VST Early-type GAlaxy Survey beyond μ_g~28 mag/arcsec^2

Enrichetta Iodice

INAF-Astronomical Observatory of Capodimonte

VST survey of Early-type GAlaxieS (VEGAS)

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

limiting integrated magnitudes at 5σ:
m_g= 27.3 mag ; m_r= 28.9 mag; m_i= 26.2 mag
Tot. Int. time: 2.5 hrs in *g*&*r* bands; 1 hr *i* band

➡ **INAF-GTO large program**: **500 hrs** (2016-2021), PI E.Iodice

➡ by the end of the survey (2022), **VEGAS will have collected a total of 55 targets, with a spatial coverage of 110 deg²**, spanning halo mass range ~ **10^{12} to 10^{15} M⊙**

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

30% of the VEGAS observing time

The Fornax Deep Survey

26 deg^2 out to R_{vir}

- joint project based on

  INAF GTO for 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

- Tot. exp. times: 3 hrs (u), 2.3 hrs (g&r), 1.8 hrs (i)

- unprecedented limits reached in mapping the light and color distribution

$$R \geq 10 - 15 R_e$$

$$\mu_g \geq 28\text{-}30 \text{ mag/arcsec}^2$$

VEGAS team

INAF

- E. Iodice (PI) - **INAF-OAC**
- M. Spavone (co-PI & head of data center) - **INAF-OAC**
- P. Schipani - **INAF-OAC**
- R. Ragusa (PhD 2020-2023)- **INAF-OAC**
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- INAF-OARoma (M.A. Raj)
- INAF-IRA Bologna (I. Prandoni)
- INAF-OAPadova & Univ. of Padova (E.M. Corsini, E. Dalla Bontà, L. Greggio, M. Gullieuszik, E. Held, P. Mazzei, A. Pizzella, R. Rampazzo)
- INAF-OACagliari (P. Serra)

VEGAS team

INAF

&

collaborations

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- INAF-OACagliari (P. Serra)

M. Arnaboldi, E. Emsellem, D. Gadotti, M. Hilker, M. Rejkuba, S. Mieske

K. Dolag, S.R. Remus

D. Forbes

S. Brough

J. Falcòn-Barroso

G. van de Ven

R. Peletier

D. Krajnović

Project plan & science goals

Project plan & science goals

VEGAS
PI: E. Iodice

Data management

Science

<u>D-WP1: survey design & observation plan:</u>

- **OB preparation P108 (August 2021)**
- **2 runs in visitor mode (Nov 2021 & Jan 2022)**

<u>D-WP2: data reduction:</u>

- **data P107 (Oct 2021)**
- **data P108 SV (Nov 2021-March 2022)**
- **data P108 VM (Dec 2021; Feb 2022)**

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PI: E. Iodice

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- **data P108 VM (Dec 2021; Feb 2022)**

D-WP3: data release:

DR1: 2020
DR2 by 2023

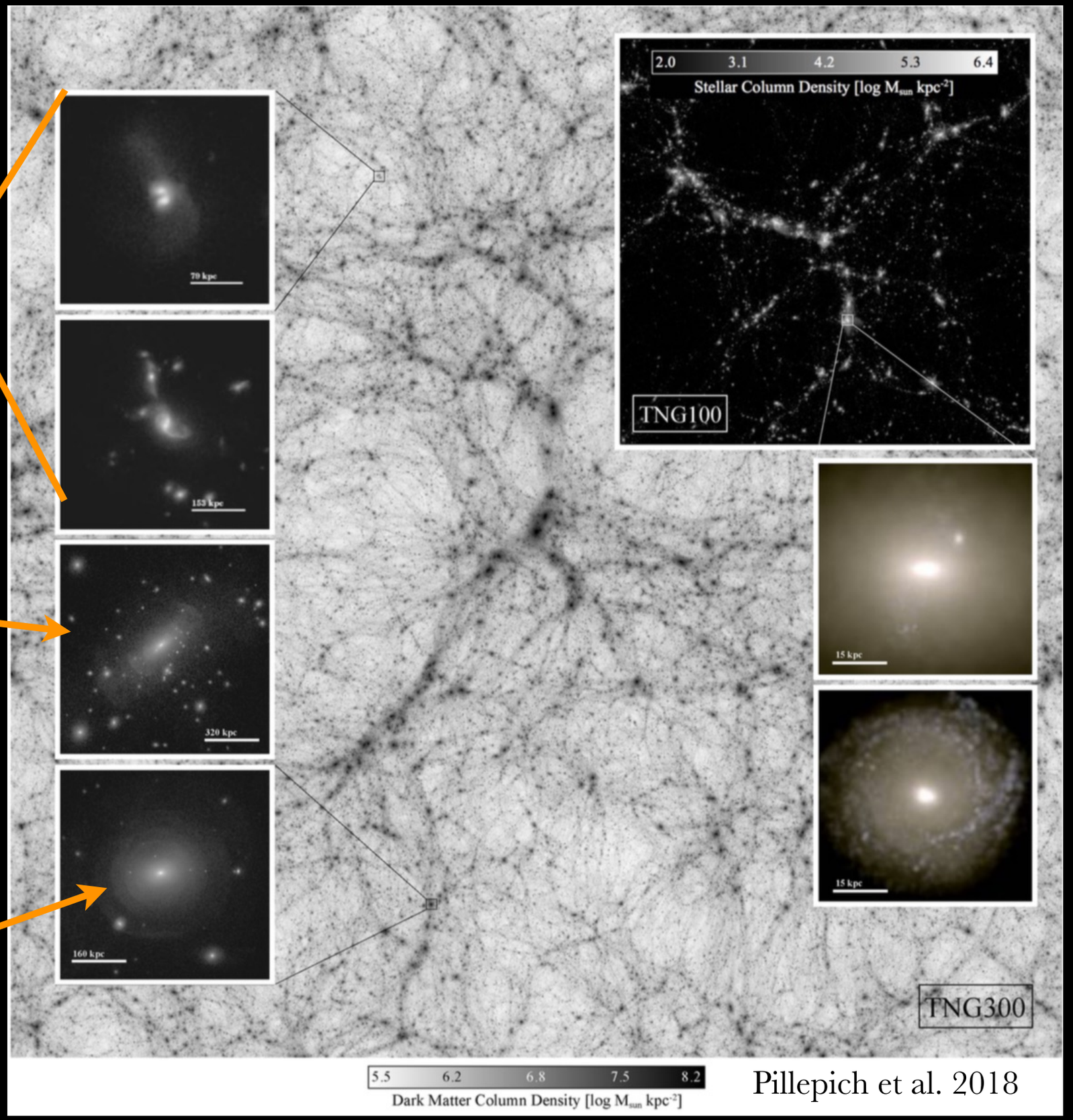
Science: context

Study the mass assembly of galaxies in all environments to constrain their formation within the LCDM paradigm

Interactions & mergers

ICL

accretion of small satellites



Pillepich et al. 2018

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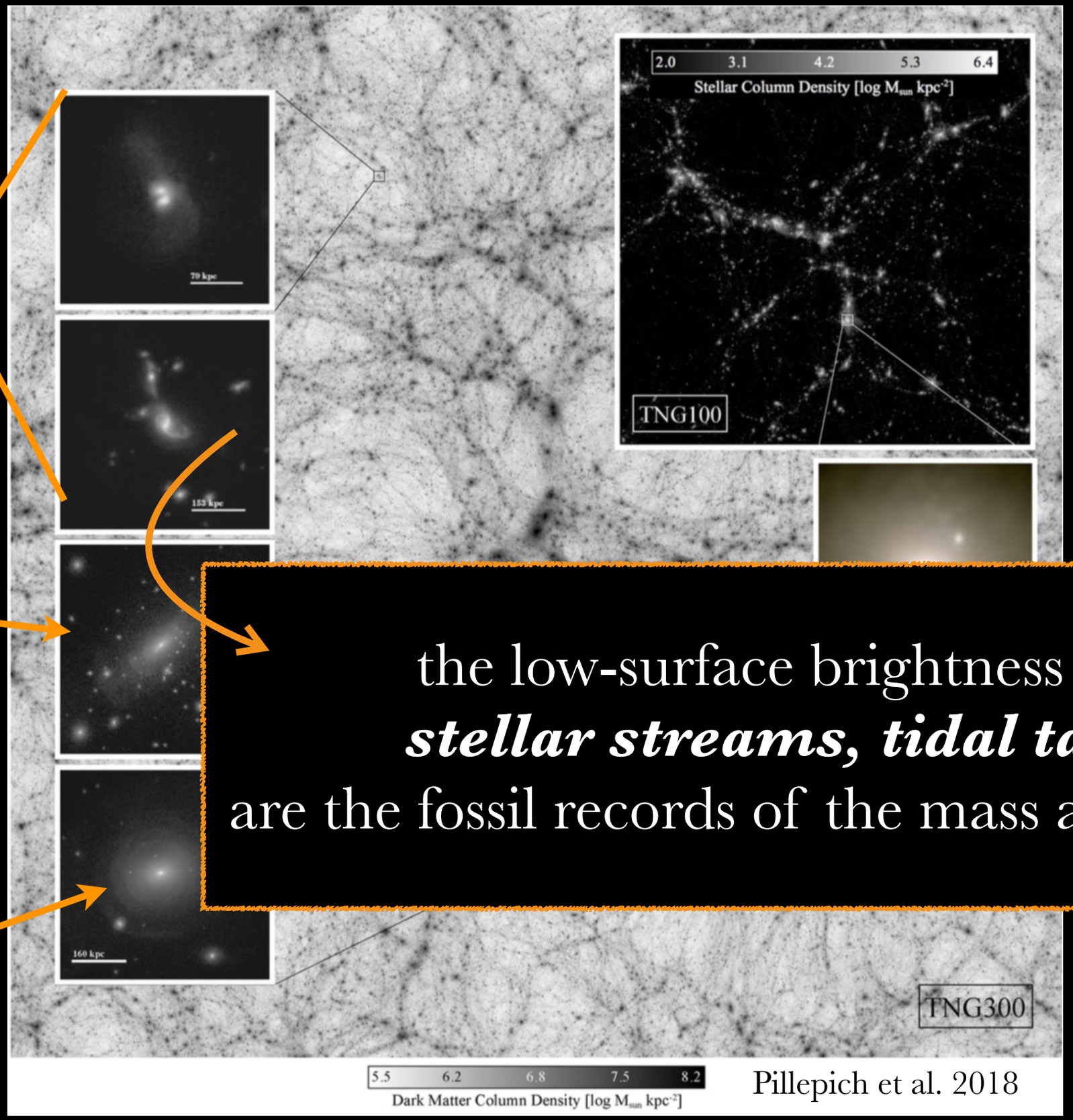

the low-surface brightness features,
stellar streams, tidal tails, ICL
are the fossil records of the mass assembly process

Pillepich et al. 2018

Science: which are the observables?

- morphology
  ➥ to constraints the processes in the mass assembly history (i.e. detection of diffuse halos *vs* fine LSB features)
- azimuthally-averaged SB profiles
  ➥ to set the scales of the different components in the galaxy (in-situ *vs* ex-situ)
- color gradients
  ➥ to derive hints on the stellar populations in the cluster/group members
- fraction of ICL
  ➥ to constraint the look-back time of the mass assembly in the cluster and/or group of galaxies
- kinematics & metallicity
  ➥ to constraint the structure & stellar population

Science: which are the observables?

VEGAS outcomes

- morphology
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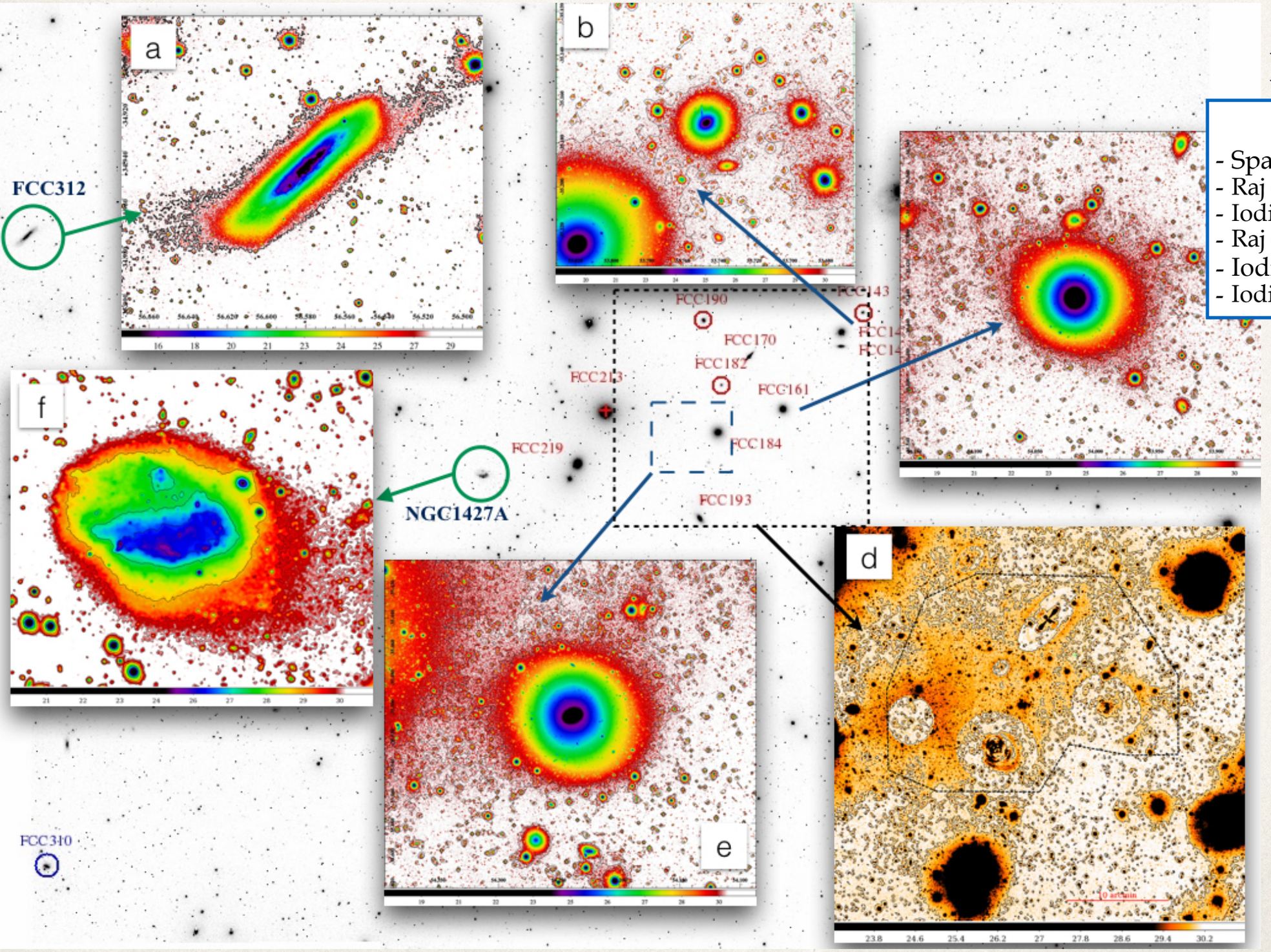
Science

S-WP1: LSB universe

led by M. Spavone (INAF-OAC) + PhD R. Ragusa

- **study of the galaxy's outskirts**
- **build-up history of the stellar halos**



Results from FDS

Publications:

- Spavone et al. 2020, A&A 639, 14
- Raj et al. 2020, A&A 604, 137
- Iodice et al. 2019, A&A 623, 1
- Raj et al. 2019, A&A 628, 4
- Iodice et al. 2017, ApJ 851, 55
- Iodice et al. 2016, ApJ 820, 42

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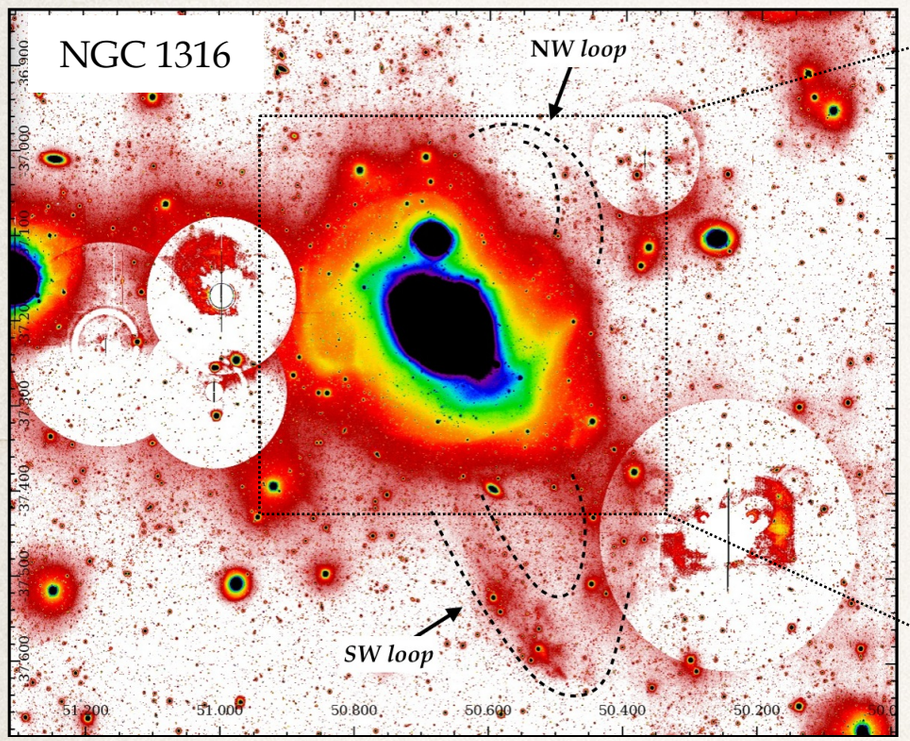
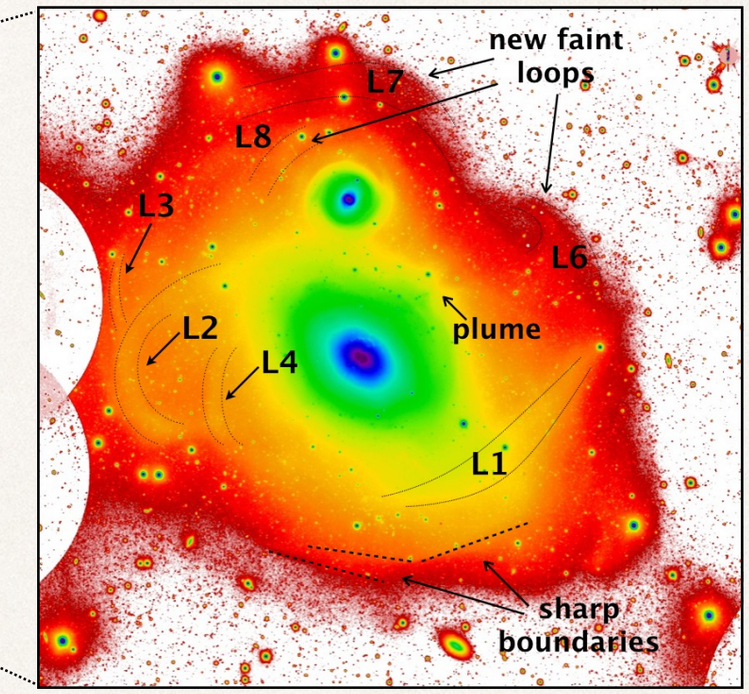
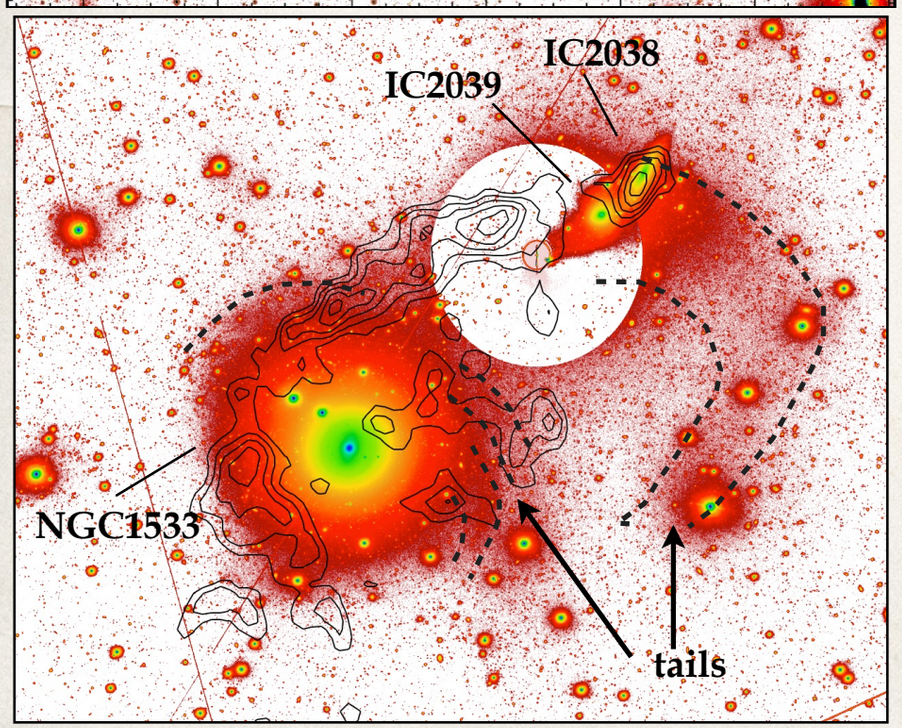
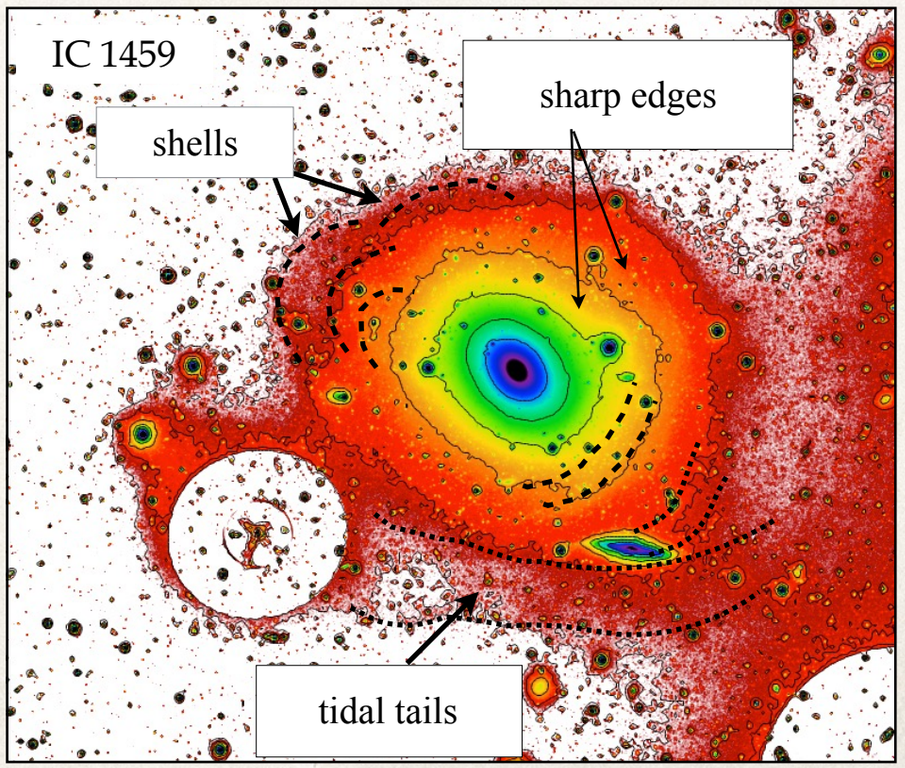








Results from VEGAS

Publications:

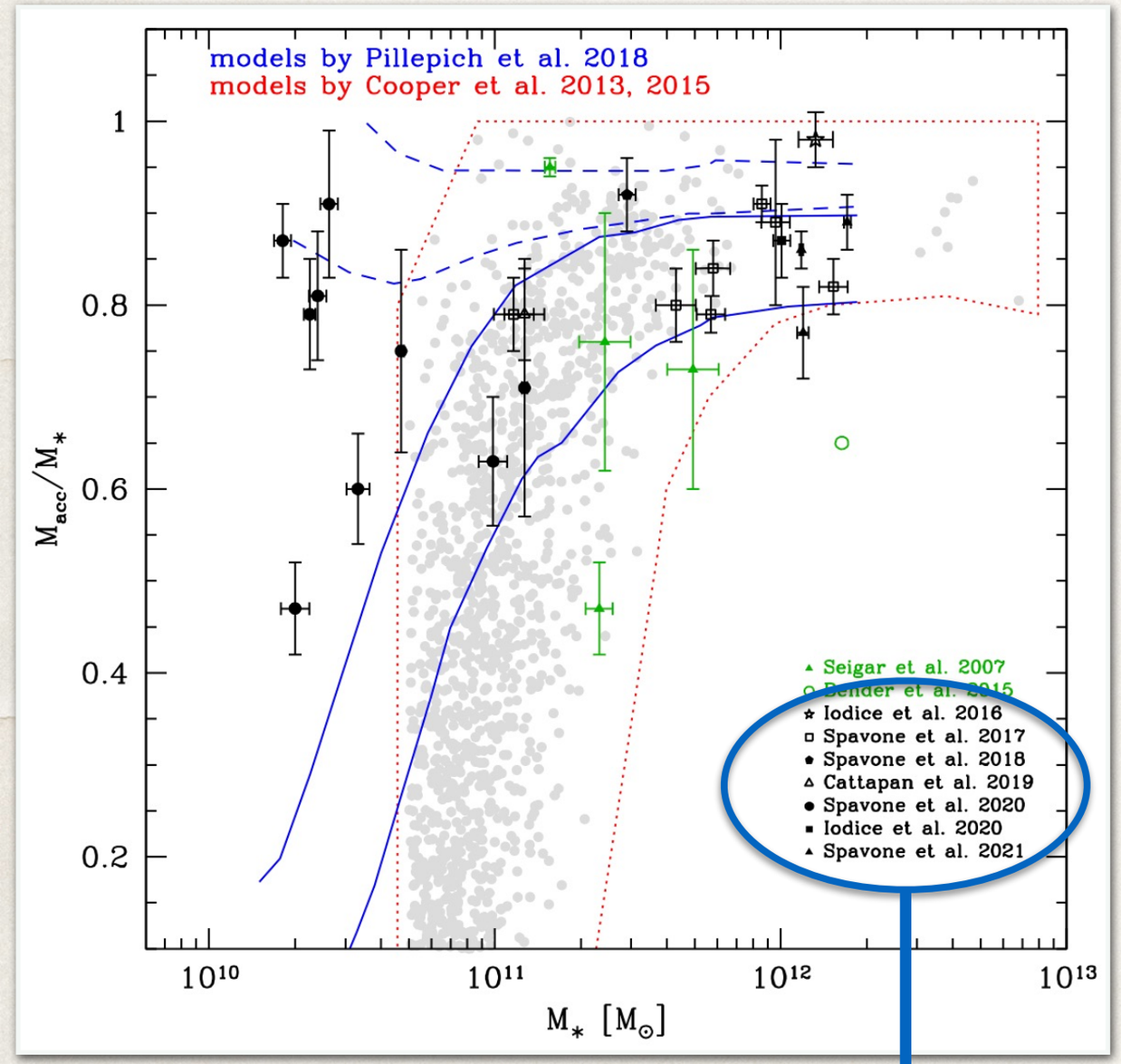
- Iodice et al. 2020, A&A 653, 3
- Cattapan et al. 2019, ApJ 874, 130
- Spavone et al. 2018, ApJ 864, 149
- Iodice et al. 2017, ApJ 839, 21

Science

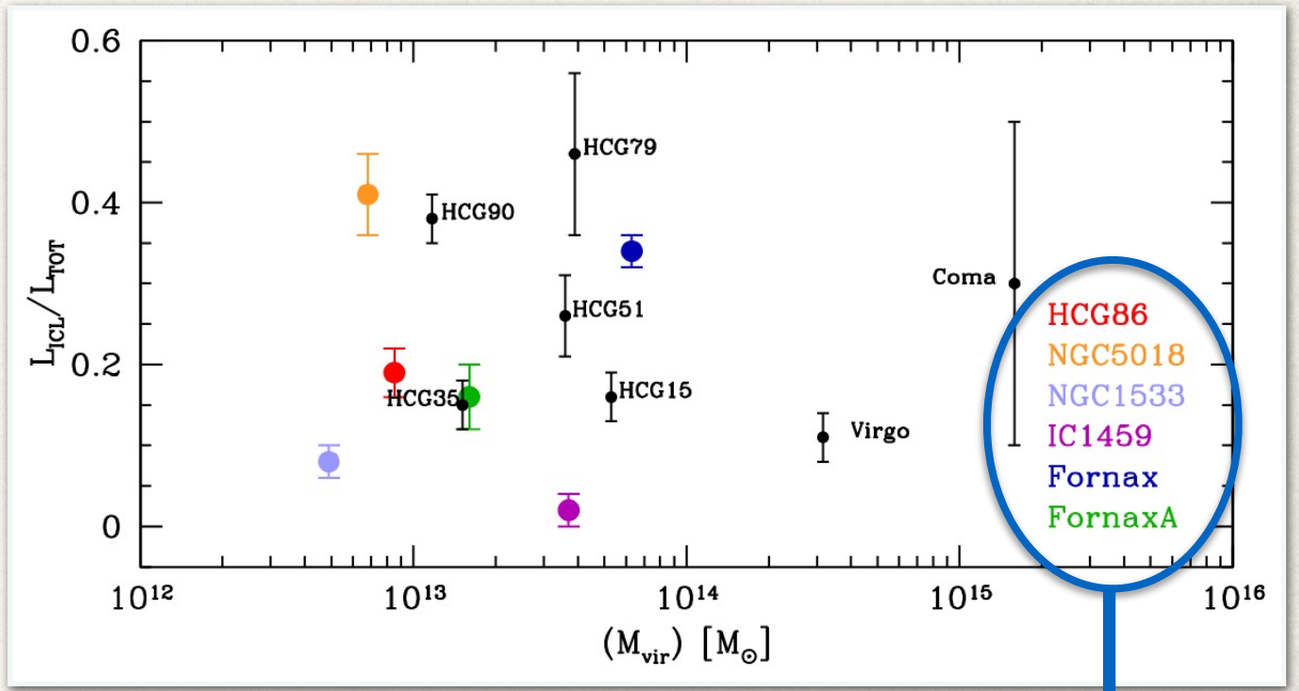
S-WP1: LSB universe

led by M. Spavone (INAF-OAC) + PhD R. Ragusa

- **build-up history of the stellar halos**
- **accreted mass fraction**
- **contribution of the ICL**



From VEGAS



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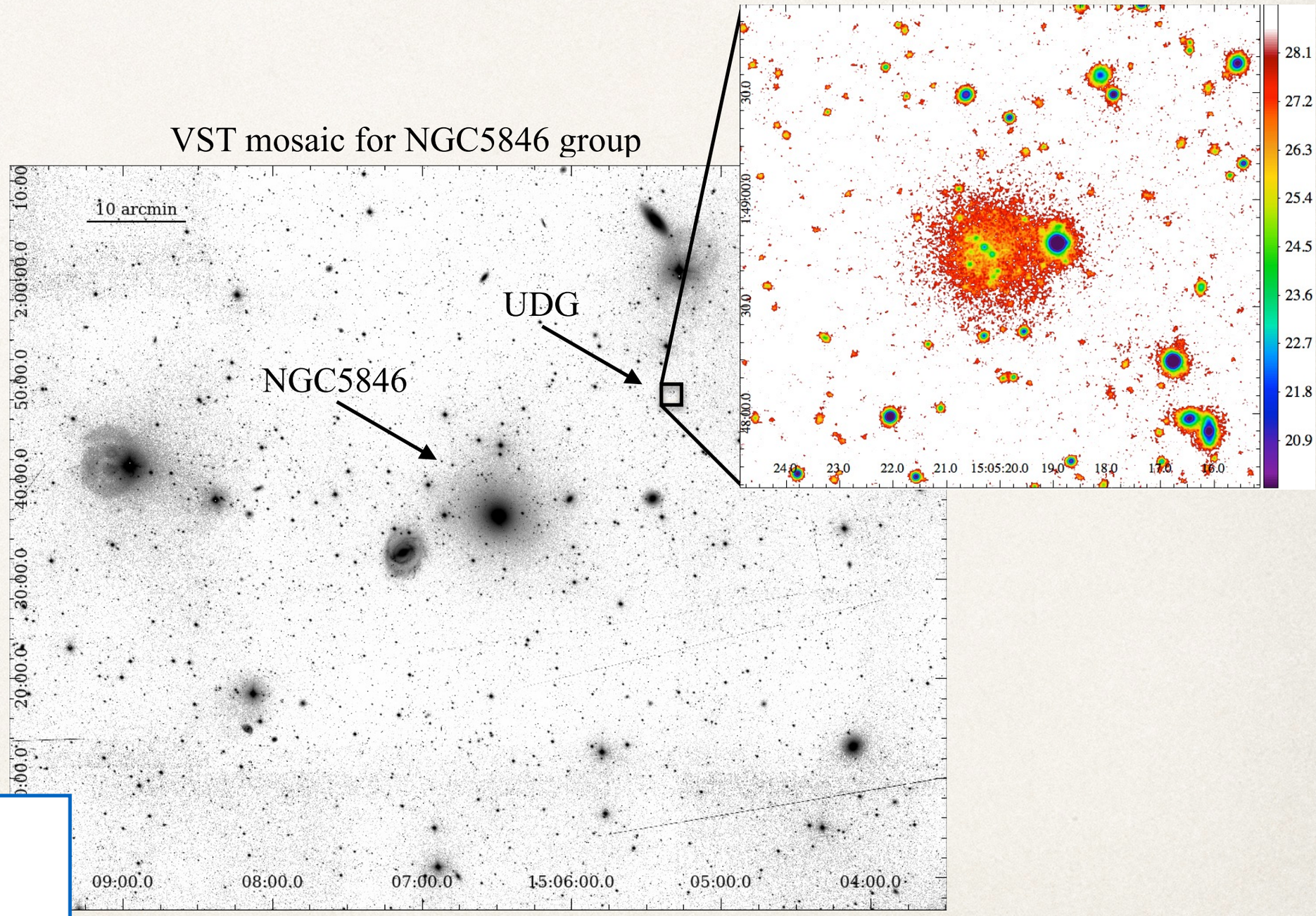
- Spavone et al. 2020, A&A 639, 14
- Spavone et al. 2017, A&A 603, 38
- Raj et al. 2020, A&A 604, 137
- Iodice et al. 2017, ApJ 851, 55
- Capaccioli et al. 2015, A&A 581, 10

Science

S-WP2: Ultra-VEGAS

led by E. Iodice (INAF-OAC) + Fellow A. La Marca + PhD project approved INAF&IAC

- **build of statistically large sample (~1300) of newly discovered UDGs in groups & clusters**
- **structure & formation of UDGs**



Publications:

- Iodice et al. 2021, A&AL sub
- La Marca et al. 2021, in prep
- Iodice et al. 2020, A&A 642, 48
- Forbes et al. 2020, MNRAS 494, 5293
- Forbes et al. 2019, A&A 626, 66

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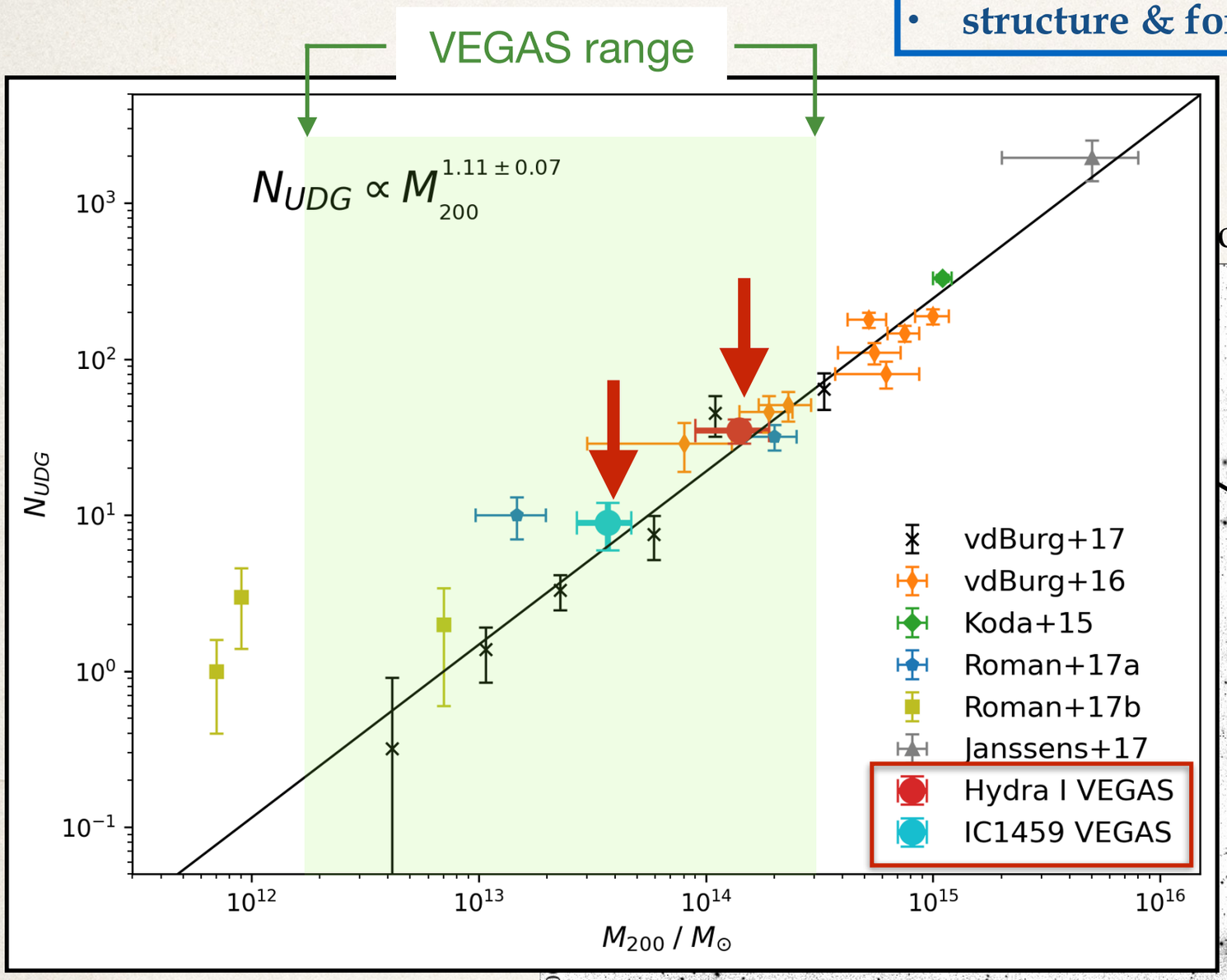

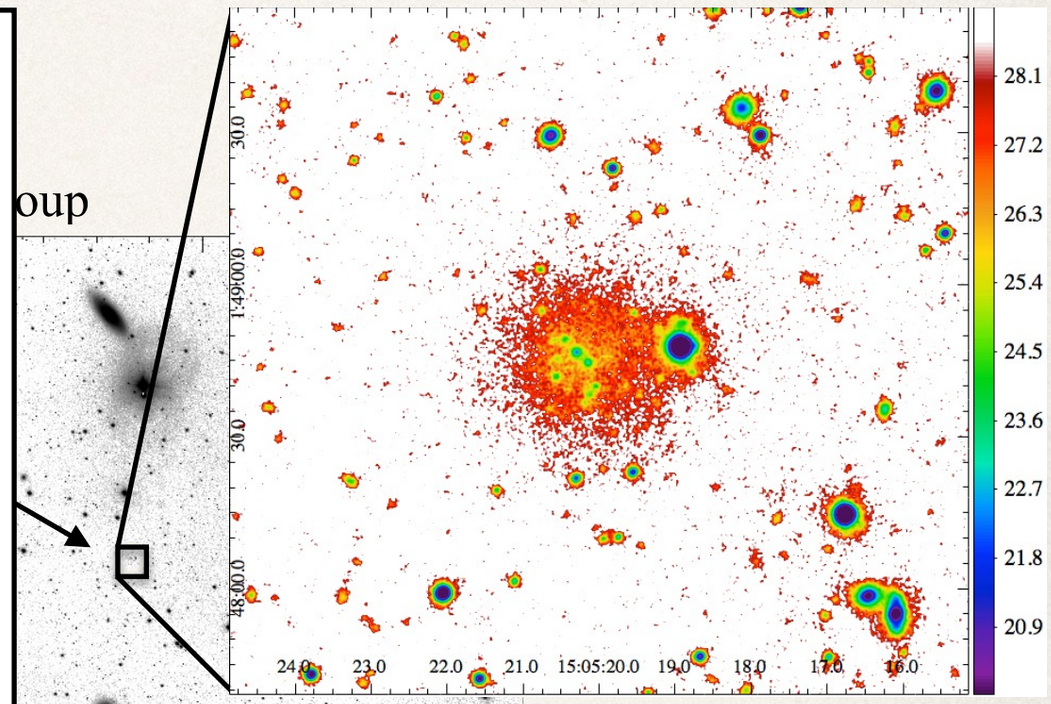

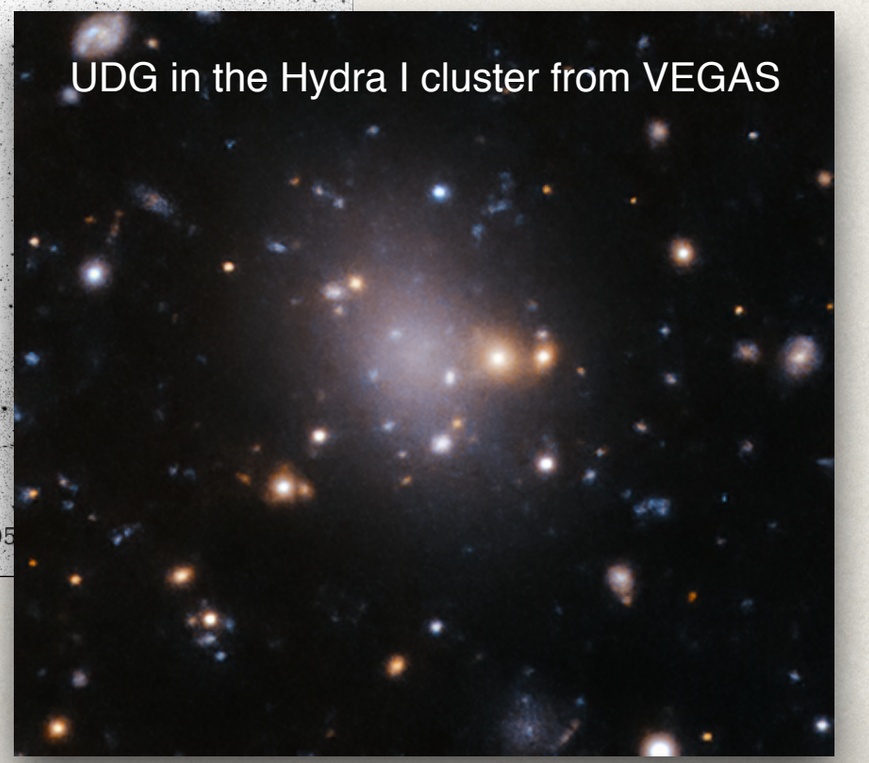

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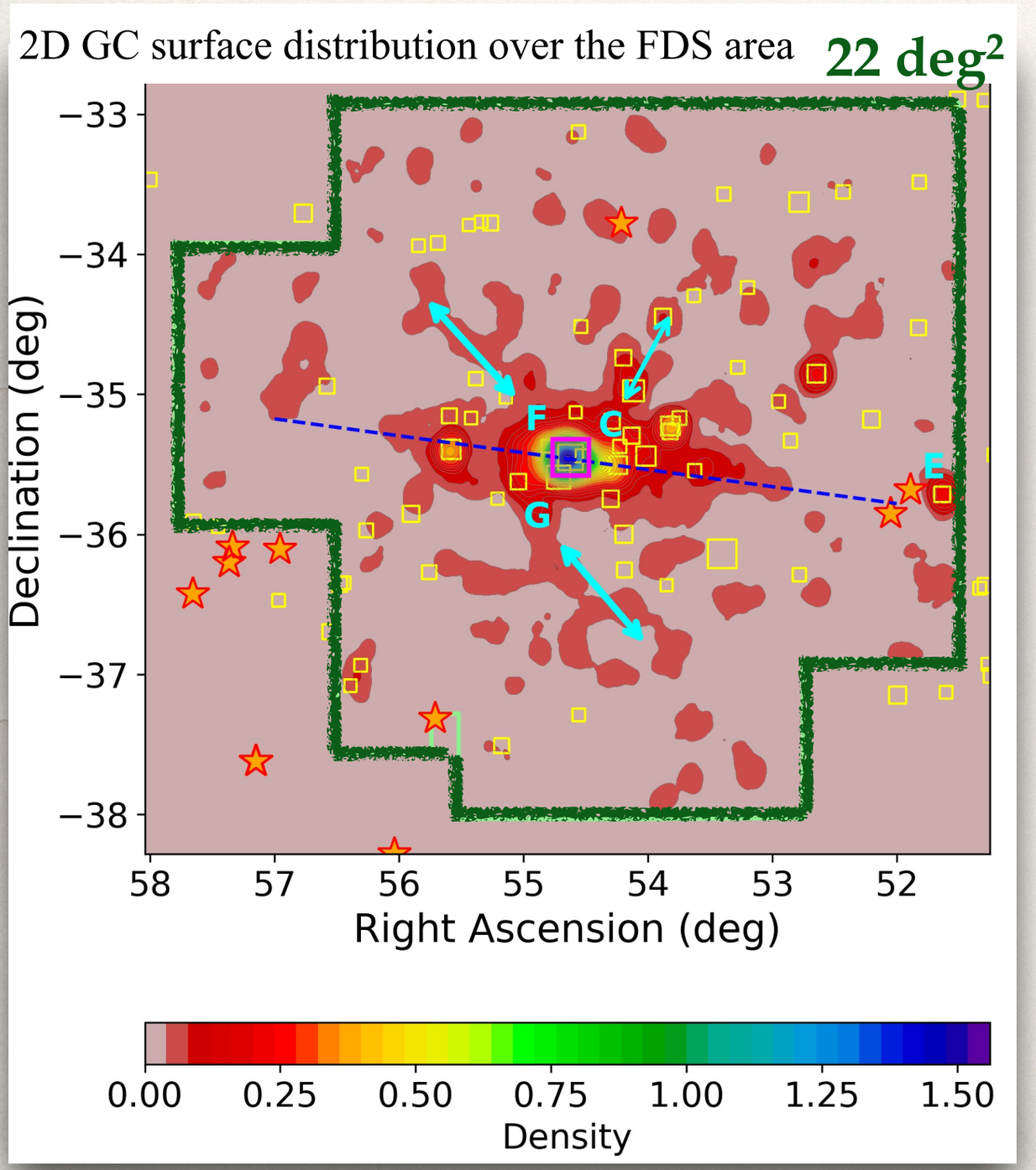
Science

S-WP3: VEGAS-SSS

led by M. Cantiello (INAF-OATeramo) +

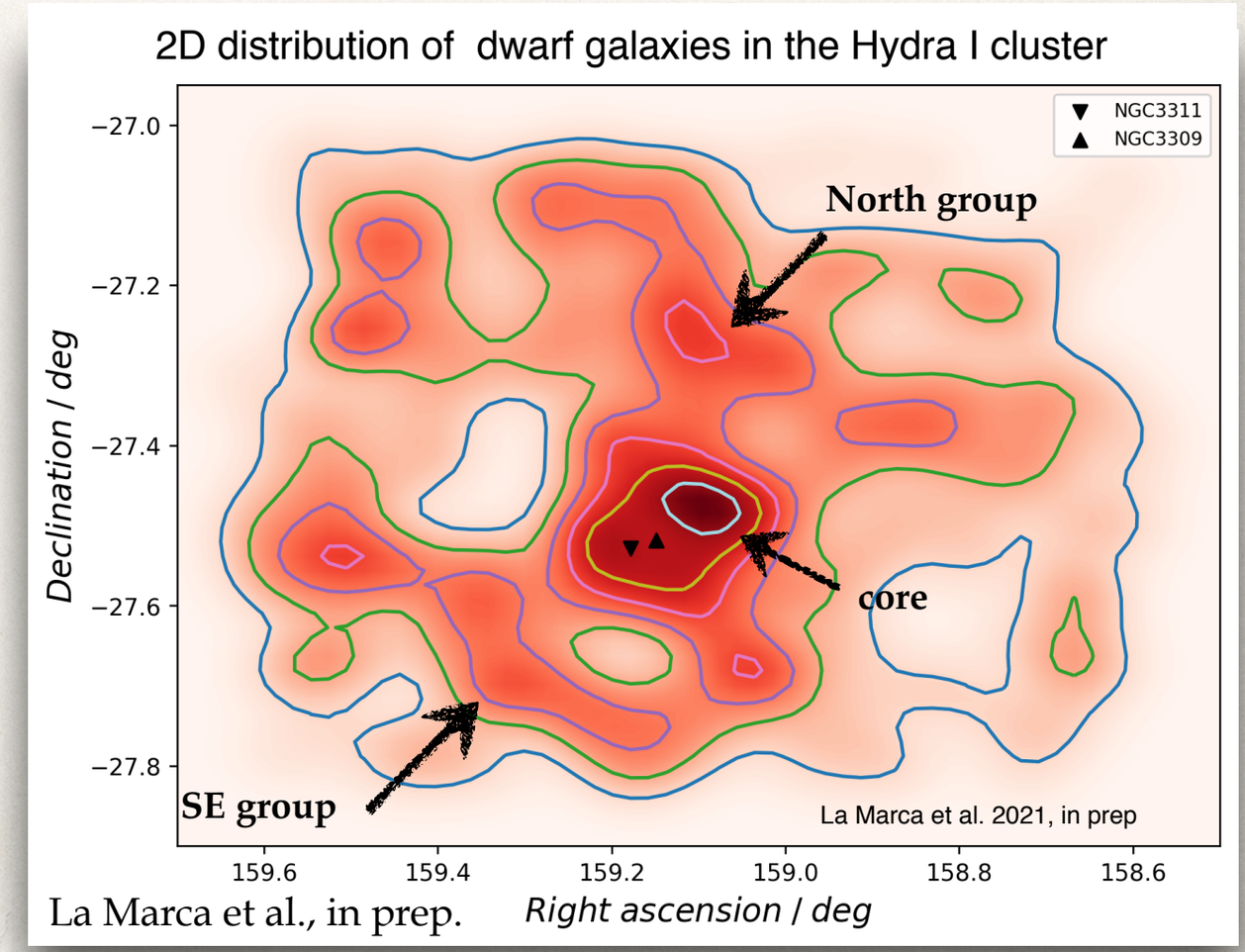
Fellow A. La Marca + MsC M. Mirabile

- **inventory of GCs & dwarf galaxies**
- **number density, structural properties**



Publications:

- Cantiello et al. 2020, A&A 639, 36
- Venhola et al. 2019, A&A 625, 143
- Cantiello et al. 2018, A&A 611, 93
- Venhola et al. 2018, A&A 620, 165
- Venhola et al. 2017, A&A 608, 142
- D'Abrusco et al 2016, ApJL 819, 31
- Cantiello et al. 2015, A&A 576, 14



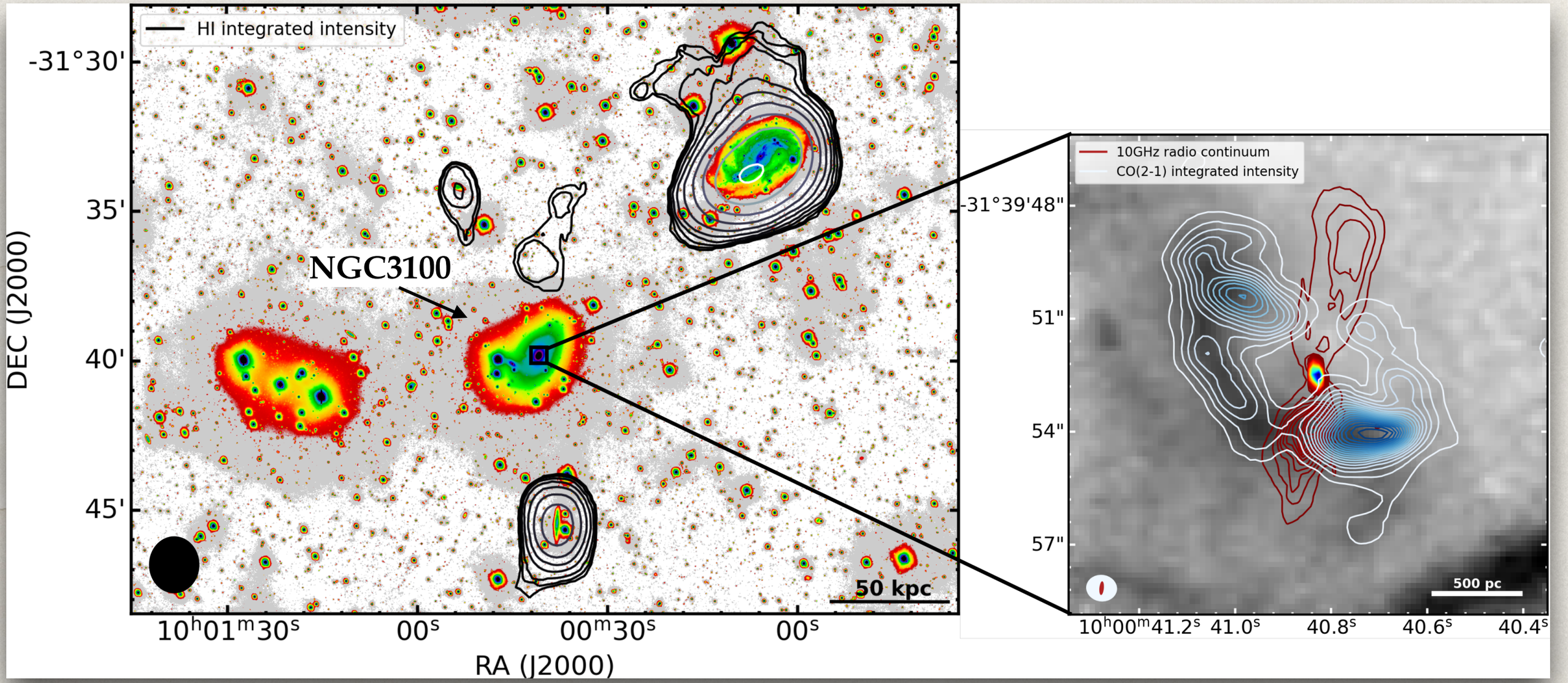
La Marca et al., in prep.

Science

S-WP5: ETGs radio loud

started in 2021 (led by I. Prandoni)
+ Postdoc I. Ruffa (Cardiff)

- **detection of the optical counterpart of the HI gas**
- **connection with the environment**



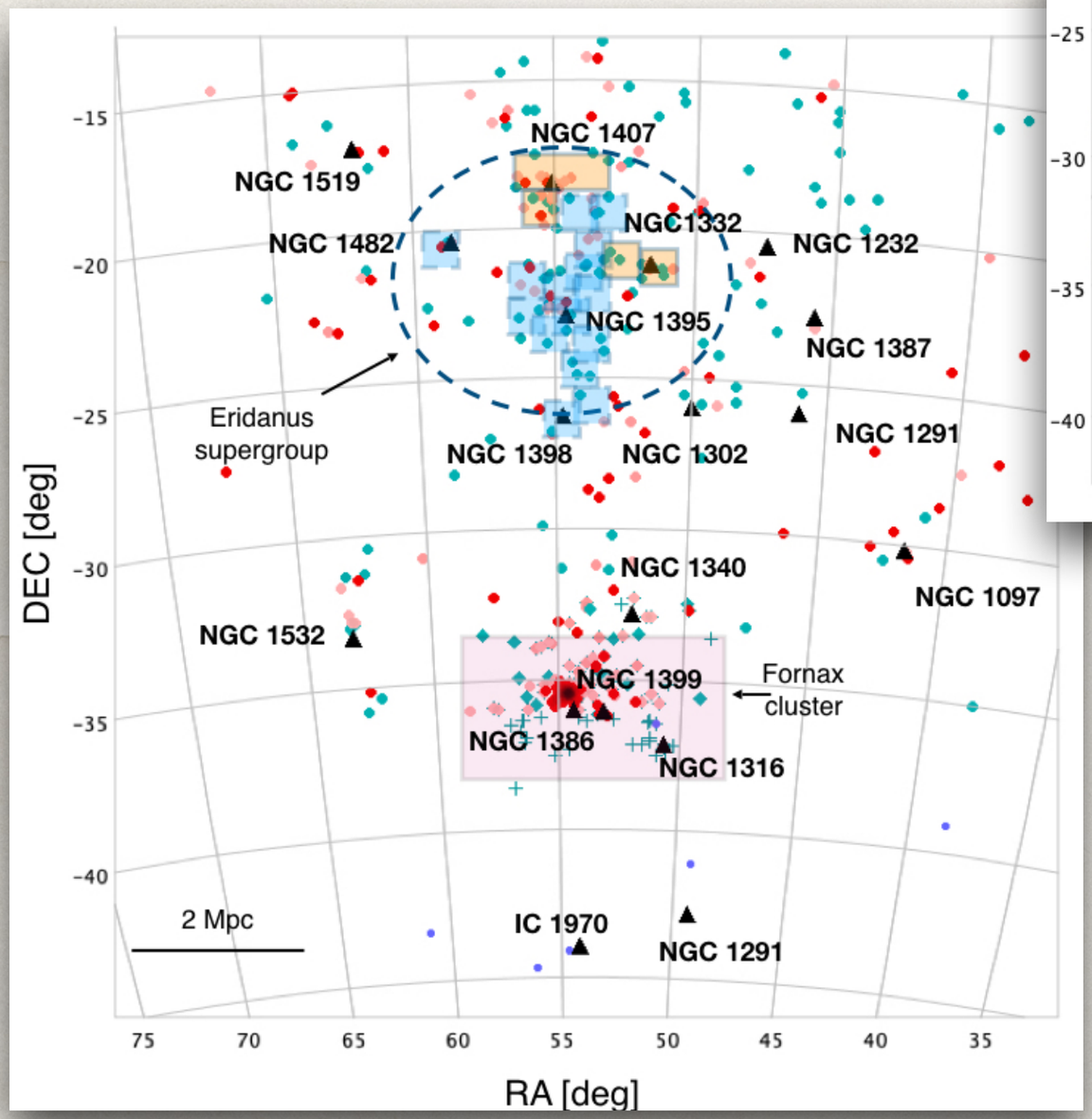
Science

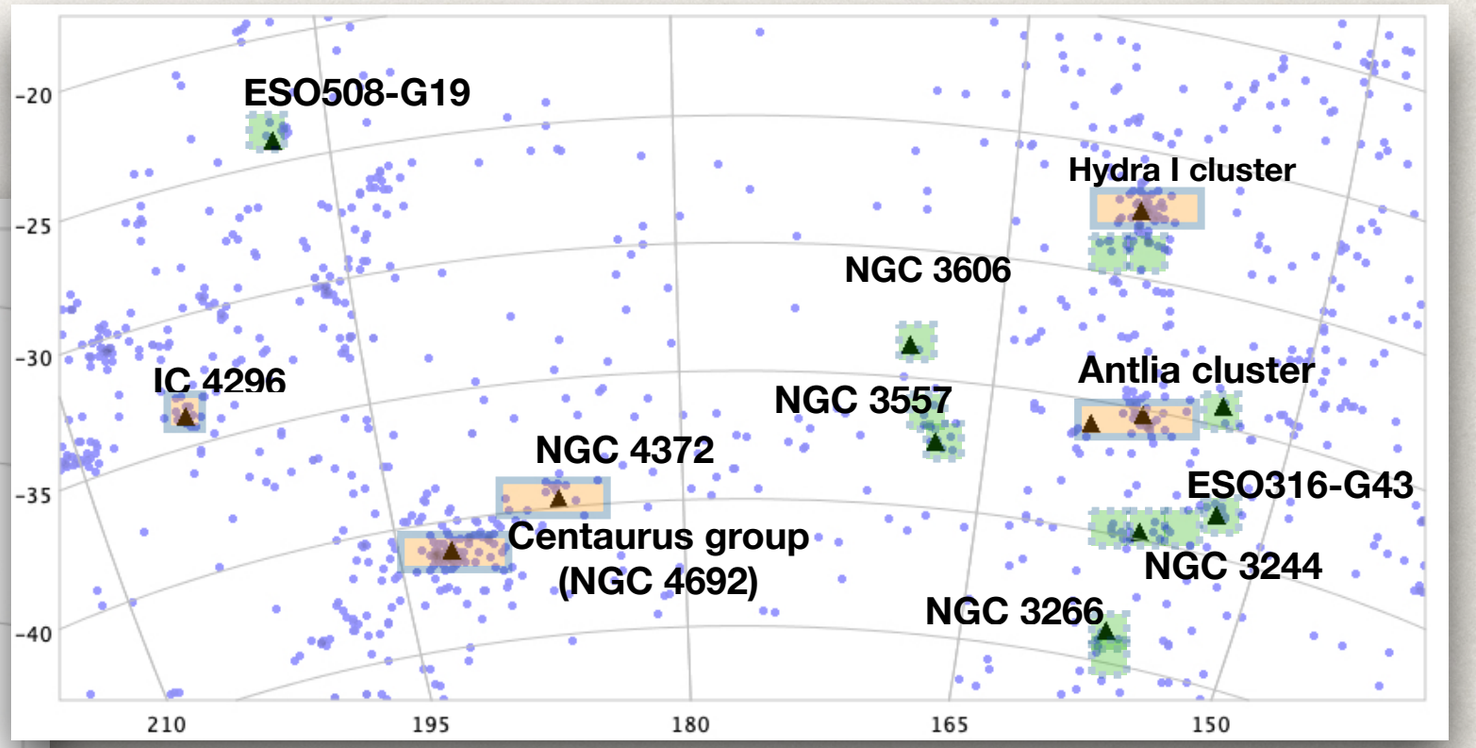
Future plans

S-WP3: VEGAS-LSS

study of the unexplored regions of voids and filaments in the LSS down to the LSB regime

Fornax-Eridanus supercluster (D~20 Mpc)





Hydra I-Centaurus supercluster (D~40 - 60 Mpc)

Letter of intent for VST beyond 2021

Proposed new fields **Existing OmegaCam data** **Analysed (FDS)**

Science

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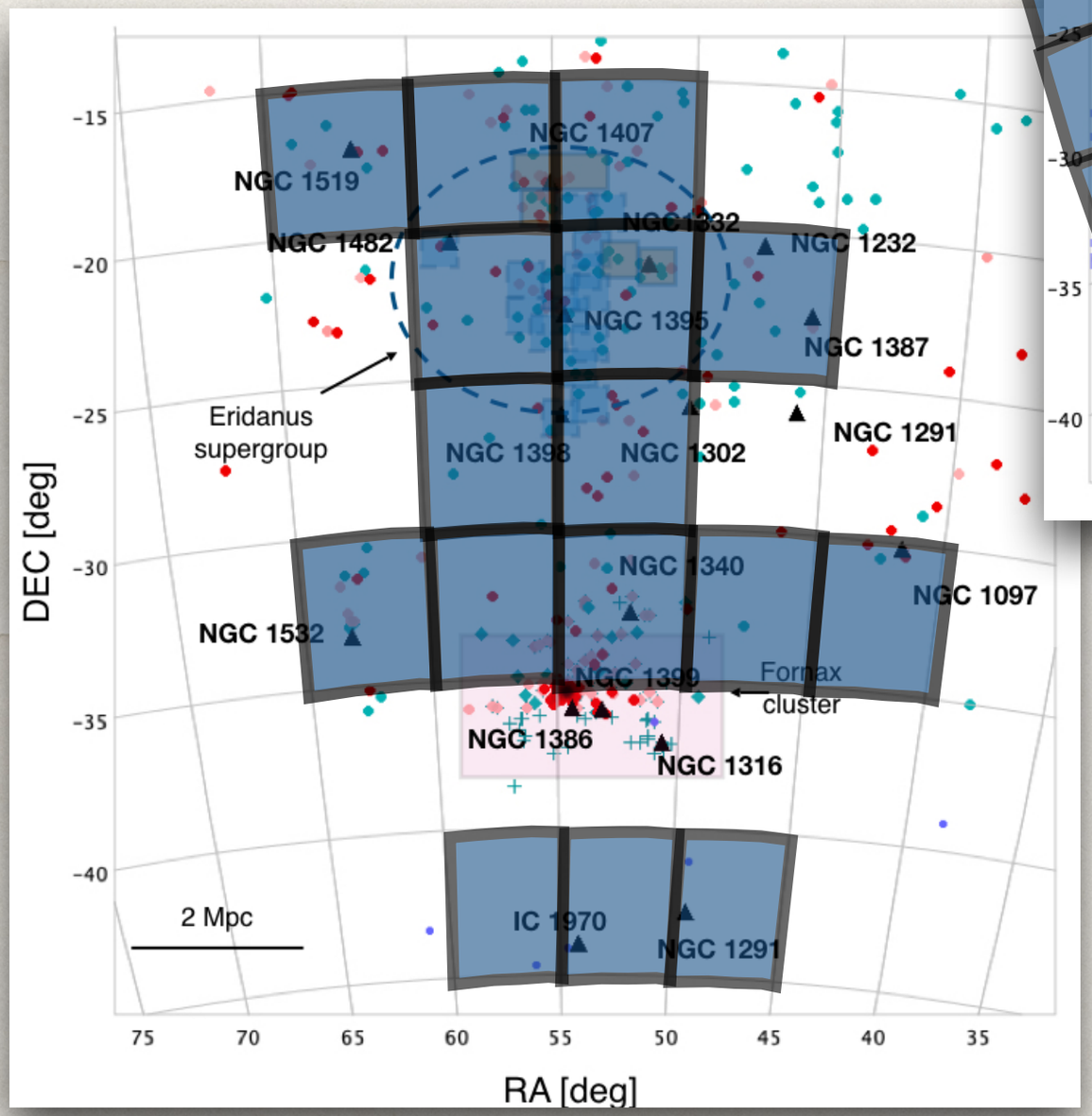

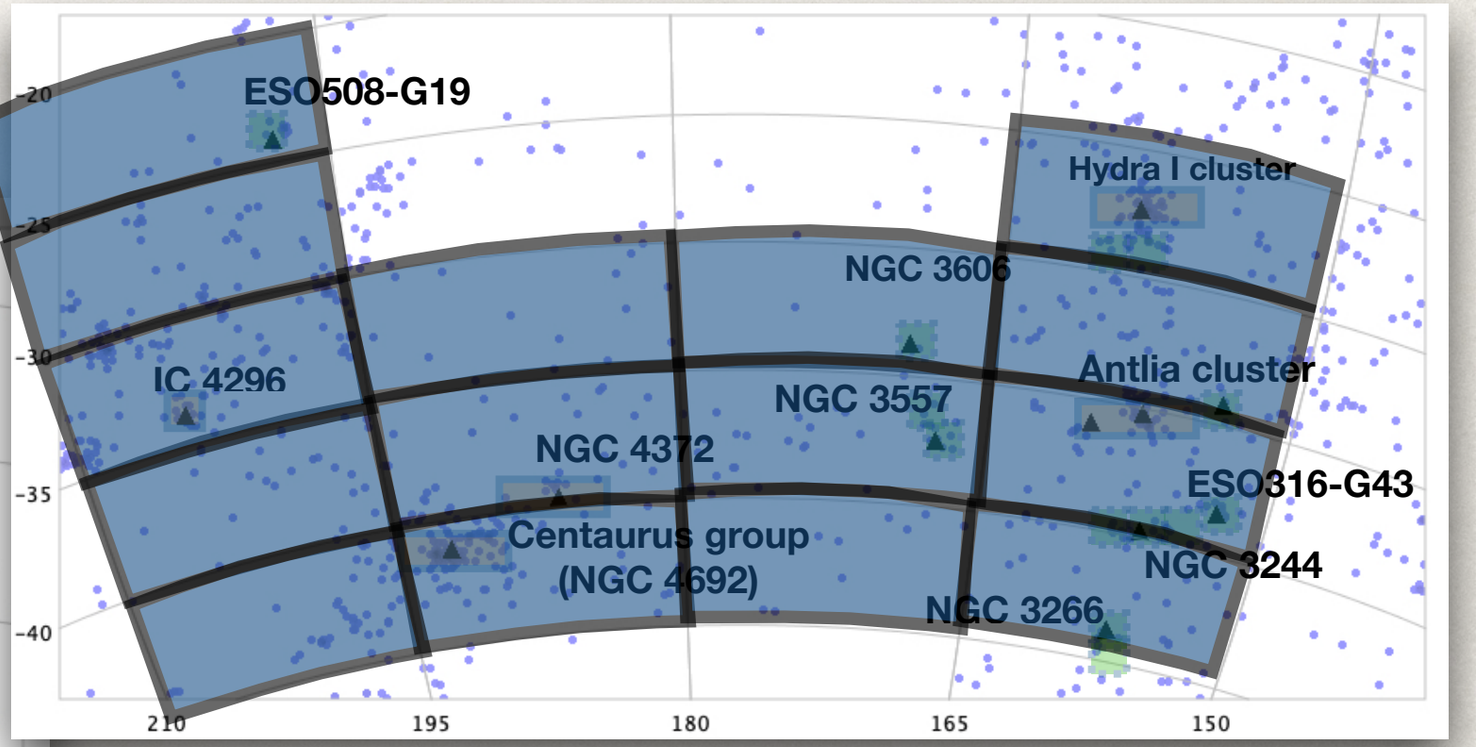

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The panorama of deep imaging surveys

~ LSB optimised **small telescope** and **telescope arrays**: μ_g ***~ 29.5 mag/arcsec^2***

Burrell Schmidt (Mihos et al. 2017),
Dragonfly image array (Abraham & van Dokkum 2014; Merritt et al. 2016)

~ using **3m-class telescope**: μ_g ***~ 28.5 - 29 mag/arcsec^2***

NGVS@CFHT (Ferrarese et al. 2012); ATLAS3D@CFHT (Duc et al. 2015); CFHT Legacy Survey (Gwyn 2012); **FDS&VEGAS@VST** (Iodice et al. 2019)

~ using **4m-8m class telescope (wider area)**: μ_r ***~ 27.5 - 28.5 mag/arcsec^2***

DECam@CTIO (Dey et al. 2019); Hyper Suprime-Cam Subaru Strategic Program@Subaru (Aihara et al. 2018)

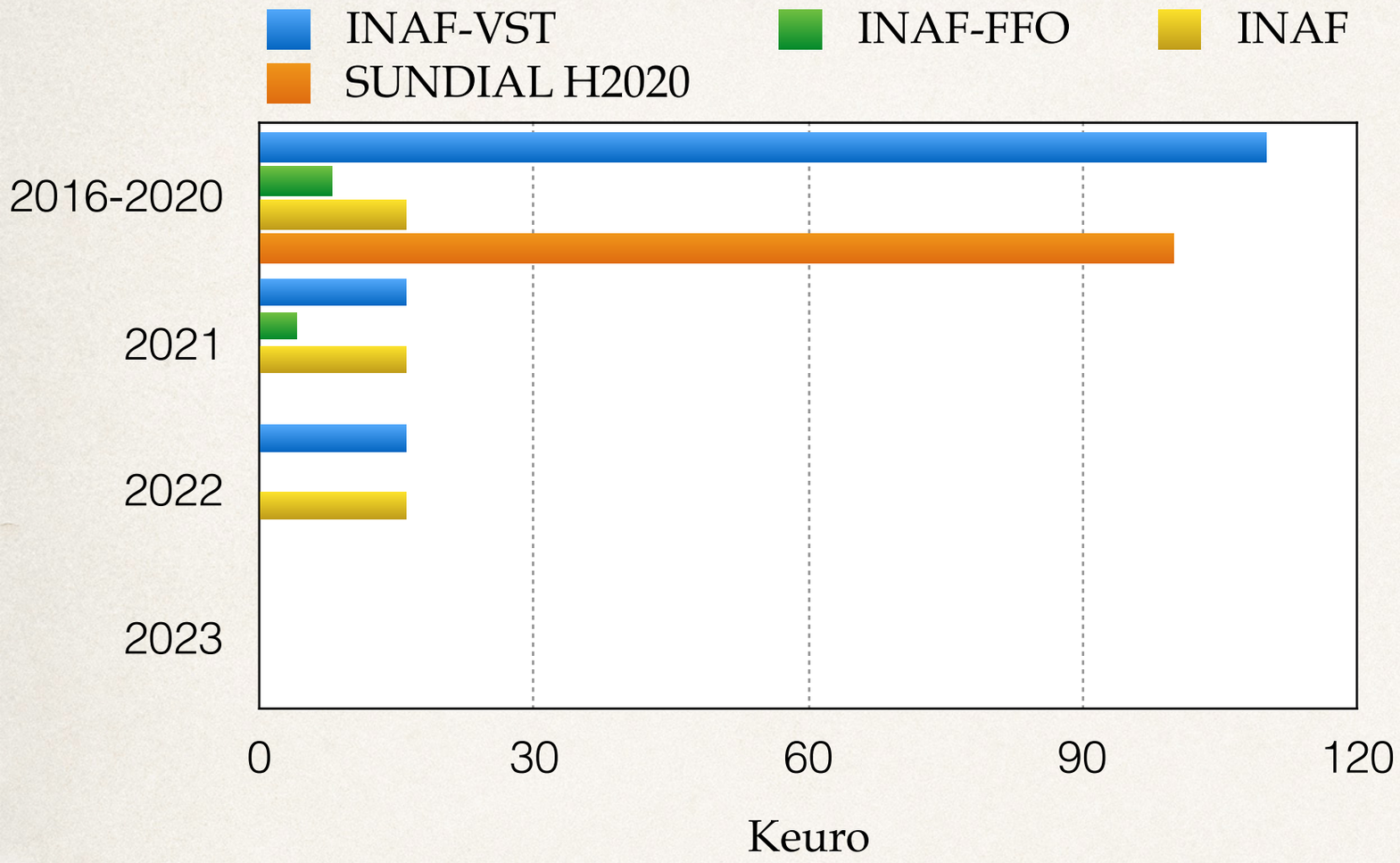
~ using **10m GTC telescope (FOV=5')**: μ_r ***~ 31.5 mag/arcsec^2***

(Trujillo & Fliri 2016)

~ using **HST**: μ ***~ 31 mag/arcsec^2***

(ICL in Hubble Frontiers Fields by Montes & Trujillo 2018)

Funds: ~250 keuro 2016-2021 in total



INAF - VST

- 1 postdoc fellowship (2016-2018)
- 1 post degree fellowship (2019)
- co-funding INAF PhD (2019-2022)
- support DR1
- travels & publications

INAF - FFO

- 1 post degree fellowship (2021)
- travels

INAF

- co-funding INAF PhD (2019-2022)

SUNDIAL → **FDS**

- 1 PhD (2017-2020)
- travels

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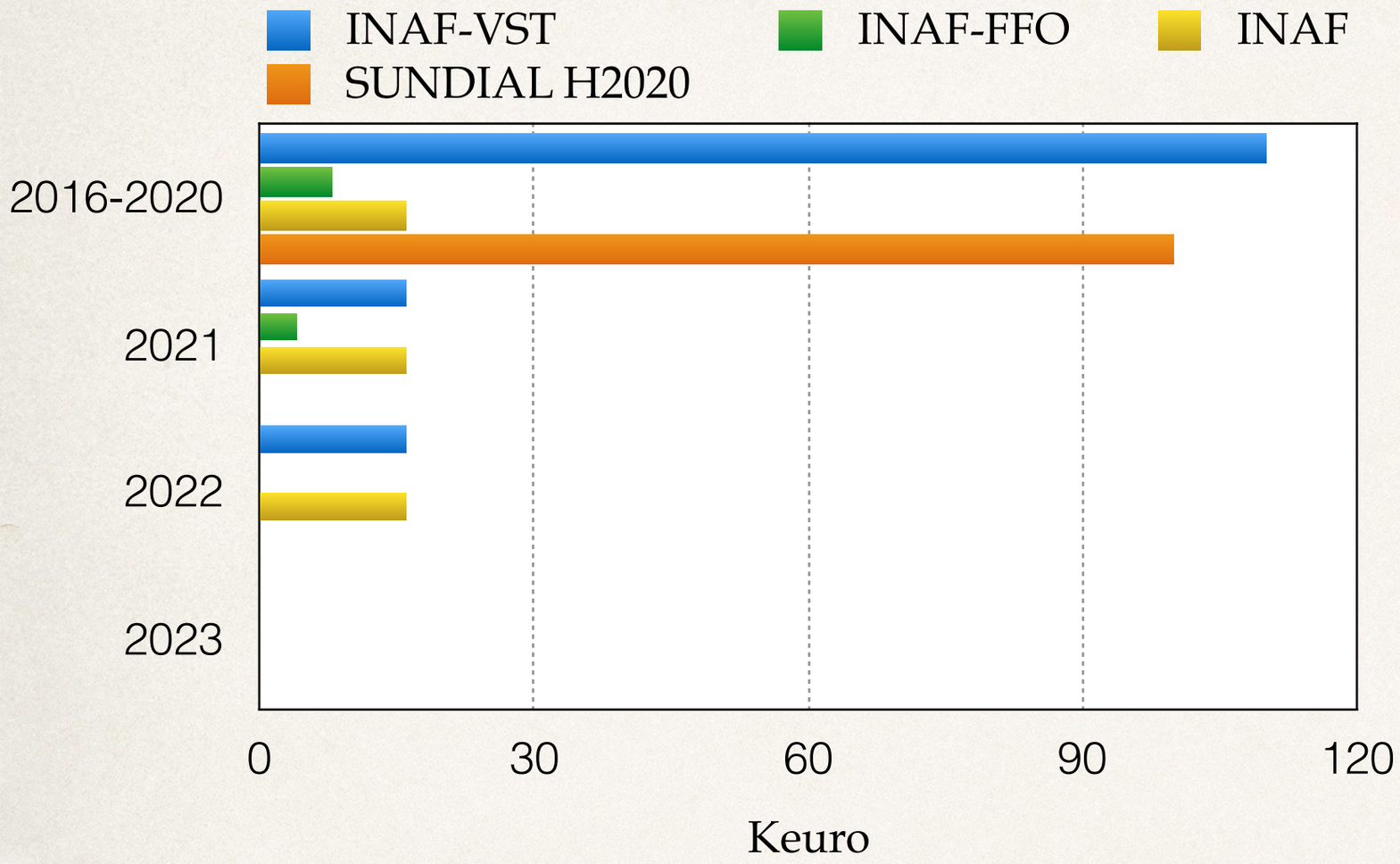

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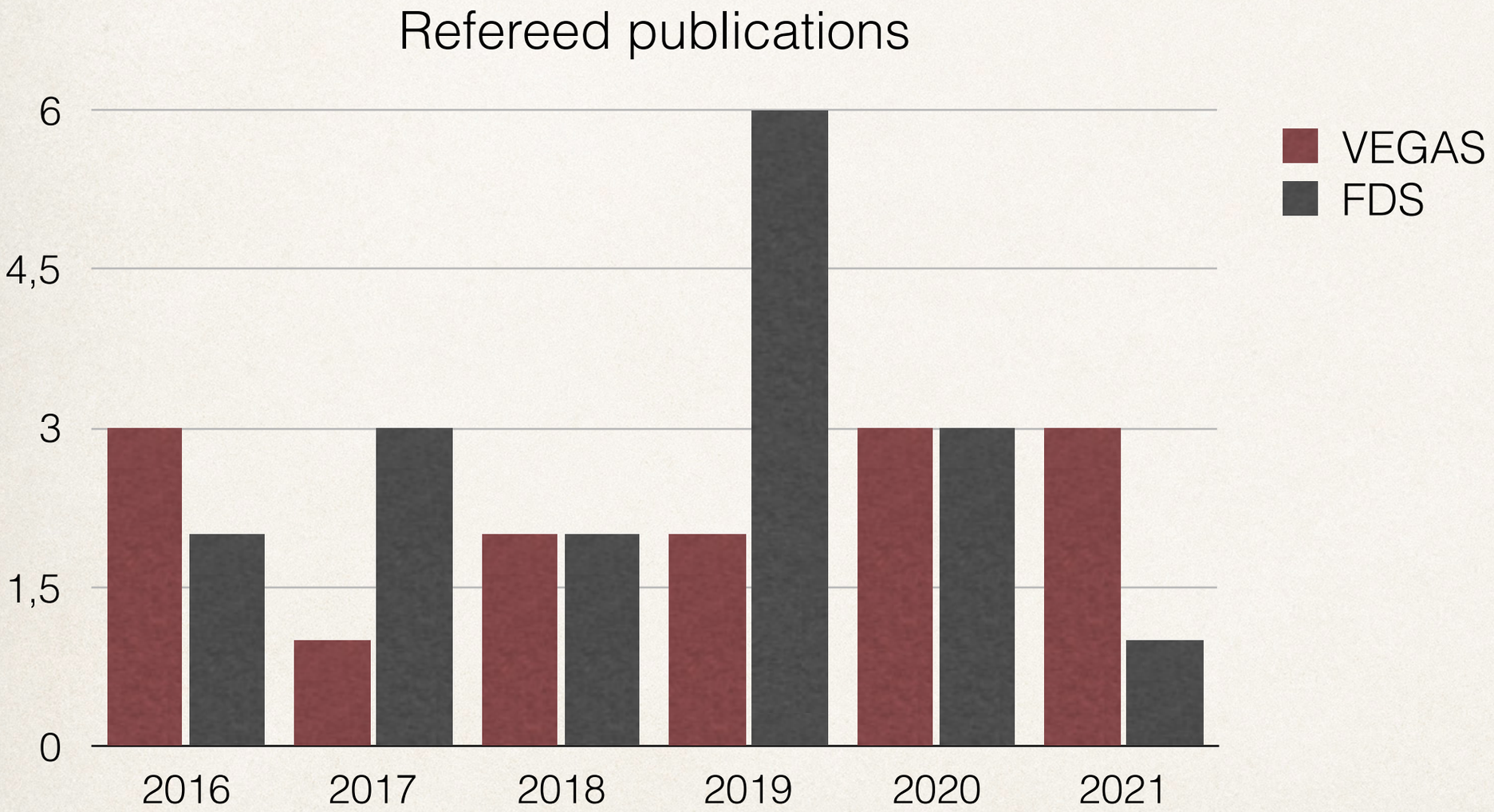
proposal for PRIN MUR 2021 (~680 Keuro)

SearchIng foR the faIntest nUggetS (SIRIUS): study of the ultra-diffuse galaxies in preparation for next generation astronomical surveys

Publications & press coverages

2016-2021

- 31 papers on refereed journals
- 4 invited talks (2018-2021)
- 3 ESO Messenger papers + 1 by May 31st
- 3 ESO photo releases



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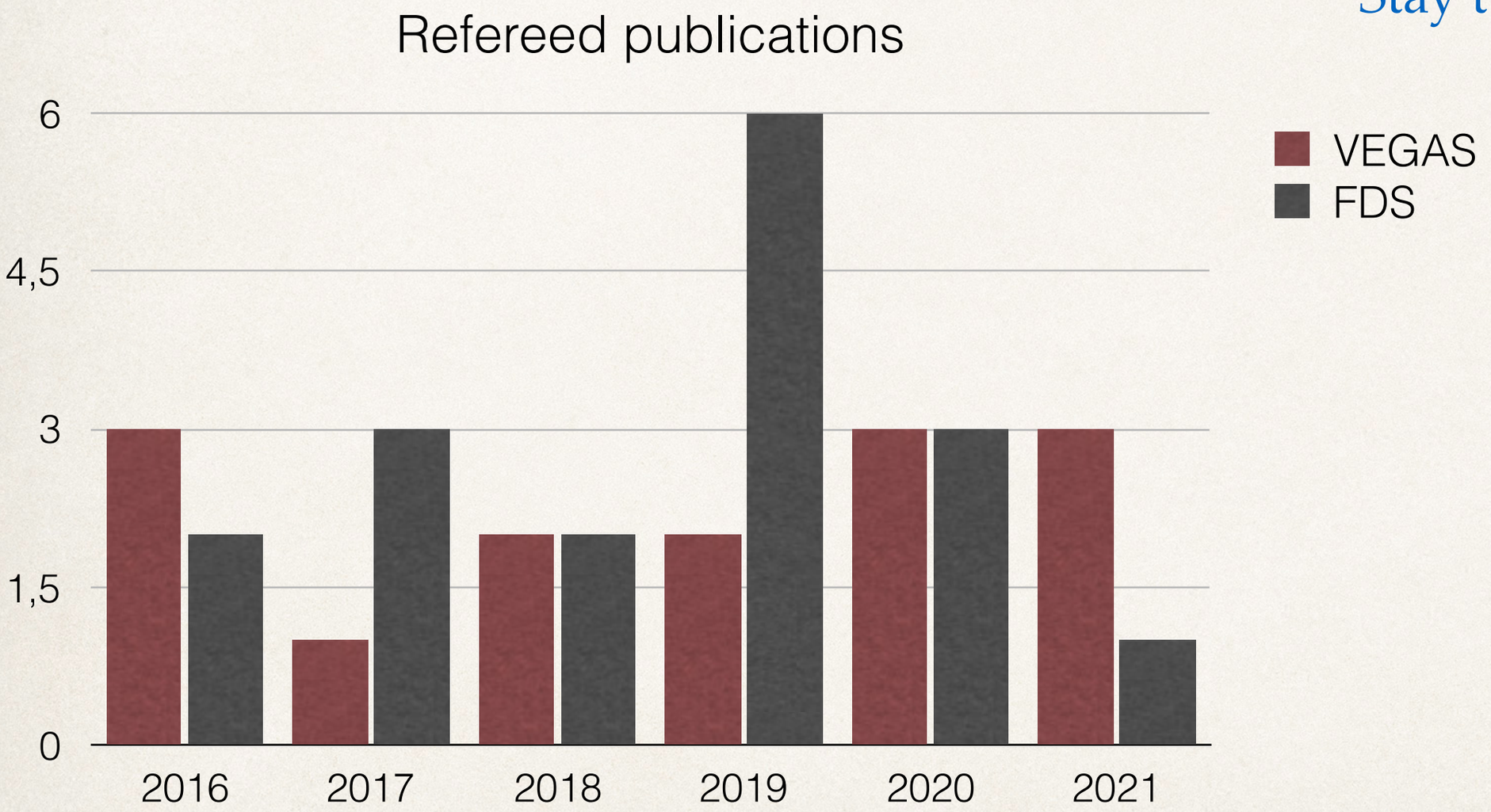
a new VEGAS image as
ESO picture of the week on May 31…

Stay tuned!



Future perspectives

- DR2 by 2023
- VEGAS-LSS (VST beyond 2021?)
- Euclid: SWG-LU -> LSB WP (in collaboration with R. Scaramella)
- LSST: SWG challenge 4
- WALLABY (in collaboration with P. Serra)

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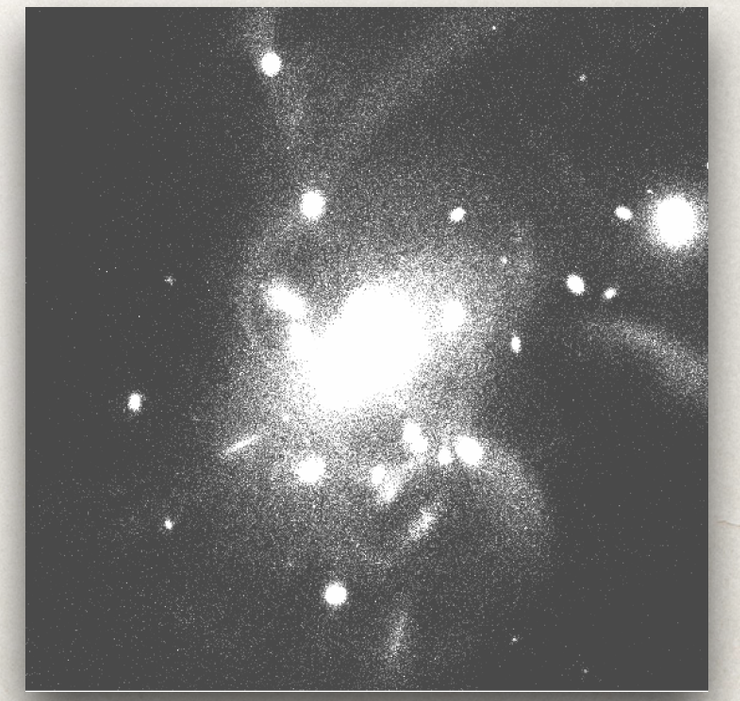
- LSST: SWG challenge 4

  ➥ apply the techniques developed in VEGAS to study the mass assembly at simulated LSST images

- WALLABY (in collaboration with P. Serra)



Credit: M.G. William

Future perspectives

- DR2 by 2023

- VEGAS-LSS (VST beyond 2021?)

  ➥ could exploit the excellent photometric wide field capabilities of VST to study the unexplored regions of voids in the LSS down to the LSB regime

- Euclid: SWG-LU -> LSB WP (in collaboration with R. Scaramella)

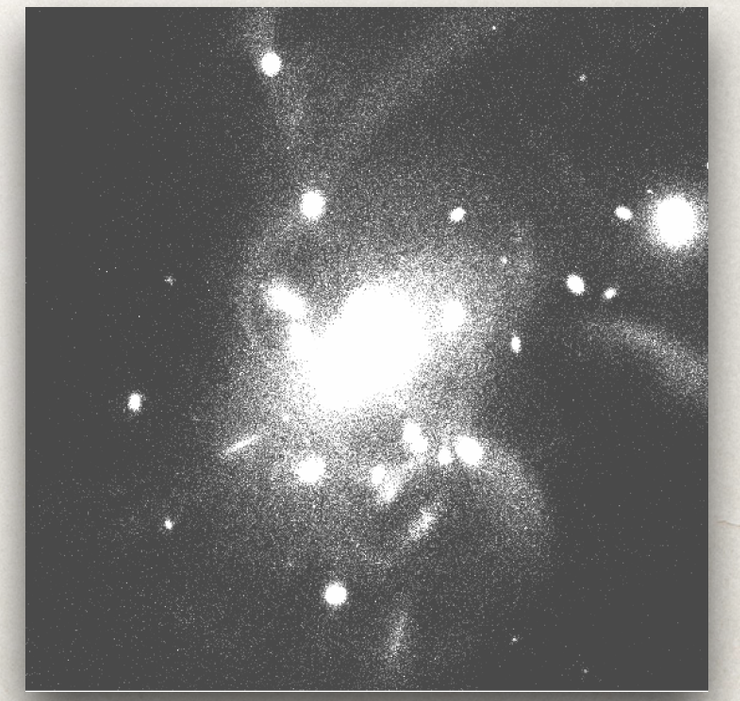
  ➥ detection & selection of LSB galaxies in simulated galaxies + detection & characterisation of the LSB structures in the galaxy outskirts

- LSST: SWG challenge 4

  ➥ apply the techniques developed in VEGAS to study the mass assembly at simulated LSST images

- WALLABY (in collaboration with P. Serra)

  ➥ shared the VEGAS data



Credit: M.G. William

Critical issues

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- Team

- funds (2016-2021)

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  - ➥ main stream INAF (2018) ☒
    PRIN INAF (2019) ☒
    PRIN MUR (2021) ☐