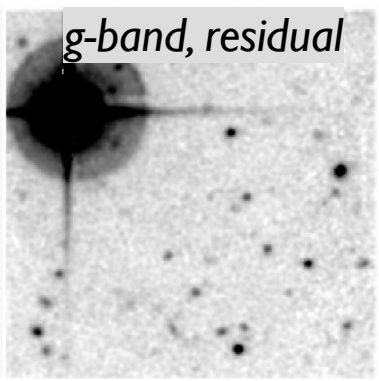


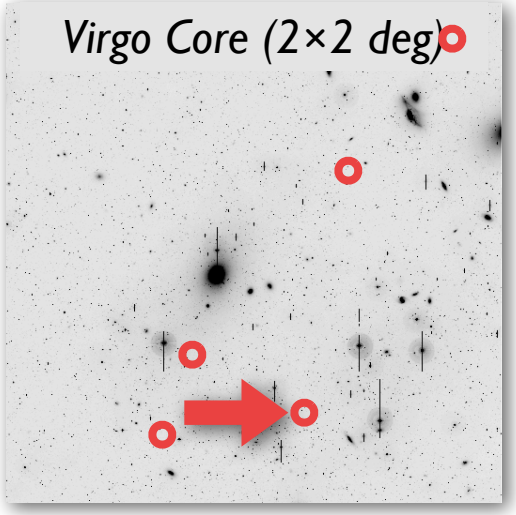
NGVS12:29:27.794+11:51:50.27 Unclass. M(g) = −7.69 mag

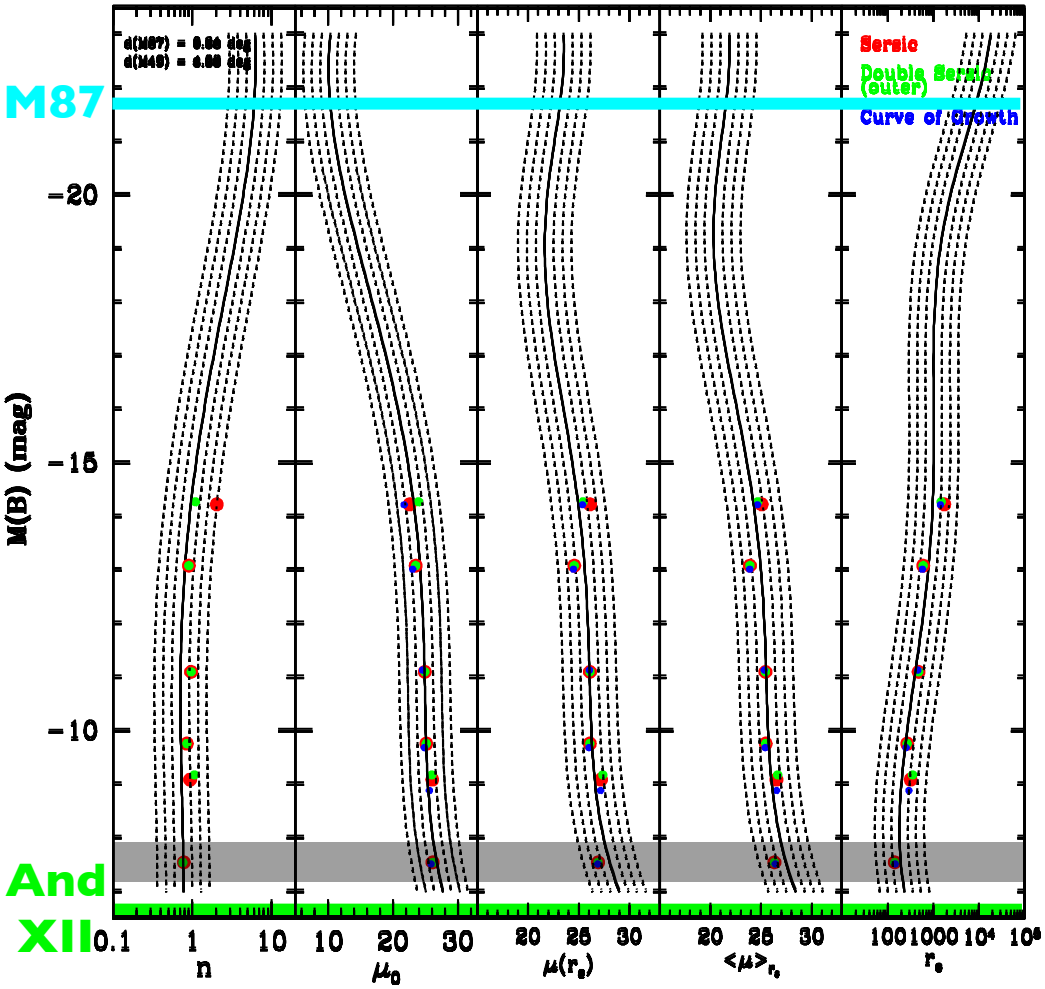


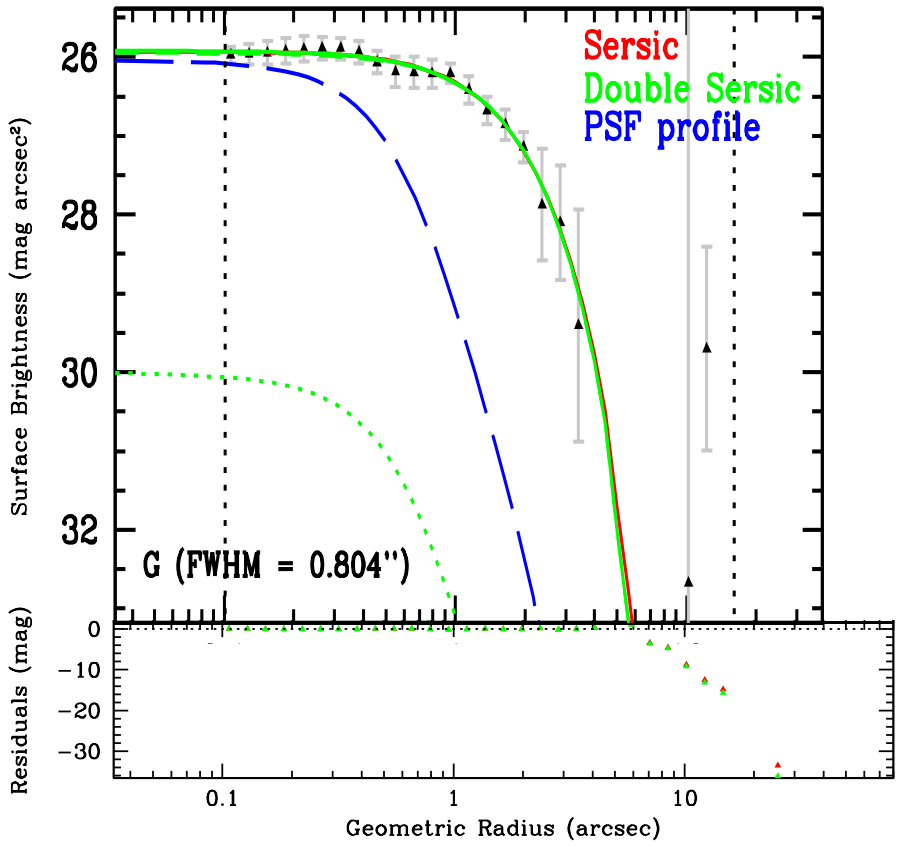




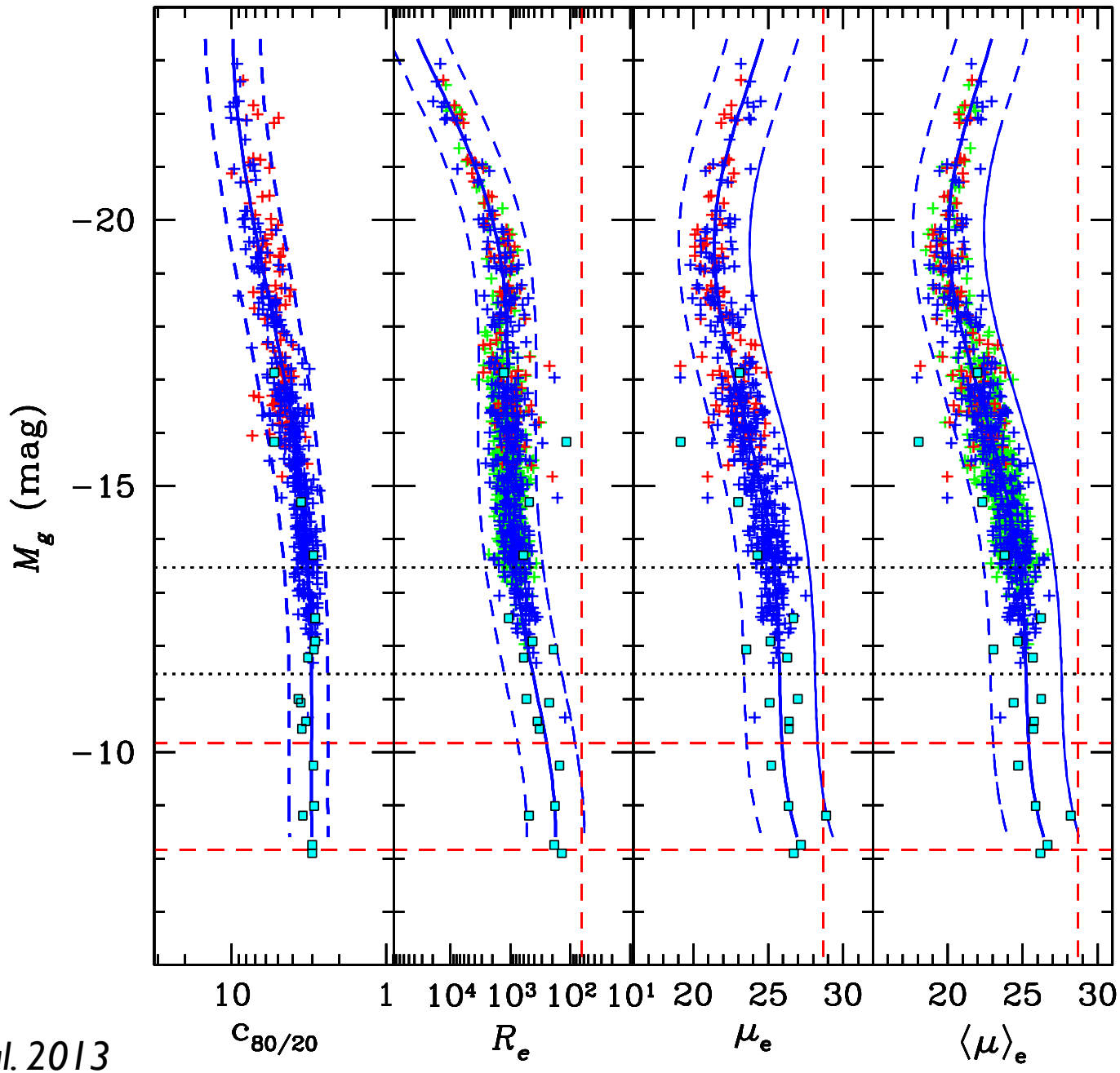








Galaxy Scaling Relations in the Virgo Core



Chen et al. (2010): ACSVCS (Côté et al. 2004)

Janz & Lisker (2009)

McLaughlin et al. (2013): data from Ferrarese etal. 2006, Gavazzi etal. 2004, Stiavelli etal. 2001

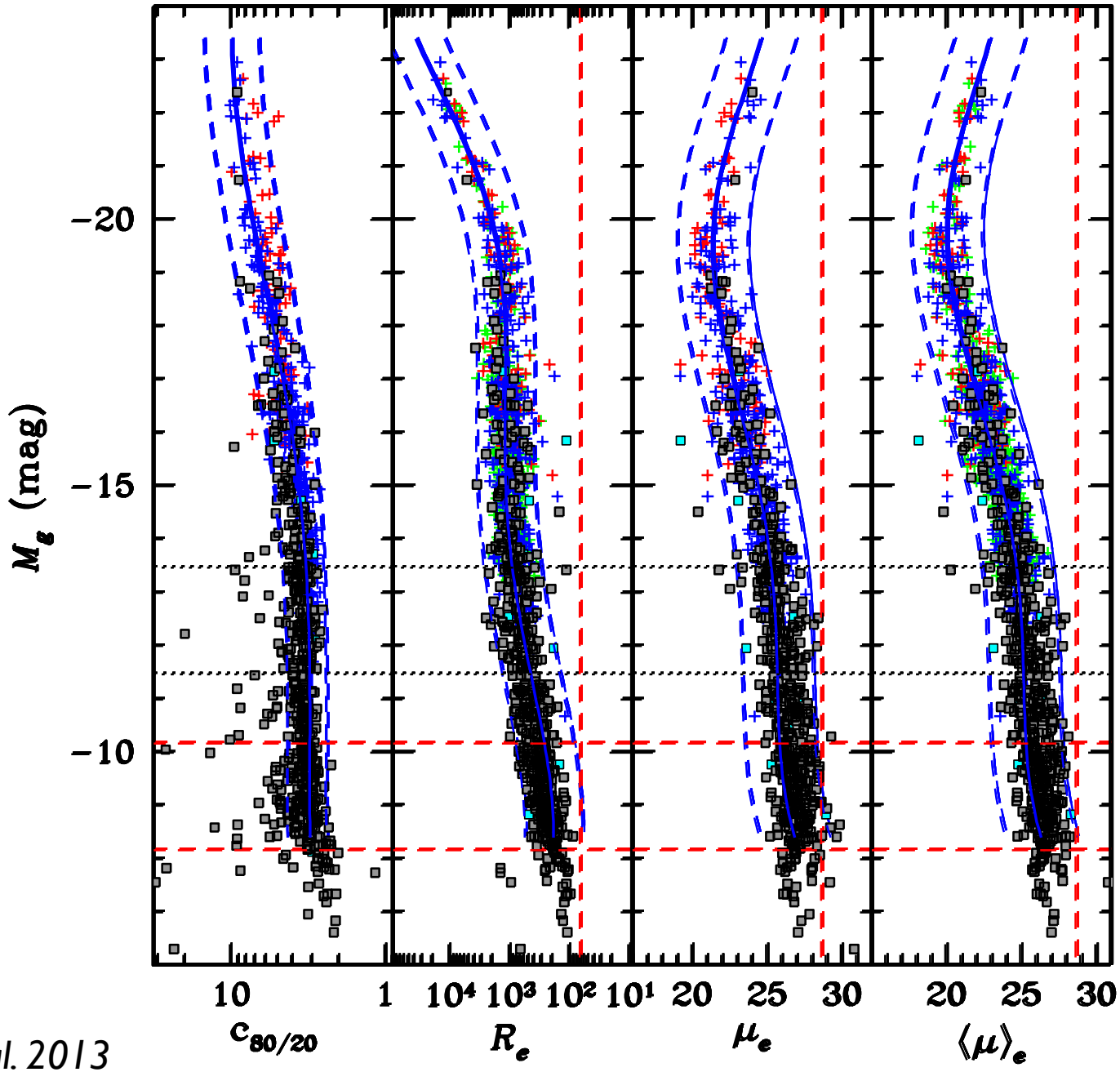
VCC (100% completess)

VCC (0% completeness)

Local Group galaxies; compilation from McLaughlin et al. 2011; also Misgeld & Hilker 2011.

Côté et al. 2013

Galaxy Scaling Relations in the Virgo Core



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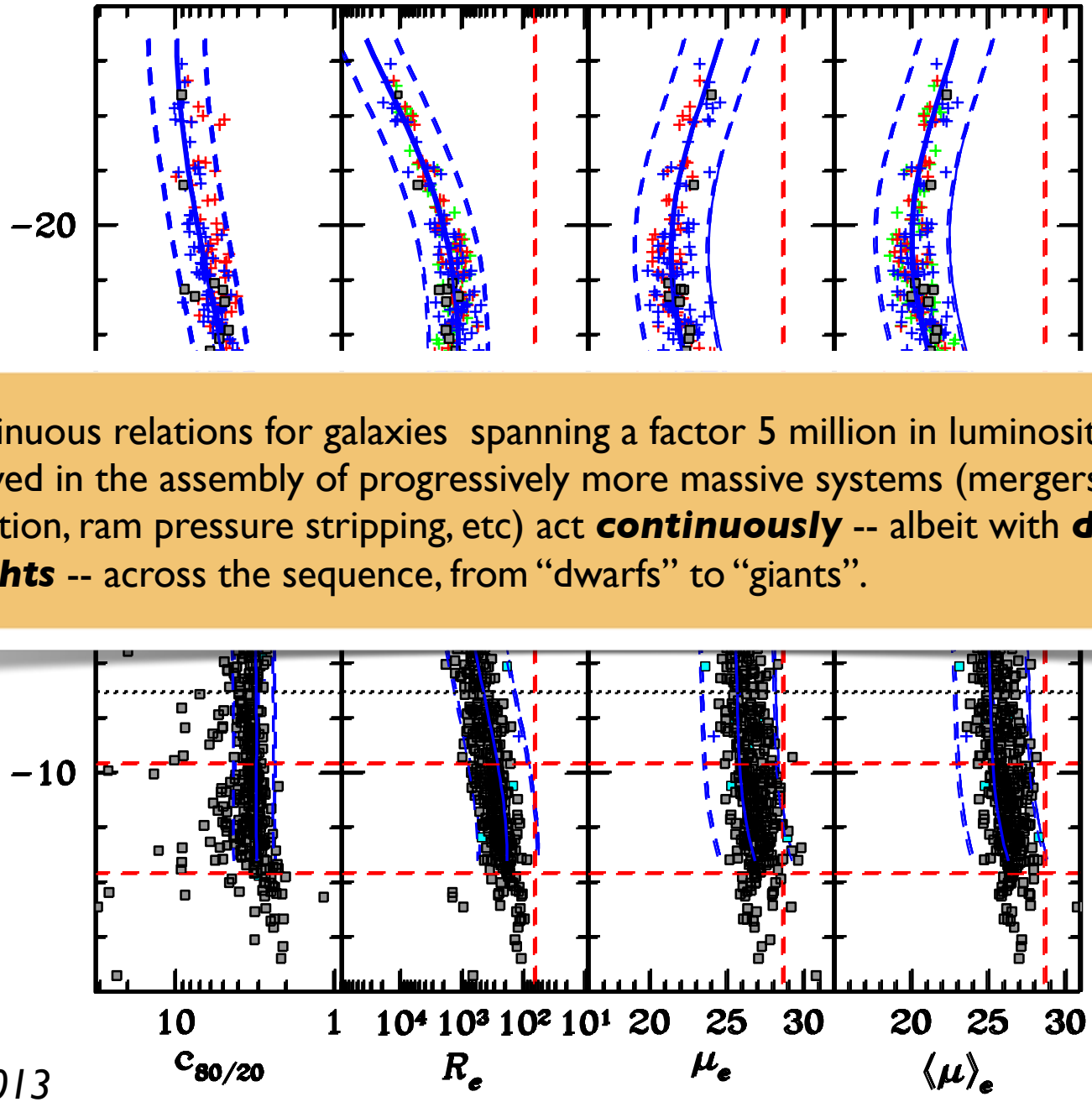


Chen et al. (2010): ACSVCS (Côté et al. 2004)

Janz & Lisker (2009)

McLaughlin et al.

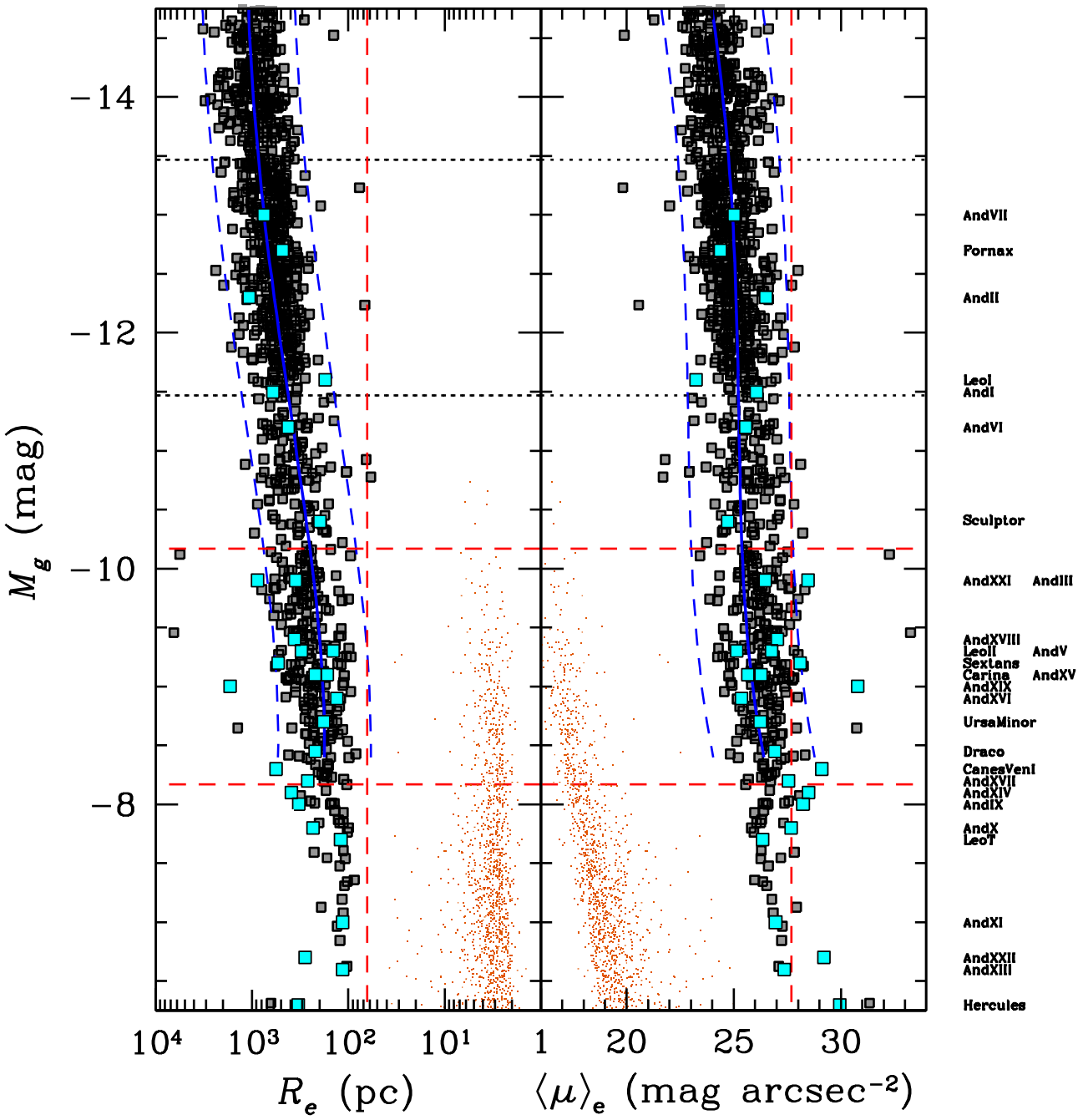
- Continuous relations for galaxies spanning a factor 5 million in luminosity: the processes involved in the assembly of progressively more massive systems (mergers, harassment, accretion, ram pressure stripping, etc) act ***continuously*** -- albeit with ***different weights*** -- across the sequence, from "dwarfs" to "giants".

VCC (0% completeness)

Local Group galaxies; compilation from McLaughlin et al. 2011; also Misgeld & Hilker 2011.

Côté et al. 2013

Galaxy Scaling Relations in the Virgo Core



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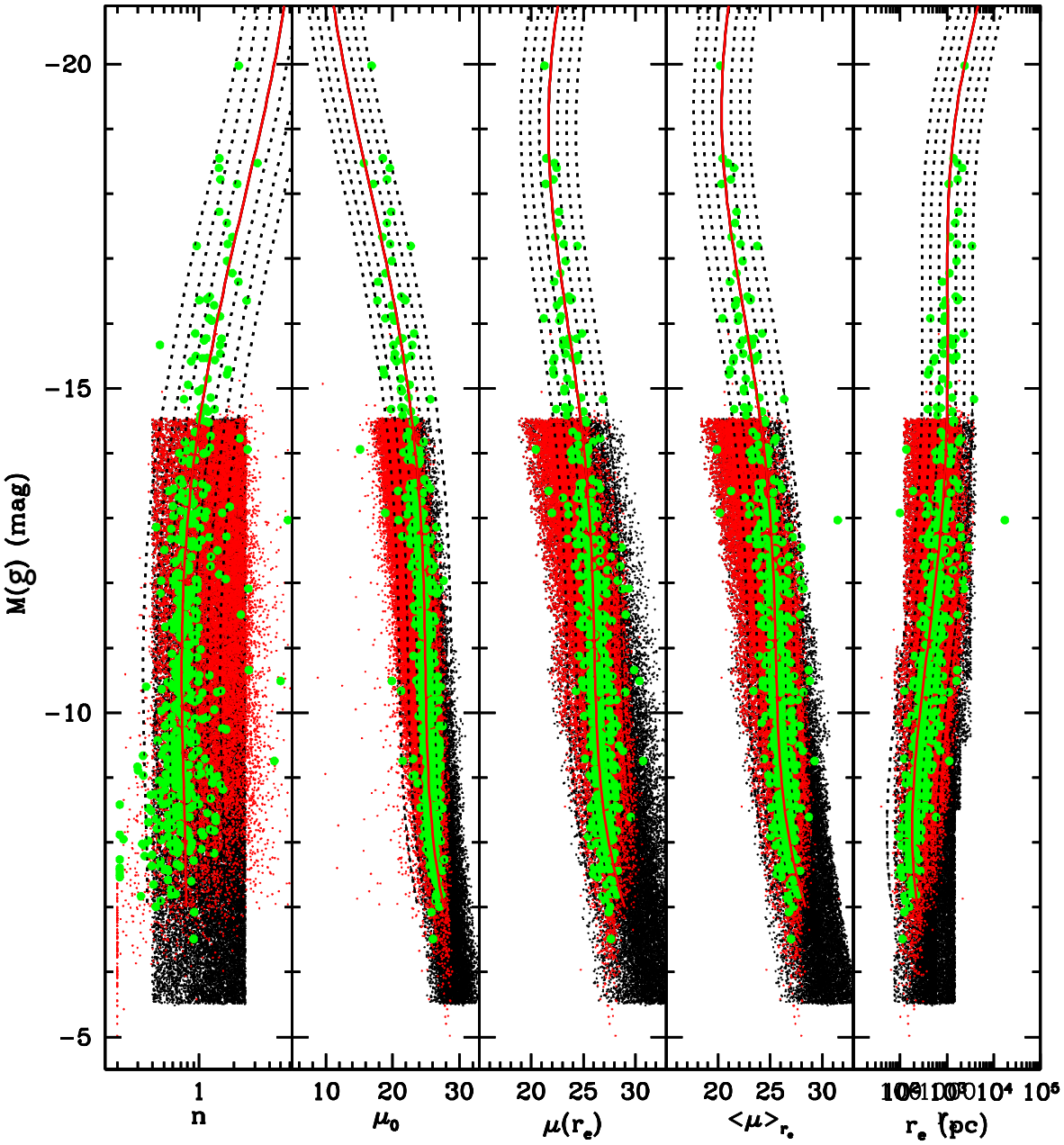
THE LUMINOSITY FUNCTION IN THE VIRGO CORE

The Luminosity Function of the Virgo Core: Simulations

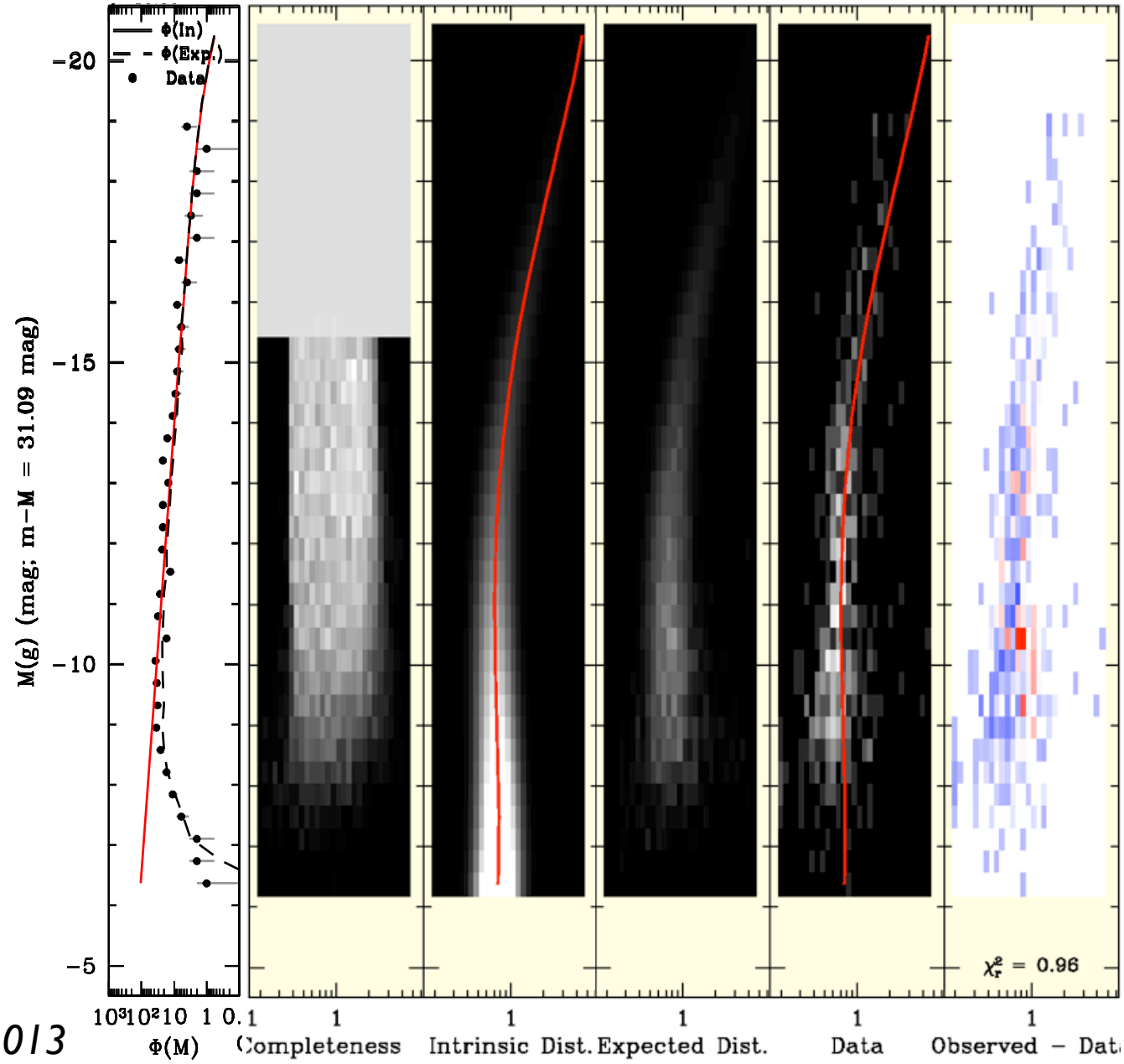
- Faint end slope still not well constrained, with value ranging from -1.2 to -2.2 (Sandage et al. 1985; Impey et al. 1998; Philips et al. 1998, Trentham & Hodgkin 2002; Sabatini et al. 2003; Rines & Geller 2008; Lieder et al. 2012)

- Crucial elements in constraining the luminosity function: depth, *membership, completeness, biases*

- 36,500 simulated galaxies added to the Virgo core fields detected and measured as the real galaxies (MacArthur et al. 2013): -15 <M_g< -5; 0.4 <n< 2.4; 8pc <re< 1500pc;



The Luminosity Function of the Virgo Core



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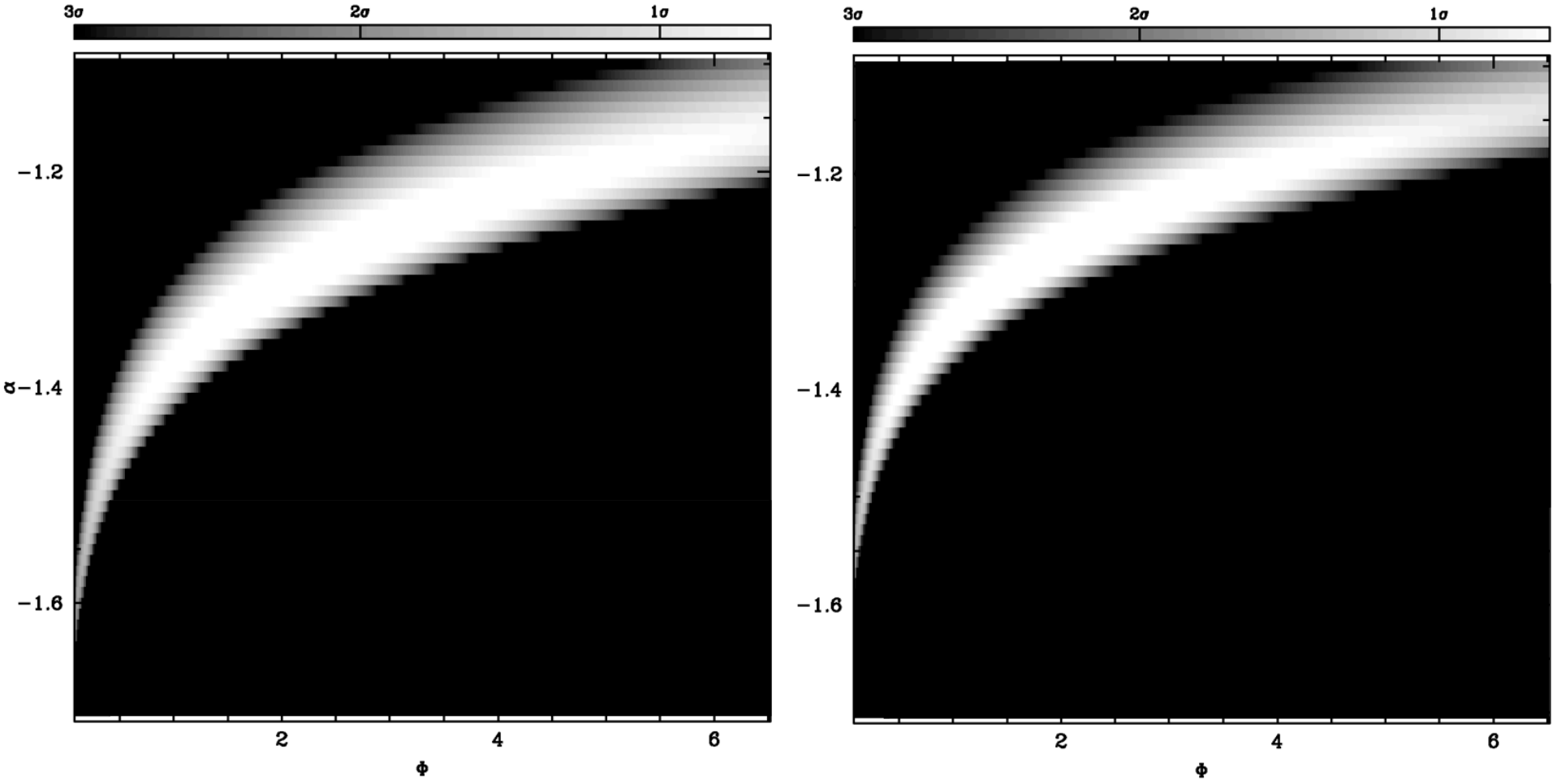
The Luminosity Function of the Virgo Core

- Results depend on M*



Ferrarese et al. 2013

The NGVS Team

Chantal Balkowski
Michael Balogh
John Blakeslee
Samuel Boissier
Alessandro Boselli
Frederic Bournaud
Claude Carignan
Ray Carlberg
Scott Chapman
Patrick Côté
Stephane Courteau
Jean-Charles Cuillandre
Tim Davidge
Serge Demers
Pierre-Alain Duc
Pat Durrell
Eric Emsellem
Thomas Erben
Laura Ferrarese
Giuseppe Gavazzi
Raphael Gavazzi
Stephen Gwyn
Henk Hoekstra

Patrick Hudelot
Marc Huertas
Olivier Ilbert
Andrés Jordán
Ariane Lancon
Lauren MacArthur
Alan McConnachie
Dean McLaughlin
Simona Mei
Yannick Mellier
Chris Mihos
Chien Peng
Eric Peng
Thomas Puzia
Marcin Sawicki
Luc Simard
James Taylor
John Tonry
R. Brent Tully
Wim van Driel
Ludo van Waerbeke
Bernd Vollmer
Christine Wilson

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Photo by Jean-Charles Cuillandre