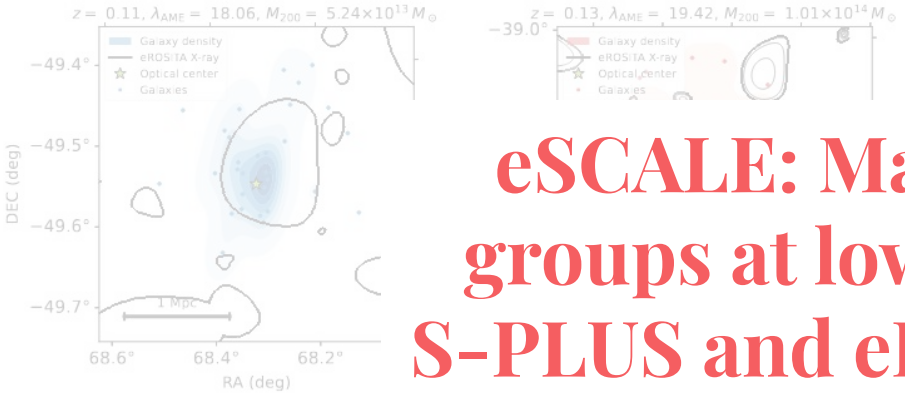
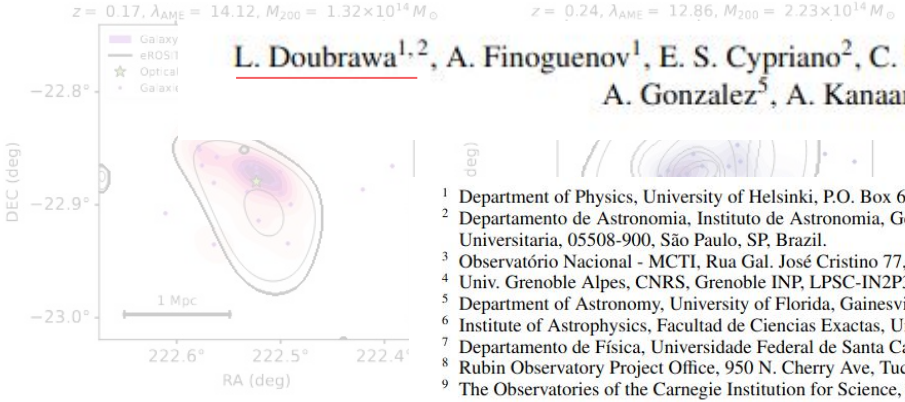


eSCALE: Mapping galaxy groups at low redshift with S-PLUS and eROSITA surveys



L. Doubrawa[1,2], A. Finoguenov[1], E. S. Cypriano[2], C. Mendes de Oliveira[2], E. V. Lima[2], L. Nakazono[3], J. Comparat[4], A. Gonzalez[5], A. Kanaan[6], T. Ribeiro[7], and W. Schoenell[8]

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[4] Univ. Grenoble Alpes, CNRS, Grenoble INP, LPSC-IN2P3, 53, Avenue des Martyrs, 38000, Grenoble, France
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[7] Departamento de Física, Universidade Federal de Santa Catarina, Florianópolis, SC 88040-900, Brazil
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[9] The Observatories of the Carnegie Institution for Science, 813 Santa Barbara St, Pasadena, CA 91101, USA

Submitted

S-PLUS Clusters And Large-scale Environments (SCALE):

II. PZWav vs redMaPPer identification of eRosita groups

L. Doubrawa[1,2], A. Finoguenov[1], E. S. Cypriano[2], C. Mendes de Oliveira[2], E. V. Lima[2], L. Nakazono[3], J. Comparat[4], A. Gonzalez[5], A. Kanaan[6], T. Ribeiro[7], and W. Schoenell[8]

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S-PLUS eROSITA

SCALE program:
S-PLUS **C**lusters **A**nd **L**arge-scale **E**nvironments

- S-PLUS imaging with spectroscopy and multiwavelength data.
- Paper I. (Mendes de Oliveira et al., submitted),
  - 83 galaxy groups and clusters were selected
  - Dynamical properties: Masses, radii, velocity dispersions, and spectroscopic membership
  - Detailed study of Abell 4038

ted

S-PLUS Clusters A

II. PZWav vs red

L. Doubrawa[1,2], A. Finoguenov[1], E. S. (
A. Gonzal(

[1] Department of Physics, University of Helsinki, P.O
[2] Departamento de Astronomia, Instituto de Astronc
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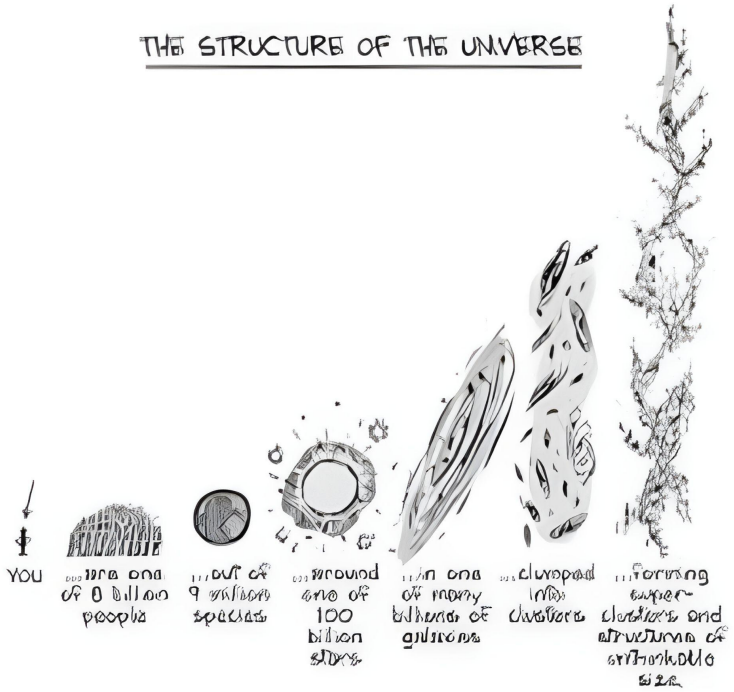
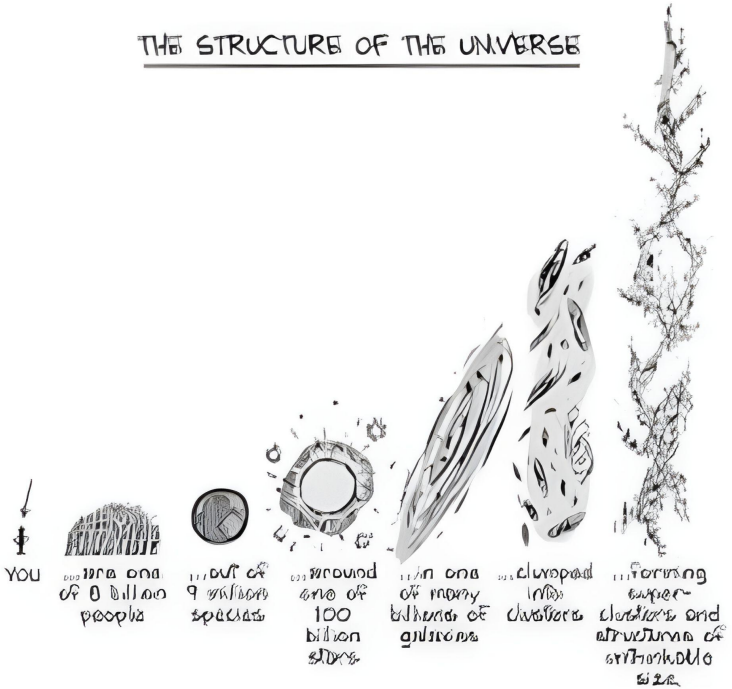
IA USP Universidade de São Paulo
FAPESP SÃO PAULO RESEARCH FOUNDATION
UNIVERSITY OF HELSINKI

Introduction



- The Universe is composed of large structures such as galaxies, groups and galaxy clusters, and regions of low-density.

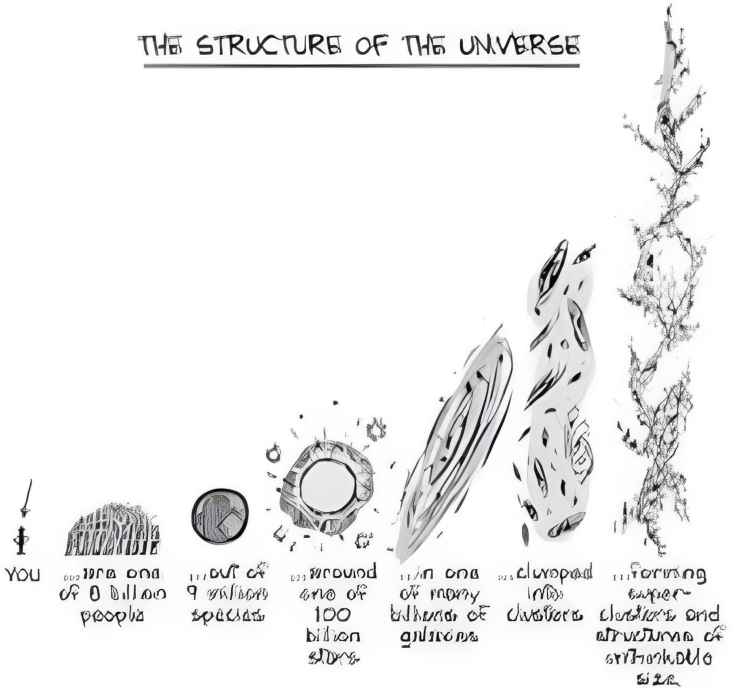
Introduction



- The Universe is composed of large structures such as galaxies, groups and galaxy clusters, and regions of low-density.

- Hierarchical structure formation
    - Low mass structures form earlier giving rise to larger systems.

Introduction



- The Universe is composed of large structures such as galaxies, groups and galaxy clusters, and regions of low-density.
- Hierarchical structure formation
  - Low mass structures form earlier giving rise to larger systems.
- Galaxy groups as ideal laboratories for studying AGN feedback

Data

eRosita

- Data from the 1st data release
  - 10 sqr. deg. tiles
  - 0.6–2.3 keV energy band: Unaffected by Galactic emission, reduces contamination from LSS
  - Remove small scales sources (0.5 arcmin - PSF size)
  - 2 - 4 arcmin
  - X-ray contours are generated after a wavelet decomposition

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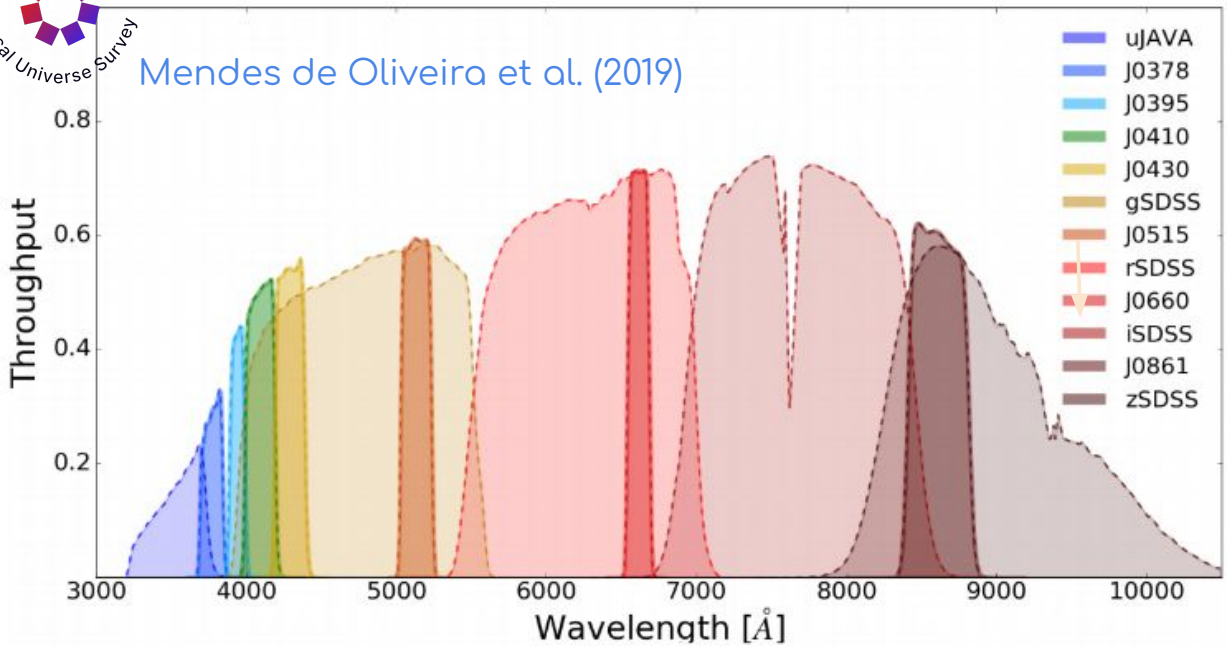
S-PLUS

- Data from 5DR (~4,600 sqr deg ~ overlap of 2,500)
  - 12 filters (5 broad band + 7 narrow)

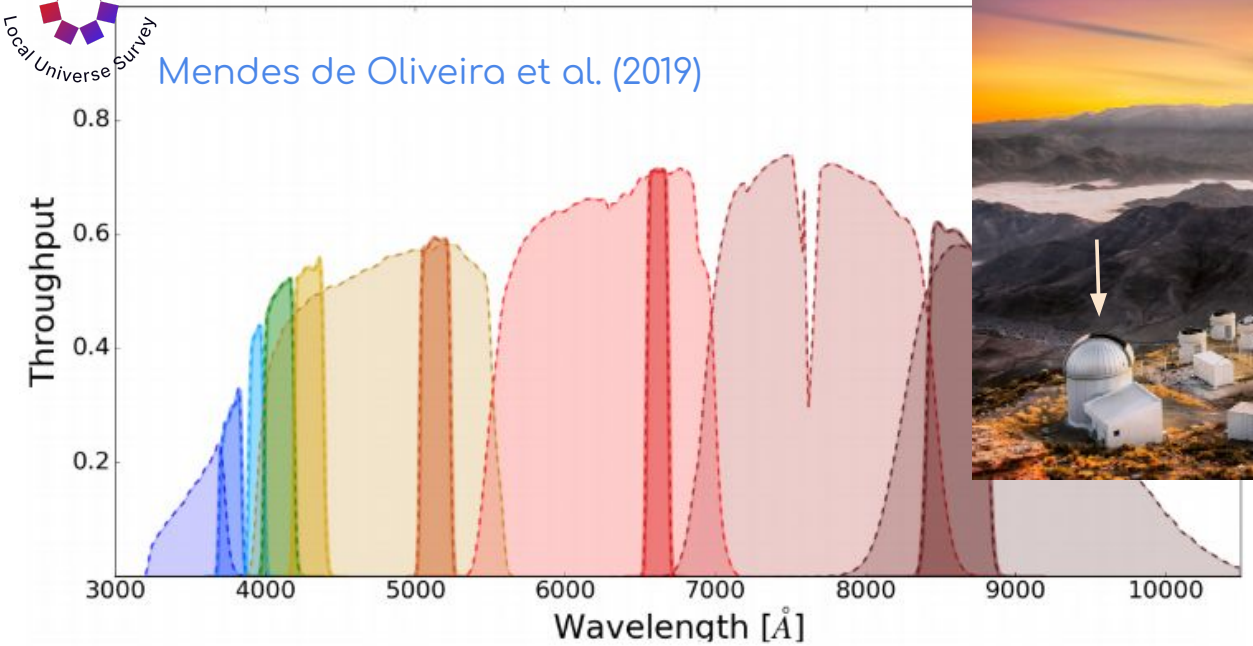
Imaging surveys with narrow-band filters



- σ_z = 0.019

Imaging surveys with narrow-band filters

Mendes de Oliveira et al. (2019)



T-80 at Cerro Tololo (Chile)

- σ_z = 0.019

Data

eRosita

- Data from the 1st data release
  - 10 sqr. deg. tiles
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S-PLUS

- Data from 5DR (~4,600 sqr deg ~ overlap of 2,500)
  - 12 filters (5 broad band + 7 narrow)

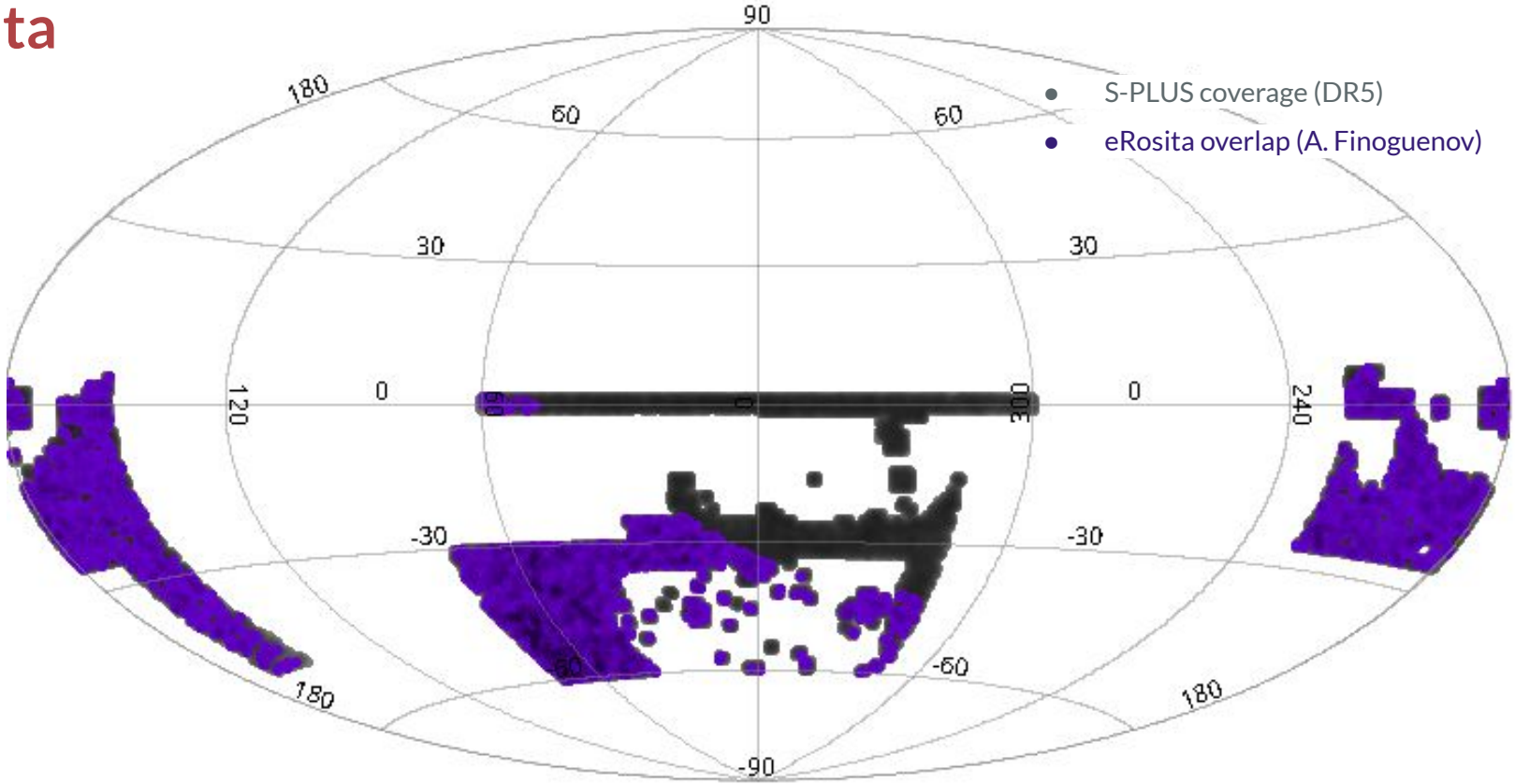
$0.08 < z < 0.25$:

- Low-z is affected by Horologium–Reticulum supercluster
- At $z > 0.25$, the eROSITA data detect galaxy clusters

Data cleaning: Matching with spec-z data + ML classification

CLASS == “GALAXY” , SEX_FLAGS < 3, r_auto < 21

Data



- S-PLUS coverage (DR5)
- eRosita overlap (A. Finoguenov)

cluster detection z<0.4

Cluster identification using **PZWav** (SNR>4)

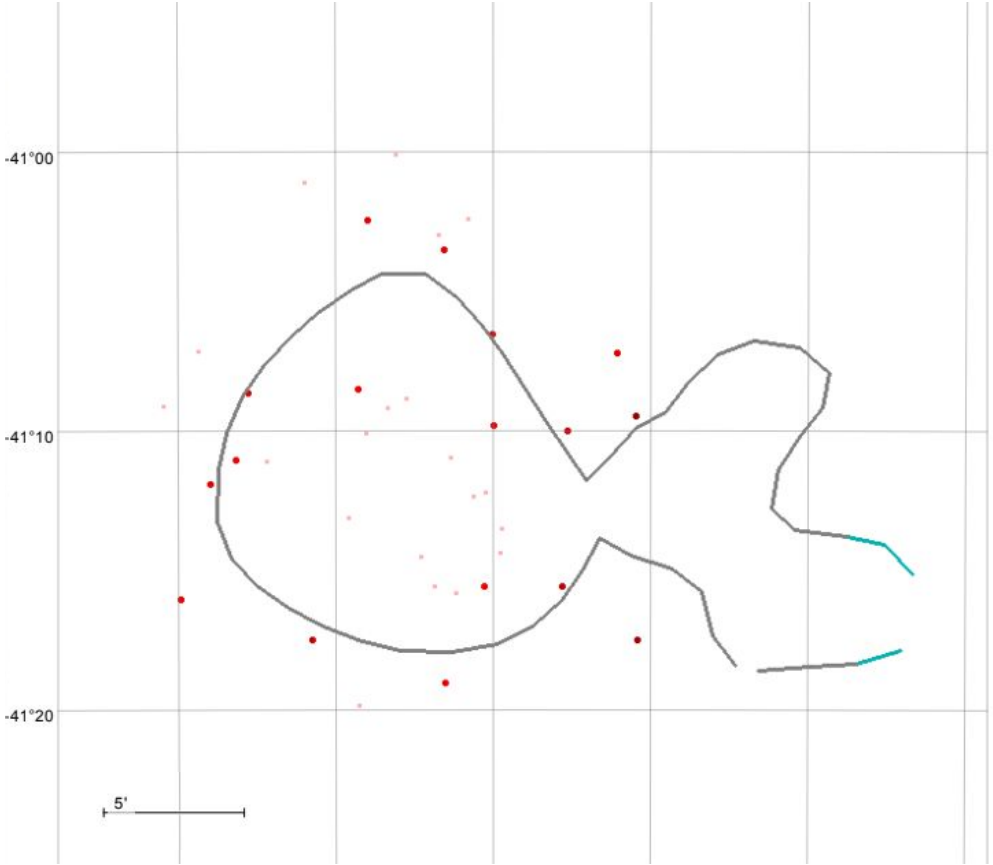
Matching

spatial scales:

2-4 arcmin

Based on the modified Hausdorff distance

- Robust to outliers and noise



Matching

spatial scales:

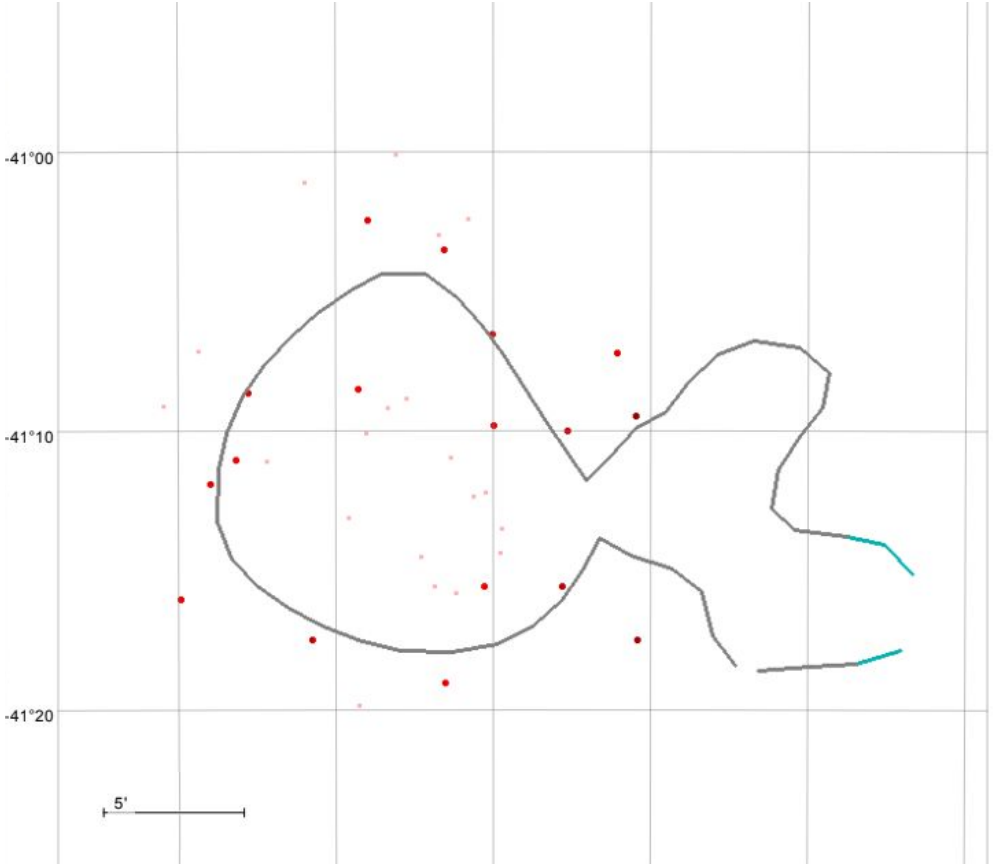
2-4 arcmin

Based on the modified Hausdorff distance

- Robust to outliers and noise

Purer samples means stricter matching conditions

randoms → +10 deg to the cluster RA



Matching

spatial scales:

2-4 arcmin

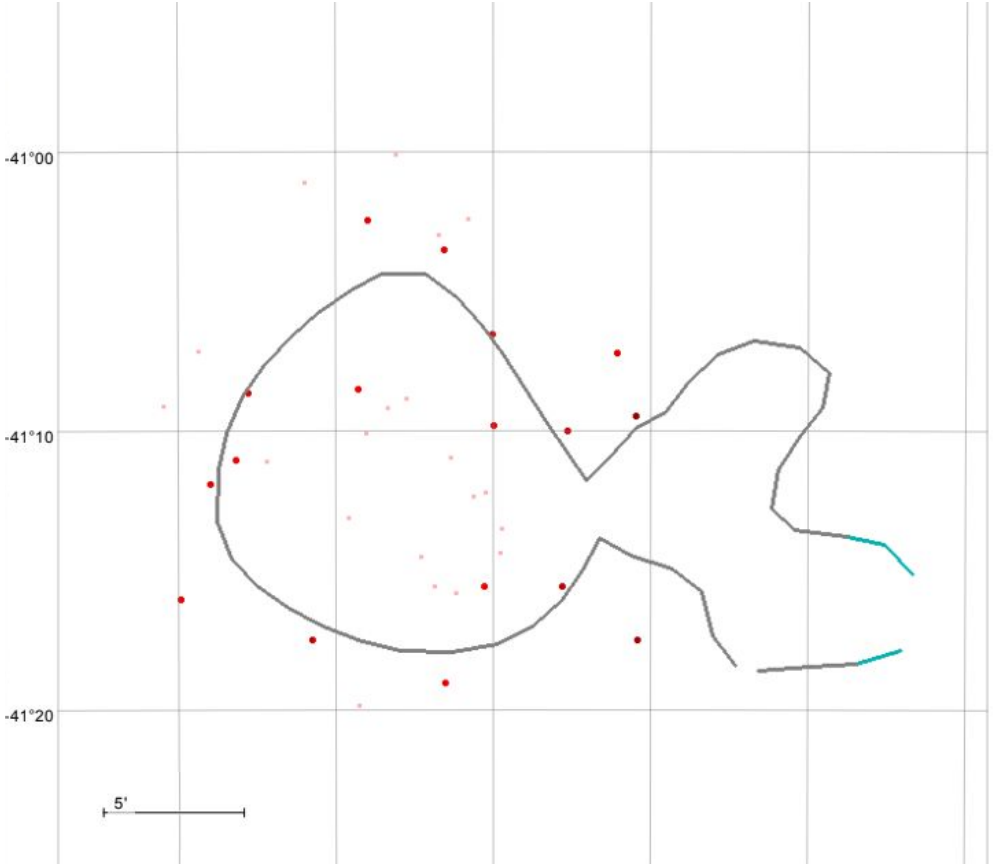
Based on the modified Hausdorff distance

- Robust to outliers and noise

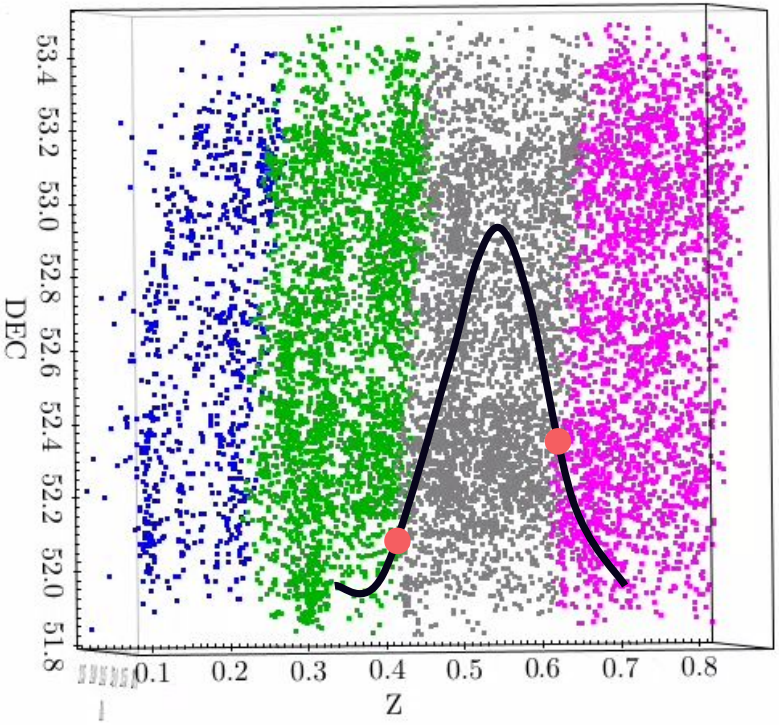
Purer samples means stricter matching conditions

randoms → +10 deg to the cluster RA

Purity = 1 - n_rnd/n_det



PZWav (Gonzalez 2014) → Density-based algorithm



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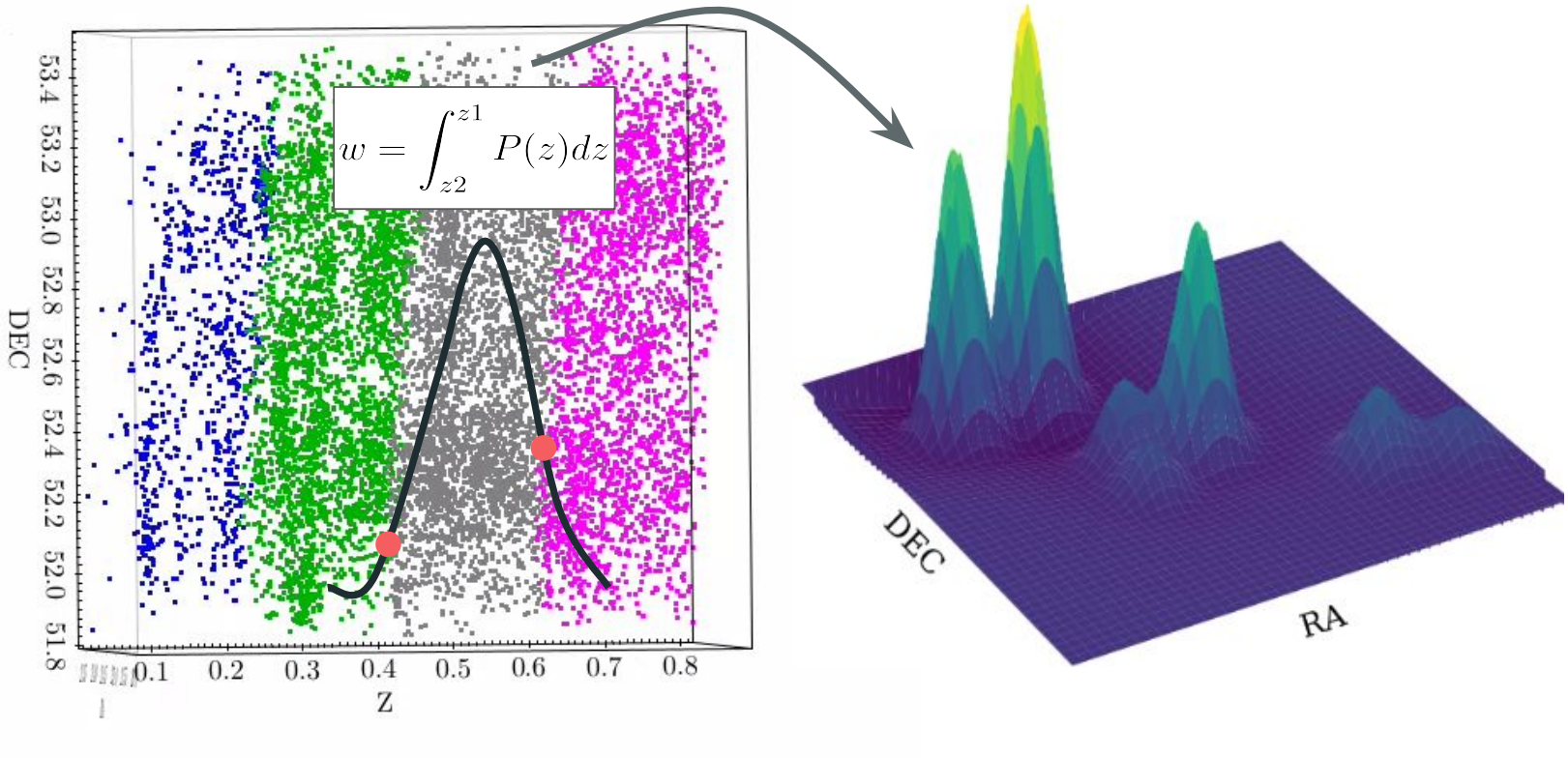

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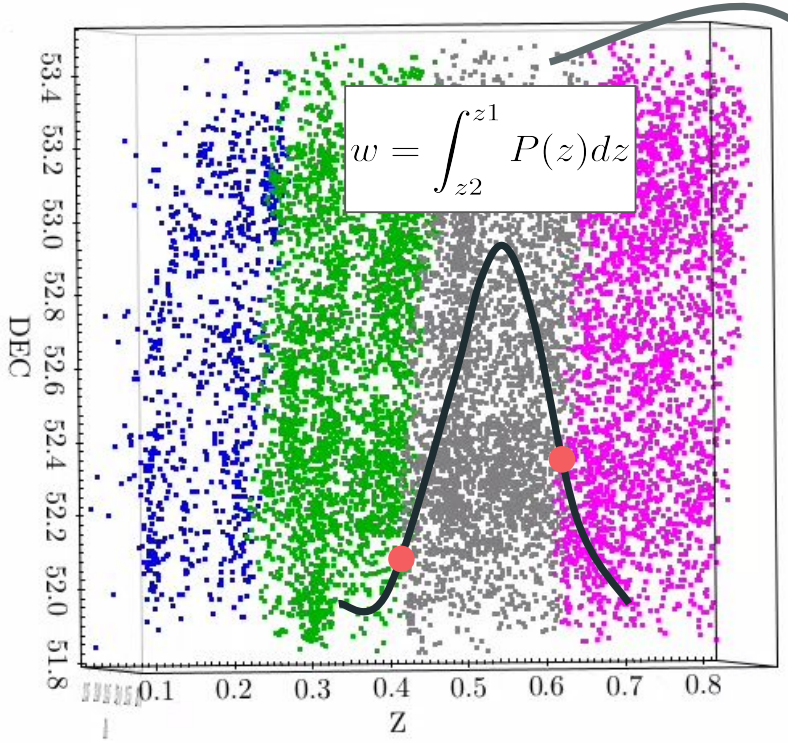


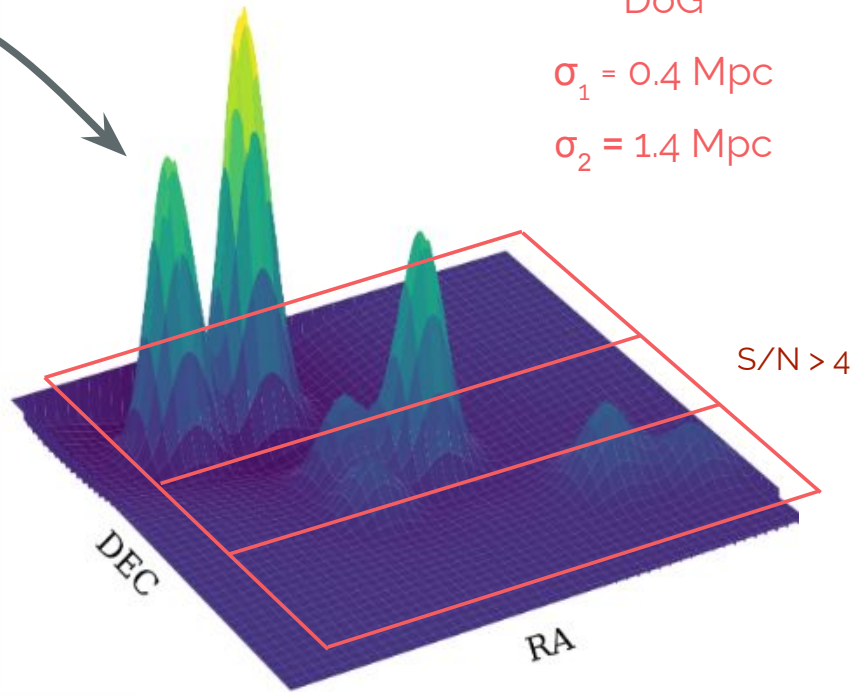
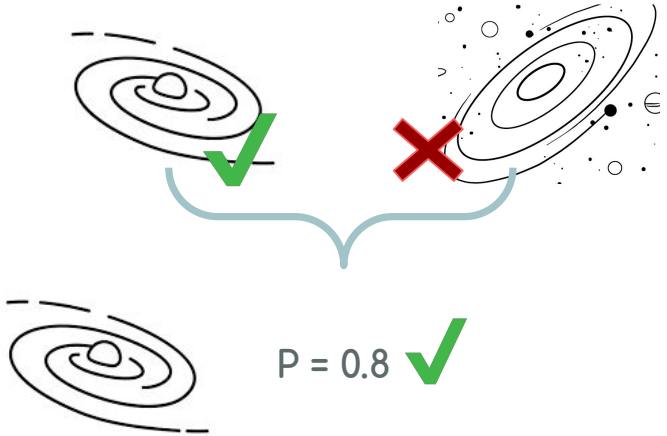


Photo-z & memberships

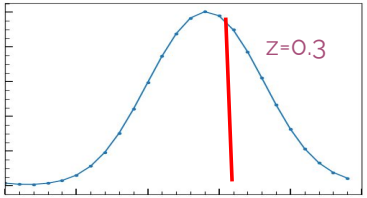
- Contamination due to photo-z errors
  - σ_z = 0.02 → 6000 km/s
  - Typical $\sigma_{v,cl}$ = 500 – 1000 km/s

- Probabilistic membership
  - Castignani et al. (2016)
  - Bellagamba et al. (2019)
  - Lopes et al. (2020)

Both membership and cluster detection!



AME Adaptive Membership Estimator



- Given a cluster candidate with: z_{cl}, ra_{cl} and dec_{cl}

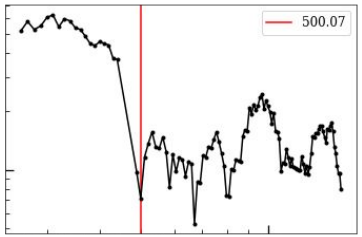
Select galaxies within a fixed radius and redshift

Detect a break in the galaxies radial density profile.

Draw a random redshift from PDFs

Calculate the cluster velocity dispersion (3σ clipping)

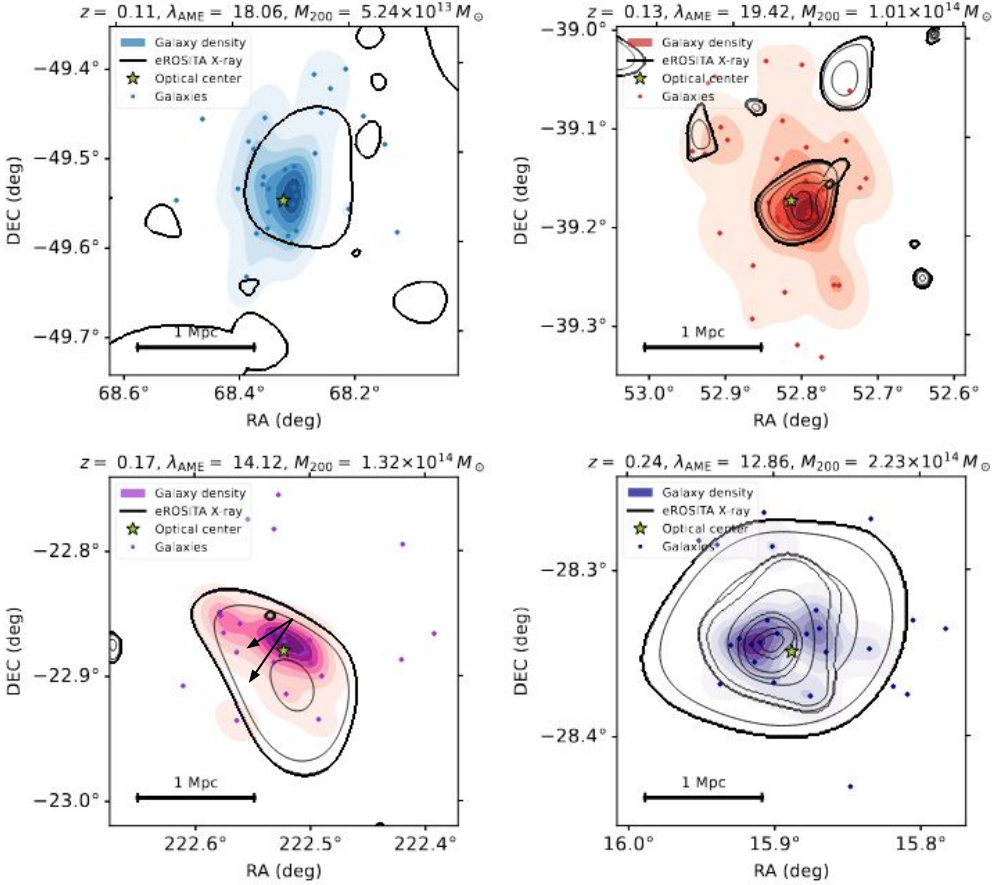
Run HDBSCAN (Campello et al. 2013)



$$P_{mem} = N_{times}/N_{runs}$$

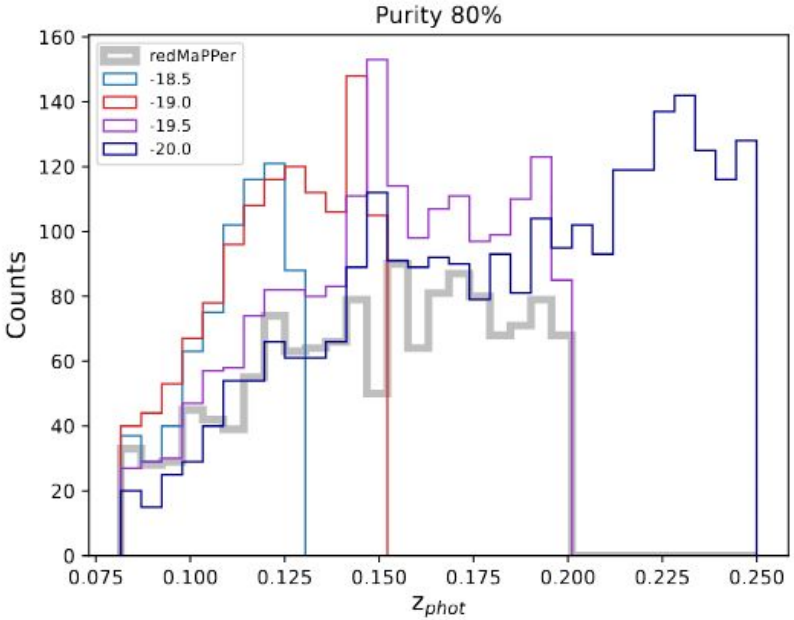
Matching

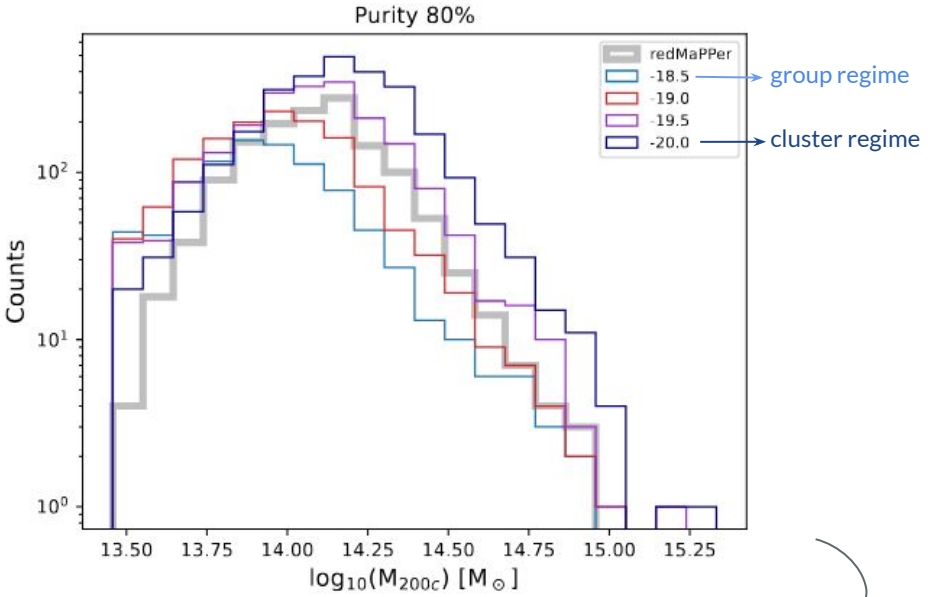
Some examples!



Results - Properties of the catalogs

Different absolute magnitude cuts = different galaxy inputs for matching and redshift ranges = different outputs

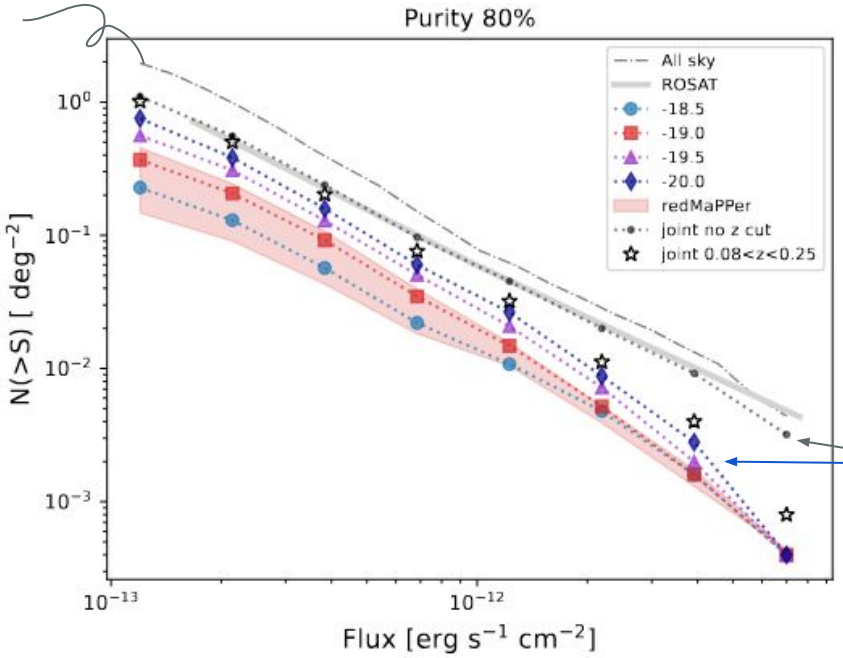




Weak lensing calibration of Leauthaud et al. (2010)

Results – Flux distribution and completeness (log N-log S)

all sources within S-PLUS footprint



Good recovery for both high and low-flux ends!

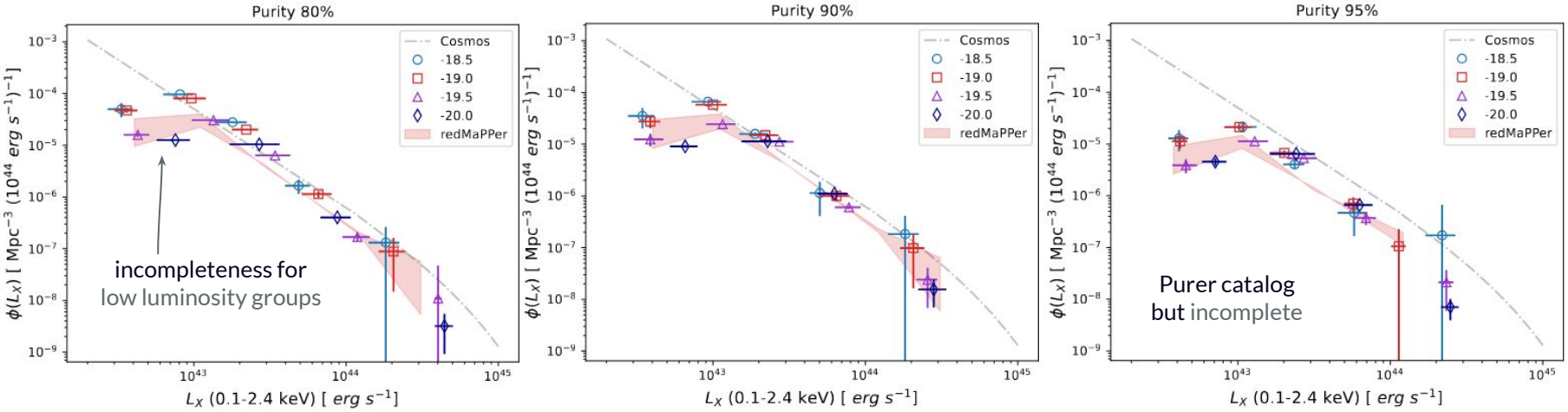
High-flux clusters are lost due to redshift clipping z>0.08

redMaPPer*
0.08>z>0.2

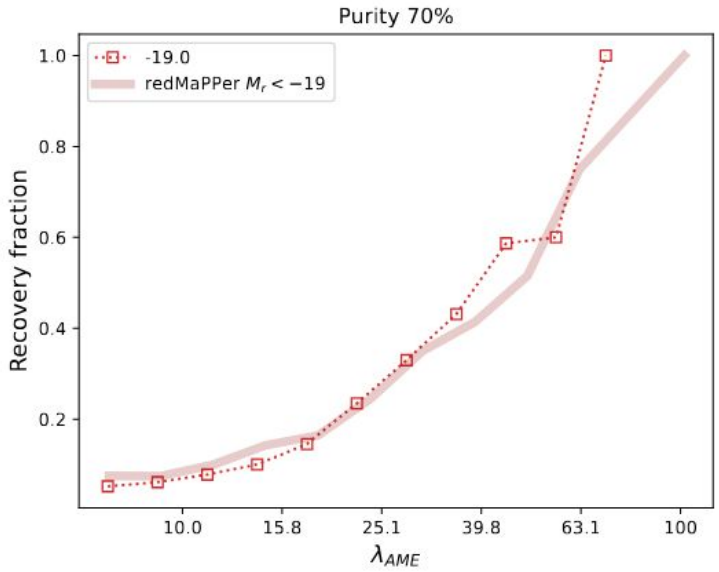
* Not a totally fair comparison due to the depth of the data

Results - X-ray luminosity function

effects of ambient in XLF:
superclusters → curve becomes flatter
voids → curve becomes steeper



Results - Comparison with redMaPPer cluster and group catalog



Things are working as they should!

Same recovery rate for both detection methods!

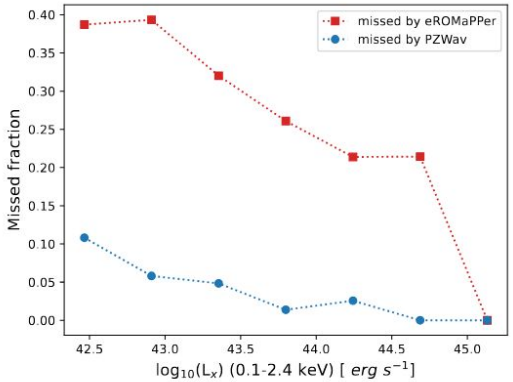
No bias due to the membership!

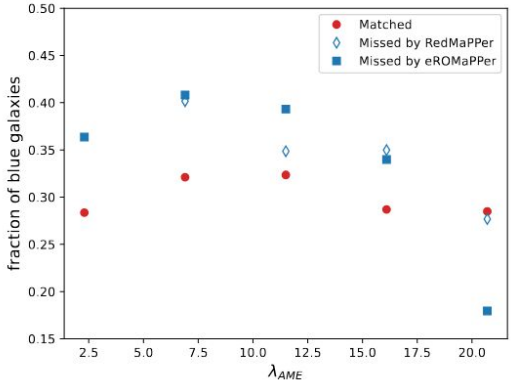
Results - Comparison with redMaPPer cluster and group catalog

Number of matched sources within S-PLUS footprint:

redMaPPer = 2,078

eSCALE = 3,500





1,254 matches with redMaPPer (XID) → $\Delta z = -0.008 \pm 0.024$

1,020 eSCALE sources completely missed by eROMaPPer ($\Delta R < 5'$)

87 redMaPPer sources missed by PZWav (35 within masked areas)

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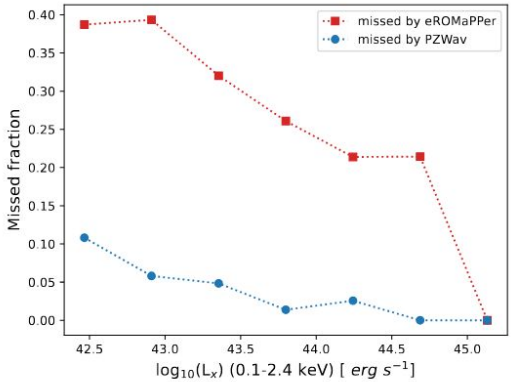

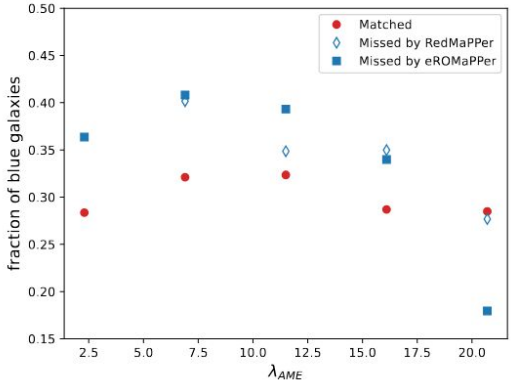

Optical

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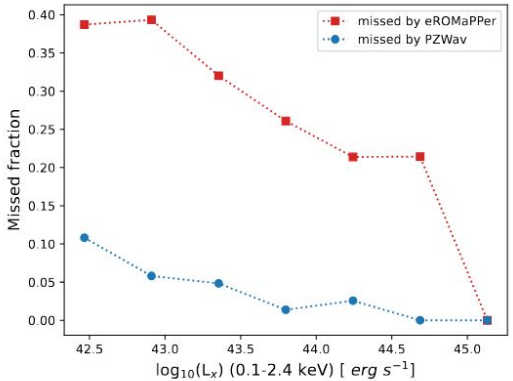

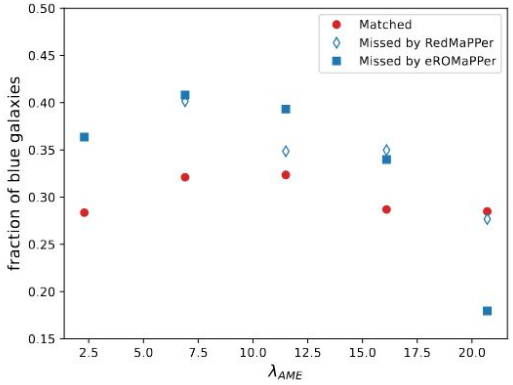

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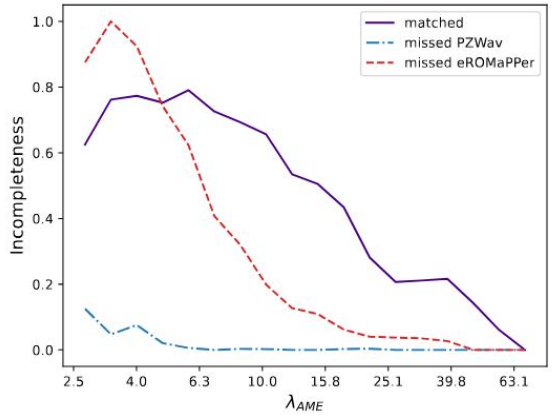

Summary:

– The choice of absolute-magnitude limit critically shapes the recovered cluster population. Fainter cuts (Mr < −18.5, −19) enhance sensitivity to low-mass groups, while brighter cuts (Mr < −19.5, −20) preferentially select more massive systems and extend the effective redshift range.

– Purity selection offers a tunable parameter for controlling catalog contamination. Higher purity levels yield cleaner samples but incur a significant reduction in completeness, particularly for low-luminosity and low-mass systems.

– The log N–log S distributions confirm that our matched catalogs recover the majority of luminous clusters within the eROSITA footprint while maintaining higher completeness at low fluxes compared to existing optical cluster catalogs.

– The X-ray luminosity functions derived from our matched catalogs are in good agreement with previous determinations. Observed deviations at the faint and bright ends are consistently explained by the interplay of incompleteness, purity selection, and survey volume effects.

– Comparison with the redMaPPer cluster catalog reveals consistent scaling trends and significant overlap. Combining both optical selection methods yields a modest improvement in overall detection completeness.

– Inclusion of blue cluster members through the PZWav+AME approach enhances sensitivity to low-mass and low-luminosity systems, which are underrepresented in red-sequence-selected catalogs such as redMaPPer.

This highlights the importance of multi-color optical selection for a more complete galaxy group census.

 (lia.doubrawa@helsinki.fi)