



Validation of the Euclid Catalogue of Galaxy Clusters with external data: the example of eROSITA

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Scientific context - Galaxy Clusters

- Largest and most massive known gravitationally bound structures: $10^{14} - 10^{15} M_{\odot}$, 1 - 5 Mpc, 100 ~ 1000 galaxies
- Galaxies, gas, dark matter
- Optical, X-rays, SZ effect



Euclid, ESA

Scientific context - Euclid mission

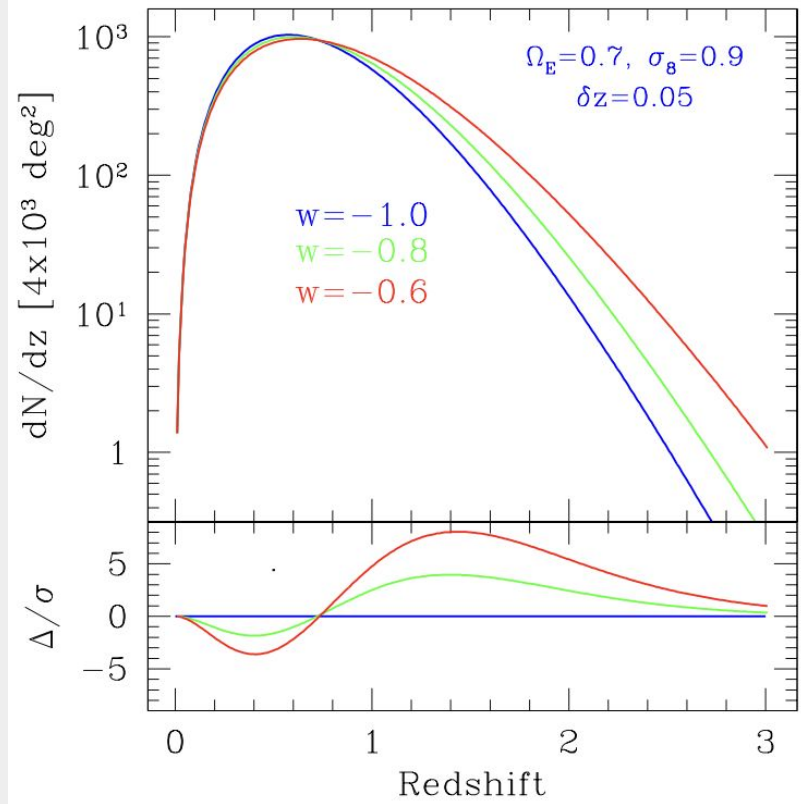
- Launched in July 2023 to the Earth-Sun Lagrange point L2
 - Beginning of nominal survey operations: February 2024
 - 6 years, 15 000 deg² of its extragalactic sky survey
- Catalogue of hundred of thousand clusters



ESA

Scientific context - Clusters and Dark Energy

- Cluster formation very sensitive to quantities of dark matter and dark energy
- Catalogue of clusters detected with redshift up to 2 → cluster counting as a function of redshift and mass → constraints on w (DE eq of state parameter)



Mohr et.al., 2002

Validation of Euclid catalogue: motivation

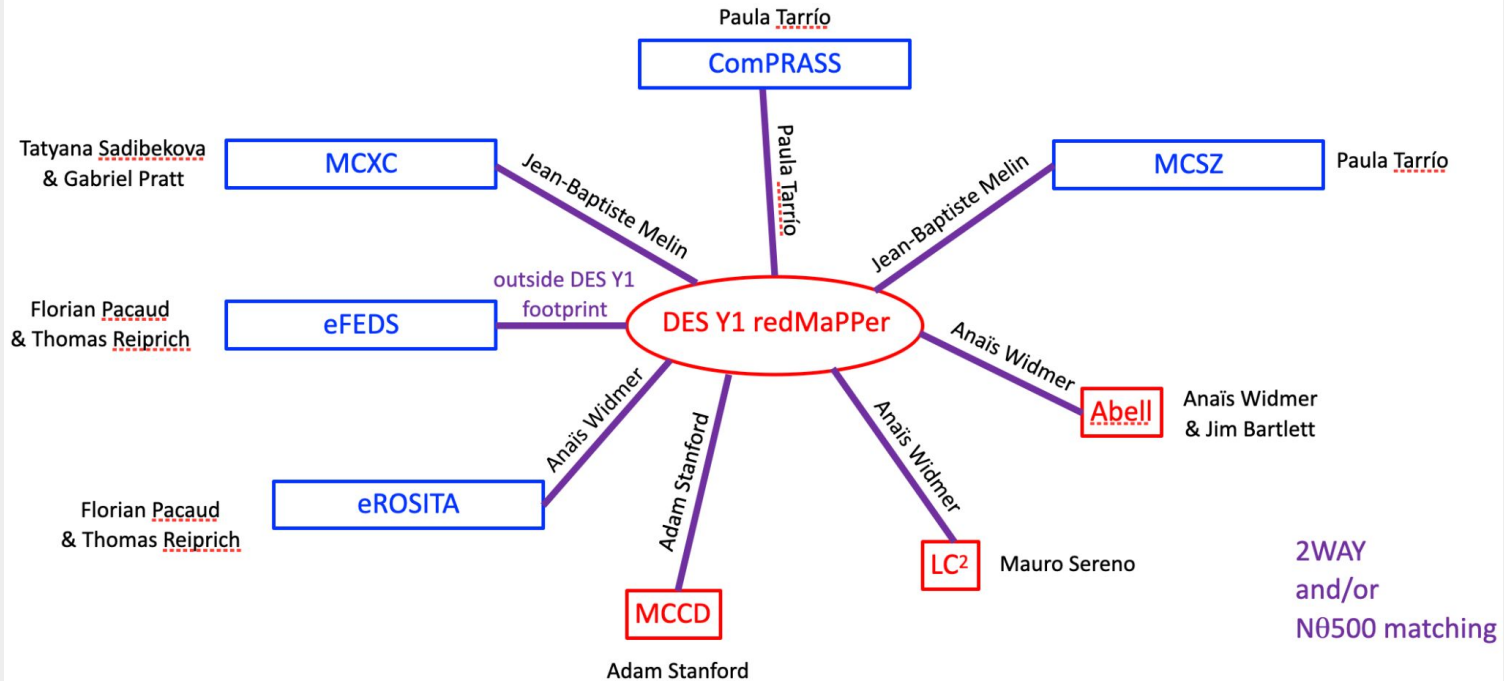
Identification of counterparts: association with and comparison to known clusters from other surveys

- Check for newly discovered clusters
- Prepare analyses of scaling relations
- Characterize *Euclid* selection function

J.-B. Melin, A. Stanford, A. Widmer, P. Tarrío, J.G. Bartlett, ..., *Euclid preparation: Validation of the Euclid Catalogue of Galaxy Clusters with external data*, in prep.

Catalogues

Catalogues and Meta-Catalogues



Catalogues - DES Y1 RedMaPPer

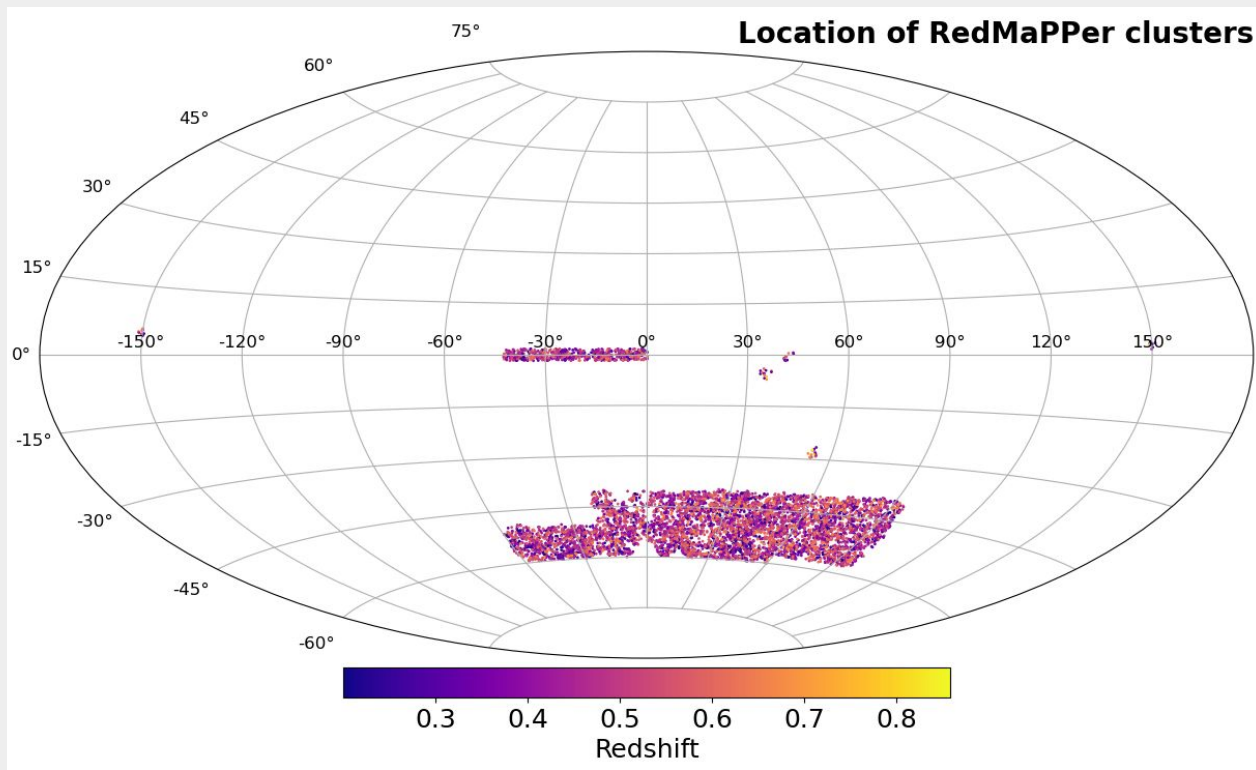
Surrogate for the future
Euclid Catalogue

Similar features: optical
selection based on
galaxies.

6729 detections over
about 1650 deg²

Rykoff et.al., 2016 ([arXiv:1601.00621](https://arxiv.org/abs/1601.00621))

Abbott et.al., 2020 ([arXiv:2002.11124](https://arxiv.org/abs/2002.11124))

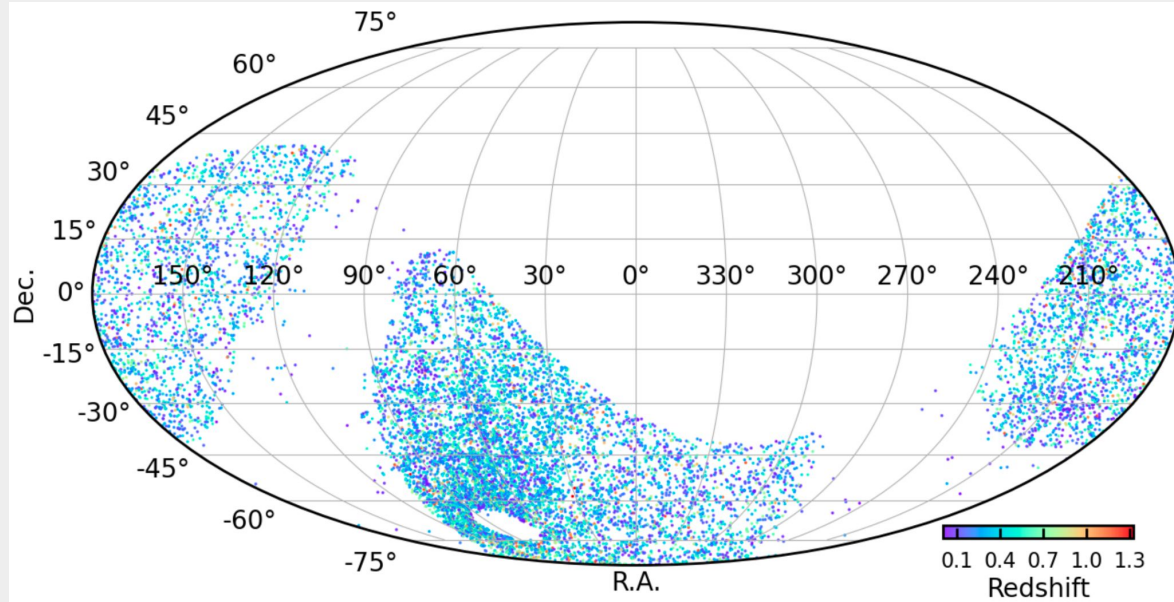


Catalogues - eROSITA

X-ray telescope, energy range 0.2 - 2.3 keV

First catalogue covers the Western Galactic hemisphere

12,247 sources over 13,166 deg²

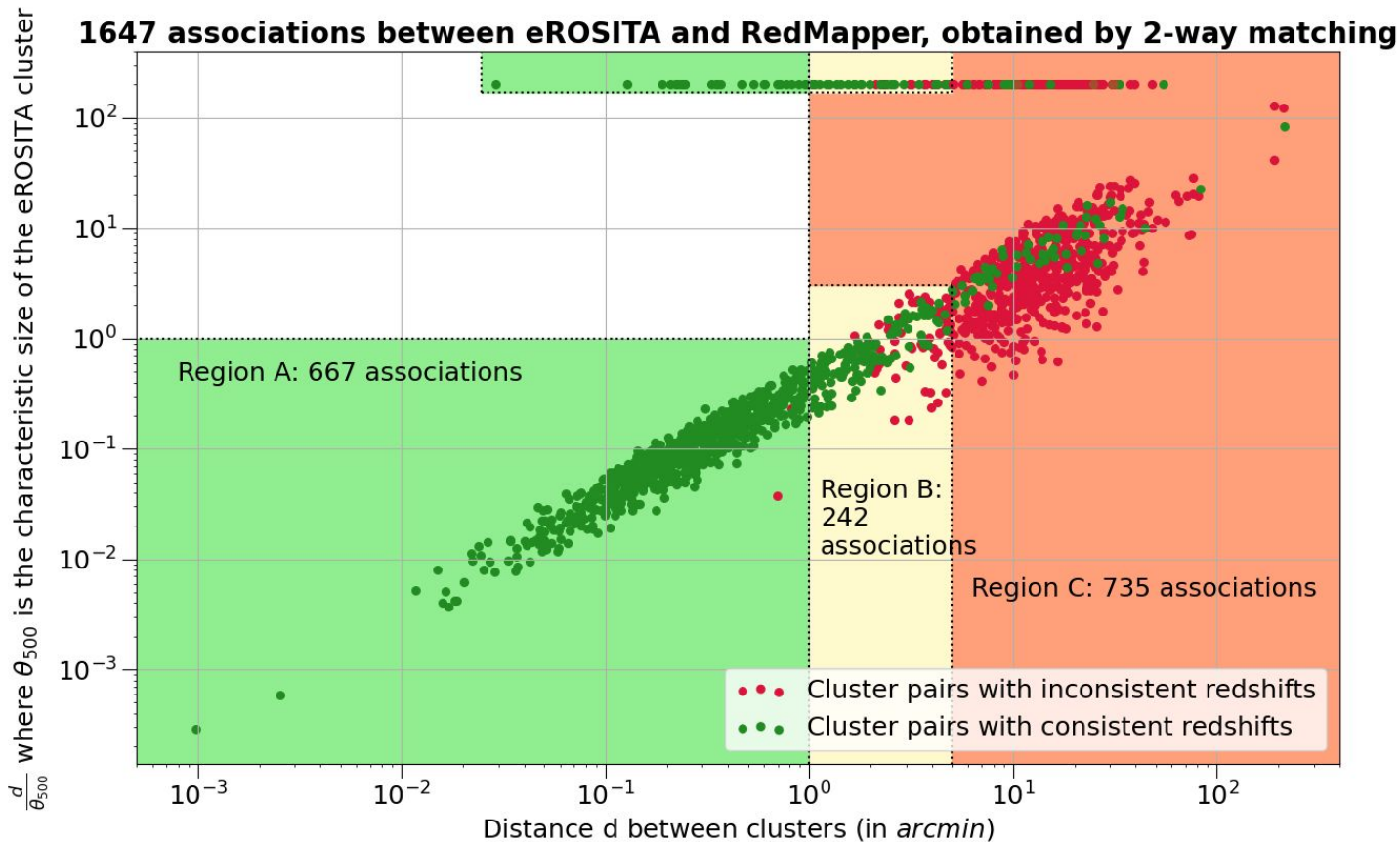


Bulbul et.al., 2024 ([arXiv:2402.08452](https://arxiv.org/abs/2402.08452))

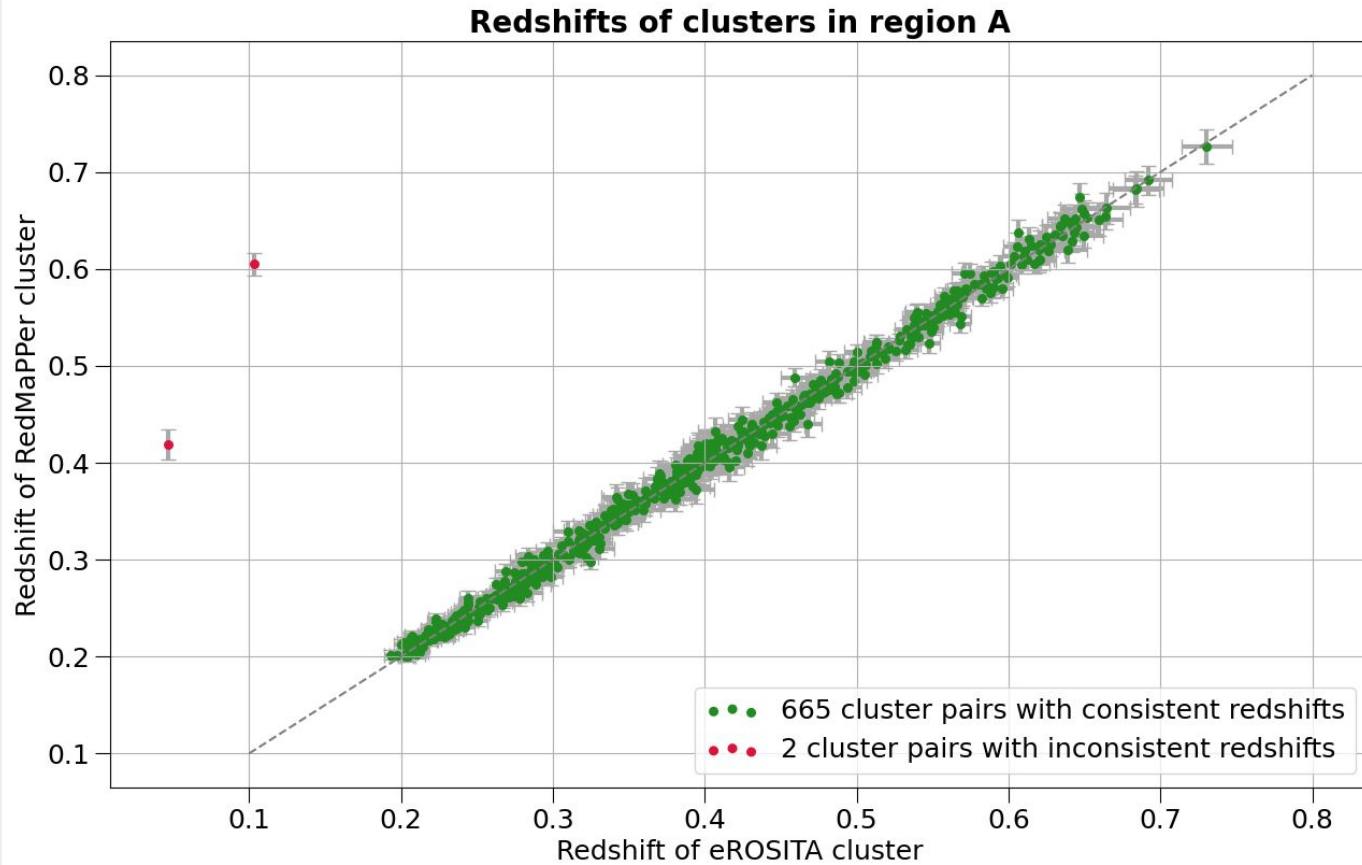
First method: two-way matching

- For each RM cluster, compute distance to eR clusters and keep the closest eR cluster.
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 - Keep only the pairs that are the same.
- Plot the distance between the two clusters normalized to the characteristic size θ_{500} of the eR cluster as a function of distance.

First method: two-way matching



First method: two-way matching



$$\frac{\Delta z}{1+z_{eR}} < 0.03$$

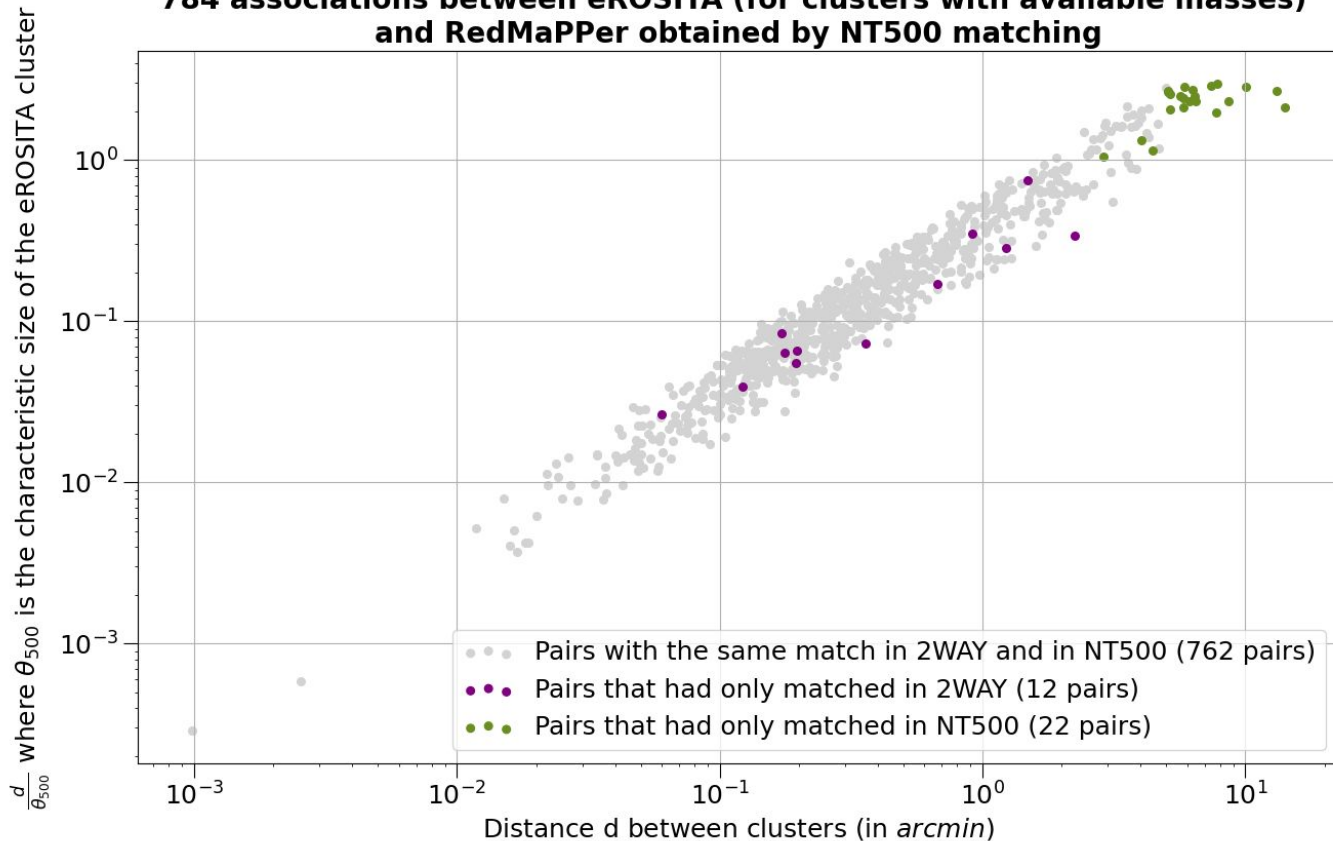
Second method: $N\theta_{500}$ matching

For each eR cluster :

- Select all the RM clusters that are inside a circle of radius $N \theta_{500}$ ($N = 3$) around the eR cluster.
- Keep the RM cluster with the closest redshift.
- Keep only the pairs with $\frac{\Delta z}{1+z_{eR}} < 0.03$.

Second method: N θ 500 matching

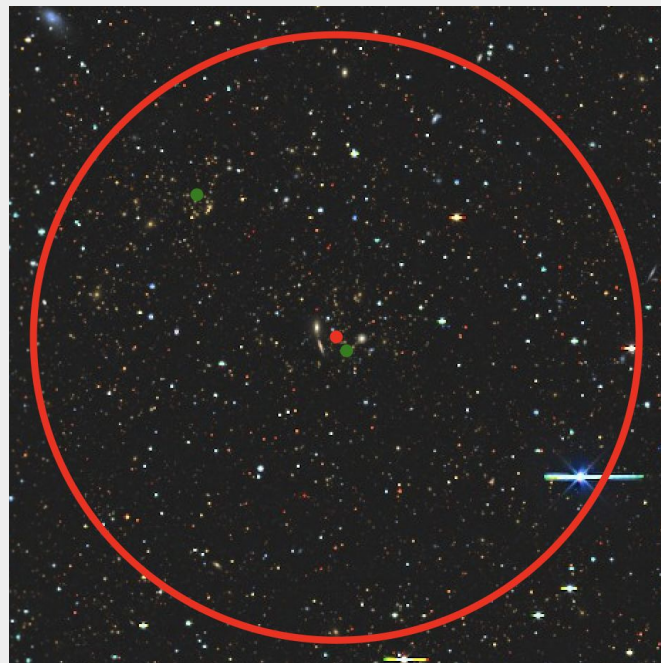
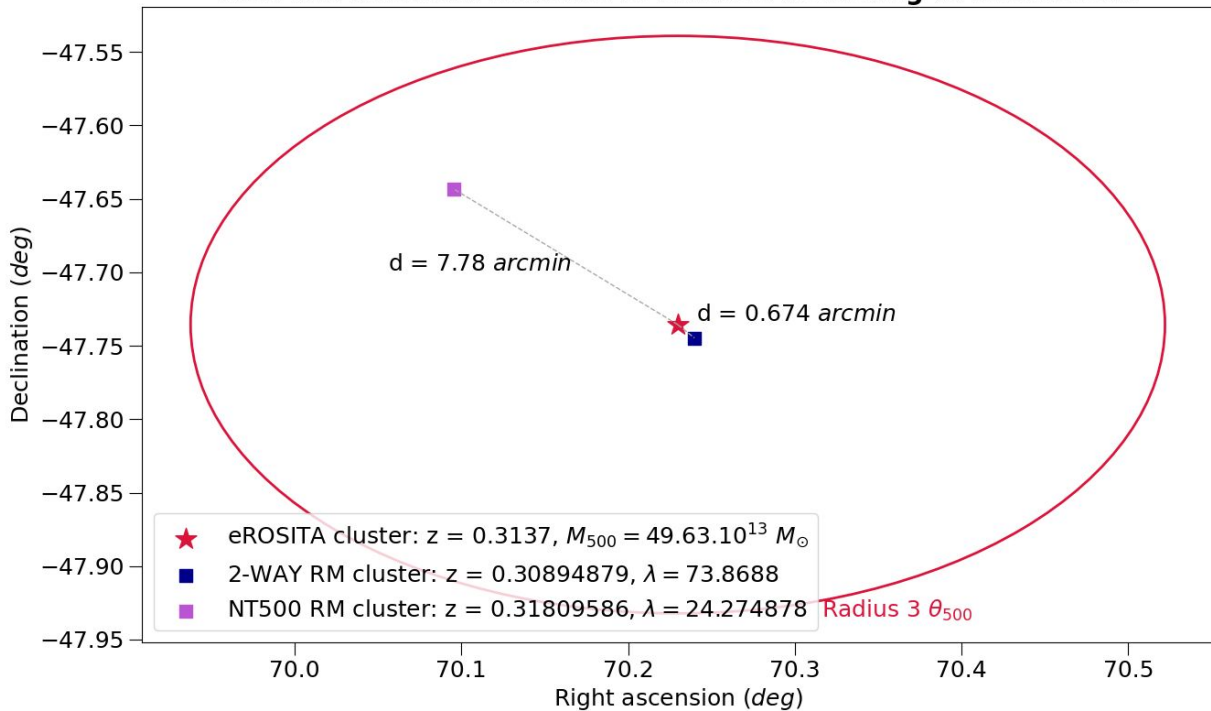
784 associations between eROSITA (for clusters with available masses) and RedMaPPer obtained by NT500 matching



Second method: N₀₅₀₀ matching - special case

DESI Sky Viewer (optical)

Study of eROSITA clusters that have been matched with two different RedMaPPer clusters according to the method



Multiple systems ?

Format of the validated catalogue

DES Y1 redMaPPer

+

one block
for each
meta-catalogue
and
for each
cross-correlation
method

MCCD_2WAY_MATCH	INT	1	Does it match match with a MCCD cluster?
MCCD_2WAY_INDEX	LONG	154	Which MCCD cluster?
MCCD_2WAY_SEP	DOUBLE	0.43600000	What is the absolute separation in arcmin?
MCCD_2WAY_NORMSEP	DOUBLE	0.22020000	What is the separation normalized to the MCCD cluster radius?
MCCD_2WAY_Z	FLOAT	0.294000	What is the redshift of the MCCD cluster?
LC2_2WAY_MATCH	INT	1	
LC2_2WAY_INDEX	LONG	337	
LC2_2WAY_SEP	DOUBLE	0.43656297	
LC2_2WAY_NORMSEP	DOUBLE	0.098154866	
LC2_2WAY_Z	FLOAT	0.294000	
LC2_NT500_MATCH	INT	1	
LC2_NT500_INDEX	LONG	337	
LC2_NT500_SEP	DOUBLE	0.43656297	
LC2_NT500_NORMSEP	DOUBLE	0.098154866	
LC2_NT500_Z	FLOAT	0.294000	

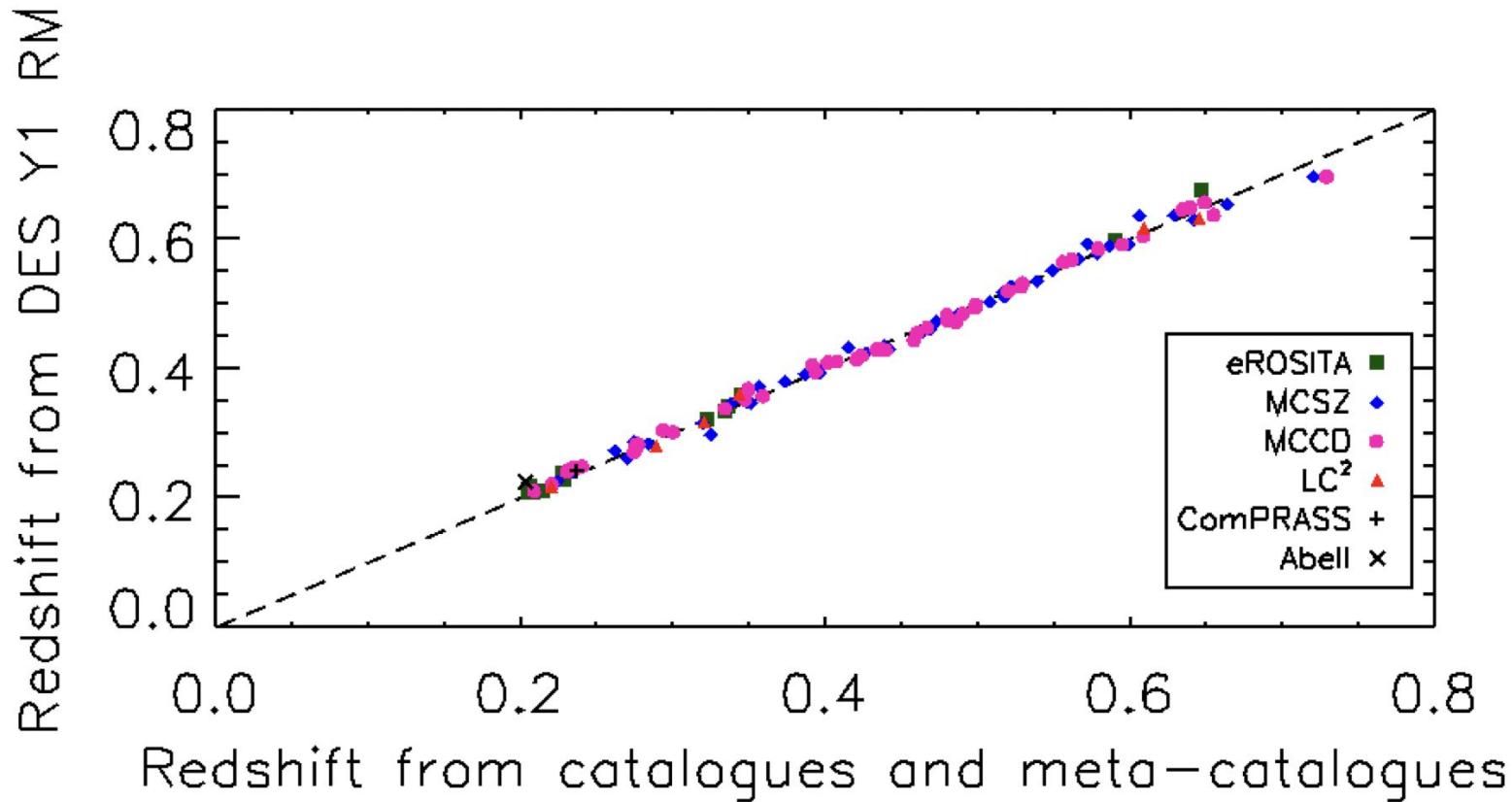
J.-B. Melin

Summary of matching DES Y1 RM

Cluster catalogue or meta-catalogue	Number of matches with DES Y1 RM	Number of unique matches with DES Y1 RM
MCXC	28	4
MCSZ	435	175
ComPRASS	60	0
eROSITA	826	572
MCCD	48	4
LC ²	29	8
Abell	32	4
In two catalogues		188
In three catalogues		44
In four catalogues		28
In five catalogues		9
In six catalogues		2
In seven catalogues		2
Unmatched		5689
Total		6729

J.-B. Melin
et. al., in
prep

Summary of matching DES Y1 RM



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Conclusion

- Efficient method for cross-matching the DES Y1 RM catalogue with external data: plan to use it for validating the Euclid catalogue
- Limitations: time and human resources
- Other catalogues (XCLASS, MARD Y3, ...)