Disentangling the evolutionary histories of IllustrisTNG galaxies: a comparative study

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Introduction and Background

- Galaxies have varied individual evolutionary histories (e.g. Cohn 2018), suggesting at a variety of mechanisms at play in their evolution, and the existence of multiple subpopulations of galaxies (e.g. Donnari et. al. 2020).
- Unsupervised learning (clustering) applied to IllustrisTNG-100 galaxies
- Used compressed (NMF) star formation and metallicity histories to explore **evolutionary histories, galaxy-halo connection**
- Emphasized the use of "observables" in our parameter space → **reproducible**, applicable to real world datasets (i.e. SDSS IV)
- Clustered using GMM (Gaussian Mixture Model)

Goal: Find sub-populations with distinct evolutionary histories, link to non-observables for verification. Extend this beyond photometric subpopulations commonly found in literature.

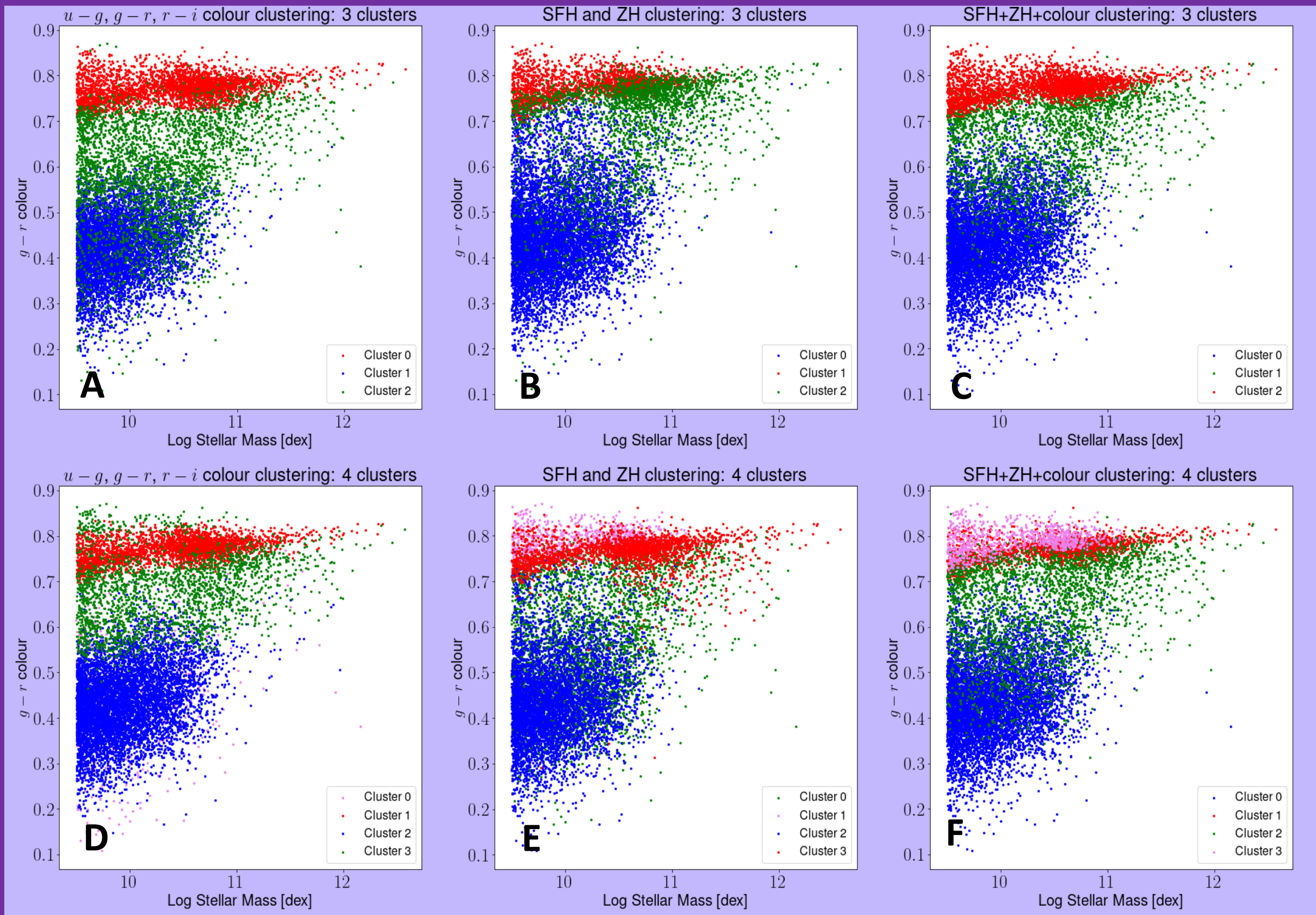

Figure 1: Colour-Mass plots of the six clusterings of interest, we find cases B and E to be the most effective in terms of producing distinct evolutionary histories

Results and Populations of Interest

Star formation and metallicity histories

- Several cases of interest, but found case E as the one producing the most distinct populations (see Figures 1-4)
- NMF four component representations of each
- Distinct quenching regimes for each population
- Such splits also extended to non-observable/quantities only accessible in simulations

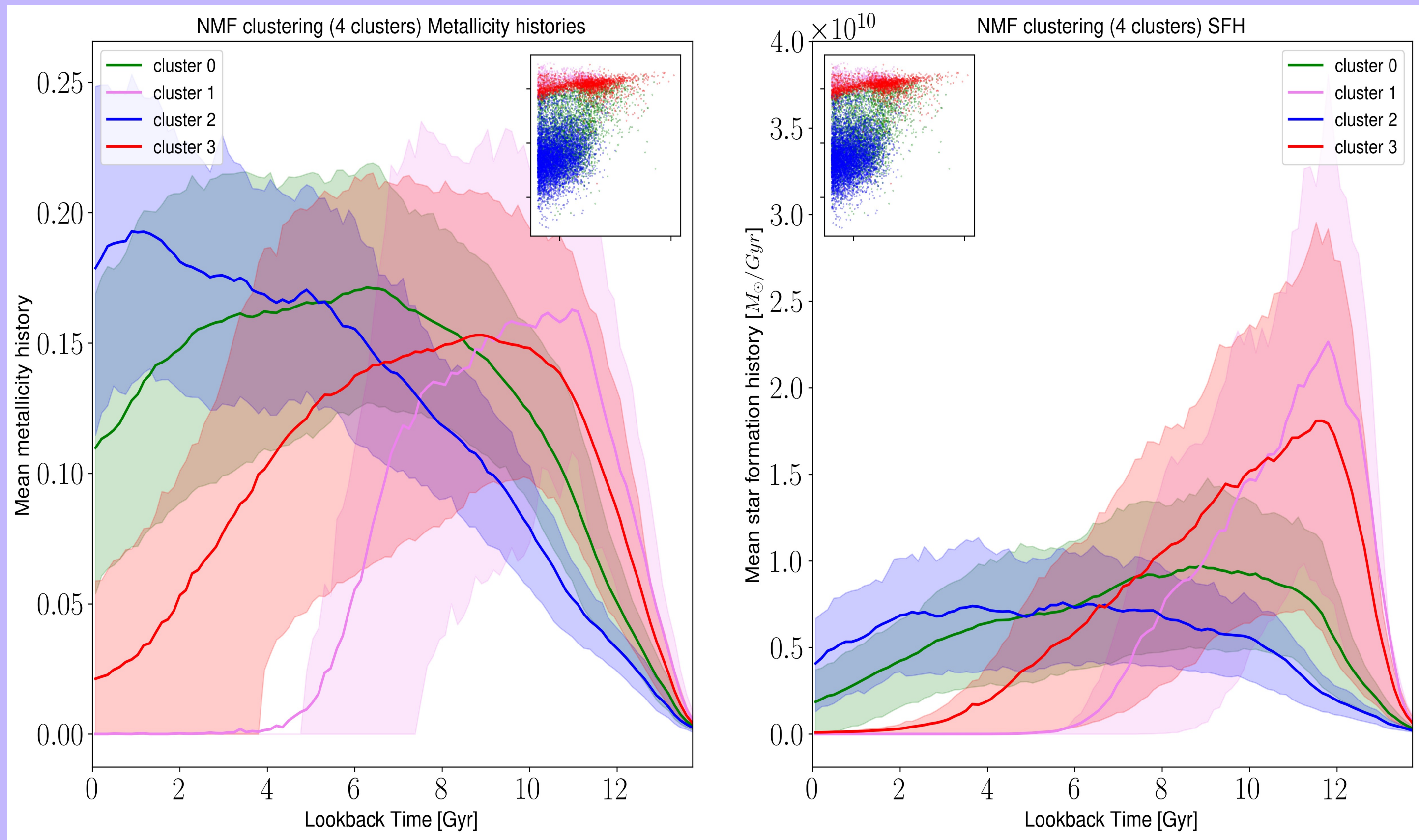

Figure 2: Star formation(SFH) and metallicity histories (ZH) for clusters found in case E of our clustering (see Figure 1). Distinct quenching rates and peaks in both SFH and ZH clearly identifiable, reinforcing that our clustering sorted galaxies by their SFH and ZH.

Discussion: Examining evolutionary histories

- Distinction extends to halo mass assembly history, ex-situ mass fractions
- Late peak in halo mass assembly history for satellite galaxies, in satellite dominated populations (clusters 1,3)
- Strongly suggests at the role of mergers in driving quenching, general evolution of these populations of galaxies
- Further reinforced by ex-situ mass fraction distribution of cluster 1

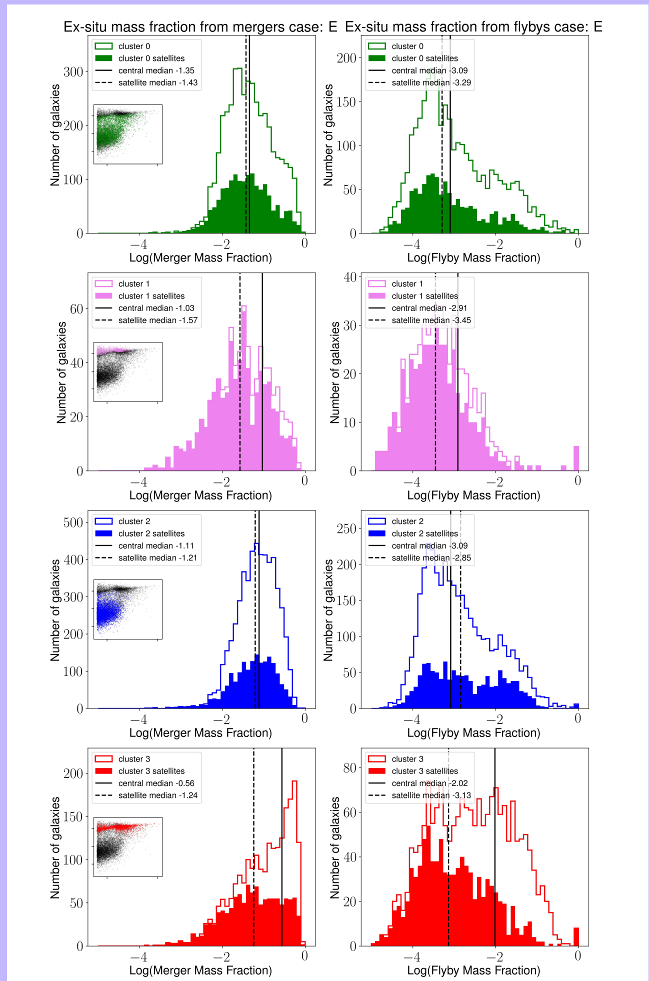

Figure 3: Distribution of ex-situ mass fraction, split by merger status and central/satellite membership.

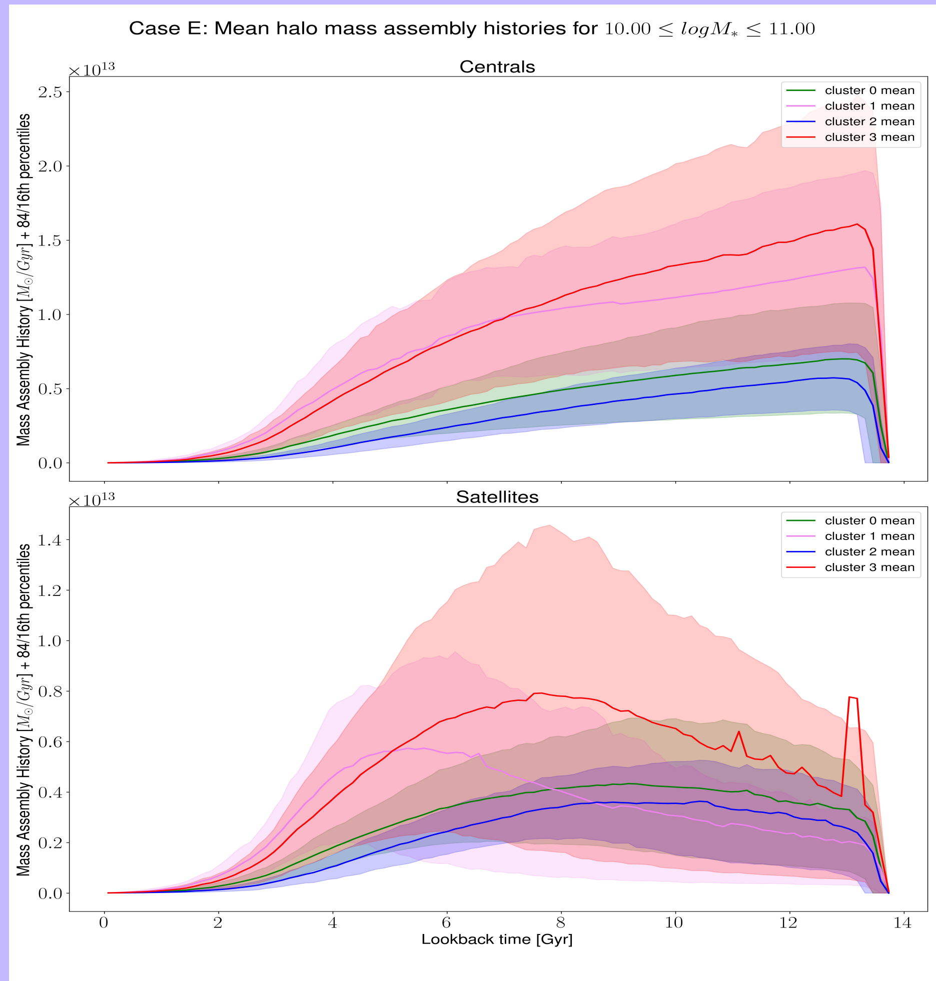

Figure 4 : Mass assembly histories of case E, extracted from IllustrisTNG-100, split by cluster and central/satellite membership

Additional comments

Merger histories - time of last merger

- We extracted the merger histories of IllustrisTNG-100 galaxies, and applied the cluster labels to them
- Found significant differences in when the last major and last minor mergers occur for different populations (see Figure 5), and their cumulative distribution
- The prevalence of major mergers might have some effect on quenching, for certain populations (cluster 3) and none on others (cluster 1). Links to Quai+2020, Hani+2021

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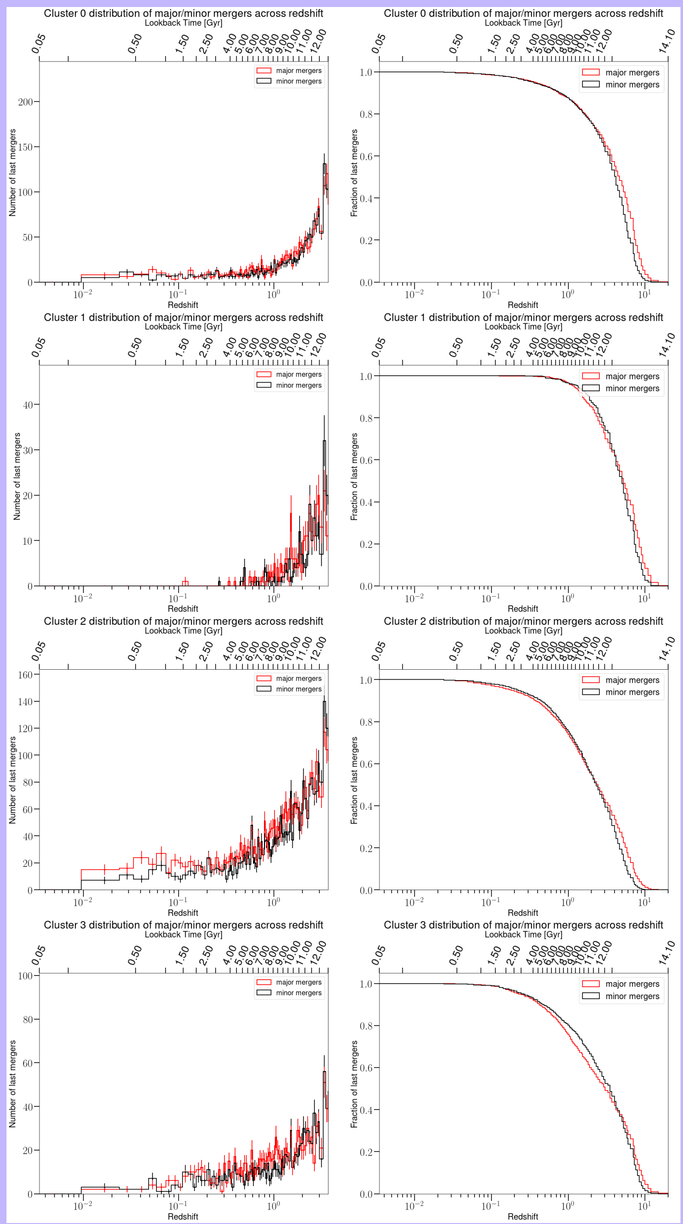

Figure 5: Histogram of time of last merger (left) and cumulative distribution of time of last merger, split by merger type.

Conclusions

- We found several populations with **distinct evolutionary histories**, in a variety of parameterizations
- In the context of observable and observationally derived quantities, using photometric **colours in clustering produced populations that were not as distinct**
- In the interest of identifying distinct evolutionary histories, **SFH/ZH is greatly preferable**, given the comparable populations found in the literature, **notably case E and Donnari et. al. 2020.** Useful if applied to empirical modelling.
- However, populations found using only photometric colours are still of interest (**see: cluster 3 of case D in Figure 1**), can **potentially apply this pipeline to SDSS photometry**, to probe for similarities
- Can also apply this clustering pipeline to **additional simulations, and compare with existing bodies of literature** on galaxy evolution in IllustrisTNG, EAGLE, etc. (e.g. Hani+2021, Quai+2020)

References
- *Quai et al. 2021, arXiv: 2104.03327*
- *Hani et al. 2020, MNRAS, 493, 3716*
- *JD Cohn 2018, MNRAS, 478, 2291*
- *Donnari et al. 2020, arXiv: 2008.00005*