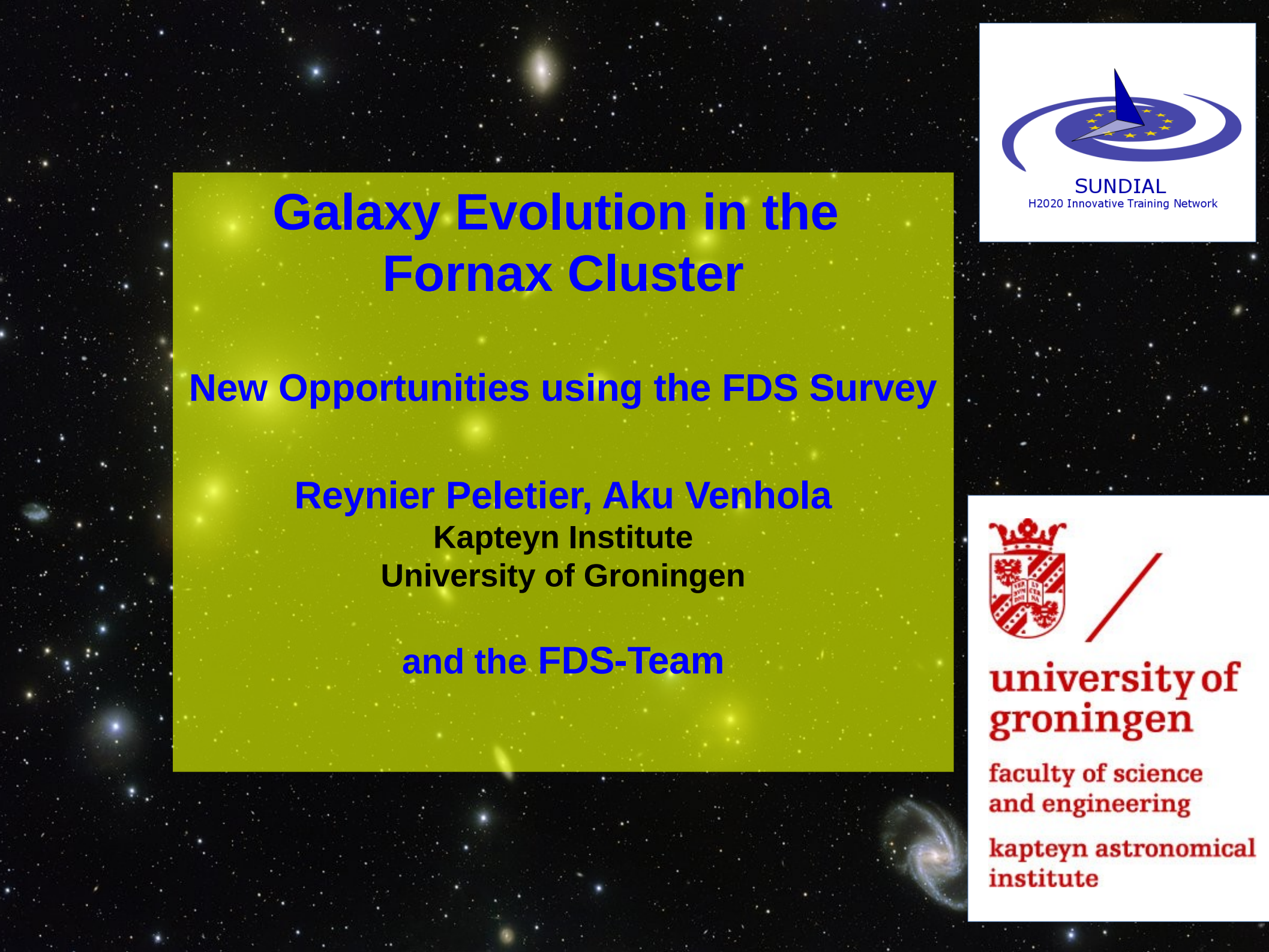


Galaxy Evolution in the Fornax Cluster

New Opportunities using the FDS Survey

Reynier Peletier, Aku Venhola
Kapteyn Institute
University of Groningen

and the FDS-Team

university of groningen

faculty of science and engineering

kapteyn astronomical institute

Contents of this talk:

1. Introduction

2. HI in the Fornax Cluster

3. The Fornax Deep Survey (FDS)

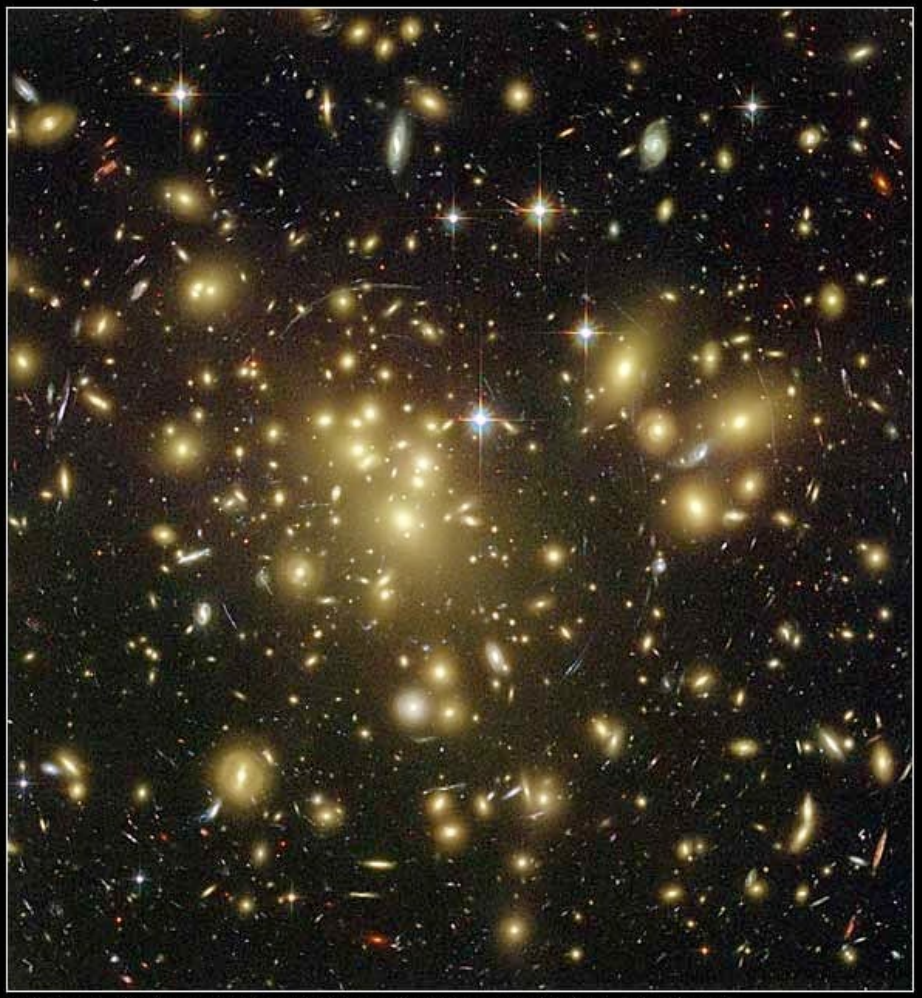
4. New science with FDS

Galaxies in “field” vs. “cluster”

Hubble Ultra Deep Field
Hubble Space Telescope • Advanced Camera for Surveys

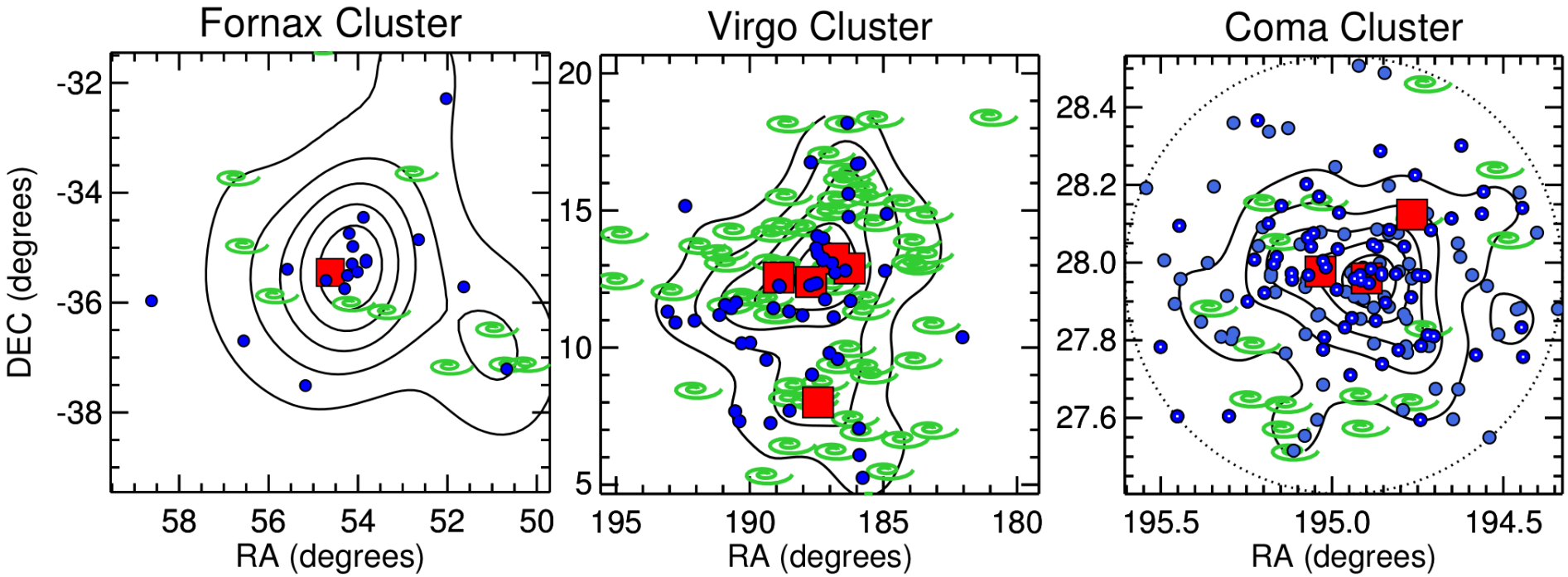
NASA, ESA, S. Beckwith (STScI) and the HUDF Team STScI-PRC04-07a

Galaxy Cluster Abell 1689 **HST** ▪ ACS



NASA, N. Benitez (JHU), T. Broadhurst (Hebrew Univ.), H. Ford (JHU),
M. Clampin(STScI), G. Hartig (STScI), G. Illingworth (UCO/Lick Observatory),
the ACS Science Team and ESA STScI-PRC03-01a

The strong morphology-density relation in nearby galaxy clusters shows that the environment is very important in shaping galaxies



(Cappellari 2016)

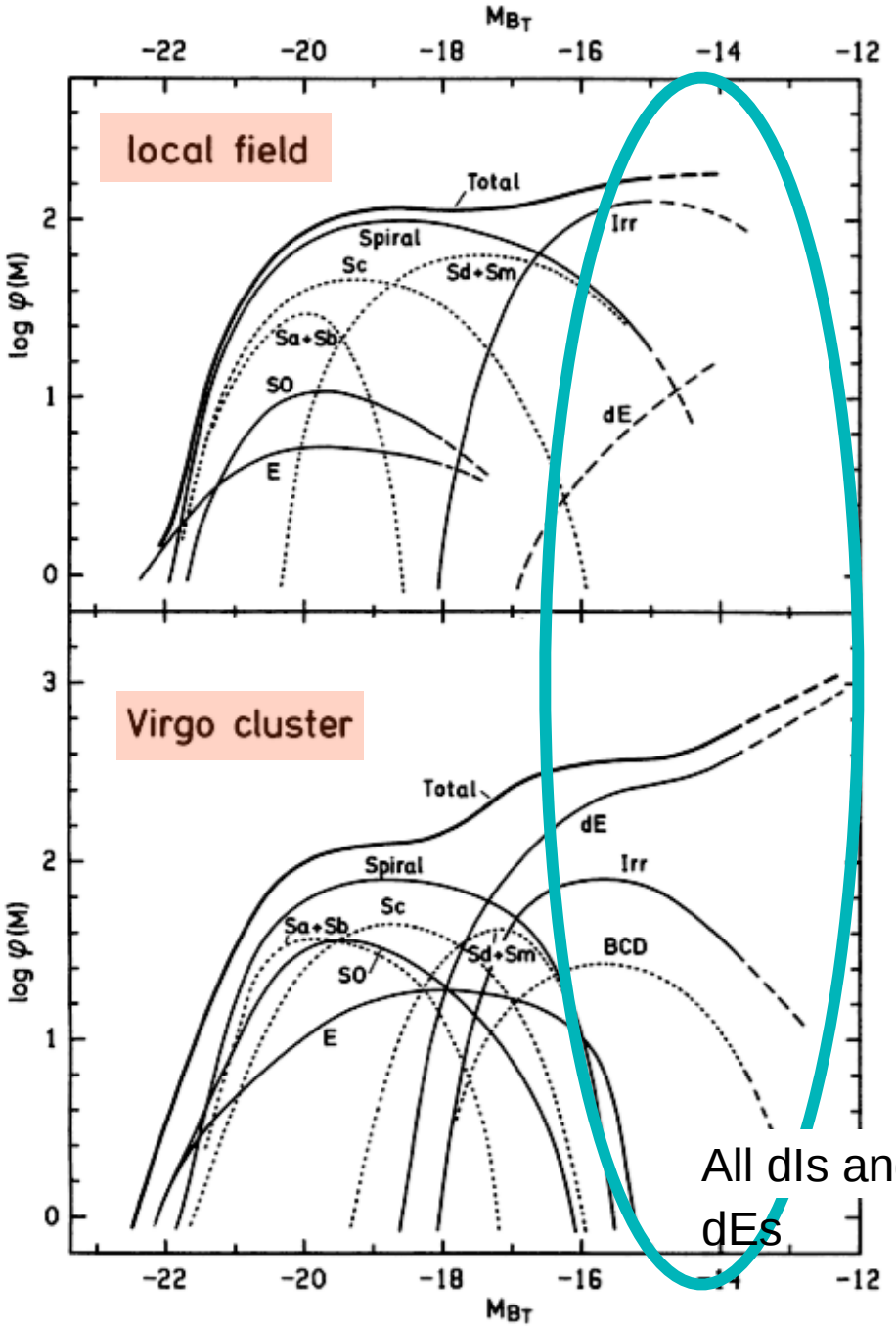
The Luminosity Function differs strongly between cluster and field

→ Dwarfs are excellent probes to study the role of the environment on the evolution of galaxies

– Dwarfs are faint, so need to be studied in the nearby Universe

– Largest nearby clusters: Virgo and Fornax. Virgo is being studied using the NGVS survey (Ferrarese et al. 2012).

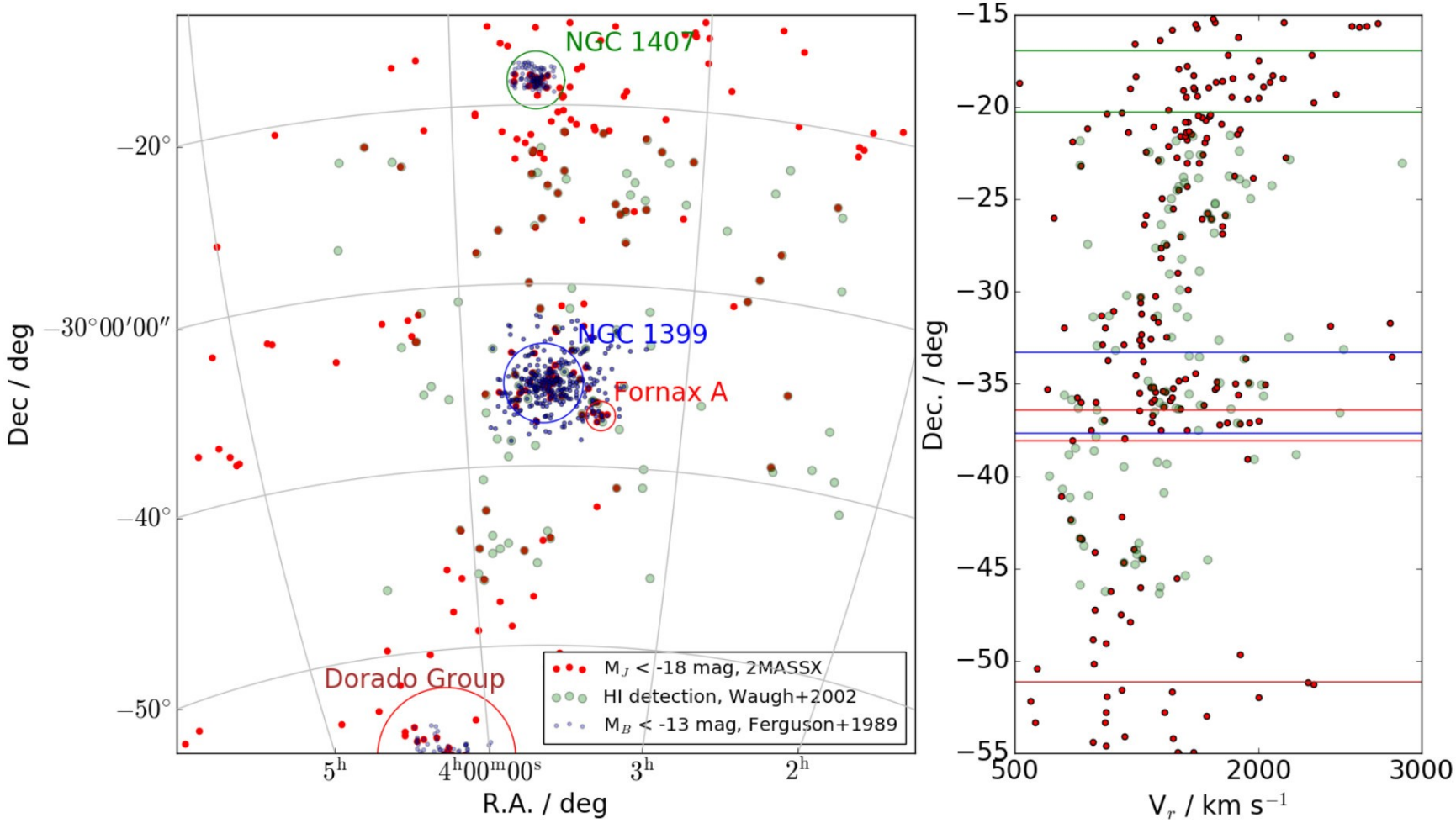
– For Fornax we have set up the **Fornax Deep Survey (FDS)**



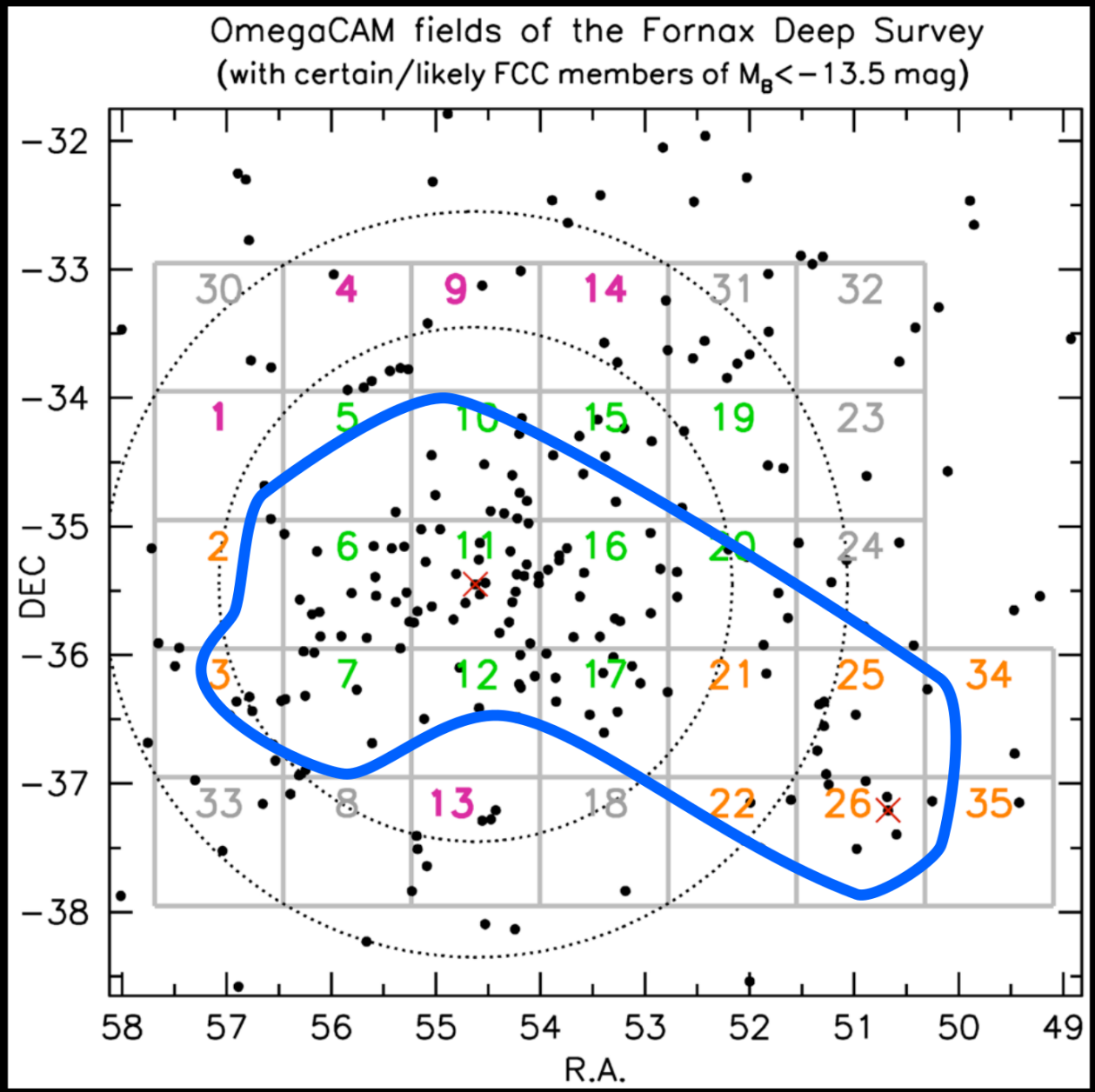
Binggeli, Sandage, Tammann ARAA (1988) ARAA ,26, 509

HI in the Fornax Cluster

Large Scale Structure around the Fornax Cluster

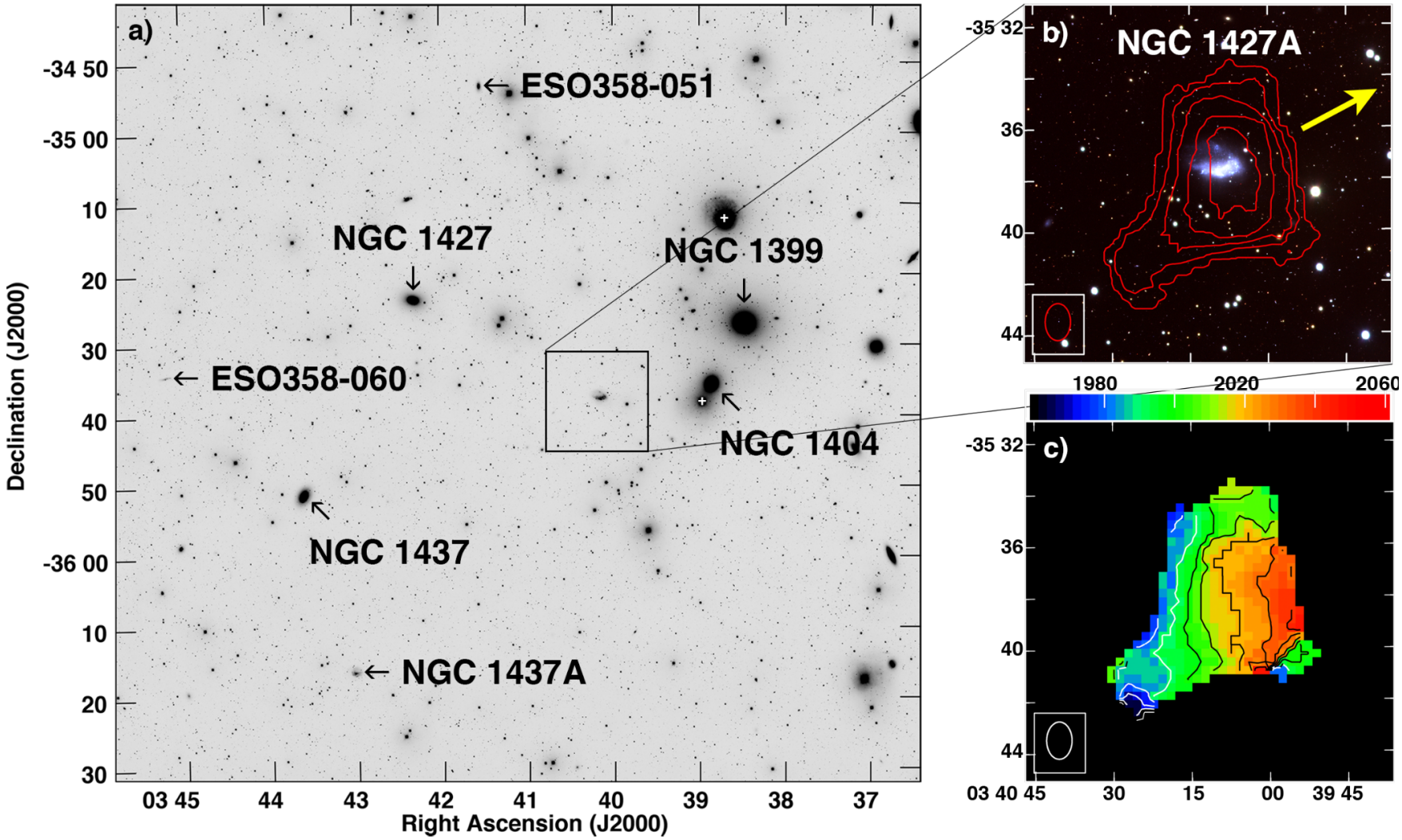


The Meerkat Fornax Survey (P.I. P. Serra)

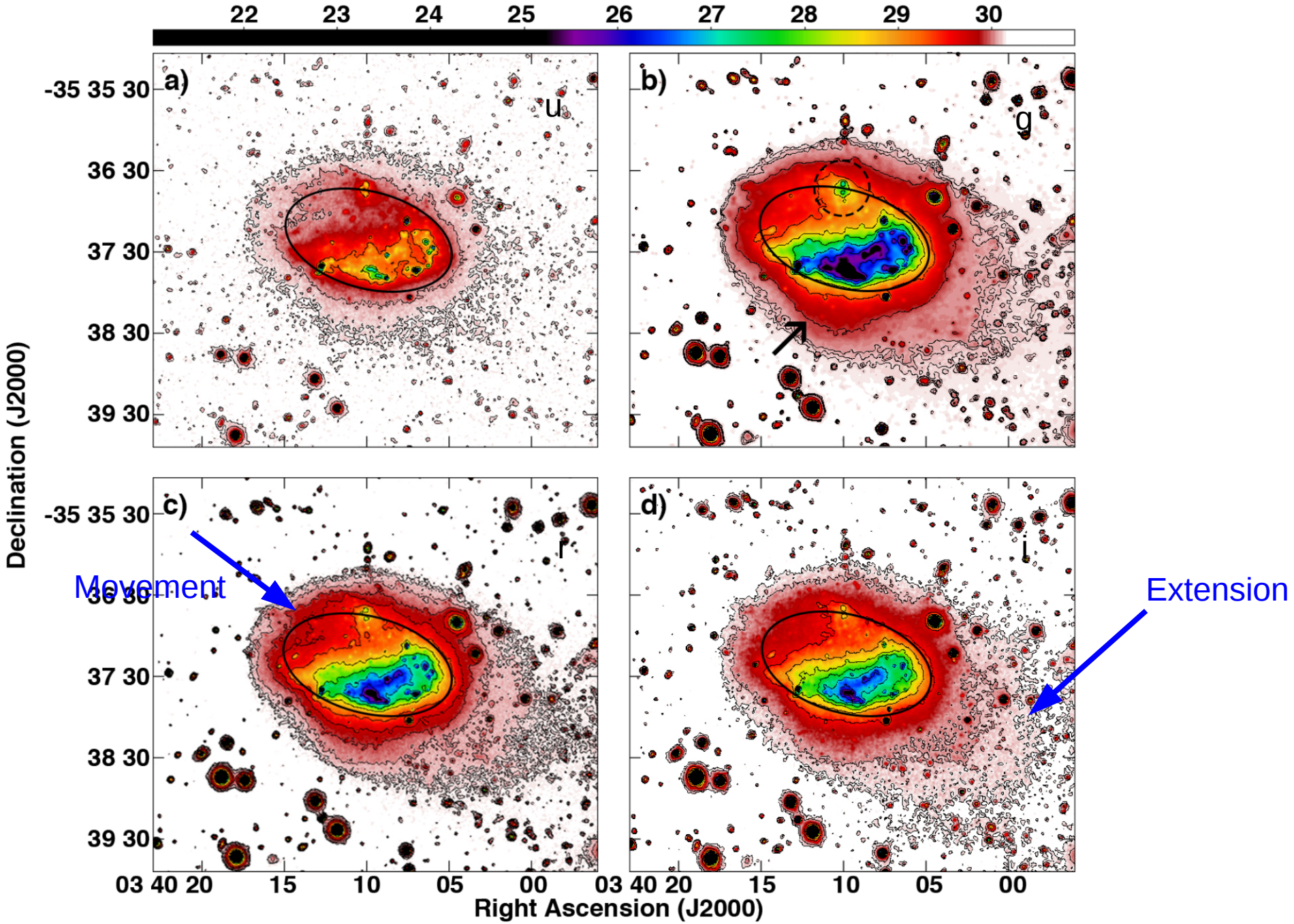


Blue: HI coverage (Meerkat)

Ram pressure in action?



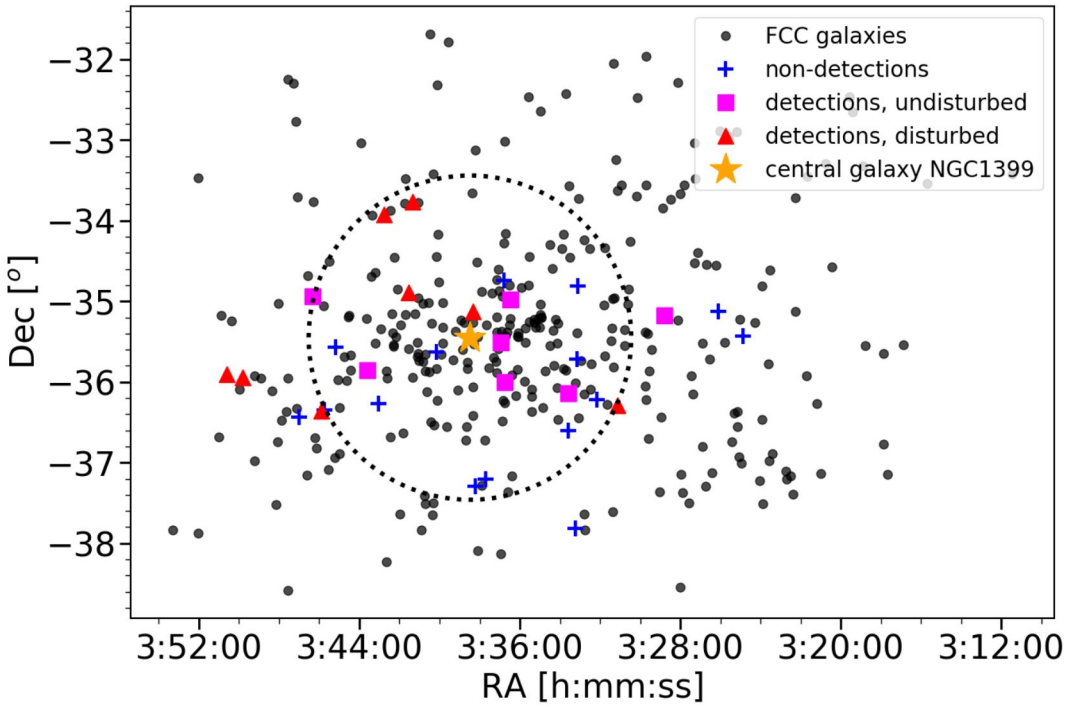
Lee-Waddell, Serra, Koribalski, Venhola, … (+ Peletier) 2018 - ATCA

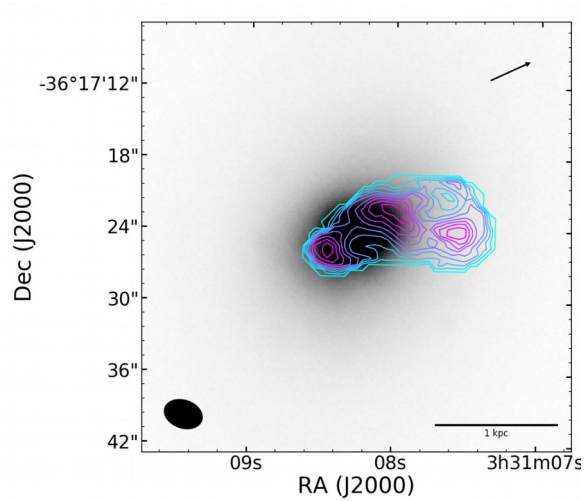


Extension on side towards which the galaxy should move argues against ram pressure stripping!

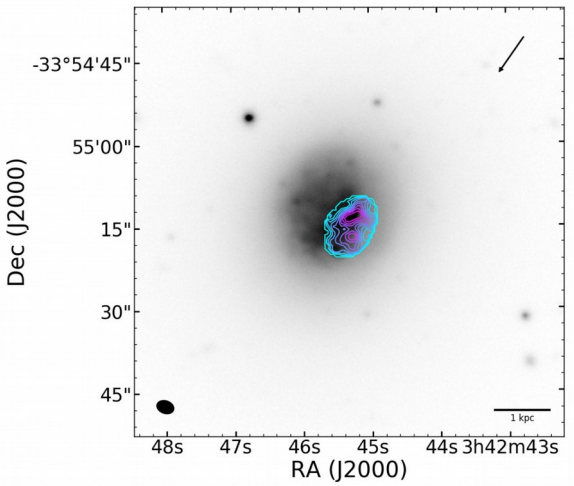
ALFOSC – CO survey of galaxies in Fornax (with ALMA)

Zabel, Davis, …, Peletier, Venhola, …, in preparation





(a) MCG-06-08-024

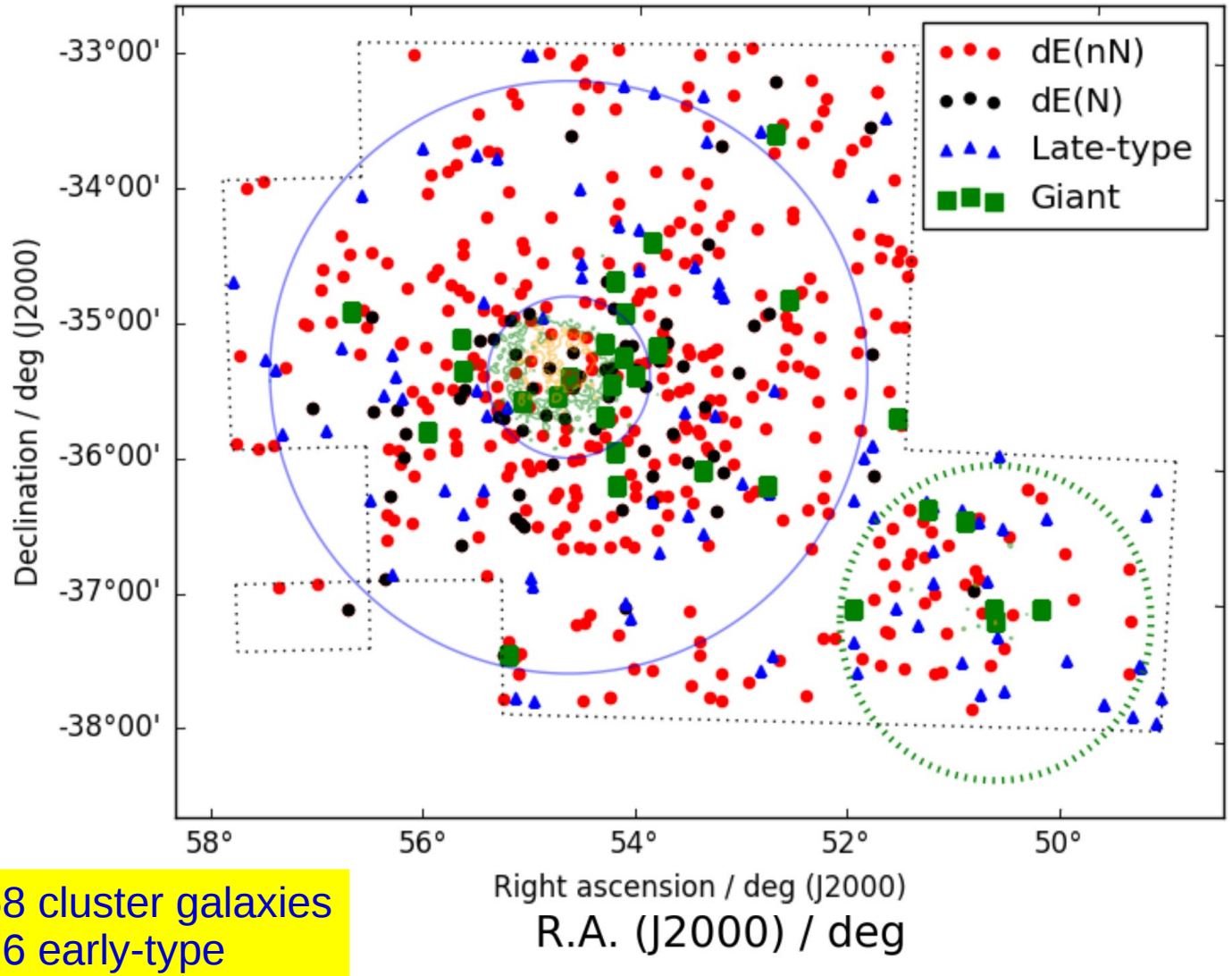


(c) FCC282

To take away from this:

Optical data fundamental to understand gas processes!

The FDS Fornax (Ultra)deep Survey ESO/2.6m VST



INTEGRATION TIMES

u' – 11000s
g' – 8000s
r' – 8000s
i' – 5000s

DEPTH (SB, 1σ)

U' – 28.0 mag arcsec^{-2}
G' – 28.6 mag arcsec^{-2}
R' – 28.1 mag arcsec^{-2}
I' - 27.2 mag arcsec^{-2}

668 cluster galaxies
476 early-type
192 late-type

ASTRO WISE

FDS: Observations finished Nov 2017, data reduction finished March 2018 by Aku Venhola;
NGC 1316 (Fornax A) area reduced by VSTTUBE (Naples), Data release: April 2019

The Fornax Deep Survey

Collaboration based on VST OmegaCAM GTO time of

NOVA/
Kapteyn

university of groningen
faculty of science and engineering
kapteyn astronomical institute

and

INAF/
Oss.
Capodimonte
Naples

PI's: **Peletier** (Kapteyn) and **Iodice** (INAF-OAC)

FDS Core Members

Massimo Capaccioli

Raffele D'Abrusco

Aniello Grado

Jesus Falcon Barroso

Michael Hilker

Thorsten Lisker

Steffen Mieske

Nicola Napolitano

Maurizio Paolillo

Marilena Spavone

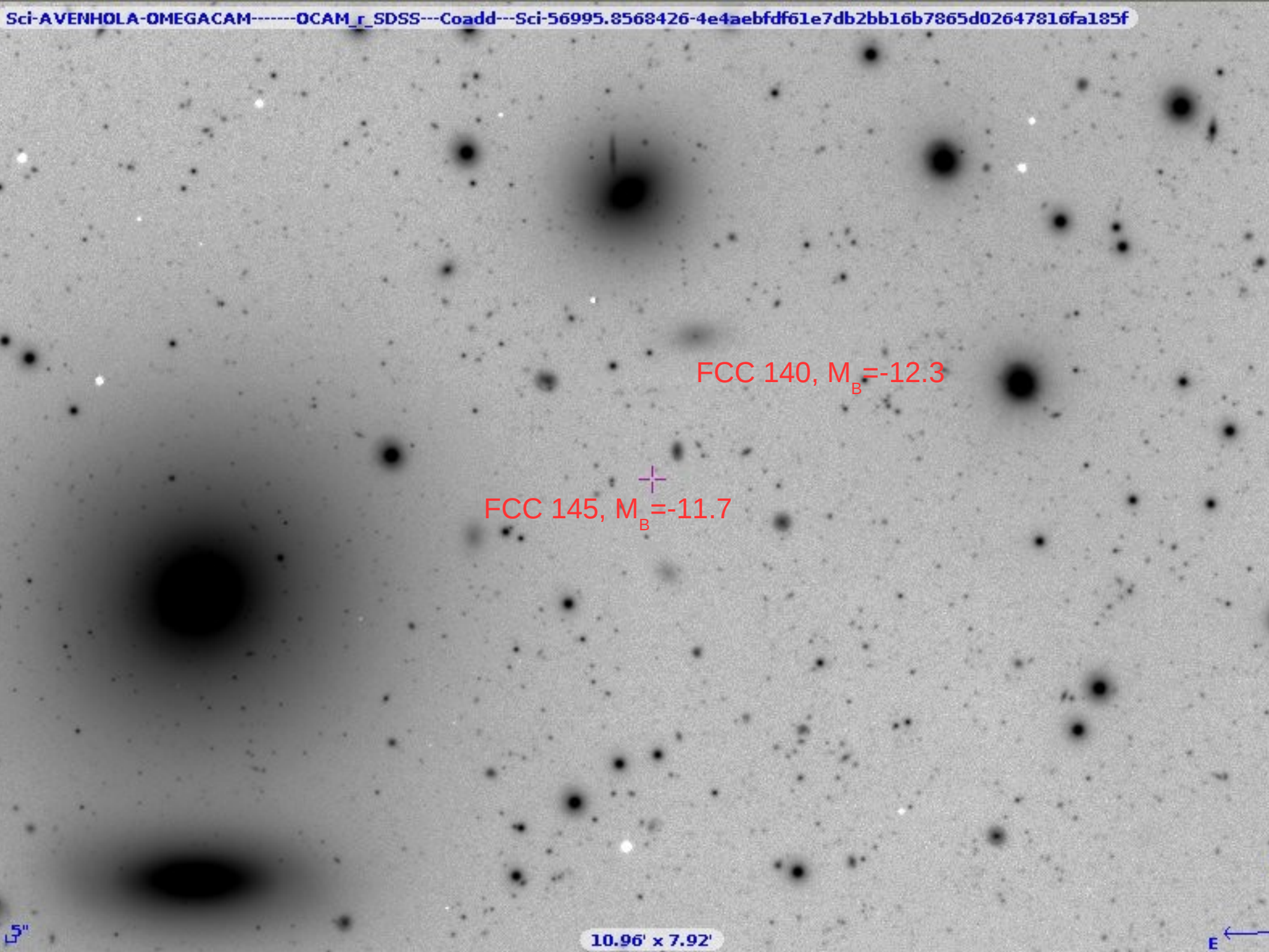
Edwin Valentijn

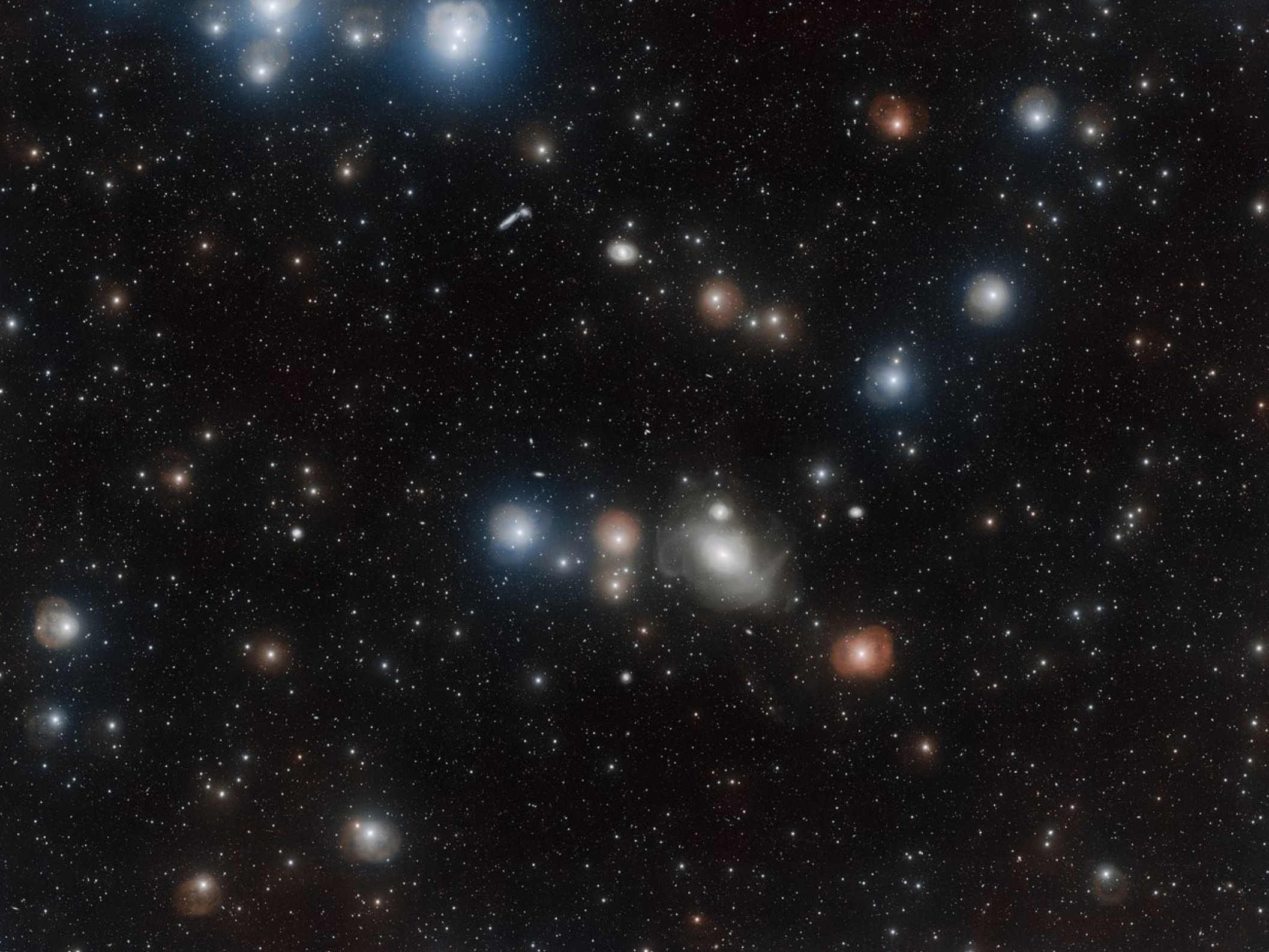
Glenn van de Ven

Aku Venhola

Gijs Verdoes Kleijn

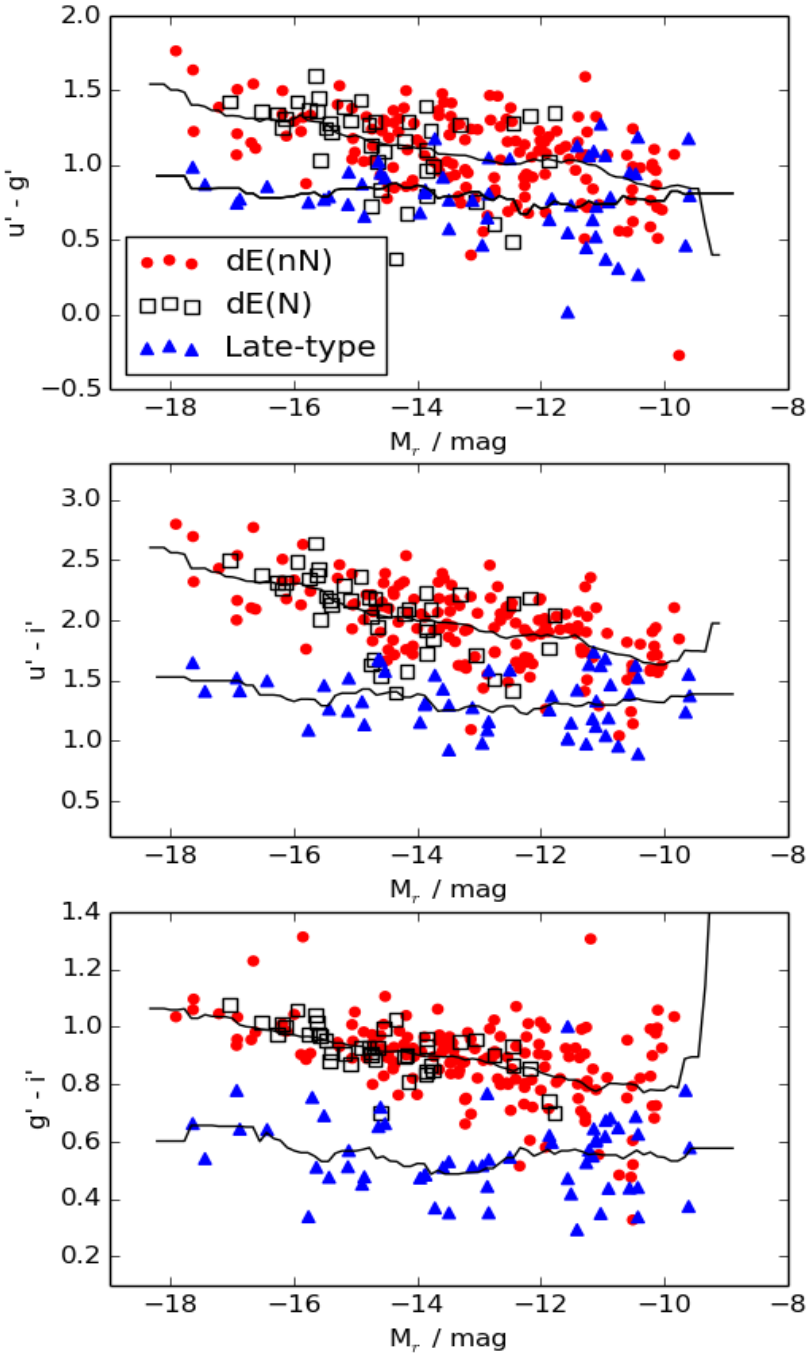
Carolin Wittmann


Sci-AVENHOLA-OMEGACAM-------OCAM_r_SDSS---Coadd---Sci-56995.8568426-4e4aebfdf61e7db2bb16b7865d02647816fa185f
FCC 140, M_B=-12.3
FCC 145, M_B=-11.7
5"
10.96' x 7.92'
E



Some new science with FDS

The Color-Magnitude Relation in Fornax (FDS)



Questions:

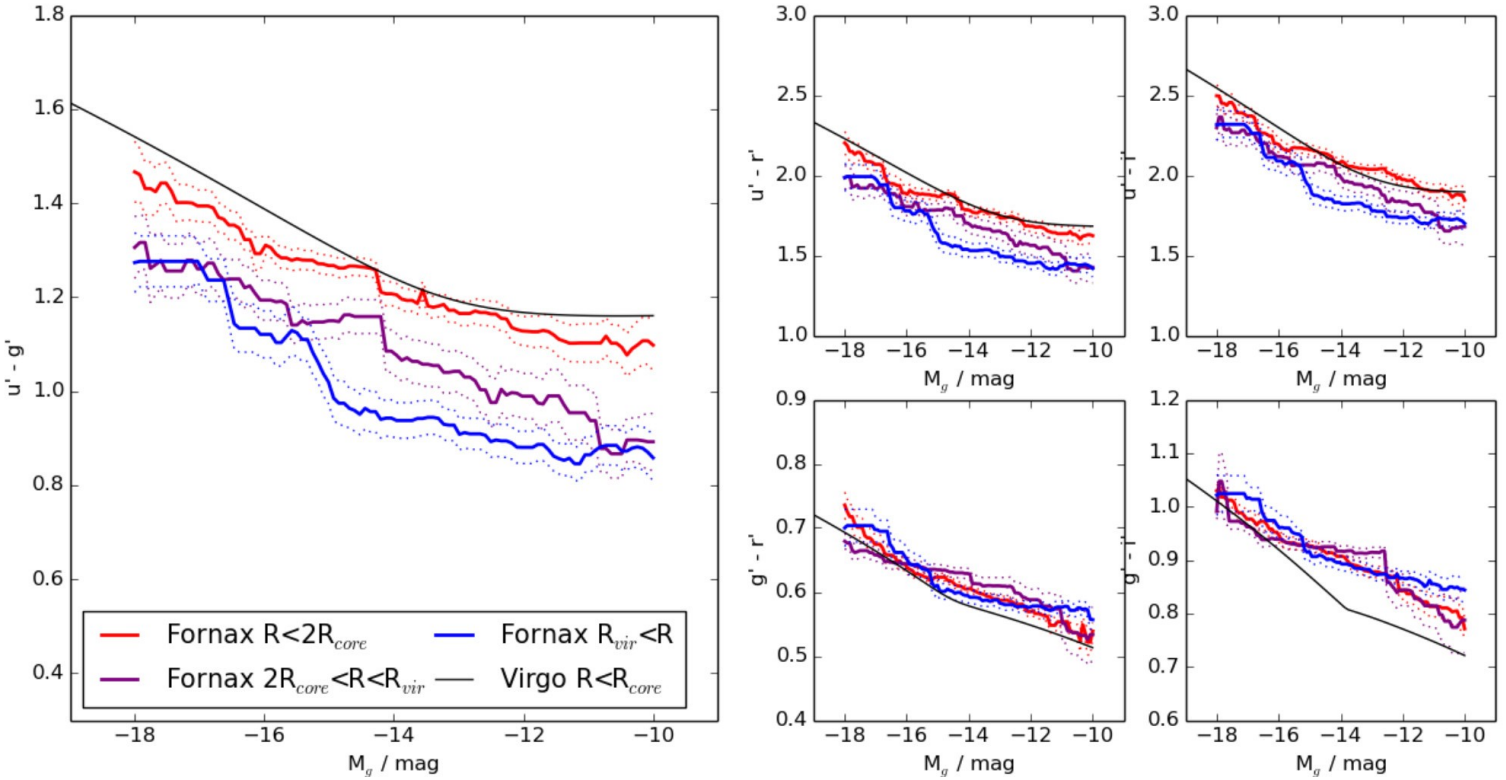
- What is the scatter along the CM relation, how many objects still need to reach the red sequence?

The cluster shows a tight CM relation, becoming less tight towards fainter magnitudes, similar to Virgo. The scatter seems, however, larger, although here we are comparing the whole Fornax Cluster with the center of Virgo.

- What is the fraction of galaxies below (young) and above (compact) the red sequence?

A few compacts above the relation, but many more irregular dwarfs (classified morphologically) than in Virgo. But again, we compare the whole Fornax Cluster with the center of Virgo.

The Color-Magnitude Relation – Comparison with Virgo



Questions:

- What is the shape of the CM relation? Roediger et al. Claim it is an S-shape. Why this shape?

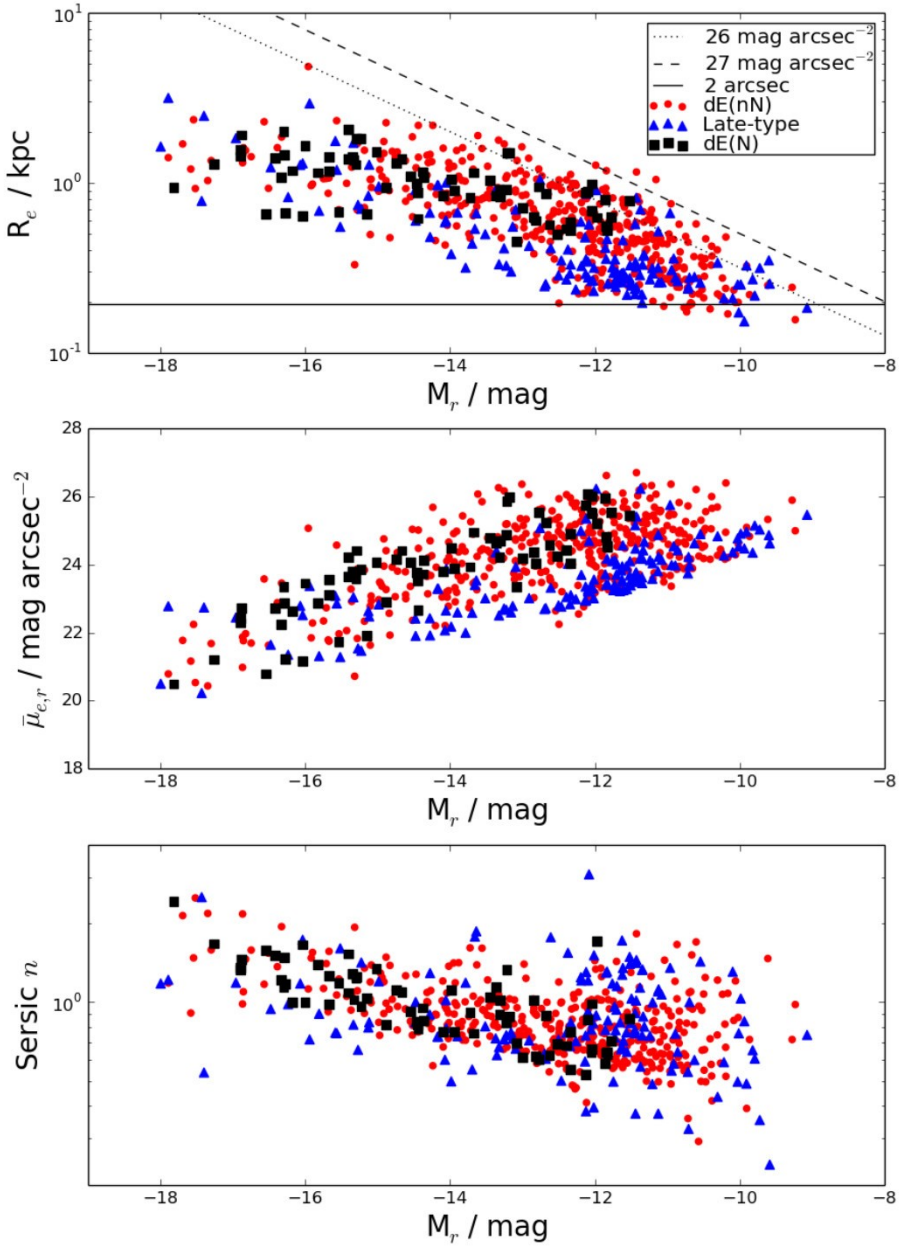
In Fornax we see the same shape.

Questions:

- How does the CM relation change as a function of environment?

It becomes slightly bluer from inner to outer parts (probably due to a combination of age and metallicity.

Kormendy Relations in Fornax

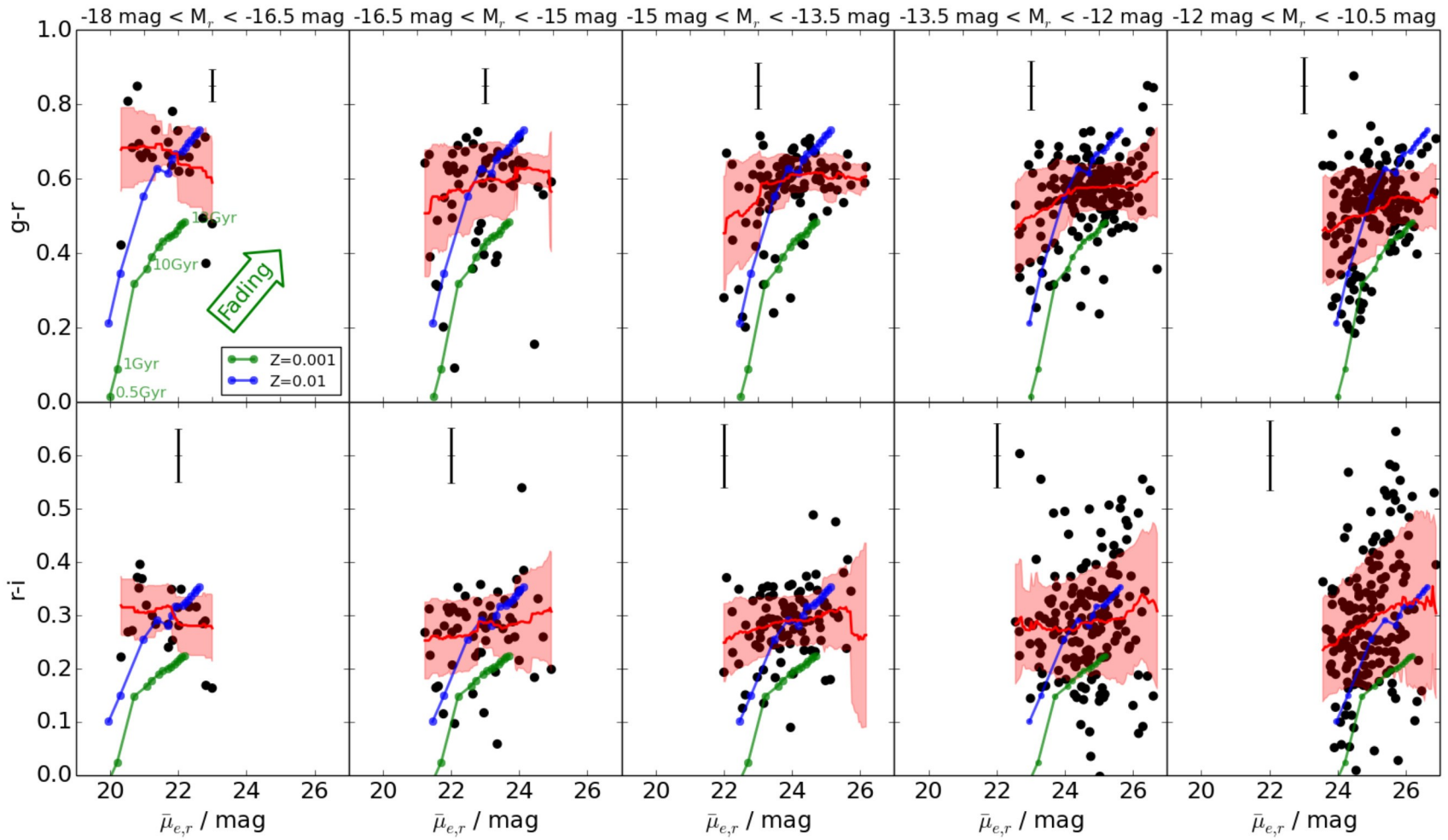


- Dwarf galaxies in Fornax show tight scaling relations, consistent with other clusters.

- Nucleated and non-nucleated dwarfs show similar behavior

- Irregular dwarfs behave differently from dwarf ellipticals, being smaller, and having higher surface brightness, but with similar Sersic indices. This is consistent with a picture that these irregulars fade into dwarf ellipticals, once their gas has been removed.

Scaling Relations as a function of magnitude



Lines show a galaxy fading (using MILES models with time changing along the line). Different colors indicate different metallicities.

Brighter dwarfs: Ram Pressure Stripping seen in action

Fainter dwarfs: Consistent with fading of Infalling dwarf irregulars

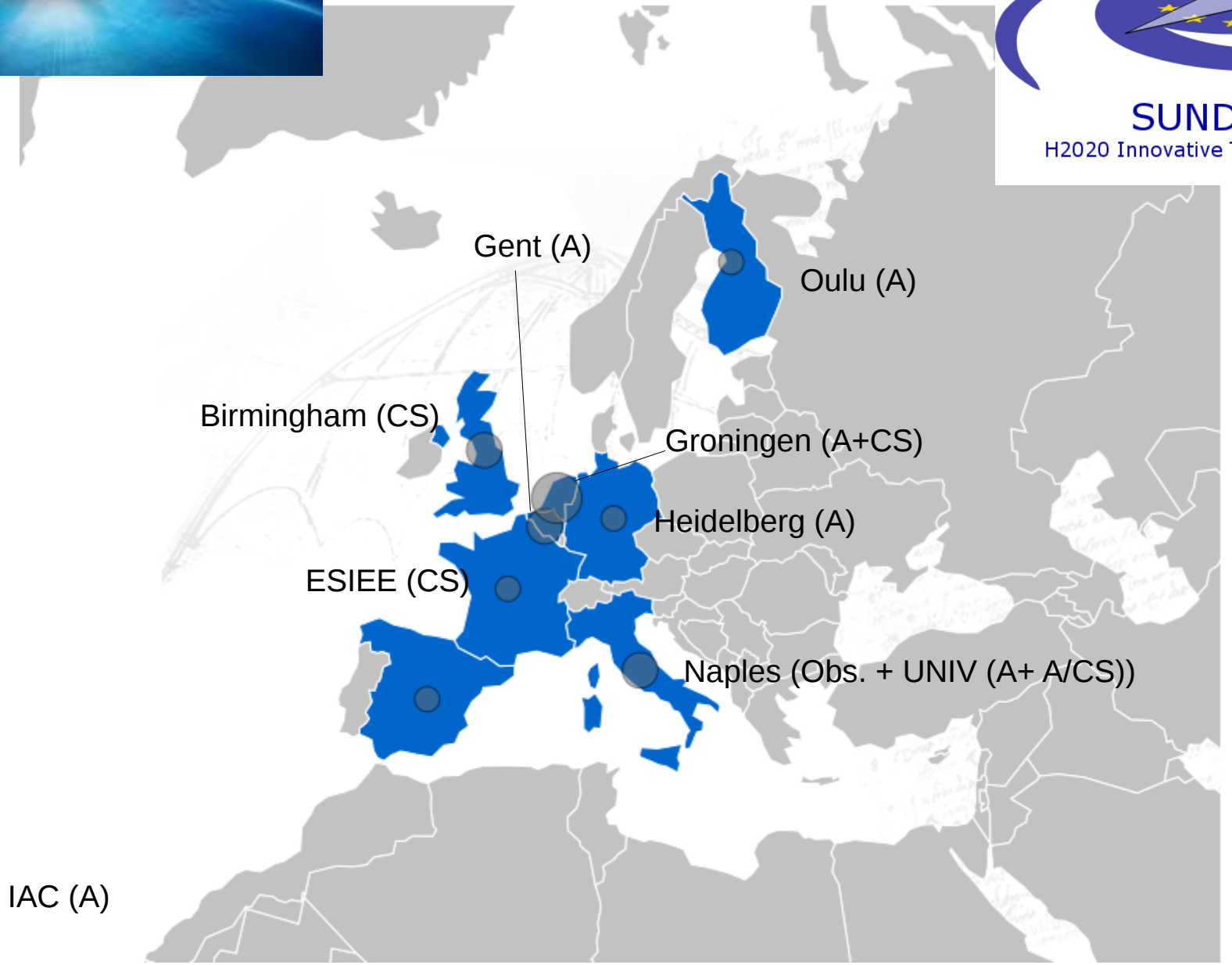
To conclude: this analysis is very preliminary, and still needs work.

However, we find that the Fornax cluster is very different from the center of the Virgo Cluster, with more dwarf irregulars. We also find that these objects have scaling relations that are not the same as those of dwarf ellipticals.

To be published: Venhola + FDS collaboration 2018

SUNDIAL ITN

SUNDIAL
H2020 Innovative Training Network



Aims of network:

Interdisciplinary collaboration of astronomers and computer scientists to determine novel algorithms to study galaxy evolution. In particular:

(1) **Automatic detection of faint low surface brightness galaxy features** (dwarf galaxies, merger remnants, intracluster light) in deep astronomical surveys, and interpreting them astrophysically in terms of galaxy formation and evolution.

(2) Automated object recognition in Big Data sets: (a) the unsupervised identification of groups of objects with similar properties (**clustering**) and (b) the supervised assignment of objects into pre-defined target classes (**classification**). The addition of **prior information** from astrophysics will be crucial in both cases.

(3) **Simulations** of galaxy interactions, their **characterisation** and **visualisation.** The simulations serve to identify the critical characterisation, necessary to optimally identify how observations can be described. Such comparisons will lead to a better parametrisation and understanding of galaxy cluster evolution.