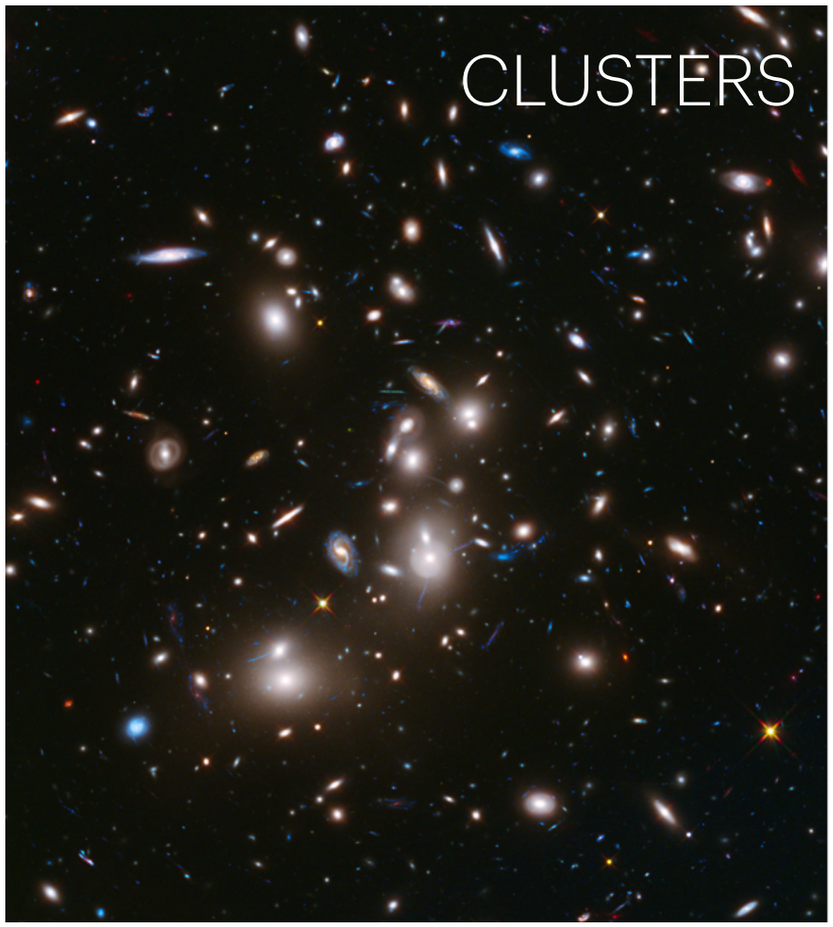
The role of the environment in shaping galaxy properties from Cosmic Noon to Cosmic Dusk

Benedetta Vulcani

Ayan Acharyya, Nina Akerman, Eric Giunchi, Marco Gullieuszik, Alessandro Ignesti, Amir Khoram, Antonino Marasco, Alessia Moretti, Giorgia Peluso, Mario Radovich, Bianca Poggianti, Peter Watson, Ariel Werle, Daria Zakharova

OaPD Days - 2024, Jun 27th

Galaxies and their environment



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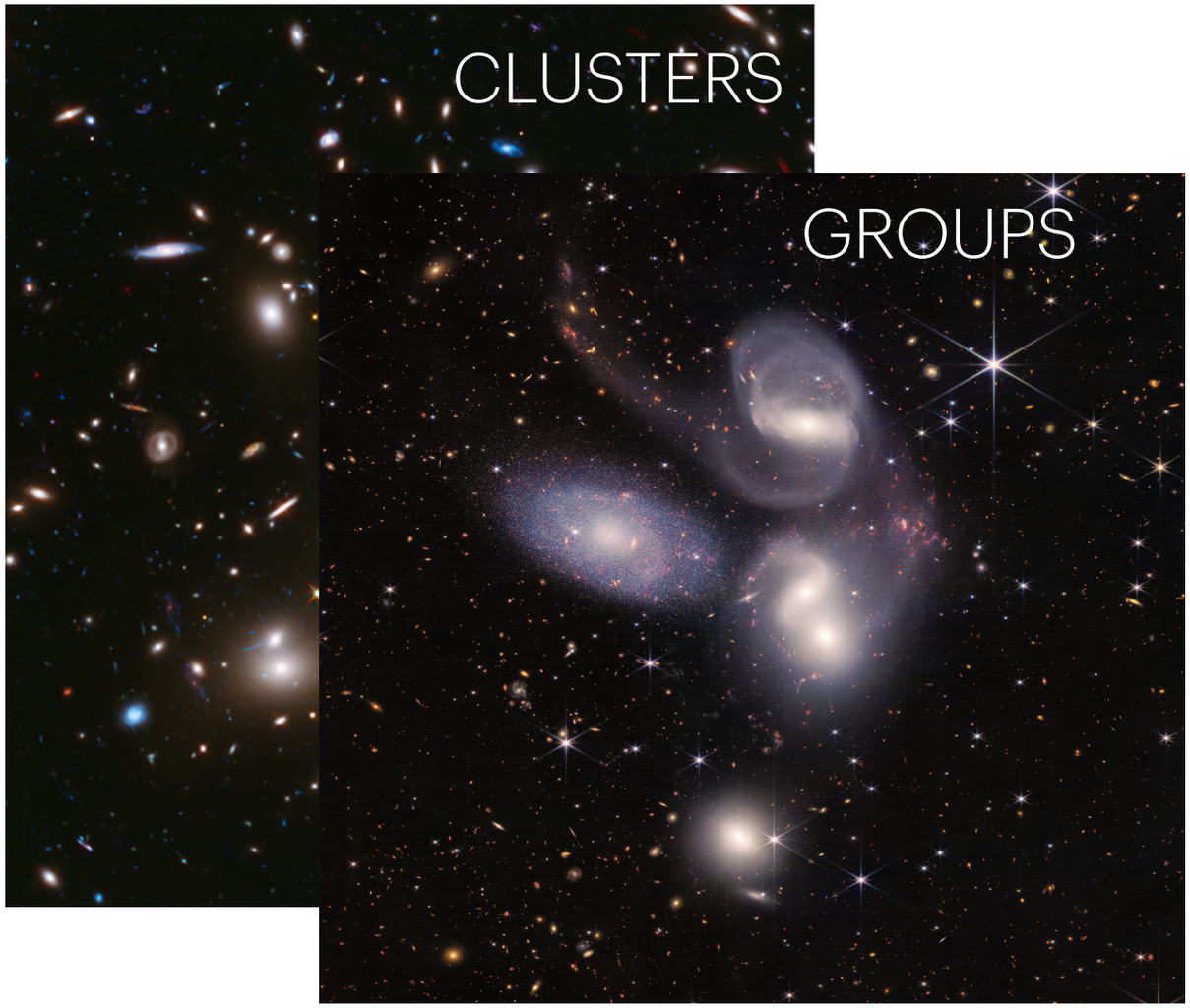

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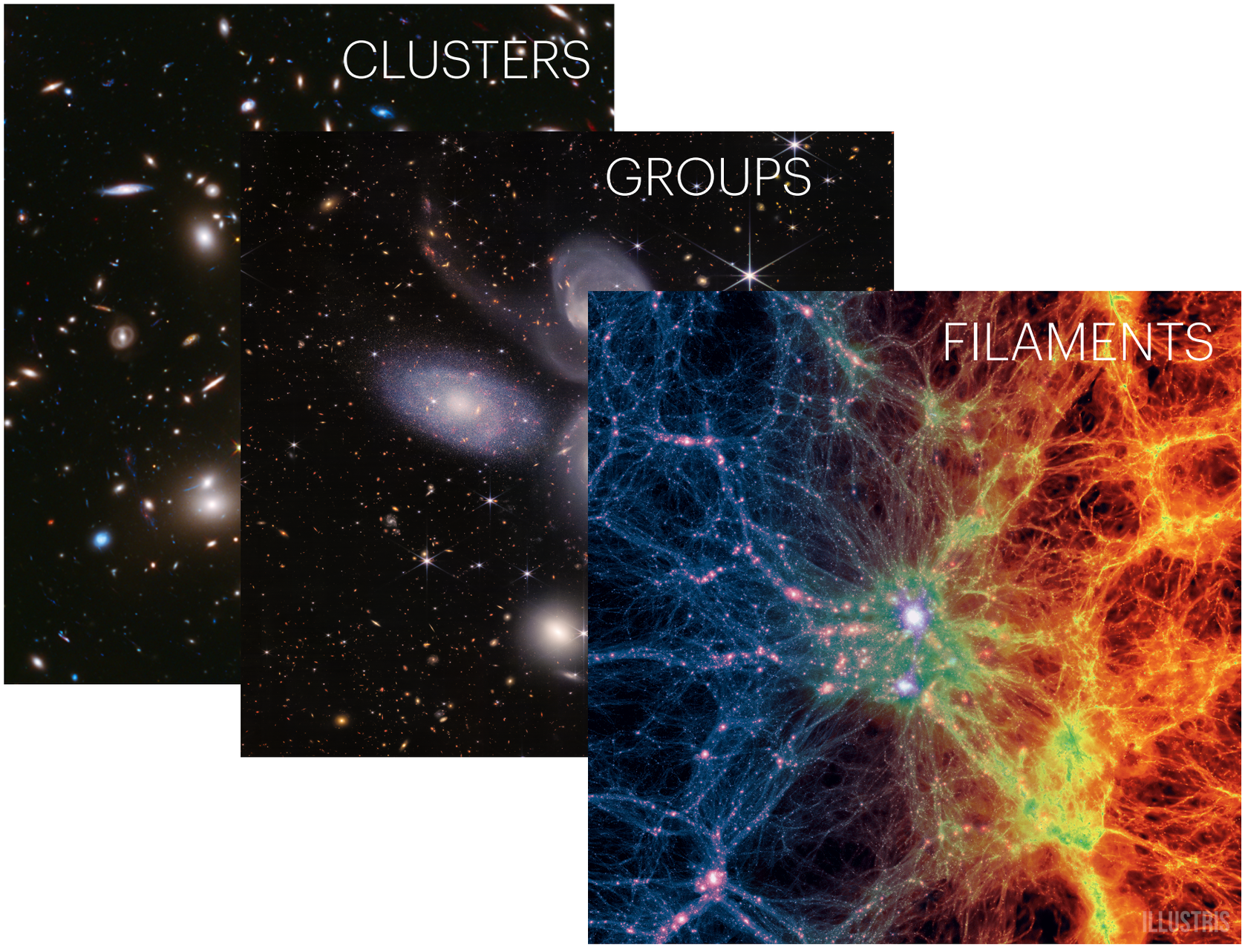
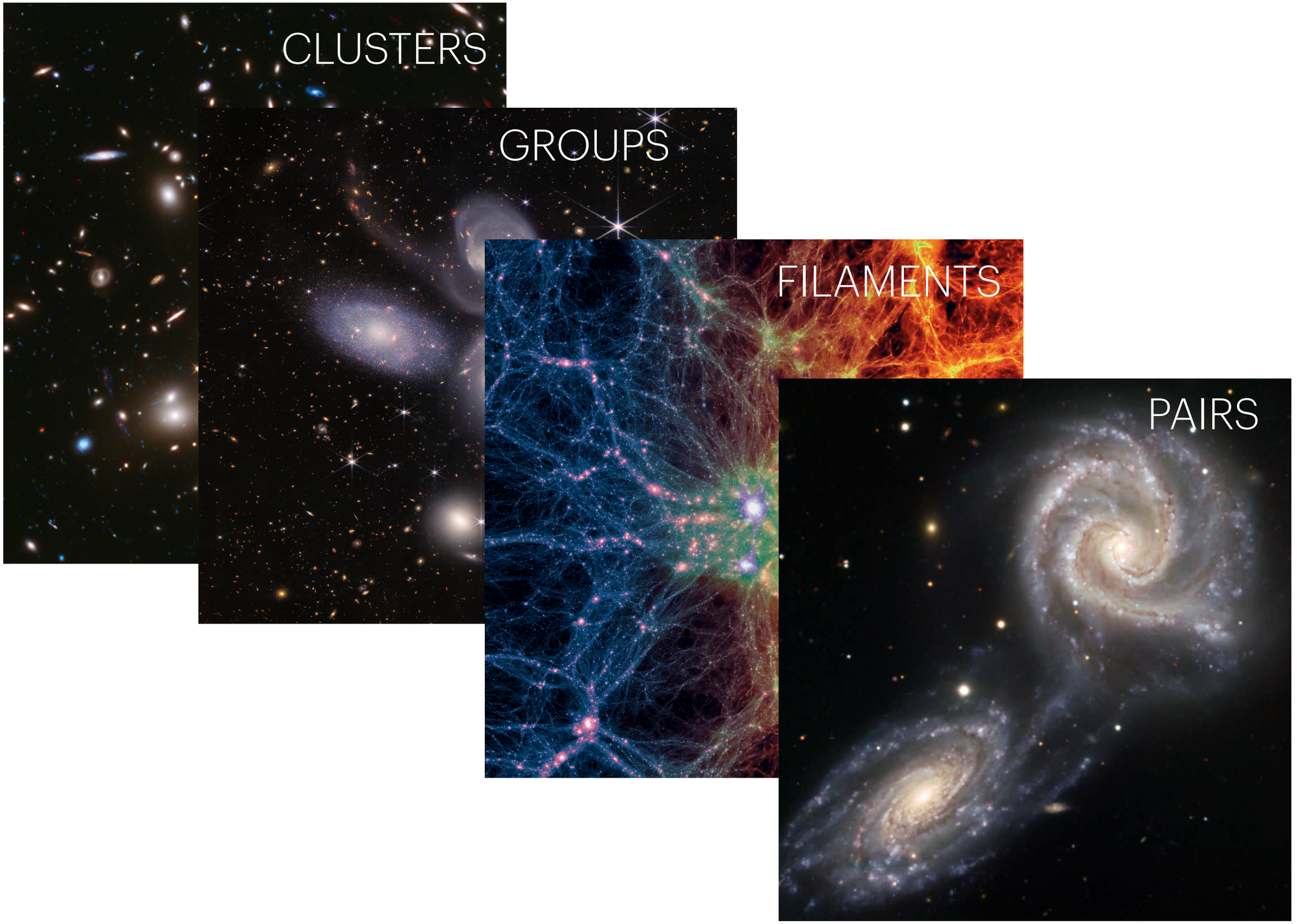


Galaxies and their environment



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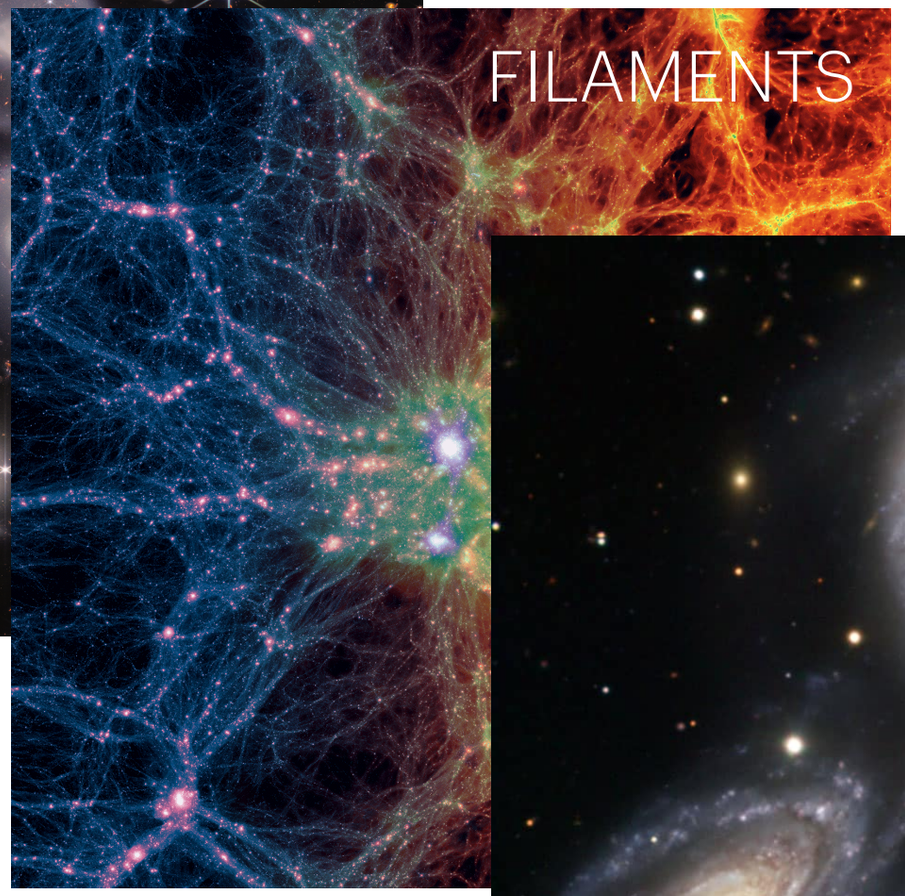
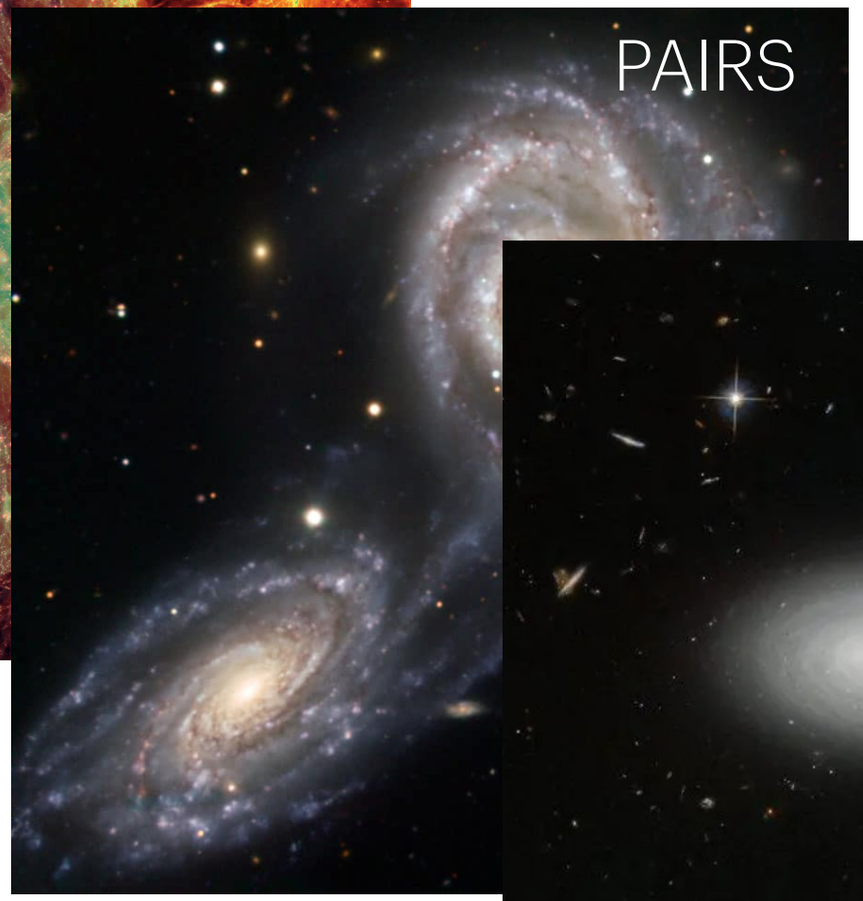
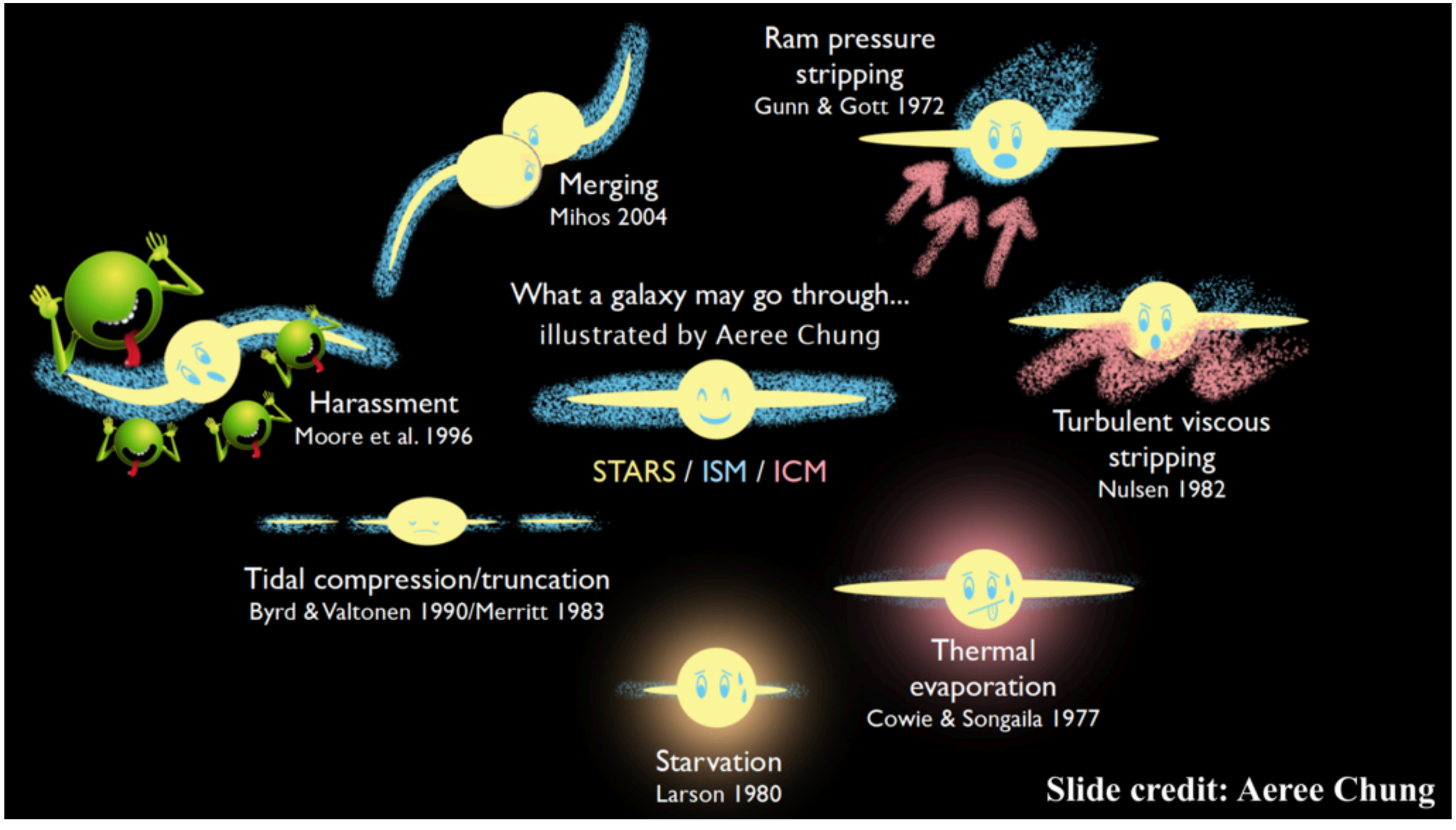
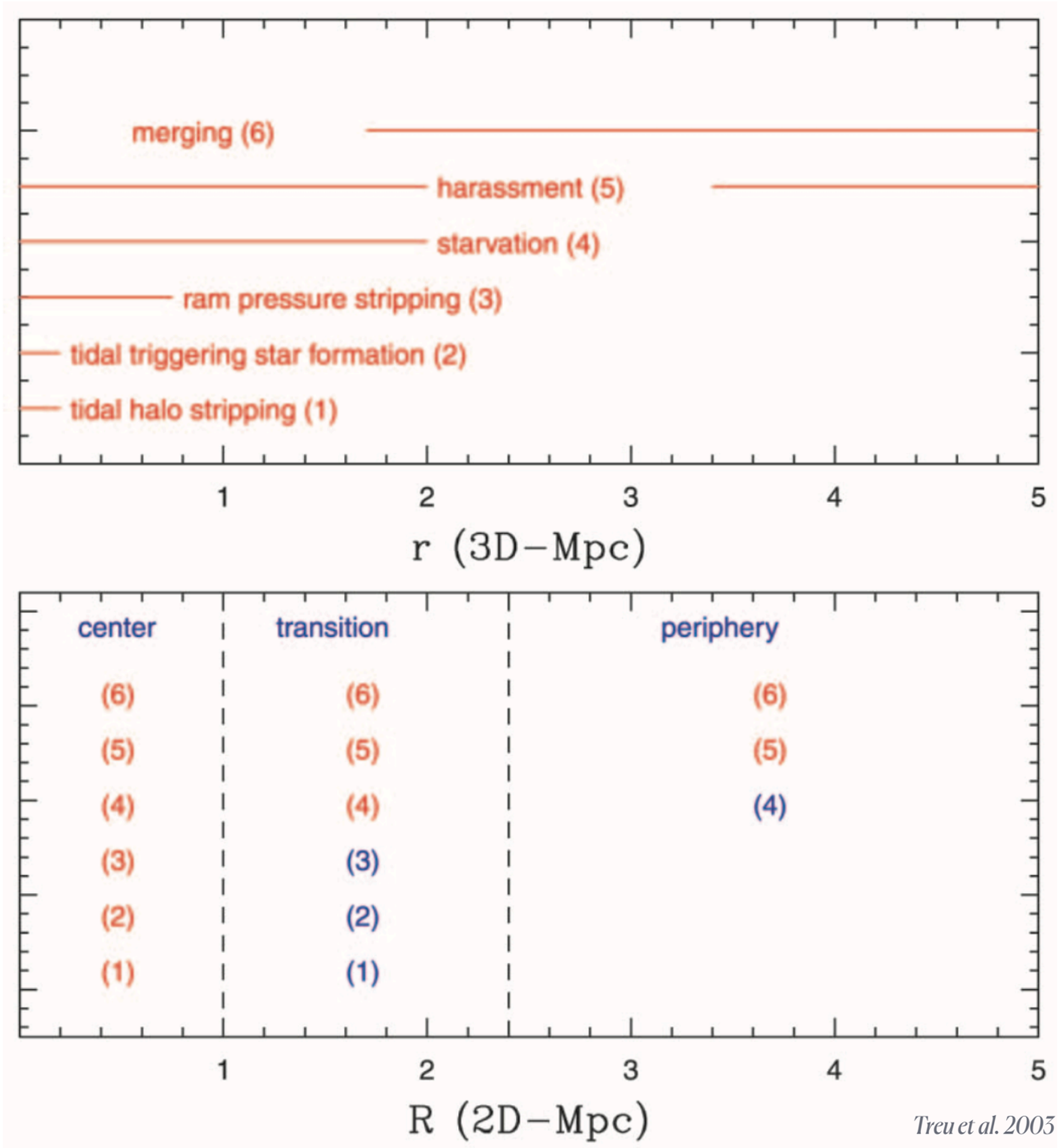




Environmental mechanisms



Environmental mechanisms



Treu et al. 2003

Our main question:

What is the role of environment in affecting galaxy properties?

Many people, many projects, many redshifts

- Virgo Filament Survey
- LEWIS
- OMEGAWINGS/GASP
- GASP/GLASS
- GOGREEN/Protoclusters
- Passage
- Beacon / Poppies

Many people, many projects, many redshifts

Redshift

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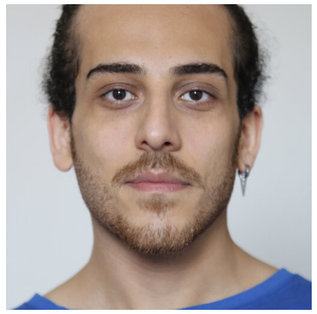
Daria Zakharova, PhD

Ayan Acharyya, post doc

Peter Watson, post doc

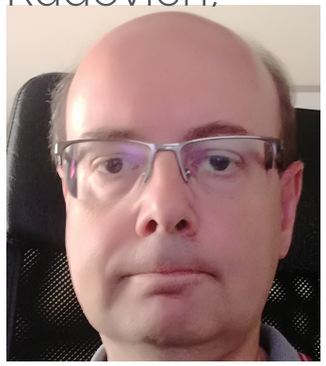
Amir Khoram, Ex Master student



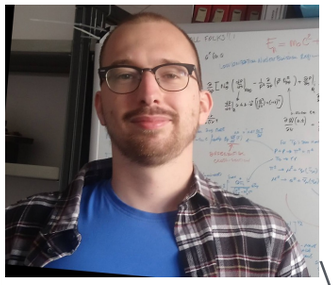
Giorgia Peluso, Ex PhD student

Antonino Marasco, staff

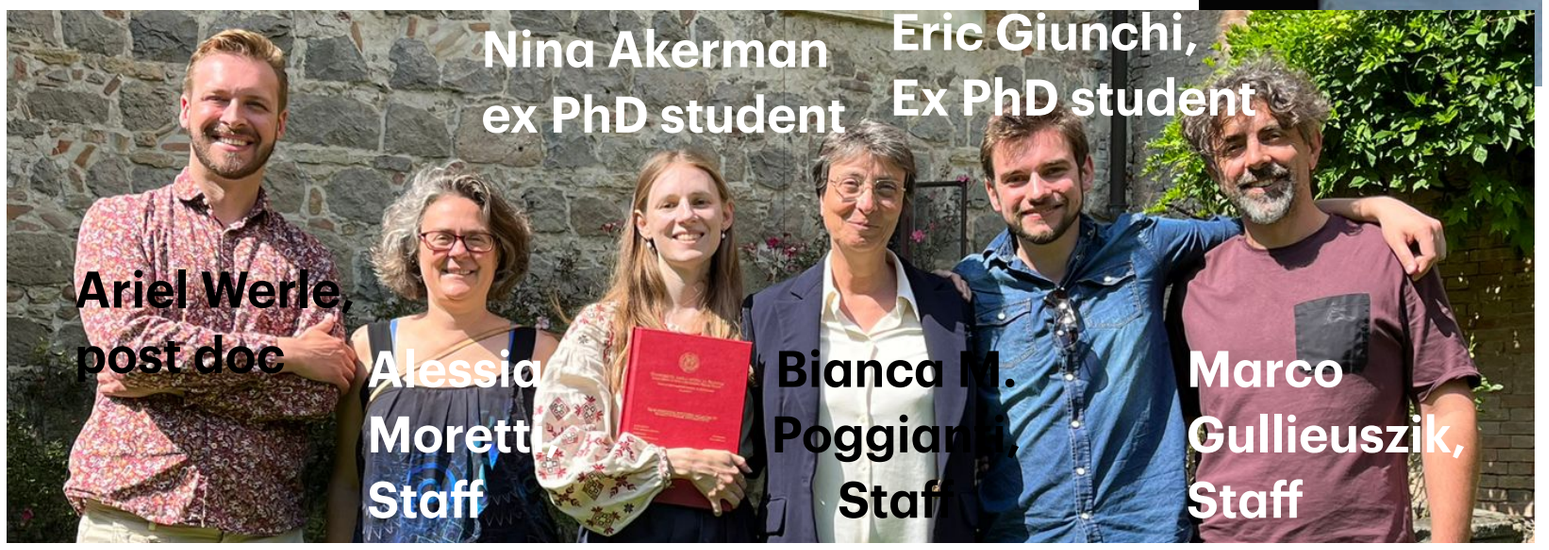
Mario Radovich,



Alessandro Ignesti, post doc



Benedetta Vulcani, staff



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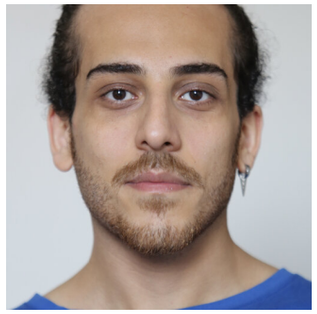

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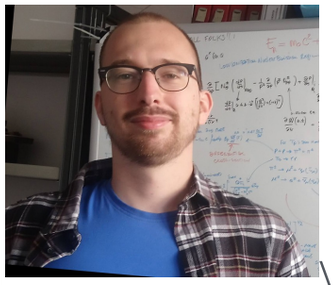
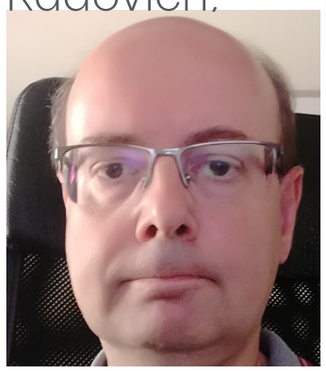
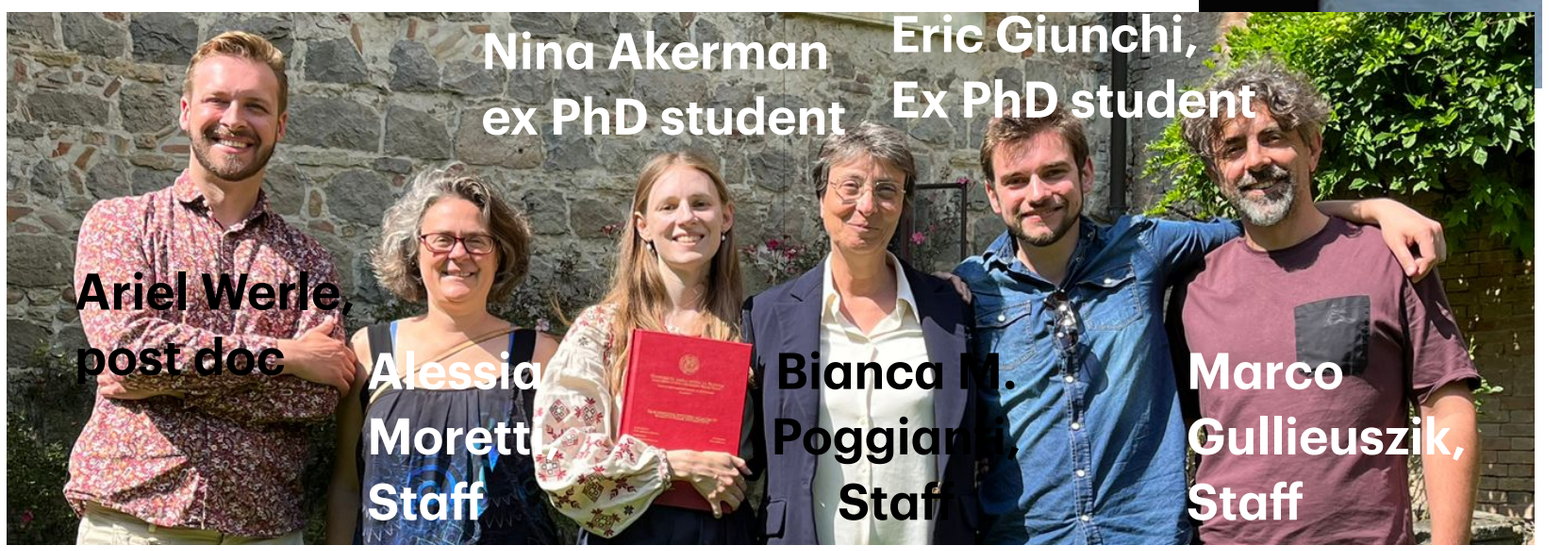


Antonino Marasco, staff

Mario Radovich,



Benedetta Vulcani, staff



WINGS OmegaWINGS

WIde-field **N**earby **G**alaxy-cluster **S**urvey and its extension

- A wide-field survey of 76 X-ray selected clusters at z=0.04-0.07
- Sigma=500-1200+km/s, Log L_X=43.3-44.7 erg/s
- B and V deep photometry (WFC/INT, WFC/2.2m, Omegacam/VST) (Gullieuszik et al. 2015, Varela et al. 2009)
- Optical fibre spectroscopy with 2dF/AAT, WYFFOS/WHT, AAOmega (>90% spec. completeness at V=20, 30k spectra) (Moretti et al. 2017, Moretti et al. 2014)
- Near-IR deep photometry, J and K with WFC/UKIRT (Valentinuzzi et al. 2009)
- U/u band with INT, LBT & Bok, Omegacam (Omizzolo et al. 2014, D'Onofrio et al. 2020)

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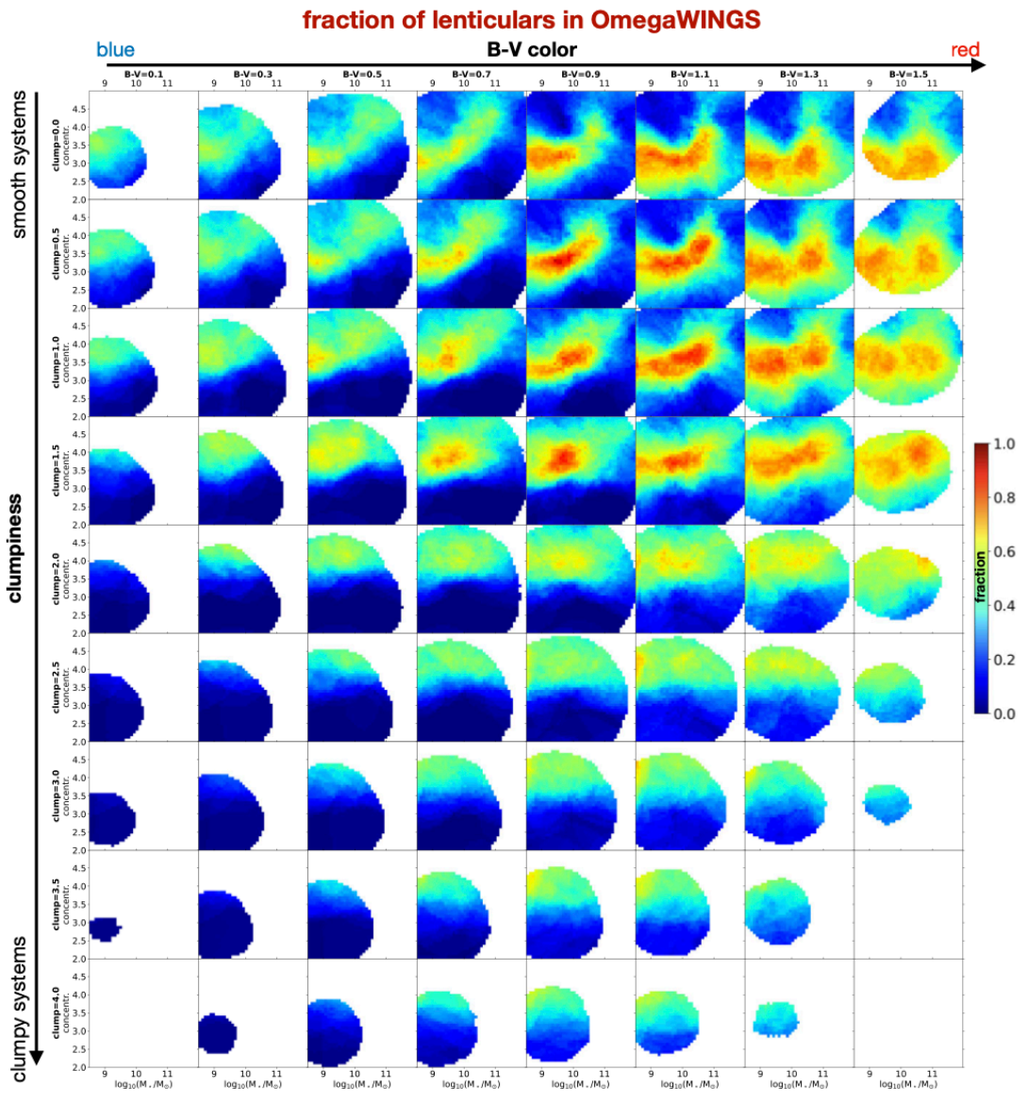
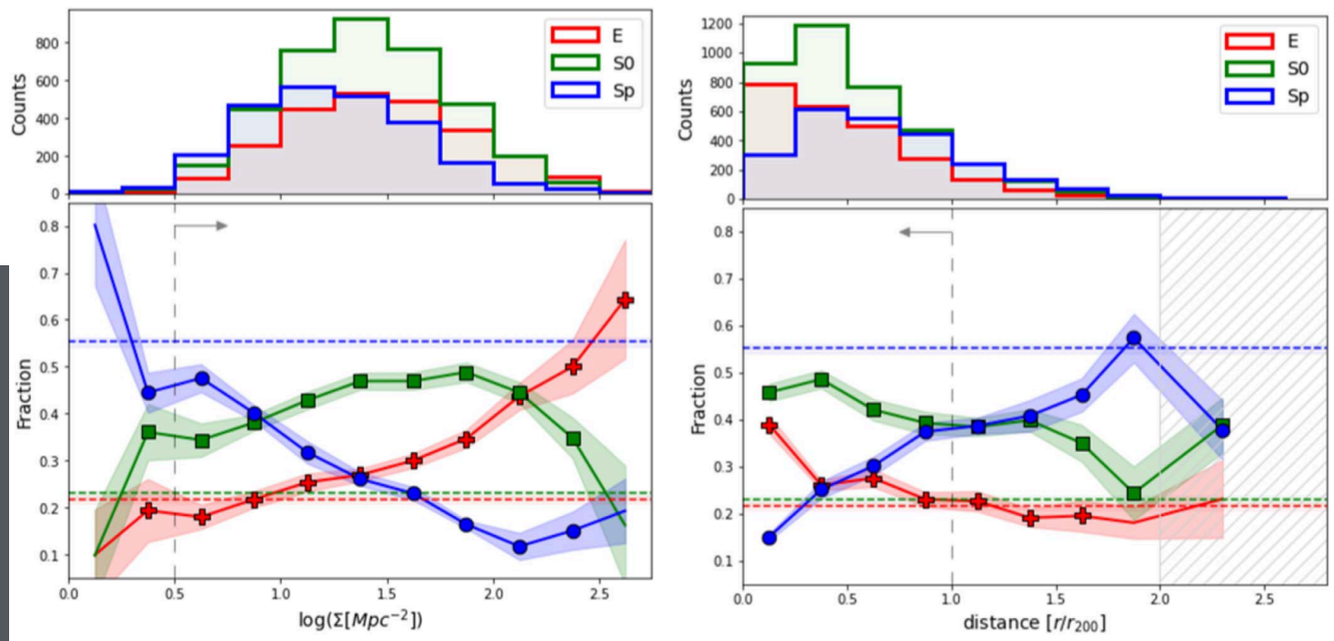
Still
the reference local
cluster sample for
upcoming surveys

WINGS OmegaWINGS



Marasco et al. 2023

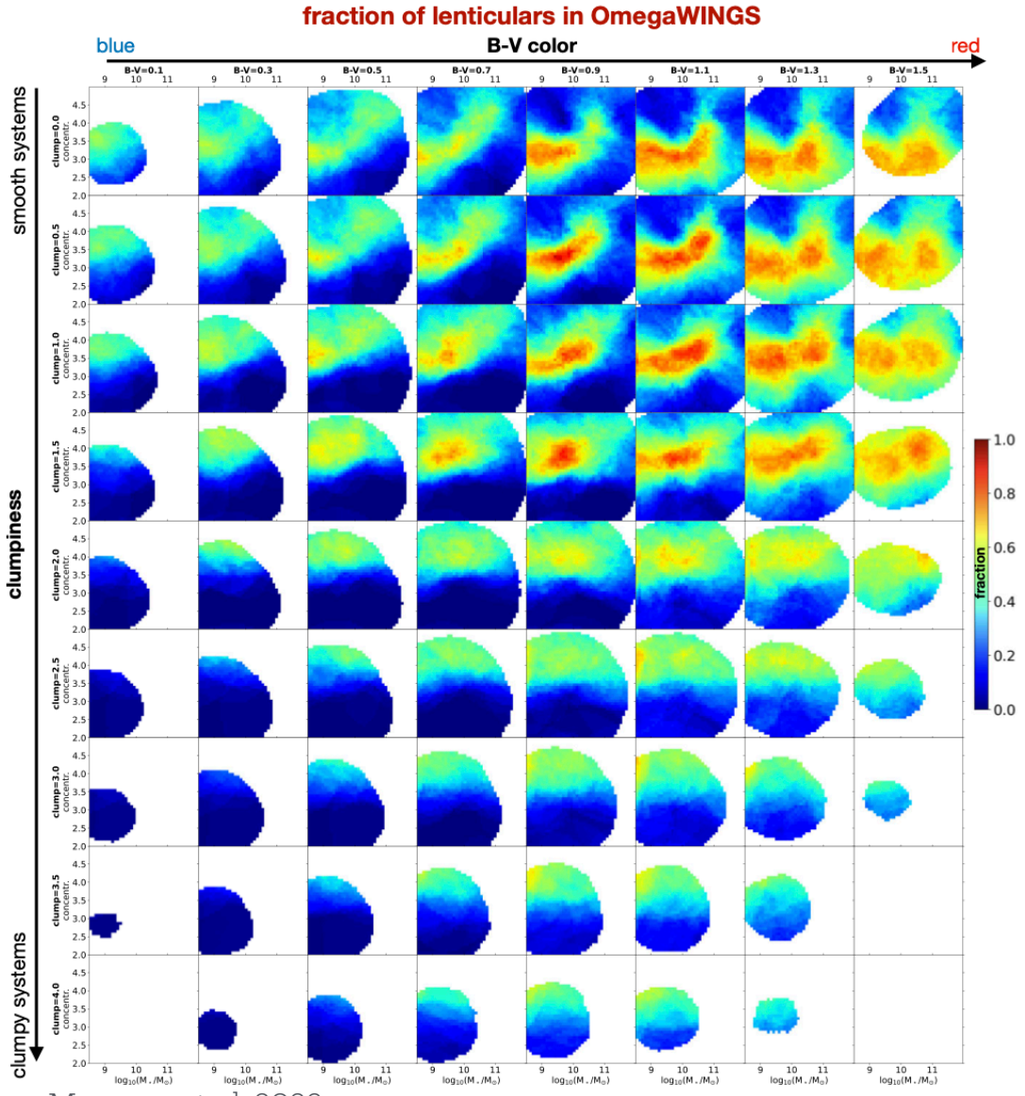
Vulcani et al. 2023



Morphological transformations of cluster galaxies

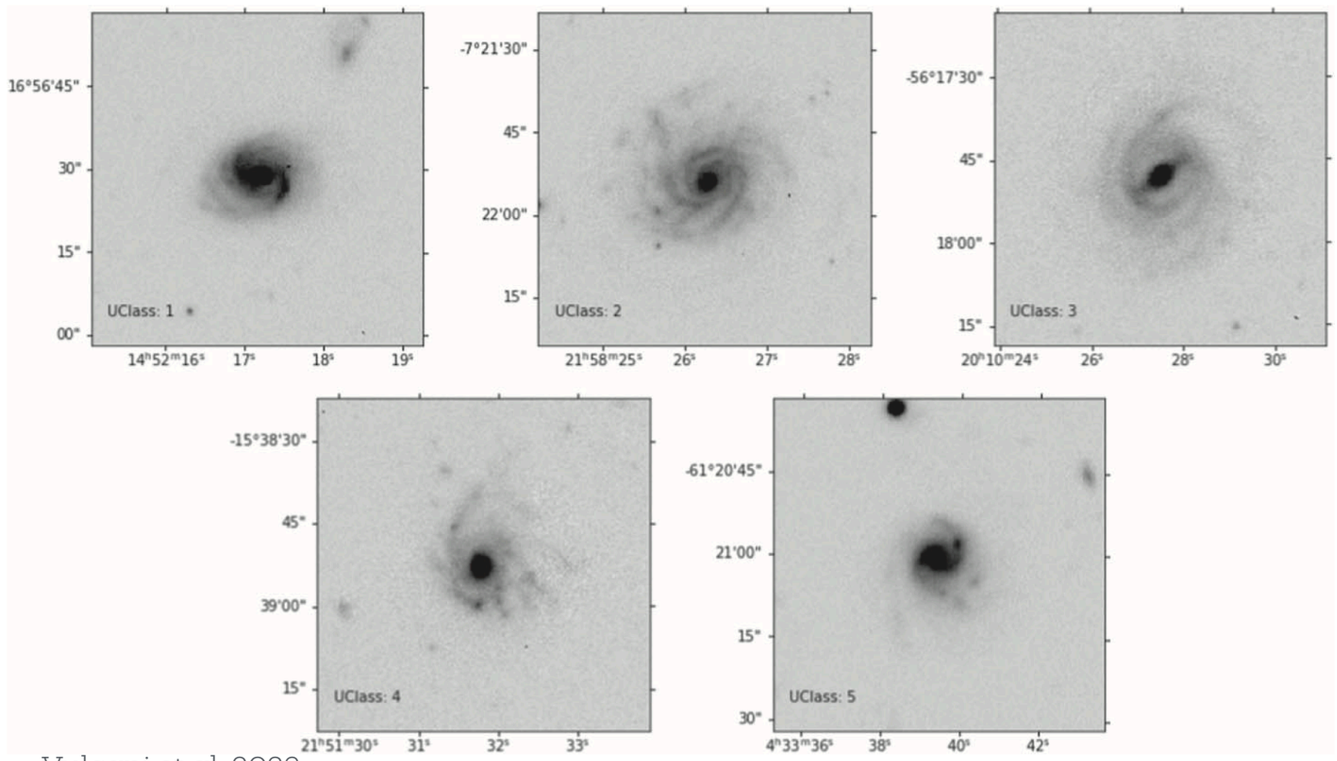
WINGS OmegaWINGS

Catalog of unwinding galaxies

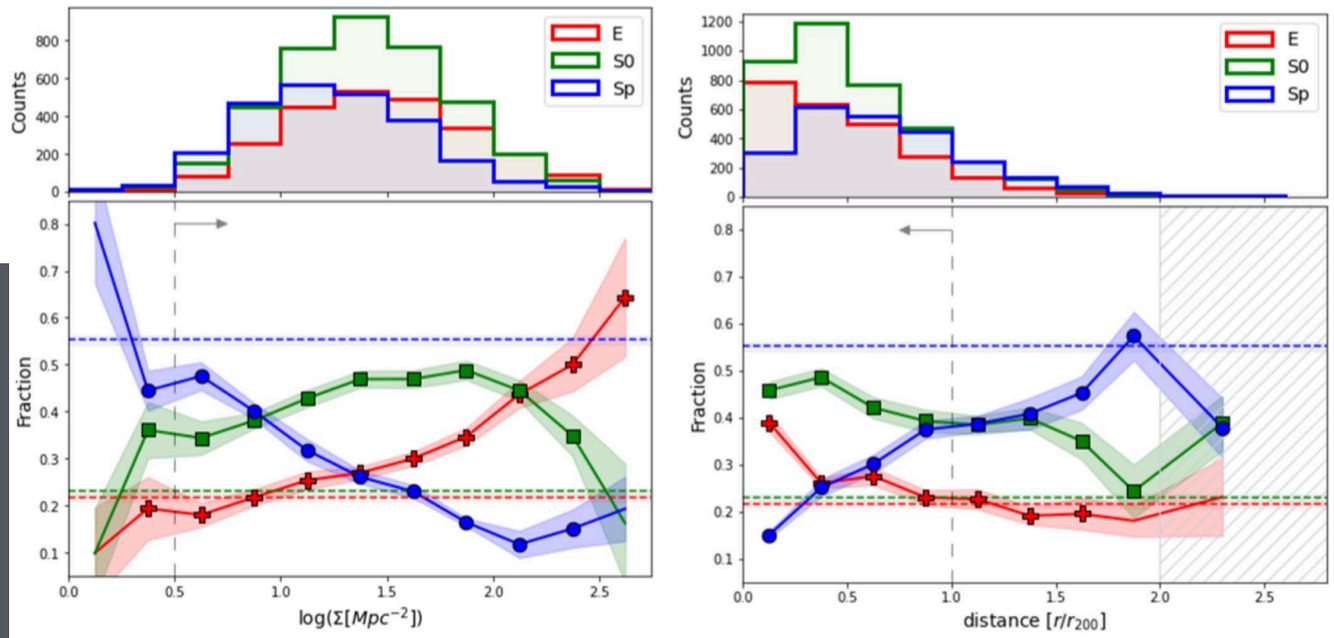


Marasco et al. 2023

Vulcani et al. 2021



Vulcani et al. 2023



Morphological transformations of cluster galaxies

GASP

http://web.oapd.inaf.it/gasp/

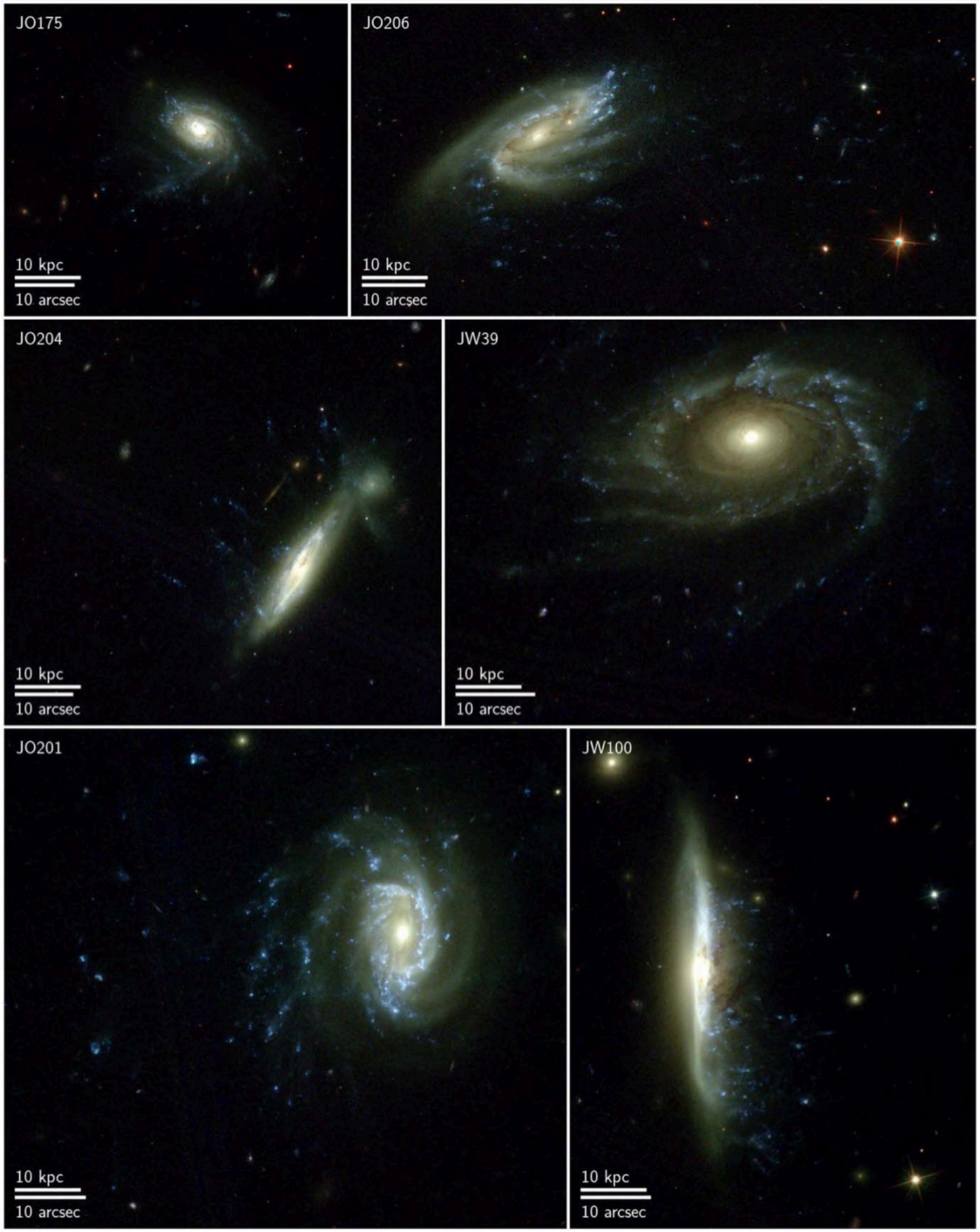
European Research Council
Established by the European Commission

MUSE ESO Large Programme, HST (Halpha, UV to I) , ALMA/APEX (CO), JVLA/MeerKAT/ LOFAR/ATCA (HI, radio cont., polariz.), UVIT@ASTROSAT (UV) + simulations

114 galaxies at z=0.04-0.07
with masses 10^9-10^11.5 Msun
in clusters, groups, filaments and isolated

Disky “disturbed” galaxies (with signs of extraplanar debris in B-band images) + control sample (~30 undisturbed disky galaxies).

PI: B. M. Poggianti, PI (INAF-OaPD)
N. Akerman (UniPD)
C. Bacchini (DARK)
C. Bellhouse (Univ. Of Nottingham)
D. Bettoni (INAF-OaPD)
A. Biviano (INAF-OaTS)
J. Crossett (Universidad de Valparaiso)
T. Deb (CFA)
J. Fritz (IRyA, UNAM)
K. George (LMU)
E. Giunchi (UniBO)
M. Gullieuszik (INAF-OaPD)
A. Ignesti (INAF-OaPD)
Y. Jaffé (Univ. de Valparaiso)
A. Lourenco (Universidad de Valparaiso)
A. Marasco (INAF-OaPD)
A. Moretti (INAF-OaPD)
A. Mueller (Ruhr-Universitat Bochum)
R. Paladino (INAF-IRA)
G. Peluso (INAF -OAB)
M. Radovich (INAF-OaPD)
M. Ramatsoku (INAF-OaC)
P. Serra (INAF-OaC)
R. Smith (Univ. de Valparaiso)
N. Tomicic (INAF-OAA)
S. Tonnesen (CCA)
J. van Gorkom (Columbia University)
M. Verheijen (Kapteyn Astronomical Institute)
B. Vulcani (INAF-OaPD)
A. Werle (INAF-OaPD)
A. Wolter (INAF-OaB)



Gullieuszik et al. 2023

Star Formation (and AGN)

Quenching, post-starburst galaxies and their relation with RPS; radio-echo due to quenching

Vulcani+2020, Ignesti+2022

Star formation rate – Stellar Mass, integrated and spatially resolved relations in jellyfish and in normal galaxies

Vulcani+2018c, 2019, 2020

SF in stripped tails: amount and clump properties (sizes, scaling relations, morphologies, masses, stellar ages etc)

Poggianti+2019, Gullieuszik+2020, 2023, Giunchi+2023a,2023b, Werle+2024, Tonnesen+in prep., Smith+in prep., Giunchi+in prep.

(Lack) of effect of stellar feedback on RPS rate

Akerman+2023a, Akerman+in prep.

Different SFR indicators

George+2018, 2023, George+submitted, Tomicic+submitted

AGN feedback, connection RPS-AGN activity (observations and simulations), AGN-excess in RPS galaxies

Poggianti+2017, George+2019, Radovich+ 2019, Peluso+2022, Akerman+2023b, Radovich+in prep,

Gas

Gas metallicities: mass-Z relation and gradients of RPS vs normal galaxies, and of AGN vs non-AGN

Franchetto+2020, 2022, 2023, Peluso+2023, **Peluso+in prep.**

Molecular gas and RPS: amount of molecular gas, efficient conversion HI to H2, formation in tails

Moretti+2018, 2020a, 2020b, 2023, Bacchini+2023, **Moretti+in prep,**

HI gas in RPS galaxies

Ramatsoku+2019, 2020, Luber+2022, Deb+2020, 2022, **Ramatsoku+in prep.**

Radio-continuum tails+ direct magnetic field detection in stripped tail

Ignesti+2022, 2023a, 2023b, Mueller+2021, **Ignesti+in prep.**

Evidence for mixing of stripped ISM with hot intra-cluster medium

Franchetto+2023, Tomicic+2021a, Campitiello+2021

RPS of hot halo and disk gas from cosmological hydro-dynamical EAGLES simulation

Kulier+2023

Diffuse Ionized Gas

Tomicic+2021a, 2021b

X-ray tails

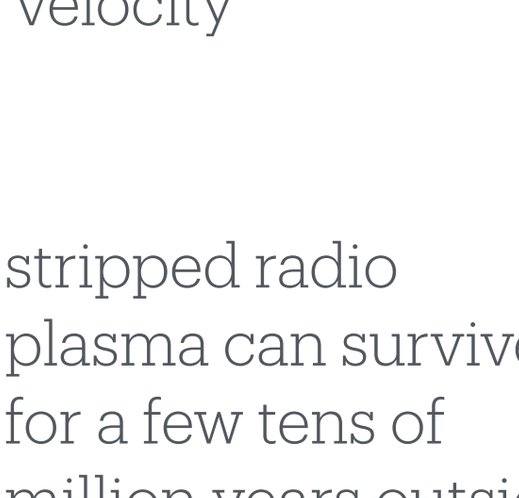
Poggianti+2019, Campitiello+2021, Bartolini+2022

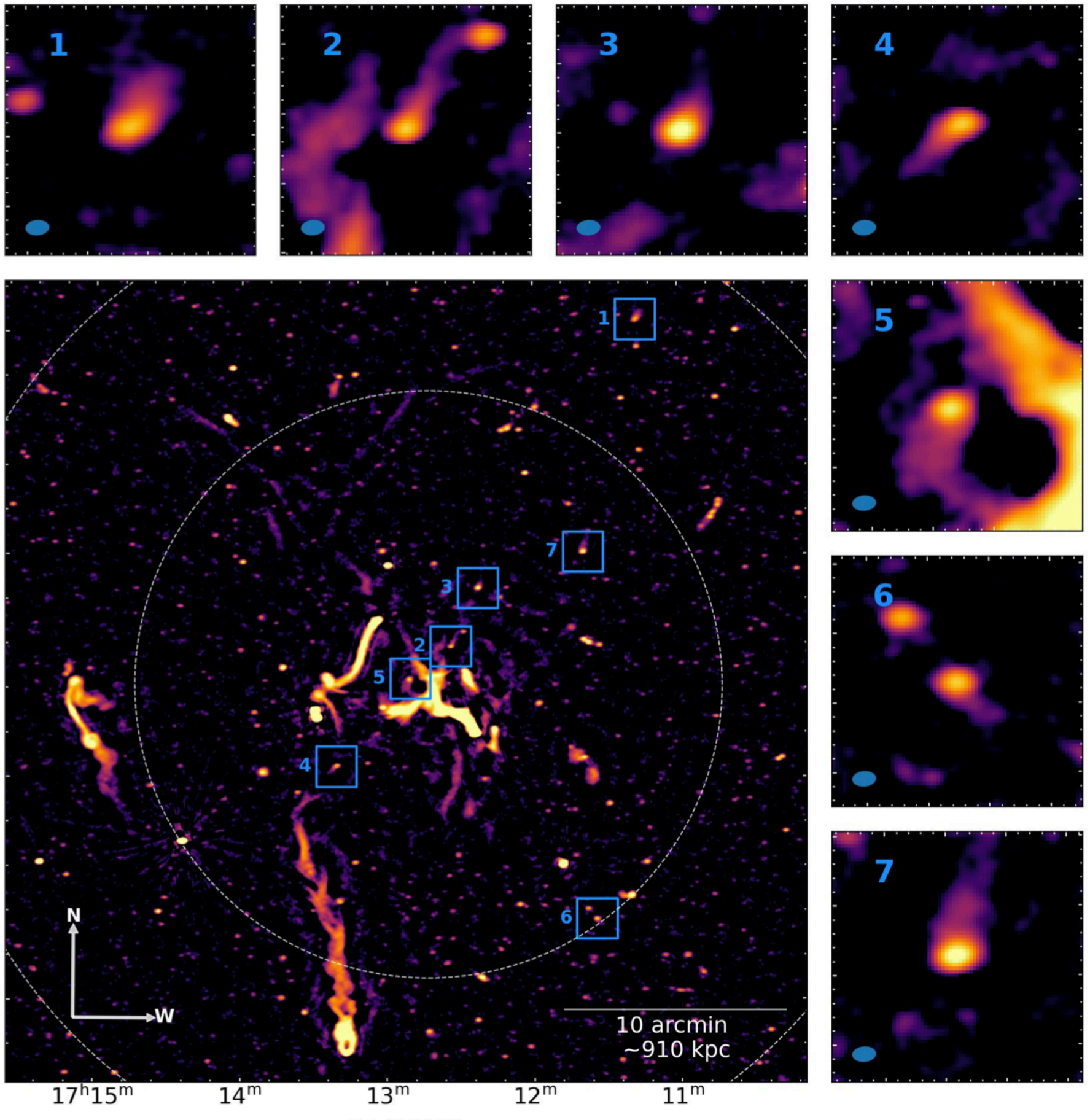
Single galaxy detailed studies of the gas and stellar properties

Poggianti+2017, Bellhouse+2017, 2019, Fritz+ 2017, Gullieuszik+2017, Moretti+2017, Vulcani+2017, 2018a

first indirect measurement of the stripped, nonthermal ISM velocity

stripped radio plasma can survive for a few tens of million years outside of the stellar disk





Environment+ Galaxy Structure

Orbits and phase-space of RPS galaxies, tail direction, jellyfish galaxies and cluster dynamical status

Jaffe'+2018, Biviano+2024, Smith+2022, Lourenco+2023, Salinas+2024

Incidence and importance of RPS in galaxy clusters

Vulcani+2022

Outside of clusters: different processes act in the same group; galaxy filaments; case-studies of gas accretion and merging, evidence of multiple processes

Vulcani+2017, 2018a, 2018b, 2019, 2021

Indirect (Impact) of RPS on galaxy morphology/ structure: unwinding of spirals arms, spectro-morphological evolution, bars

Bellhouse+2021, Vulcani+2022, Marasco+2023, Sanchez-Garcia+2023, Bellhouse+in prep, Marasco+in prep.

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Bellhouse+2021, Vulcani+202
Sanchez-Garcia+2023, Bellhouse
Marasco+in prep.

New postdoc coming!

Environment+ Galaxy Structure

Orbits and phase-space of RPS galaxies, tail direction, jellyfish galaxies and cluster dynamical status

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Incidence and importance of RPS in galaxy clusters

Vulcani+2022

Outside of clusters: different processes act in the same group; galaxy filaments; case-studies of gas accretion and merging, evidence of multiple pr esses

Vulcani+2017, 2018a

MAGNET

Indirect (Impact) of RPS on galaxy morphology/ structure: unwinding of spirals arms, spectro-morphological evolutio bars

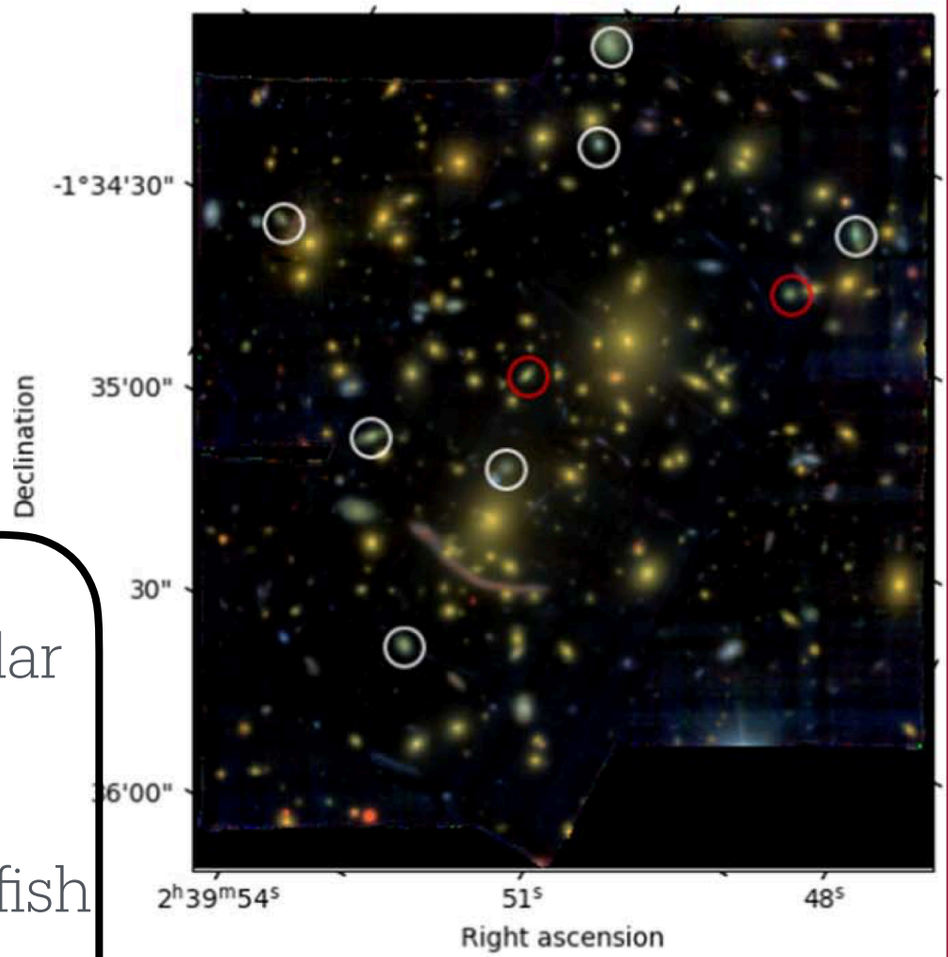
Bellhouse+2021, Vulcani+202
Sanchez-Garcia+2023, Bellhouse
Marasco+in prep.

New postdoc coming!

GASP @ z=0.3-0.5

10 clusters observed by the MUSE GTO time

Moretti et al. 2022



Importance of
RPS in galaxy clusters

Moretti+2022, Moretti+in prep

Star formation rate – Stellar Mass,
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Vulcani+2024

Gas metallicities: mass-Z relation and gradients of RPS vs normal galaxies

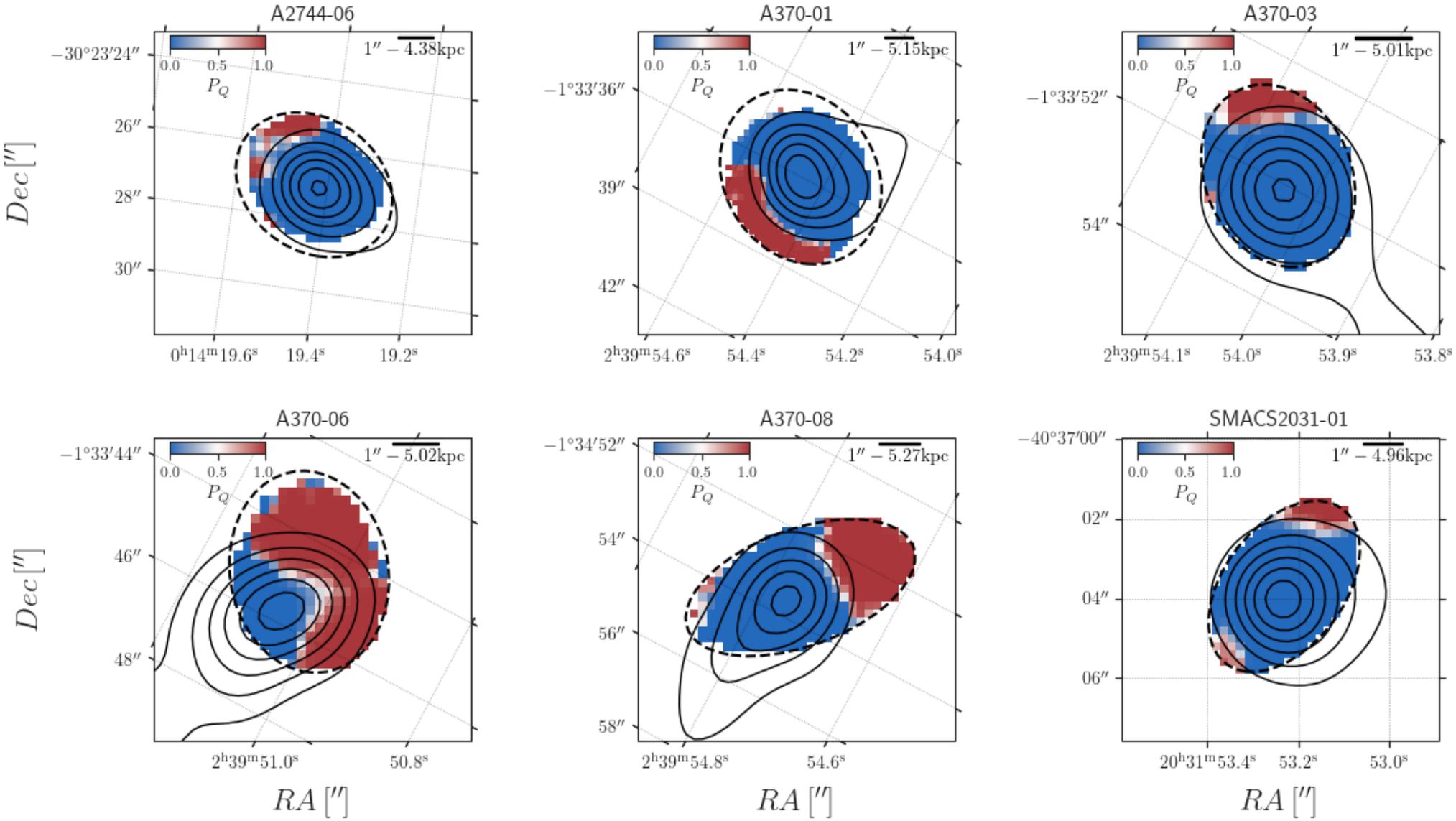
Khoram+2024, Khoram+in prep

Quenching, post-starburst galaxies and their relation with RPS

Werle+2022, Werle+in prep

Orbits and phase-space of RPS galaxies, tail direction, jellyfish galaxies and cluster dynamical status

Bellhouse+2022

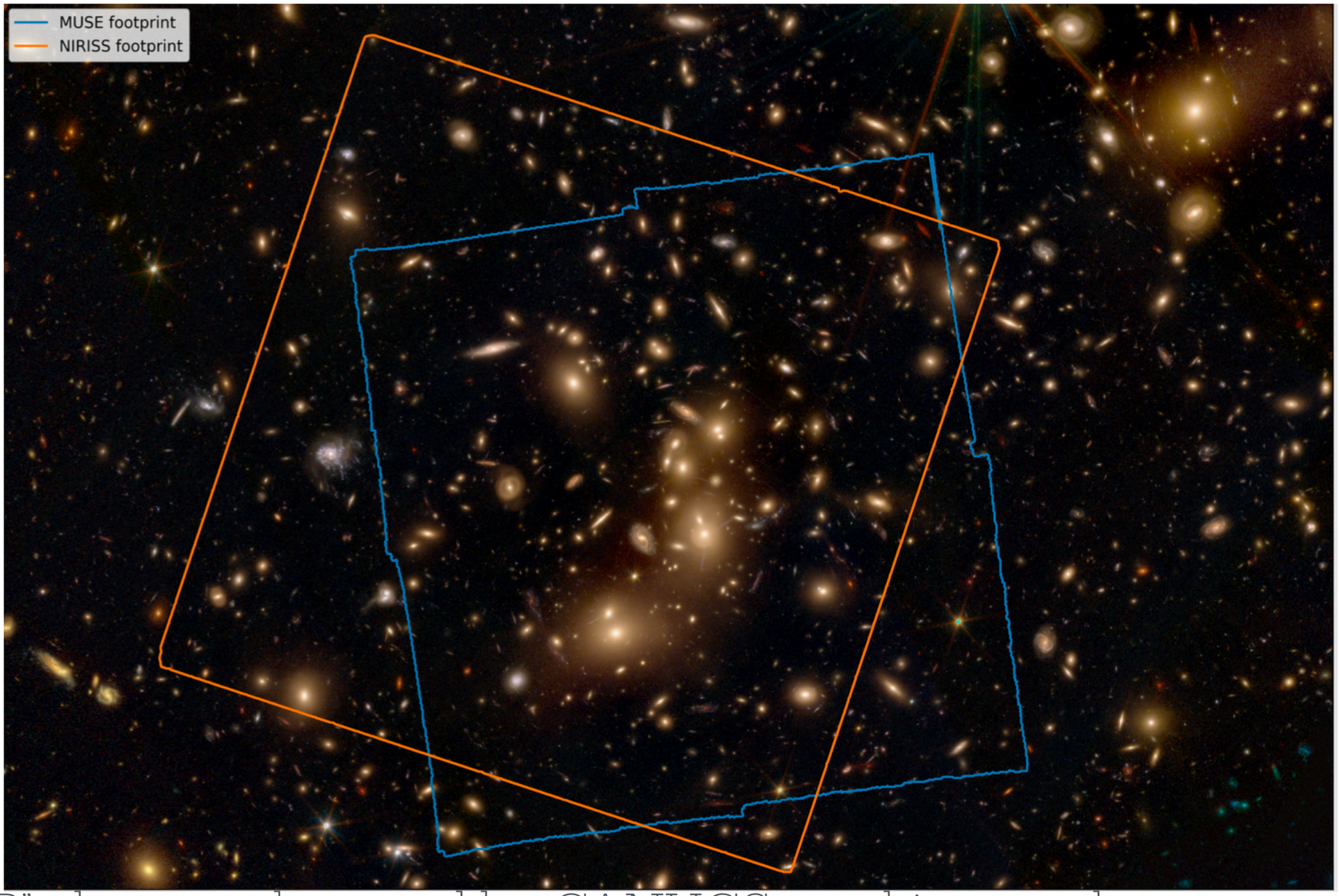


Differential quenching in galaxies

GLASS - ERS

Grism Lensed-Amplified Survey from Space - ERS (PI Tommaso Treu)

Abell 2744 is one of the best studied clusters: ACS, WFC3, NIRSpec, NIRCAM and NIRISS from HST and JWST data; Proposal IDs 11689, 13386, 13495, 1324, 3516, 4111, 1176, and 2561.

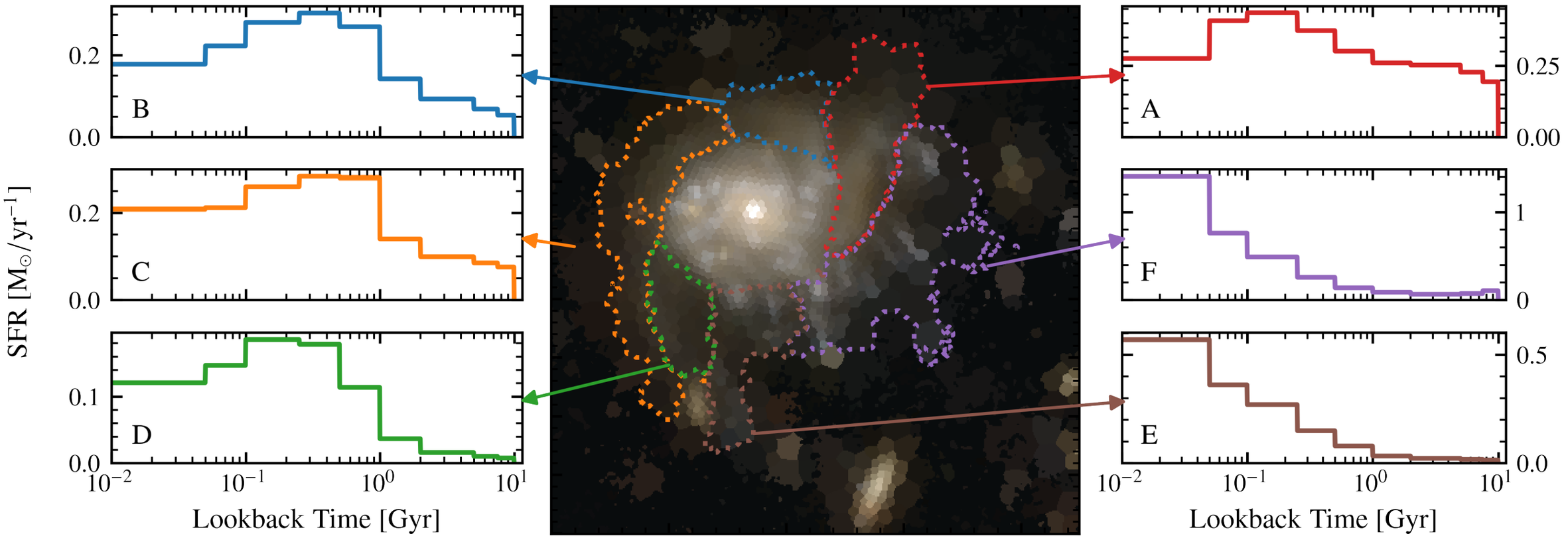


Other “GASP” clusters observed by CANUCS, working on them too

GLASS - ERS

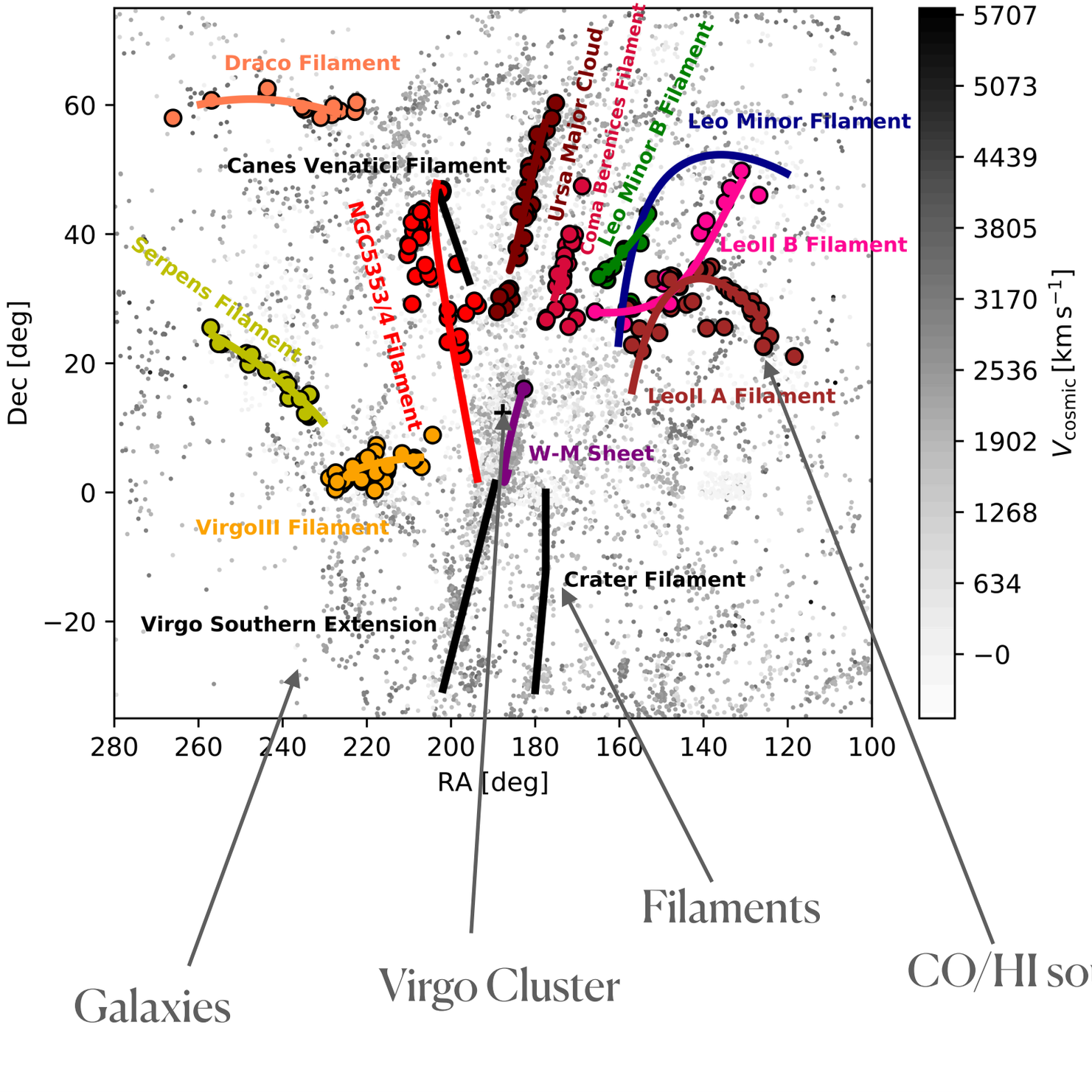
WEBB
SPACE TELESCOPE

Multiple processes in one galaxy
(Tidal interaction first, ram pressure stripping next)



Virgo Filament Team

PI Rose Finn



The catalog of galaxies
→ ~7,000 galaxies at v<3,300 km/s
→ cross matches : HyperLeda, NSA, NED

3D characterizations of the cosmic web
→ Virgo Infall model (Mould+ 2000)
→ z-independent distances (Steer+ 2017)

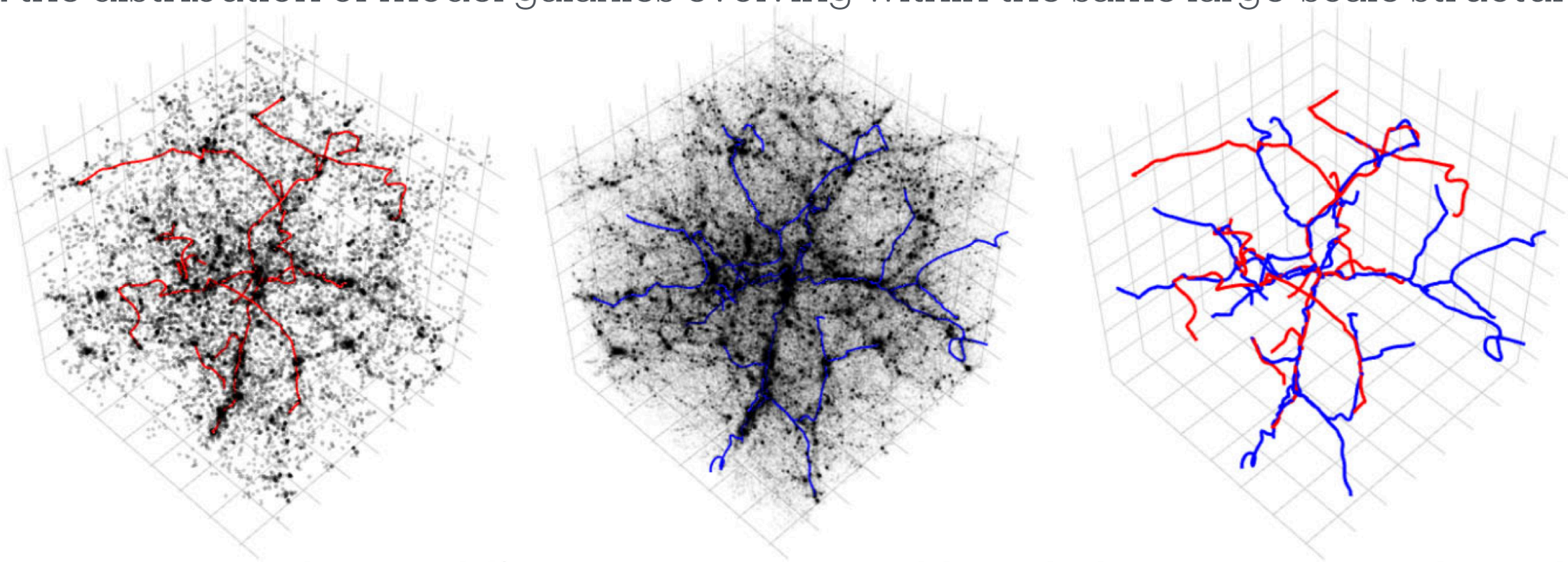
Filament spines
→ 3D tomographic characterization following Kim+2016

Castignani, BV et al. 2022

Virgo Filament Team @ OaPD

Theoretical comparison

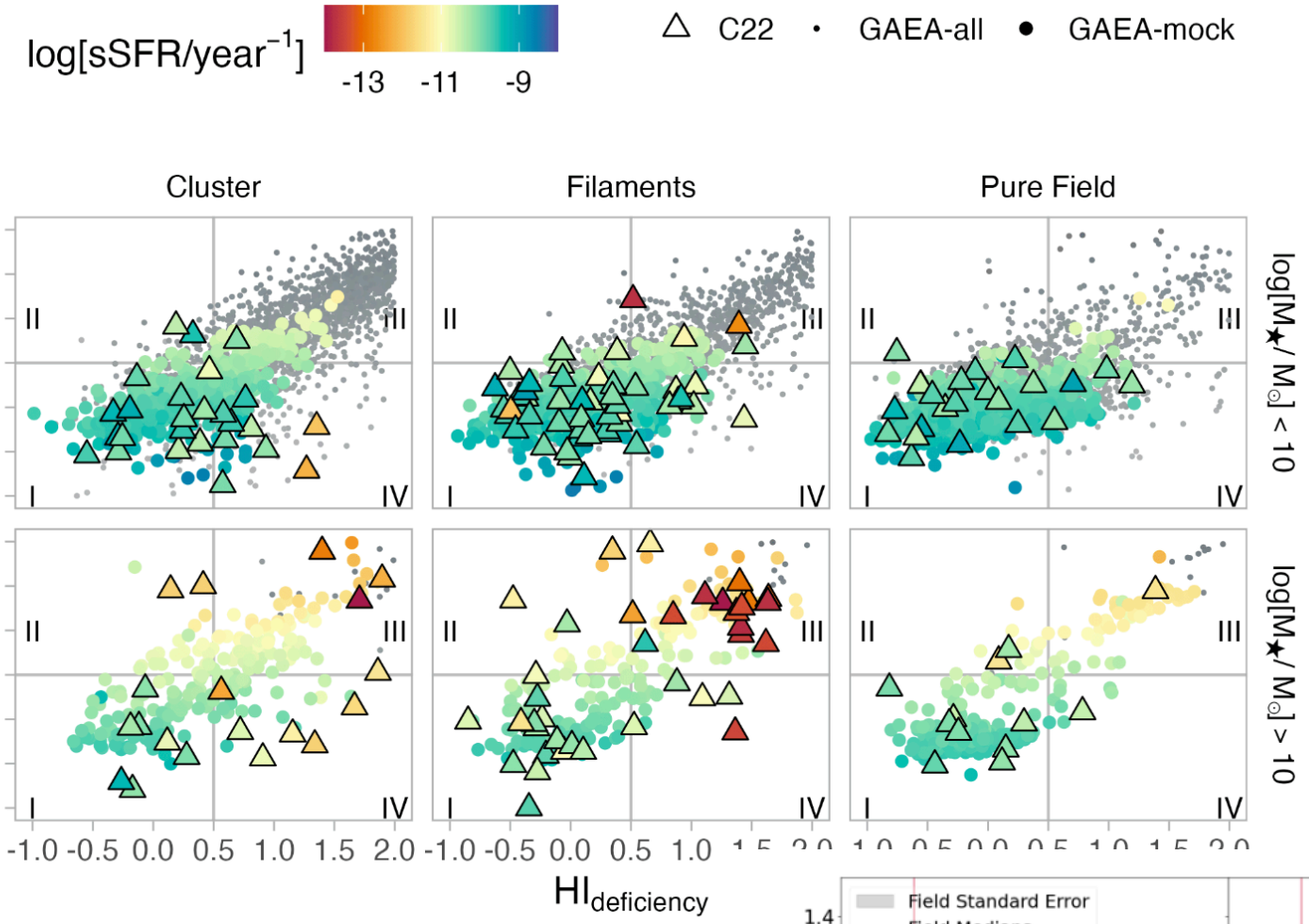
We apply the topological filament extractor DISPERSE to the predictions of the semi-analytical code GAEA (De Lucia et al. submitted) to investigate the correspondence between the properties of z = 0 filaments extracted using the distribution of dark matter and the distribution of model galaxies evolving within the same large-scale structure.



Filaments extracted using different tracers agree, although they never coincide totally
The number of filaments ending up in the massive clusters identified using galaxy distribution is typically underestimated with respect to the corresponding dark matter filament extraction.

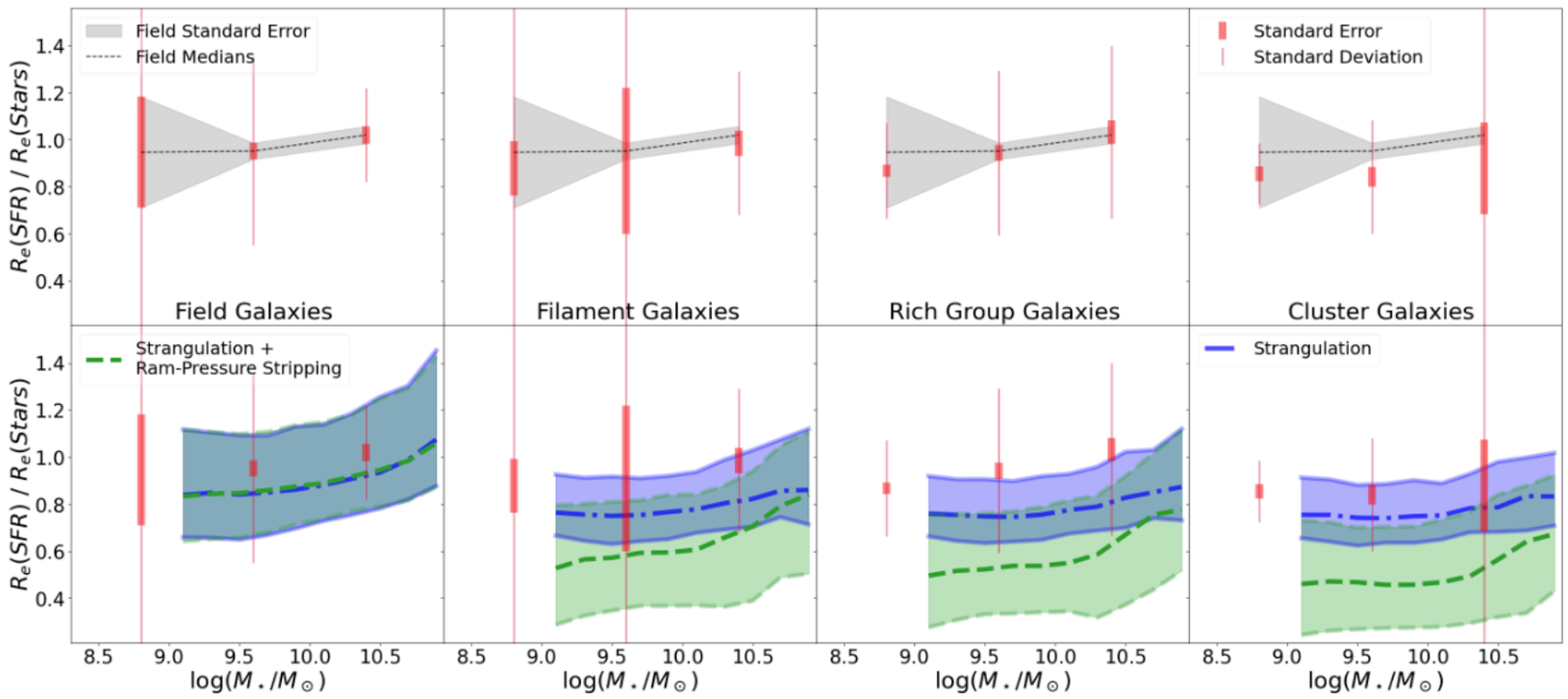
Zakharova et al. 2023

Virgo Filament Team @ OaPD



Zakharova et al. 2024

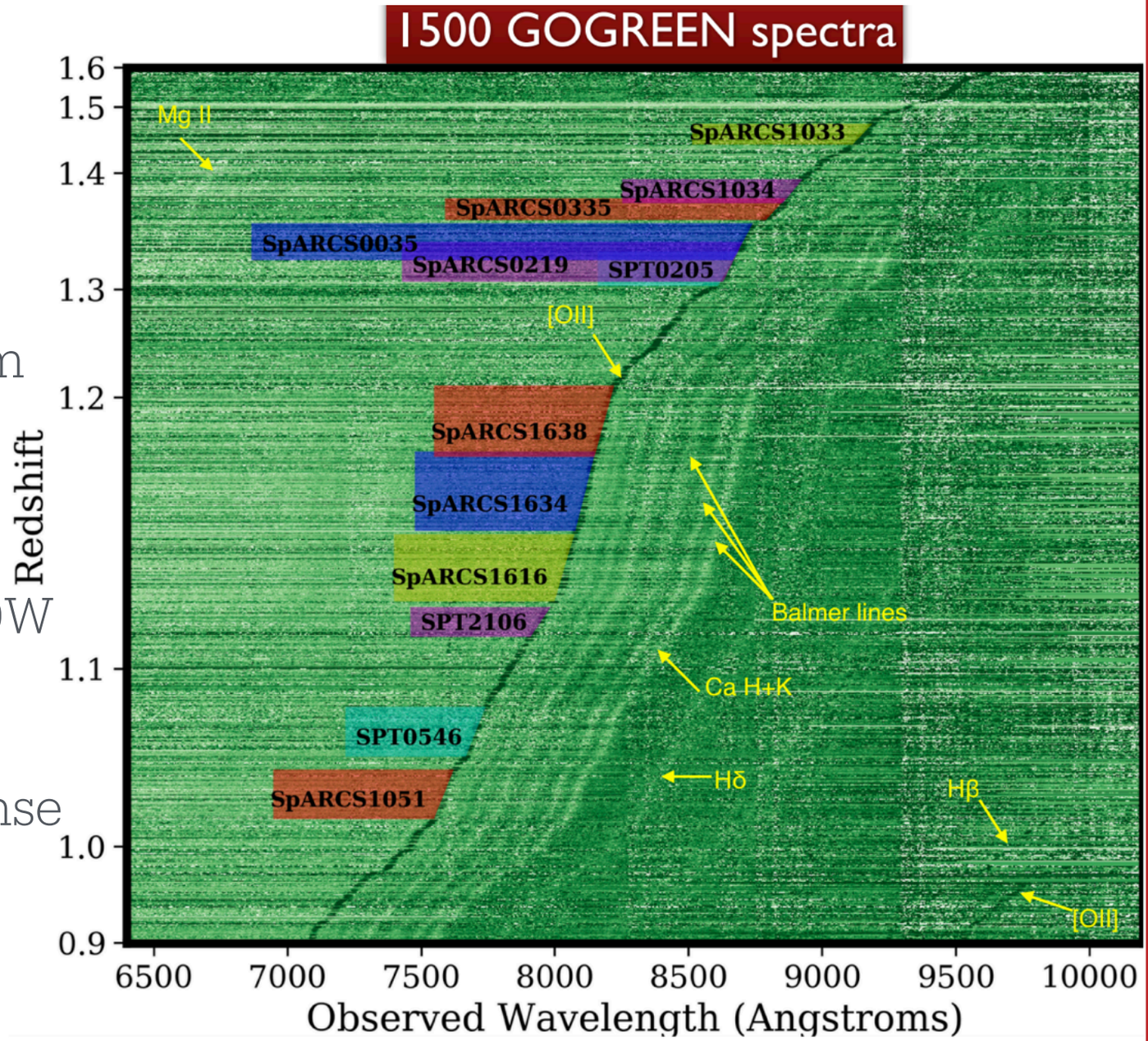
Conger, incl BV and DZ et al. 2024



GOGREEN

Gemini **O**bservations of **G**alaxies in **R**ich **E**arly **E**nvironments (PI Balogh)

- The premier spectroscopy survey of high redshift clusters
- 530h Gemini Large and Long Program
- A survey of 21 systems at 1<z<1.5
- Spans a range of halo masses from groups to clusters
- Reduced ground-based + WCF3/F160W images
- UBRIzYJK[3.6][4.5] catalogs
- 1704 redshifts from 0.8<z<1.5 in 26 dense systems

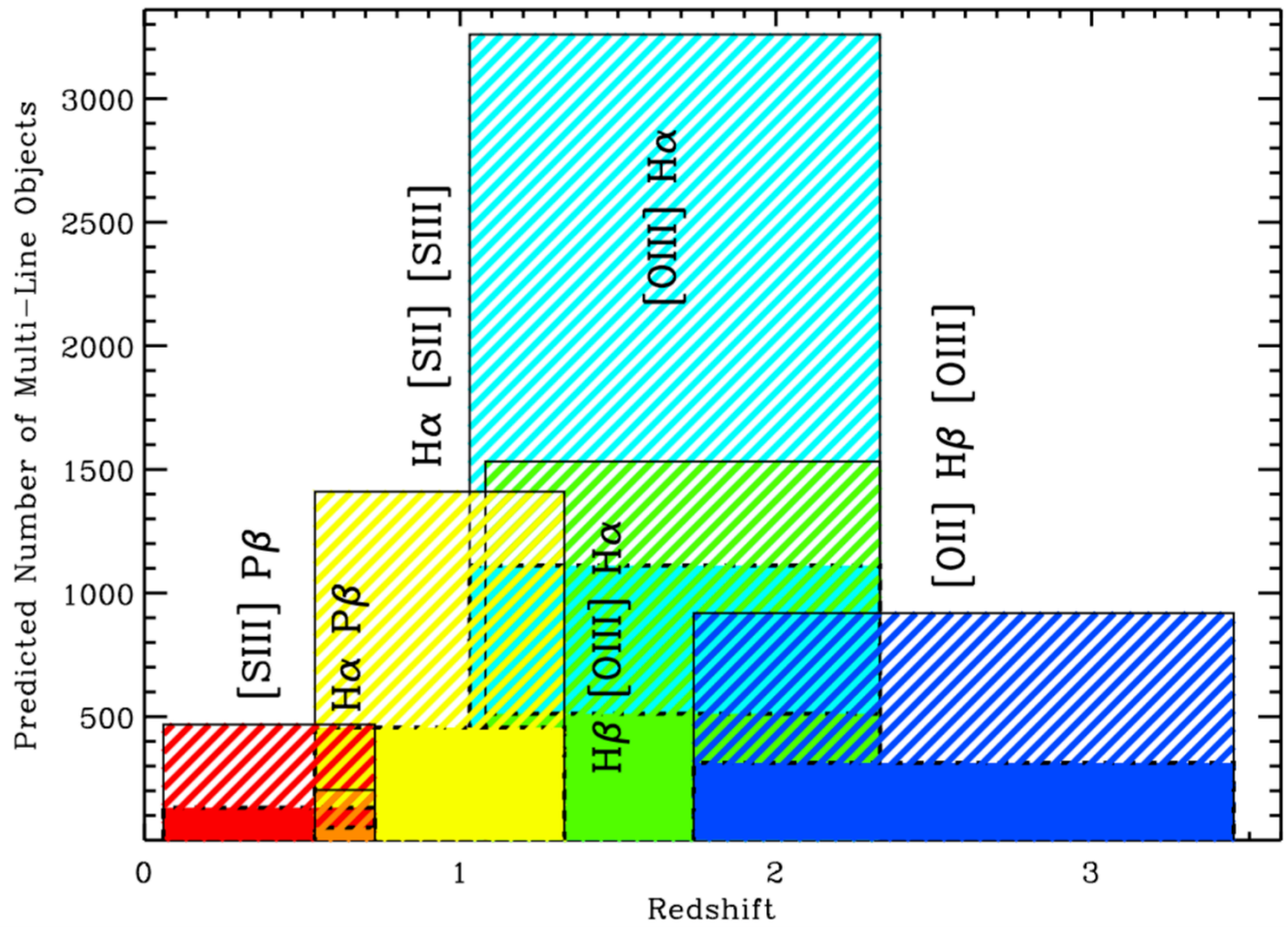


available from
https://datalab.noirlab.edu/gogreendr1/

PASSAGE

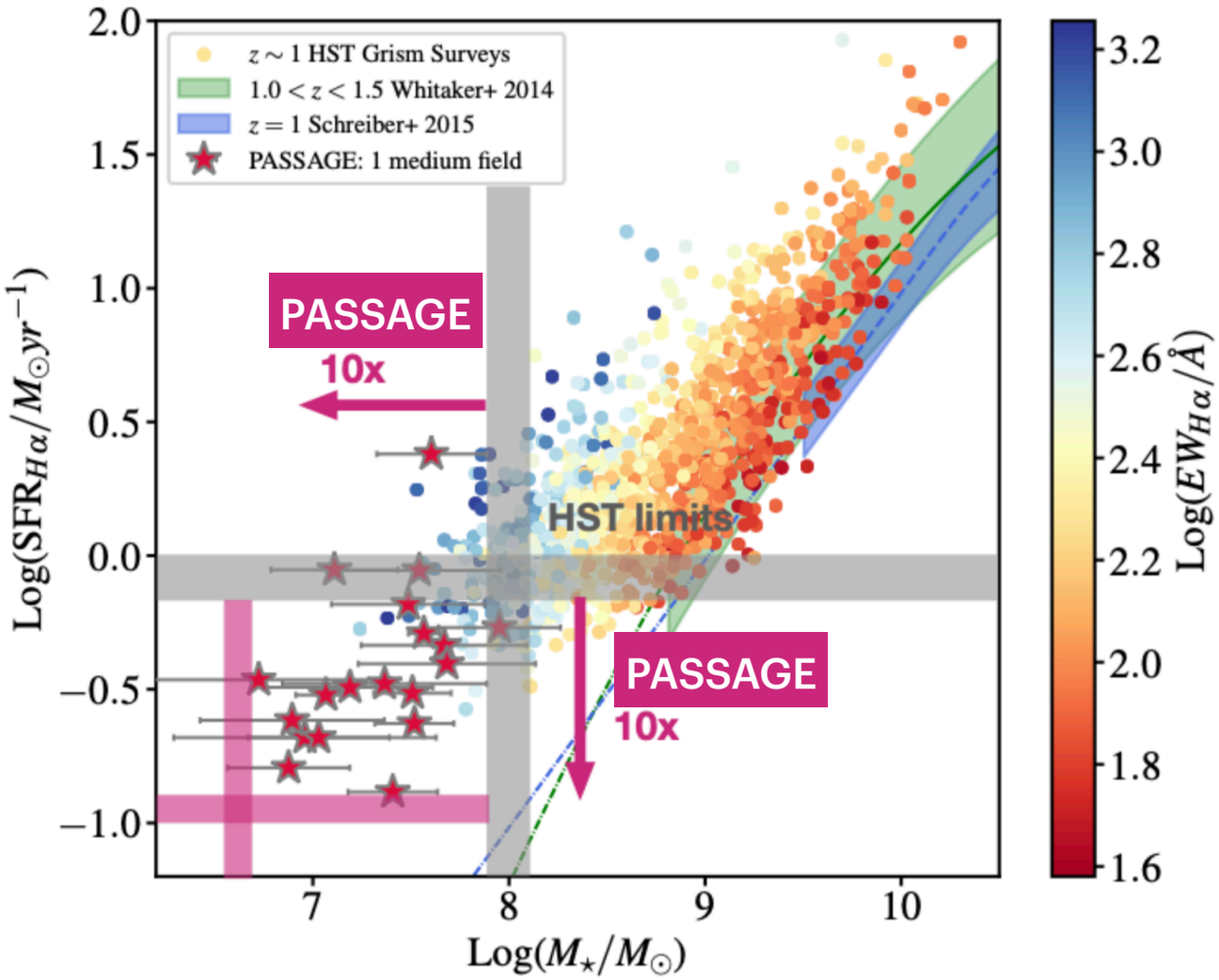
Parallel **A**pplication of **S**litless **S**pectroscopy to **A**nalyze **G**alaxy **E**volution (PI Matt Malkan)

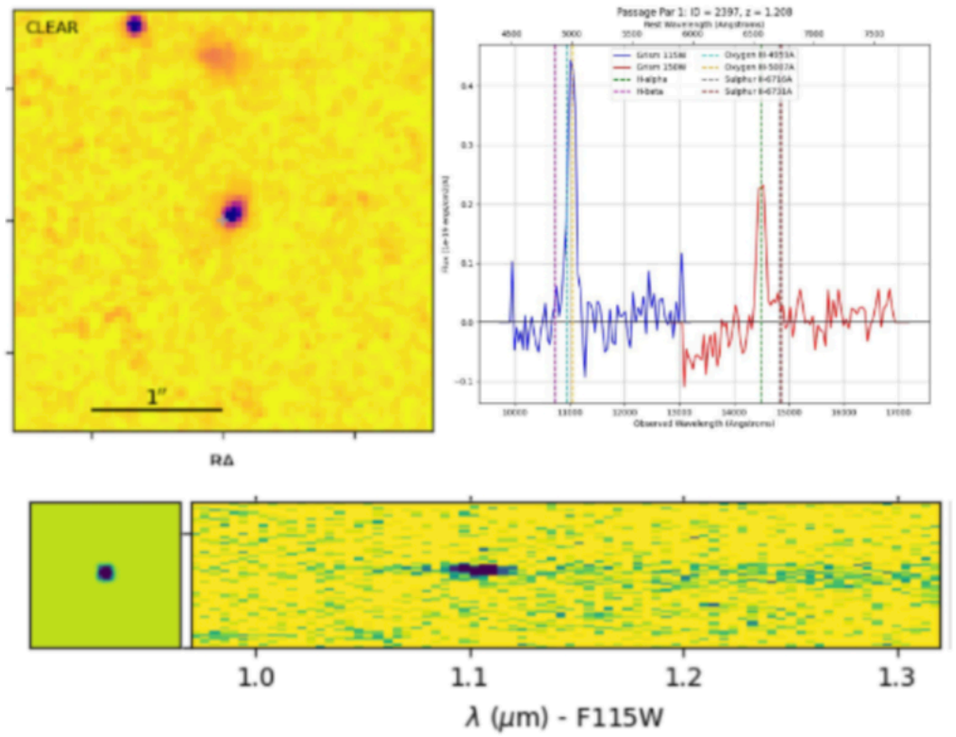
- 591 hours of JWST/NIRISS observations to obtain direct near-IR imaging and slitless spectroscopy of ~60 high-latitude fields in Pure Parallel mode.
- These have provided tens of thousands of grism spectra of faint galaxies with partial or complete coverage between observed wavelengths of 1.0 and 2.4μm.



PASSAGE

Main redshift interest: z=1.5-4





BEACON & POPPIES

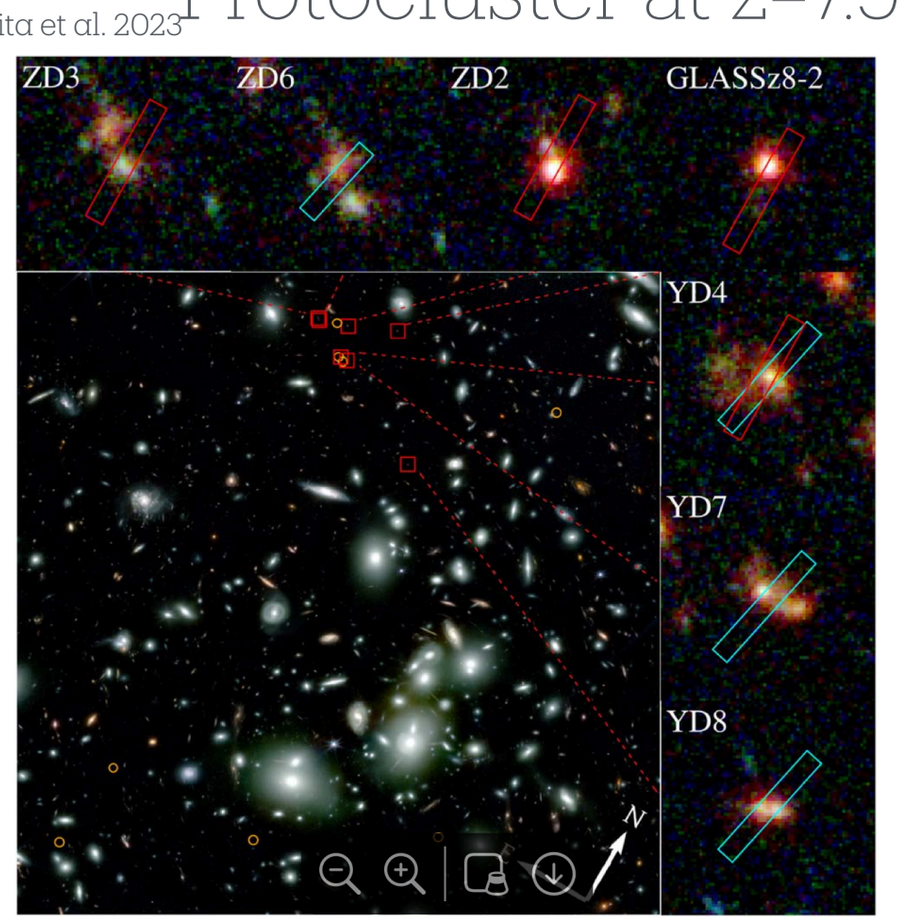
Searching for protoclusters in the high redshift universe

BEACON:

- pure-parallel imaging survey to construct a large and unbiased sample of the universe over 220 sightlines (~0.6deg^2 total area), minimizing cosmic variance
- NIRCam 8-band imaging, uninterrupted spectral coverage at 0.8-5micron,
- Robust determination of photometric redshift and physical properties of sources at z~2 to z>10 via spectral energy distribution analysis

Protocluster at z=7.9

Morishita et al. 2023



POPPIES (Public Observation Pure Parallel Infrared Emission-Line Survey):

- large area (1455 arcmin^2) NIRCam wide-field slitless spectroscopy (WFSS) program carried out in pure parallel mode
- WFSS in 1-3 filters and direct imaging in 3-8 filters over 150 fields on the sky
- Wide area blind emission line survey that is minimally impacted by cosmic variance.

The present is exciting and rich of data, the future will be even brighter!

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