Tracing the Quenching History in Galaxy Clusters in the EAGLE Simulation

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Introduction: Quenching and pre-processing

- Several authors have studied the enviromental effects on quenching of galaxies.
- These studies suggest that the quenching of star formation is enhanced by dense enviroments. (Jaffé et al. 2016)
- On the other hand, enviromental effects when a galaxy infall into a cluster could represent a preprocessing stage on galaxy evolution (Cortese et al. 2006)
- Galaxy groups may represent a natural laboratory for a preprocessing stage, and then a perfect laboratory to test why quenching occurs(Fujita 2004)

Objectives for this project

- Characterize the properties of pre-processed galaxies
- Link the quenching history of galaxies with the assembly history of clusters
- Use different criteria in order to classify where and when the quenching occurs

The Eagle Simulations

EVOLUTION AND ASSEMBLY OF GALAXIES AND THEIR ENVIRONMENTS

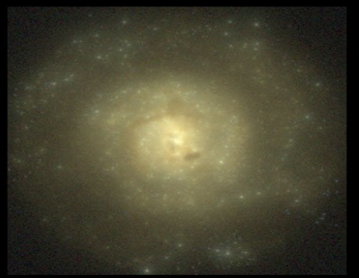
The Hubble Sequence realised in cosmological simulations










Data: The Hydrodinamical Simulation EAGLE

- In order to develop this project we used the catalogues obtained by the EAGLE cosmological Hydrodynamical Simulation Suite(Shaye et al. 2015)
- EAGLE counts with a great variety of simulations in order to cover different scientific goals.
- We use the simulation REF-L100N1504

The Hydrodinamical Simulation EAGLE: SIM RefL100N1504

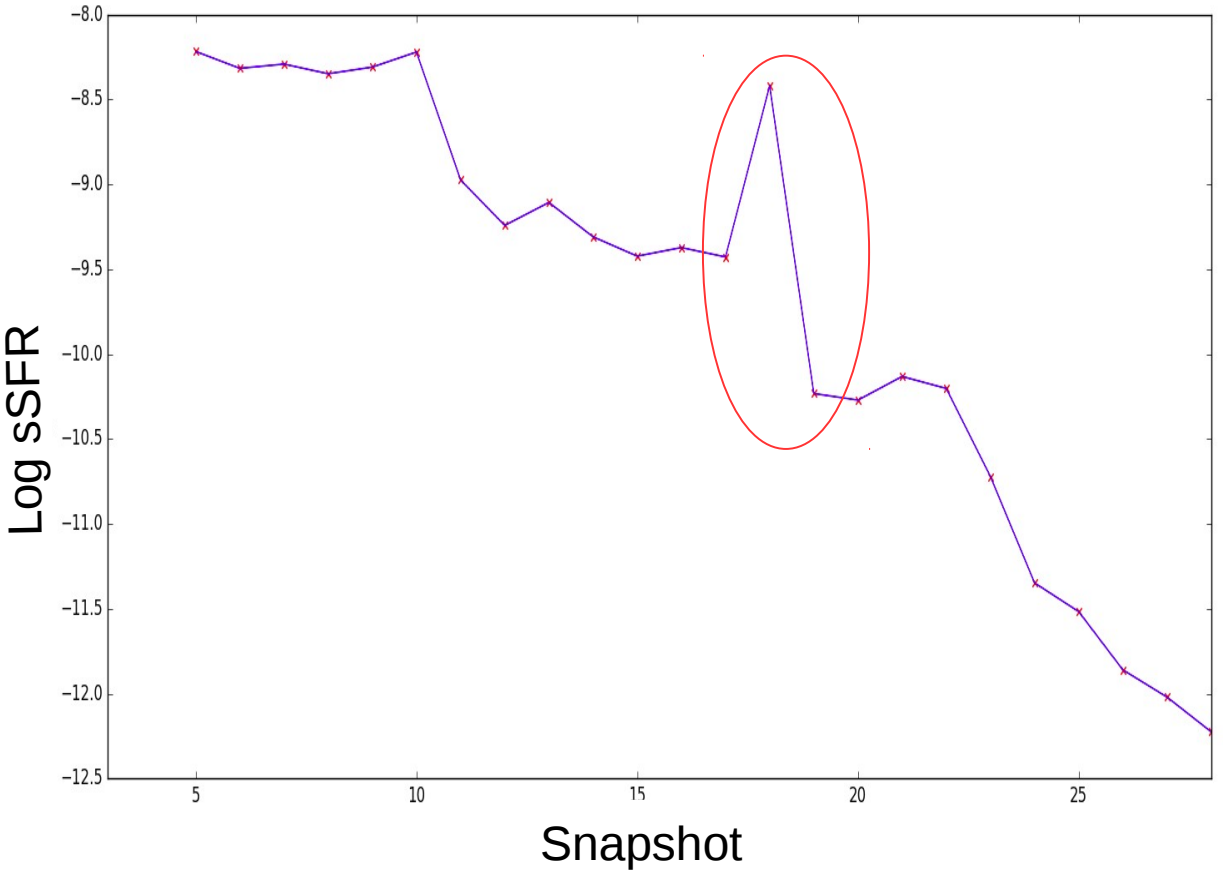
- This simulation take in count several physical parameters as: radiative cooling, star formation, stellar mass, energy feedback from star formation, gas accretion onto and mergers of SMBH, and AGN feedback.
- Posses a size of 100cMPc, mass resolution of $1{,}81 \times 10^6$ (Solar Masses).
- Due to its great convergence on the relation between SFR and Stellar mass (Furlong et al. 2015) and its high mass resolution, EAGLE simulations was our best option to develop this study.

Analysis

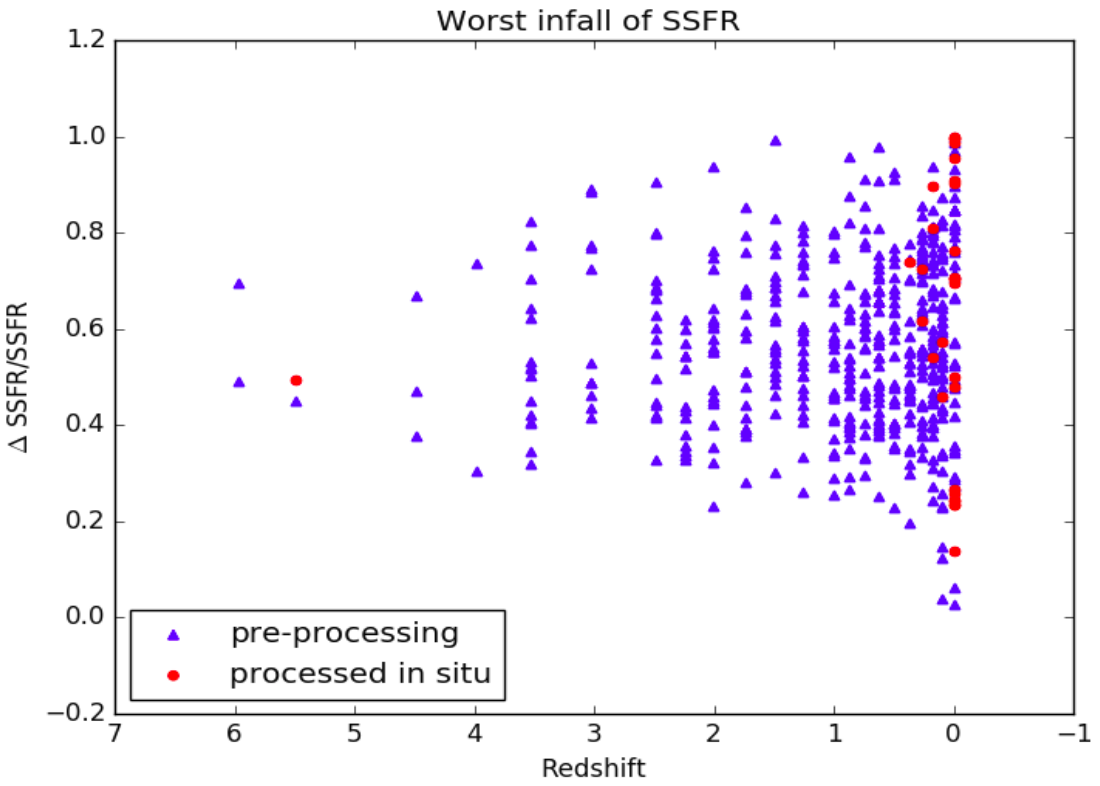
- Using the catalogues of EAGLE we choose the 10 most massive cluster on the Simulation.
- We define two criterias to define quenching: one as the strongest drop on its sSFR, and another according to Wetzel et al. 2013 (sSFR < 10^{-11} Solar Masses/year).
- In order to find an observational bound, we use a color-color diagram described by Nantais et al. 2016

Strongest drop on its sSFR

- We define quenching as the most abrupt change on its sSFR.
- Is considered pre-processing if this moment happened on a different Dark Matter Halo.

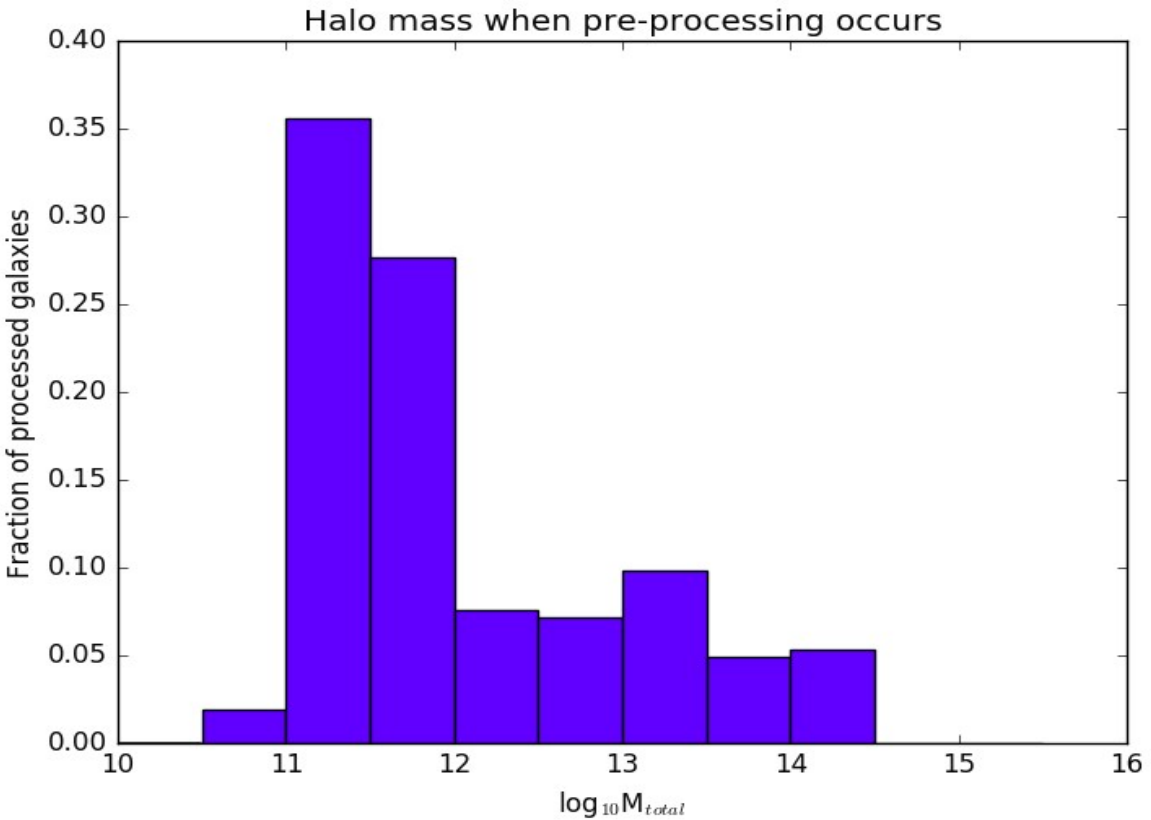


Strongest drop on its sSFR



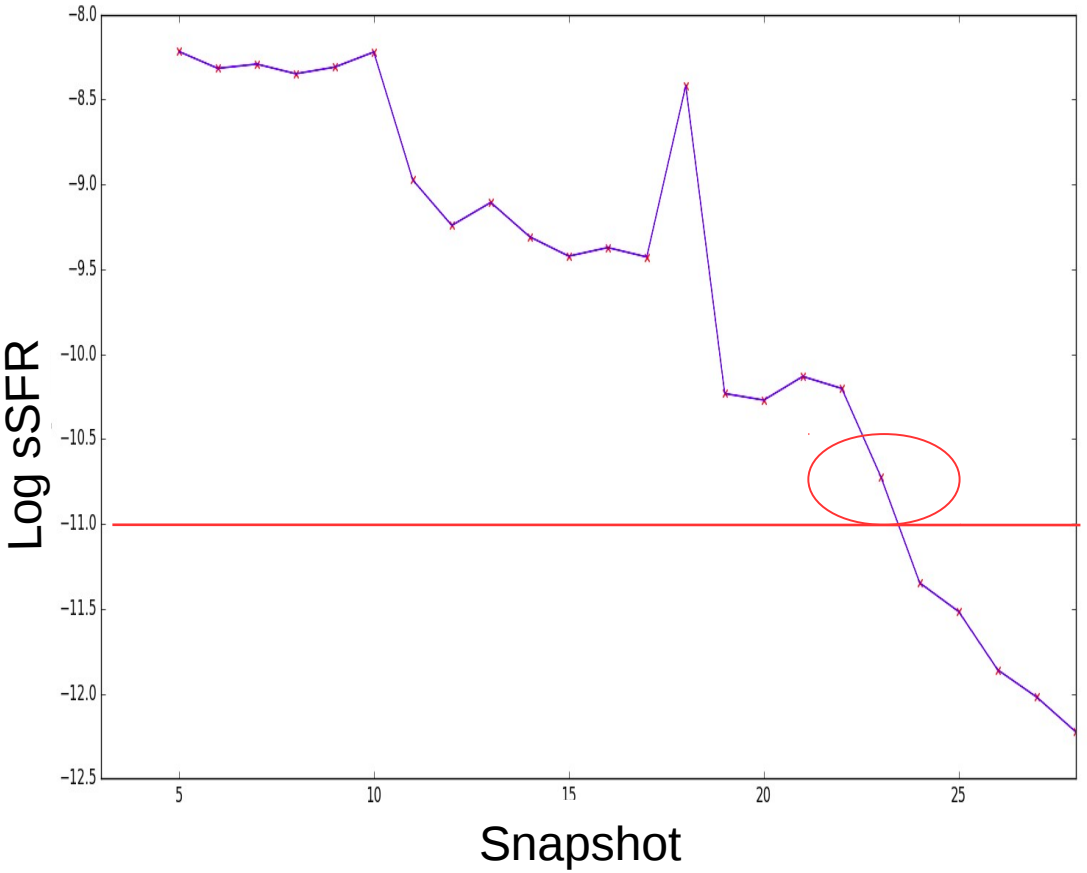
- There is no preference on redshift for pre-processing.
- Clear redshift preferences for galaxies processed in situ.
- What was the mass of the DM Halo when processing occurs?

Dark Matter Halo of the galaxies



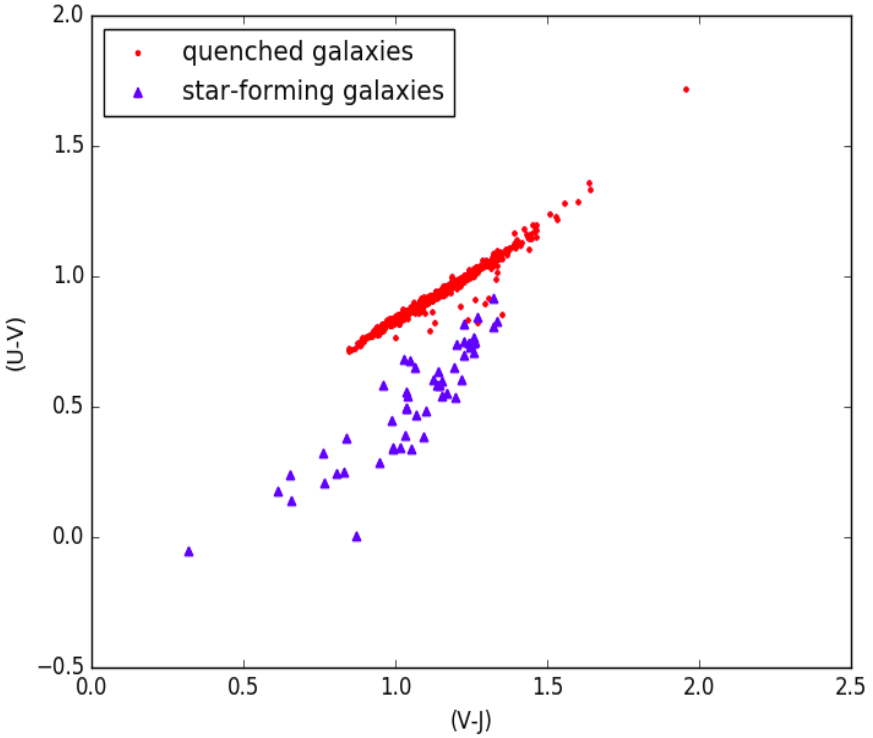
- On average almost 80% of galaxies present its processing on a different Halo
- From this galaxies, almost 70% present its processing on DM Halos between 10^{11} – 10^{12} solar Masses.

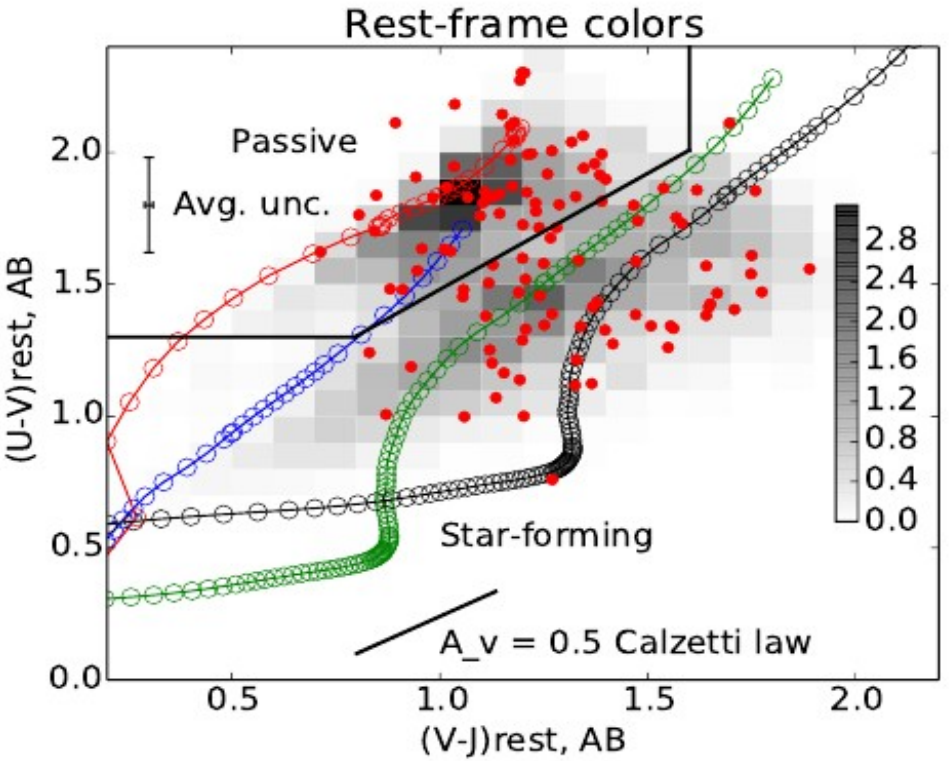
Wetzel criteria



- We will separate the galaxies between active and passive using the criteria shown on Wetzel et al. 2013
- Now, we can compare our results obtained spliting the sample using this criteria, with the obtained by Nantais et al. 2016.

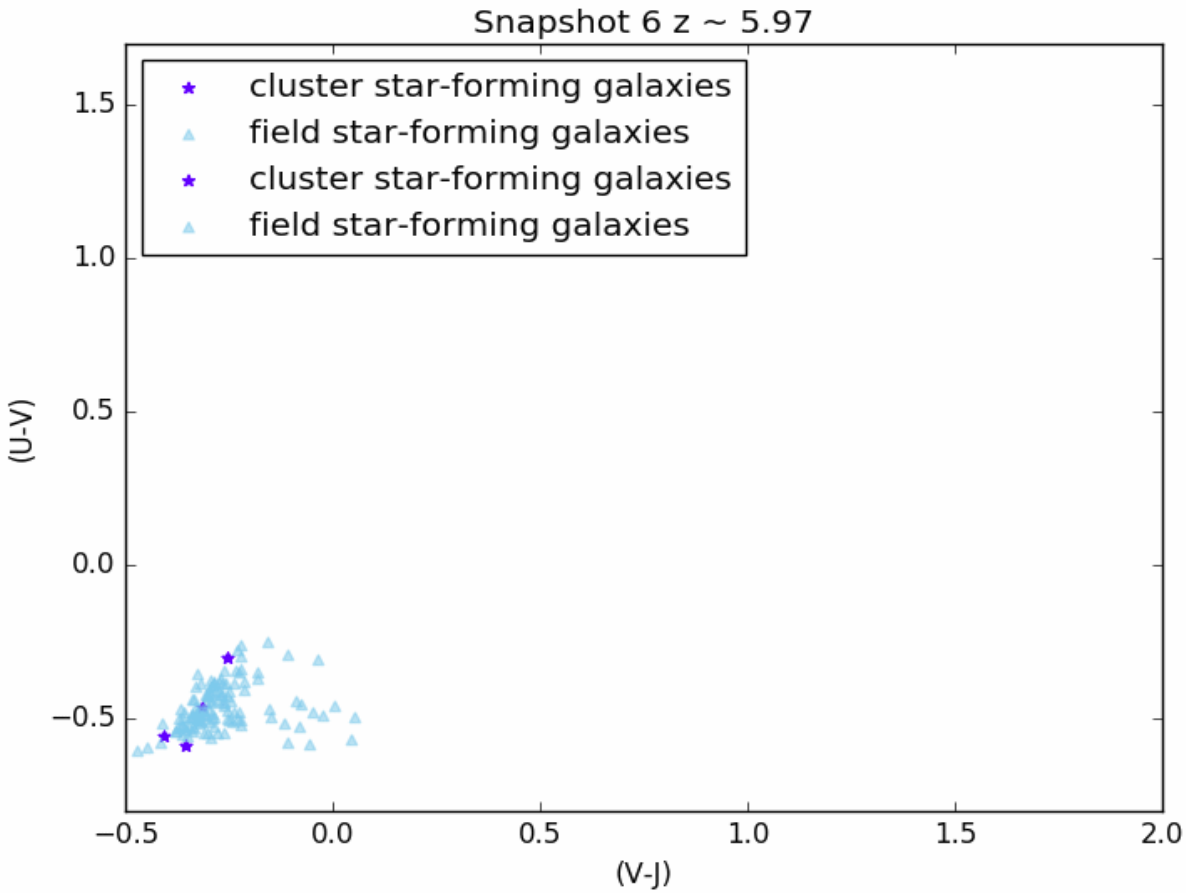
Color-Color Diagram





Color-Color Diagram

- Clearly we can see two populations and how evolves the quenched sequence.
- We found this sequence in all the massive clusters studied.



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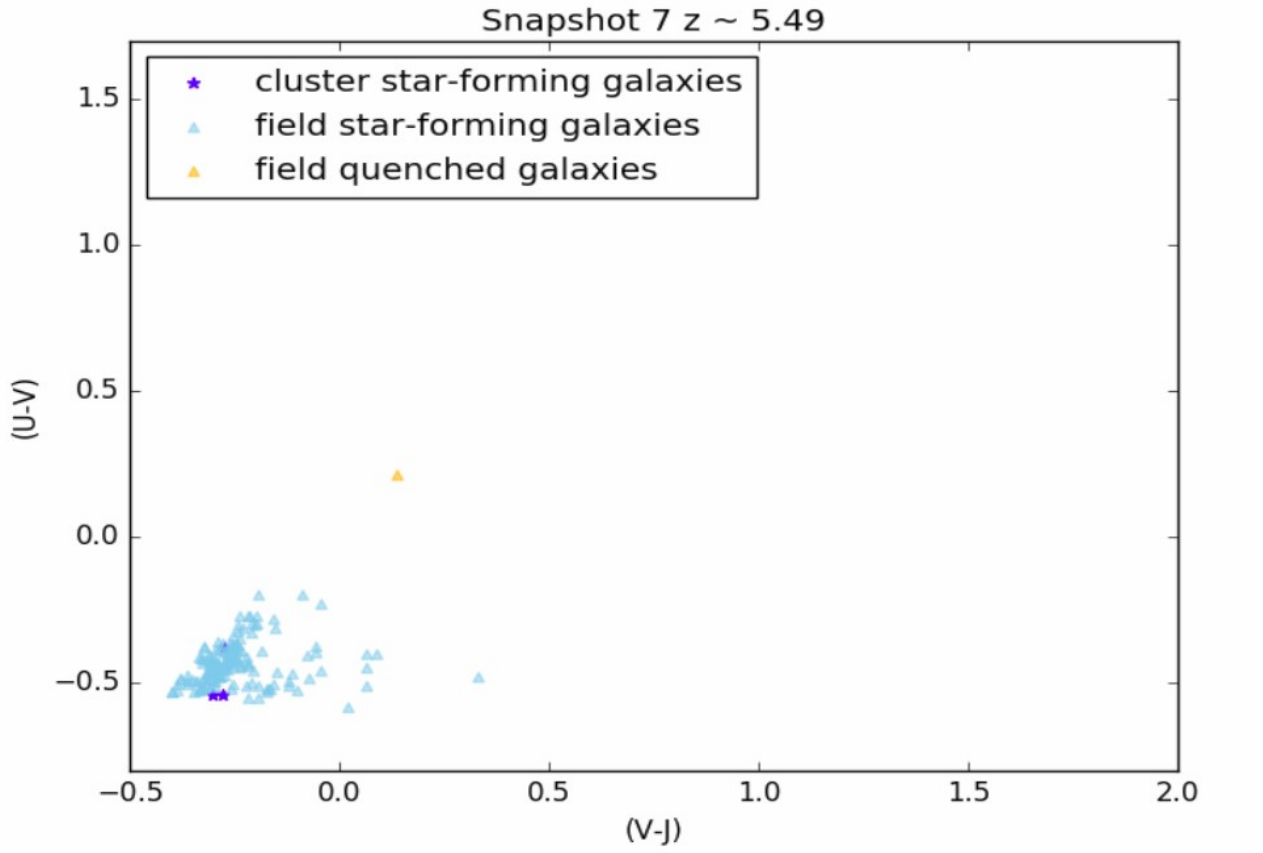

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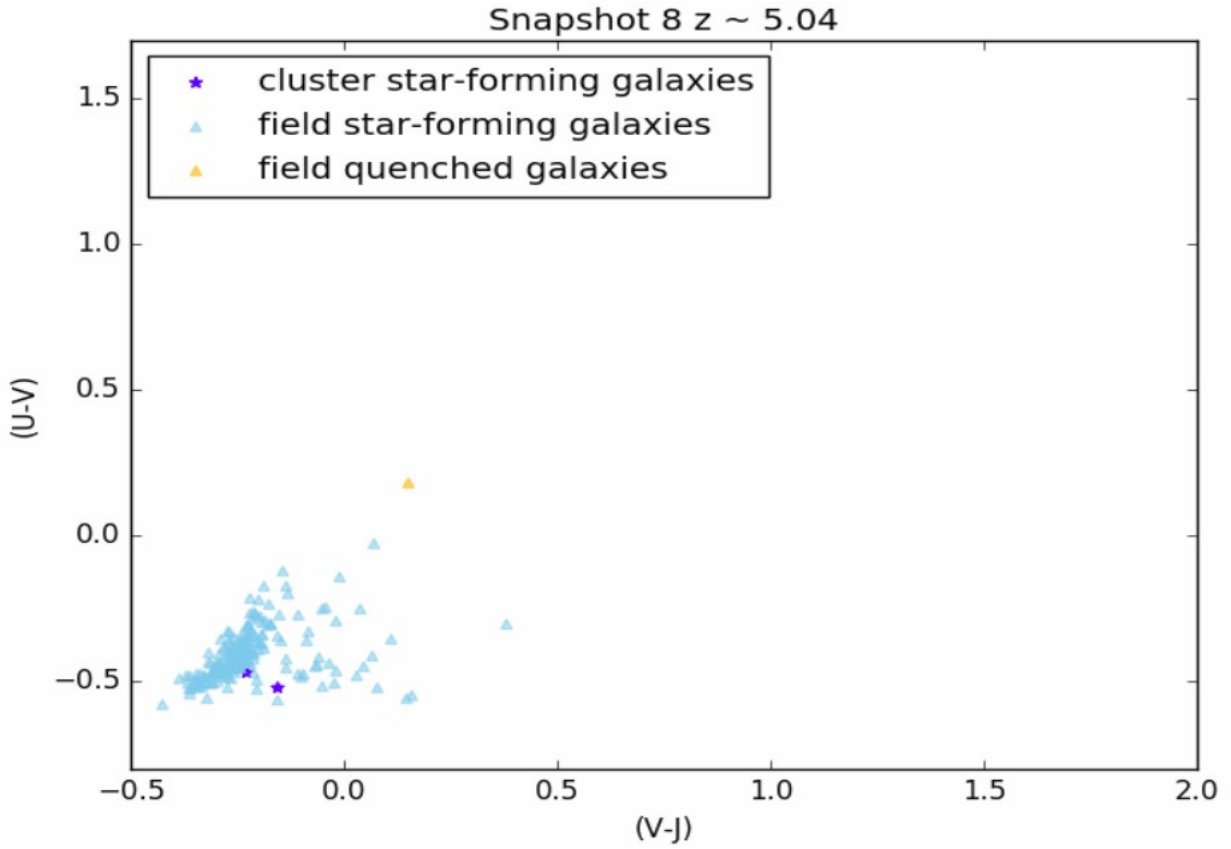

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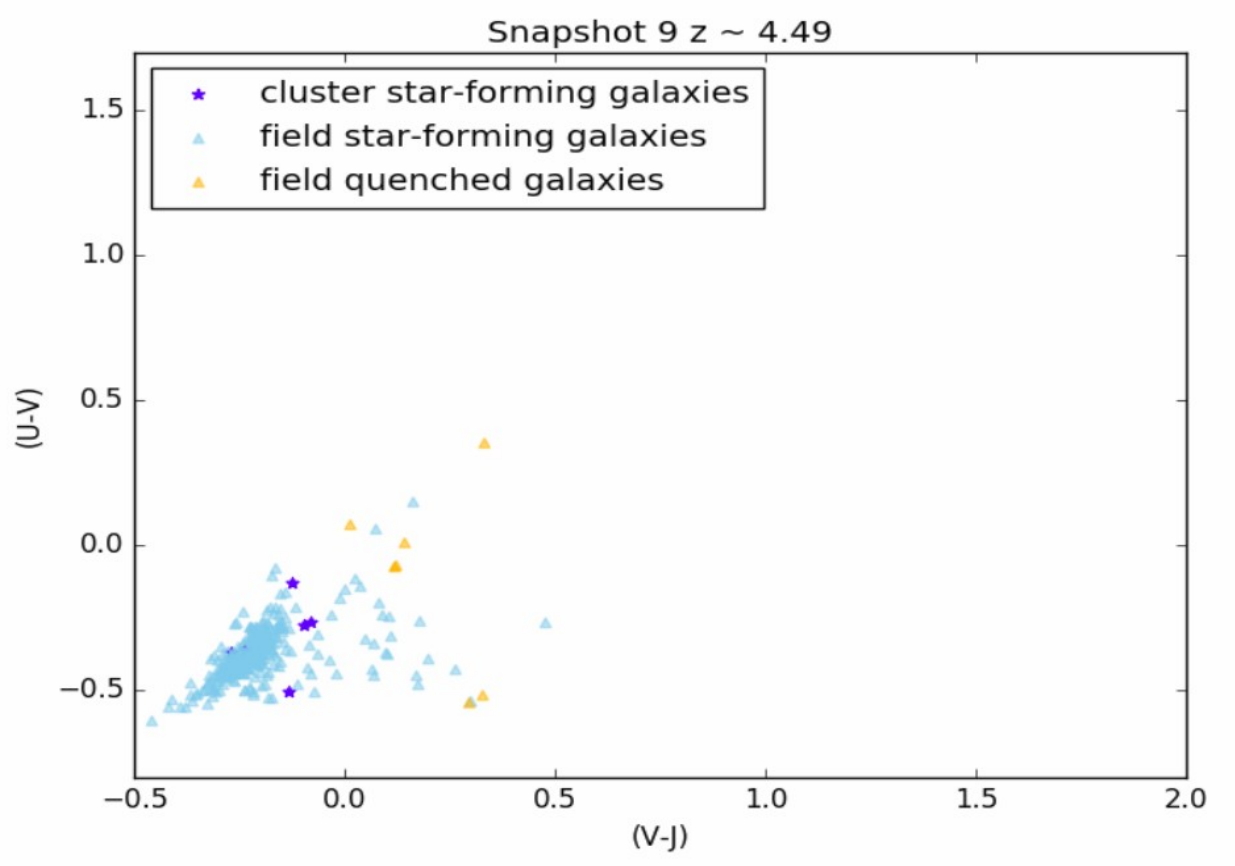

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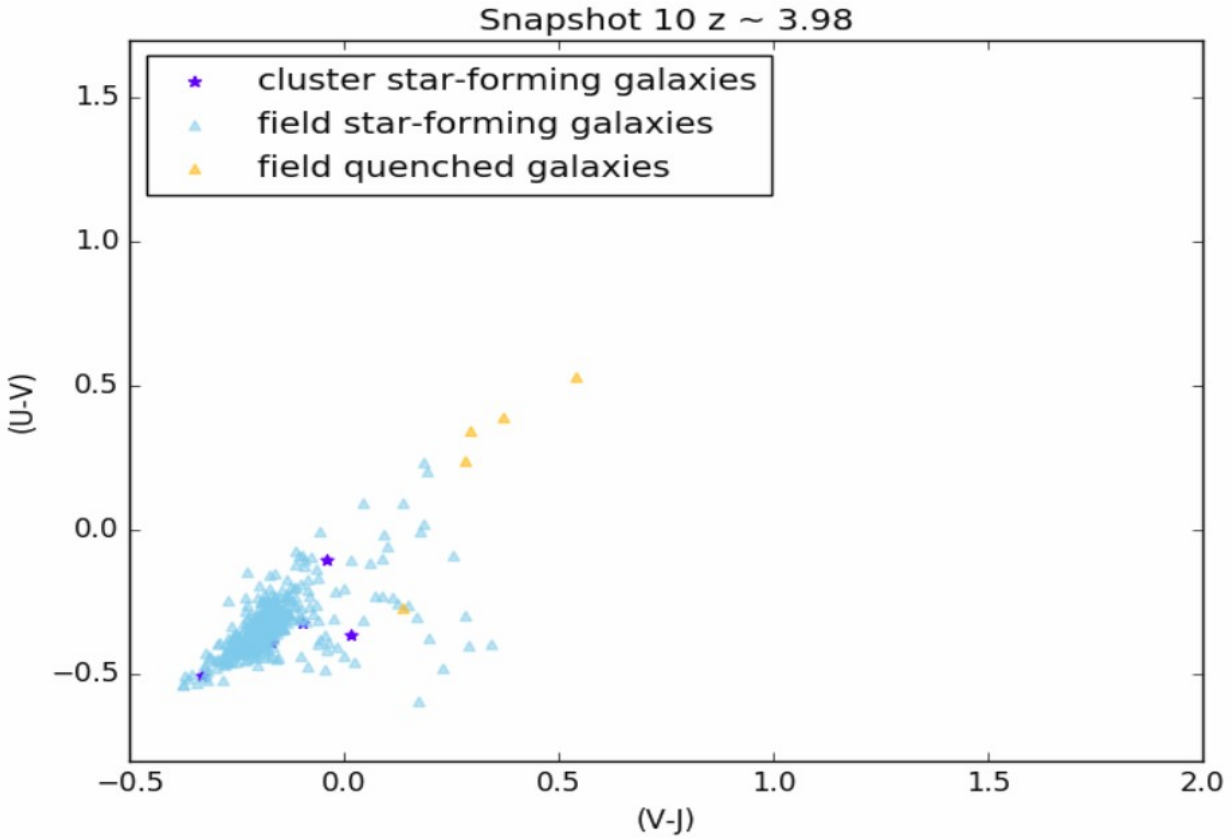

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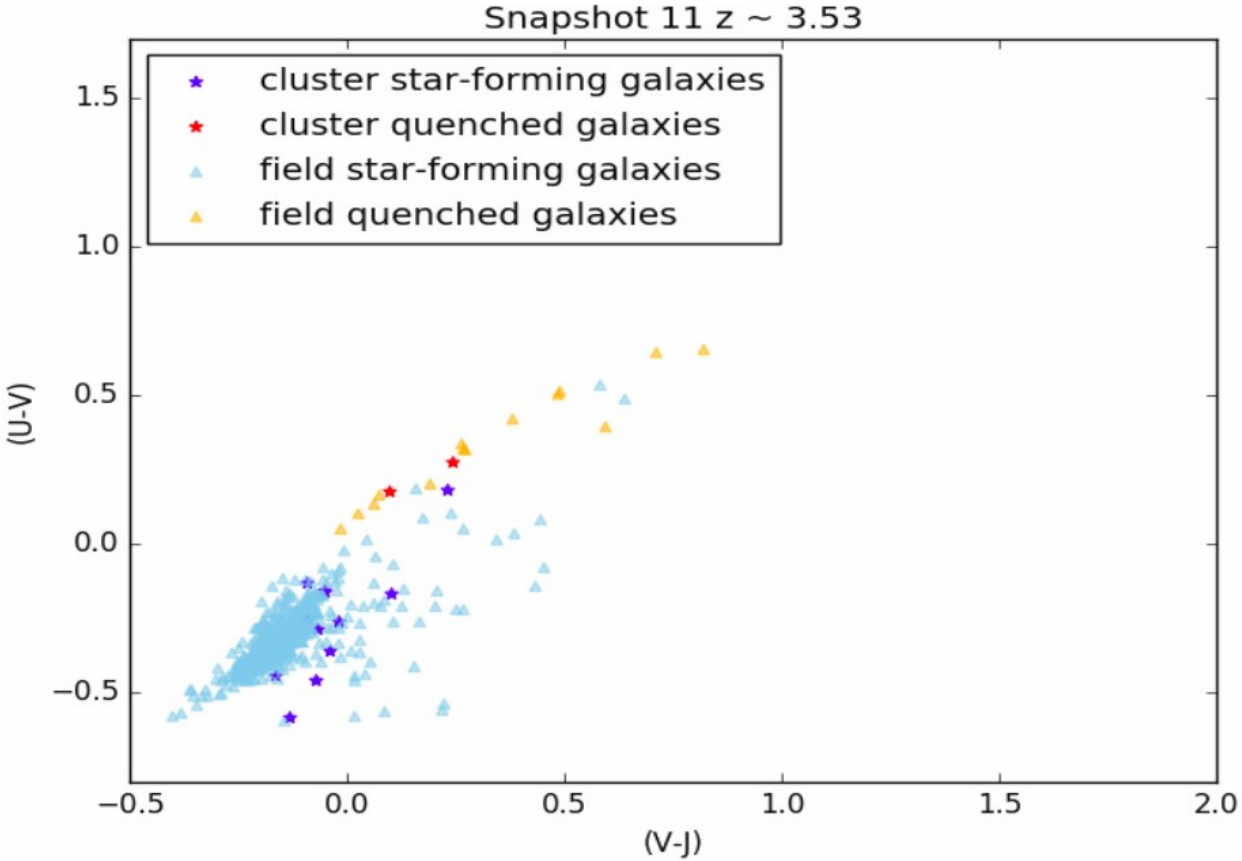

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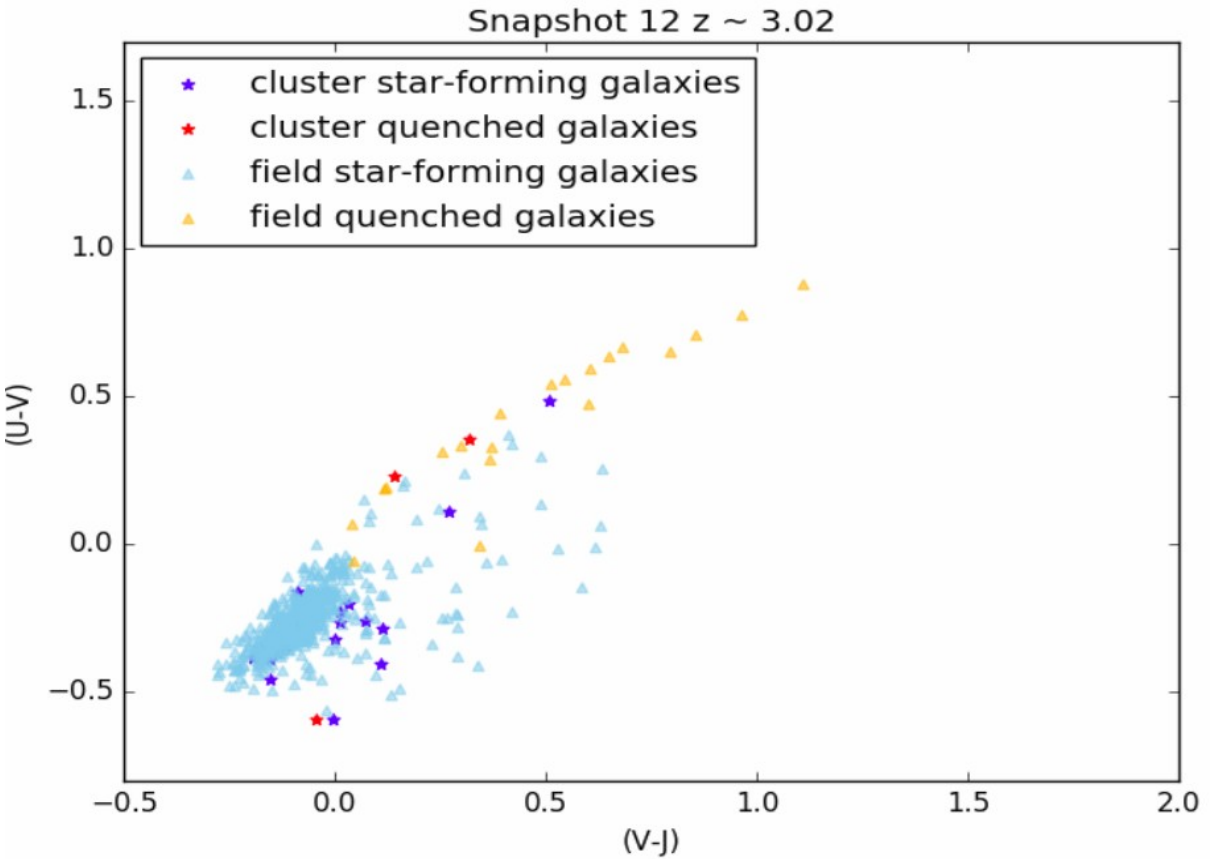

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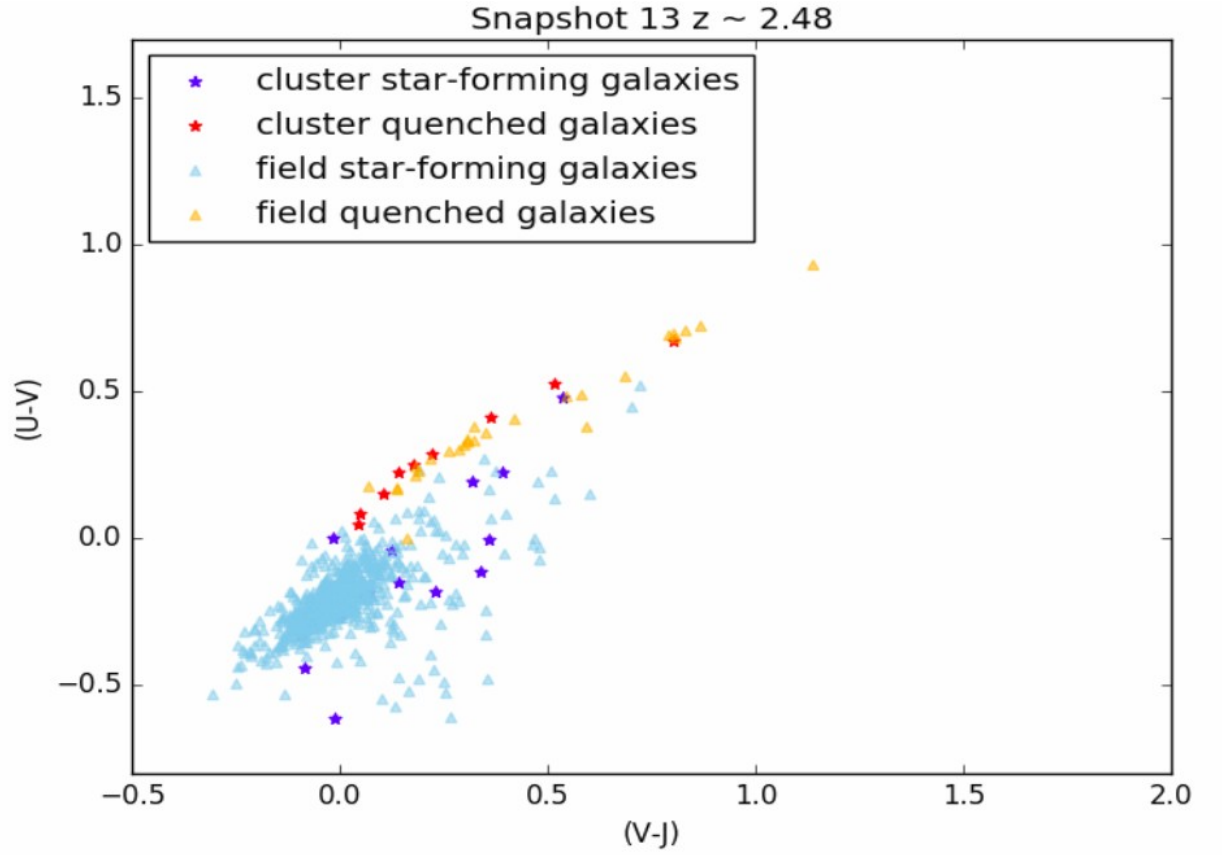

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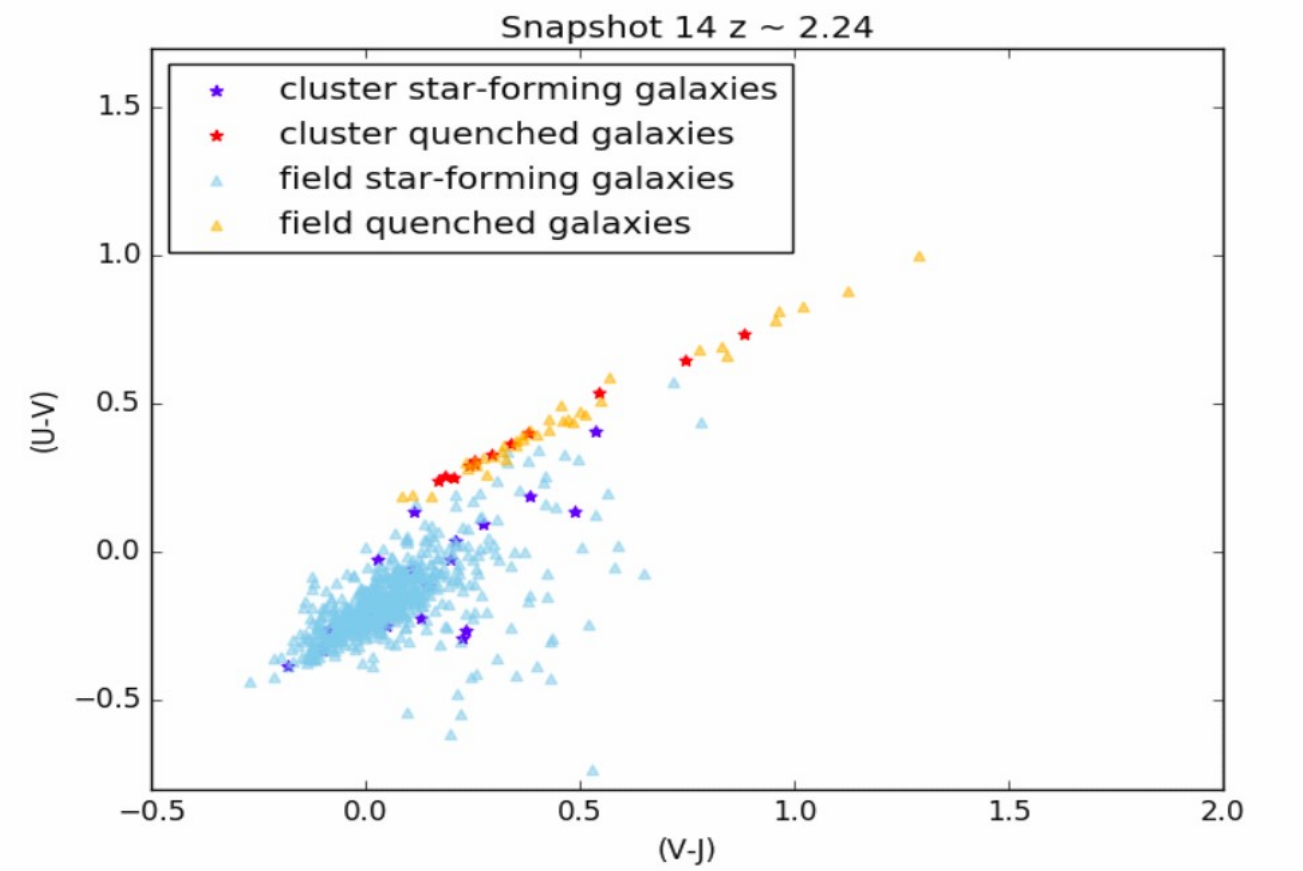

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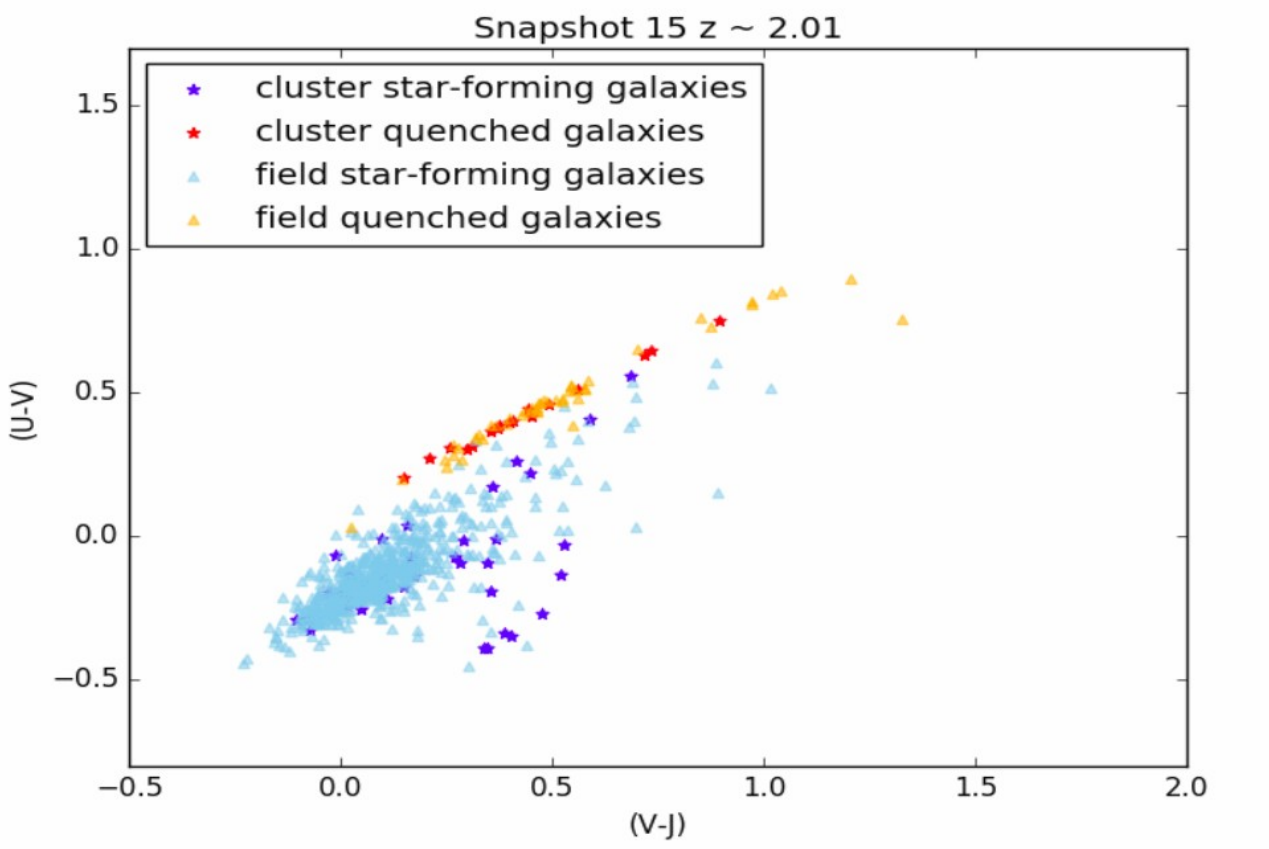

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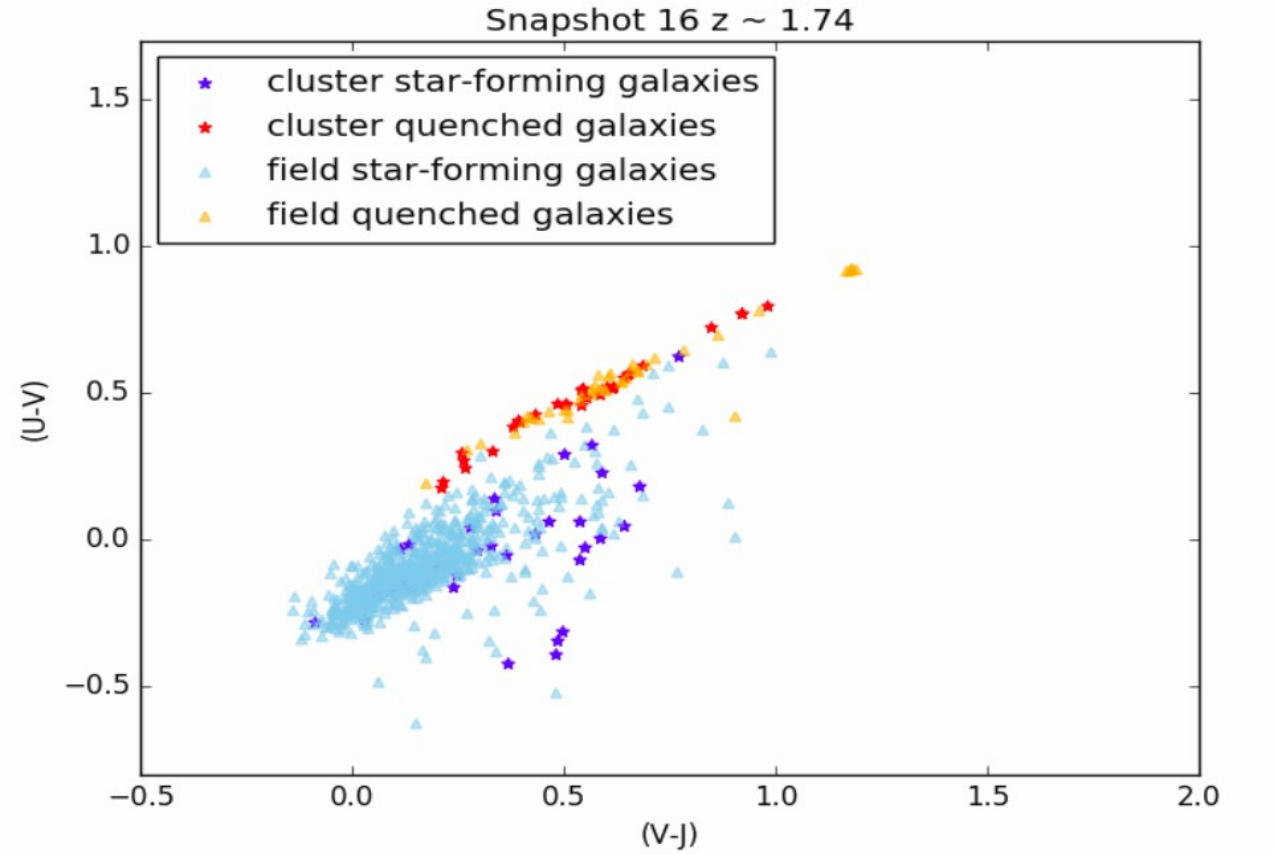

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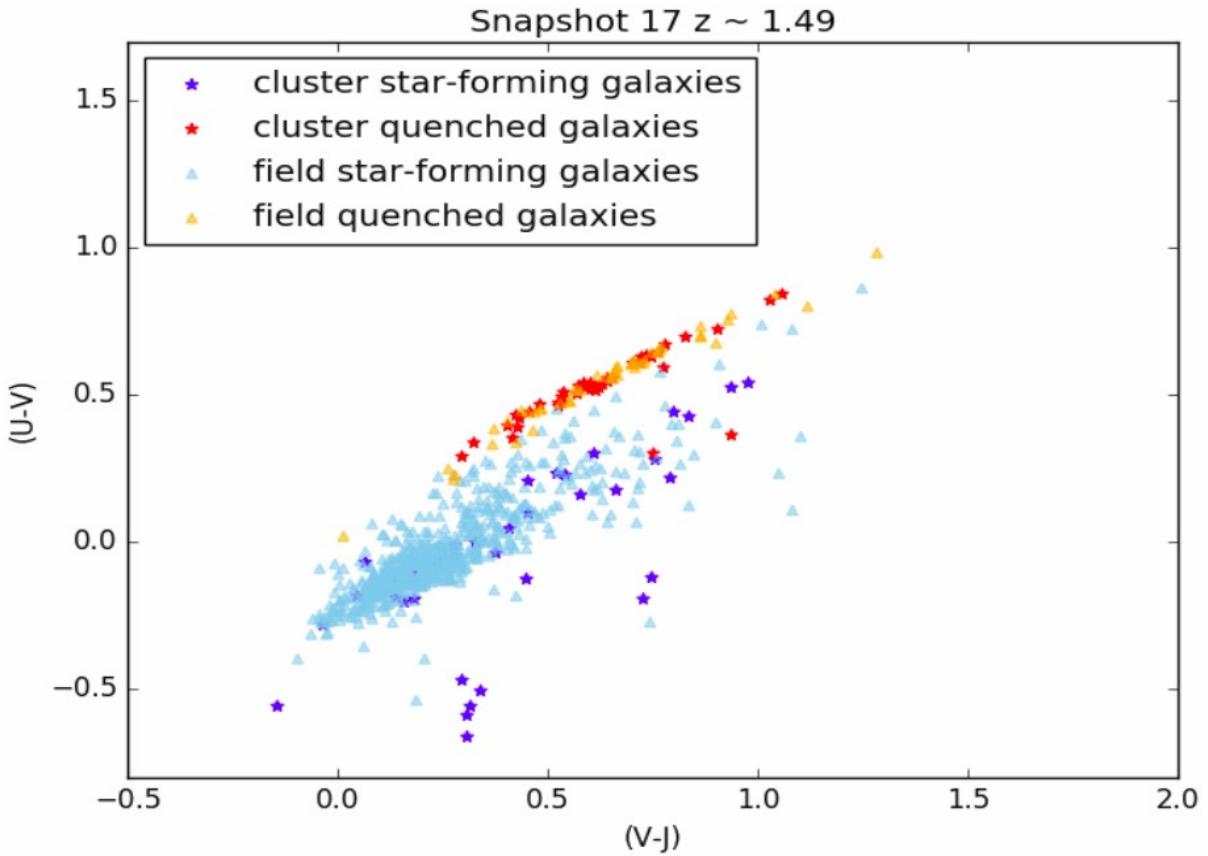

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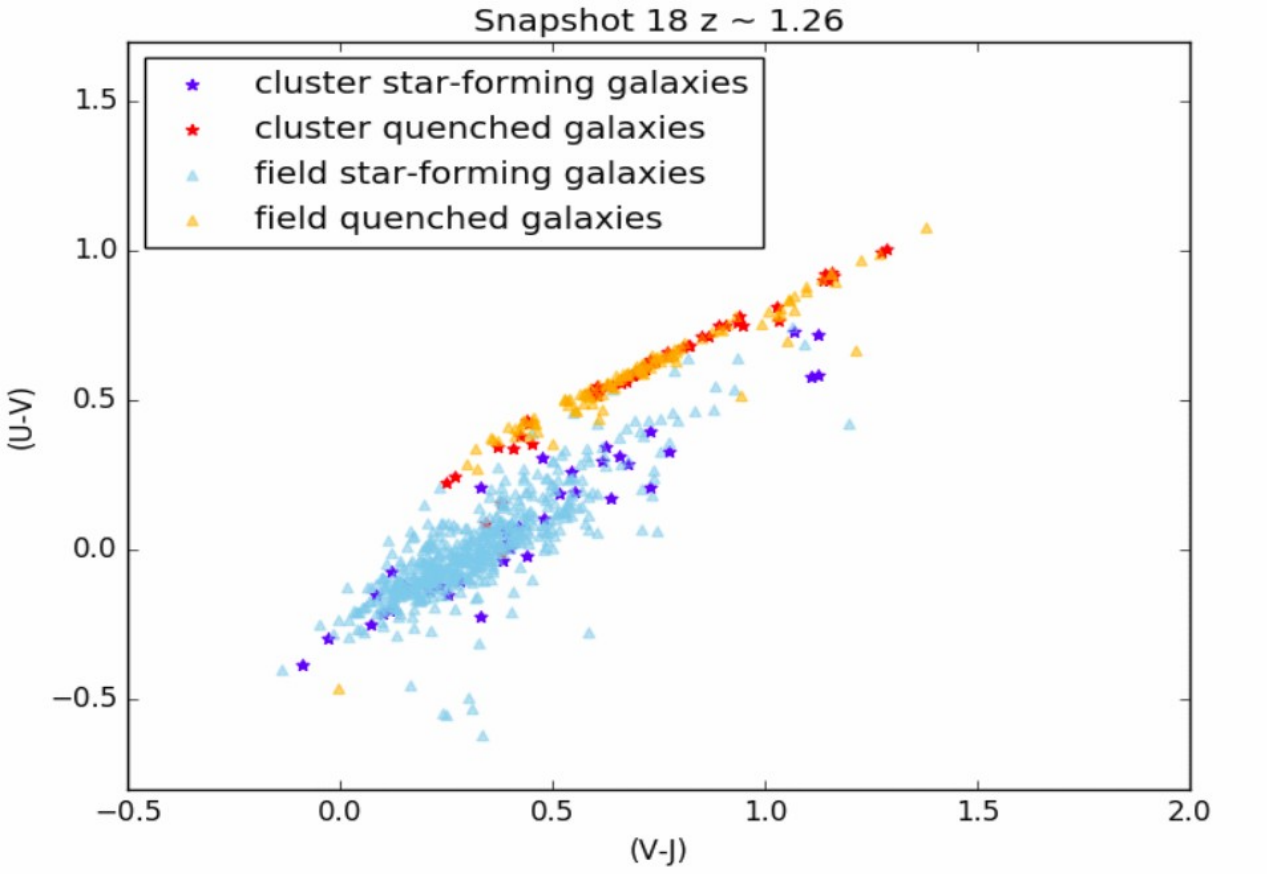

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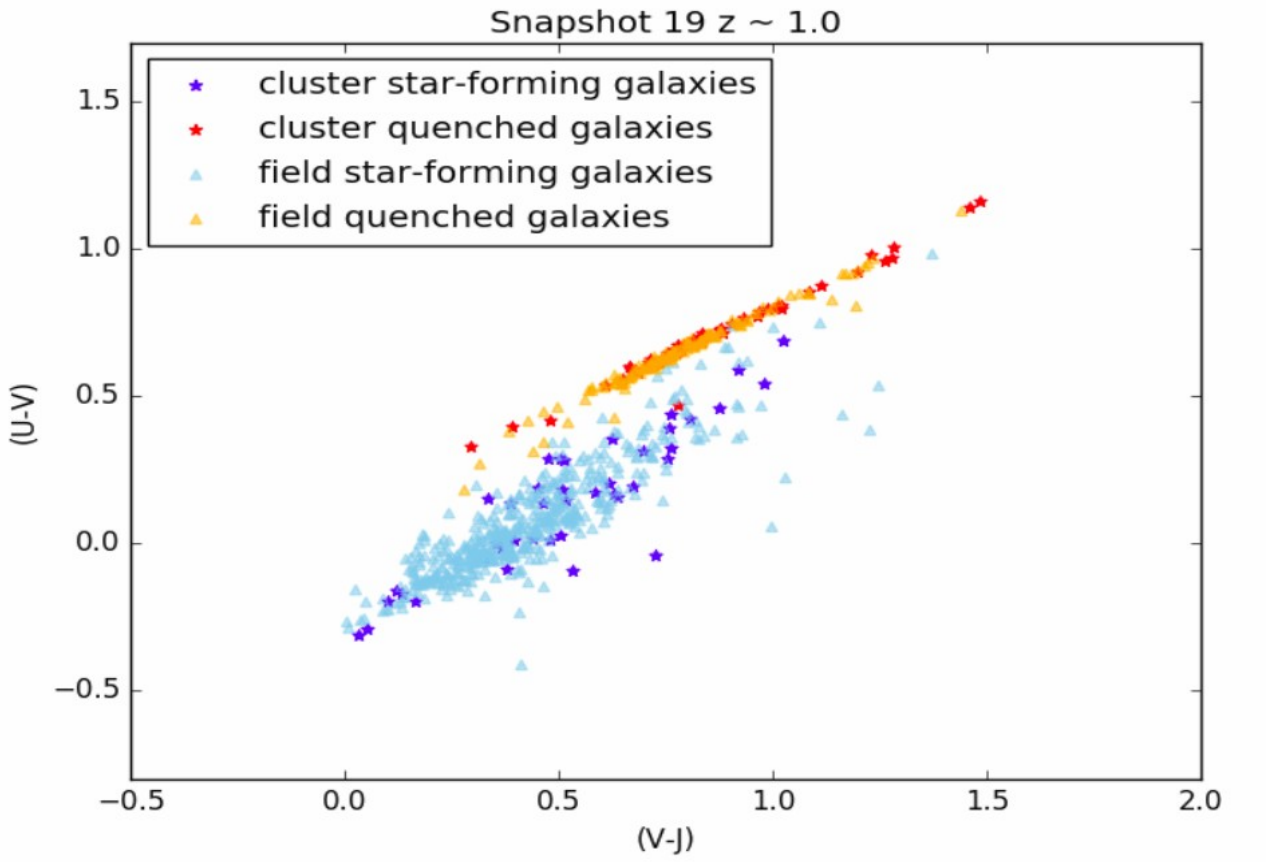

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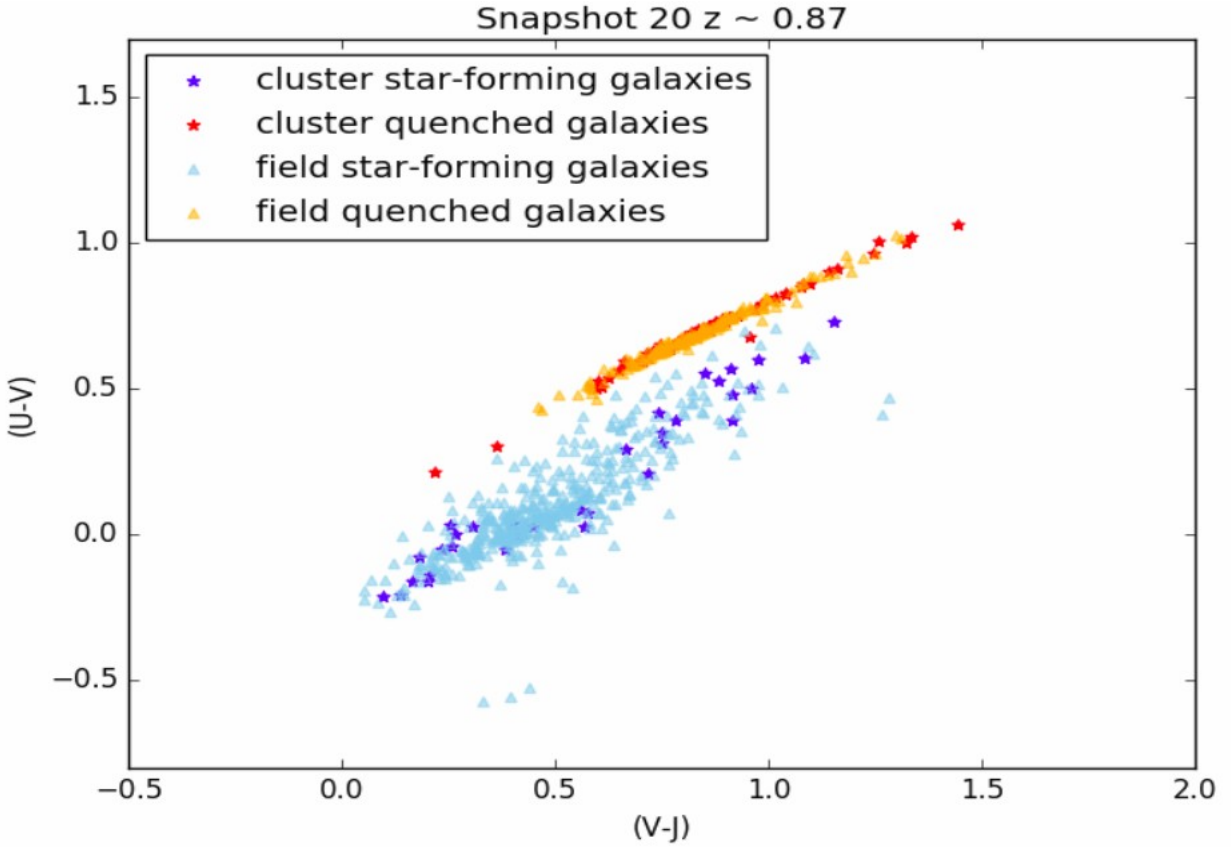

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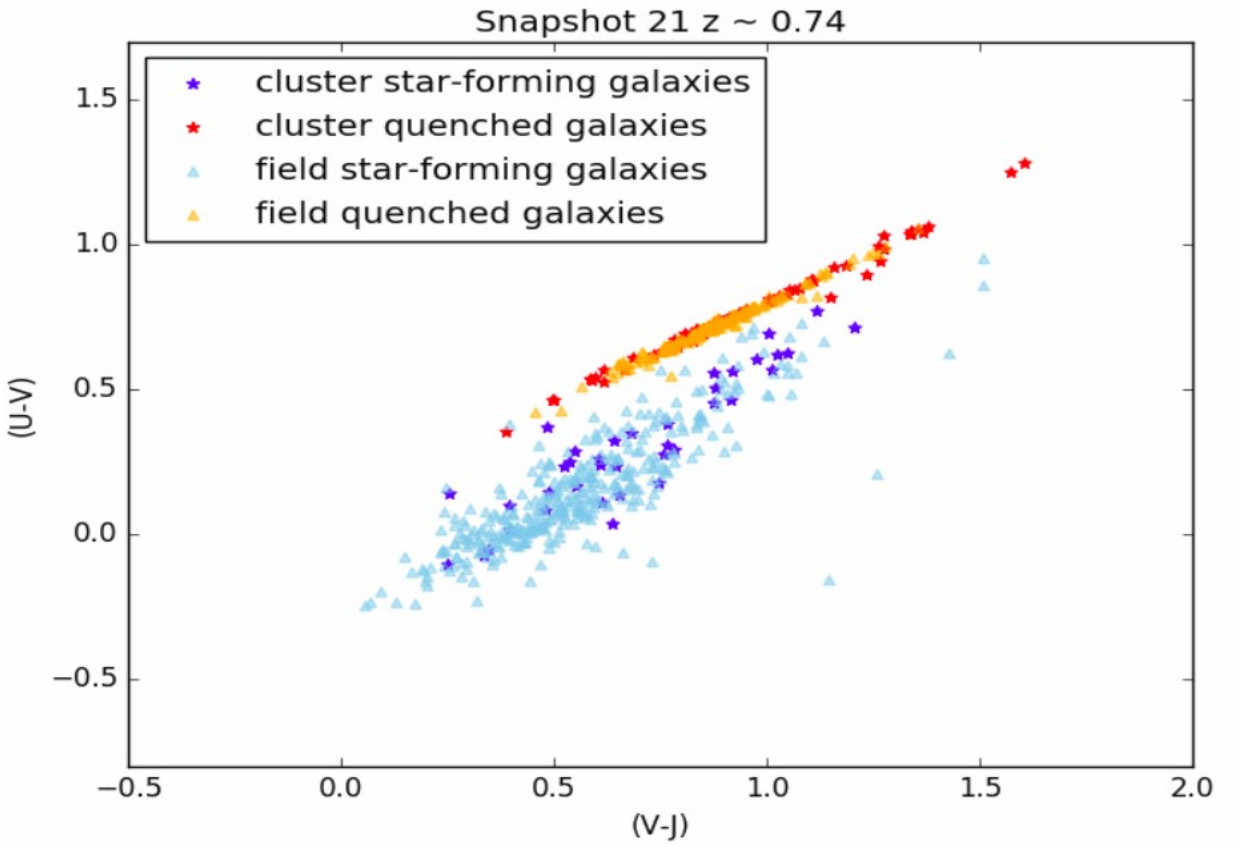

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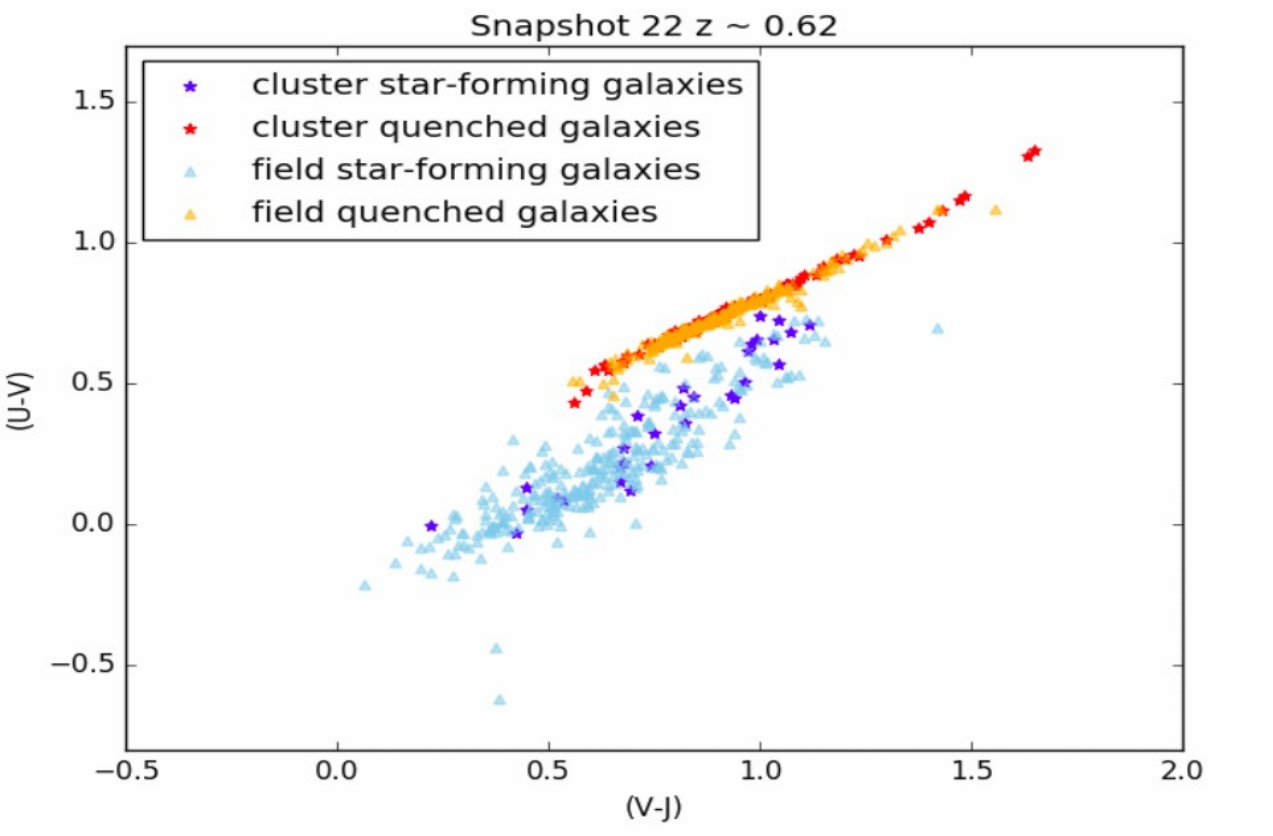

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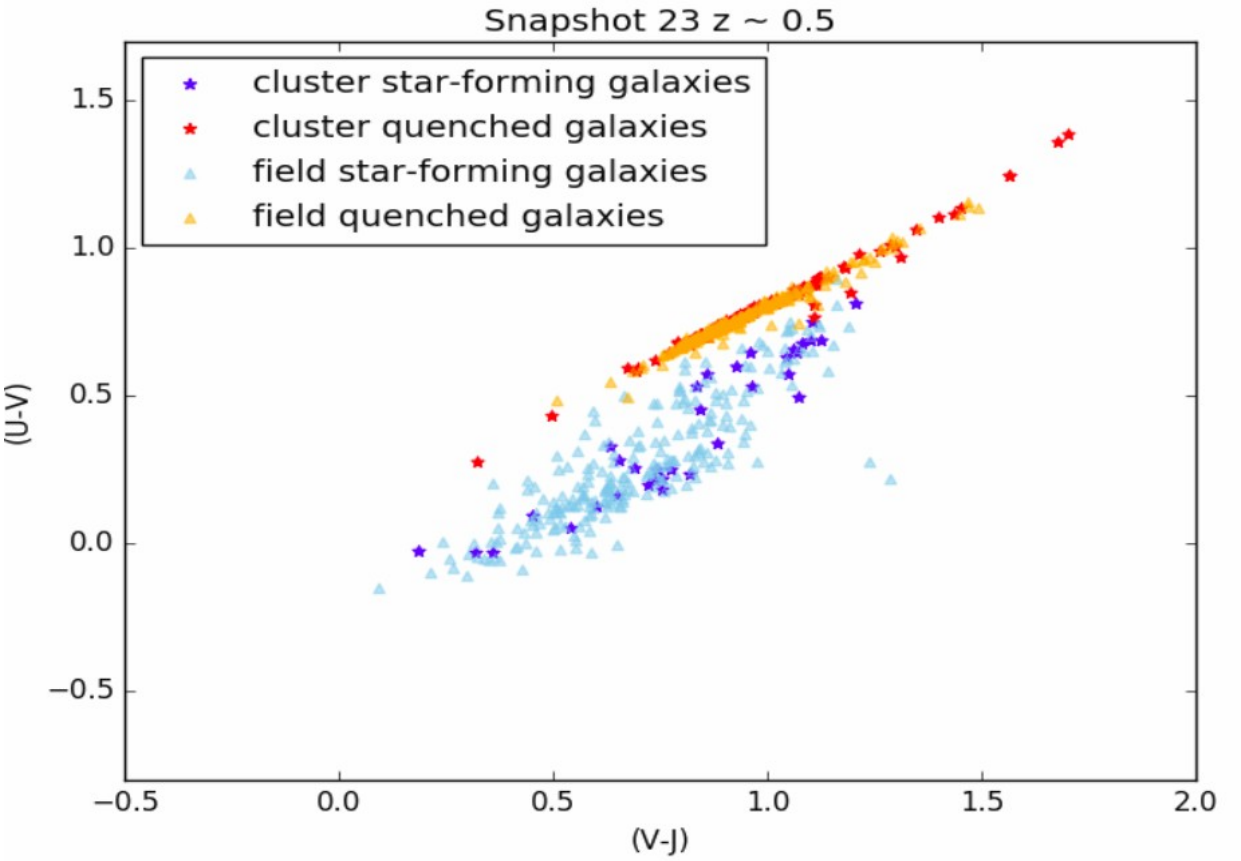

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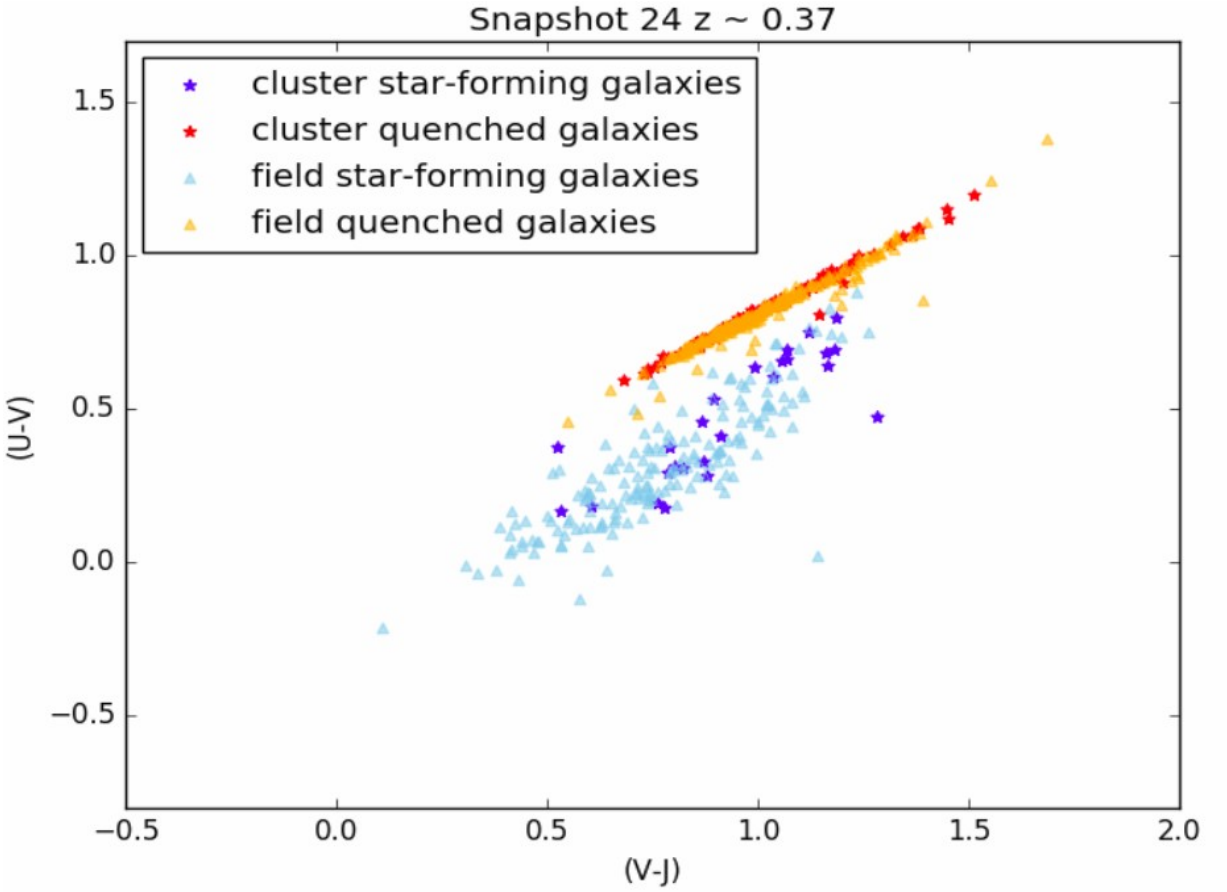

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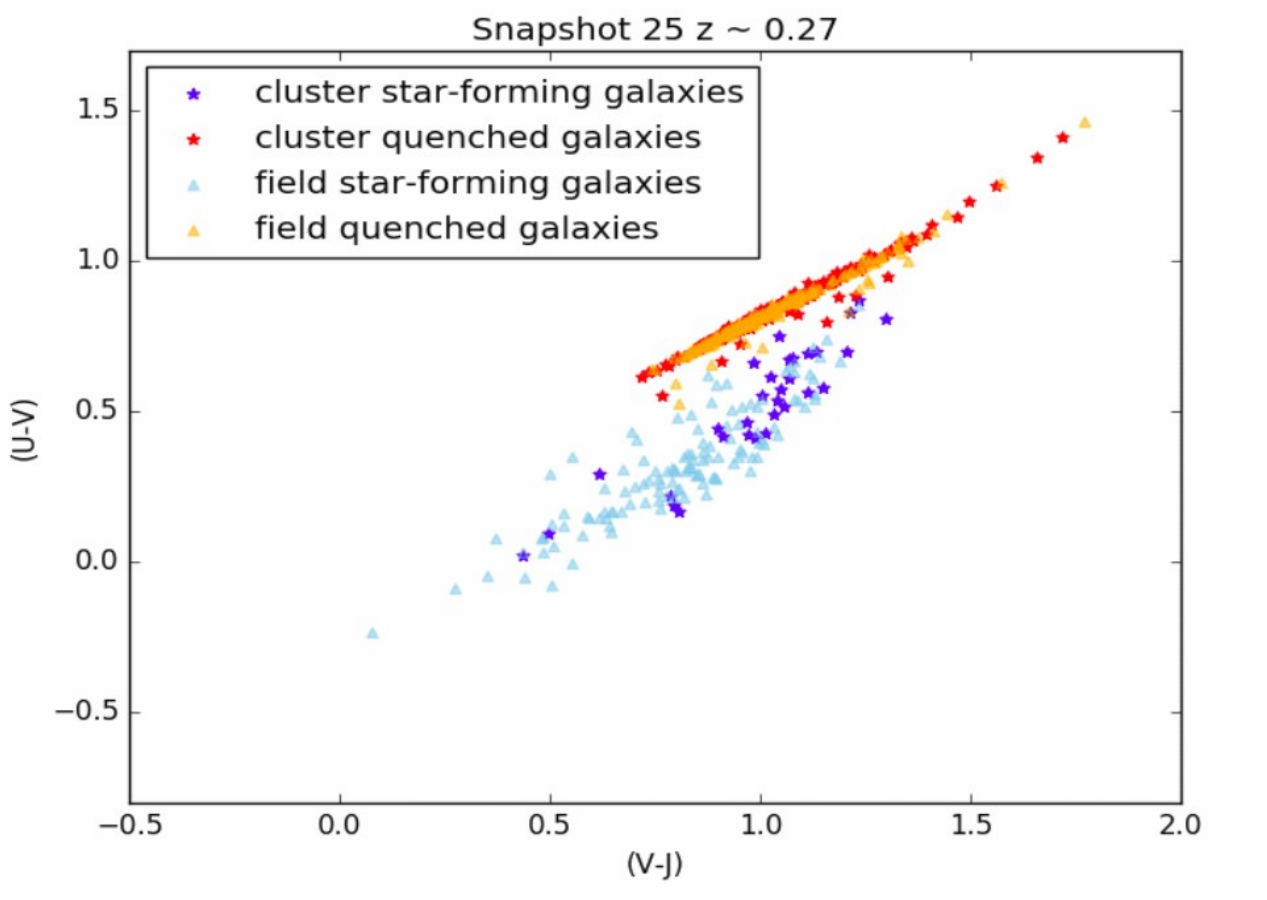

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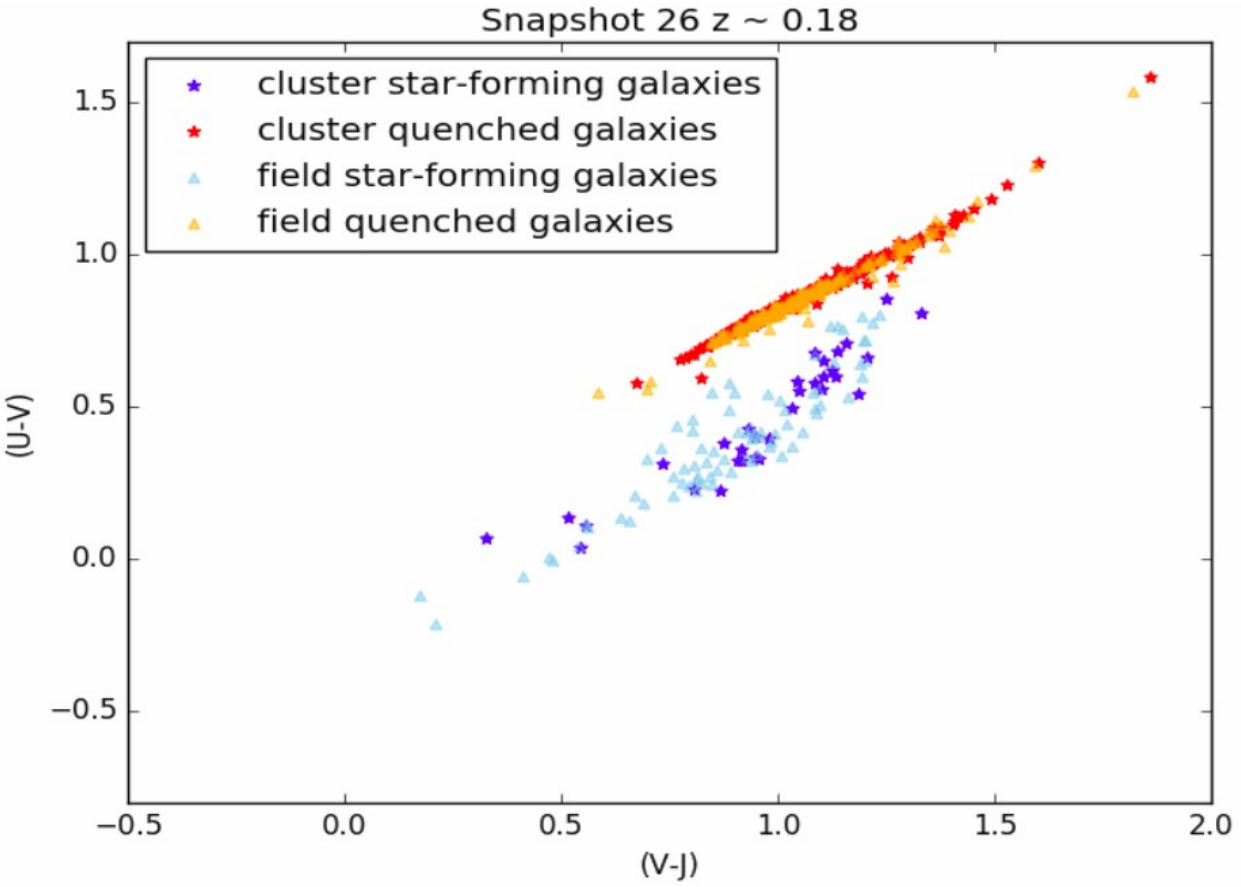

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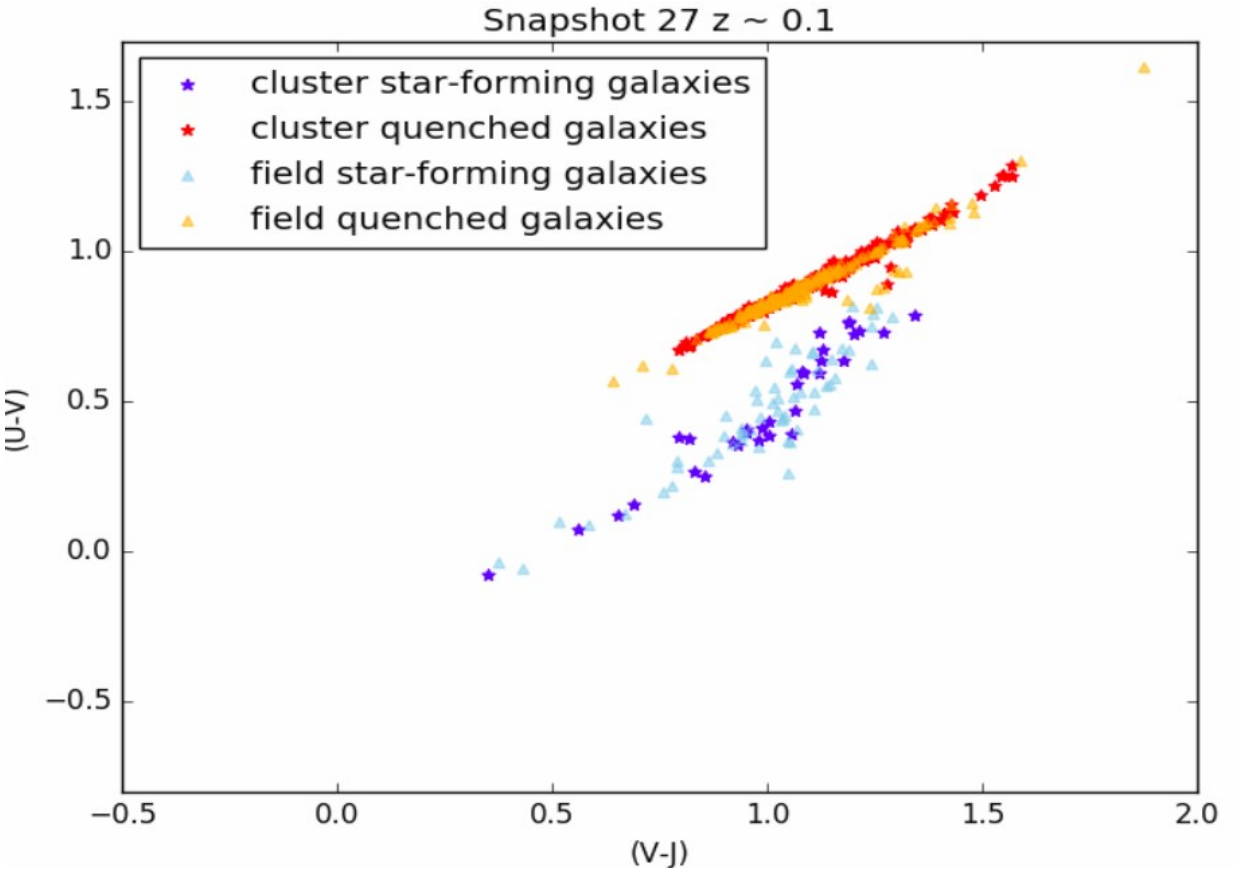

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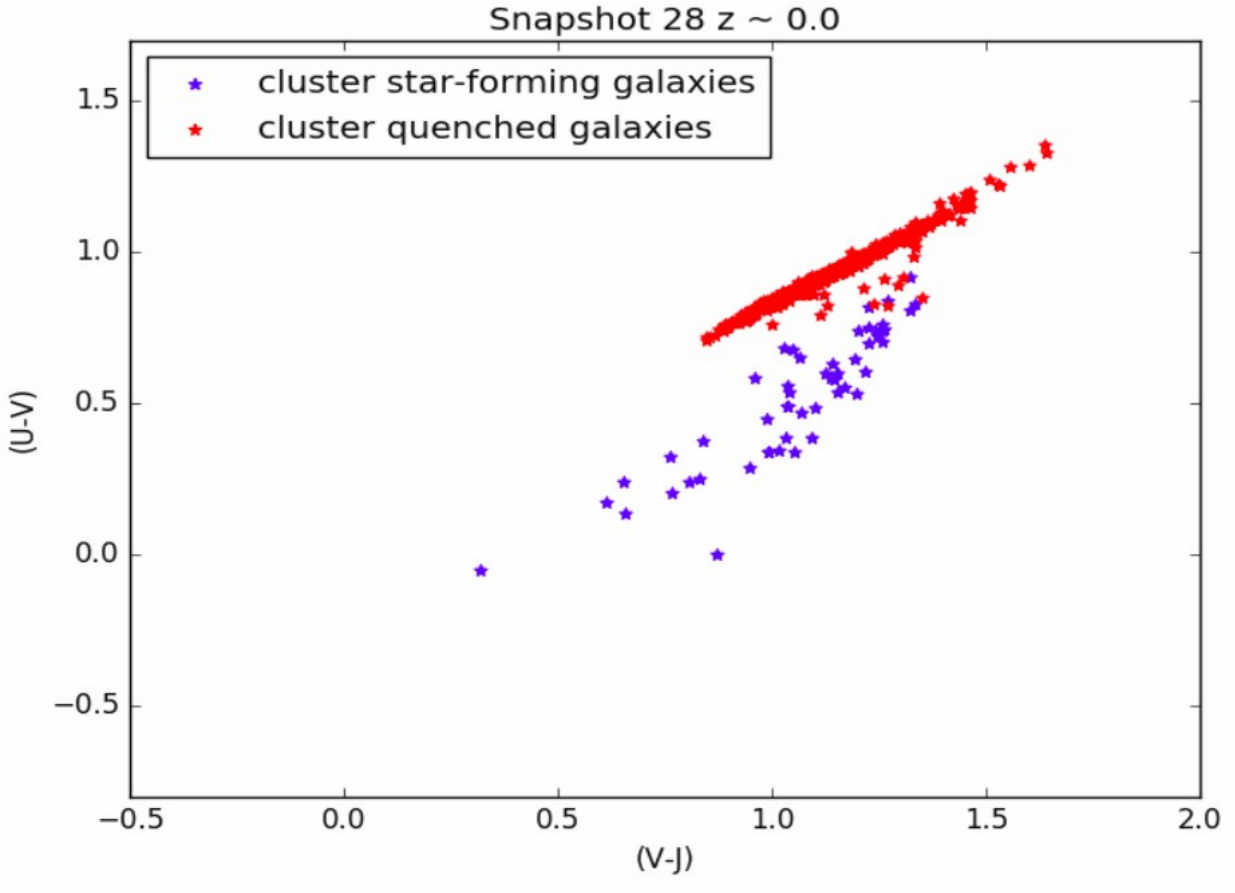
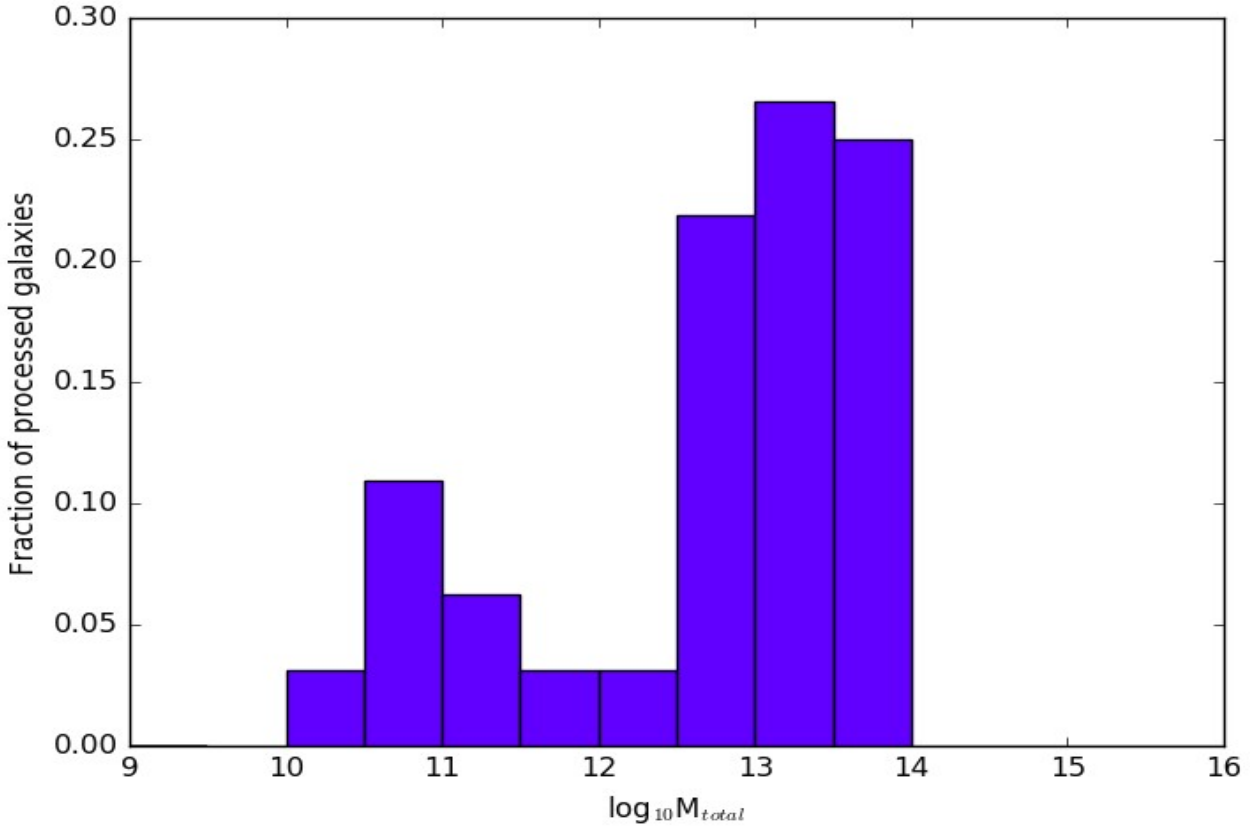


Where occurs the processing?

Mass of the DM Halo at the moment of quenching



- Between 20%- 50% of galaxies in the cluster where pre-processed
- Under this criteria, galaxies present its processing on DM Halos between 10^{13}-10^{14}.
- Only massive cluster pressent clear pre-processing

Mass of the DM Halo at the moment of quenching

Cluster Name	DM Halo Mass	Fraction of preprocessed galaxies
Cluster1	6.423e+14	0.549
Cluster2	6.220e+14	0.428
Cluster3	3.760e+14	0.188
Cluster4	3.482e+14	0.183
Cluster5	2.501e+14	0.379
Cluster6	2.306e+14	0.297
Cluster7	2.0492e+14	0.464
Cluster8	1.203e+14	0.093
Cluster9	1.186e+14	0.035
Cluster10	1.134e+14	0.066

Summary and conclusions

- We used EAGLE Simulation in order to look a preferential Halo for processing of galaxies
- Using the “strongest drop criteria”, we found that the quenching occurs preferentially in low mass Halos (10^{11}-10^{12} Solar Masses), and that near 70% of the galaxies on the clusters were preprocessed.
- Using a semi-observational criteria, we found that between 20-50% of galaxies were preprocessed, but this time the quenching occurs preferentially in bigger Halos (10^{13}-10^{14} Solar Masses)
- According to the second criteria, only massive clusters present signs of preprocessing.

Thanks