

# Cluster Finders

## The DESC Collection

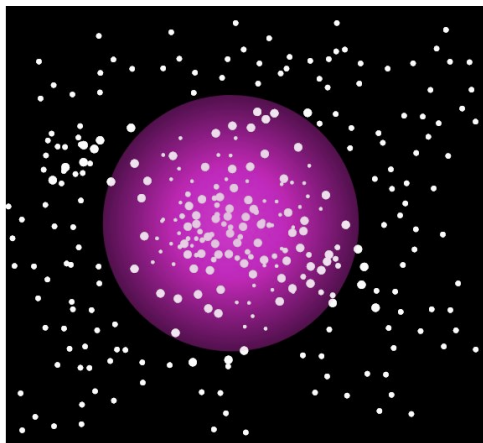
**Rance Solomon (LAPP)**  
*on behalf of the*  
*DESC Clusters Working Group*

Modified from Moriond slides

07-May 2024

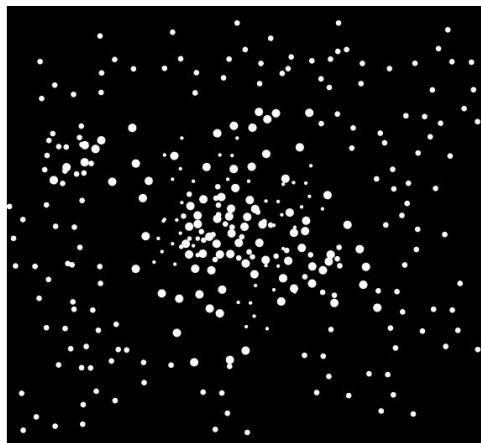


# Cluster Finding



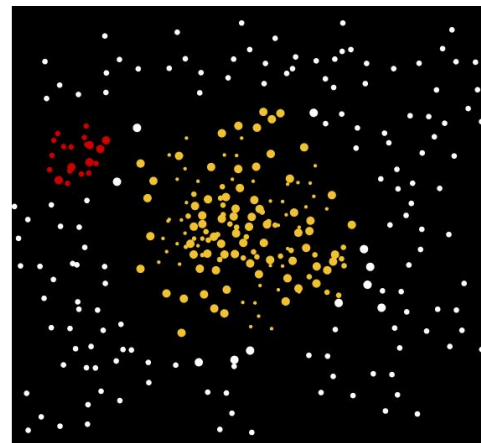
**What we want:**

DM halo position and mass



**What we see:**

Overdensity of galaxies



**What we do:**

Detect overdensities and count their members

$$\underbrace{\sum(\text{members})}_{\text{Richness, } \lambda} \propto M_{\text{halo}}$$

# Cluster Finders

The DESC CL Finders:

**AMICO** (Adaptive Matched Identifier of Clustered Objects)

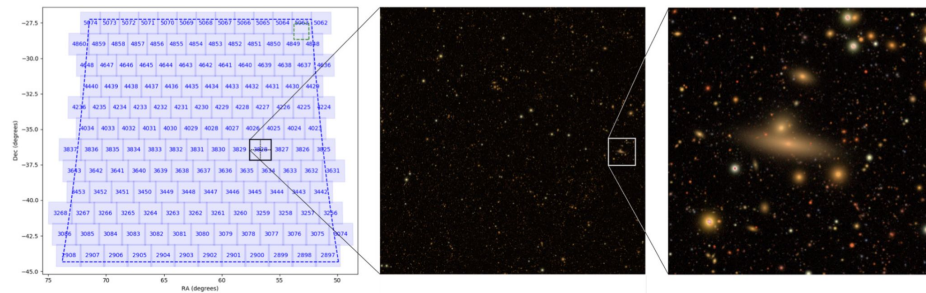
**redMaPPer** (red-sequence Matched-filter Probabilistic Percolation)

**WaZP** (Wavelet Z Photometric)

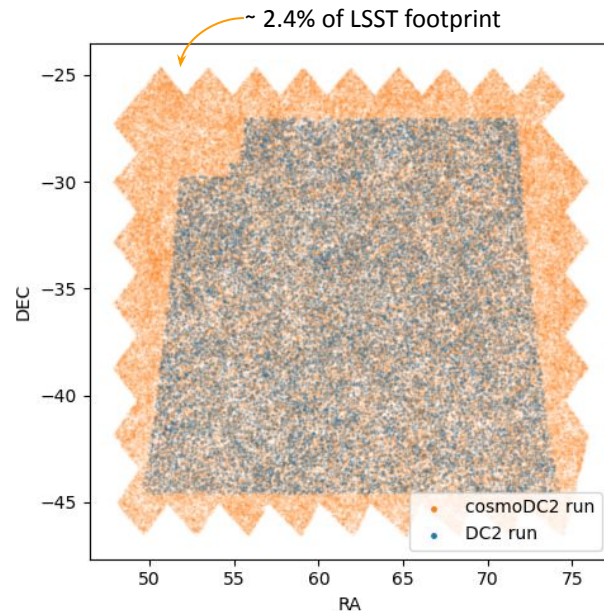
**YOLO-CL** (You Only Look Once - Clusters)

The CL Finders must be optimized and validated on LSST-like data.

We use a simulated mock galaxy catalog ([cosmoDC2](#) – 440deg<sup>2</sup> of simulated galaxies) and a simulated image-level catalog ([DC2](#) – 300deg<sup>2</sup> of image-like galaxies based on cosmoDC2).



example of galaxy cluster in the simulated images of DC2



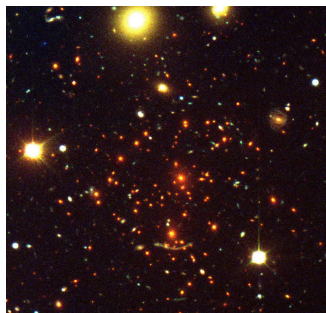
sky patch covered by the cosmoDC2 and DC2 simulations

# Cluster Finder – redMaPPer

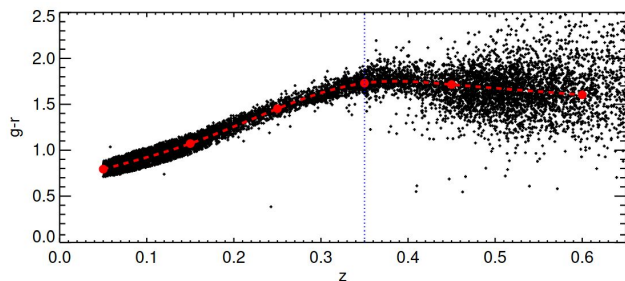
## redMaPPer

written by: E. Rykoff, E. Rozo, M. Busha, etc.  
DESC Lead: M. Ricci, E. Rykoff

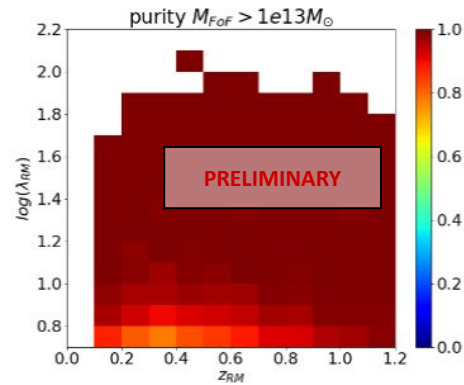
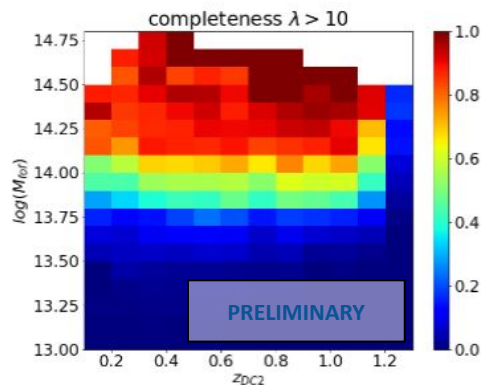
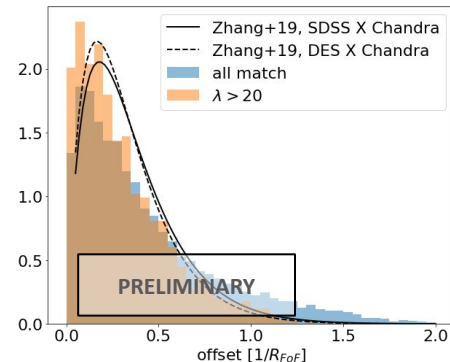
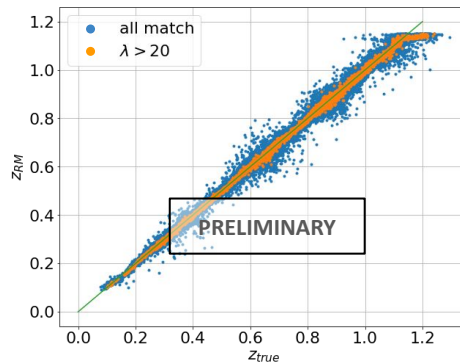
- based on color properties of galaxy clusters
- robust redshift estimation and cluster finding
- tested on SDSS and DES



(right) Abell 370;  
(bottom) training on red-sequence



[Rykoff, et al. 2014](#)

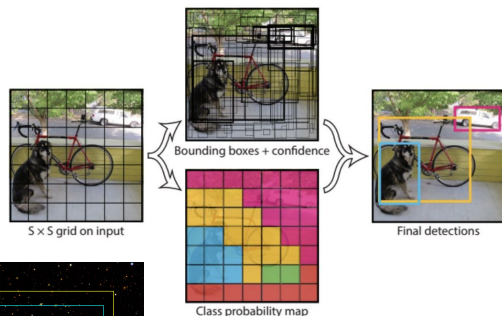


# Cluster Finder – YOLO-CL

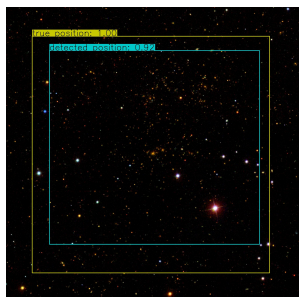
## YOLO-CL

written by: K. Grishin, S. Mei, S. Ilic  
DESC Lead: K. Grishin, S. Mei, M. Aguena, S. Ilic

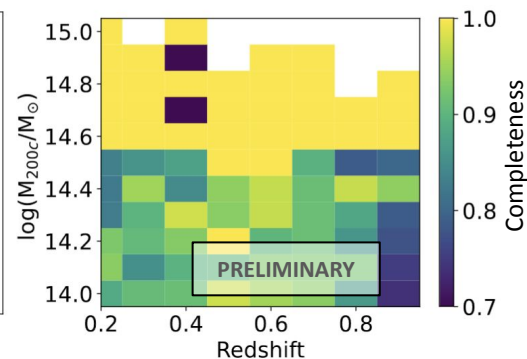
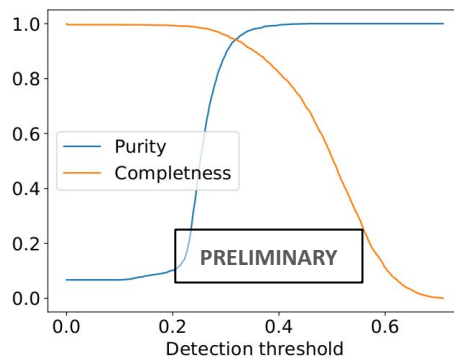
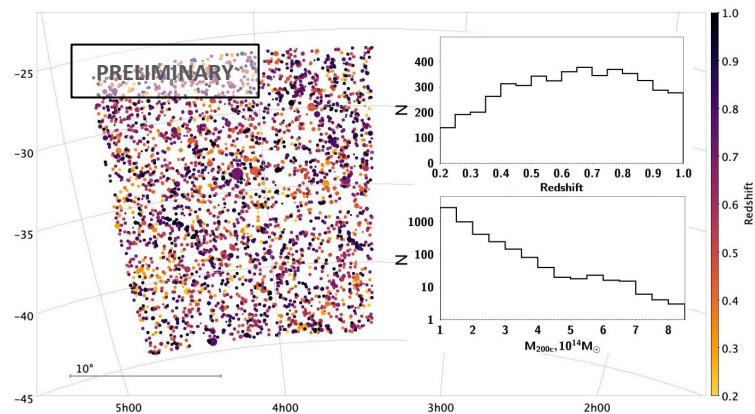
- based on YOLO object detection ML algorithm
- run directly on images – no galaxy catalogs
- 98% completeness/purity in SDSS redMaPPer clusters



(top) YOLO object detection;  
(right) YOLO-CL cluster detection



[Grishin, et al. 2023](#)

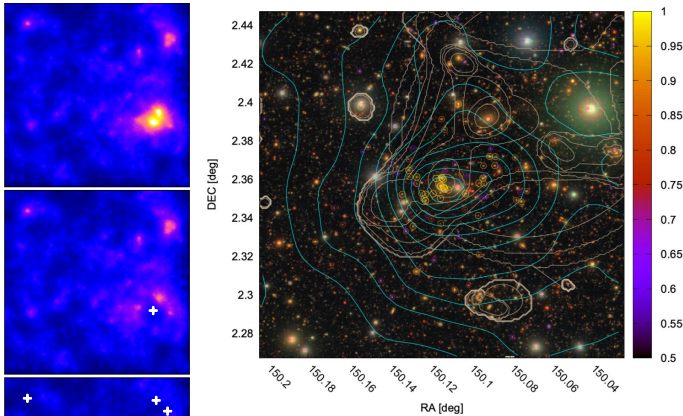


# Cluster Finder – AMICO

## AMICO

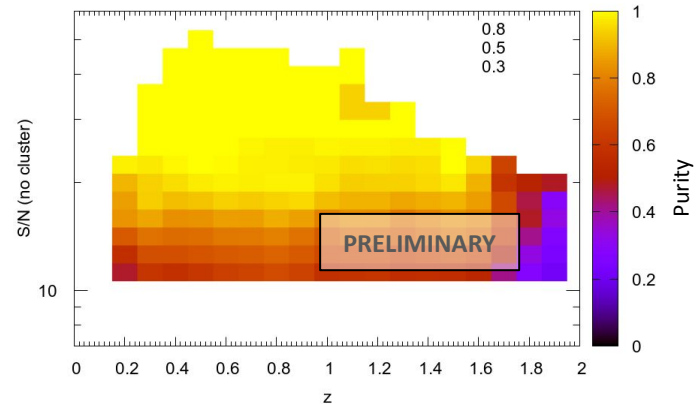
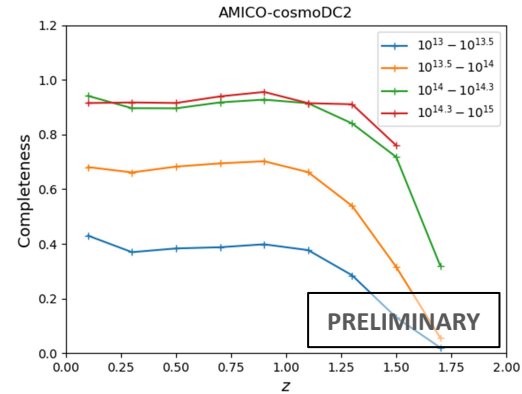
written by: M. Maturi  
DESC Lead: N. Amouroux, T. Guillemin, M. Maturi

- based on Optimal Filtering Technique - providing unbiased amplitude estimator with minimal variance
- chosen as one of the two official CL Finders for Euclid



(left) iterations of S/N map with detection removal  
(above) AMICO cluster amplitude with x-ray contours (cyan and white, respectively)

[Bellagamba, et al. 2017](#) & [Toni, et al. 2023](#)

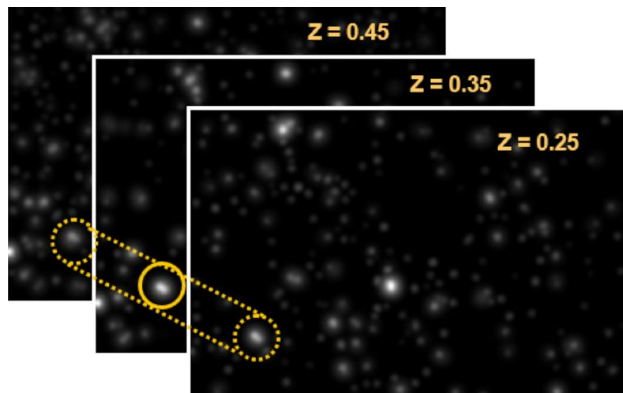


# Cluster Finder – WaZP

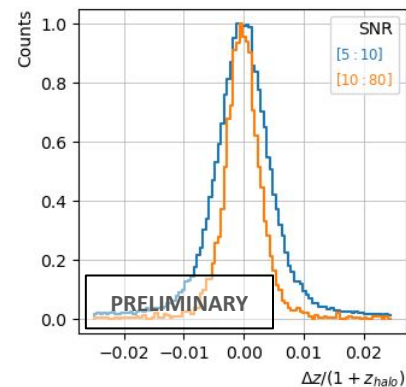
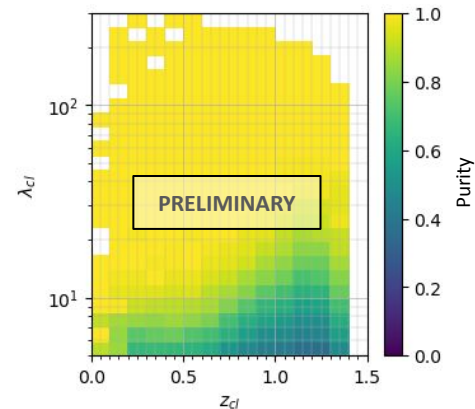
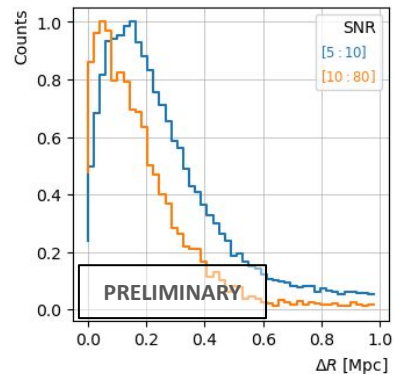
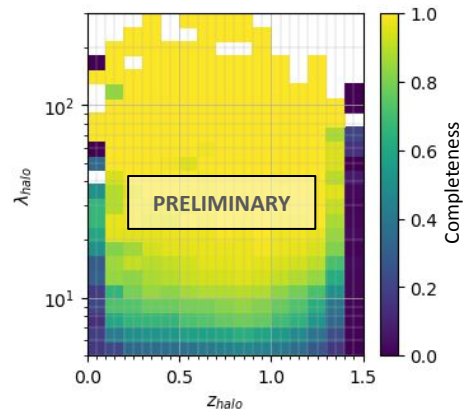
## WaZP

written by: C. Benoist  
DESC Lead: M. Aguena, R. Solomon, C. Benoist, L.N. da Costa, etc.

- detection in wavelet-based density maps in RA-DEC-z space
- minimal assumptions on cluster properties
- tested on DES with good agreement to redMaPPer



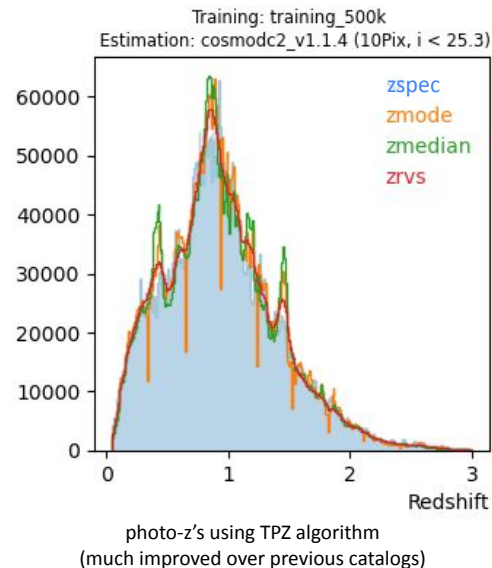
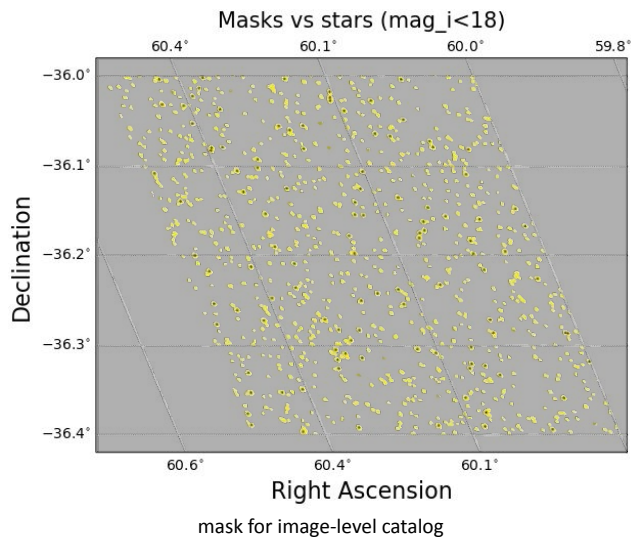
redshift slices of wavelet-passed catalog with cluster detection shown in three adjacent slices



# Related Developments

Current issues affecting multiple cluster finders:

- ① bright objects in image-level catalog – masks are being developed now
- ② poorly behaved photo-z's at high magnitudes – improved photo-z catalog has been produced

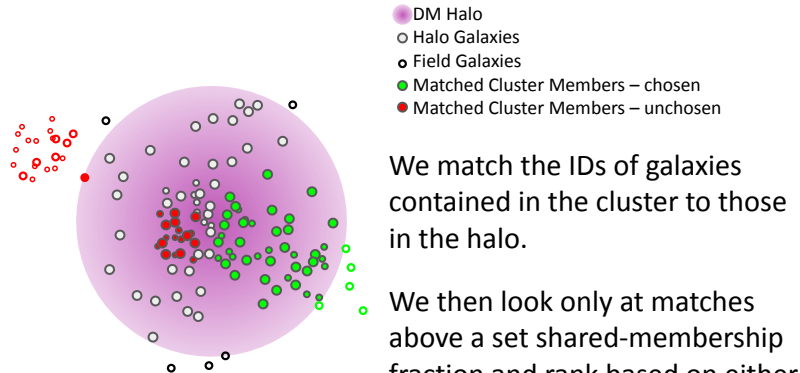




# Appendix: matching strategies

The DESC module, [ClEvaR](#), written by Michel Aguena, is used for matching cluster catalogs and allows us to determine the completeness and purity of the cluster catalog. In real data, matching will be between the DESC cluster catalogs and confirmed cluster catalogs from various other surveys. Depending on the type of survey we may want to use either *membership matching* or *proximity matching*.

## Membership Matching



We match the IDs of galaxies contained in the cluster to those in the halo.

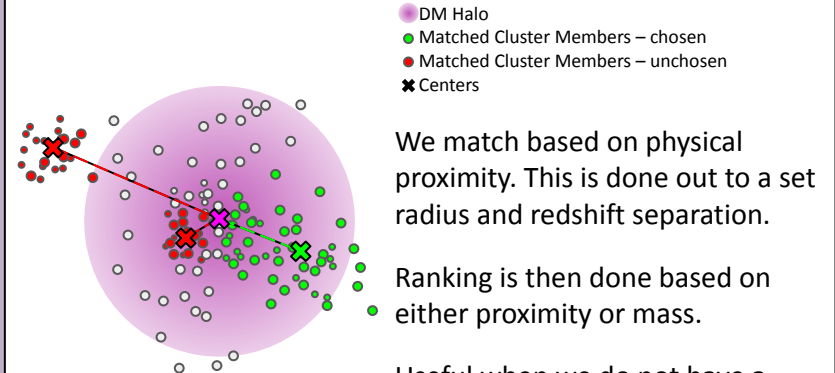
We then look only at matches above a set shared-membership fraction and rank based on either proximity or mass.

### matching parameters:

1. share frac

Useful when we have a members catalog – optical or NIR surveys.

## Proximity Matching



We match based on physical proximity. This is done out to a set radius and redshift separation.

Ranking is then done based on either proximity or mass.

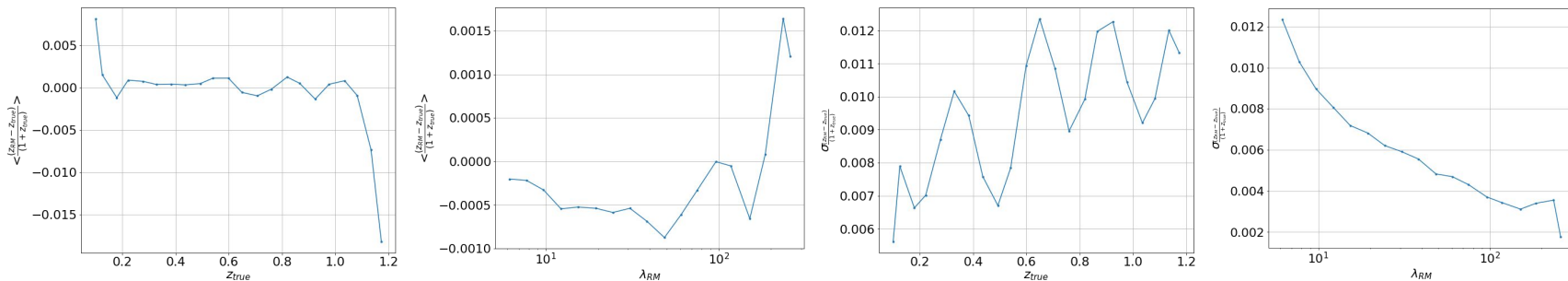
Useful when we do not have a members catalog – x-ray or mm wavelength surveys.

### matching parameters:

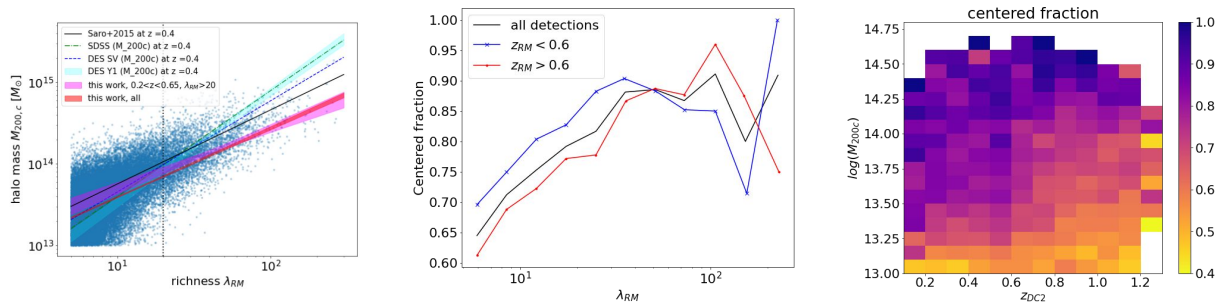
1.  $\Delta R$  threshold
2.  $\Delta z$  threshold

# Appendix: redMaPPer

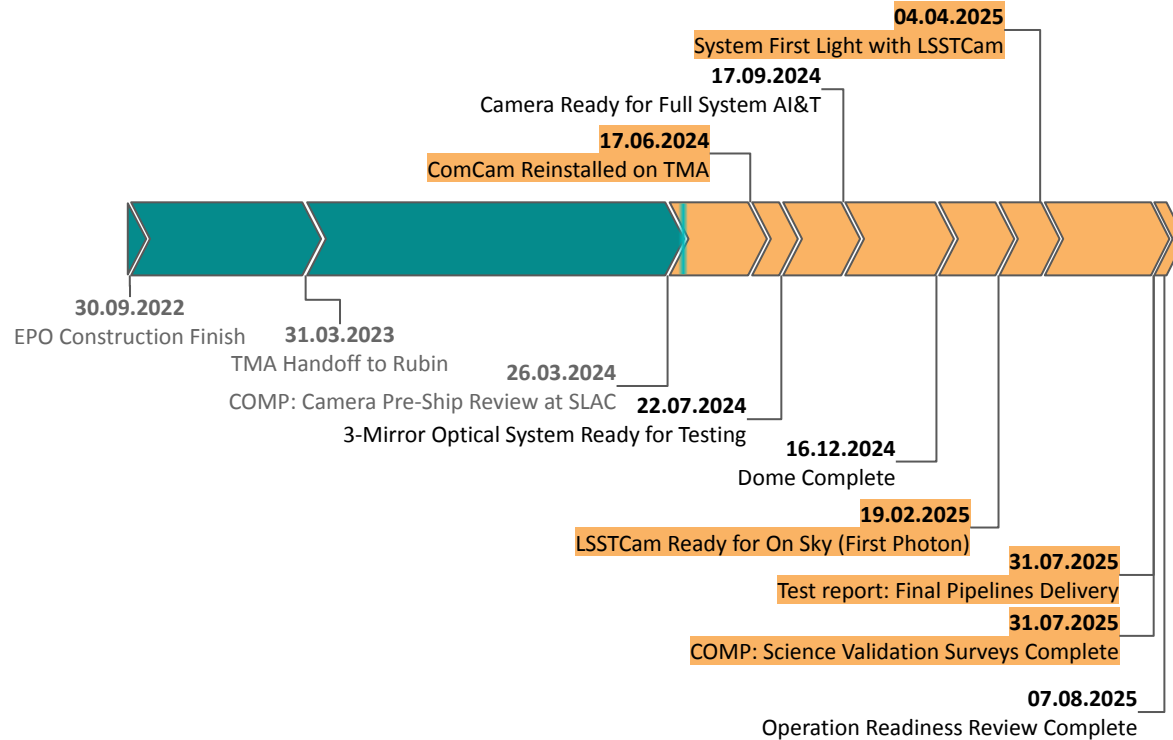
Bias and scatter in redshift behaves as expected. We can see that much of the scatter is due to low richness clusters.



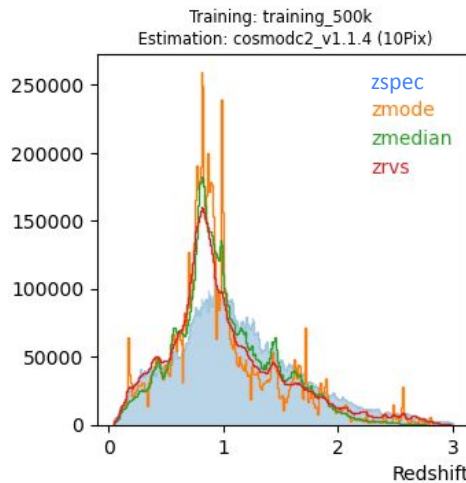
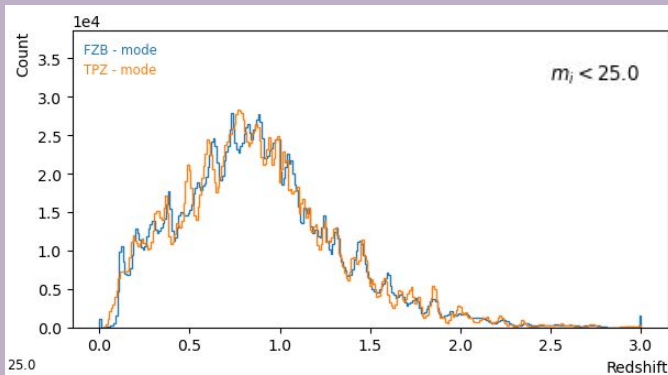
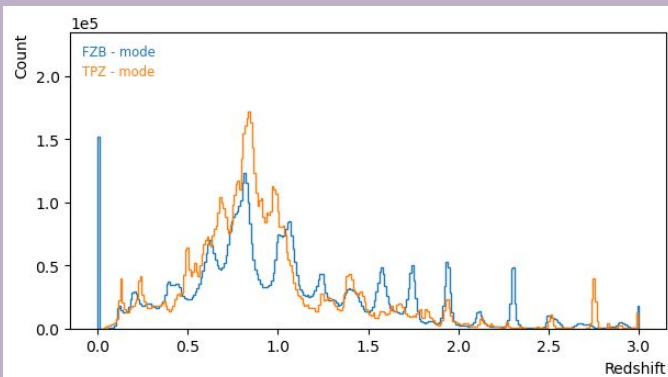
Halo-CL matching is well centered for high mass/richness systems with some redshift dependence.



# Appendix: Rubin timeline



# Appendix: photo-z peaks



peaked issues resolved with modified TPZ algorithm

problematic photo-z's for cosmoDC2 – similar peaks can be seen in HSC photo-z's

