Galaxy & AGN evolution SWG

WP11

Distribution Functions

Elena Zucca (since Dec 2012) & **William Hartley** (since Feb 2024)

Wiki page: https://euclid.roe.ac.uk/projects/geswg/wiki/Distribution_functions
Slack channel: #swg-gae-wp11-distribution-functions
Project Portal: https://euclid-projects.org/groups/224/overview/
Mailing list: swg-galaxy-agn-wp-dist-fct-group@euclid-projects.org
~50 members

WP11 - Distribution Functions

Aims:

- The main aim of this WP should be to deal with all the possible distribution functions, from the “basic” ones like luminosity and stellar mass functions, to the more complex cases of the multivariate distribution functions as a function of redshift and environment, achieving a precision and a level of information that is beyond what can be done now with current surveys.
- Devise methods for calculation of distribution functions.
- Important synergy with OU-LE3

WP11 and OU-LE3

Link with OU-LE3 processing functions

Internal Data Work Package
LMF-ID PF - Implementation Micol Bolzonella - Olivier Ilbert
Validation Elena Zucca

Galaxy Clusters Work Package
LMF-CL PF Implementation Simona Mei, Micol Bolzonella, Elena Zucca

DR1-KP-GEV-3

Statistical Distributions of galaxy properties

Elena Zucca, Daniela Vergani & William Hartley

Wiki page: https://euclid.roe.ac.uk/projects/dr1-kp-gev-3/wiki
Slack channel: #dr1-kp-gev-3
Project Portal: https://euclid-projects.org/projects/344/overview/
Mailing list: dr1-kp-gev-3-project@euclid-projects.org
~80 members

DR1-KP-GEV-3:
Statistical distributions of galaxy properties

This key project will be responsible for creating statistical distributions of galaxy properties and writing the papers presenting these.

It will also act to provide input for other KPs but papers focusing on the distribution functions primarily should reside in this KP.

DR1-KP-GEV-3: Q1 papers

Q1 first splash

Giorgia Girardi et al.

Euclid Q1: an investigation of optically faint, red objects in the Euclid Deep Fields

Q1 second splash

Will Hartley, Laura Bisigello, Micol Bolzonella, Pablo Corcho-Caballero, Olga Cucciati, Andrea Enia, Yuzheng Kang, Hui Kong, Zhiying Mao, Ana Paulino-Afonso, Lucia Pozzetti, Louis Quilley, Lingyu Wang, Elena Zucca

- Galaxy stellar mass & luminosity functions (Hartley et al.)
  - Split by morphology
  - Star-formation state
- Hα luminosity function (Paulino-Afonso et al.)

DR1-KP-GEV-3: DR1 papers

Paper 1: Galaxy luminosity functions
Paper 2: The evolution of the stellar mass function out to z~3
Paper 3: Multi-dimensional distribution functions
Paper 4: Emission line Luminosity Functions and number counts
Paper 5: Galaxy stellar mass/luminosity/ELGs functions in Euclid clusters
Paper 6: Galaxy stellar mass and star-formation history out to z=6
Paper 7: Selection of population of rare objects
Paper 8: Galaxy Photometric SEDs
Paper 9: Massive galaxies at z=3-7
Paper 10: Statistical properties of the reddest (dusty) high-z objects

DR1-KP-GEV-3: DR1 papers

Some papers are still without a leader:
please, visit the Redmine page
and indicate your interest

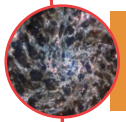
Euclid Q1: an investigation of optically faint, red objects in the EDFs

G. Girardi[1,2], **G. Rodighiero**, **L. Bisigello**, **A. Enia**, **A. Grazian**, **E. Dalla Bontà**, S. Serjeant, **G.Gandolfi**, C. Lovell, K. Caputi, **A. Bianchetti**, **A. Vietri** and more Euclidian friends

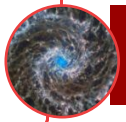
[1]Università degli Studi di Padova, [2]INAF-OAPd

HIEROs

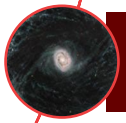
Dust-obscured, star-forming sources at $z \sim 3 - 6$



Undetected by HST: extreme red colors



Detected by Spitzer/IRAC



Limited photometric information: uncertain SED

Aim: statistically characterizing this population

Why interesting?

Non-negligible contribution to the cosmic **SFRD** up to $z \sim 5$ - 7

(Barrufet et al. 2023, Rodighiero et al. 2023, Wang et al. 2024)

Dominance in the bright end of stellar **MF**

(Rodighiero et al. 2007, Gottumukkala et al. 2024)

Euclid Q1 → **Meaningful** statistical analyses

Photometric catalogue

Euclid Q1 official catalogues + IRAC/***Spitzer*** photometry

Euclid Q1 → **Meaningful** statistical analyses

Photometric catalogue

Euclid Q1 official catalogues + IRAC/***Spitzer*** photometry

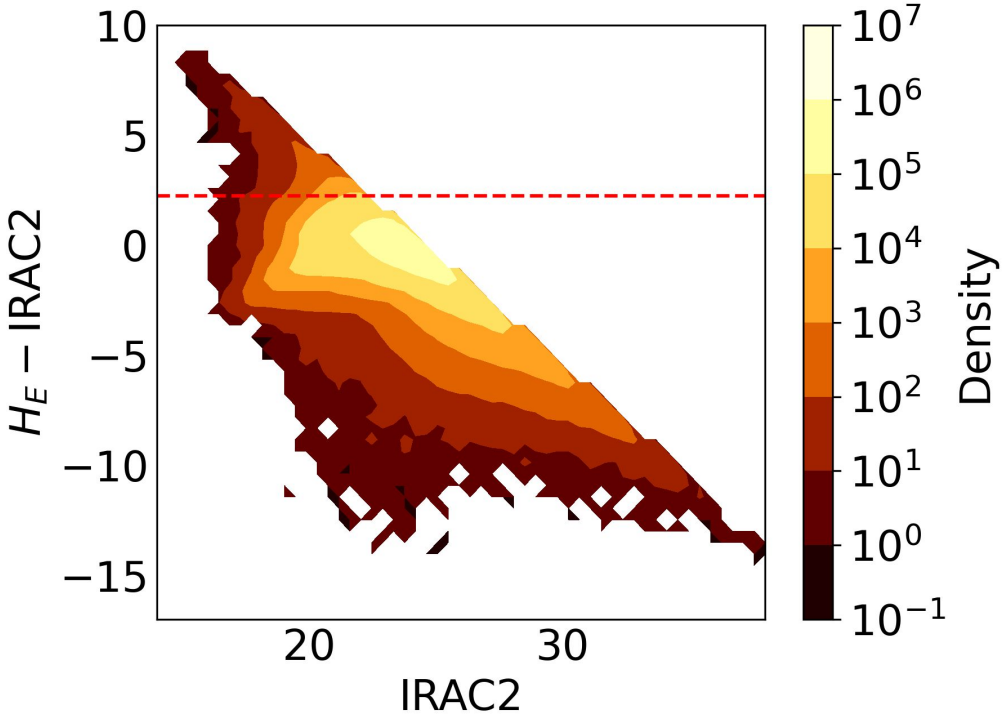
To ensure robustness:

1) removing spurious and artifacts objects
2) removing stars
3) $H_E < 24.5$ mag

H_E - 4.5 μm > 2.25

HIEROs

(Caputi et al. 2012, Wang et al. 2016)



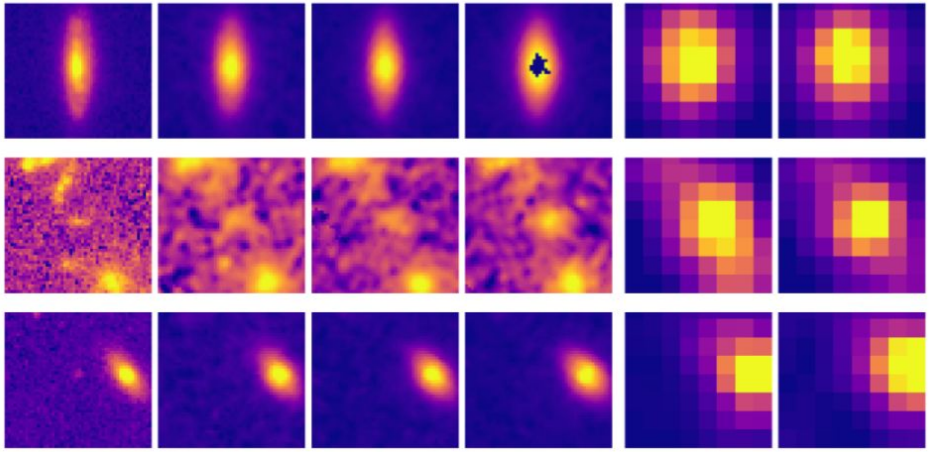
HIEROs sample:
26 906

Visual check

Final sample:
3 870

~ 14.4 %

Discarded candidates



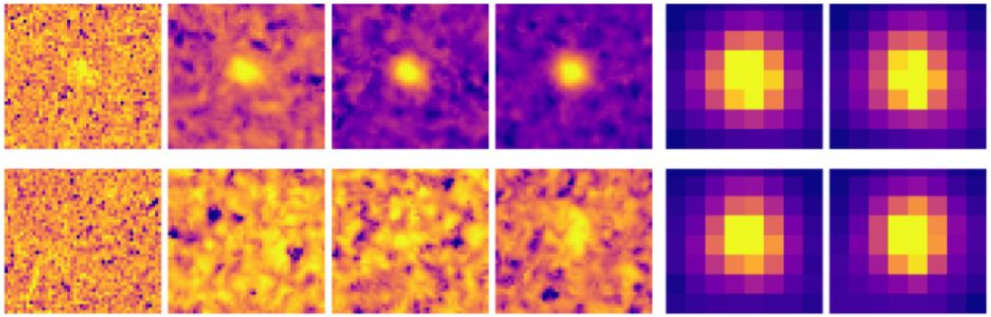
HIEROs sample:
26 906

Visual check

Final sample:
3 870

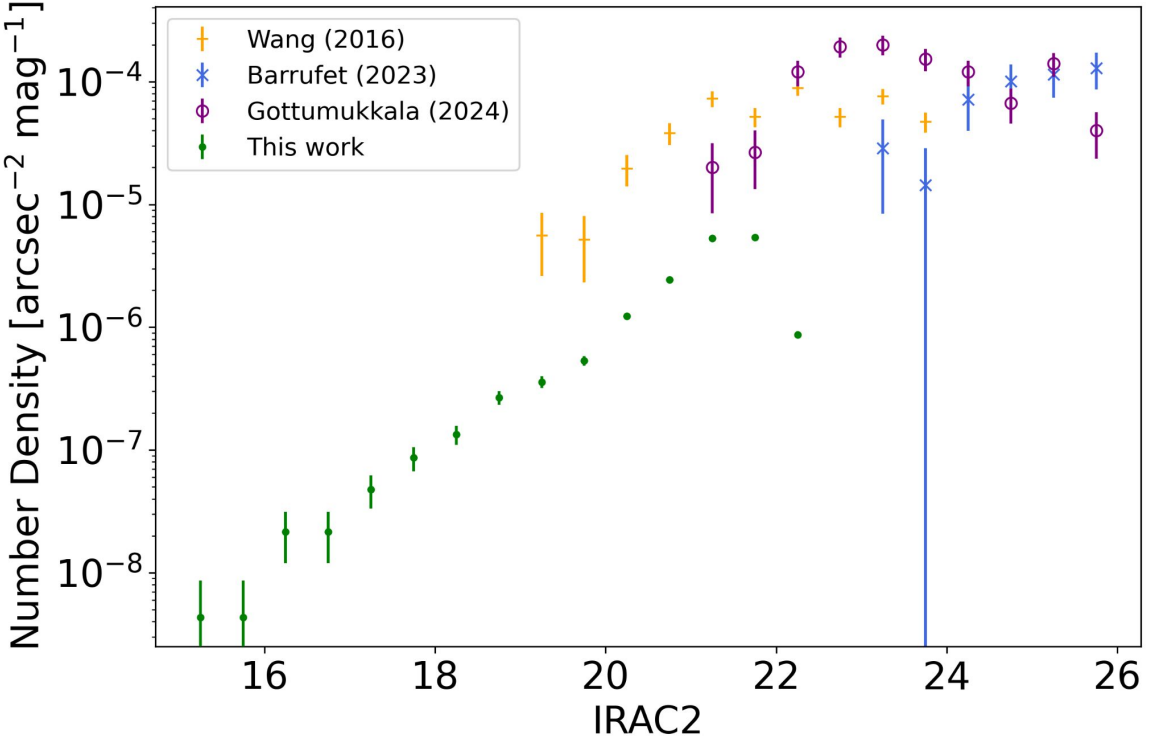
~ 14.4 %

Confirmed candidates



Number densities

- ~ **28**% statistical correction to account for blending
- ~ **1** order of mag below previous estimates
- slightly **different** selections and samples



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CIGALE:
SED fitting

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$0 < z < 15$

$A_V < 6$

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Considering objects with at least **3** detections

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3 870

CIGALE:
SED fitting

Spitzer included

Wide parameters range

$0 < z < 15$

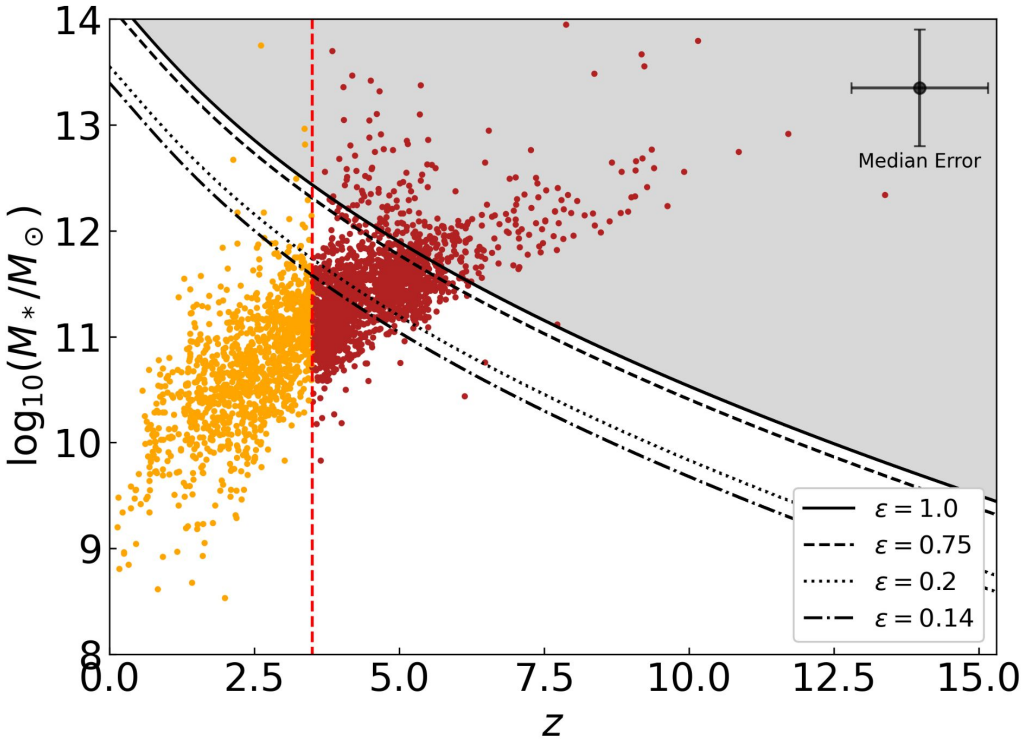
$A_V < 6$

Considering objects with at least **3** detections

2 994 left

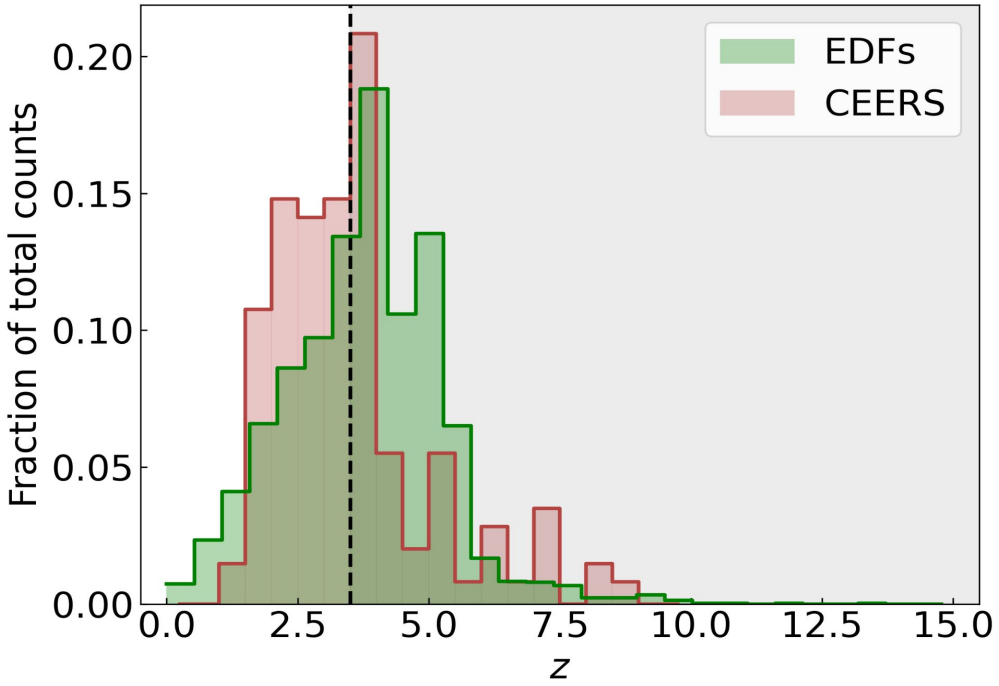
Results

- ∼ 9.7% in **contrast** with **ΛCDM** model
- many objects with $M_* > 10^{11.7}\ M_\odot$ (Forrest et al. 2024)



More counts with respect to JWST/CEERS observations

(Gottumukkala et al. 2024)



Second CIGALE run:

$z < 3.5$

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Prioritizing the
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bimodal PDF(z)

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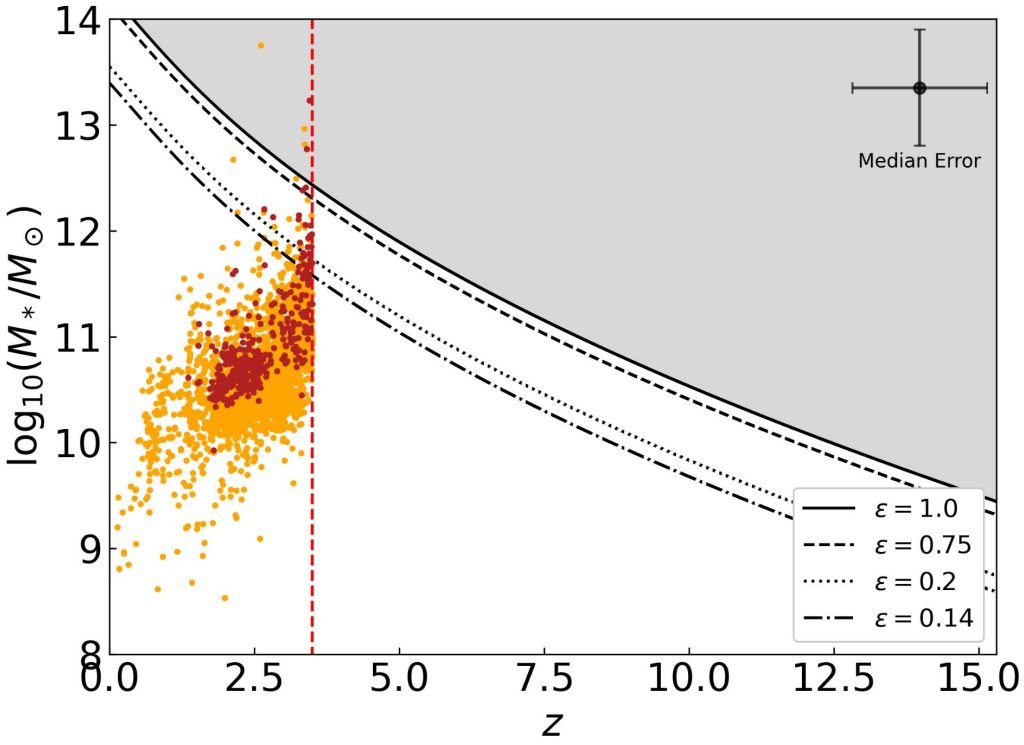
$z < 3.5$

Prioritizing the **low-*z*** solution in the bimodal PDF(z)

Degeneracy between **dust** and ***z***

$z < 3.5$

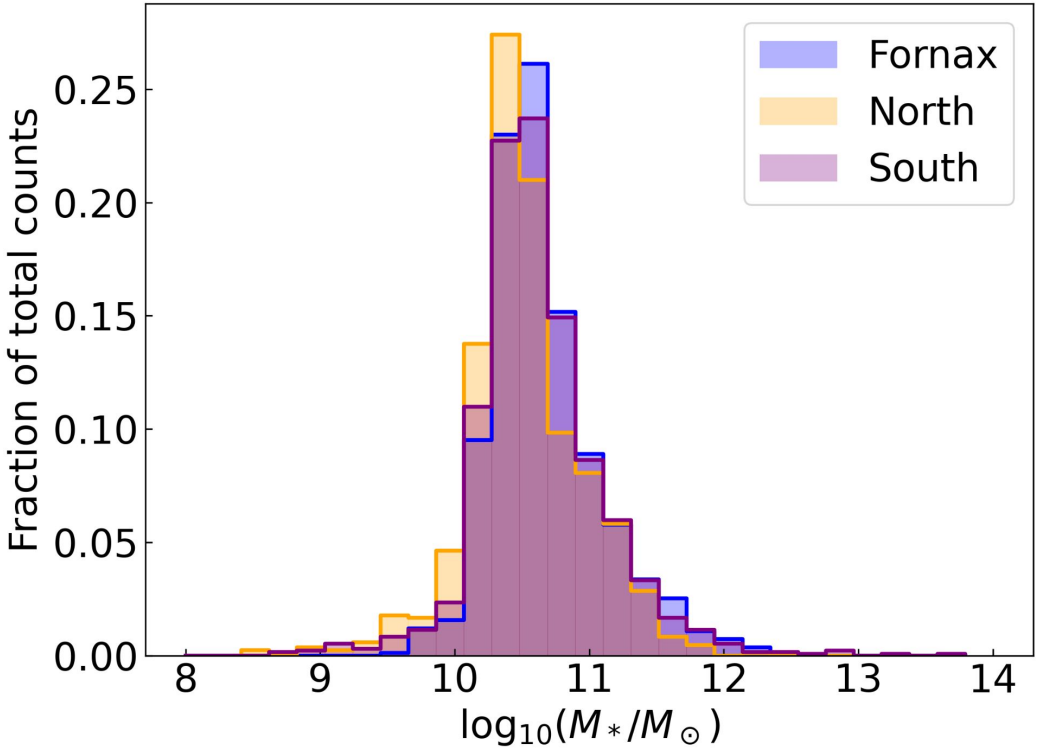
- ~ 0.17% in **contrast** with **ΛCDM** model
- including theoretical insights



$z < 3.5$

Massive sample:

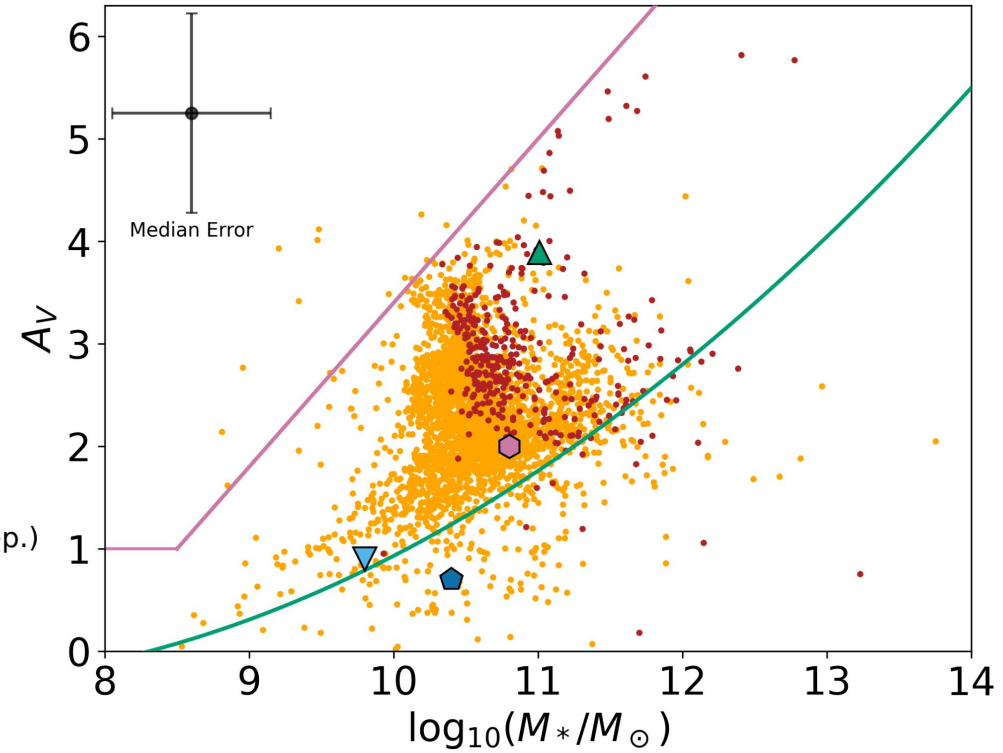
$< M_* > = 10^{10.6}\ M_\odot$



$z < 3.5$

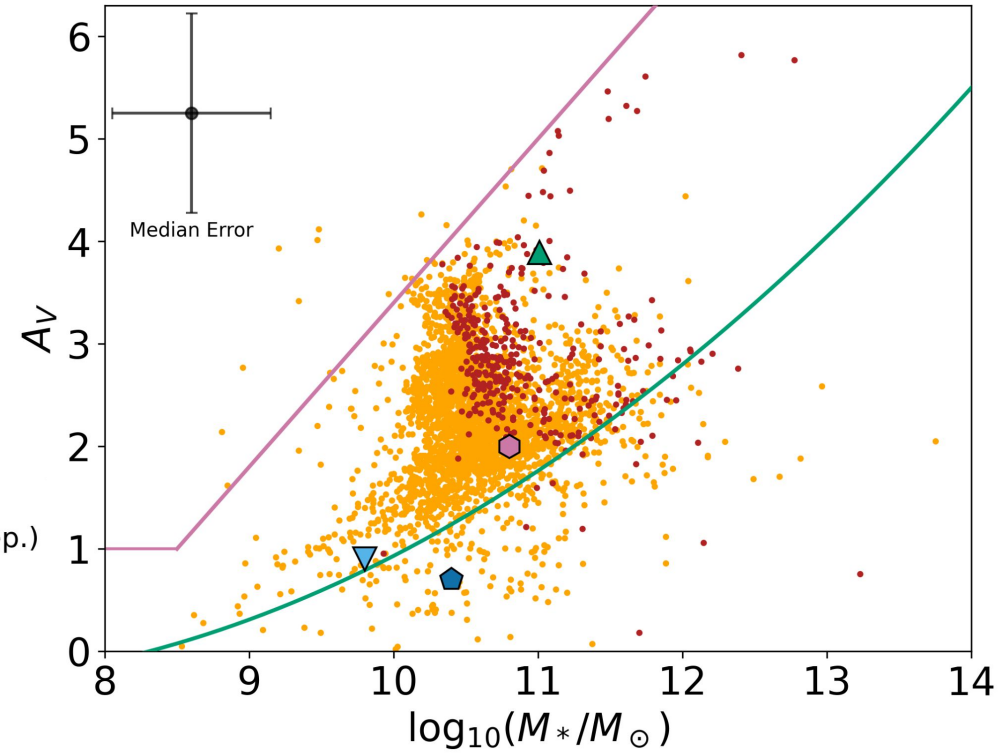
Dusty sample:

$< A_V > = 2.3$



$z < 3.5$

Potential population of **extremely obscured** objects at $M_* > 10^{10}\ M_\odot$



- McLure (2018)
- HELM selection (Bisigello et al. in prep.)
- Alcade Pampliega (2019)
- Pérez-González (2023), HST-faint
- Pérez-González (2023), HST-dark
- Gentile (2024)

To wrap up

- ***Spitzer*** + ***Euclid*** photometric catalogue
- number counts and number densities of **HIEROs** objects in EDFs
- **statistical** analyses of their **physical properties**

Euclid power in providing samples of **rare** objects