ASTRO @ TS

Finding galaxy clusters in Euclid.
A challenge among the cluster finders

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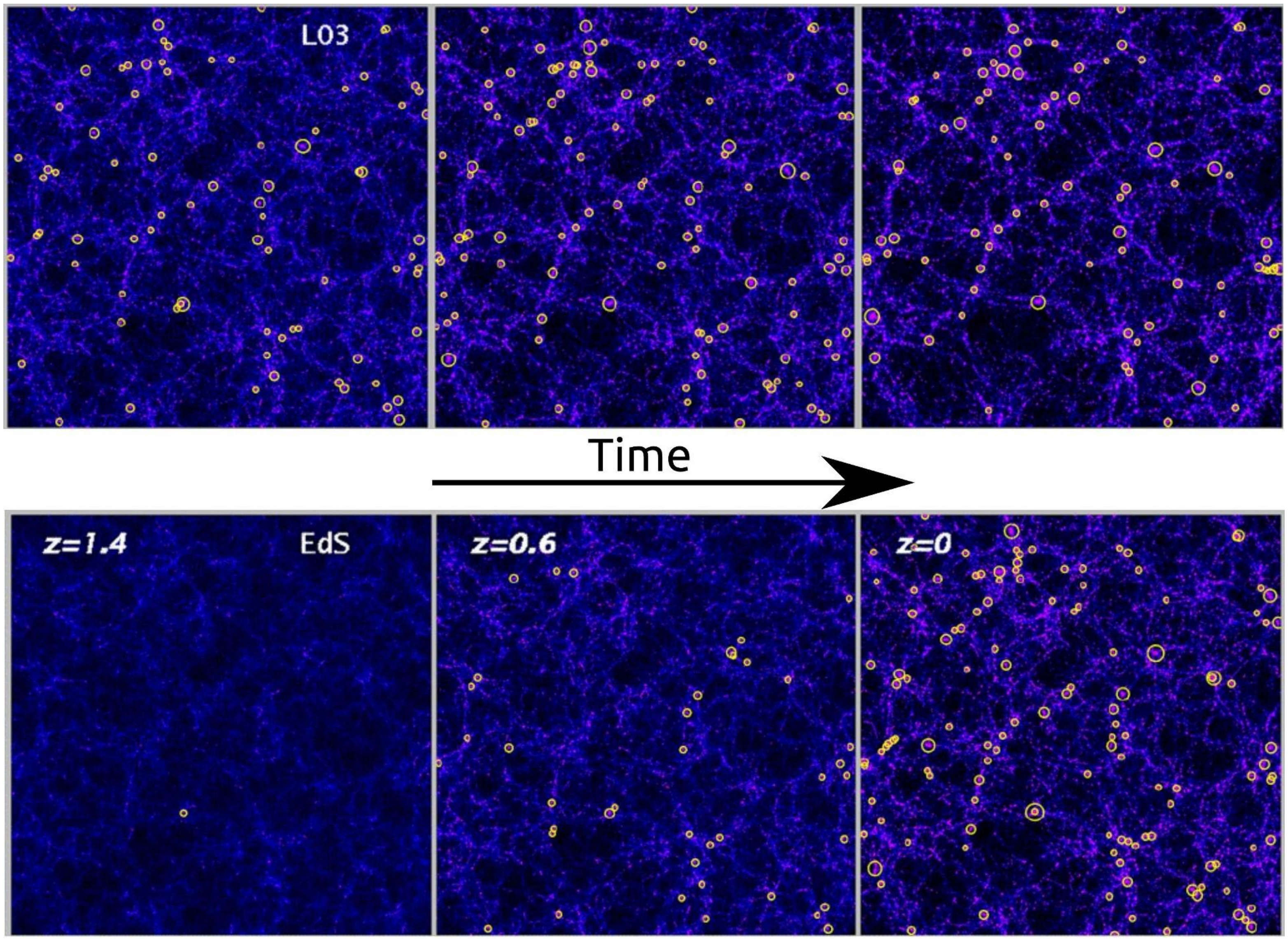
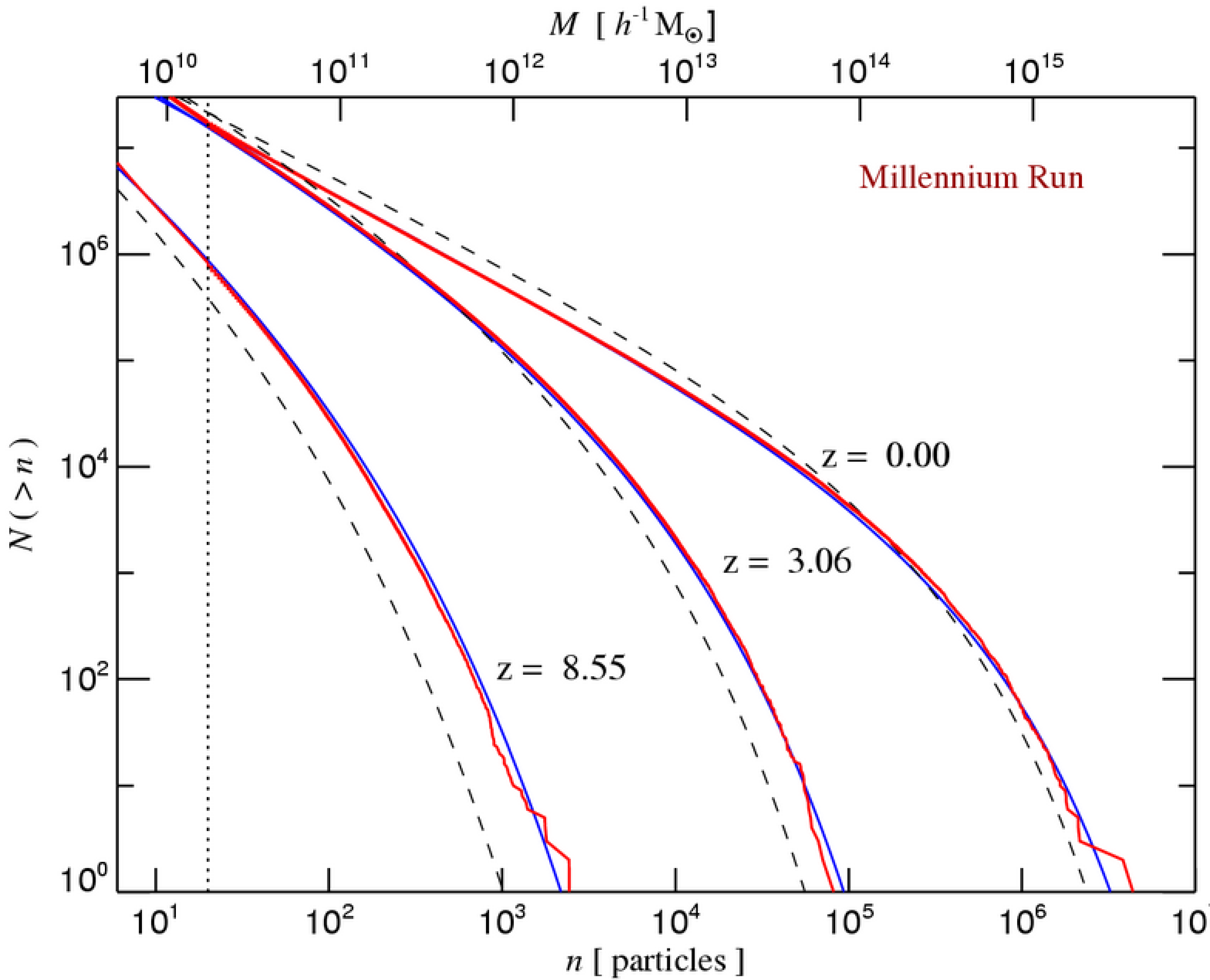
The cluster population bears the imprints of the statistical distribution of initial fluctuations, their subsequent growth and the dynamics of the collapse of dark matter halos.



Borgani & Guzzo, 2001



http://wwwmpa.mpa-garching.mpg.de/mpa/research/current_research/hl2004-8/hl2004-8-en.html

GALAXY CLUSTERS

At the intersection of filamentary structures there are the highest density peaks: galaxy clusters.

The simplest definition of galaxy cluster is that of an overdensity in the number of Galaxies.

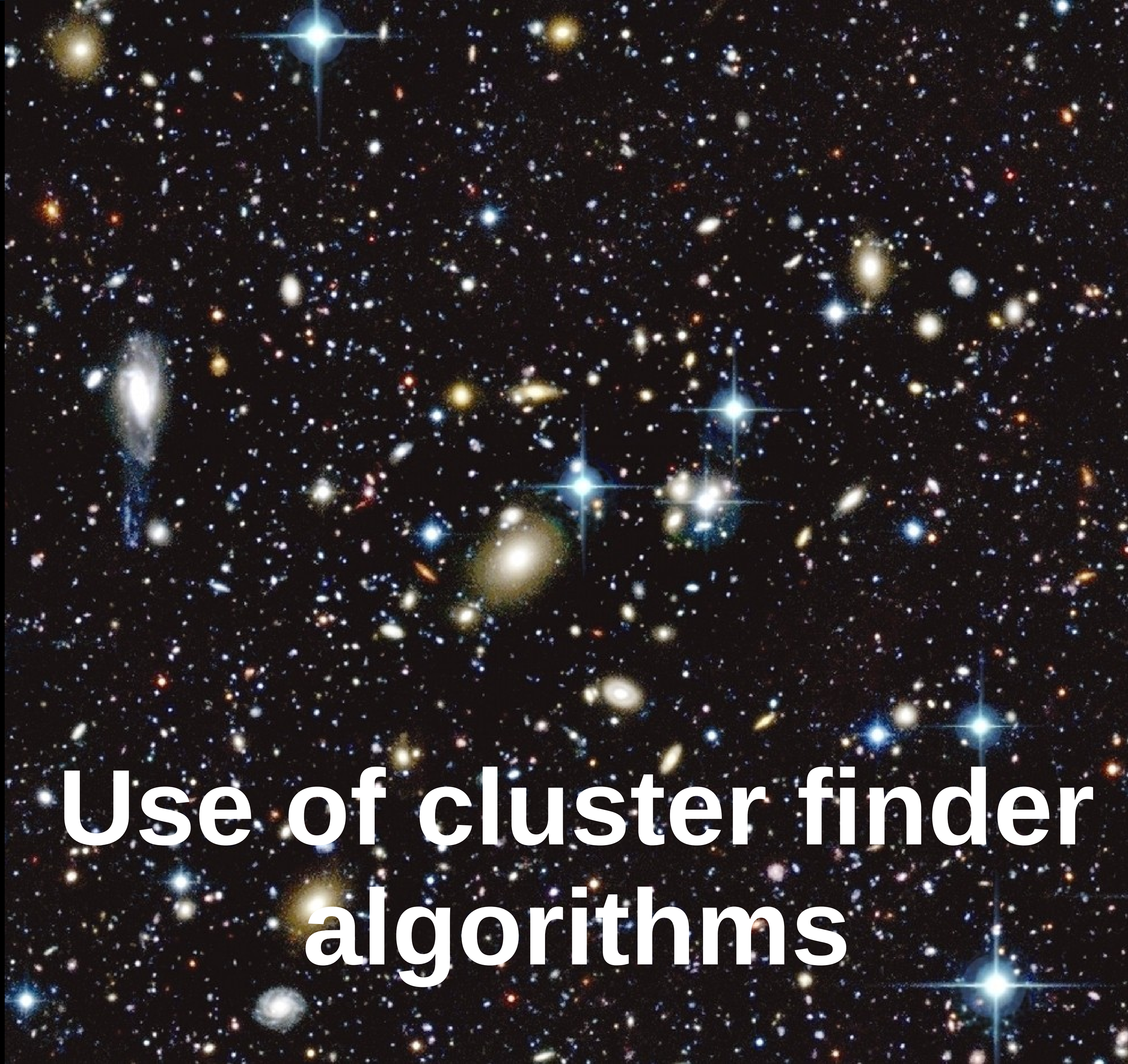
In fact galaxy clusters can contain up to some thousands galaxies, moving in the potential well of the cluster with velocities of hundreds of km/s on a scale of hundreds kpc.

Cluster mass content

~ 80% DM
~ 15% Hot plasma (ICM)
~ 5% Stars and galaxies

Although the baryon content is very small, on scales smaller than 10 Mpc gas–dynamical processes become fundamental in shaping galaxy formation and evolution and consequently the observational properties of these structures.

Abell 1689: gas detected by NASA's Chandra X-ray Observatory is shown as purple, while galaxies from optical data from the Hubble Space Telescope are coloured yellow



Use of cluster finder algorithms

How to compare different algorithms?

One possibility:

- use mock catalogs and run the algorithms
- go through the entire cosmological pipeline and extract the cosmological parameters
- Compare the values and the accuracy with which cosmological parameters are recovered (since they are known from the mocks) and choose the best one

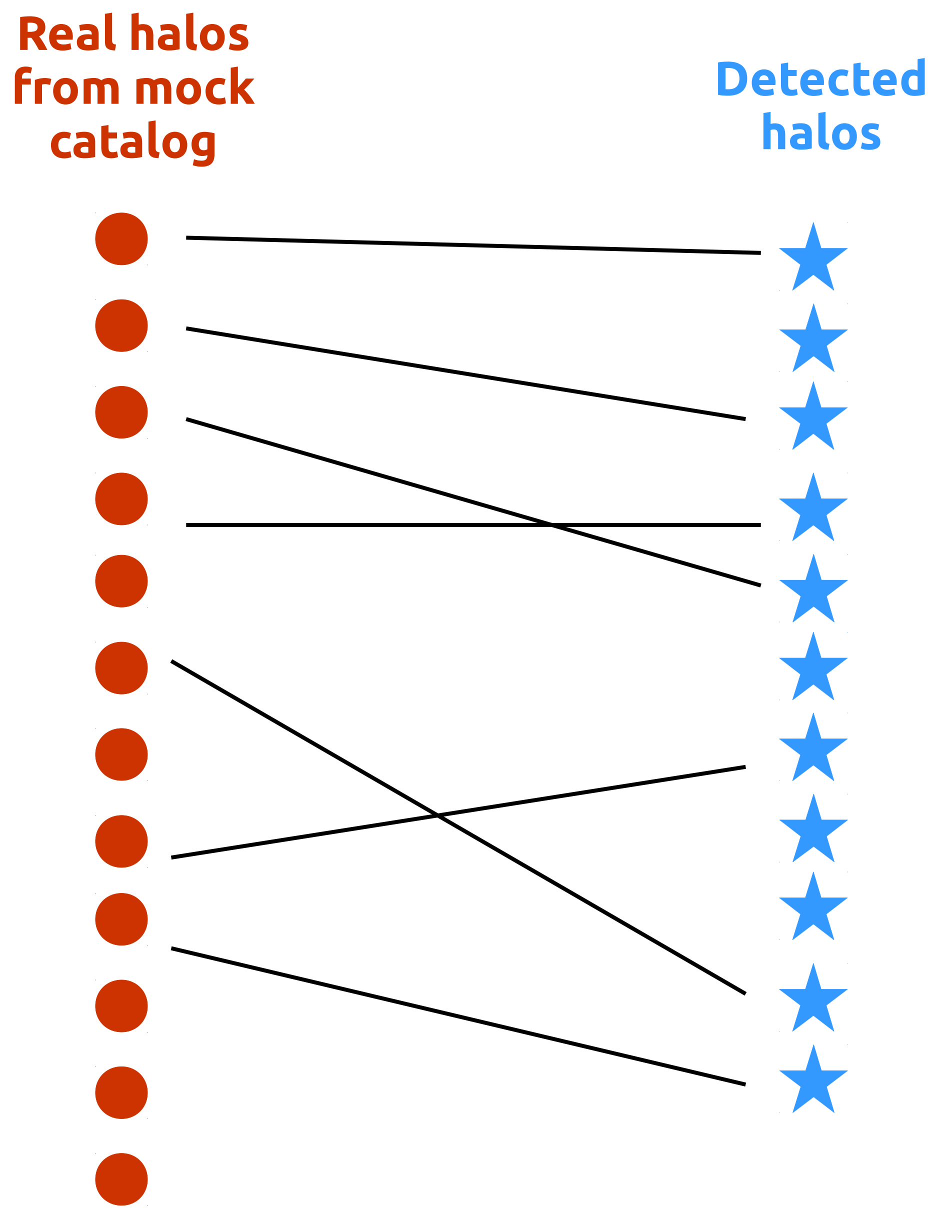
This procedure is not straightforward at all, and is the combination of the cluster finding procedure and of other procedures that make the comparison of algorithms not obvious.

E.g., for the selection function you must introduce a mass-observable relation, relying or not on the cluster members depending on whether a given algorithm provides you with membership.

Another possibility is to estimate for each algorithm the fraction of false detections and of missed detections. This means to compute PURITY and COMPLETENESS.

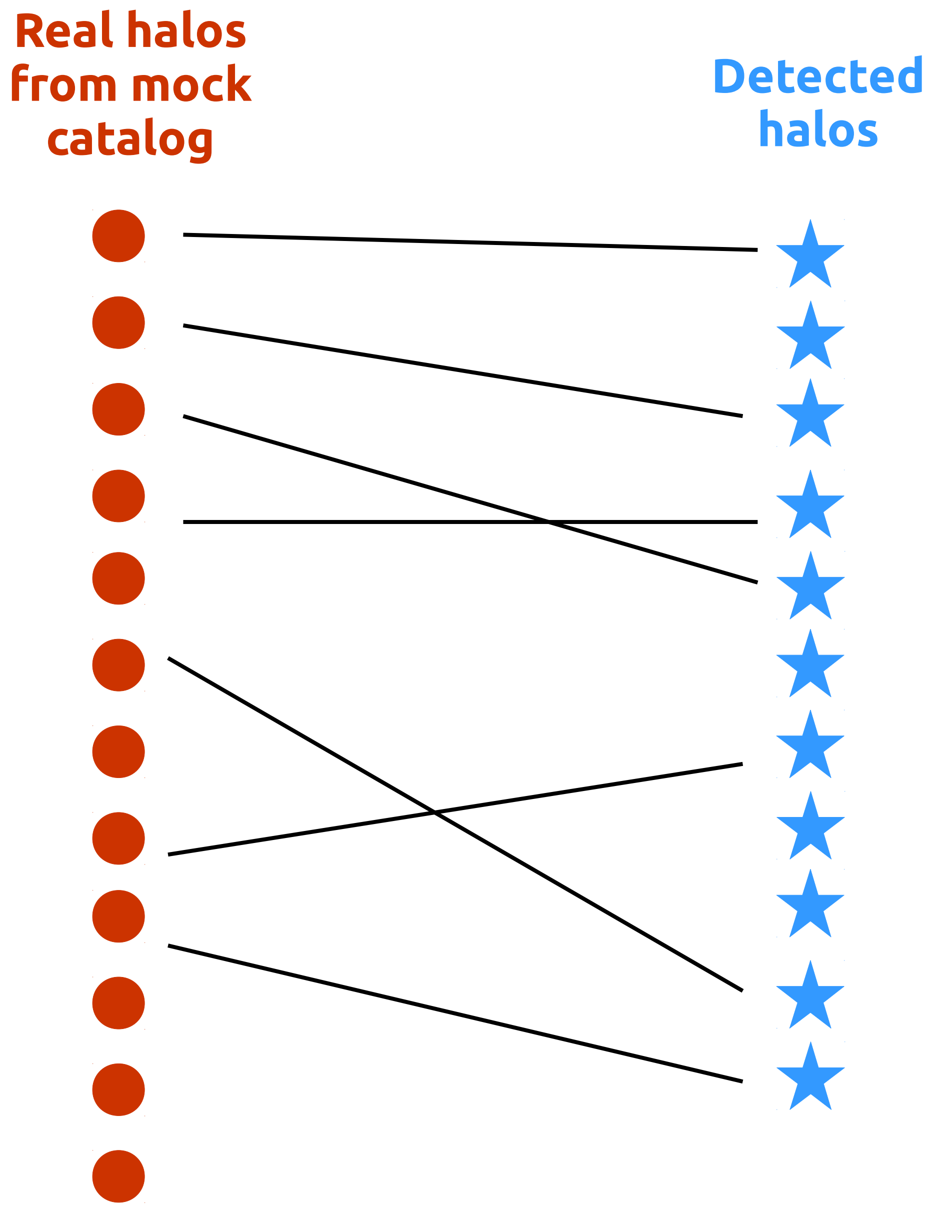
We have run the algorithms on mock catalogs providing information on position in the sky, redshift (photometric!) and magnitude for each galaxy.

Matching procedure: connects detected halos with actual halos



Completeness: what fraction of real halos have I detected?

Purity: what fraction of detected halos corresponds to actual halos?



12 halos

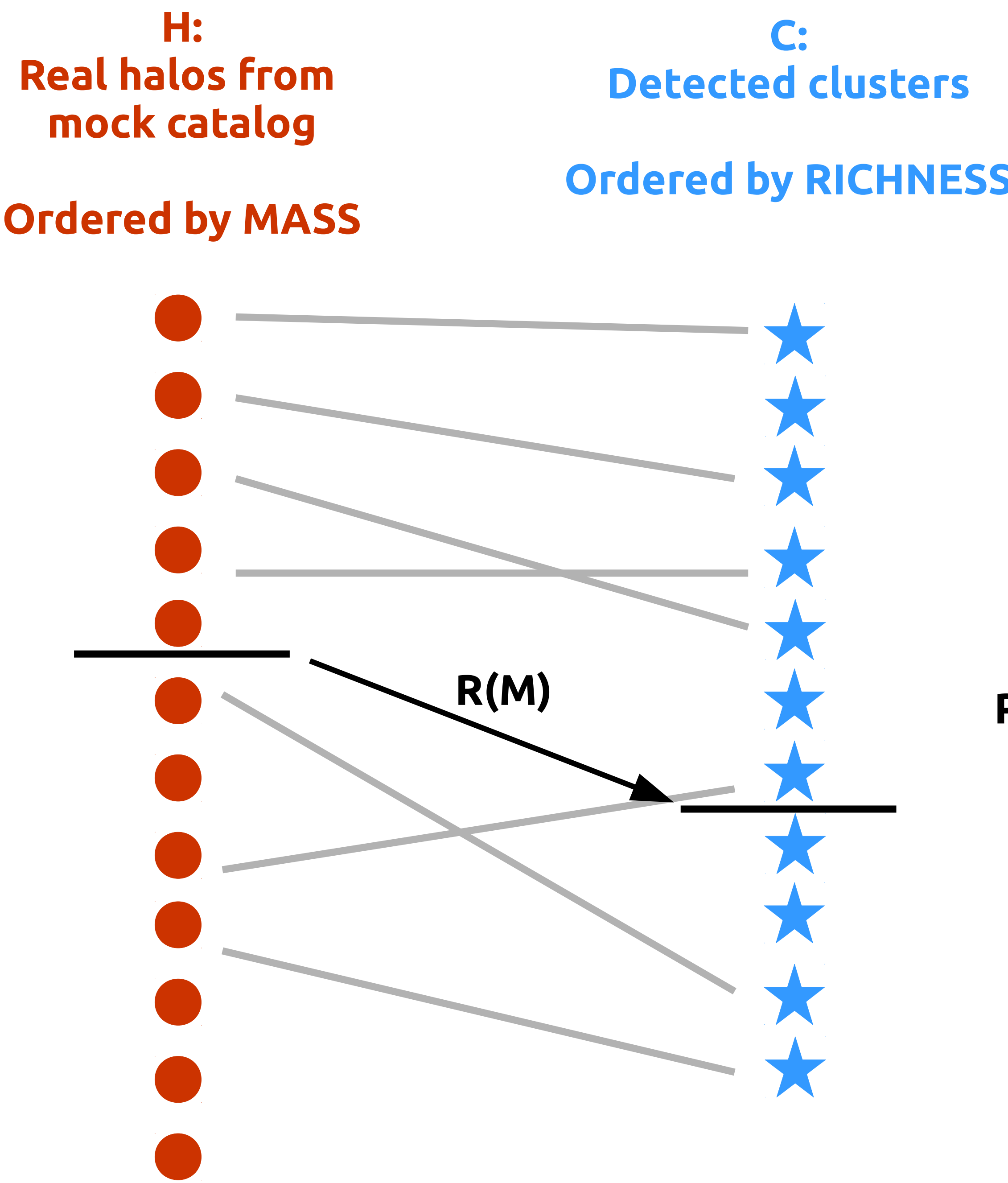
11 detections

7 matchings

$$C = 7/12$$

$$P = 7/11$$

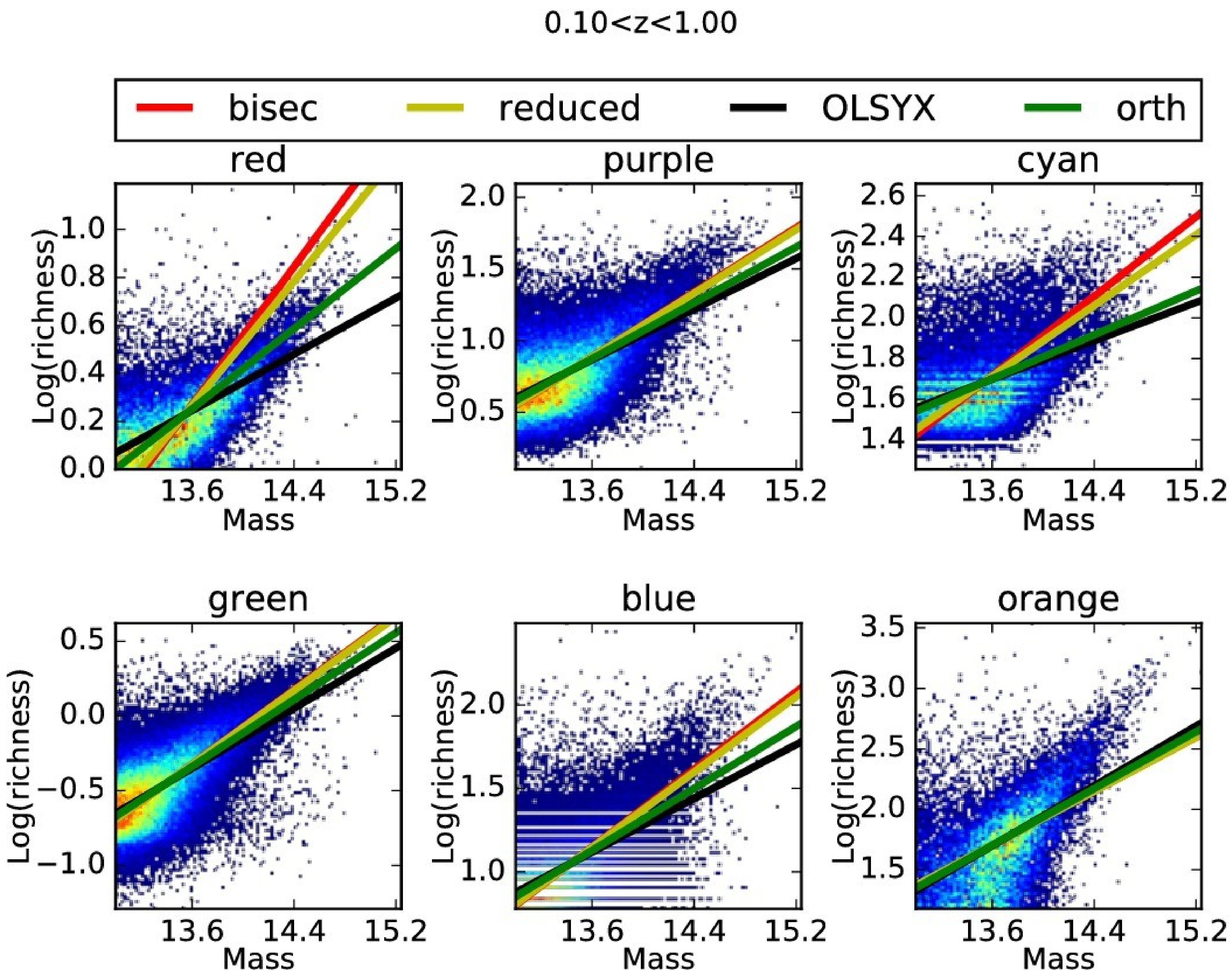
USING THE Mass-Richness RELATION

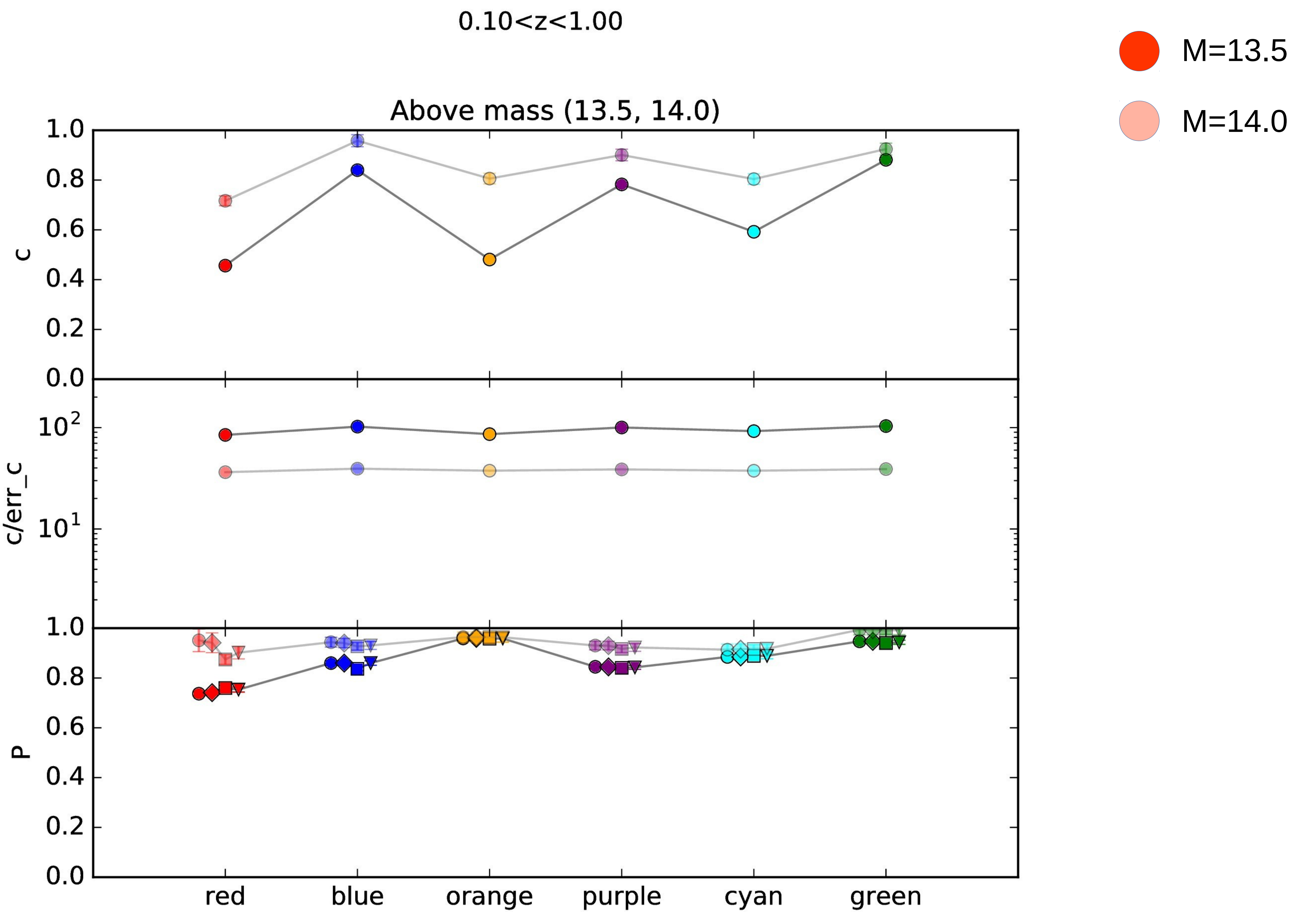


$$C = \frac{N_{match}[H\_MASS >= MASS\_TH]}{N[H\_MASS >= MASS\_TH]}$$

$$P = \frac{N_{match}[C\_RICH >= R(MASS\_TH)]}{N(C\_RICH >= R(MASS\_TH))}$$

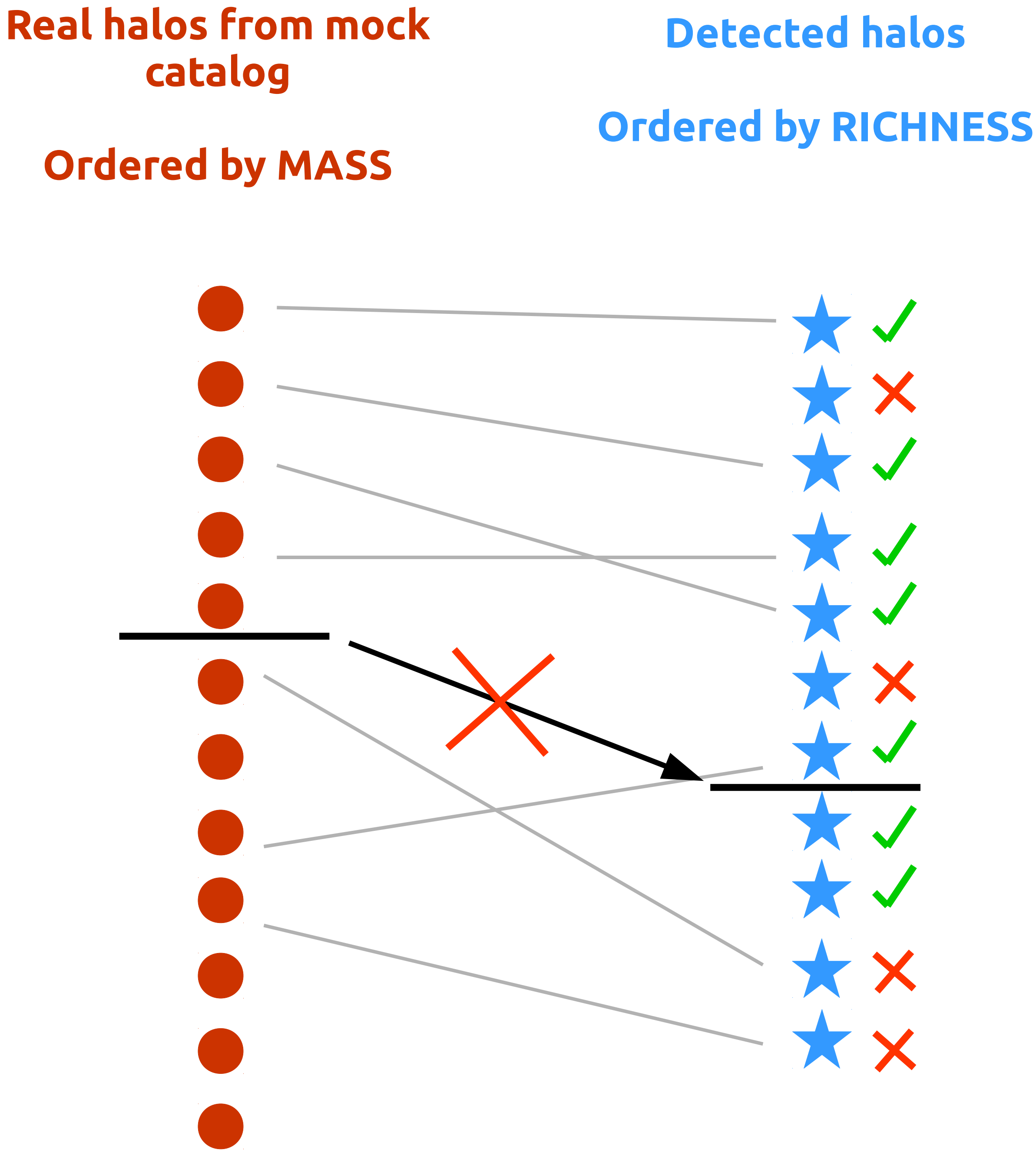
Mass-Richness relation

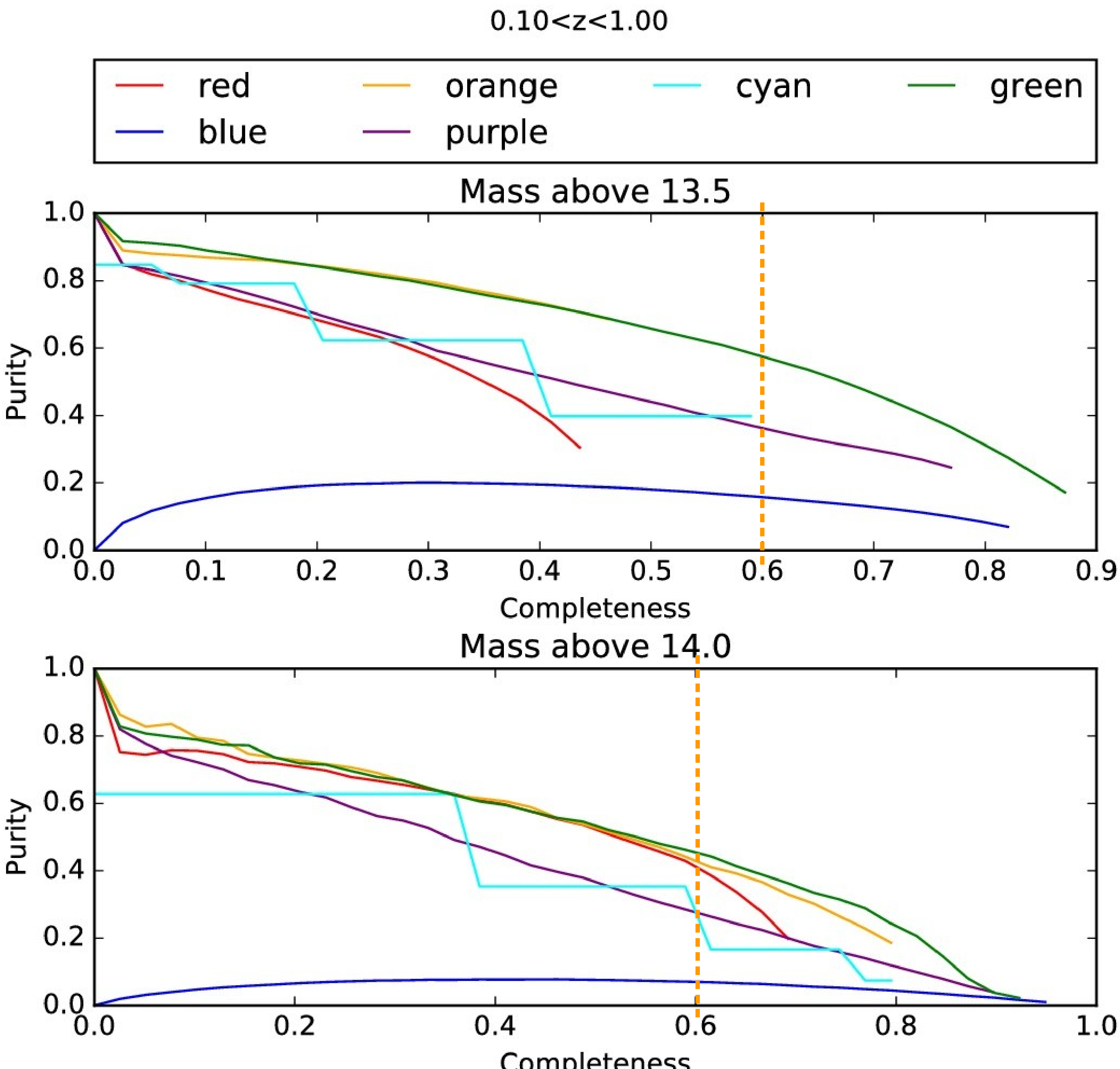




0.10<z<1.00
M=13.5
M=14.0
Above mass (13.5, 14.0)
c
c/err_c
P
1.0
0.8
0.6
0.4
0.2
0.0
10^2
10^1
red
blue
orange
purple
cyan
green

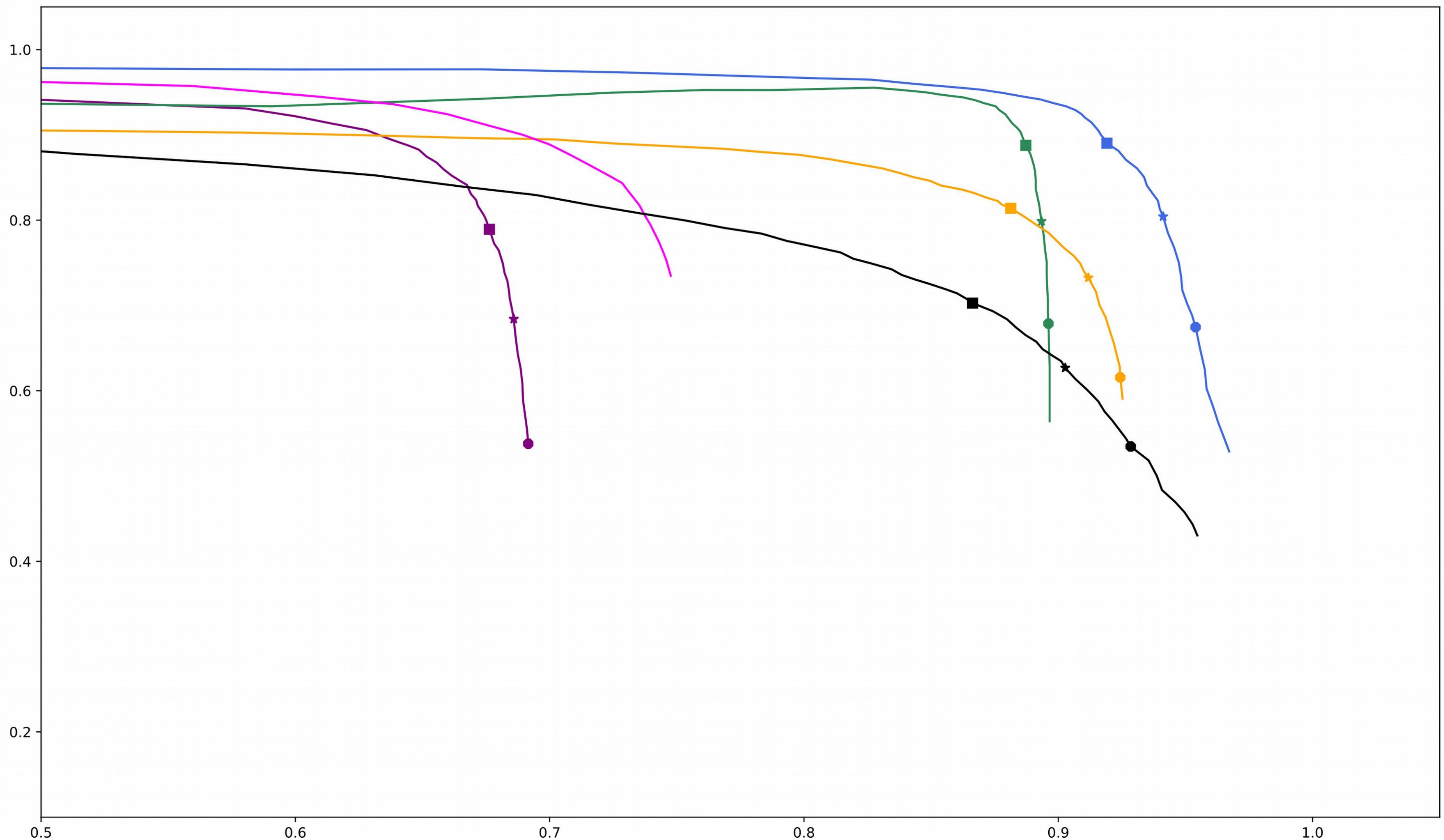
USING THE SNR INFORMATION




0.10<z<1.00
red
orange
cyan
green
blue
purple
Mass above 13.5
Purity
Completeness
1.0
0.8
0.6
0.4
0.2
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
Mass above 14.0
Purity
Completeness
1.0
0.8
0.6
0.4
0.2
0.0

Purity (all λ) vs completeness ($\log M_H \geqslant 14$), mock1, varying rank according to authors,
Markers at: 50000, 86000, 150000

z=[0.10,2.00], N_h: 241404



AMICO (Adaptive Matched Identifier of Clustered Objects)
by Bellagamba F., Roncarelli M., Maturi M., Moscardini L., arXiv:1705.03029

AMICO searches clusters by applying the Optimal Filtering technique, that is a general method to enhance the signal-to-noise ratio (SNR) of an expected signal (cluster) in a noisy data-set.

The algorithm assumes that in each point of the sky the galaxy distribution can be described as the sum of a noise (background) component and a cluster component described by the model, with an unknown amplitude. A 3D map is constructed that contains in each position an estimate of the amplitude of the cluster component, if a cluster happens to be centred in that position.

CHOICE OF A SECOND ALGORITHM

The general idea was to select at least two codes which would achieve complementary catalogs of detections. This would enable to compare selection effects, and to recover a larger diversity of cluster population than what found when using only one algorithm.
We therefore tested the gain in performances (in terms of C and P) obtained in a given interval of mass or redshift when adding one of the other cluster finders to AMICO.

PZWAV

by Gonzalez, A.

Pzwav creates galaxy density maps in photometric redshift slices and applies a wavelet smoothing kernel, and detects cluster-sized overdensities at a chosen significance level, making minimal assumptions about cluster properties.