A VST color composite image of the Fornax galaxy cluster (NGC 1316). The image shows a dense field of stars and galaxies. A prominent, bright, yellowish-white star is located in the center. To the left, there is a large, diffuse, reddish-orange nebula. The background is filled with numerous smaller stars and galaxies, some appearing as faint, distant objects. The overall color palette is rich, showing a variety of stellar colors from blue to red.

Deep (photometric & spectroscopic) Surveys of the Fornax cluster

Enrichetta Iodice

INAF- Astronomical Observatory of Capodimonte

Napoli, Italy

VST color composite image of NGC1316

The Fornax Deep Survey with VST

▶ joint project based on

VEGAS (P.I. E. Iodice)

&

OmegaCam GTO (FOCUS, P.I. R. Peletier)

▶ new, multi-imaging (u, g, r, i bands) survey of the Fornax Cluster

▶ FDS aims to cover 26 deg^2 around the core of the Fornax cluster out to the virial radius, including the region of Fornax A

VST survey of Early-type GALaxieS (VEGAS)

is a deep, multi-band (*ugri*) imaging survey of early-type galaxies in groups & clusters at VST

VST is a 2.6m wide-field optical survey telescope, located at ESO Cerro Paranal, Chile

VEGAS is based on the GTO assigned at INAF

- 2011-2016, PI: M. Capaccioli, ~55 nights
- 2016-2021, PI: E. Iodice, ~62 nights

<http://www.na.astro.it/vegas/VEGAS/Welcome.html>

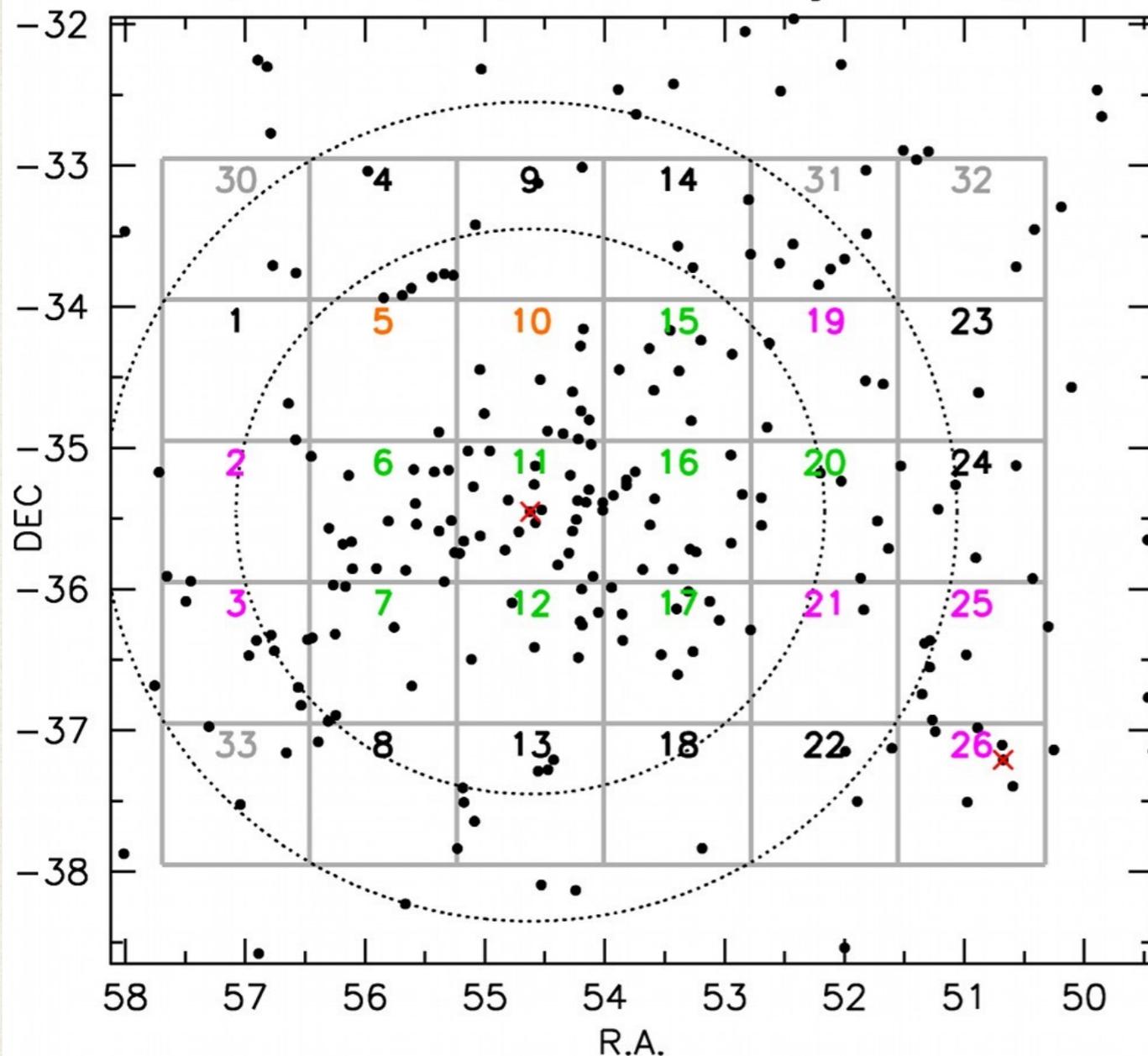
- * structure of the bright galaxies ($m_B < 15 \text{ mag}$) inside $R < R_{\text{vir}}$
(Iodice et al. 2018)
- * stellar halos in ETGs
(Iodice et al. 2016, 2017a, 2017b, Spavone et al. 2018, in preparation)
- * LSB & Dwarf galaxies
(Venhola et al. 2017; 2018)
- * science on background objects
- * GCs distribution
(D'Abrusco et al. 2016; Cantiello et al. 2018)

Fornax Deep Survey with VST

P.I.: R. Peletier & E. Iodice

FDS team: M. Cantiello (INAF); J. Falcon-Barroso (IAC); A. Grado (INAF); M. Hilker (ESO); S. Mieske (ESO); N.R. Napolitano (INAF); M. Paolillo (UniNa); P. Schipani (INAF); M. Spavone (INAF); C. Spiniello (INAF); G. van de Ven (ESO); A. Venhola (Kapteyn)

OmegaCAM fields of the Fornax Deep Survey
(with certain/likely FCC members of $M_B < -13.5$ mag)



Tot int. time / field:

u: 3 hrs

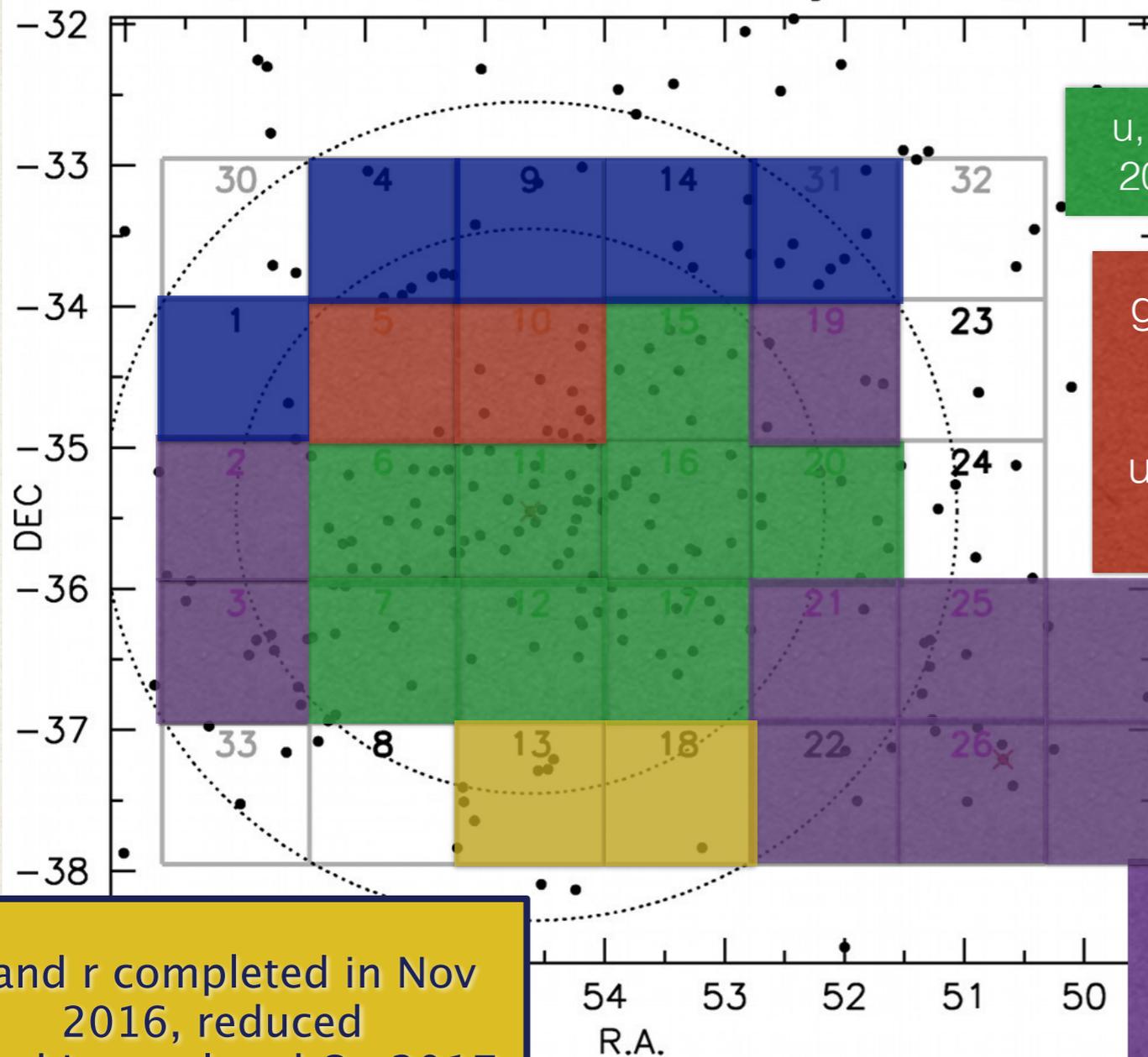
g & *r*: 2.3 hrs

i: 1.8 hrs

Fornax Deep Survey with VST

observation were completed in Nov 2017 - reduced data will be released in 2019

OmegaCAM fields of the Fornax Deep Survey
(with certain/likely FCC members of $M_B < -13.5$ mag)



Tot int. time / field:

u: 3 hrs

g & *r*: 2.3 hrs

i: 1.8 hrs

u, *g*, *r* and *i*: completed in 2013+2014 and reduced

g and *i* completed in 2014 and reduced

u and *r* completed in 2015 and reduced

g, *r* and *i* completed in Nov 2016, to be reduced

u completed in 2017

g and *r* completed in Nov 2015 and reduced

i completed in Nov 2017

g and *r* completed in Nov 2016, reduced
u and *i* completed Oct 2017

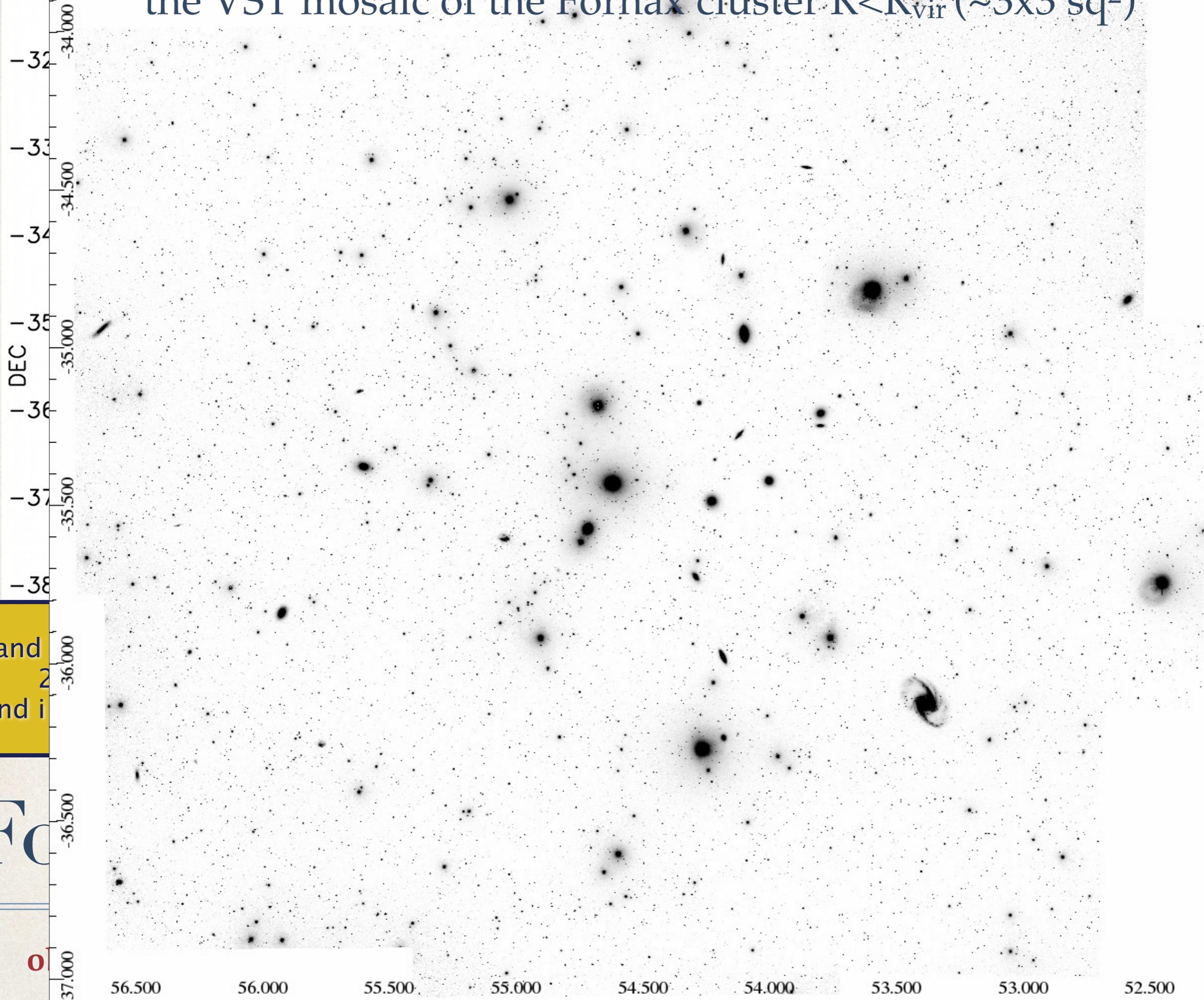
Fornax Deep Survey with VST

observation were completed in Nov 2017 - reduced data will be released in 2019

the VST mosaic of the Fornax cluster $R < R_{\text{vir}}$ ($\sim 3 \times 3 \text{ sq}^{\circ}$)

field:

rs



g and
u and i

Fc

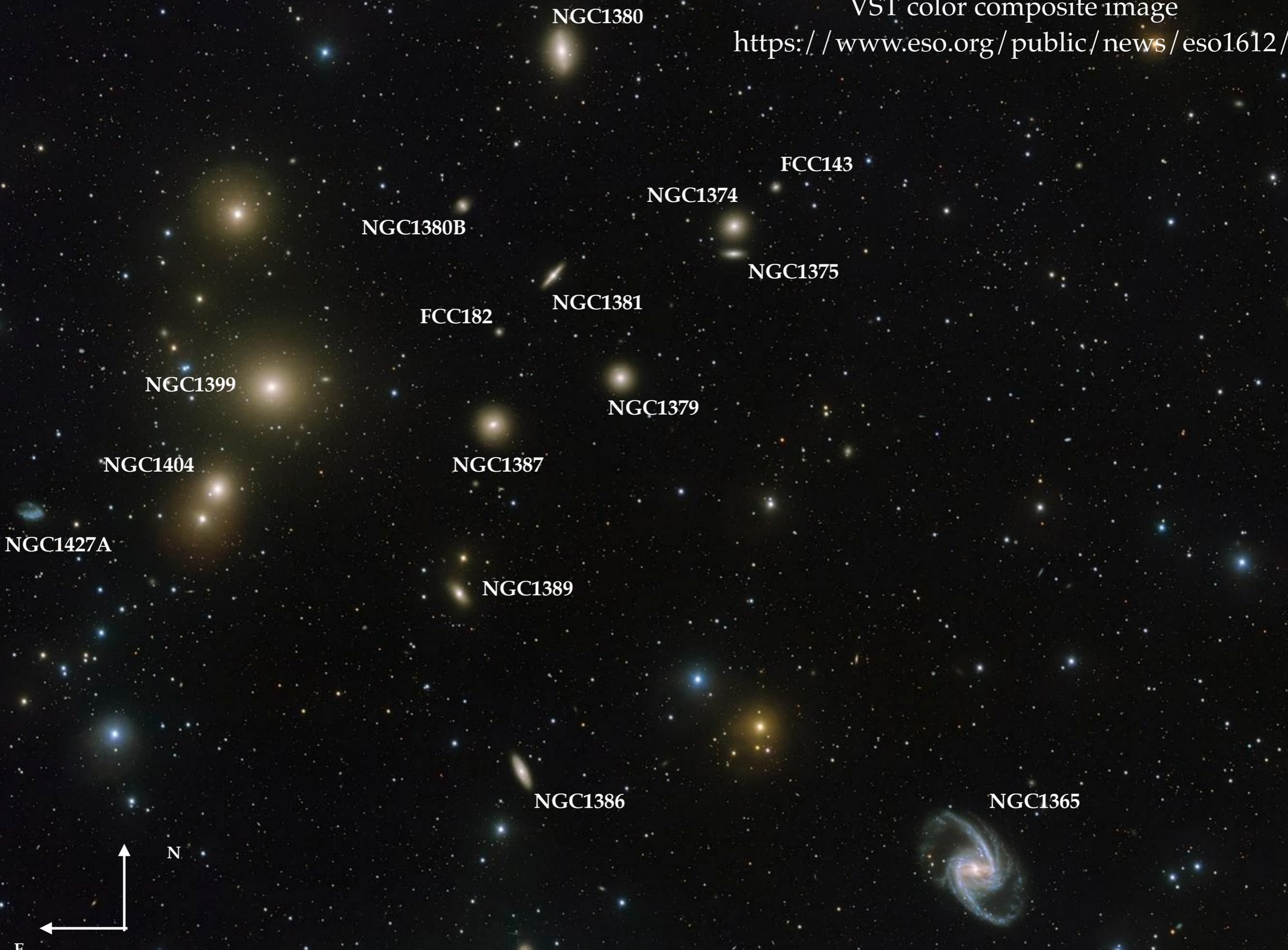
0

9

VST color composite image

<https://www.eso.org/public/news/eso1612/>





NGC1380

FCC143

NGC1374

NGC1380B

NGC1375

FCC182

NGC1381

NGC1379

NGC1399

NGC1404

NGC1387

NGC1427A

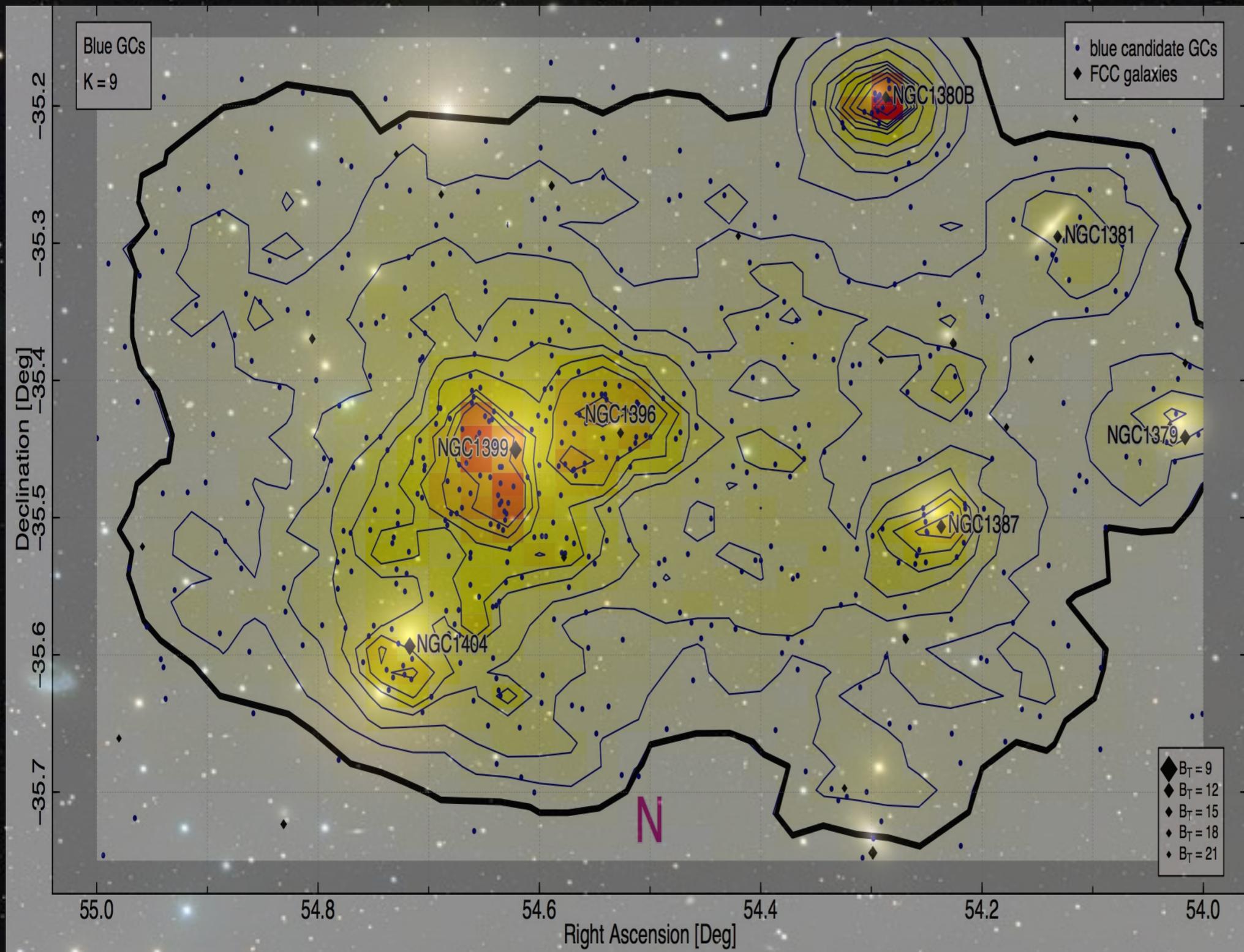
NGC1389

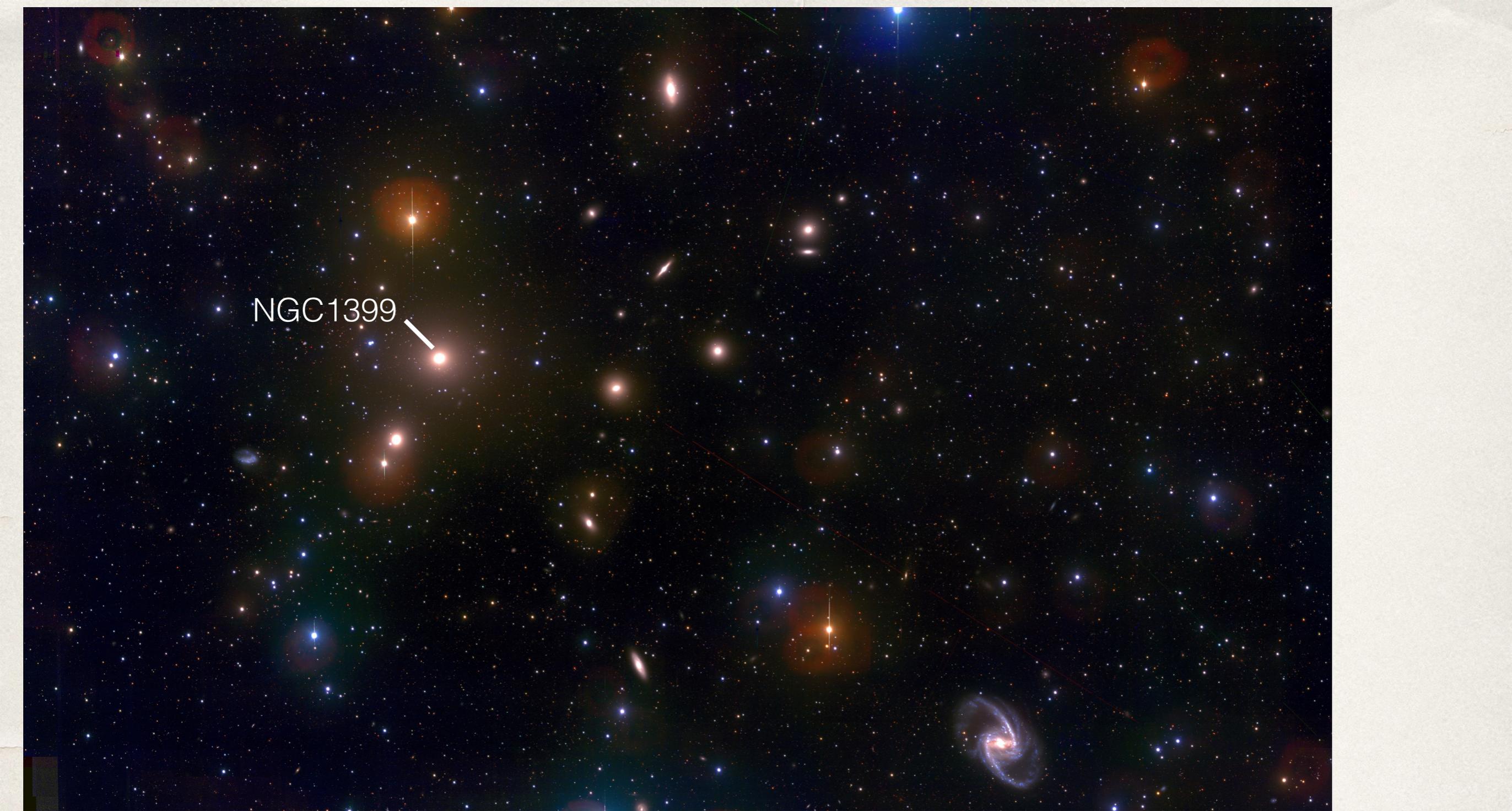
NGC1386

NGC1365

N

E

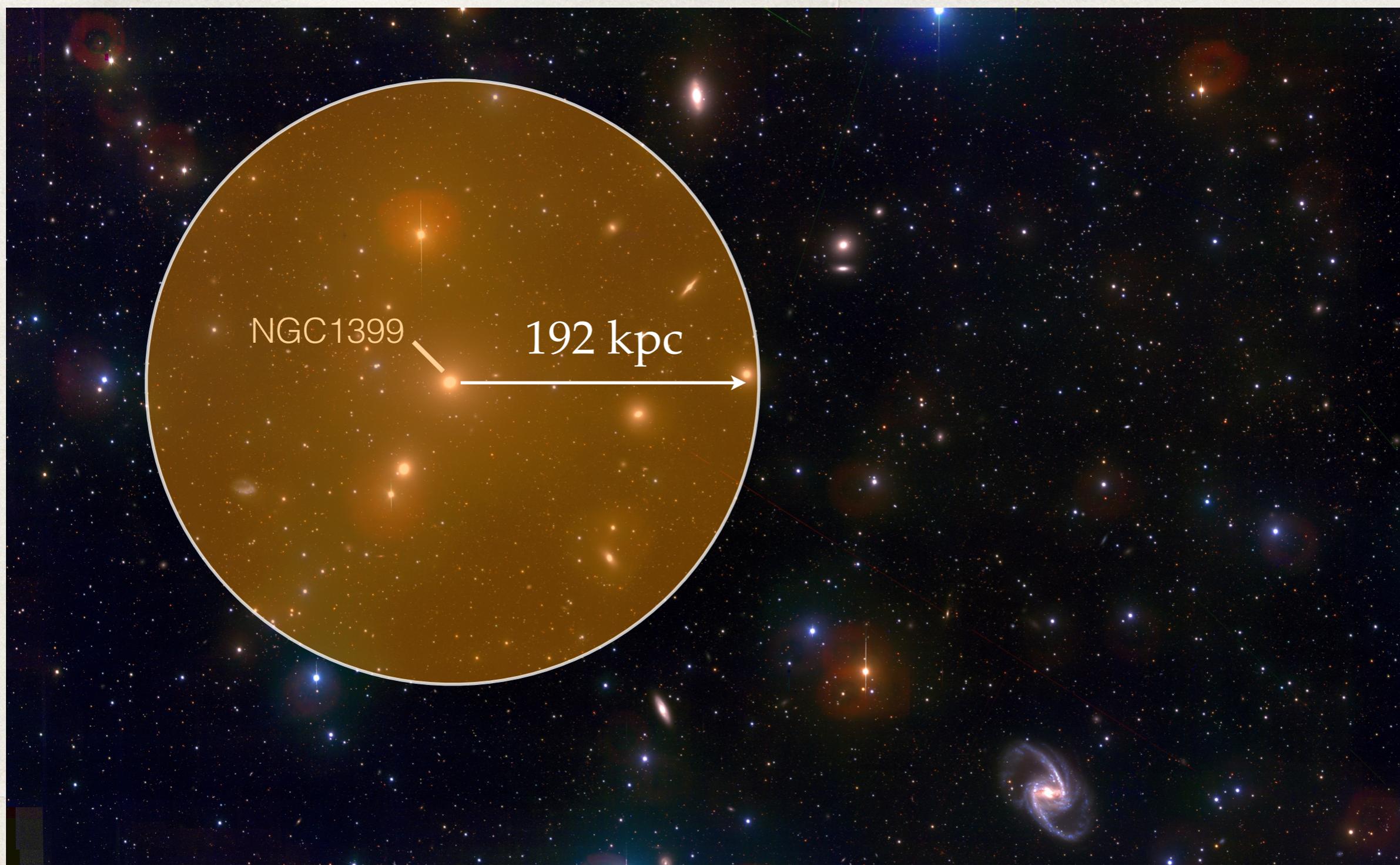




NGC1399

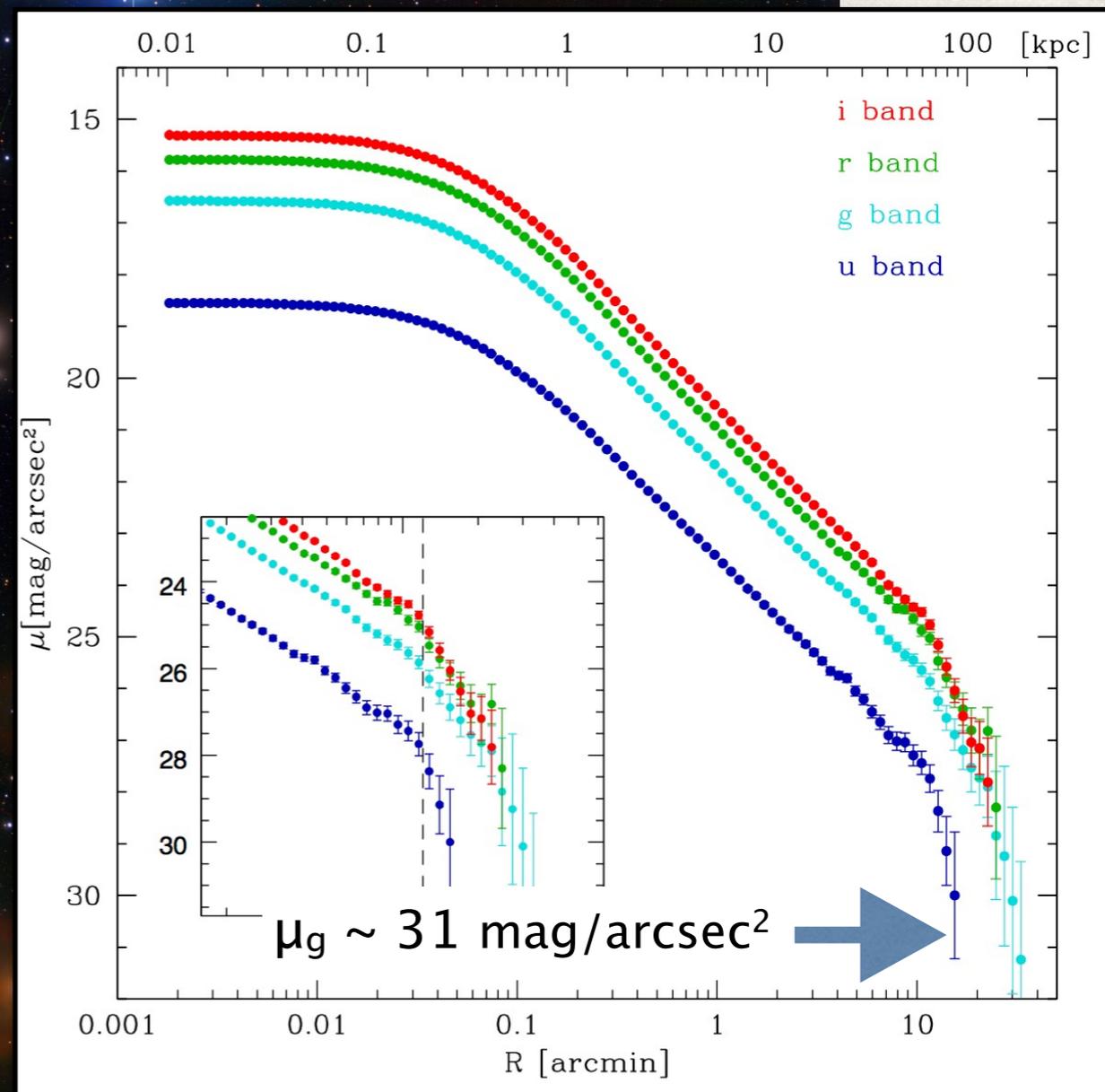
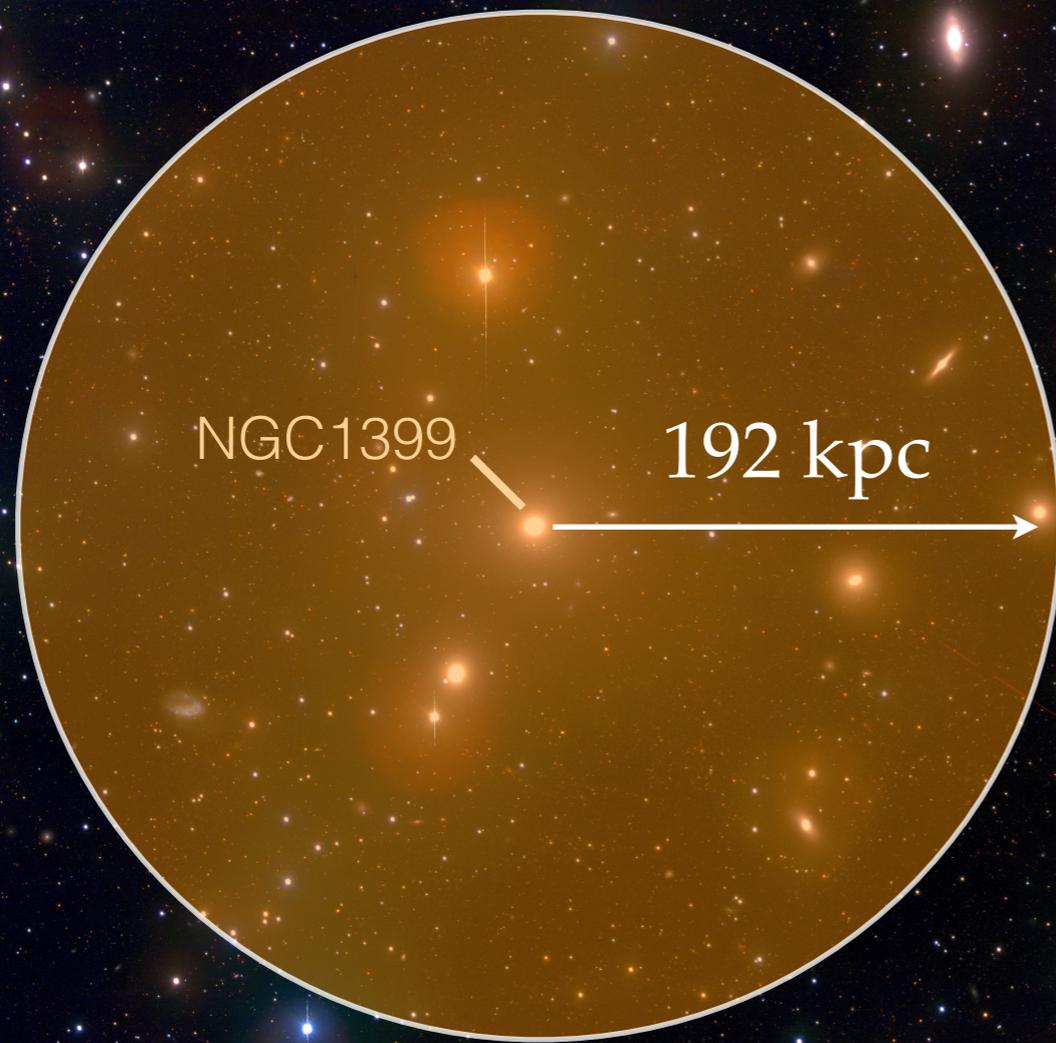
The extended stellar halo of NGC1399

Iodice et al. 2016, ApJ, 820, 42

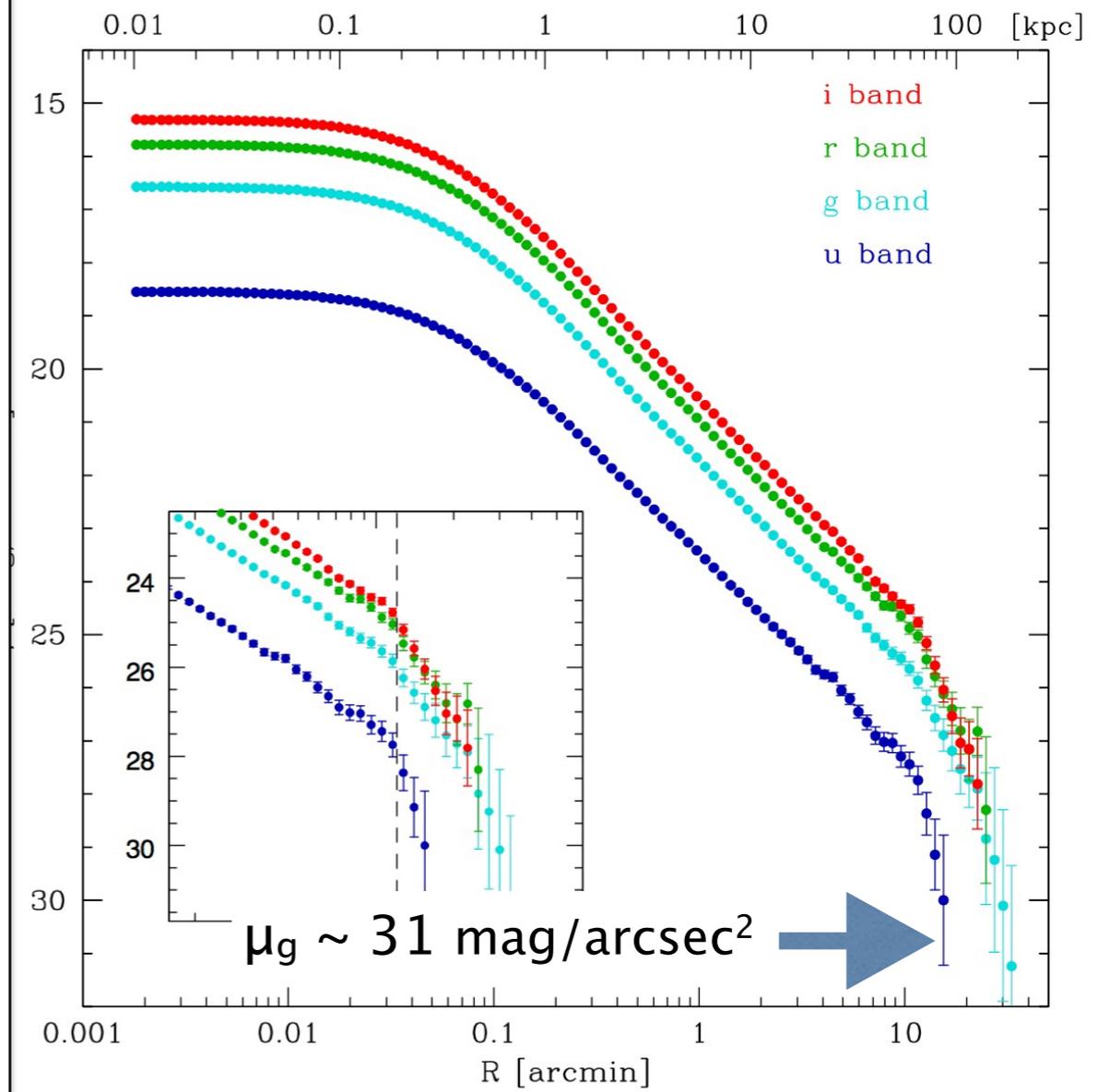
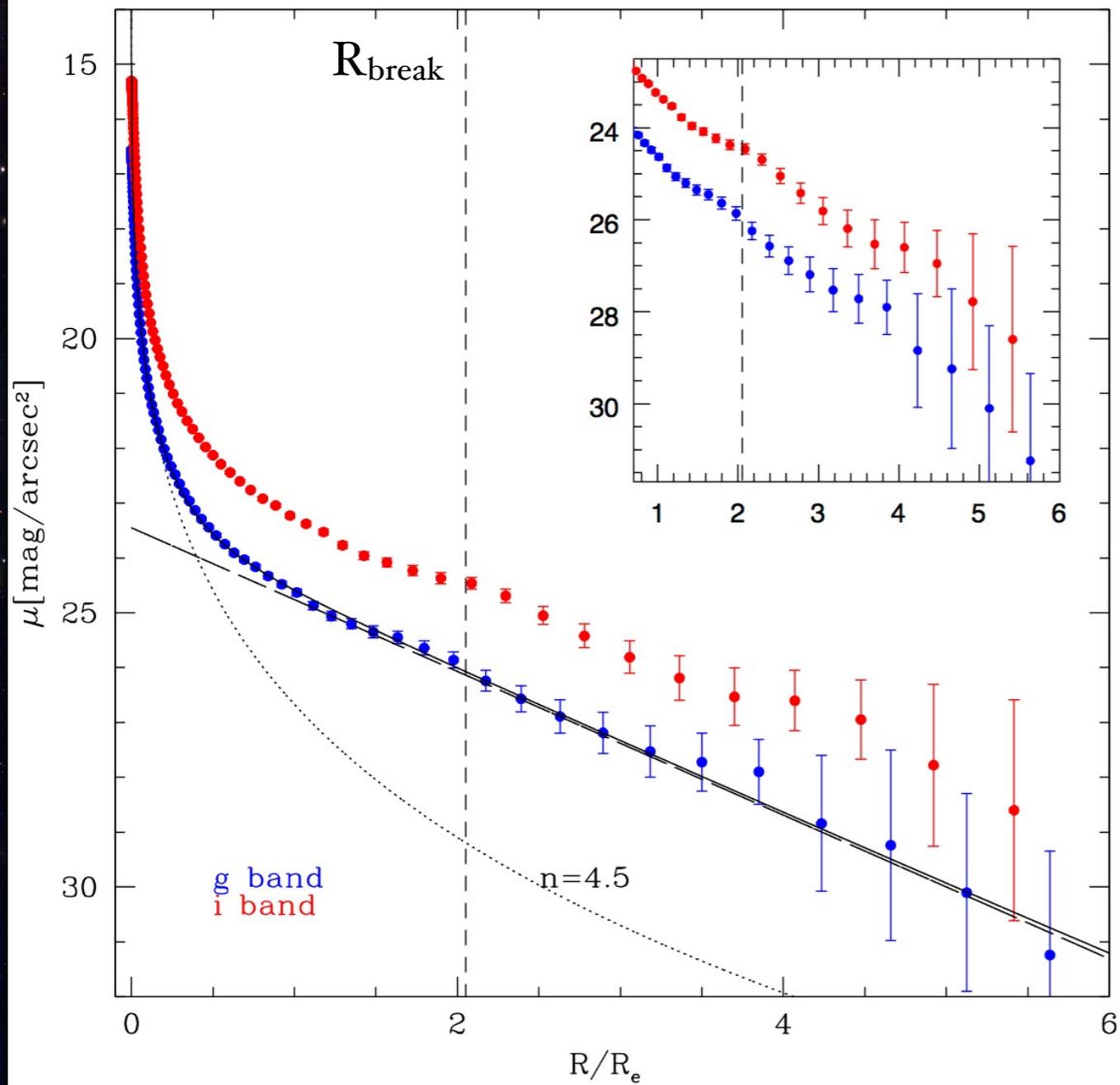


The extended stellar halo of NGC1399

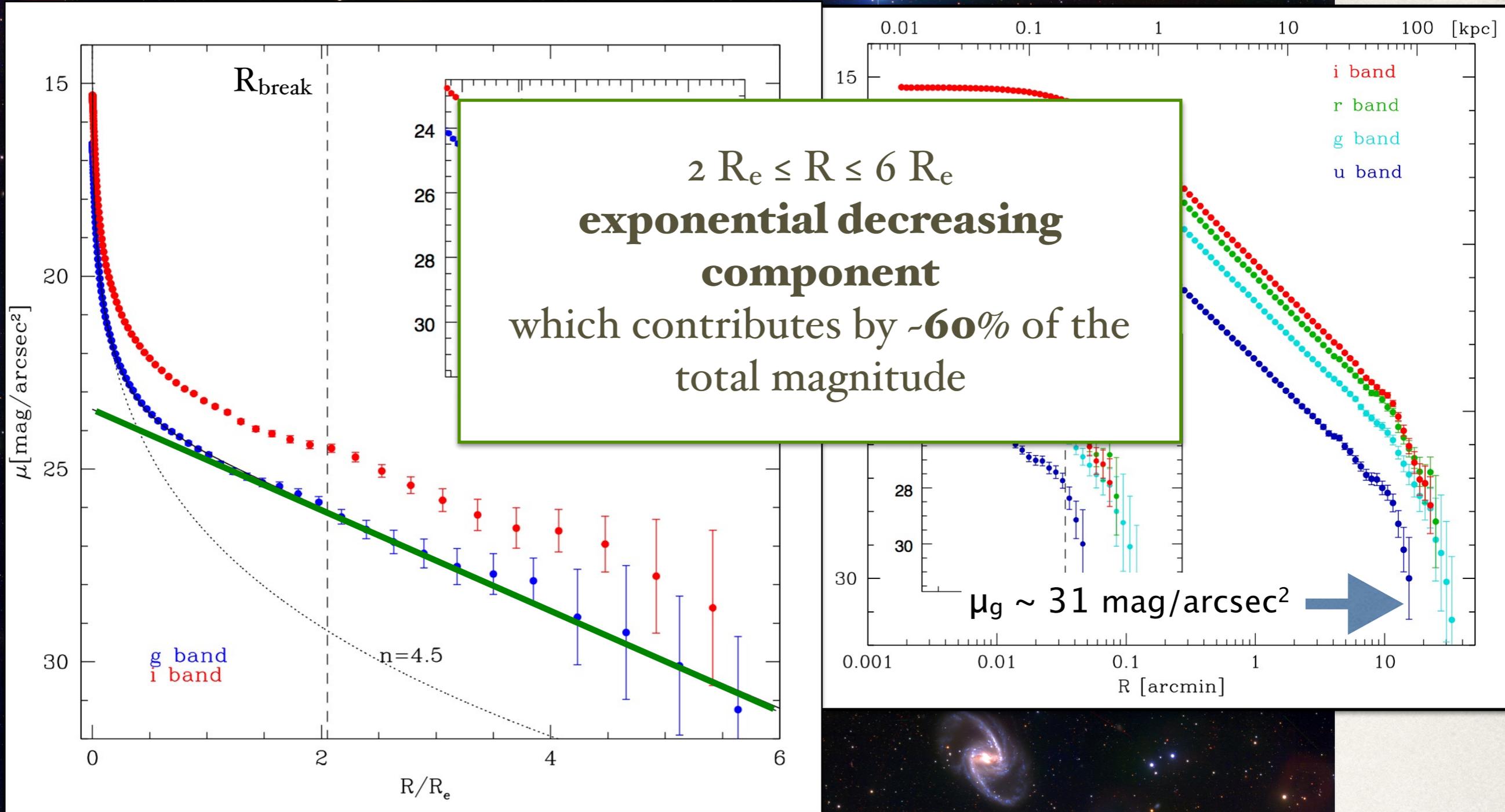
Iodice et al. 2016, ApJ, 820, 42



The extended stellar halo of NGC 1399



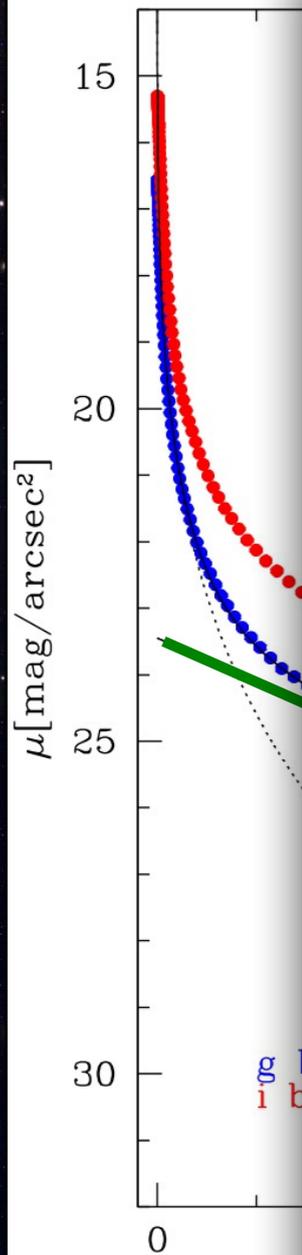
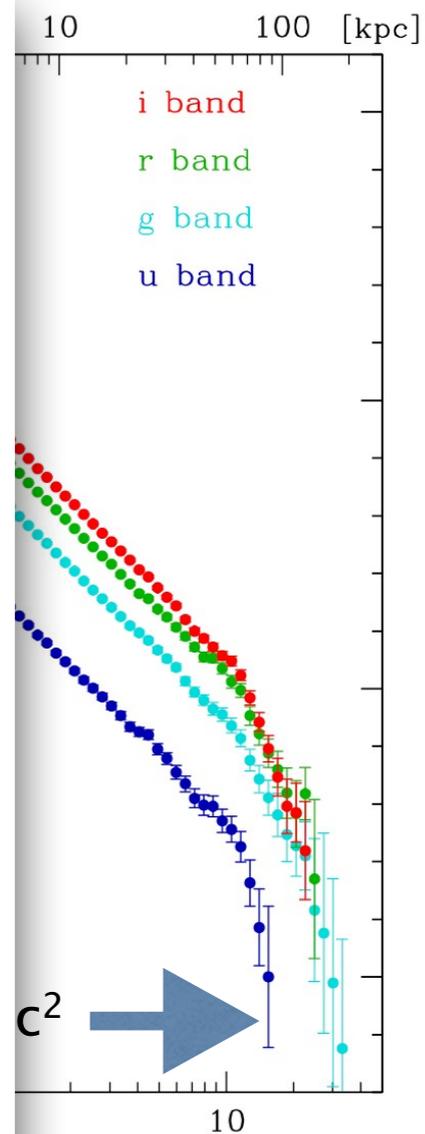
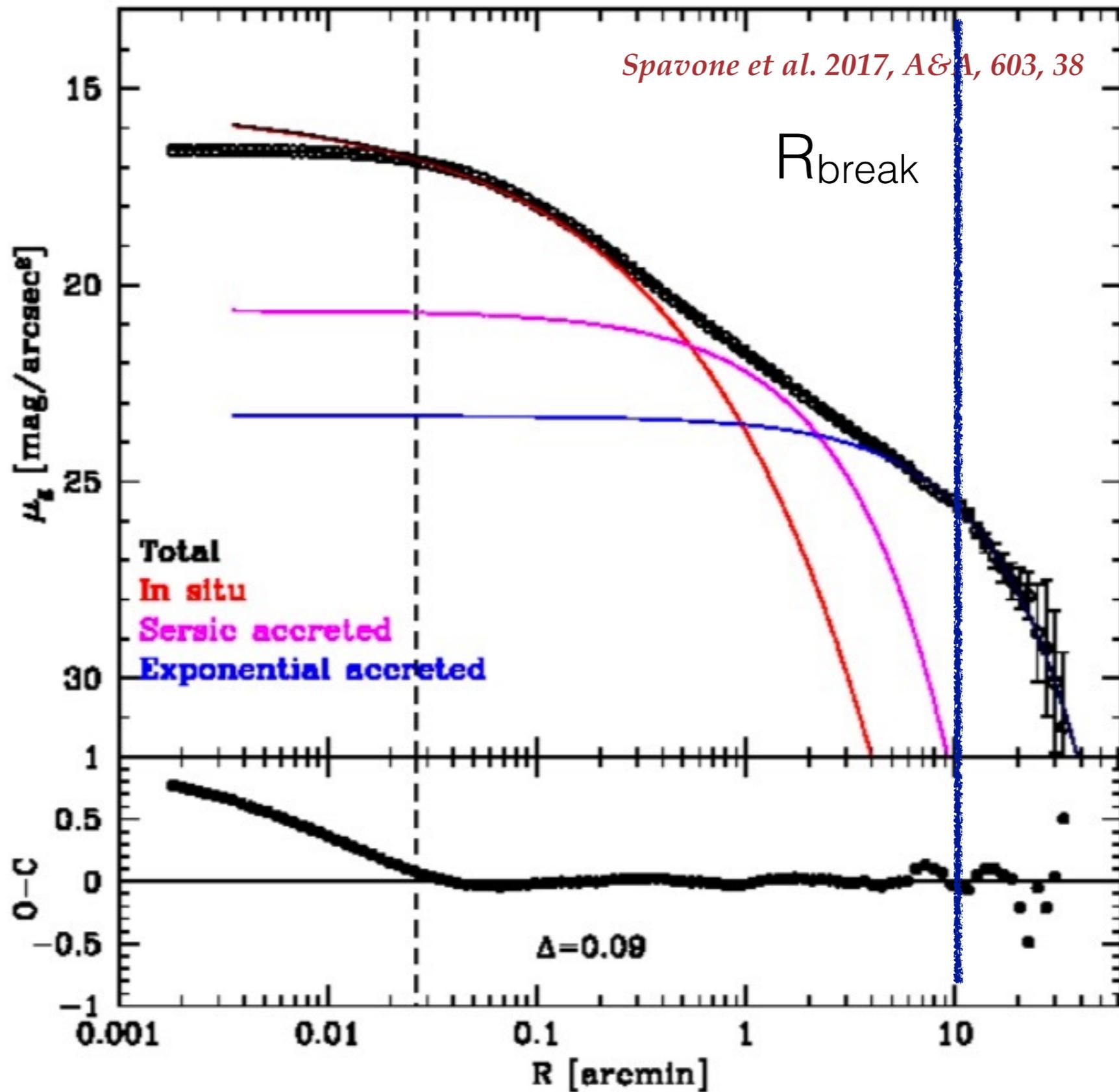
The extended stellar halo of NGC1399



The extended stellar halo of NGC1399

NGC 1399

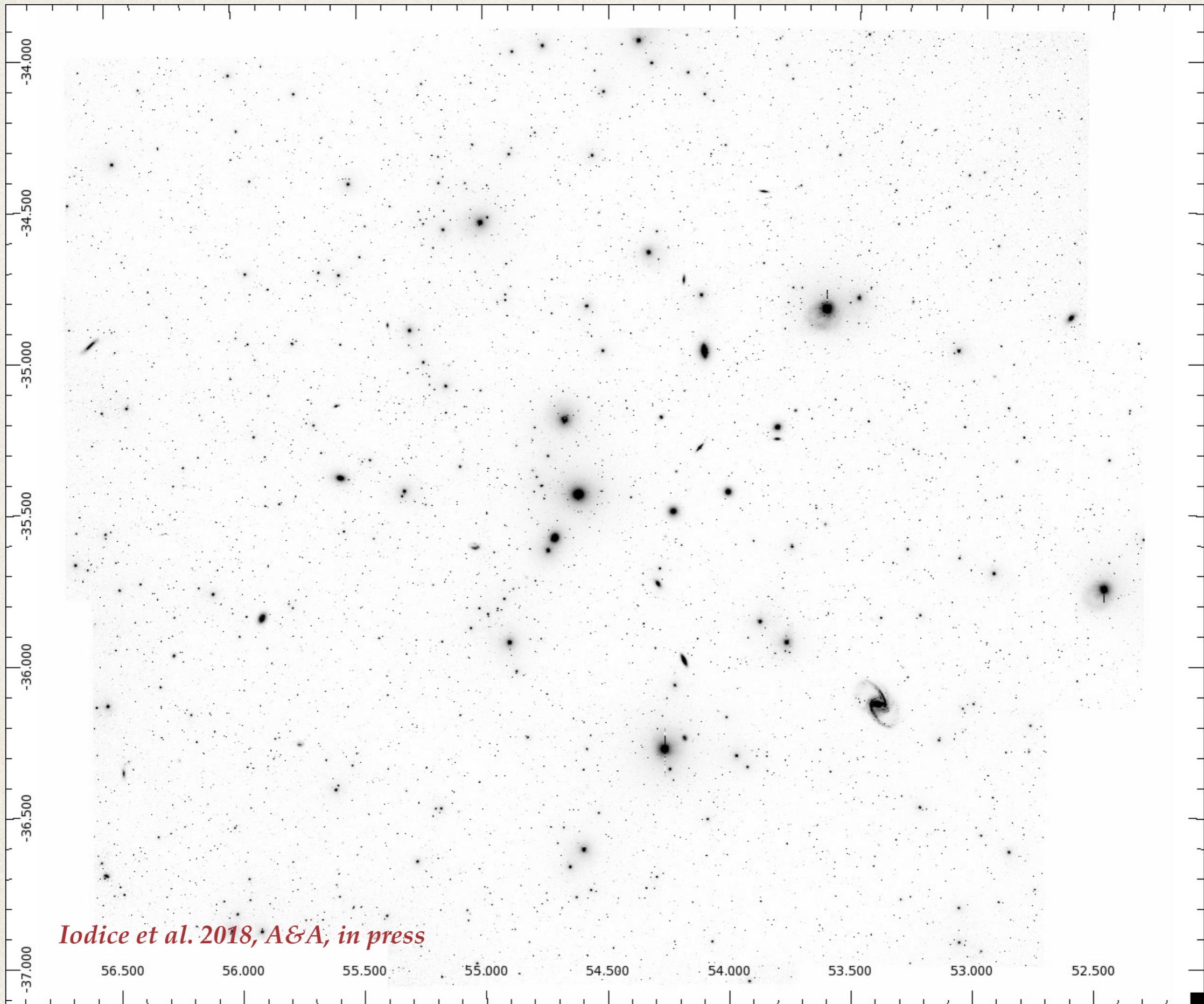
Spavone et al. 2017, A&A, 603, 38



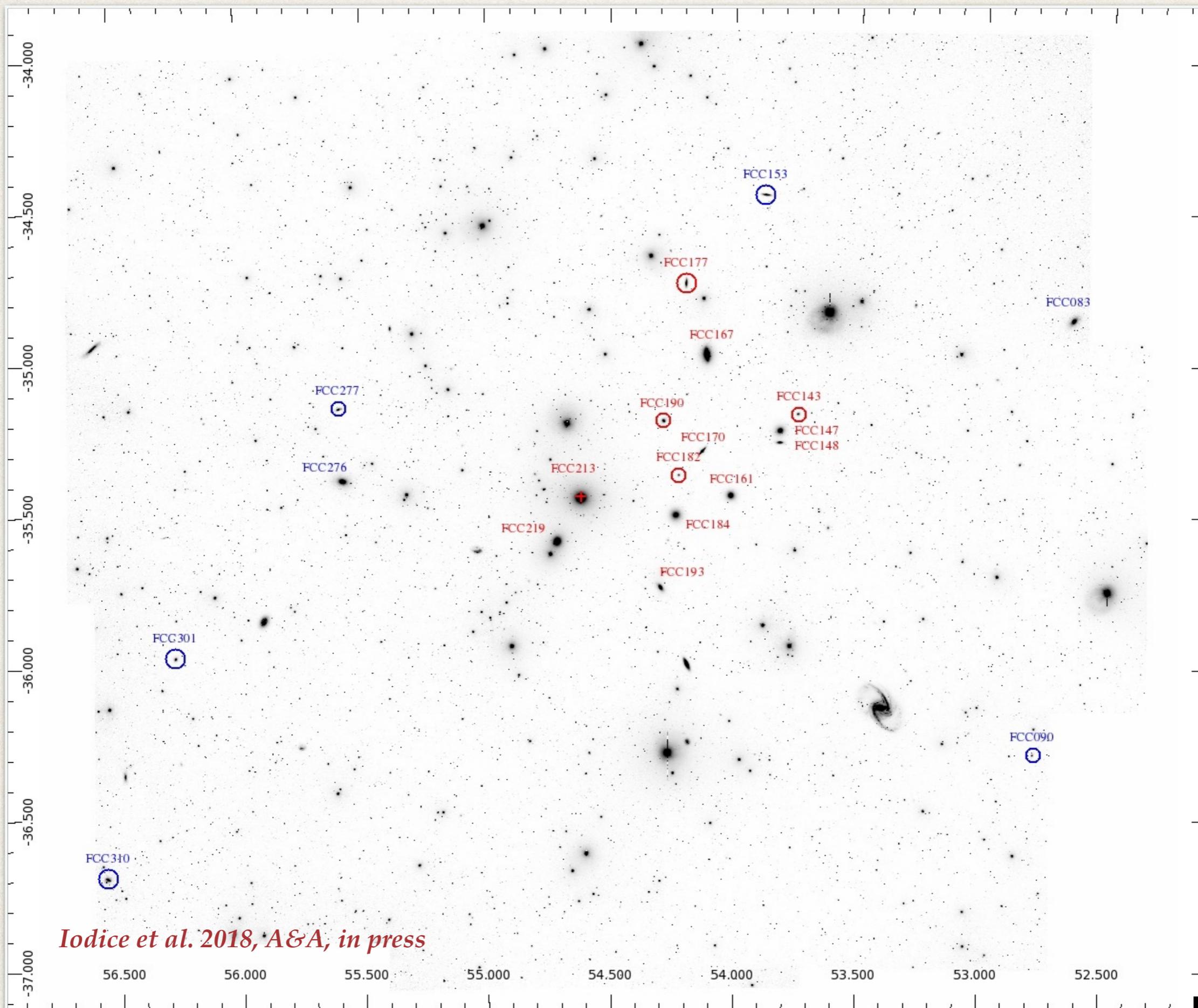
The c

C1399

The bright ETGs in the R_{vir} of the cluster: RESULTS

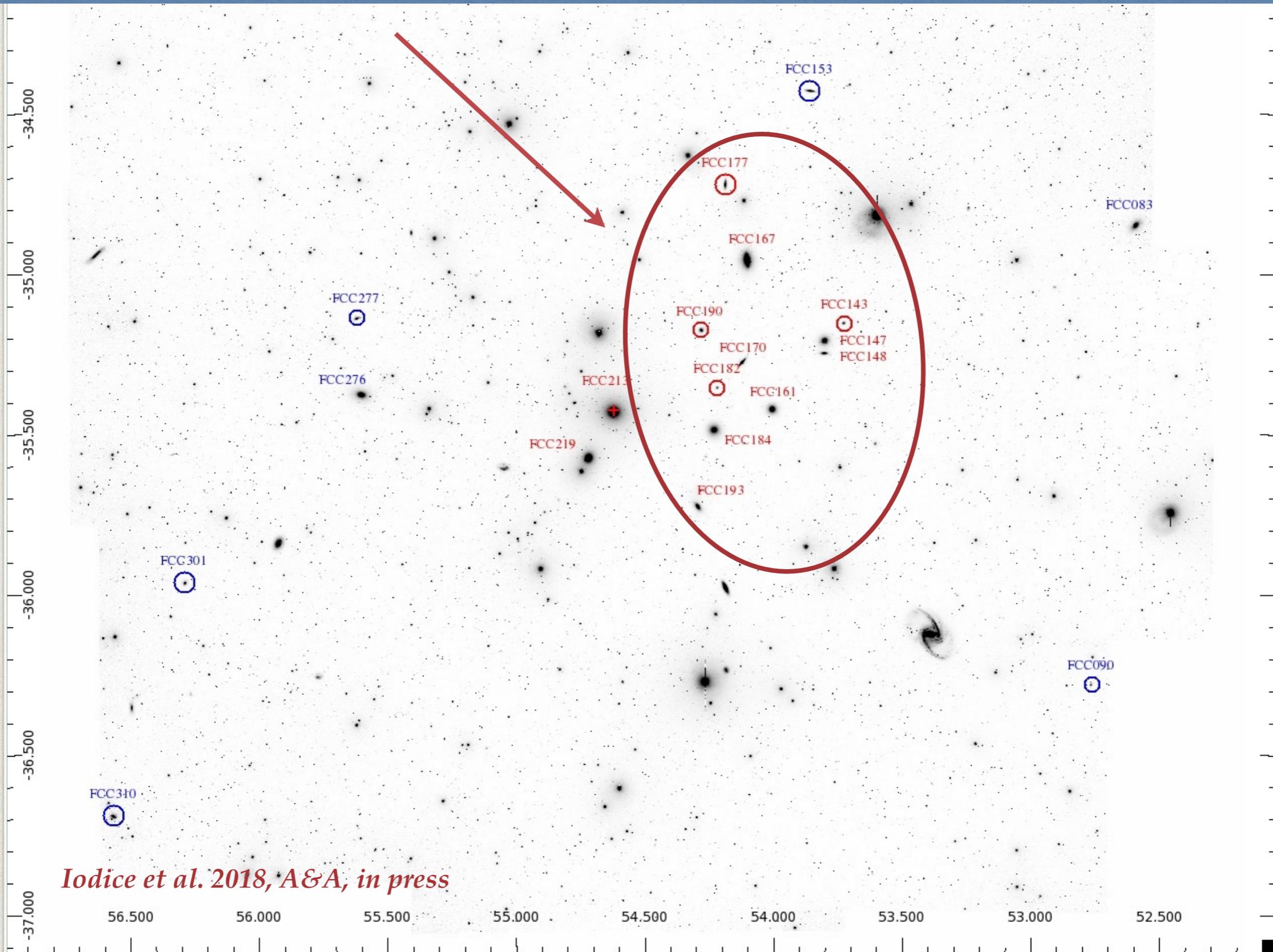


The bright ETGs in the R_{vir} of the cluster: RESULTS



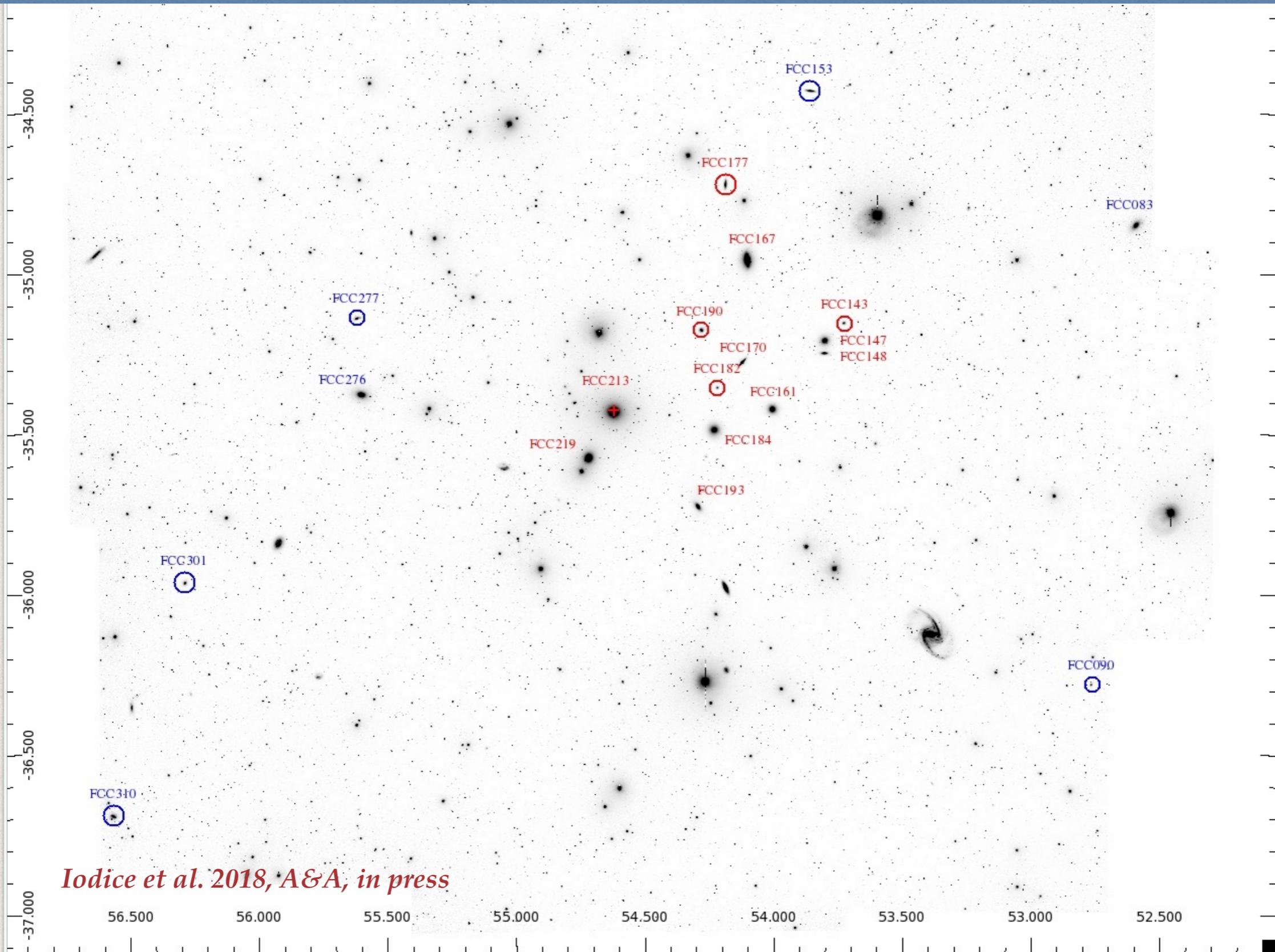
Iodice et al. 2018, A&A, in press

the bulk of the gravitational interactions between galaxies should have happened on the W-NW side of the cluster, where most of the bright ETGs are located and where the intra-cluster baryons are found

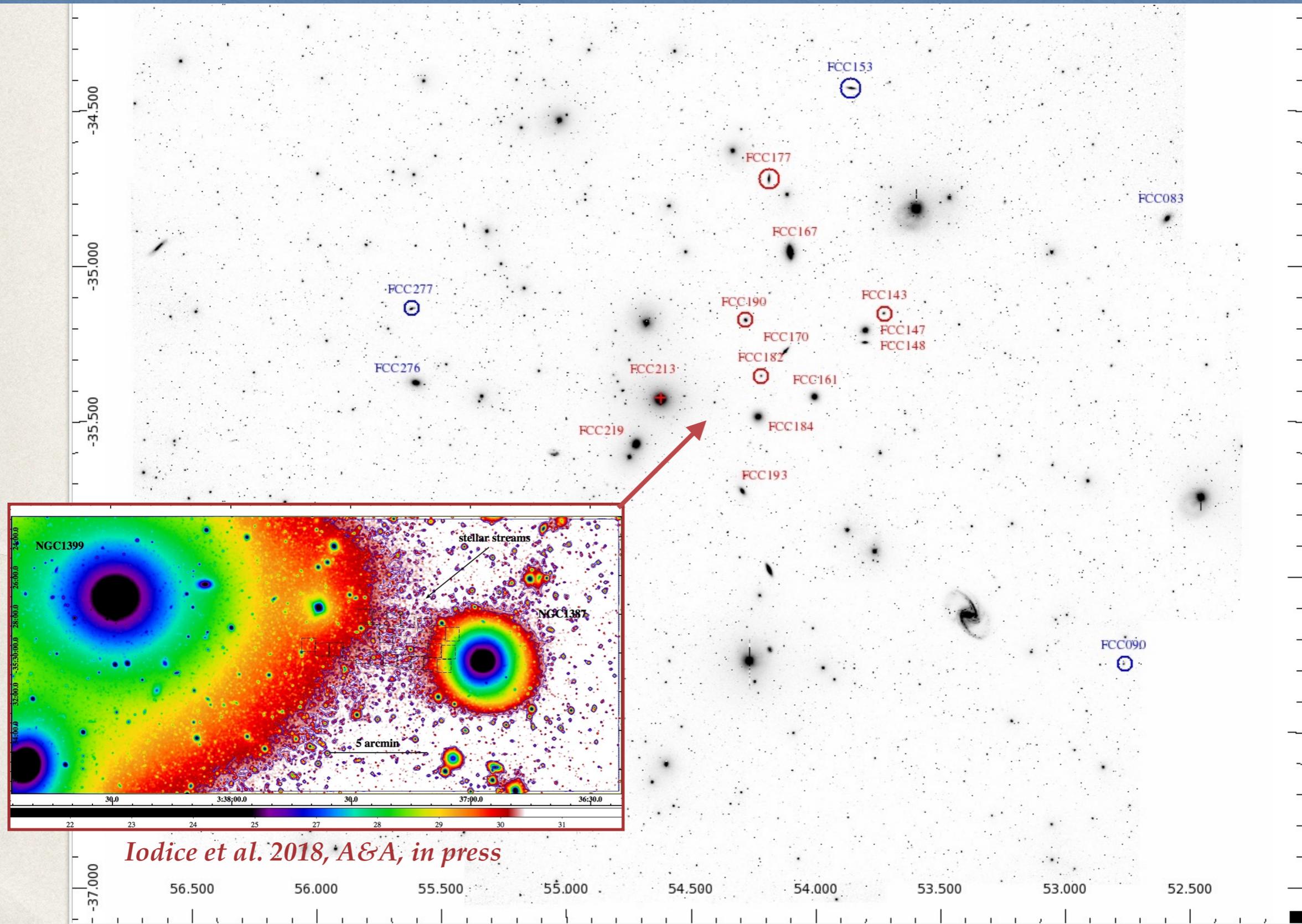


Iodice et al. 2018, A&A, in press

the bulk of the gravitational interactions between galaxies should have happened on the W-NW side of the cluster, where most of the bright ETGs are located and where the intra-cluster baryons are found

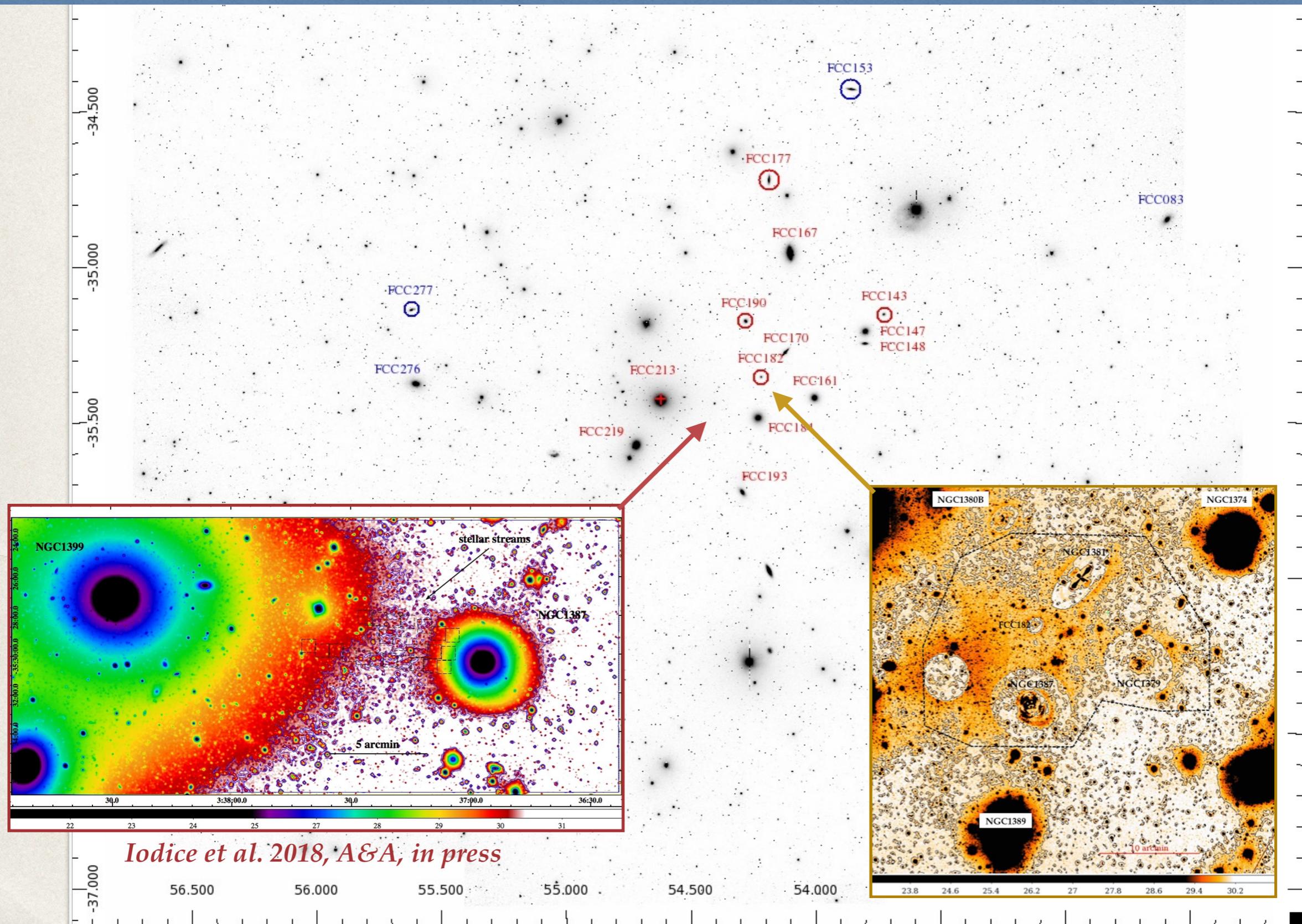


the bulk of the gravitational interactions between galaxies should have happened on the W-NW side of the cluster, where most of the bright ETGs are located and where the intra-cluster baryons are found

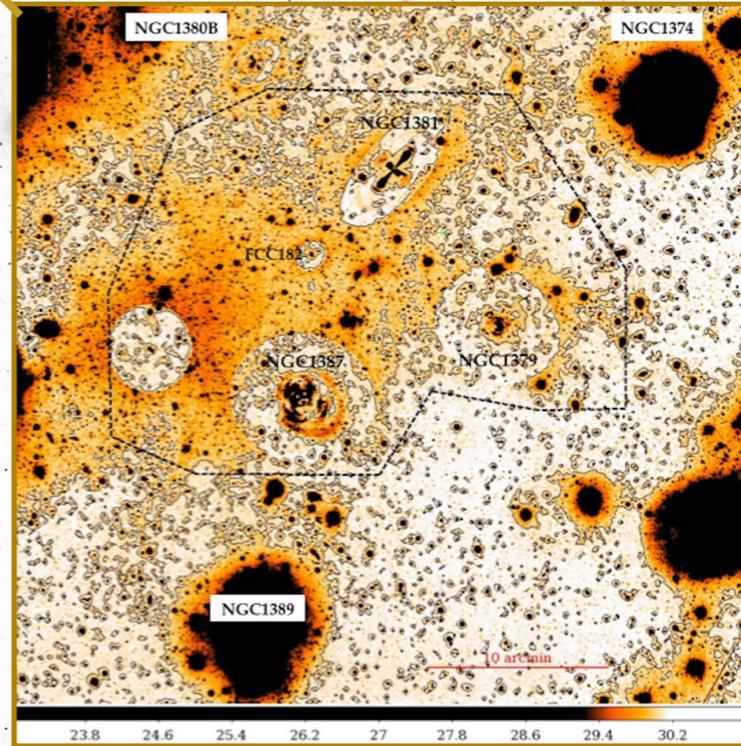
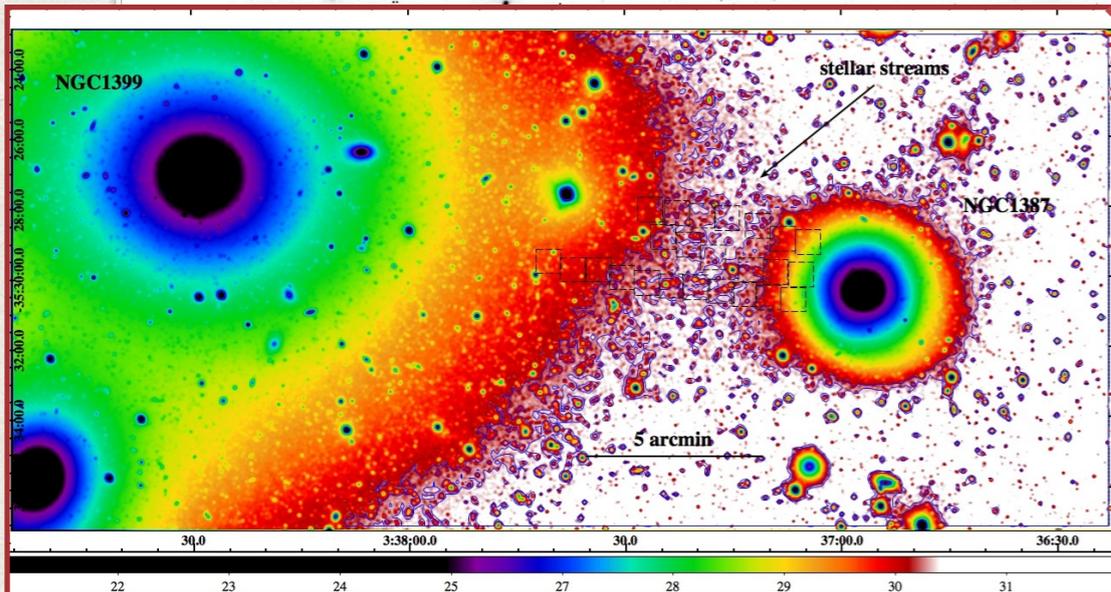
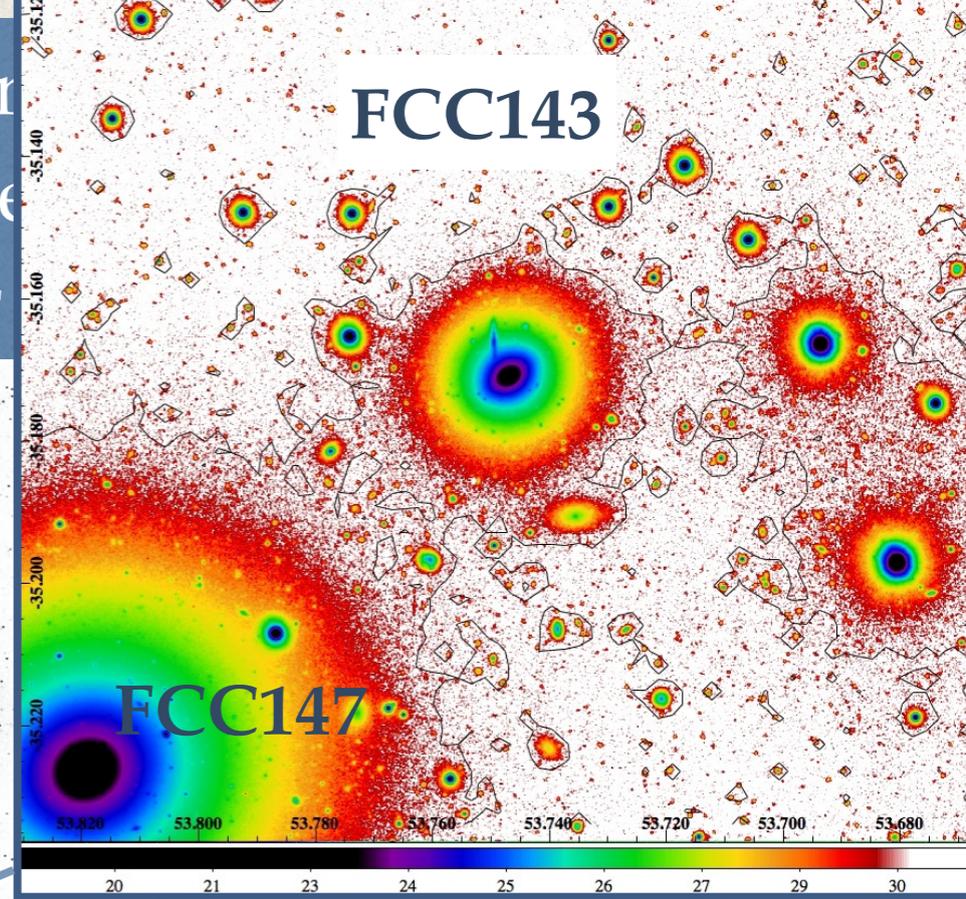
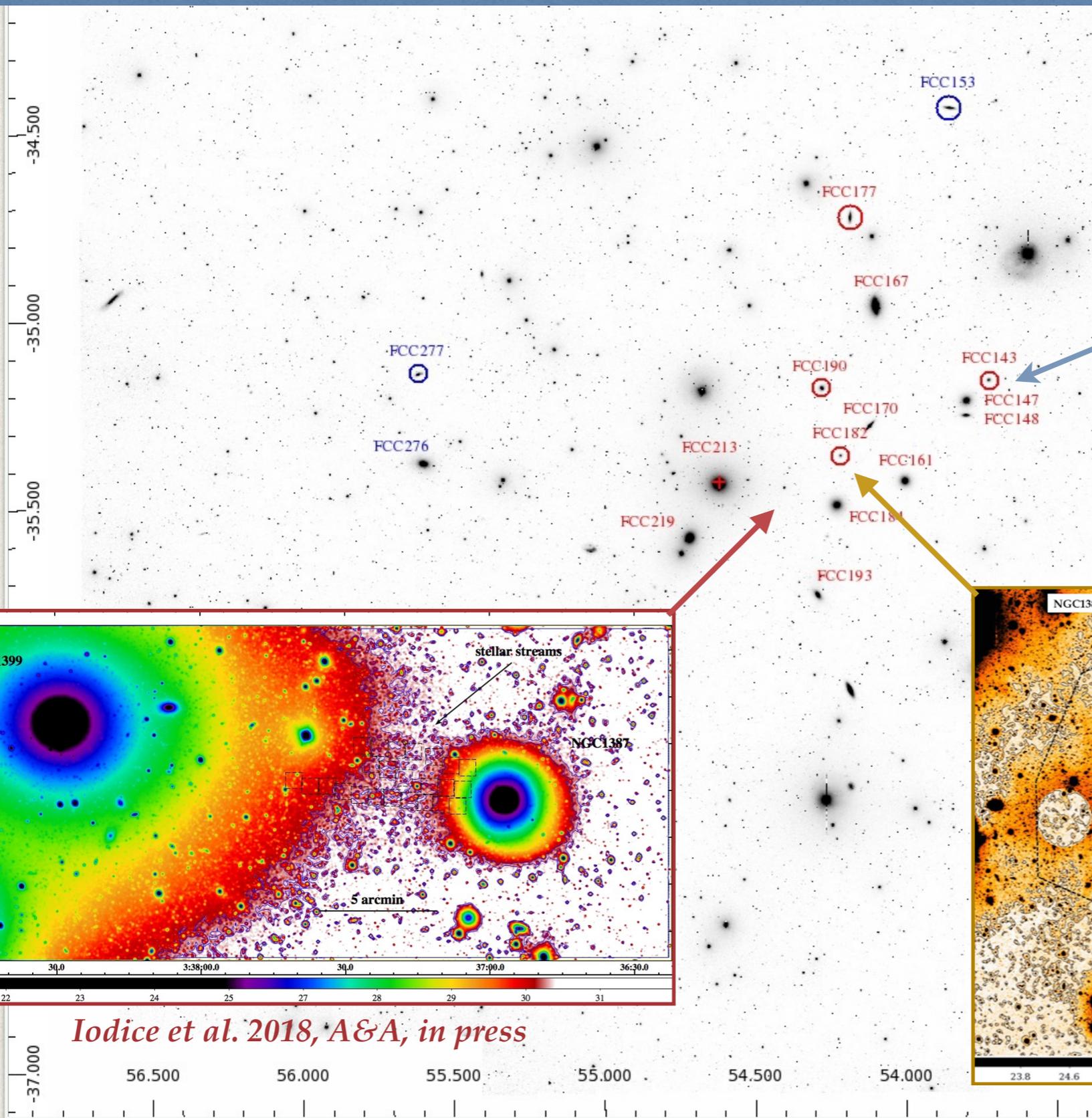


Iodice et al. 2018, A&A, in press

the bulk of the gravitational interactions between galaxies should have happened on the W-NW side of the cluster, where most of the bright ETGs are located and where the intra-cluster baryons are found

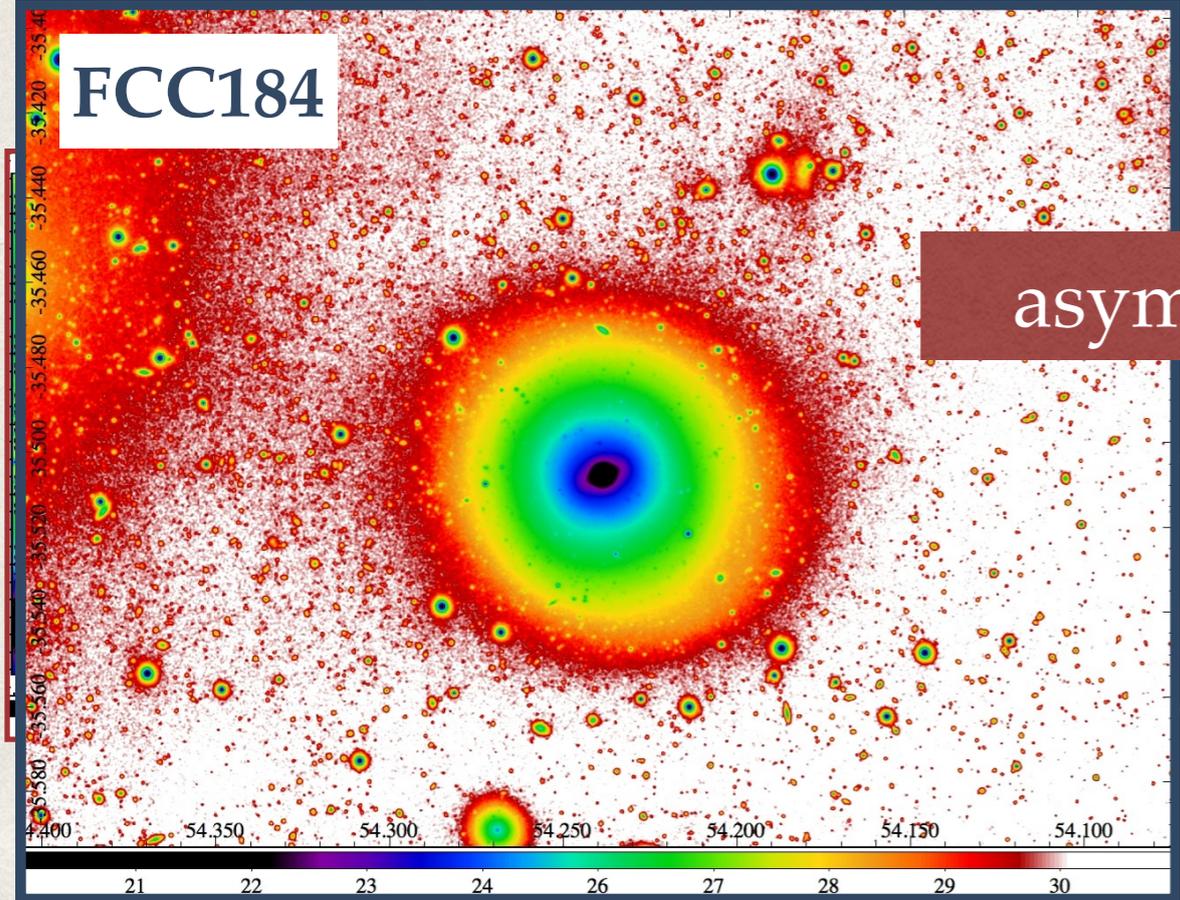
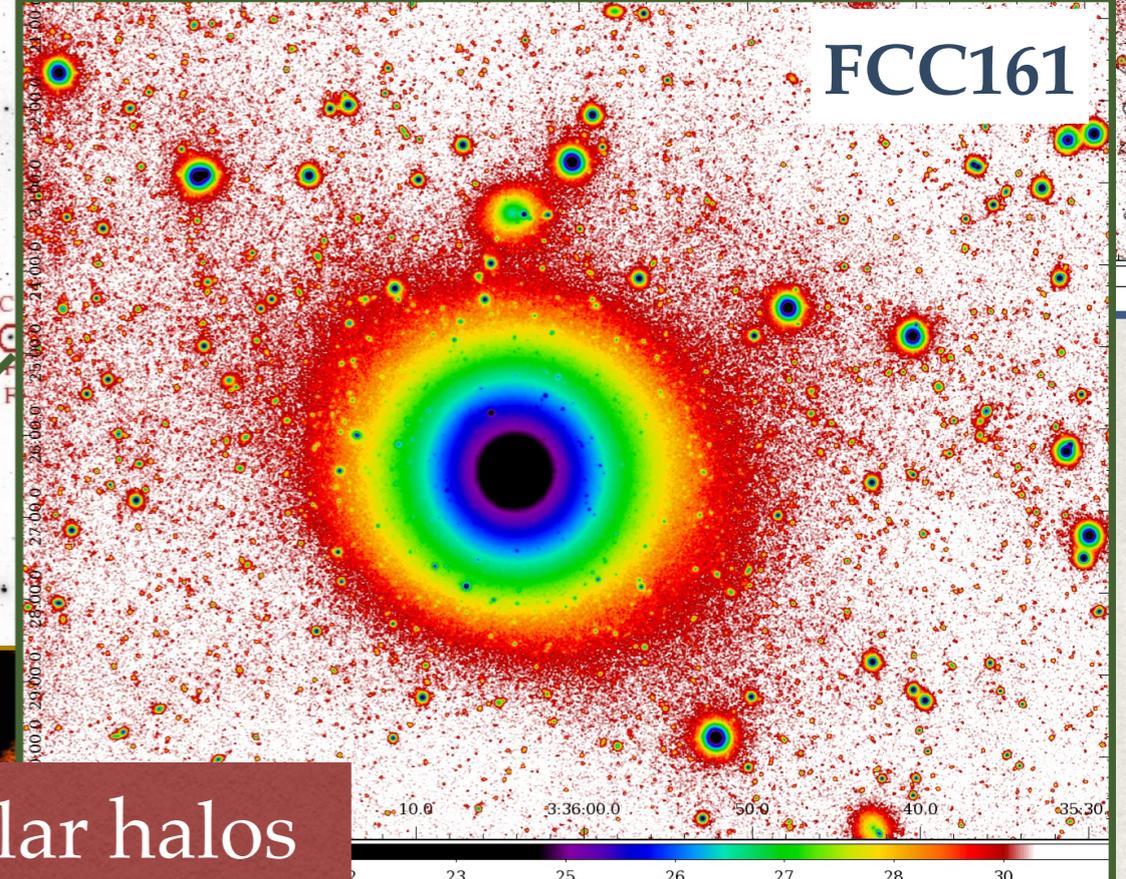
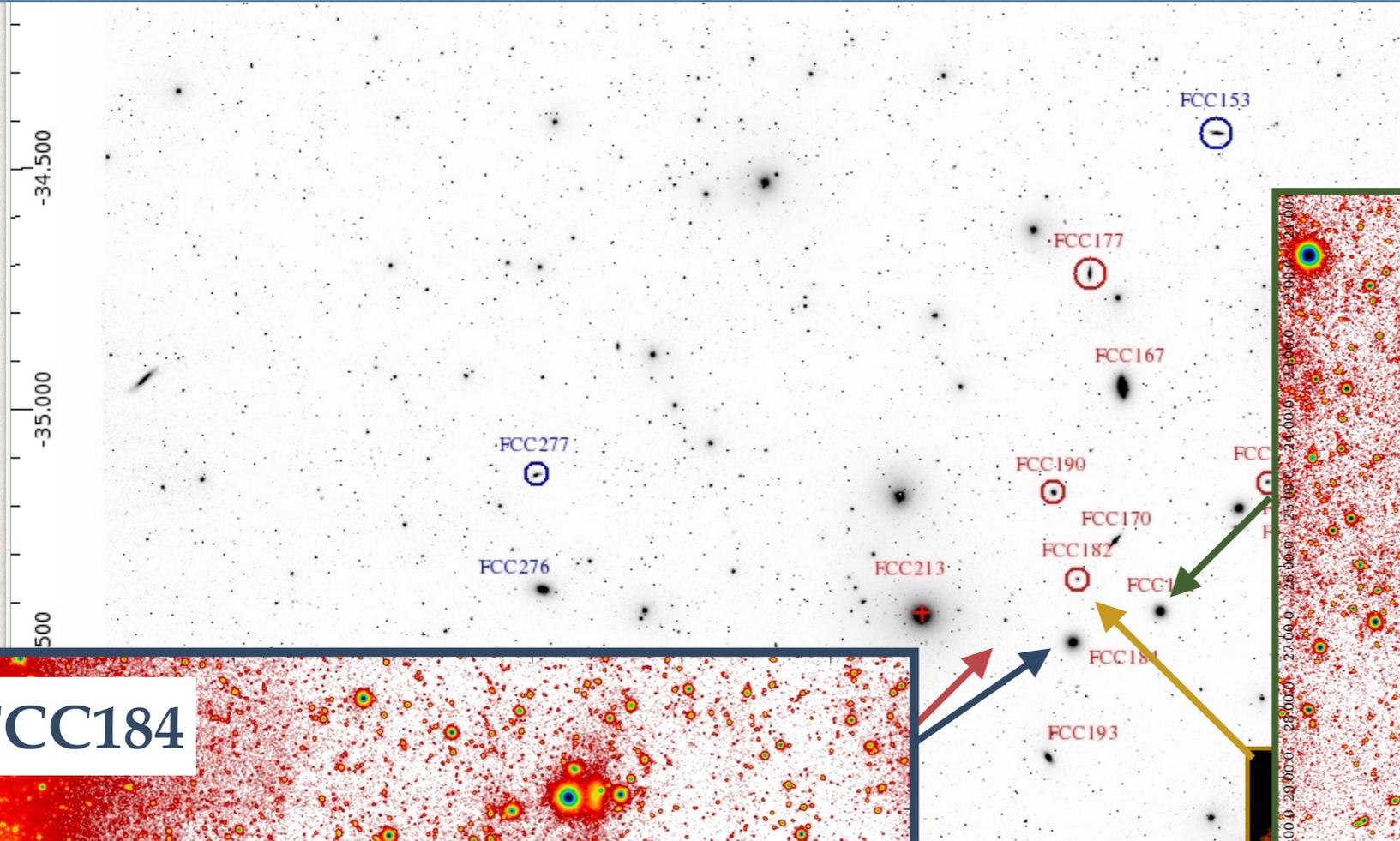
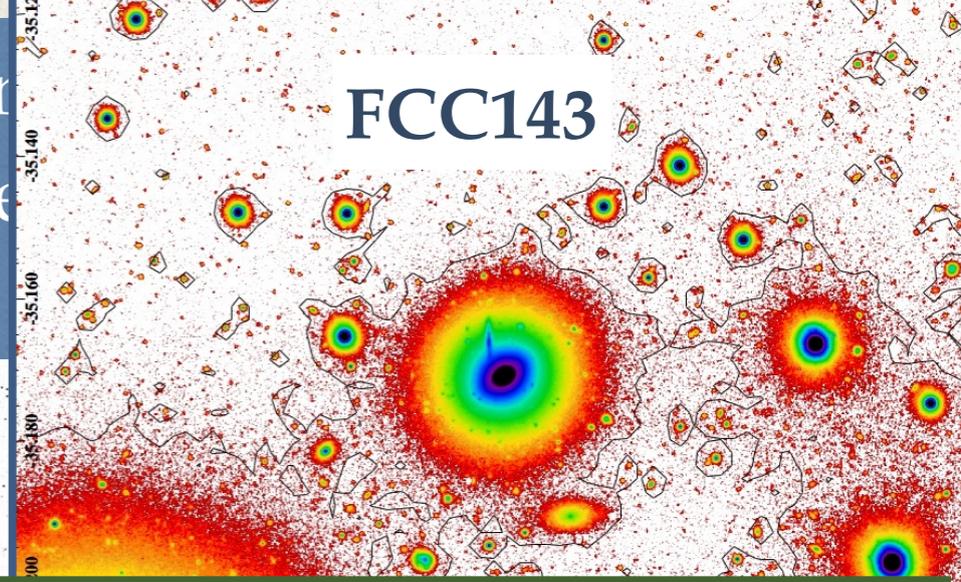


the bulk of the gravitational interactions between
happened on the W-NW side of the cluster, where
ETGs are located and where the intra-cluster

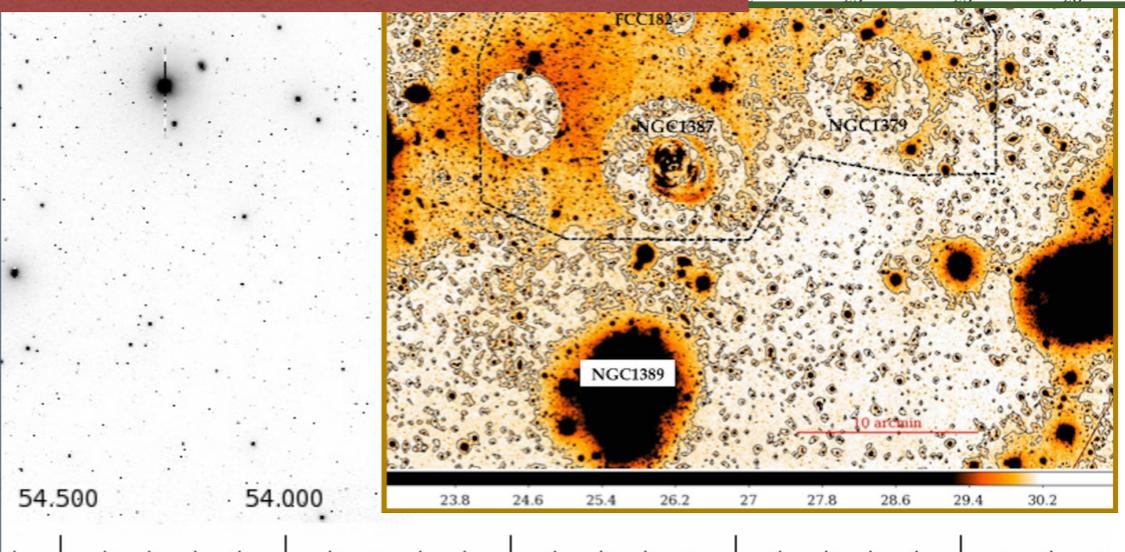


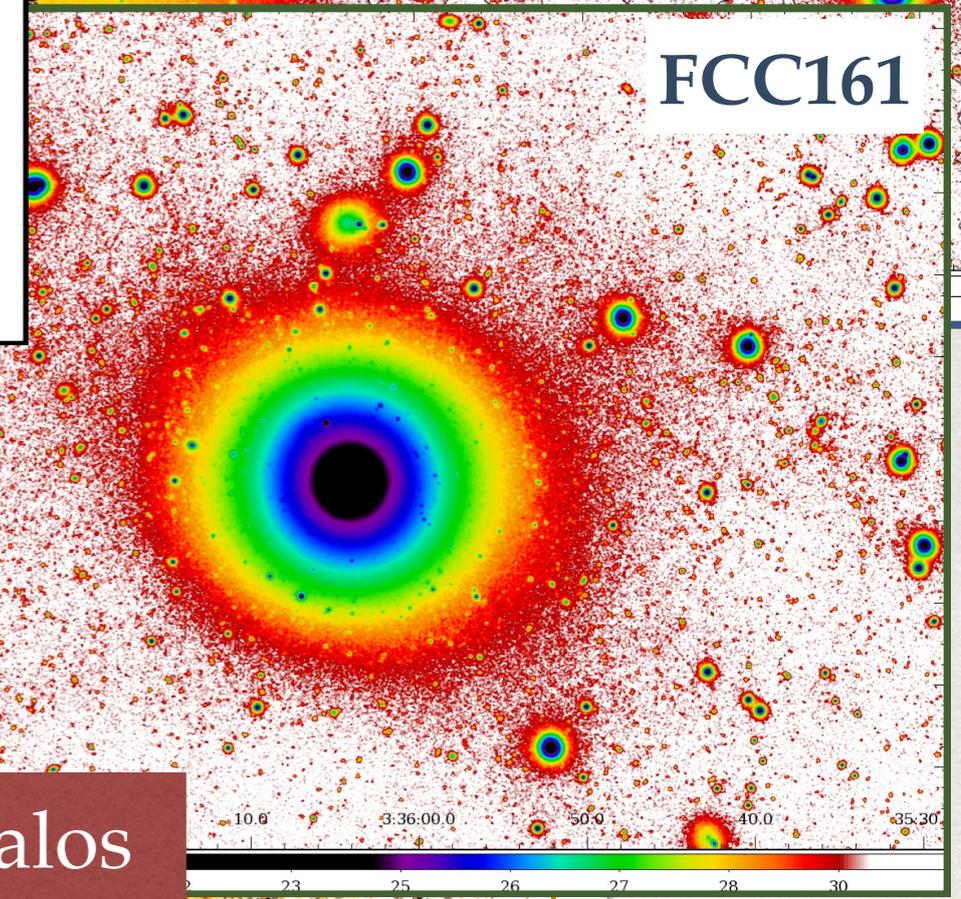
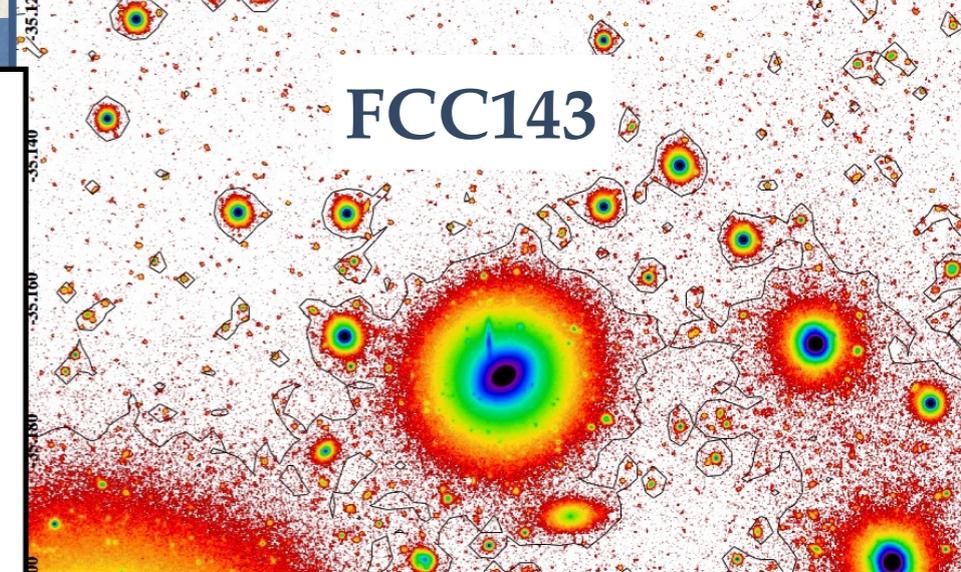
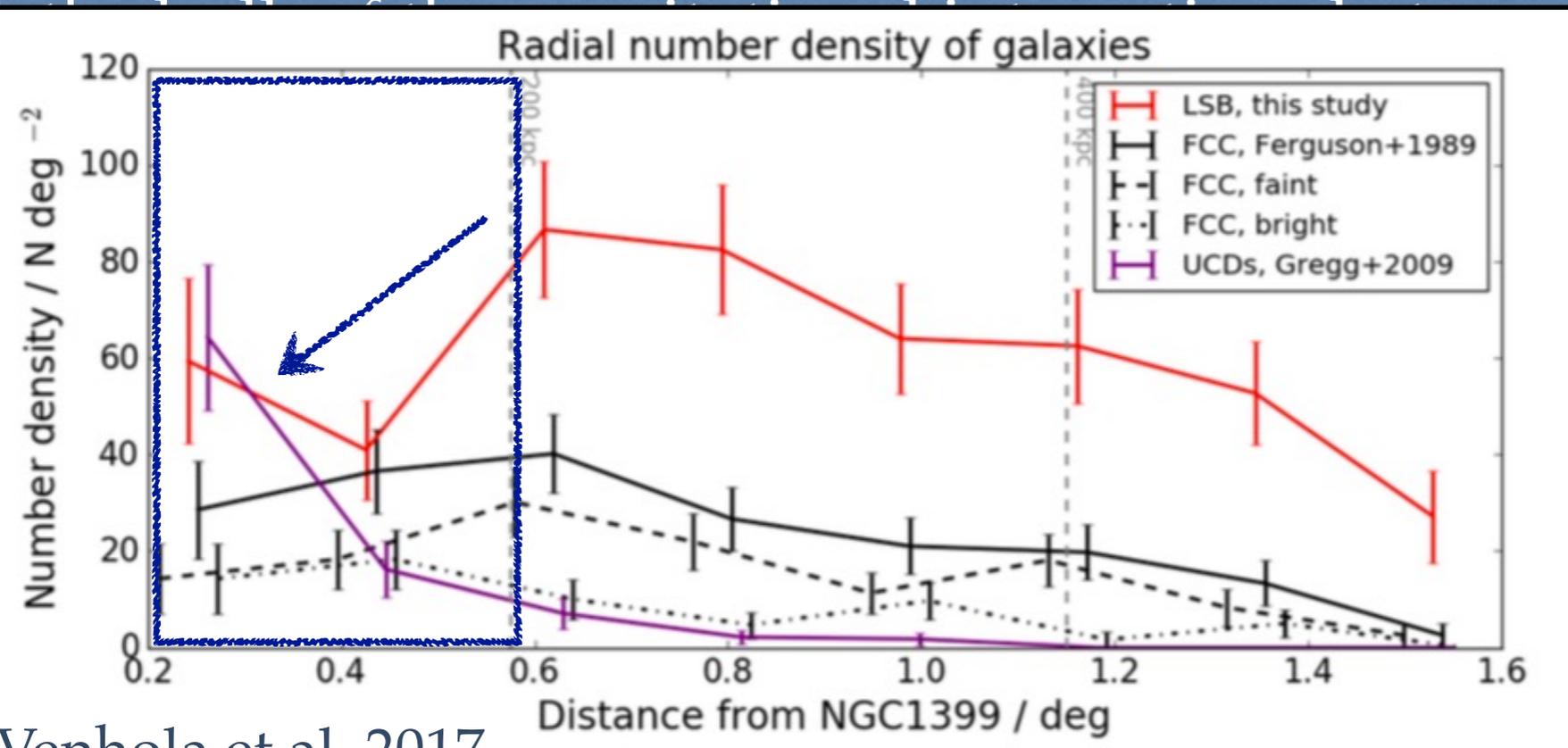
Iodice et al. 2018, A&A, in press

the bulk of the gravitational interactions between
happened on the W-NW side of the cluster, where
ETGs are located and where the intra-cluster

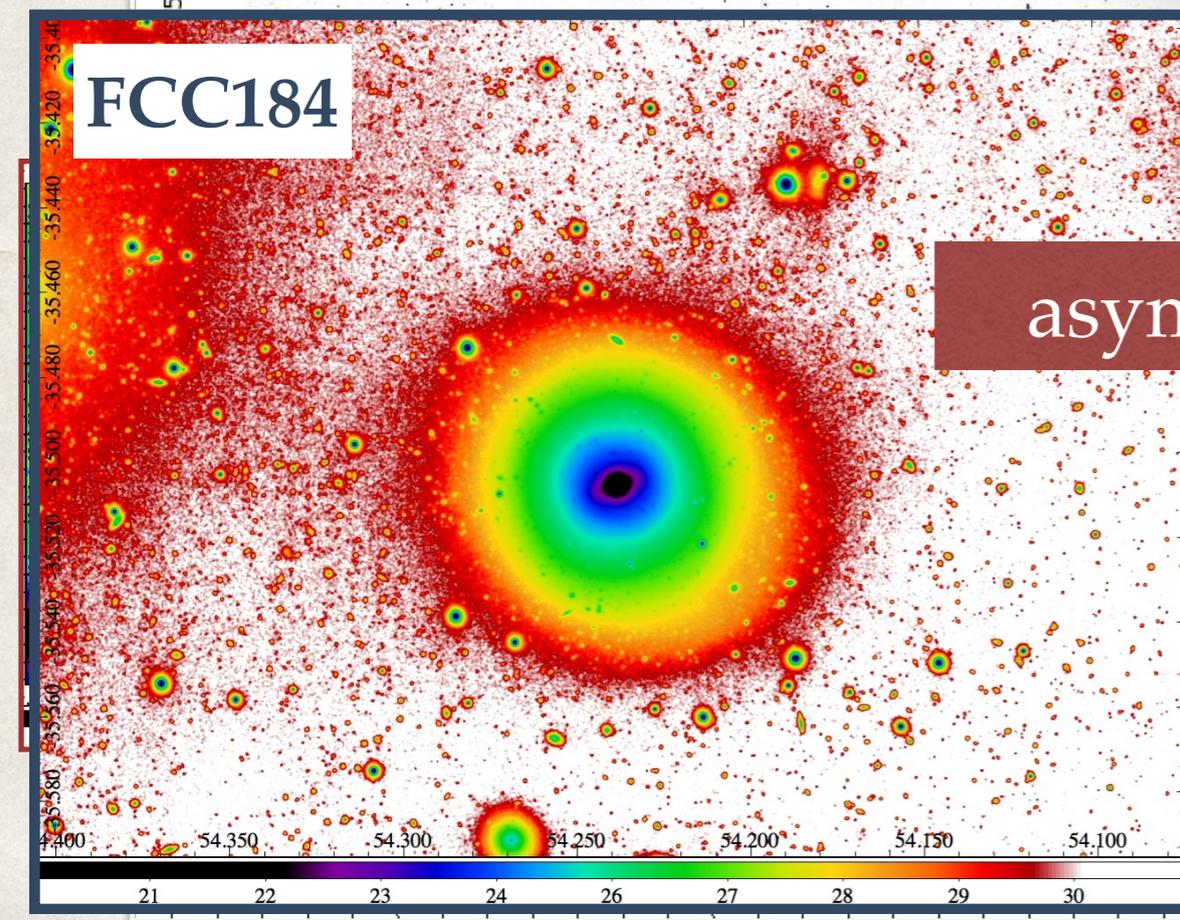
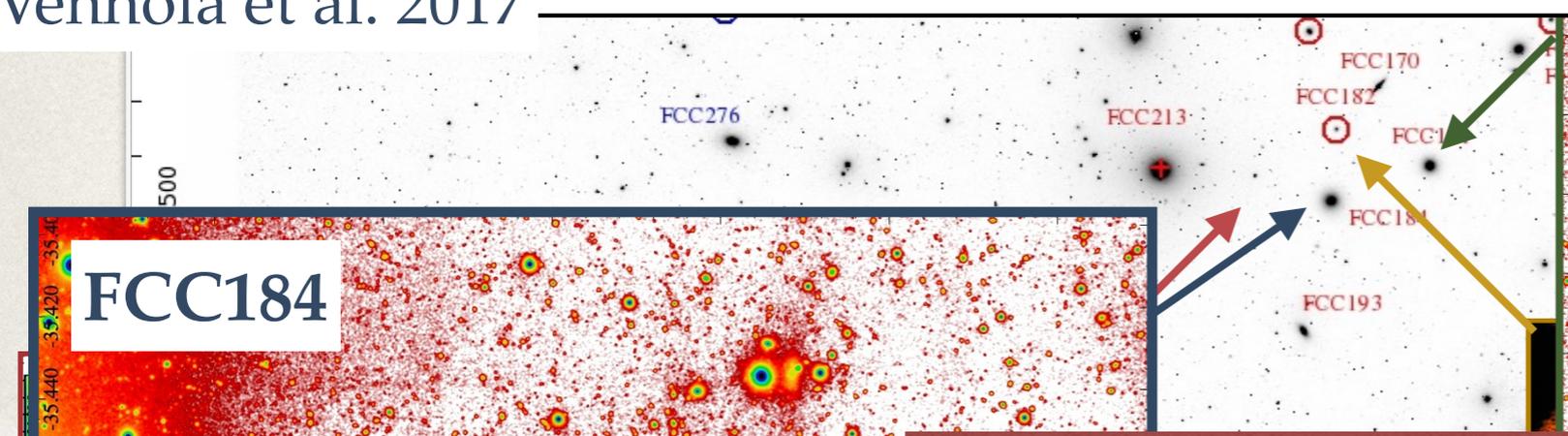


asymmetric stellar halos

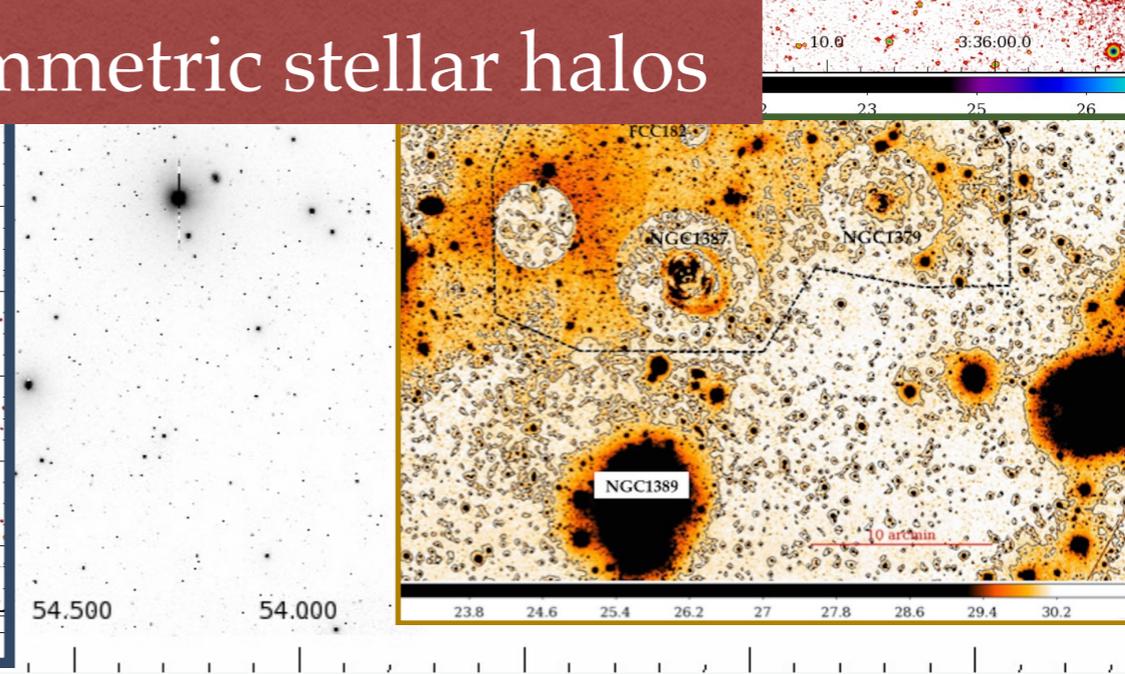




Venhola et al. 2017



asymmetric stellar halos



Multi-wavelengths observations

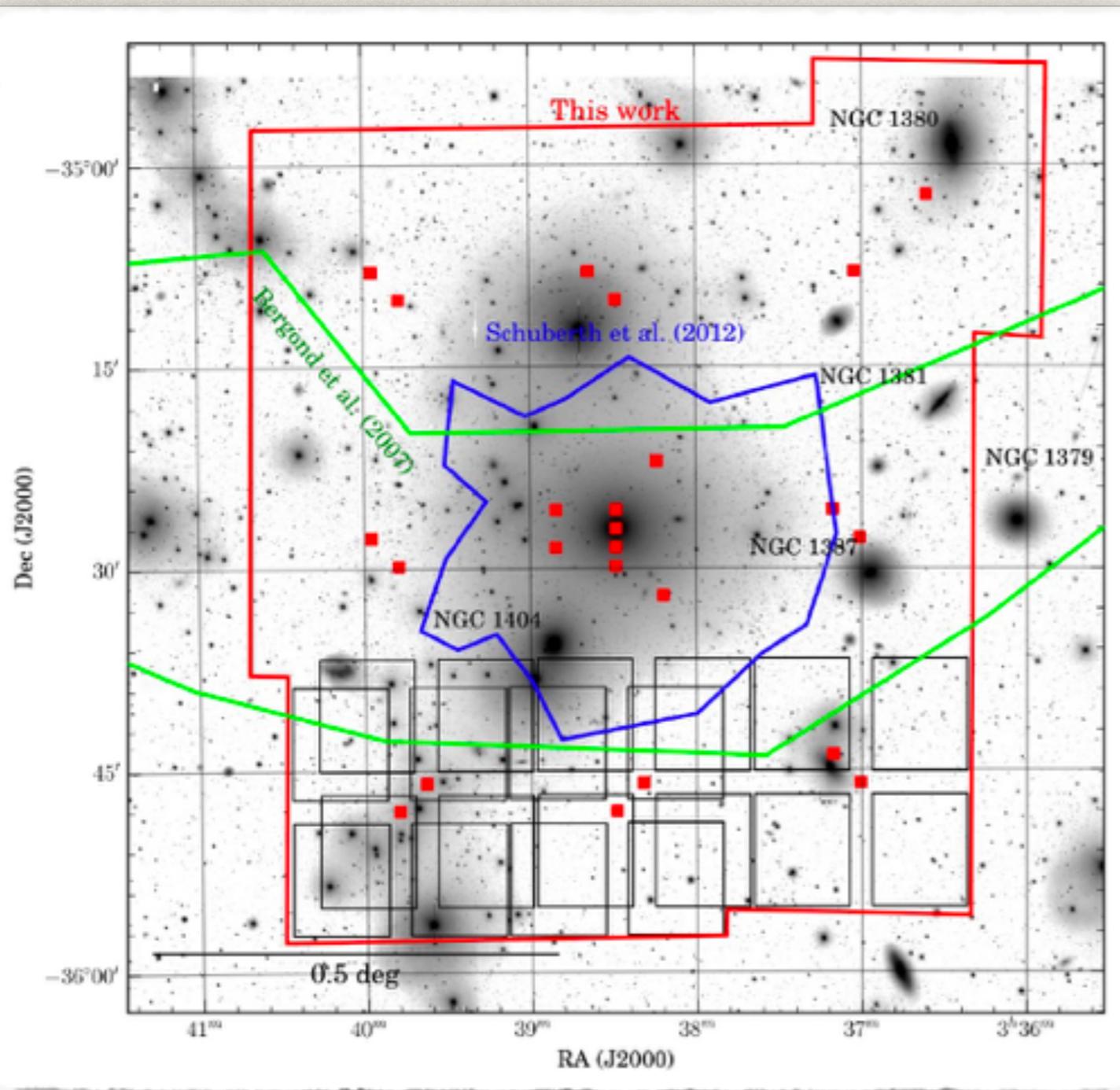
- * **Herschel survey** $R \leq 16 \text{ deg}^2$ (P.I. Davies): cold dust in ~ 30 ETGs & LTGs
- * **ALMA survey** on the Herschel sample (P.I. Davis)
- * **SAMI integral field spectroscopy** of dwarf galaxies (P.I. Scott)
- * **MUSE survey** of the Fornax members inside R_{vir} (P.I. Sarzi/Iodice)
- * **MUSE survey of dwarfs** (P.I. Peletier)
- * **VIMOS Survey of GCs** (P.I. Napolitano)
- * **FORS2 Survey of PNe** (P.I. M. Capaccioli)
- * **MeerKAT HI survey of Fornax** (P.I. Serra)
- * **VISTA data** (P.I. Puzia)
- * **Archival data: Chandra, HST, GALEX**

Multi-wavelengths observations

- * **Herschel survey** $R \leq 16 \text{ deg}^2$ (P.I. Davies): cold dust in ~ 30 ETGs & LTGs
- * **ALMA survey** on the Herschel sample (P.I. Davis)
- * **SAMI integral field spectroscopy** of dwarf galaxies (P.I. Scott)
- * **MUSE survey** of the Fornax members inside R_{vir} (P.I. Sarzi/Iodice) ←
- * **MUSE survey of dwarfs** (P.I. Peletier)
- * **VIMOS Survey of GCs** (P.I. Napolitano) ←
- * **FORS2 Survey of PNe** (P.I. M. Capaccioli) ←
- * **MeerKAT HI survey of Fornax** (P.I. Serra)
- * **VISTA data** (P.I. Puzia)
- * **Archival data: Chandra, HST, GALEX**

FVSS: the Fornax cluster VLT Spectroscopic Surveys

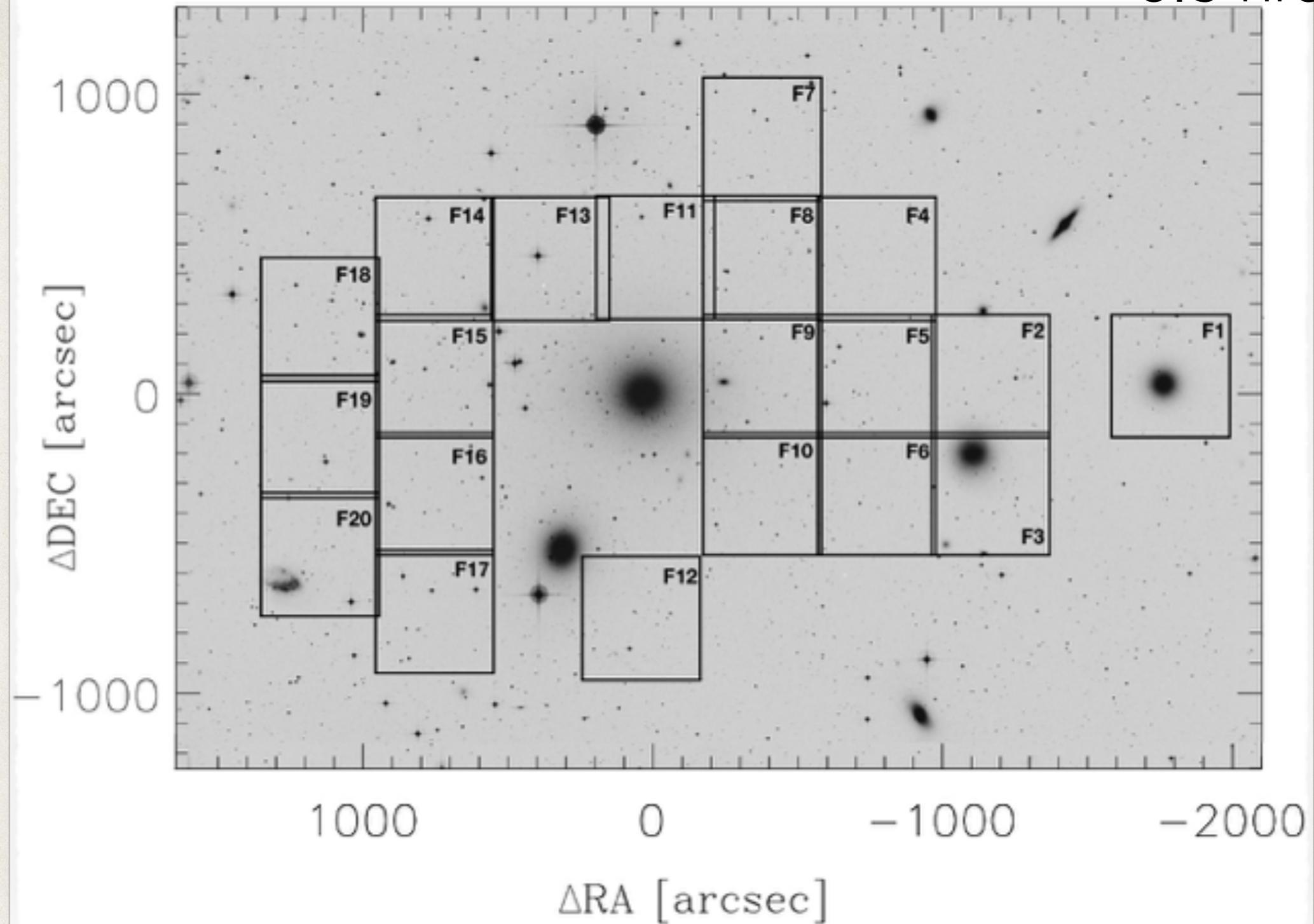
- * To obtain the full kinematic map of the baryonic structures and the orbital distribution of stars and GCs in the Fornax core
- * Constrain the baryonic and dark mass distribution in the core of Fornax
- * Shed light on the assembly history of massive galaxies in one of the most nearby dense environments.
- * Study the assembly of the stellar and dark matter haloes



- * 25 VIMOS pointings (1.5 hrs per mask)
- * 4500 low resolution VIMOS spectra (4800 - 10000Å) in the central 1 deg² around NGC 1399 (R~175 kpc)
- * 372 new GCs and 15 ultra Compact Dwarfs
- * We collected a total of 1130 tracer particles around NGC1399, including literature

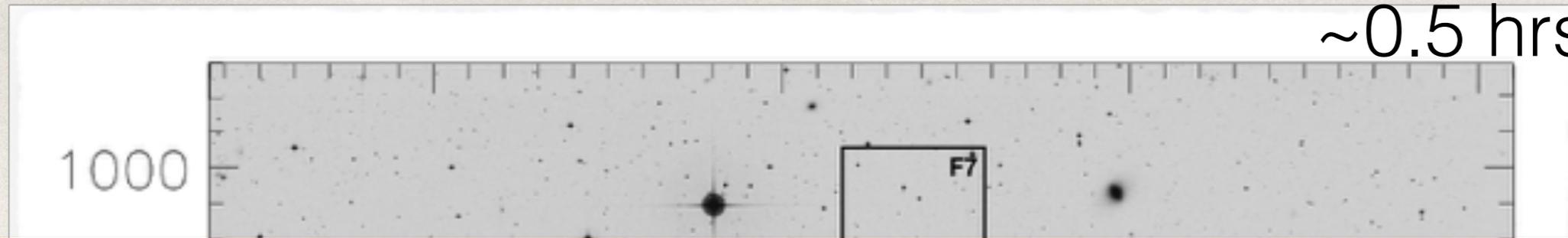
FVSSI: VIMOS spectroscopy of compact sources

~0.5 hrs / field

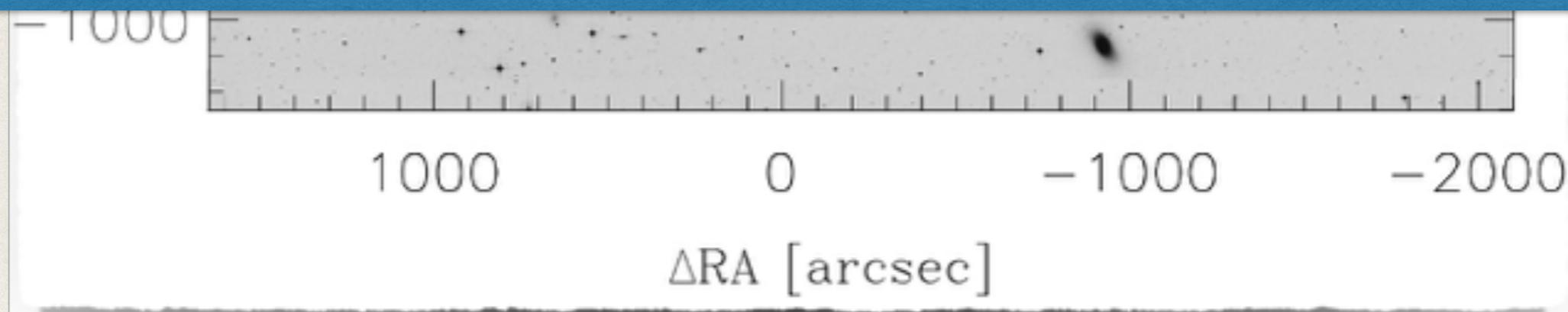


FVSSII: FORS2 PNe kinematics within 200 kpc

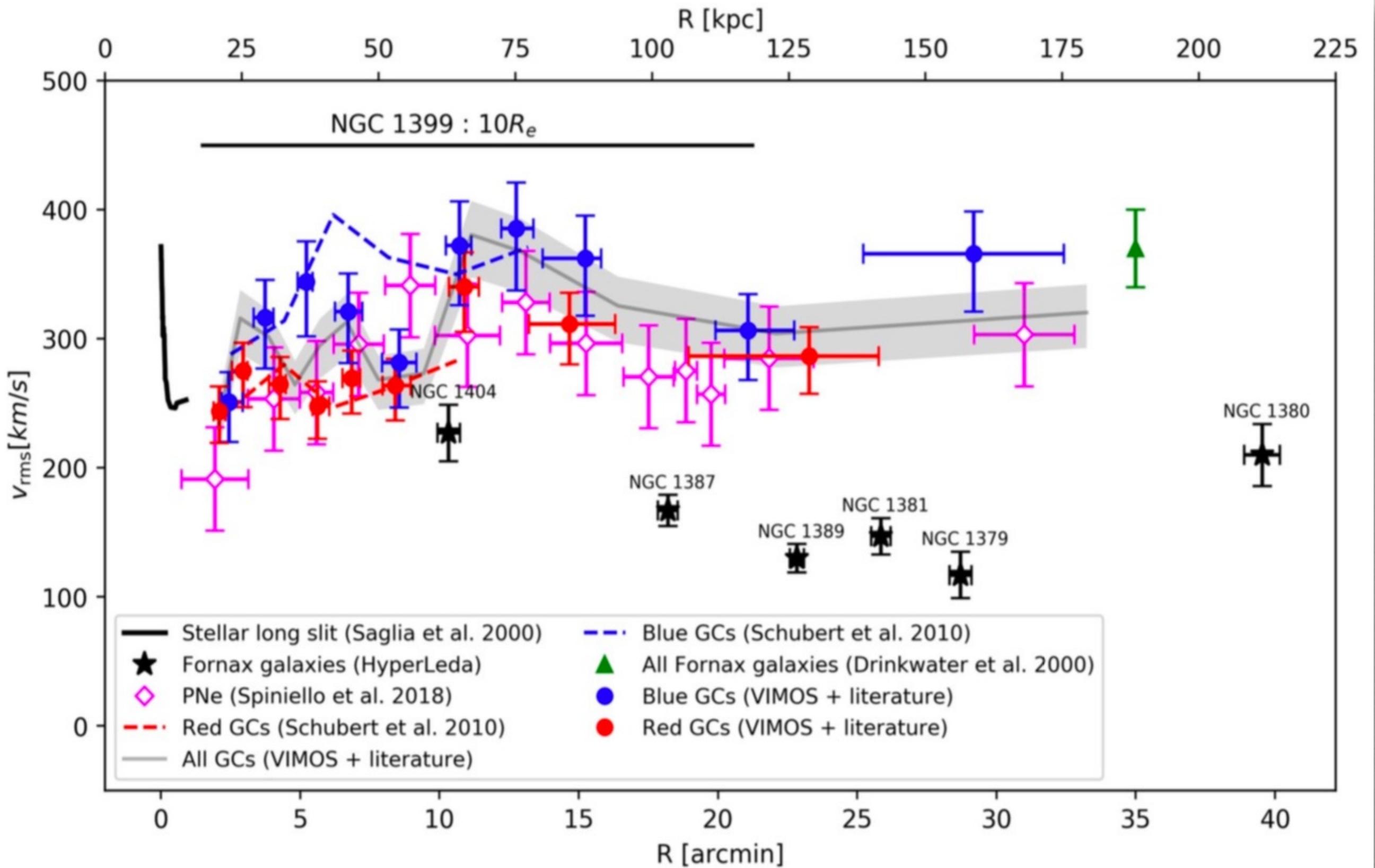
~0.5 hrs / field



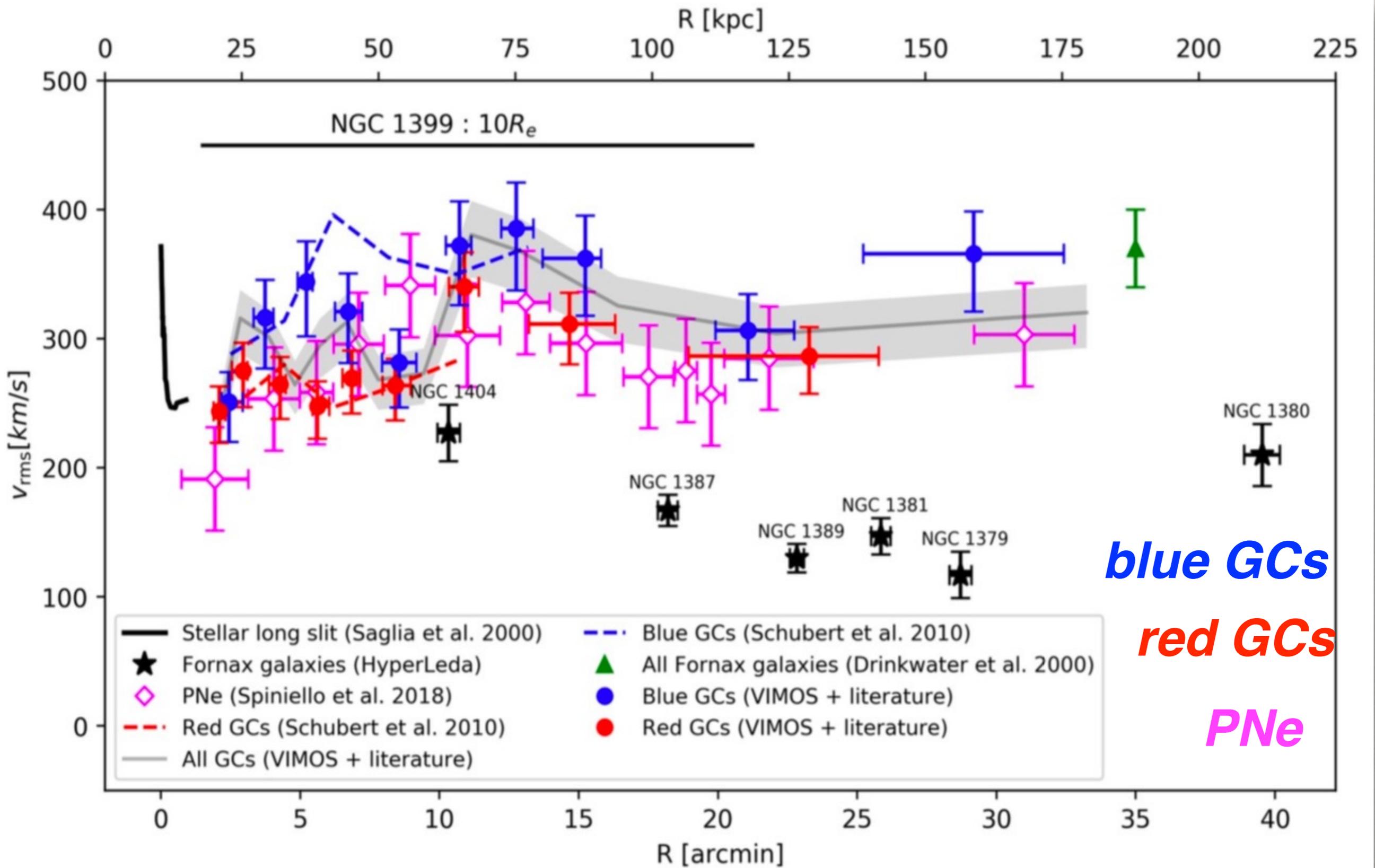
- Detection and kinematics of *1452 PNe out to 200 kpc* in the cluster core using a counter-dispersed slitless spectroscopic technique
- The largest PNe catalog ever obtained for the Fornax Cluster
- We can study separately the stellar halos of the cluster main galaxies and the intracluster light



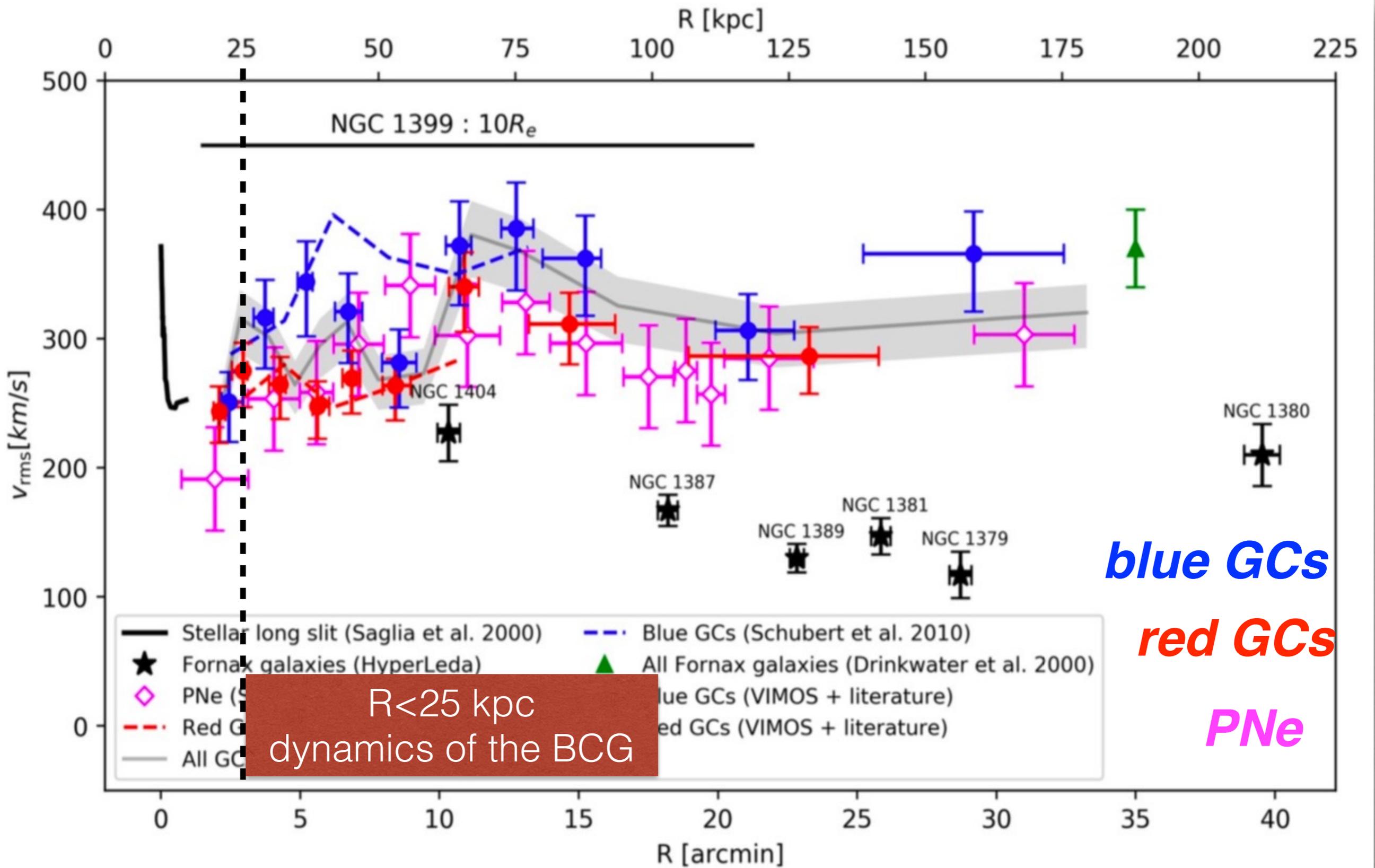
FVSSII: FORS2 PNe kinematics within 200 kpc



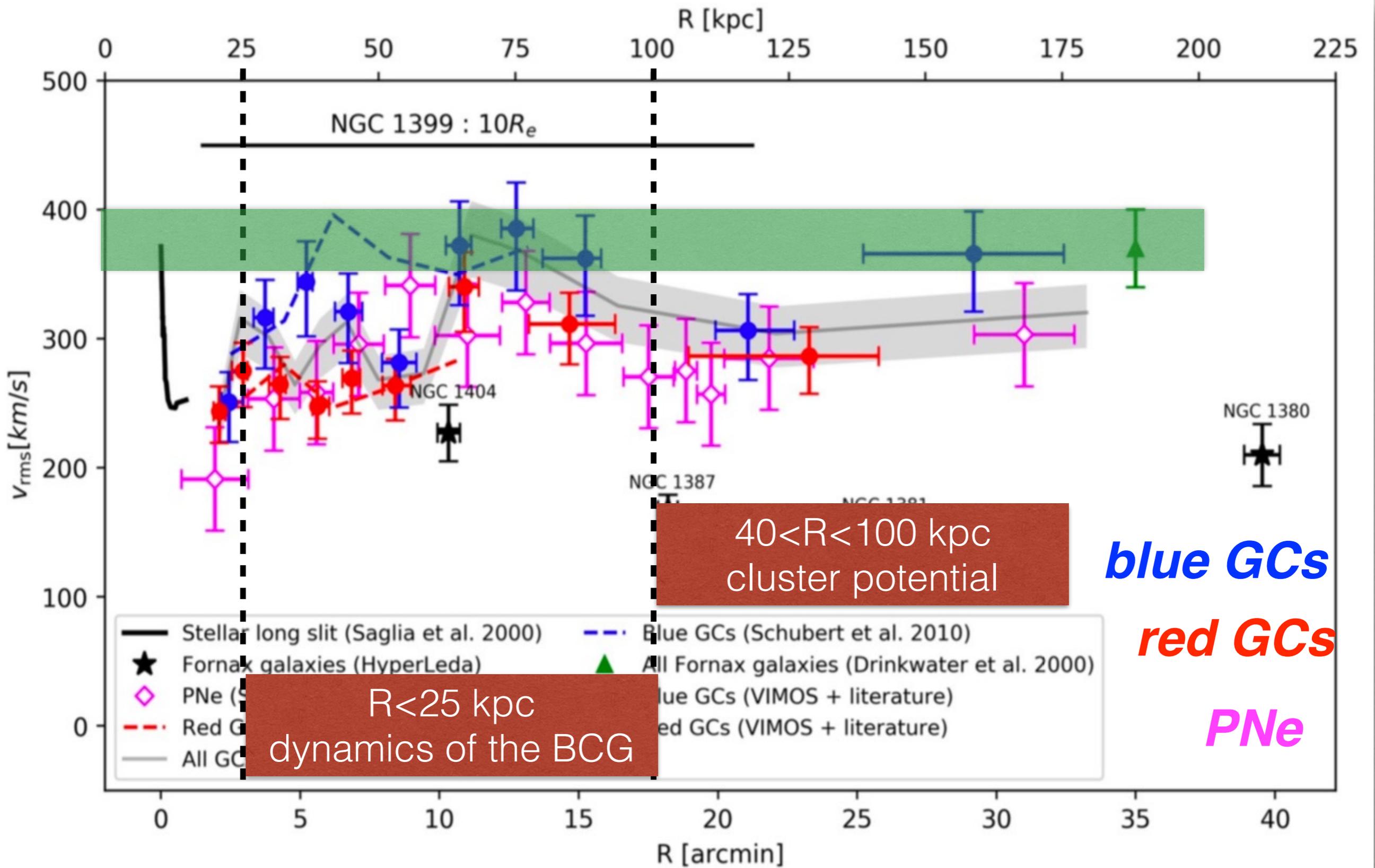
FVSSI + FVSSII



FVSSI + FVSSII

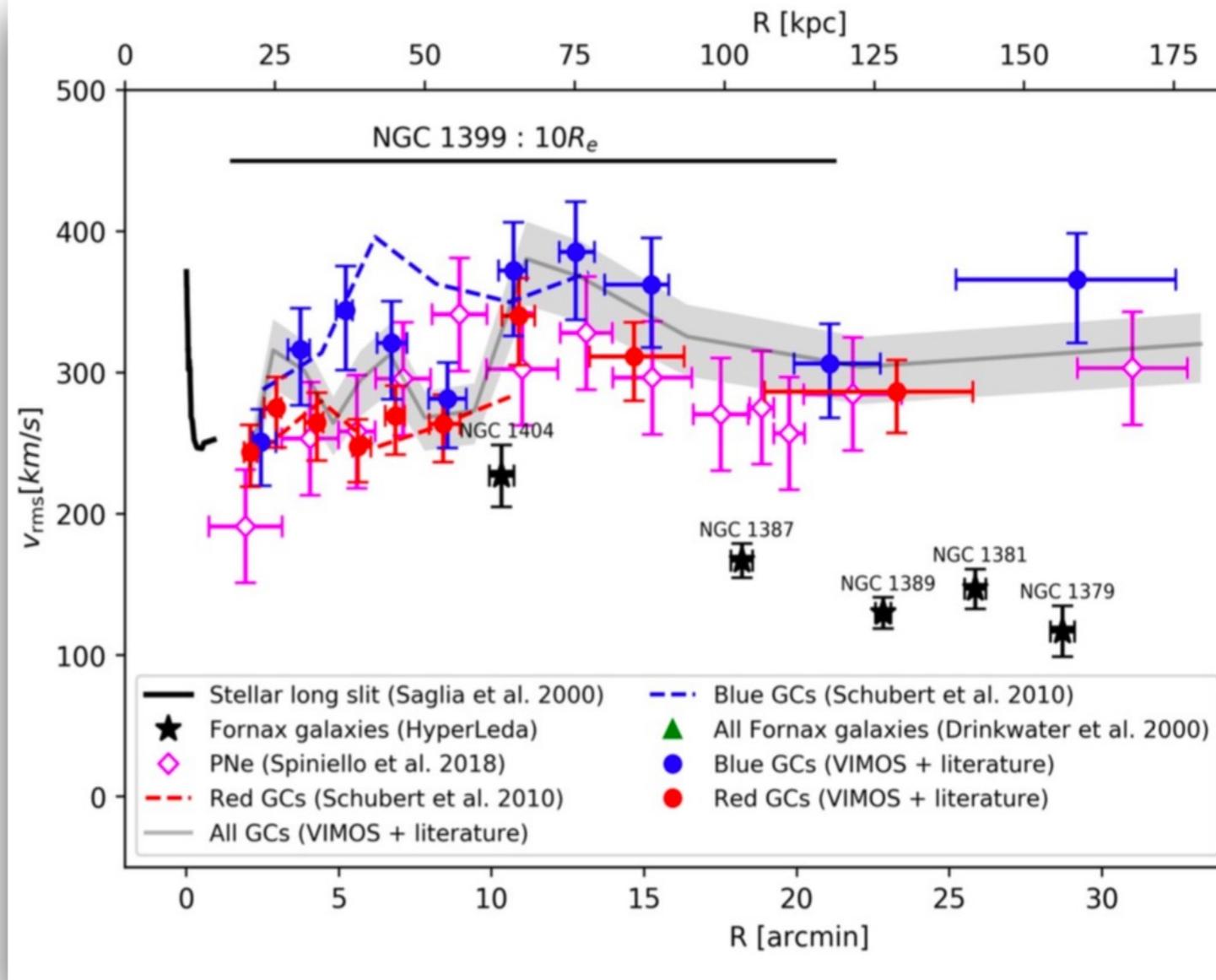
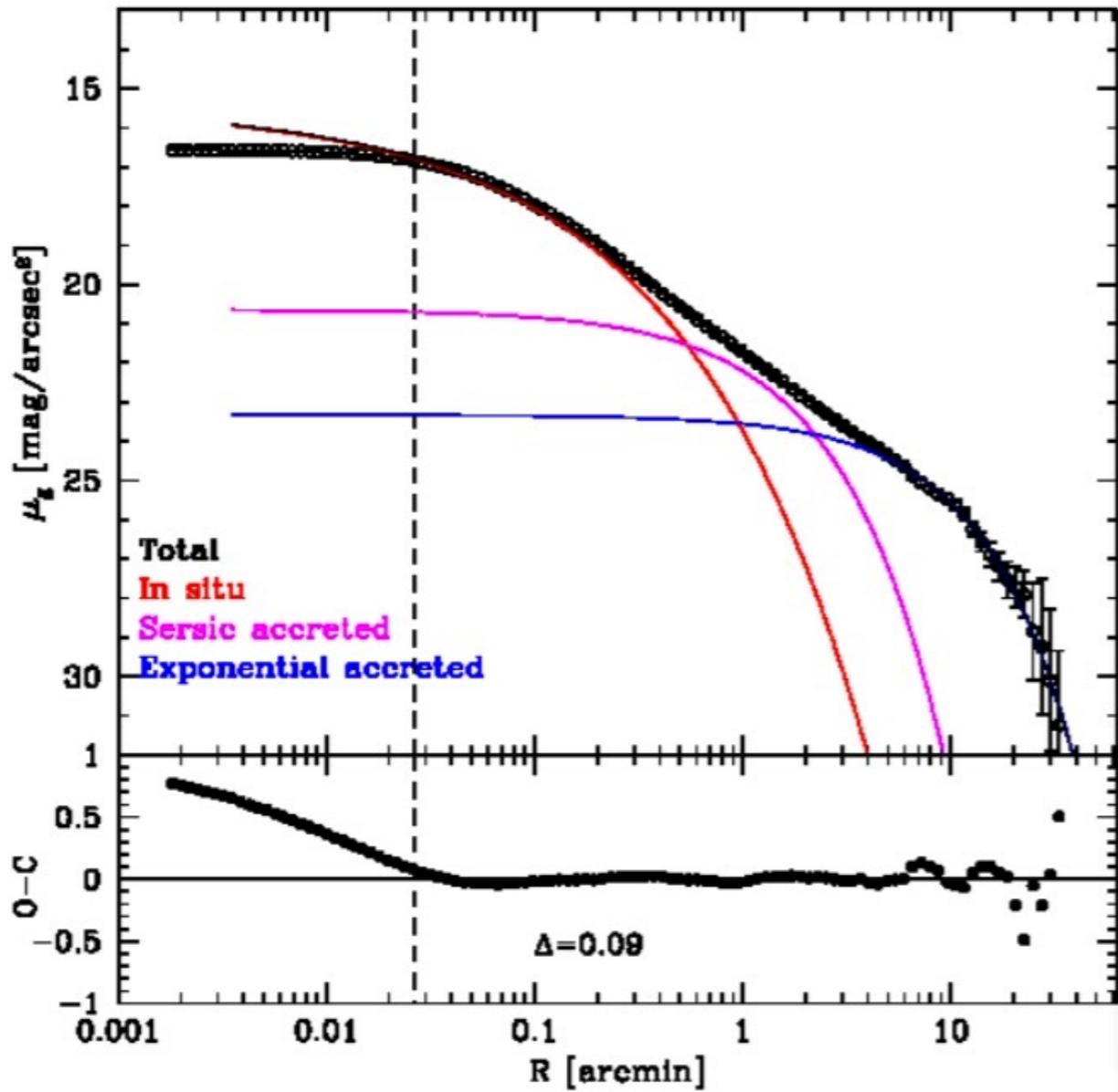


FVSSI + FVSSII

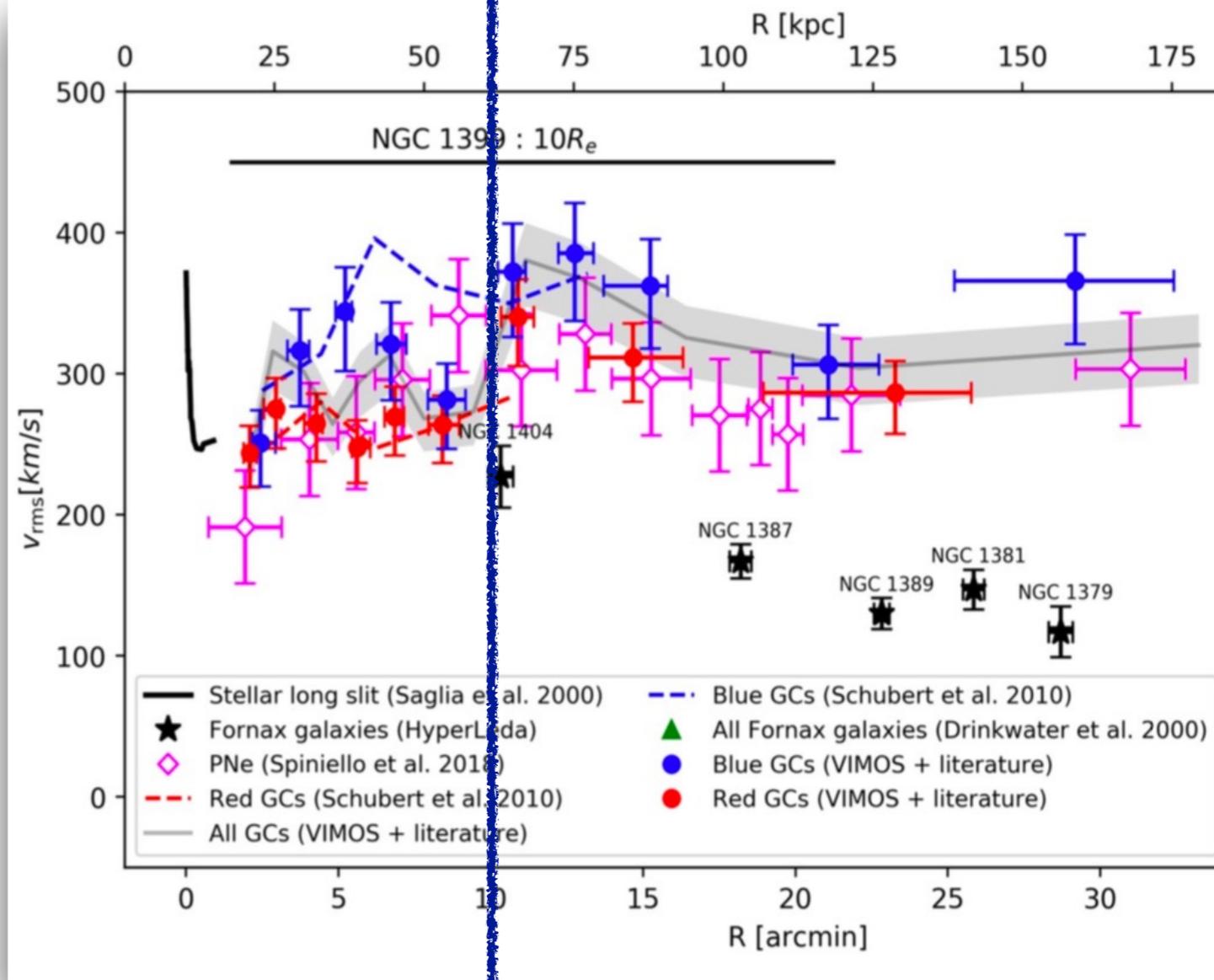
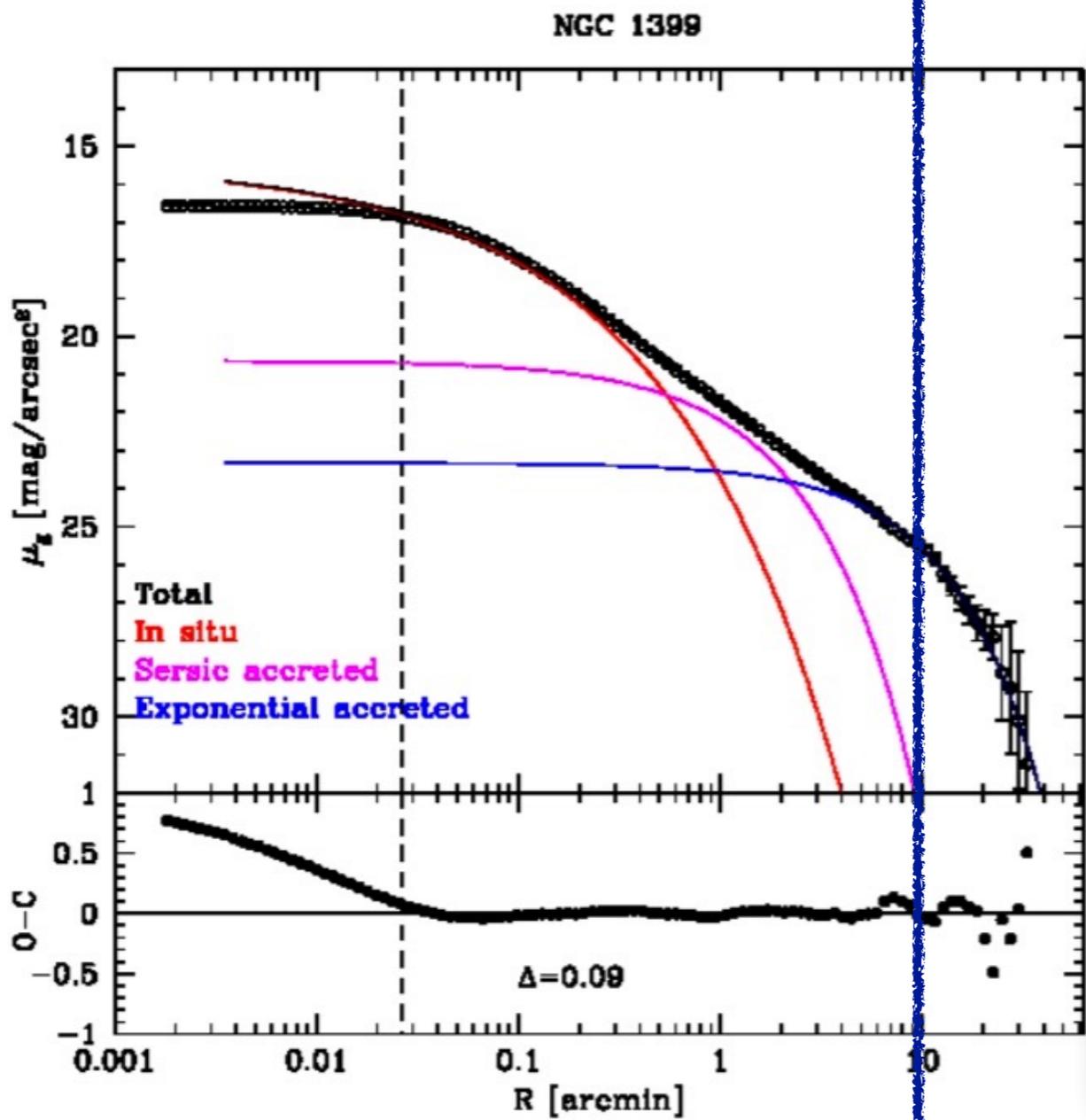


FVSSI + FVSSII

NGC 1399



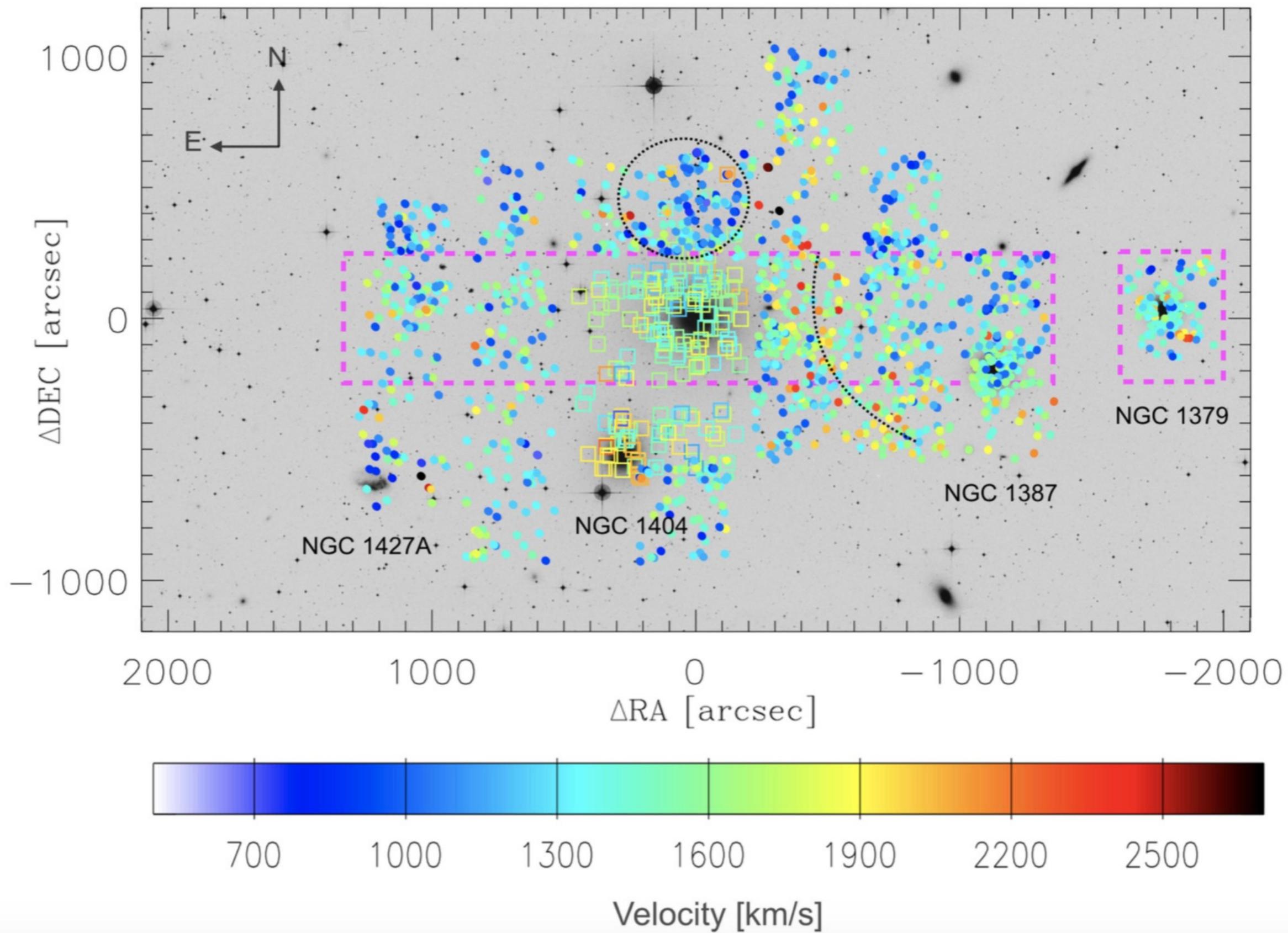
FDS + FVSSII: photometry vs spectroscopy



R_{break}

evidence for the transition radius from the gravitationally bounded to unbound accreted material

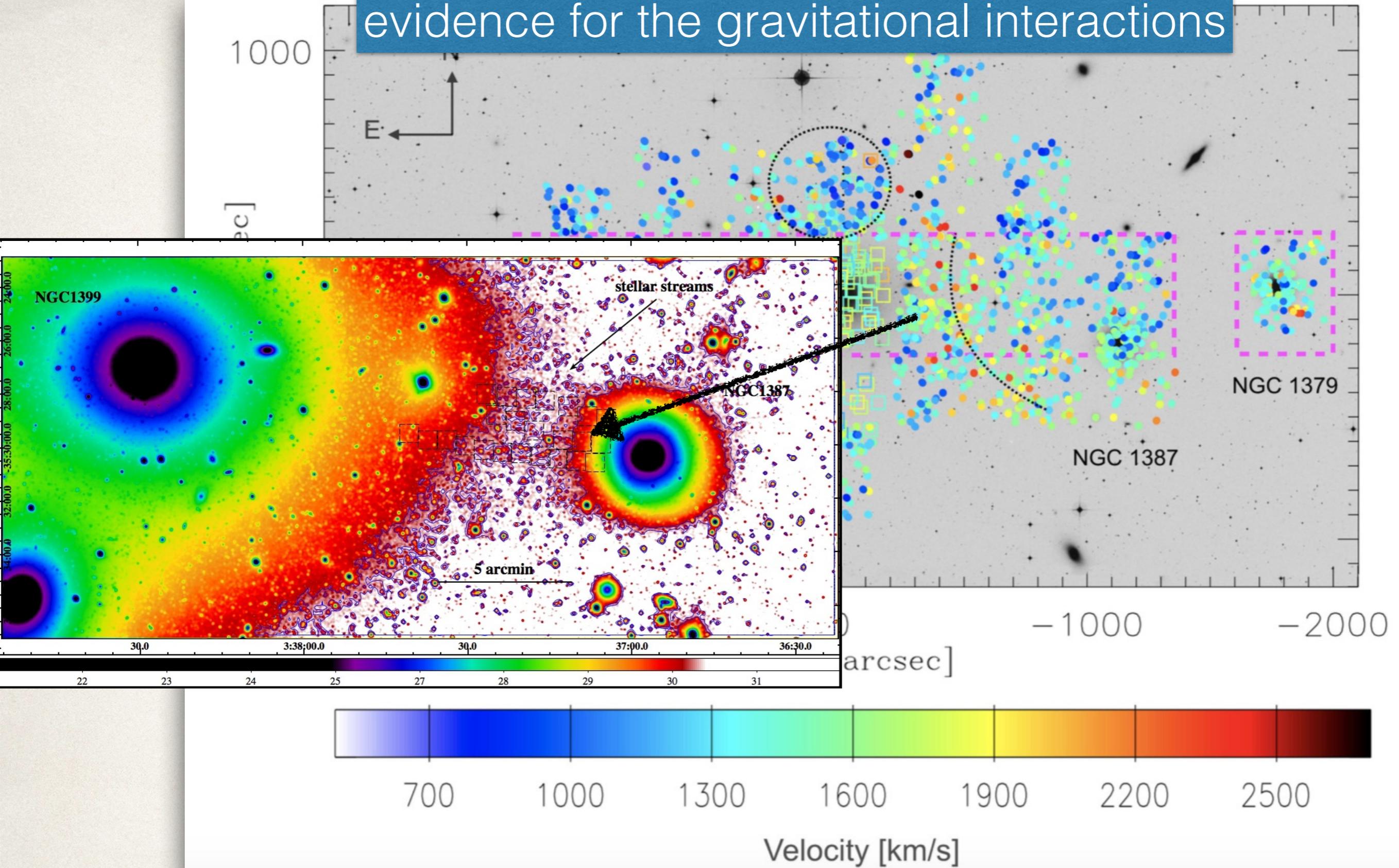
FDS + FVSSII: photometry vs spectroscopy



FDS + FVSSII: photometry vs spectroscopy

Spiniello et al. 2018, MNRAS 477, 1880

evidence for the gravitational interactions



FDS + FVSSII: photometry vs spectroscopy

Spiniello et al. 2018, MNRAS 477, 1880

what next on Fornax?

Fornax3D: A magnitude-limited survey of galaxies within the virial radius of the Fornax Cluster with MUSE

Sarzi et al. 2018, A&A in press

Team

M. Sarzi (P.I., Armagh Obs.- UK) - E. Iodice (P.M., INAF- Italy)

E. M. Corsini (PD, Italy)

J. Falcon-Barroso (IAC, Spain)

D. Gadotti (ESO, Germany)

M. Lyubenova (ESO, Germany)

I. Martìn-Navarro (Univ. of California Observatories, Santa Cruz, USA)

R. McDermid (Macquarie University, Australia)

F. Pinna (IAC, Spain)

Glenn van de Ven (ESO, Germany)

Tim de Zeeuw (Leiden, Netherland)

Fornax3D: A magnitude-limited survey of galaxies within the virial radius of the Fornax Cluster with MUSE

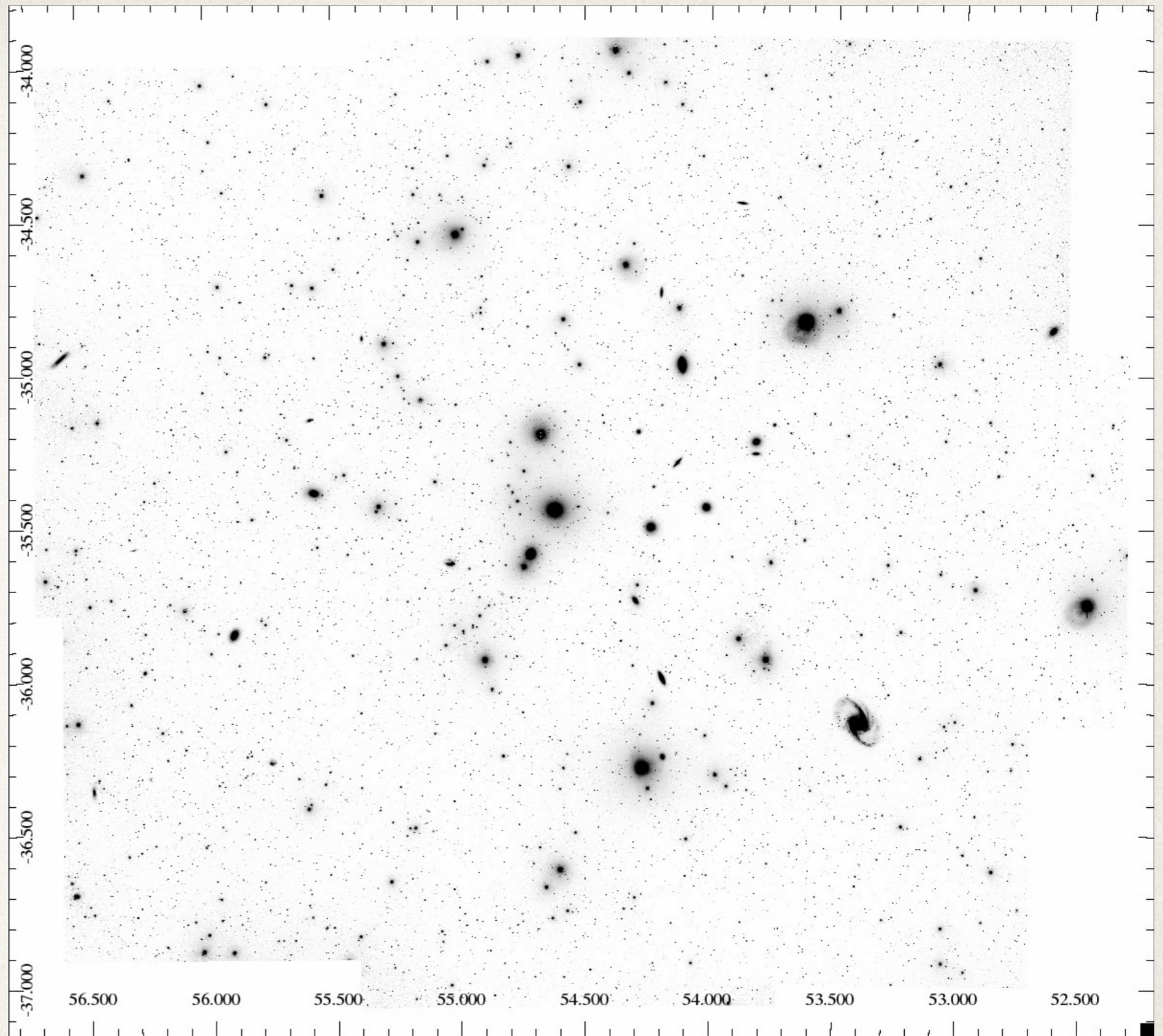
Sarzi et al. 2018, A&A in press

— Survey —

- * 2D map of 32 galaxies in the core of the Fornax Cluster
- * brighter than $M_B = -16$
- * within the R_{vir} (0.7 Mpc)
- * ETGs (23) & LTGs (9)

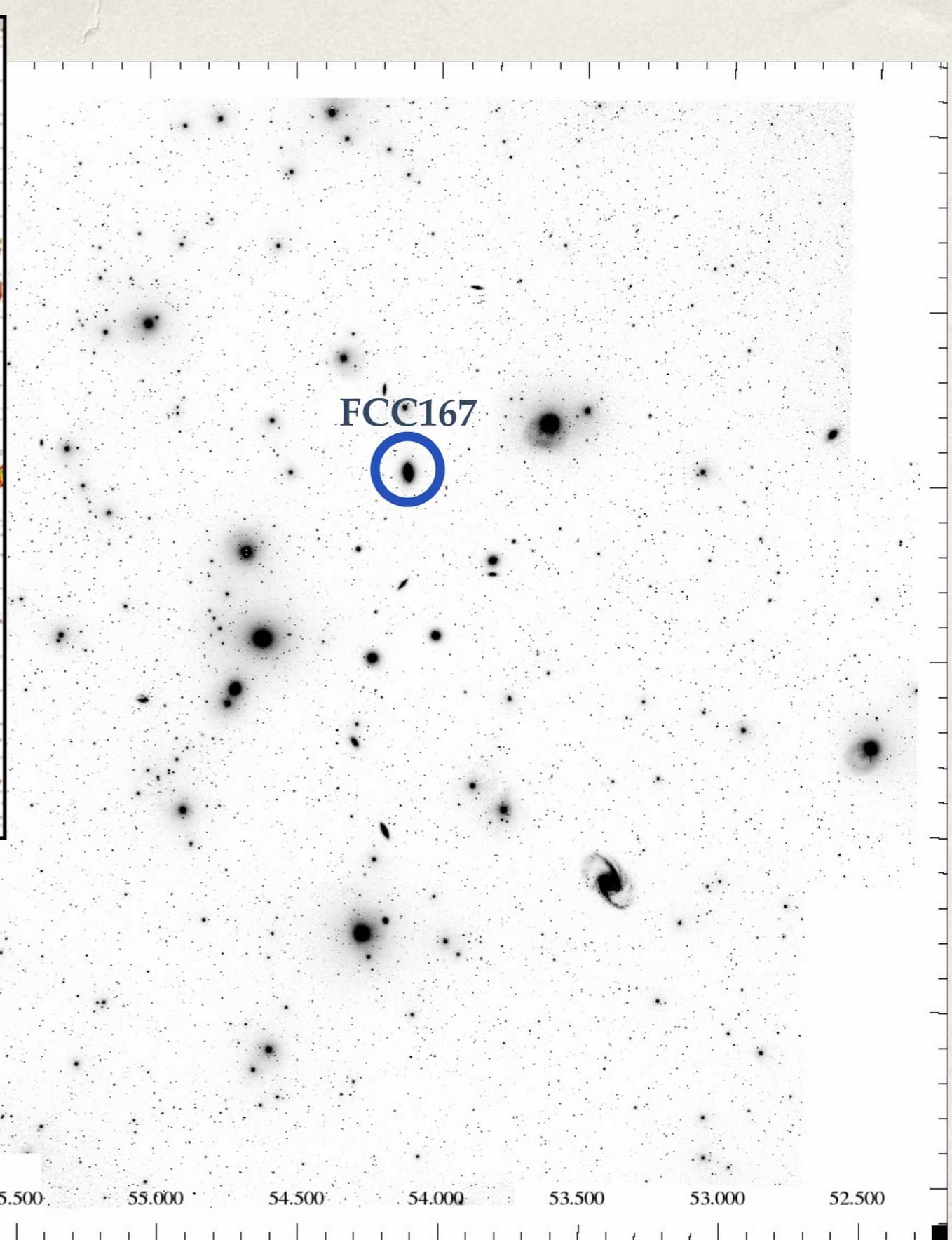
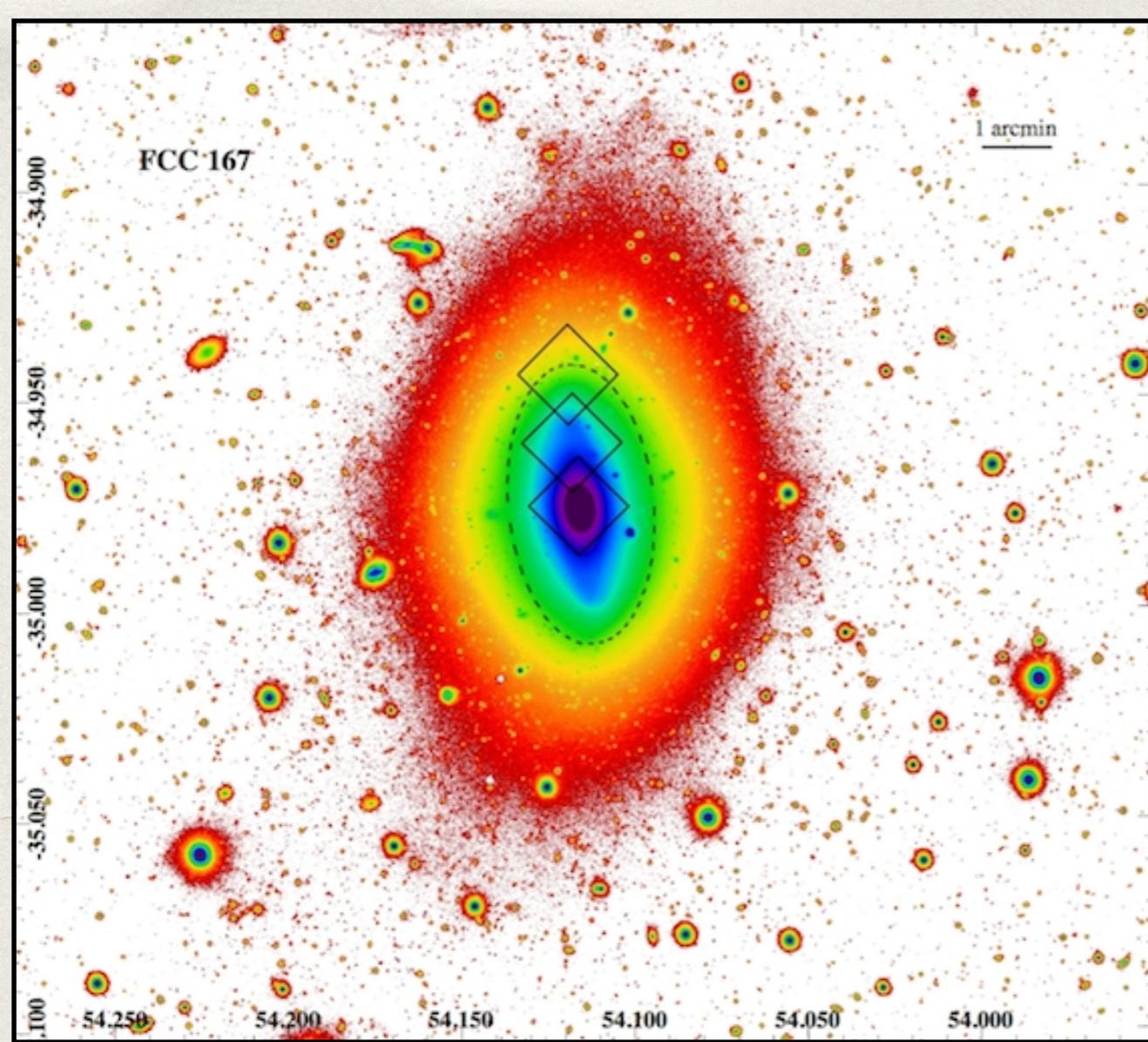
— science goals —

- * structural stellar components (bulges, disks, bars, kinematically decoupled structures) via spectral and dynamical modelling decomposition
- * IMF and stellar population in halos (\sim outside $2R_e$)
- * Stellar population: origin of the chemically distinct structures (Mg, Fe, Na disks) and galaxy structural components
- * Census of PNe & GCs
- * Study and evolution of nuclear stellar disks/clusters



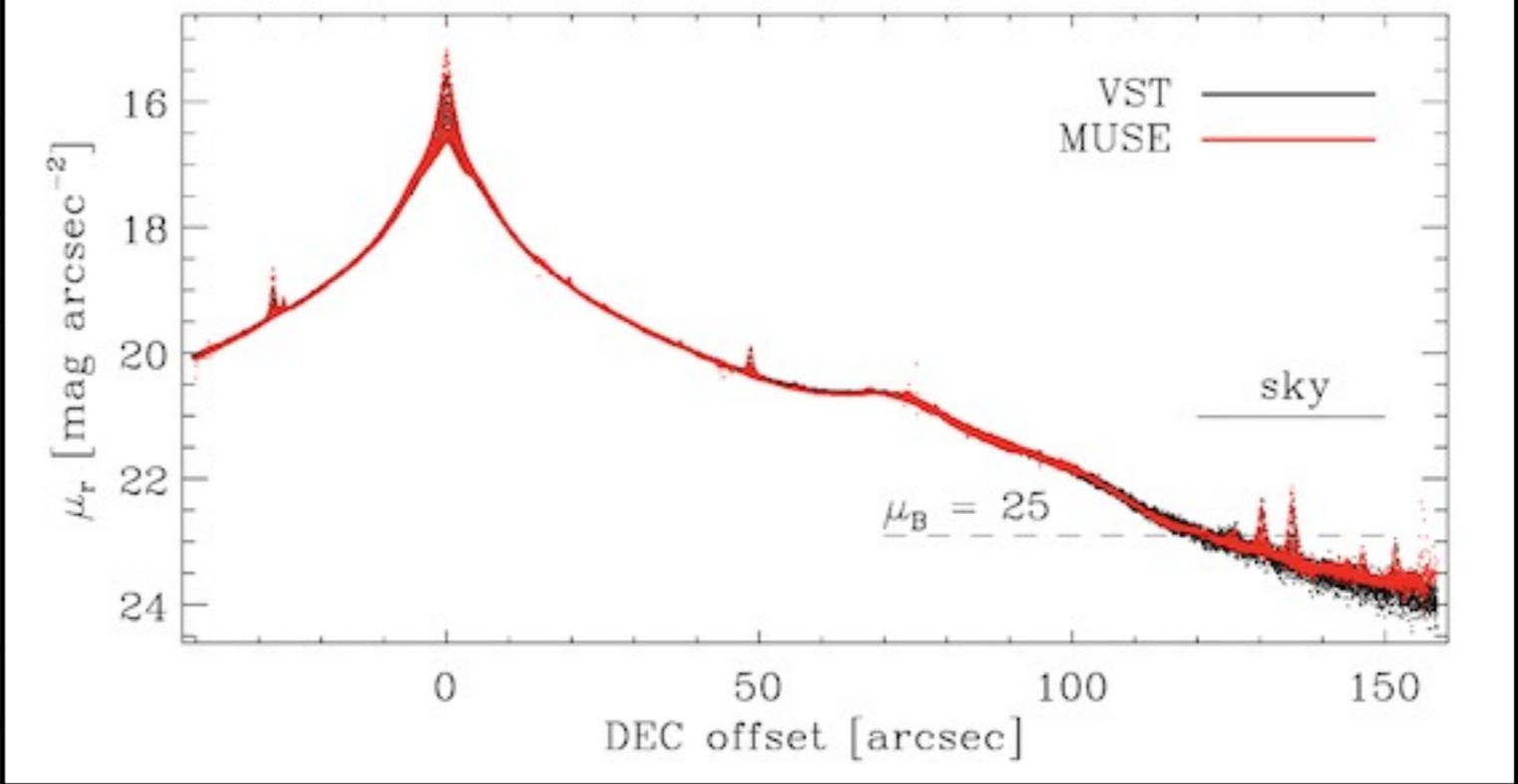
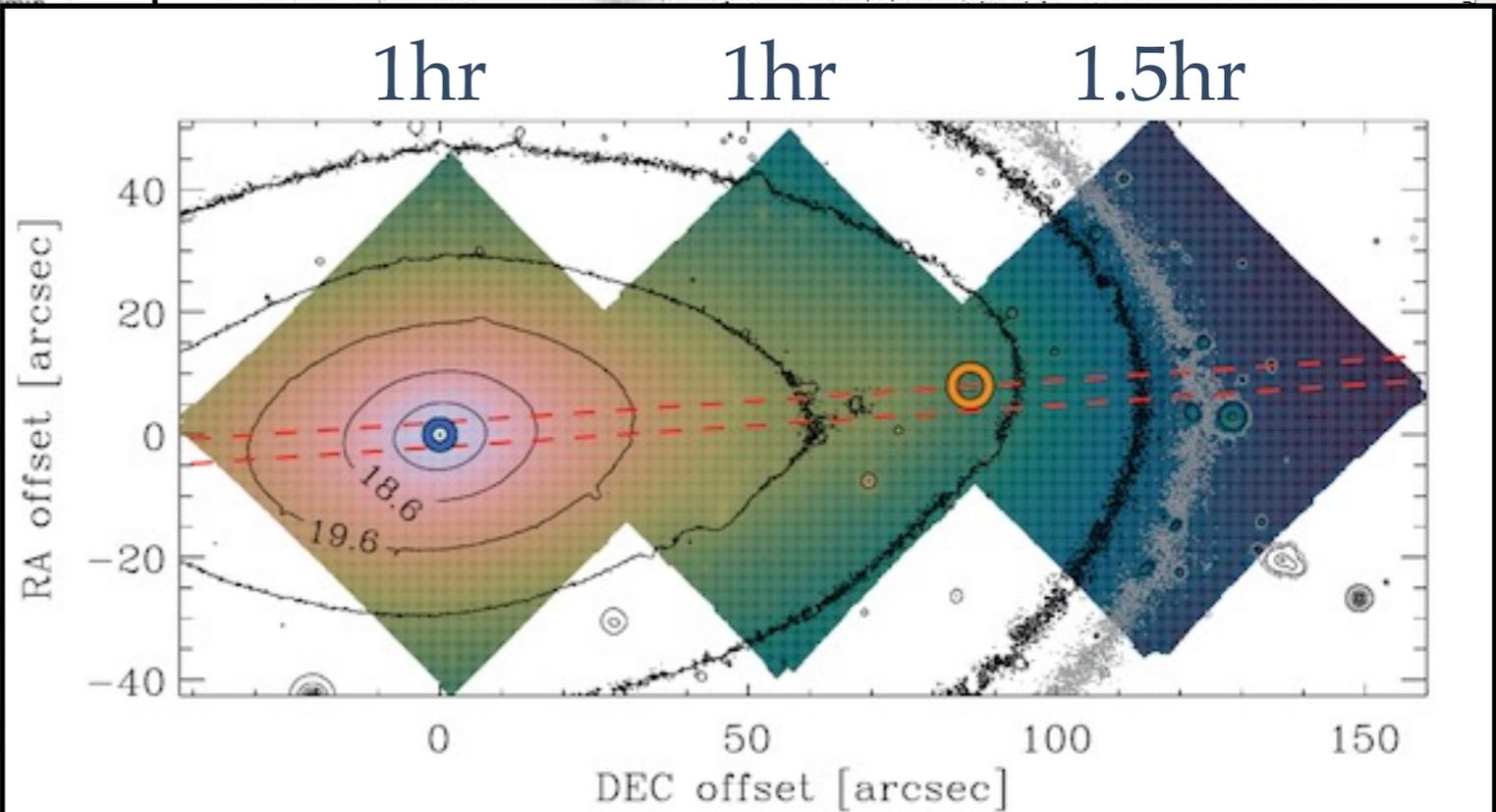
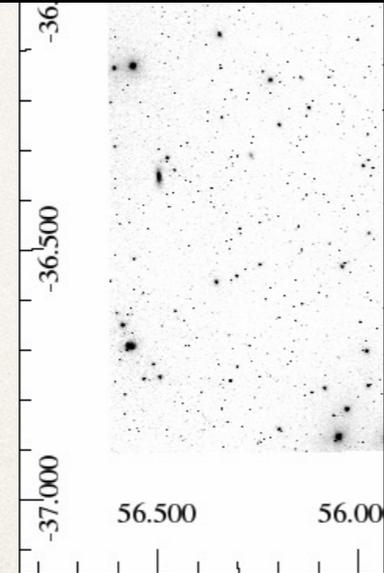
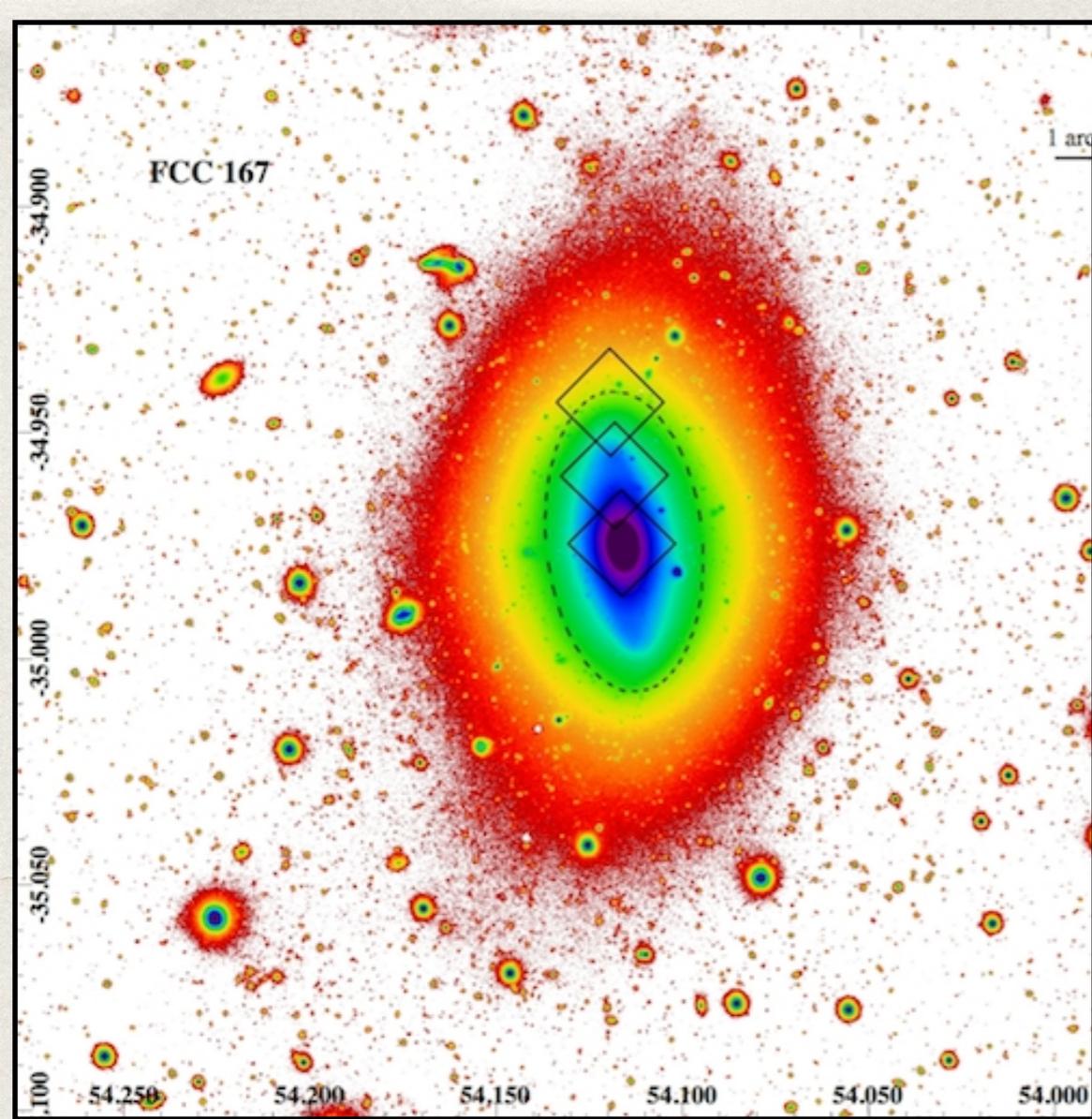
Fornax3D

Sarzi, Iodice et al. 2018, A&A in press

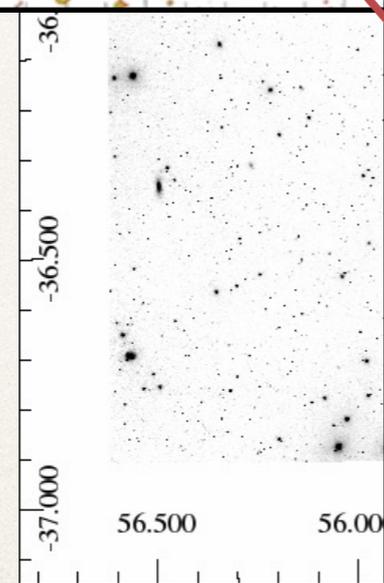
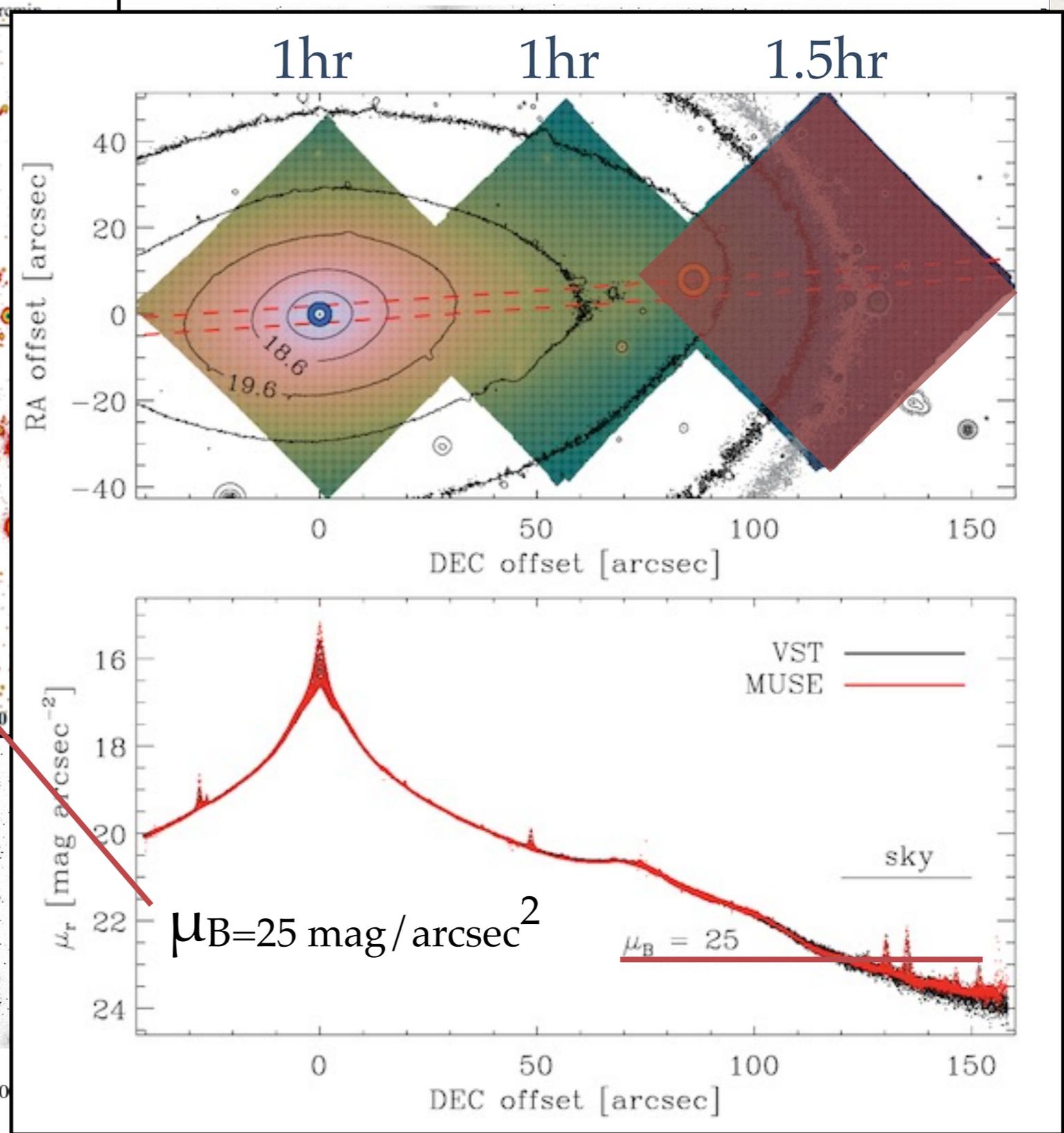
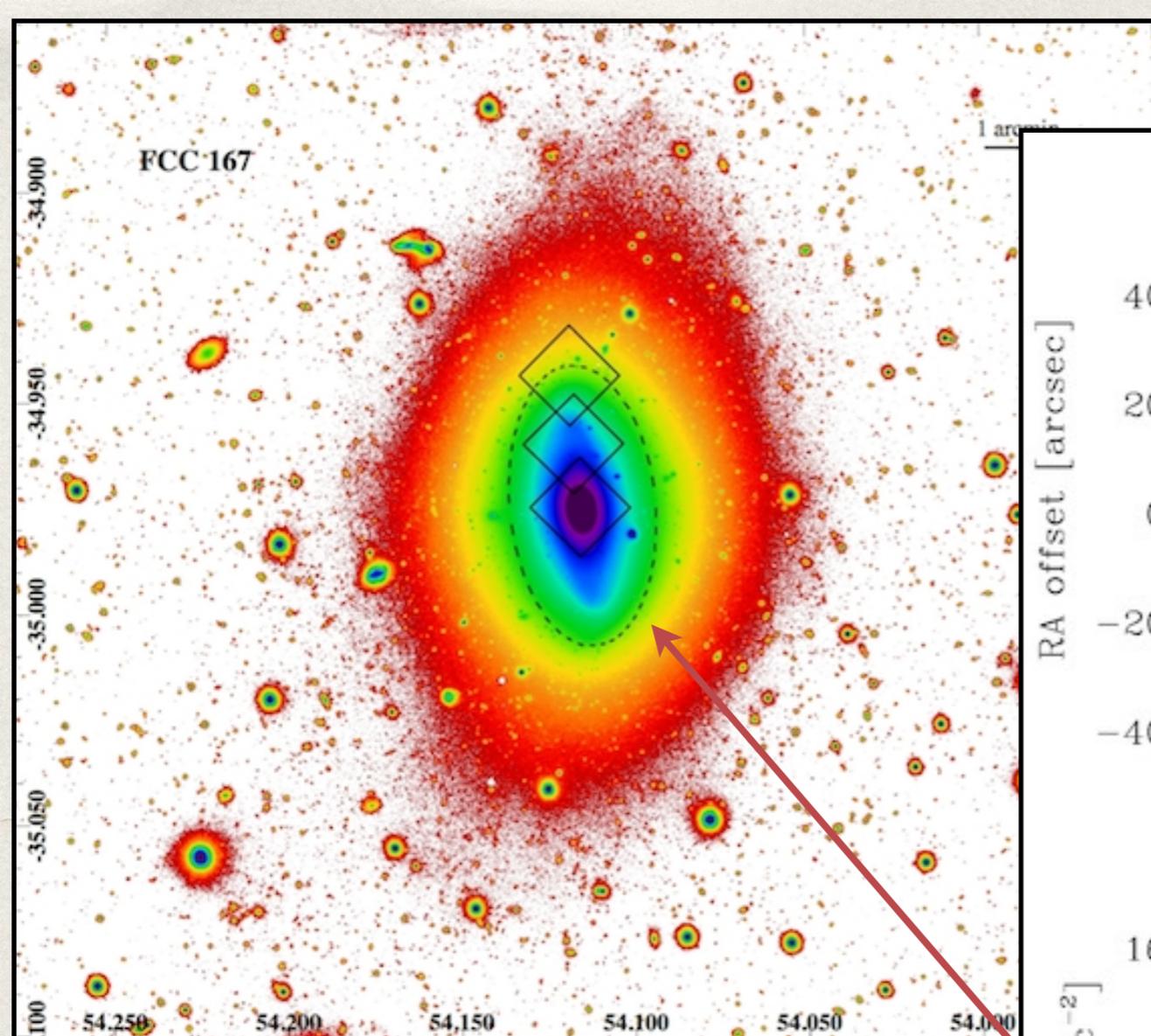


Fornax3D

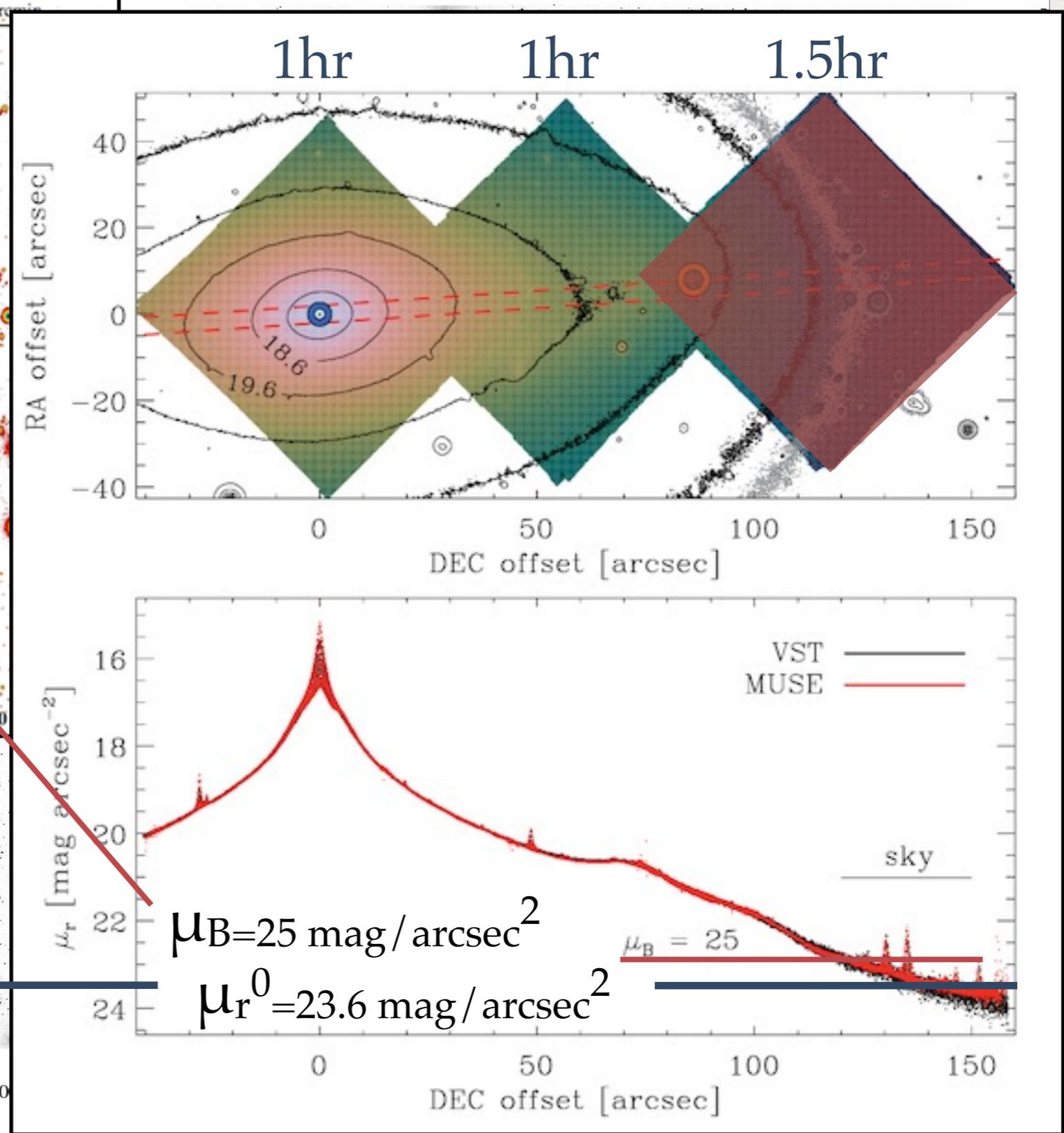
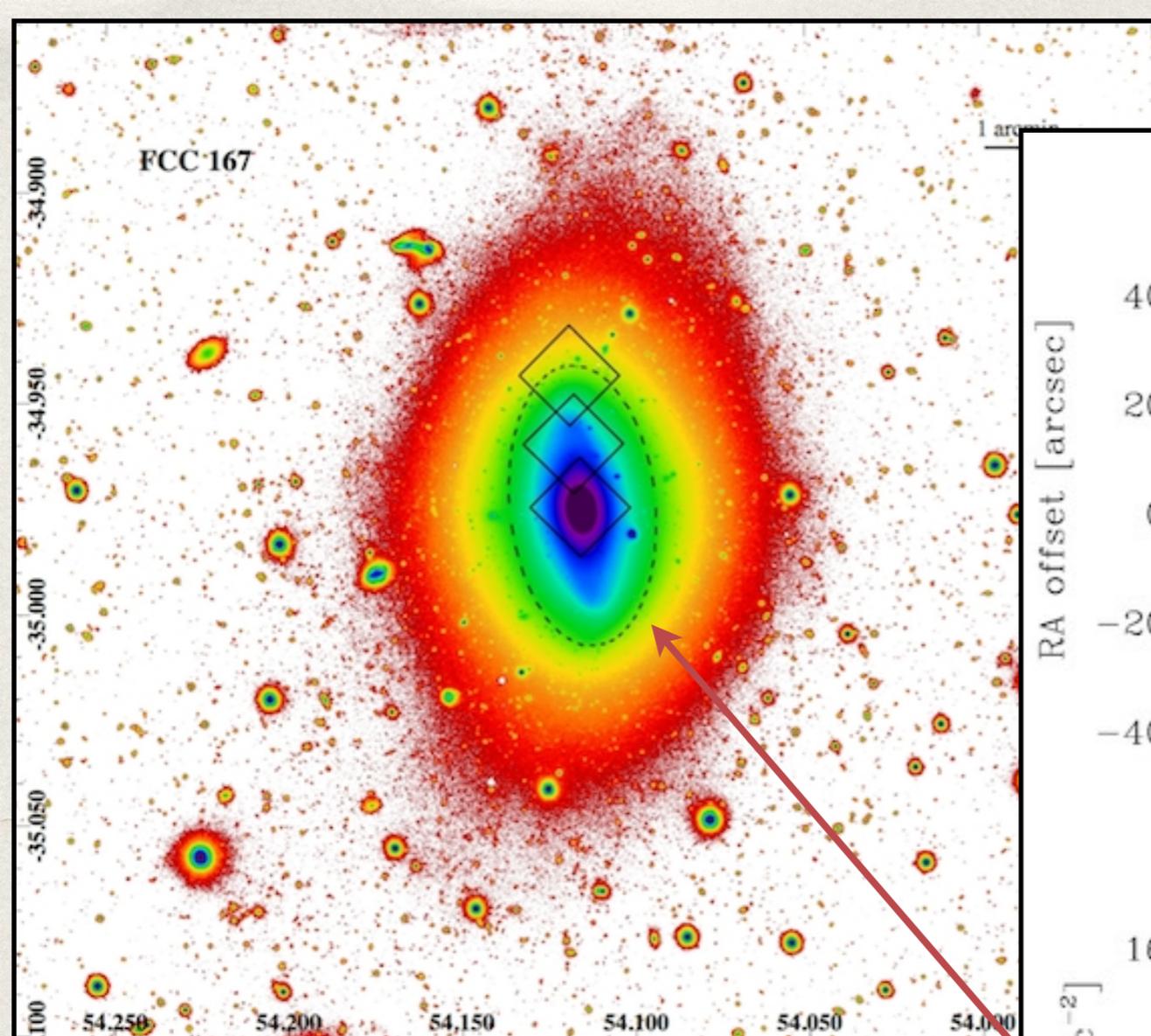
Sarzi, Iodice et al. 2018, A&A in press



Fornax3D



Fornax3D



central surface brightness of the stellar halos

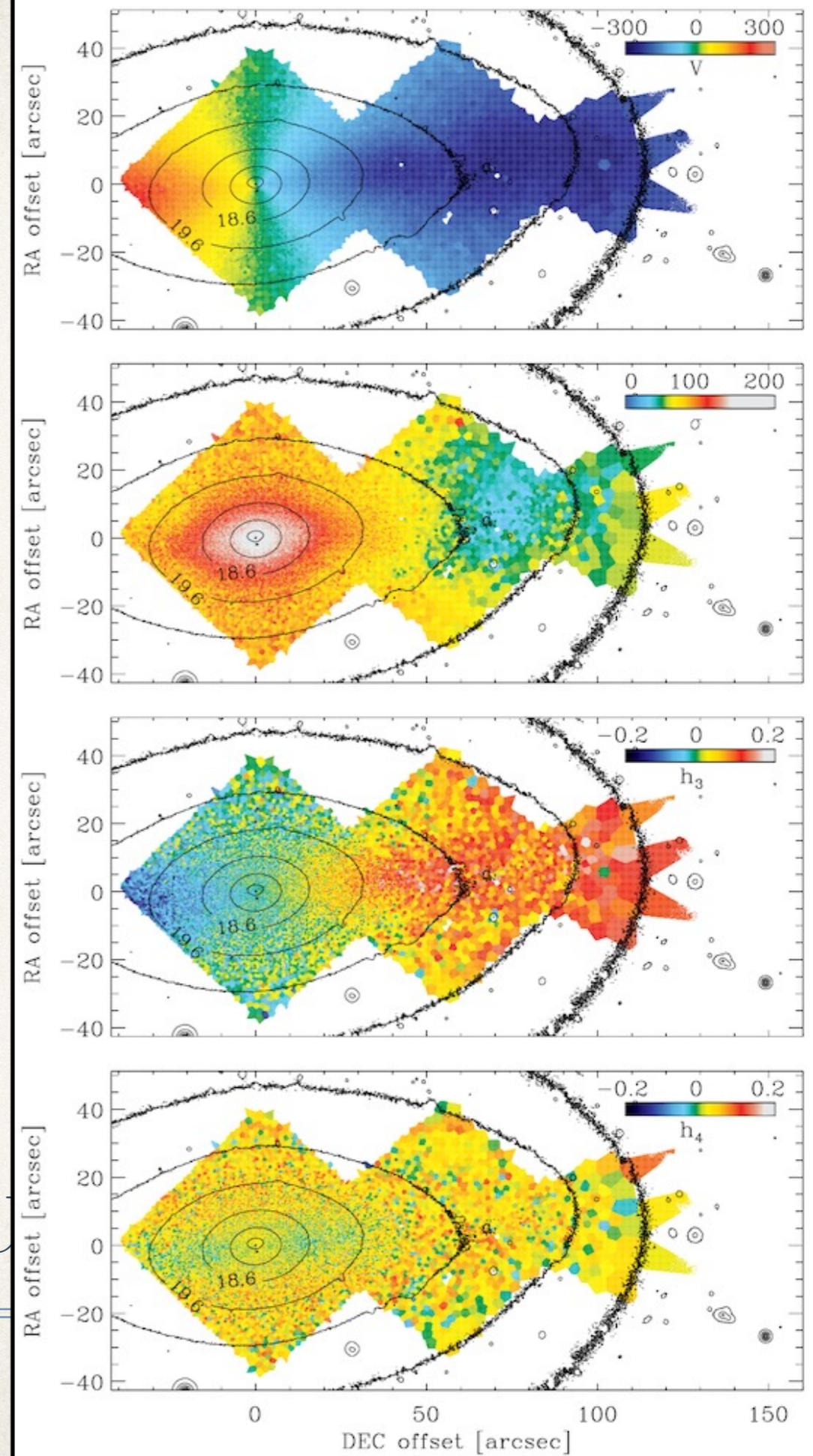
Fornax3D

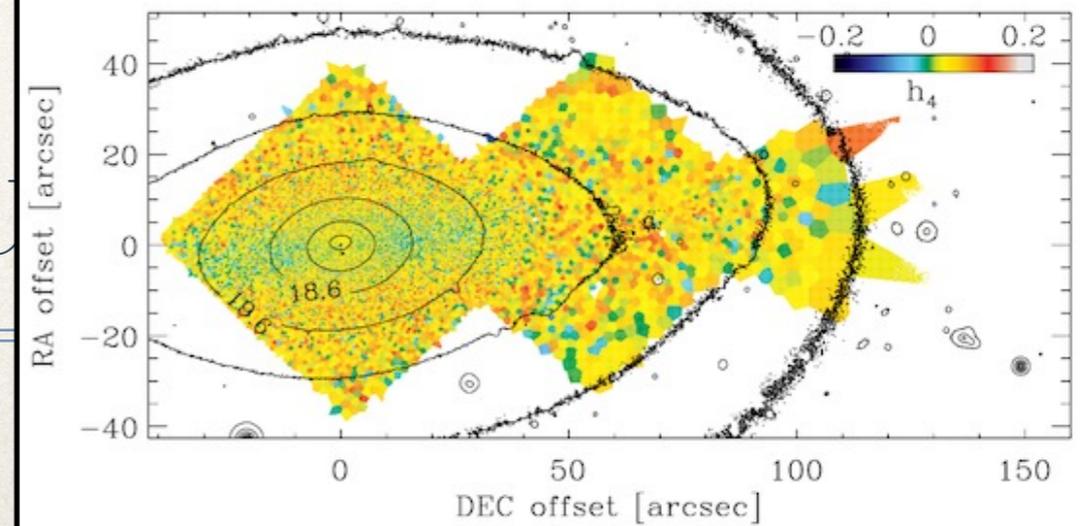
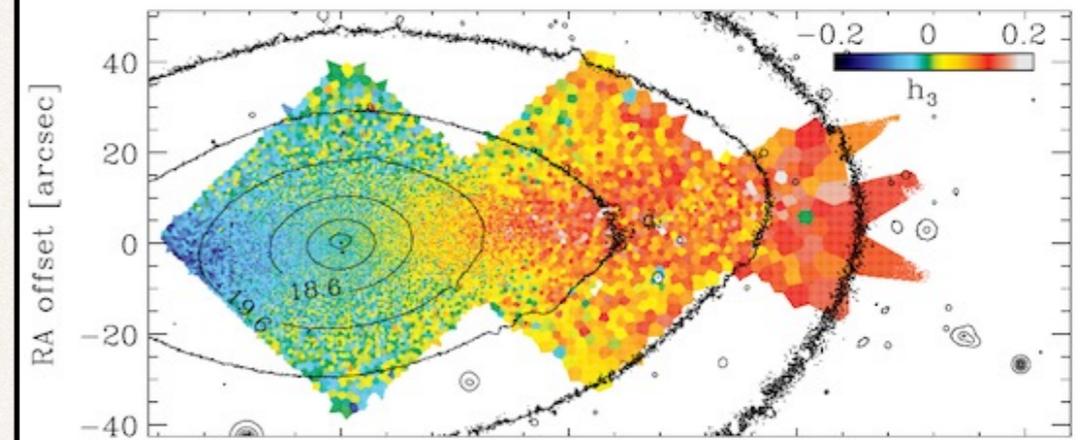
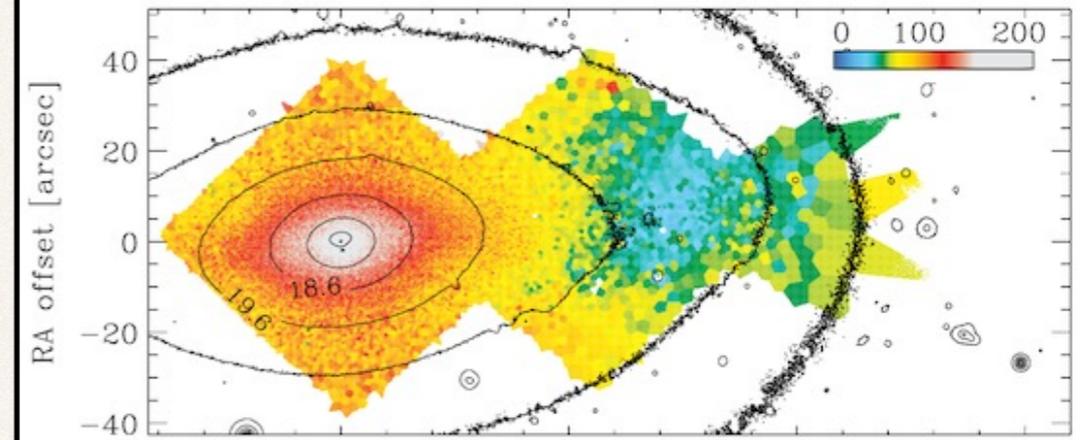
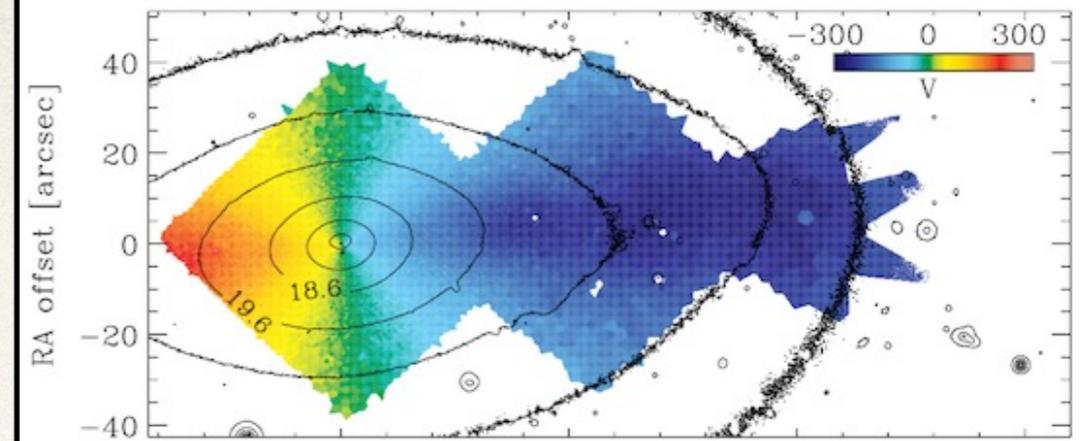
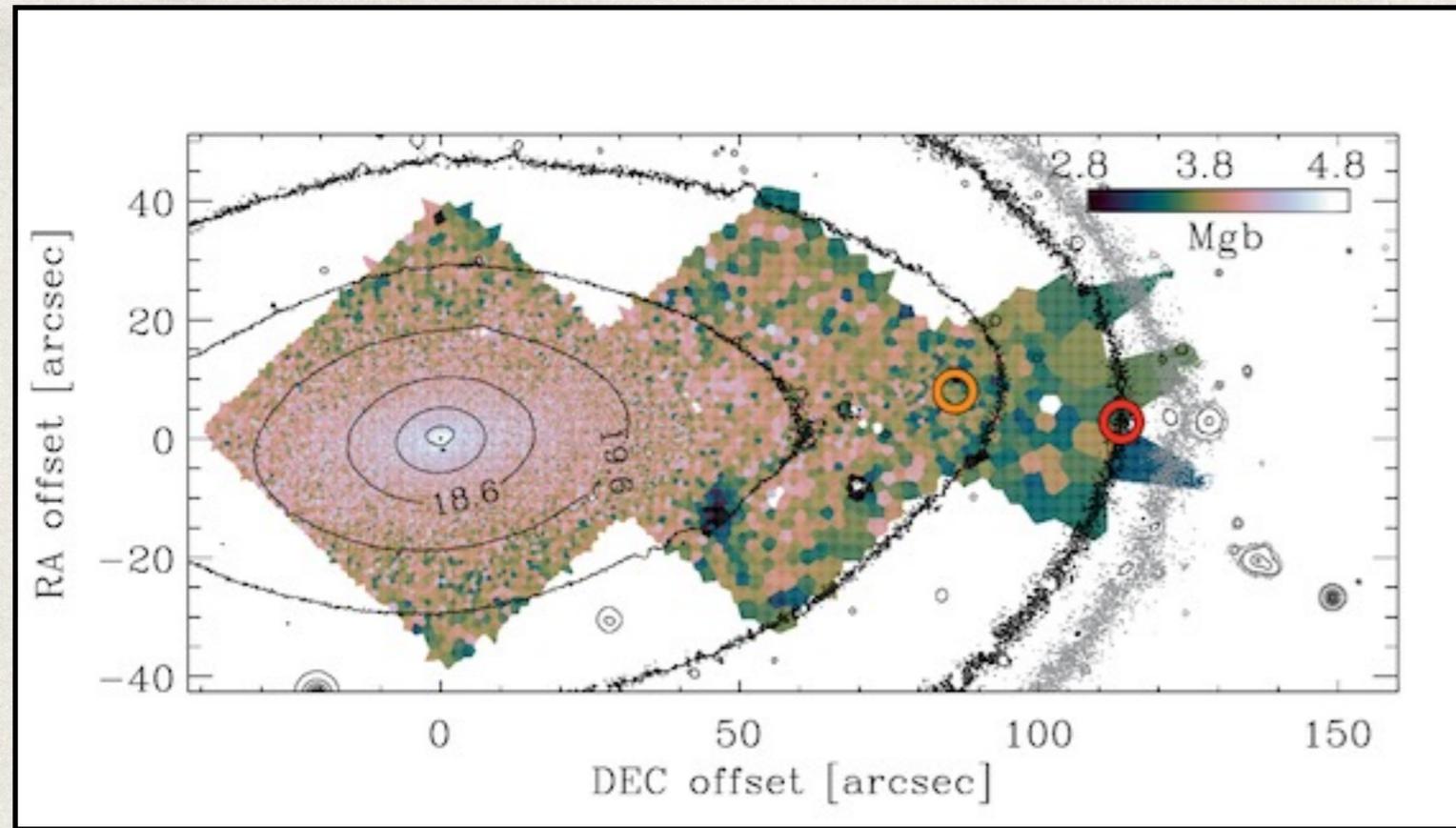
Fornax3D: some results

Sarzi et al. 2018

Fornax3D: some results

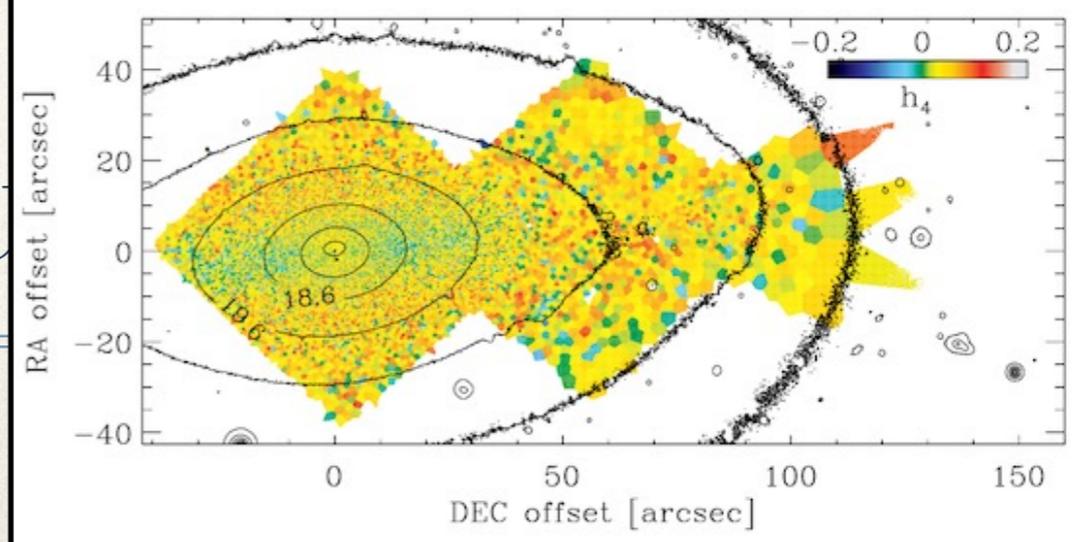
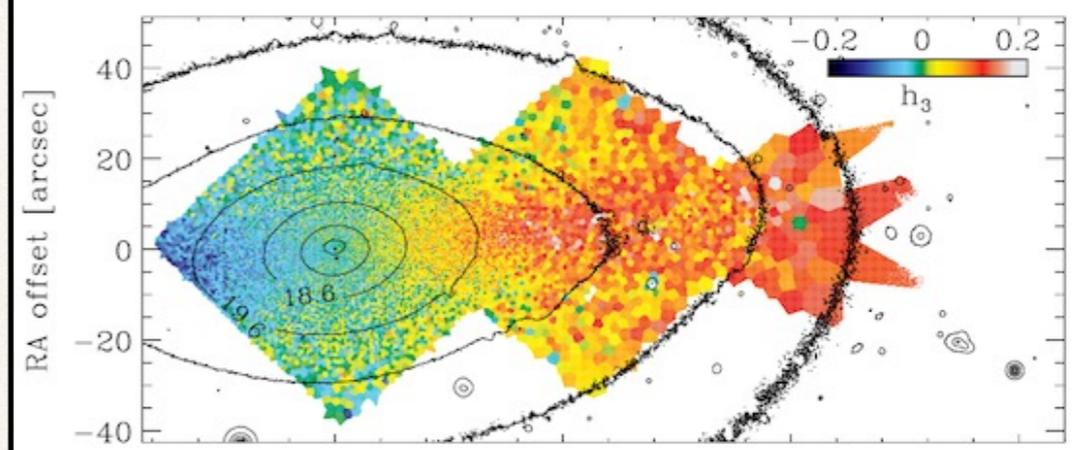
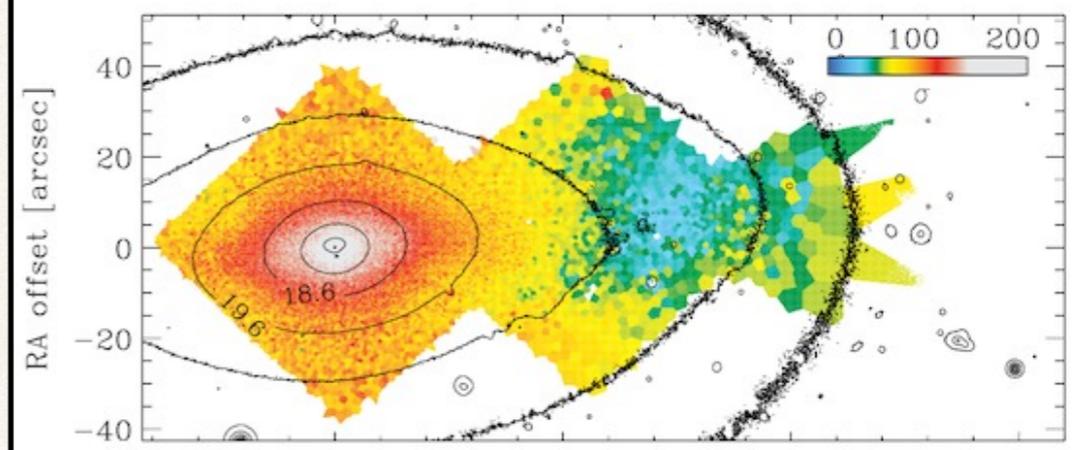
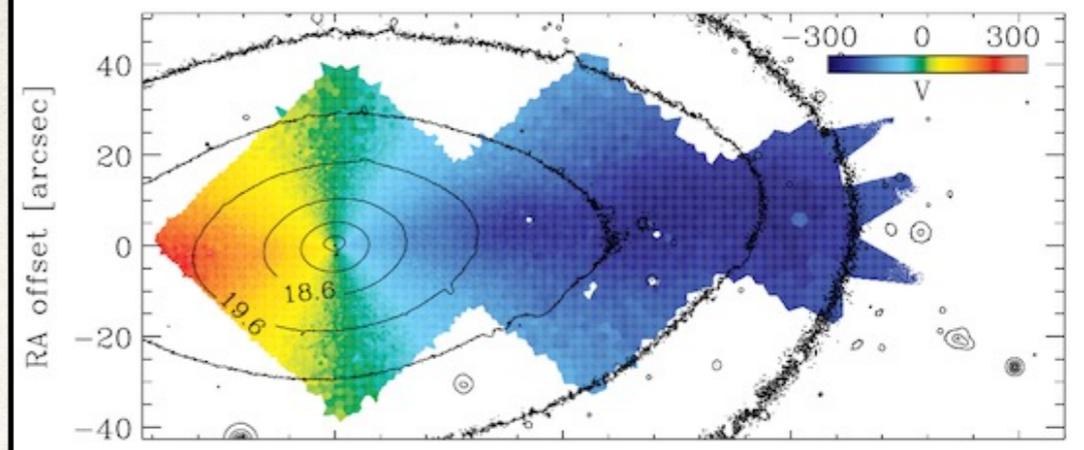
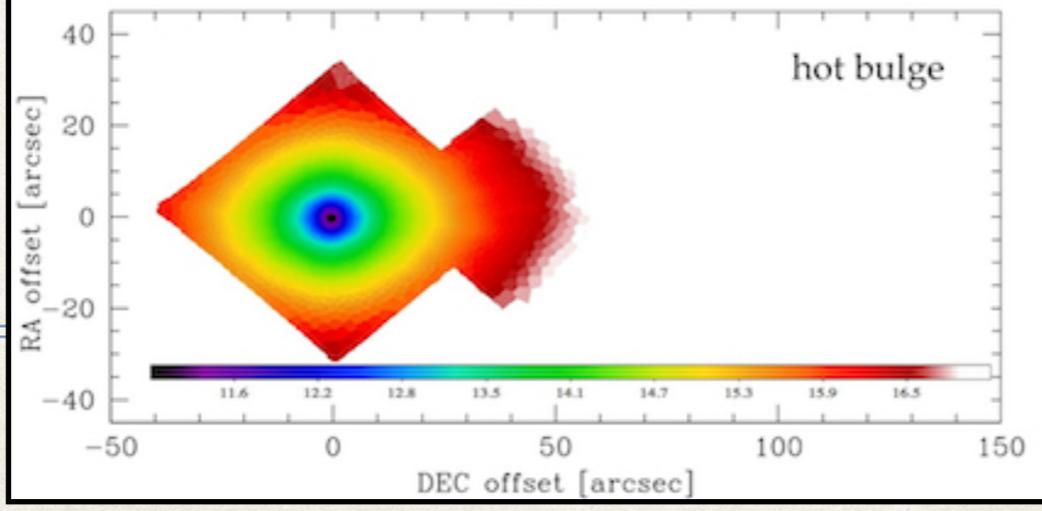
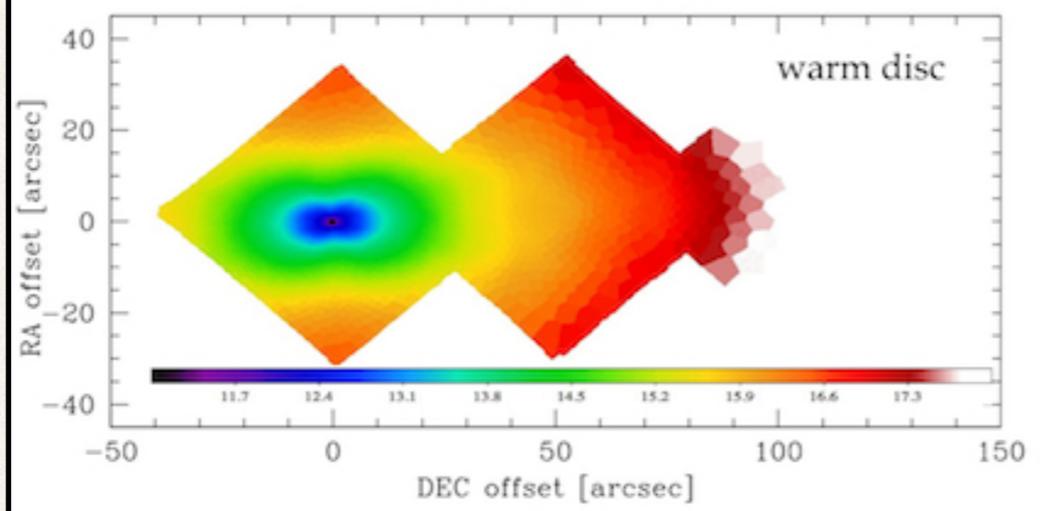
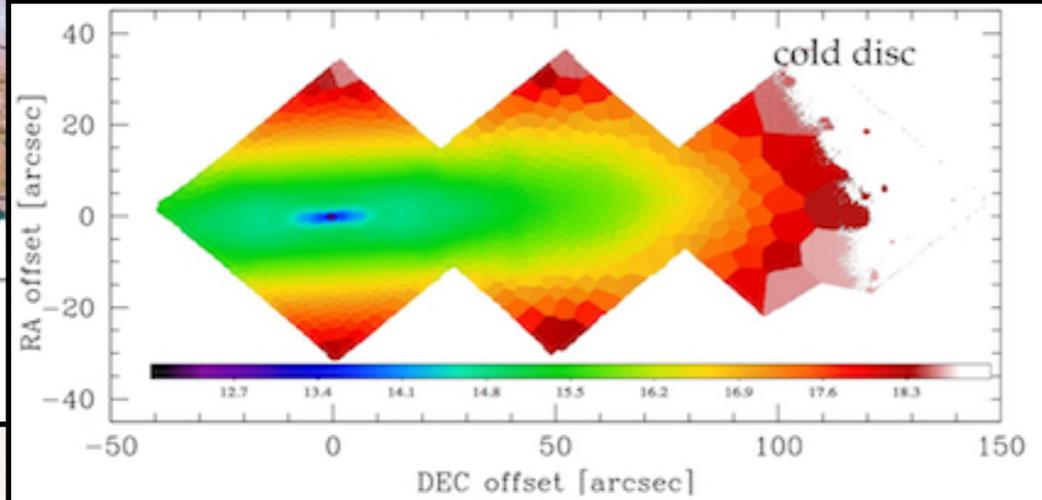
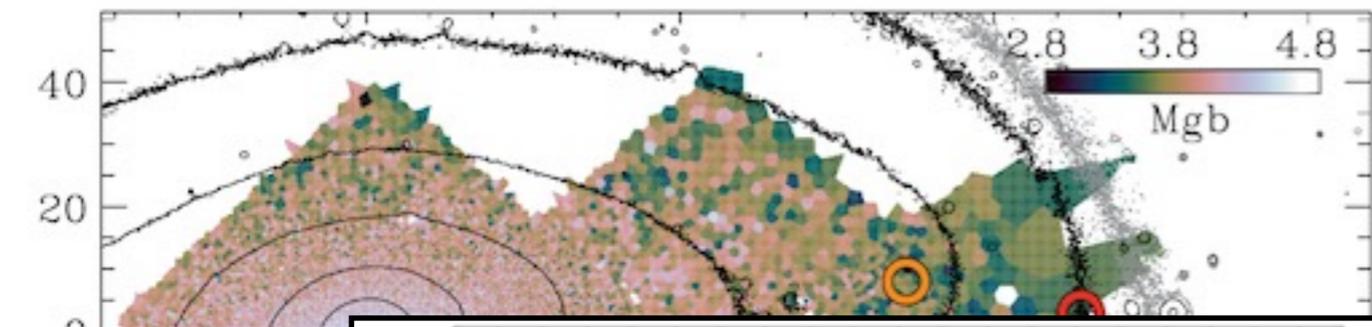
Sarzi et al. 2018





Fornax3D: some results

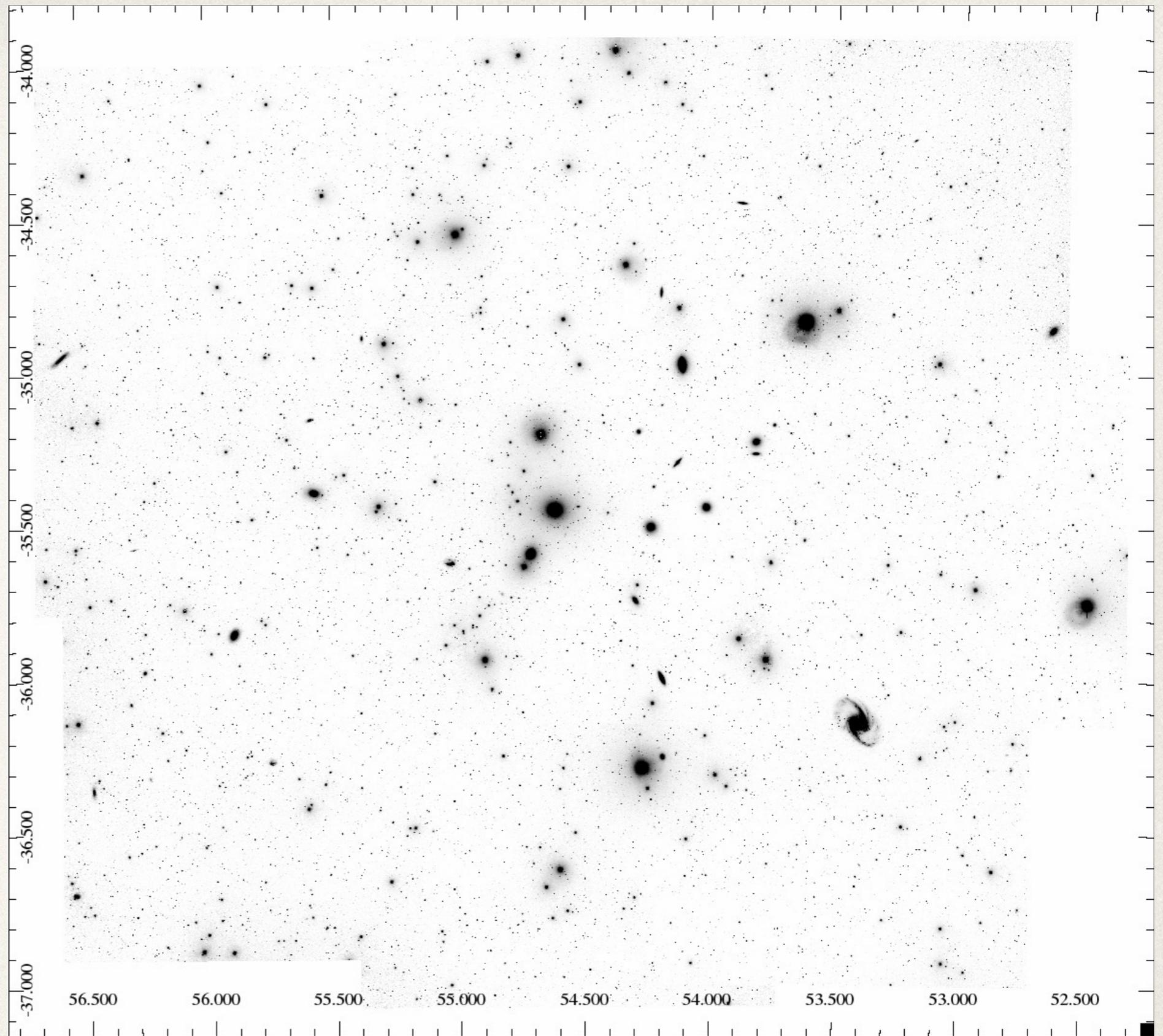
RA offset [arcsec]

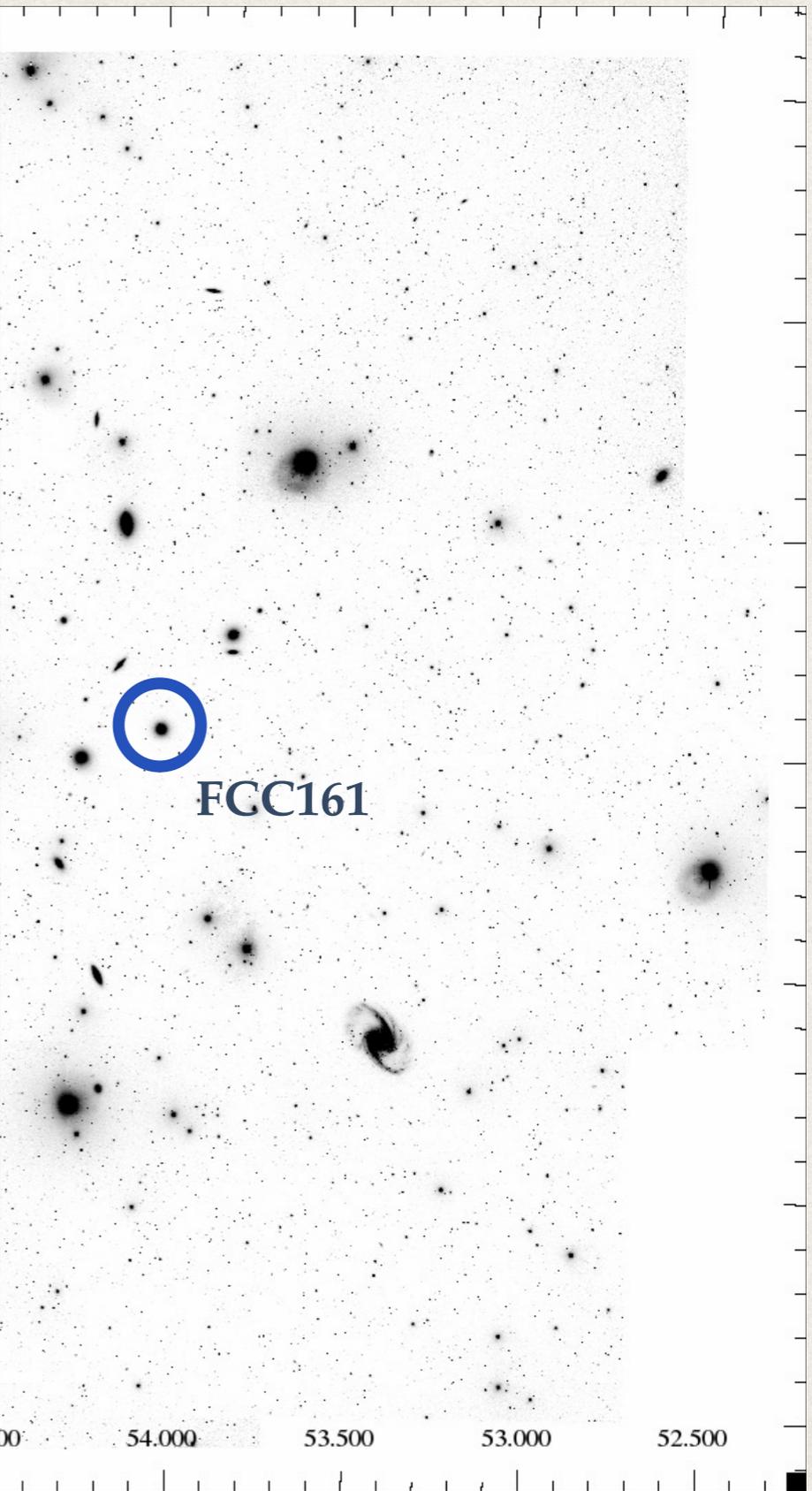
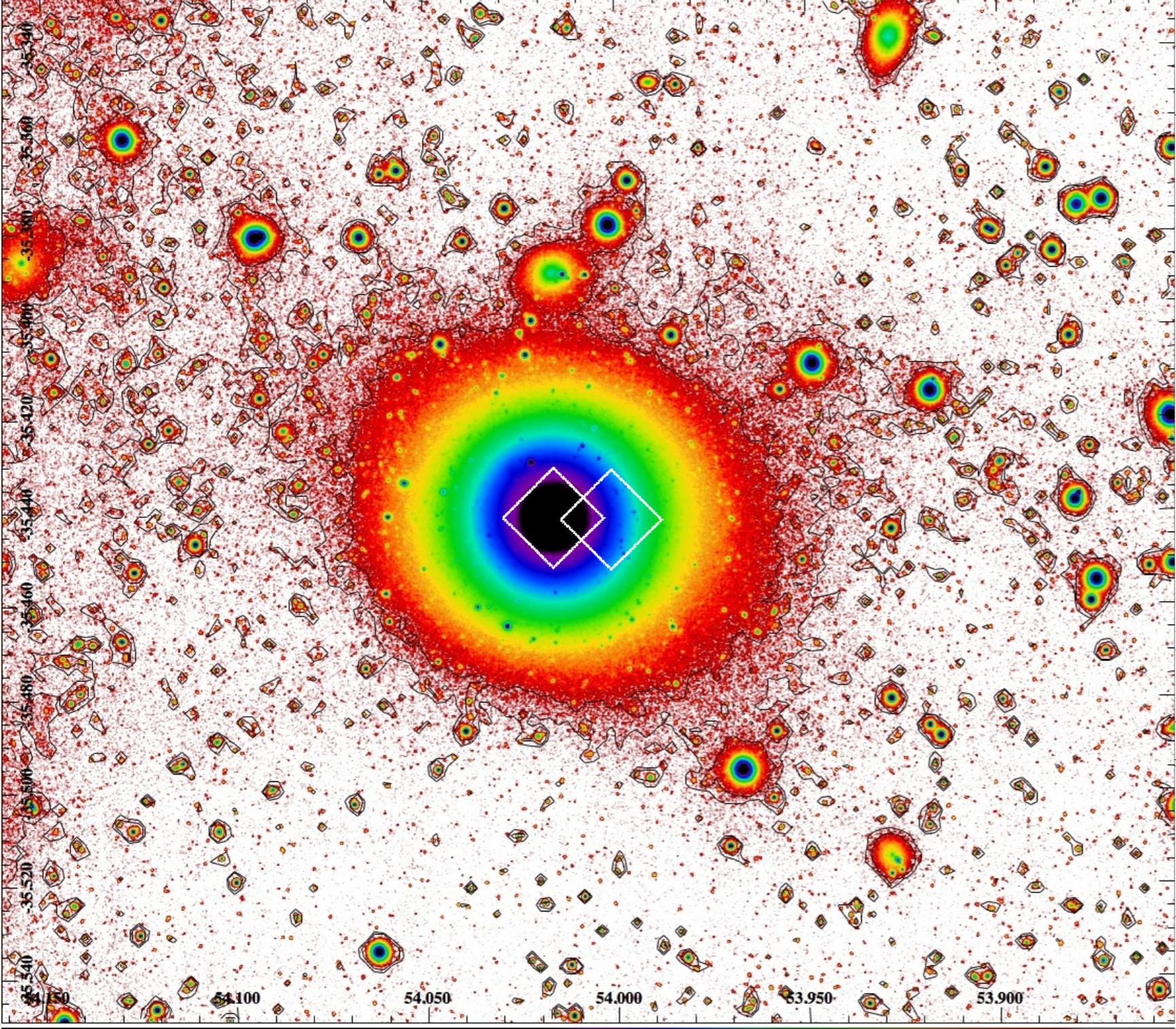


Forn

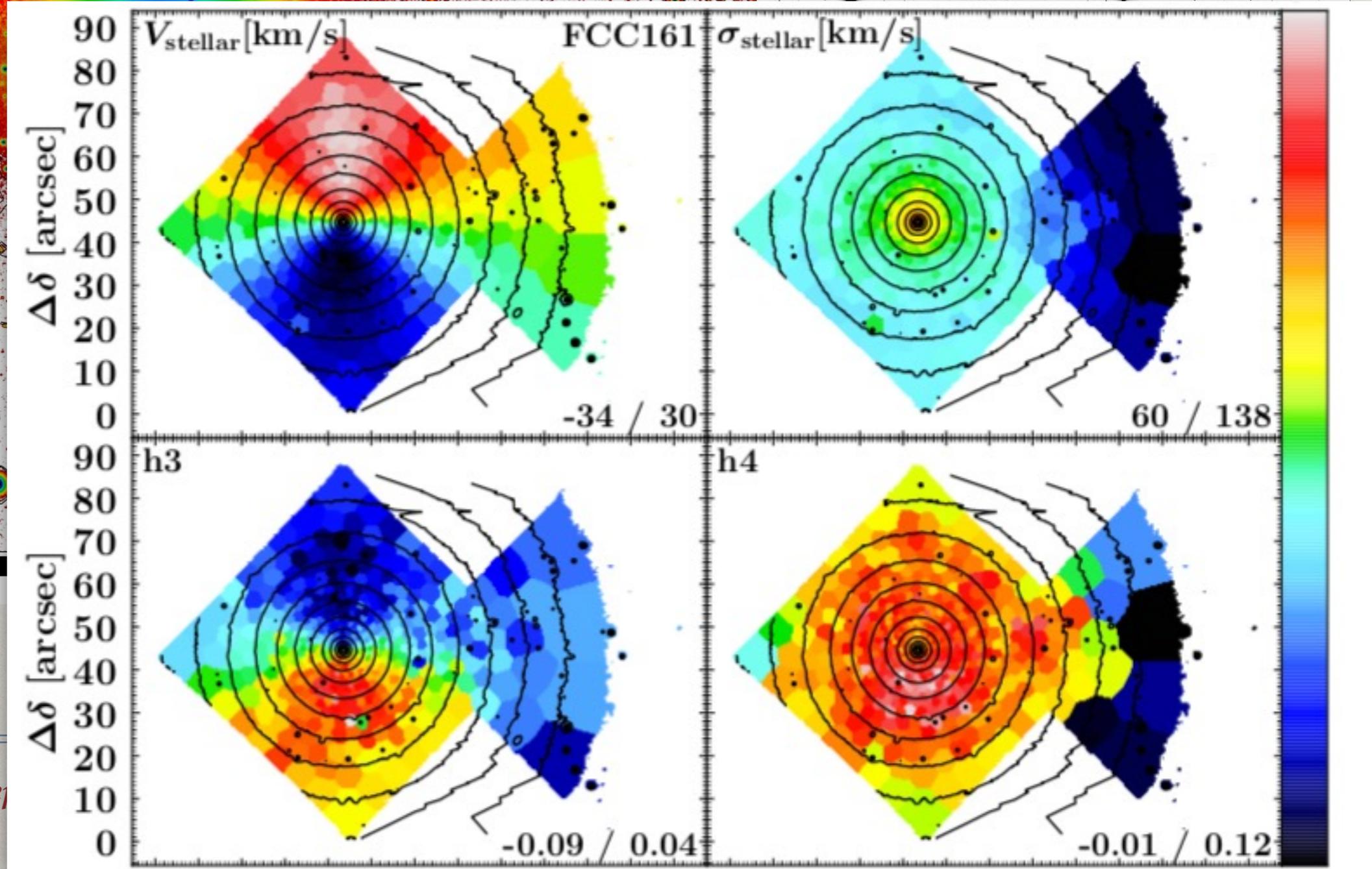
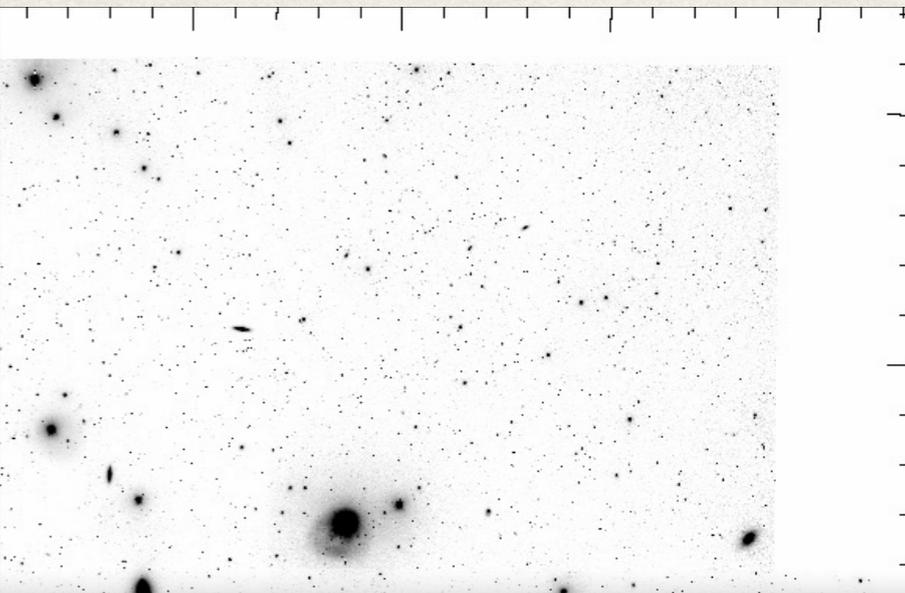
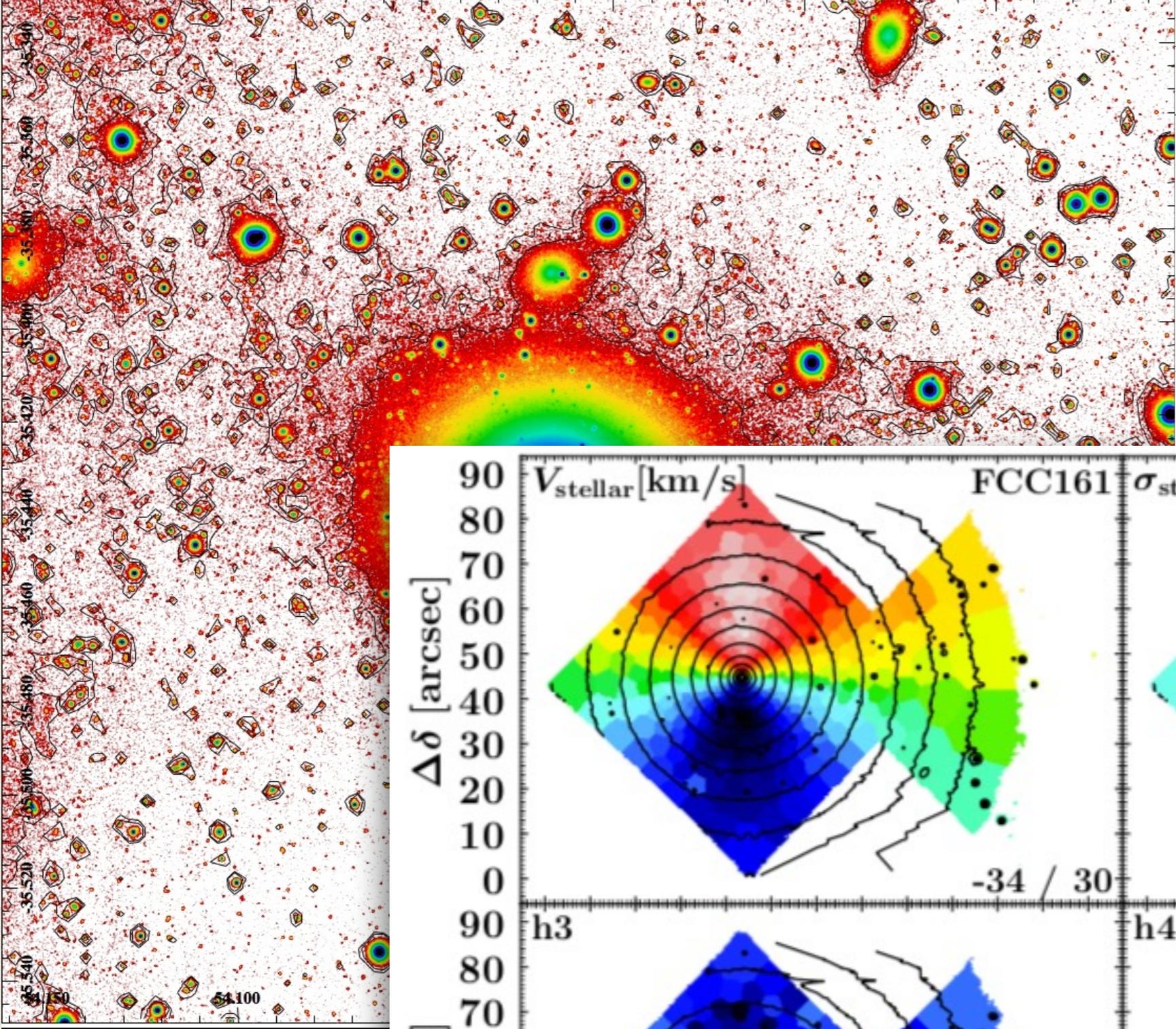
SU

Sarzi et al. 2018





Iodice et al. 2018, in preparation



Iodice et al. 2018, in prep