Nordic-Baltic Astronomy Days,
Turku, Finland

Galaxy Unsupervised Learning classification combining UMAP and clustering algorithms

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EXCOSM

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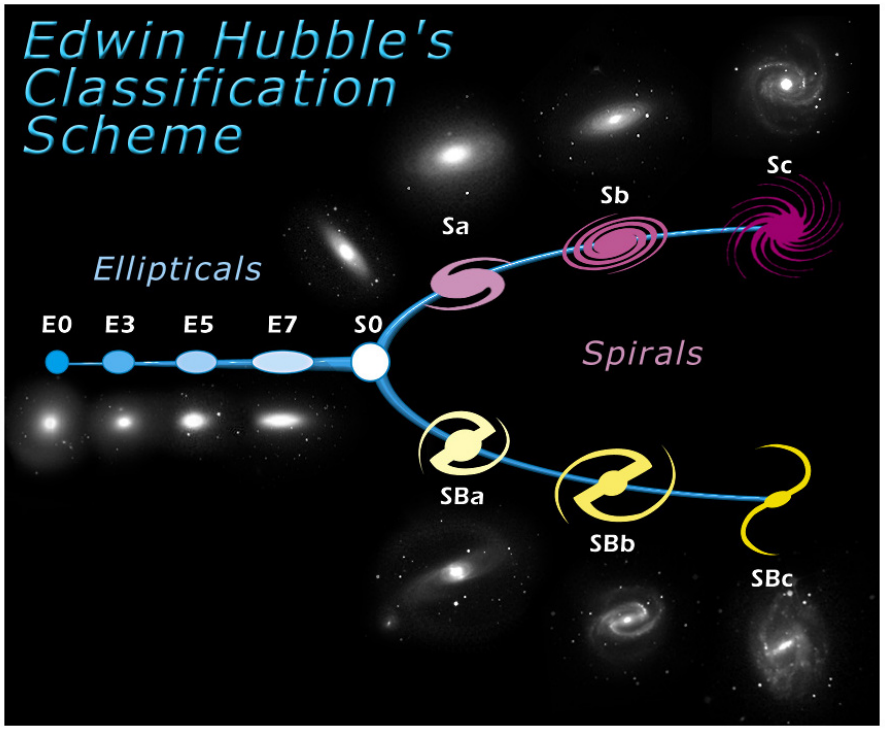
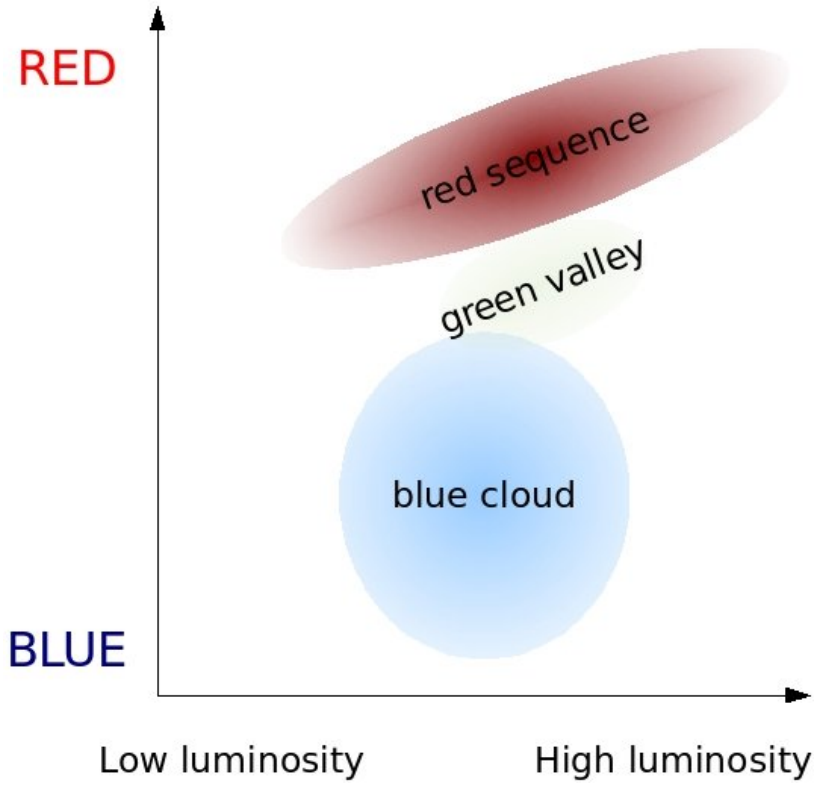
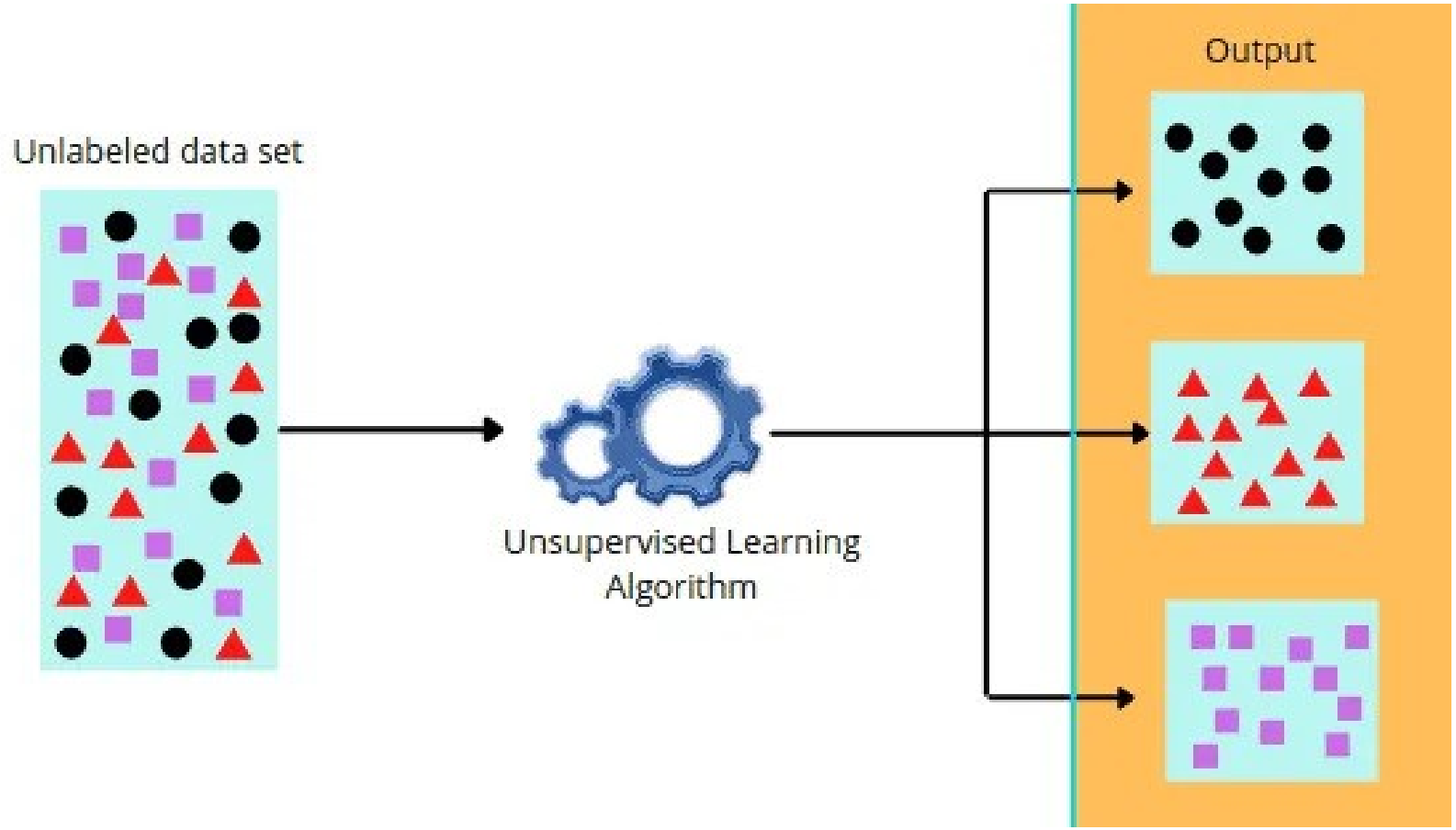
Galaxy Classification





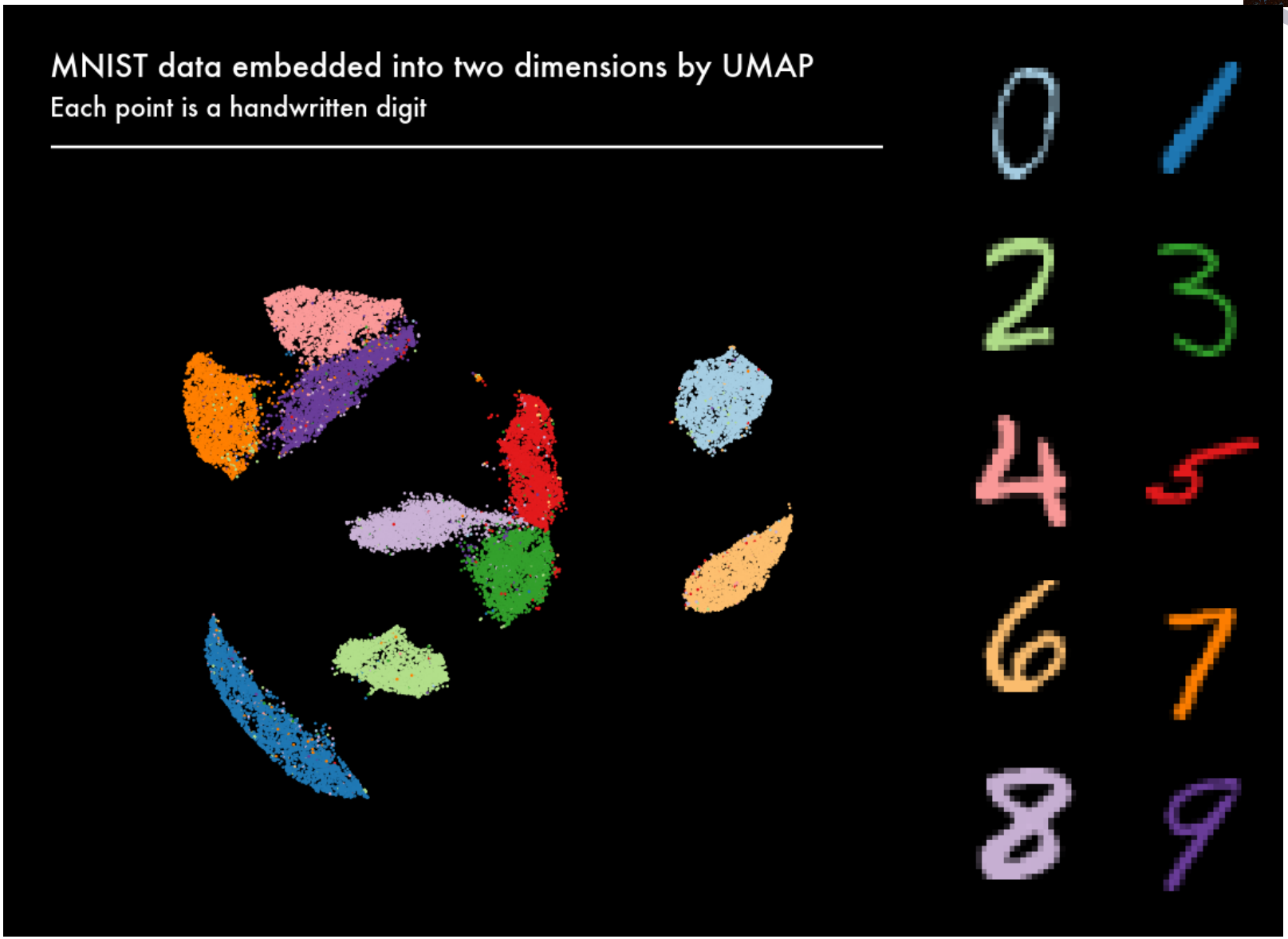
Unsupervised Machine Learning
What it is

Machine Learning on **unlabelled data**



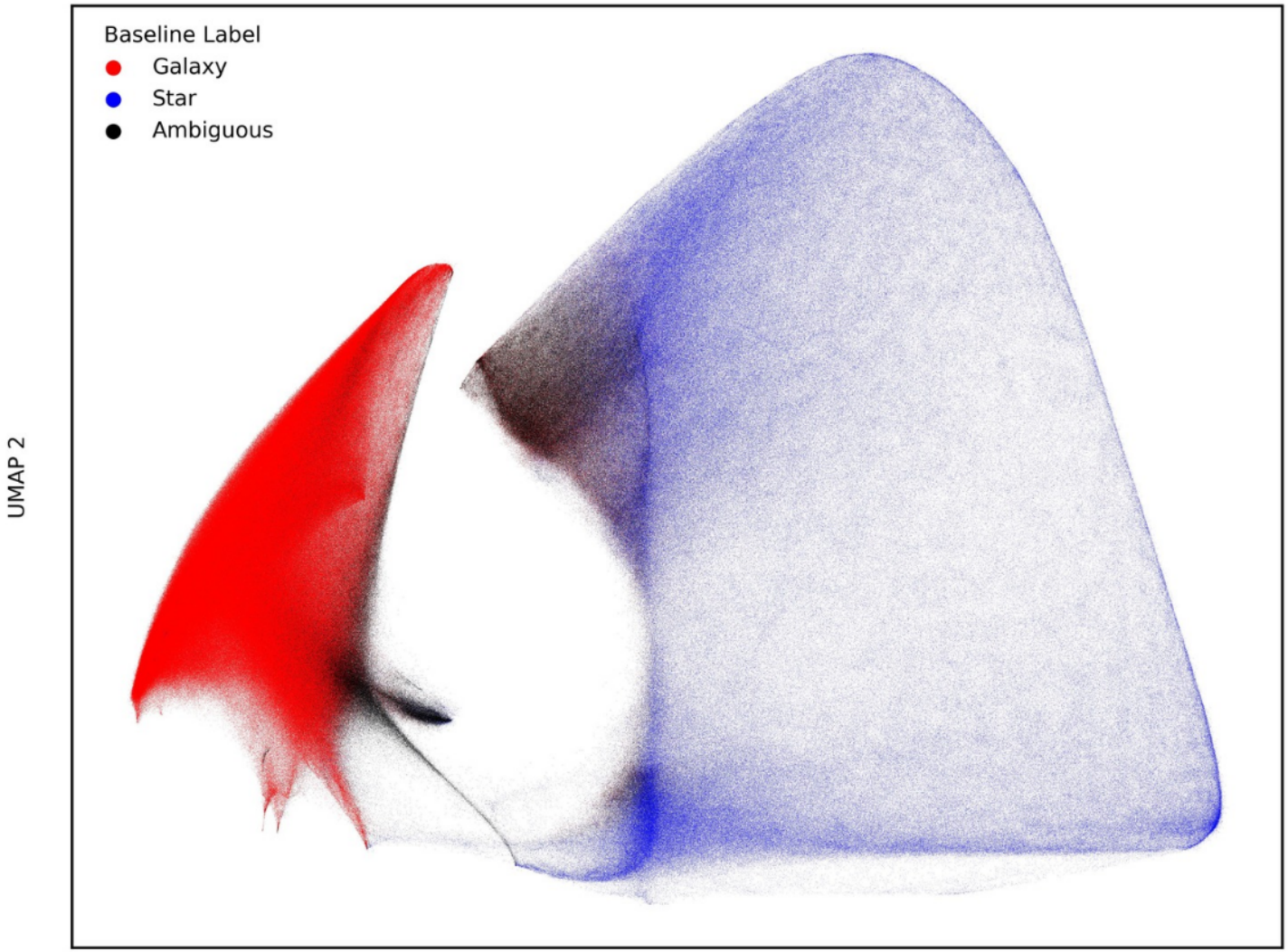
Credit: https://hands-on.cloud/ml-unsupervised-learning-guide/

Unsupervised Example I



Credit: Jeroen Janssens

Unsupervised Example II



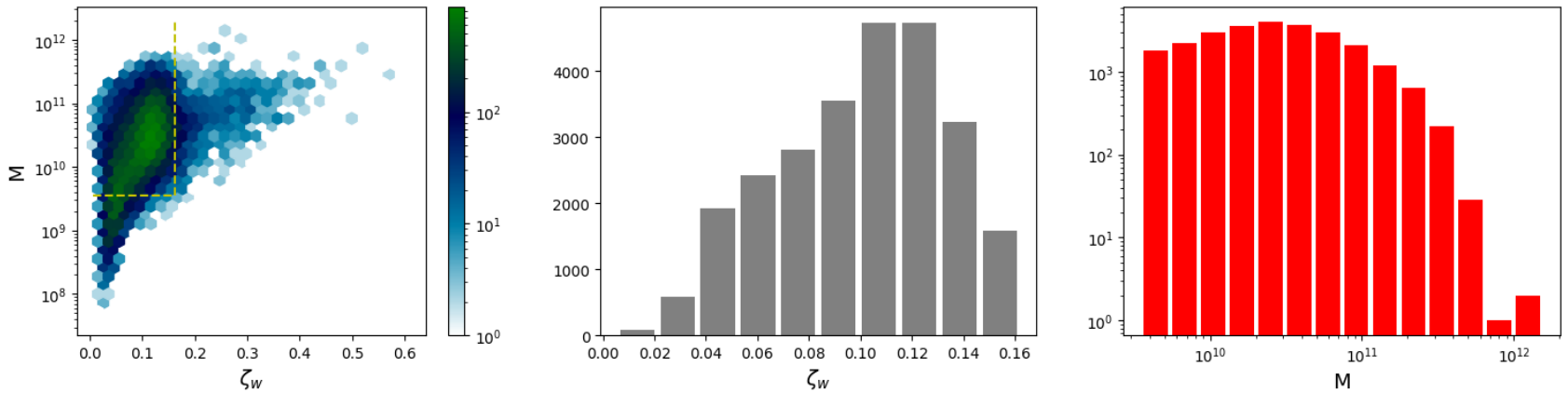
Credit: Cook +24

Can Unsupervised Machine Learning be useful for galaxy classification?!

What data, how, and why?

- GAMA spectroscopic sources (redshifts!) + Galaxy Zoo classifications

  mass limited sample



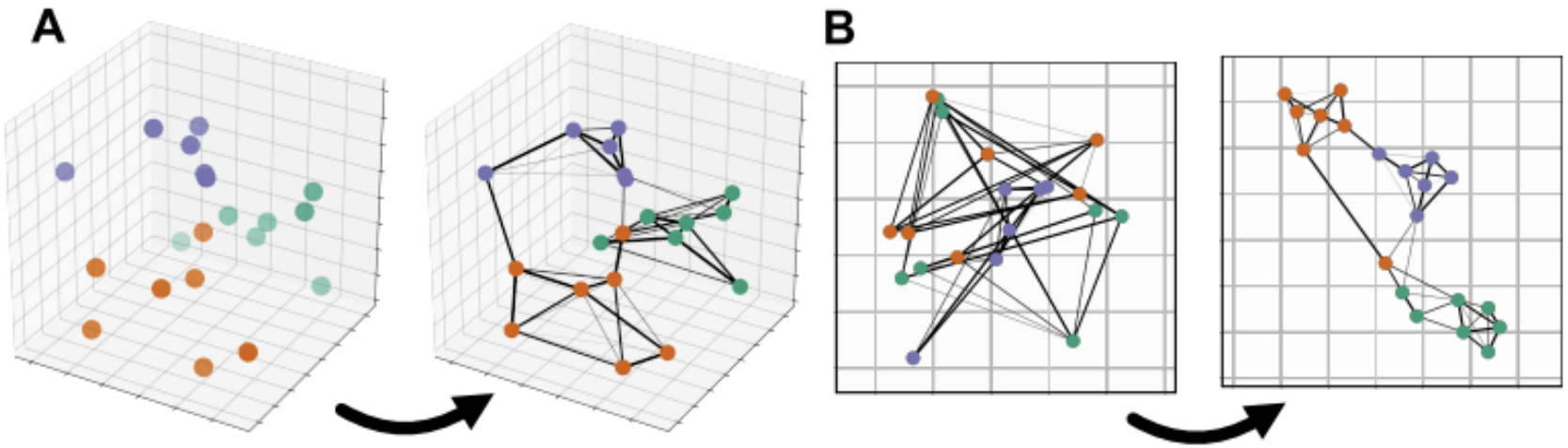
ζ = Ln (1 + z)

- k-corrected KiDS+VIKING photometric colours

  median-normalized $\rightarrow$ 4+5 bands $\rightarrow$ 36 colours

Step 1. Dimensionality Reduction

UMAP

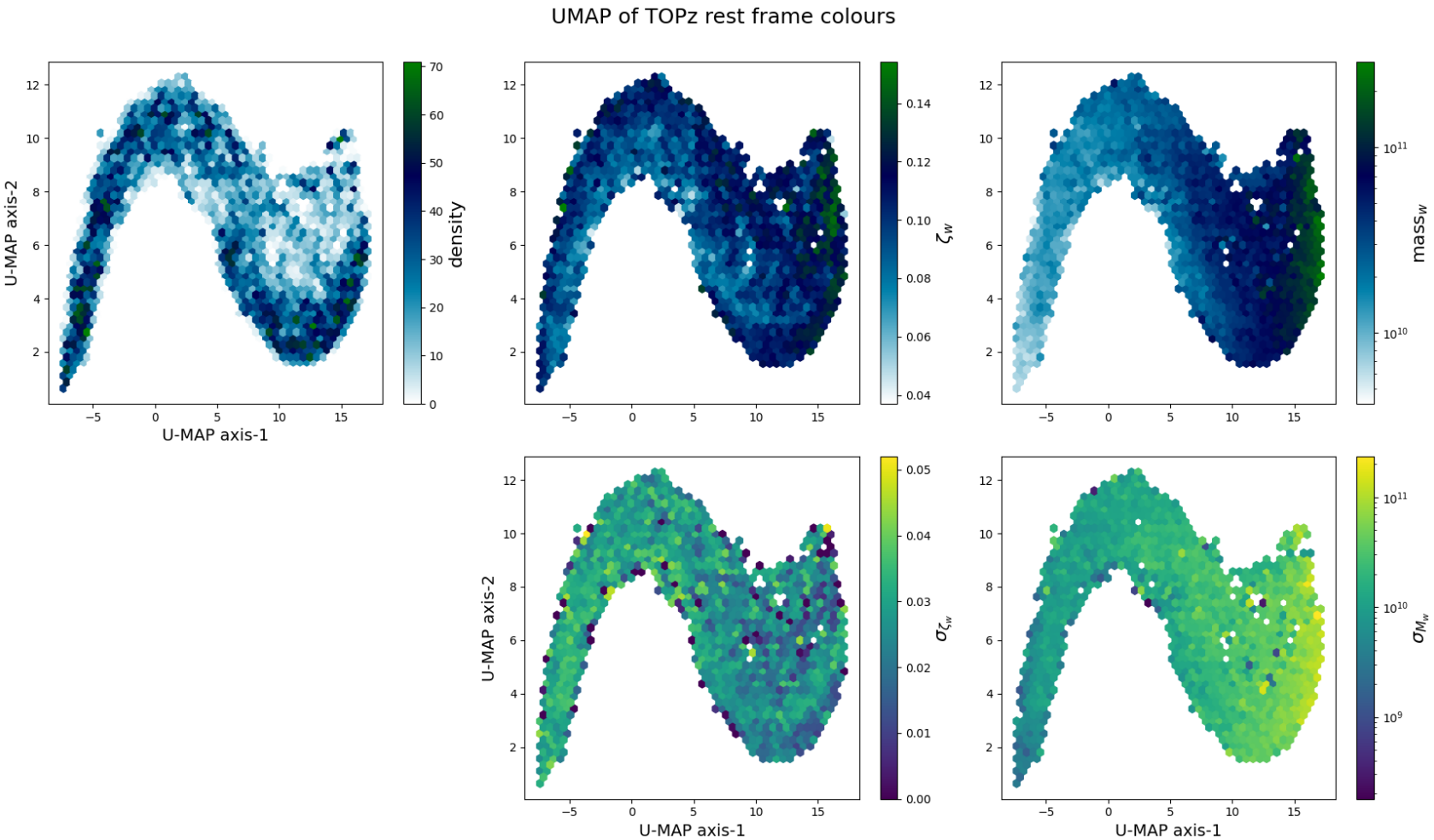


A **Manifold**: generated in the N-dimensional space

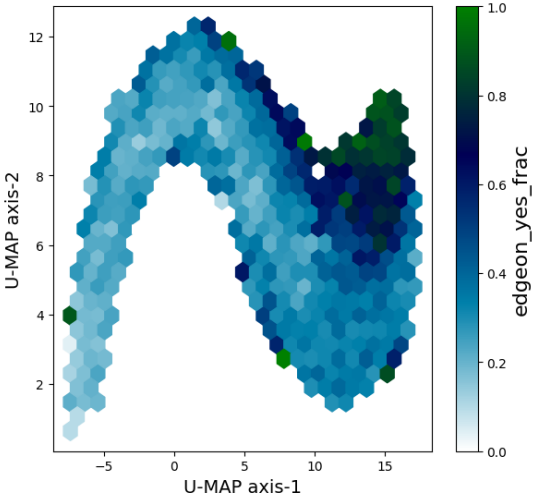
- described as a *fuzzy simplicial complex*

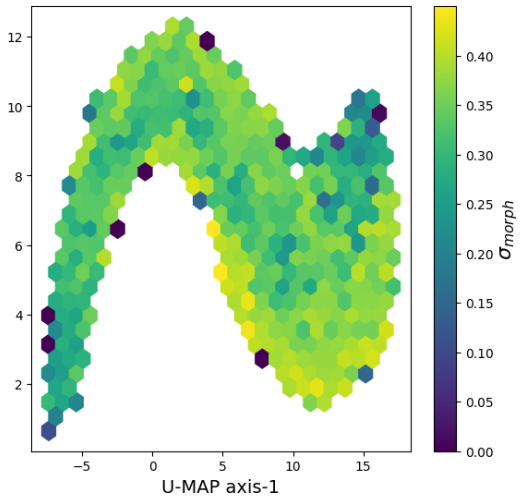
B **Embedding**: fit the 2-dim manifold (according to algorithm parameters)

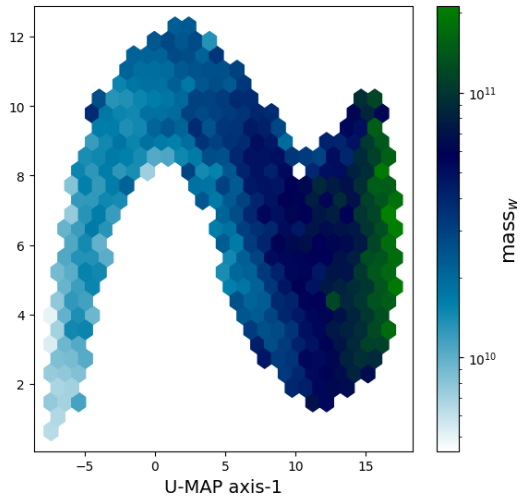
UMAP Rest Frame k-corrected colours for GAMA-Galaxy Zoo Mass-Limited sample



UMAP change with Galaxy Zoo properties



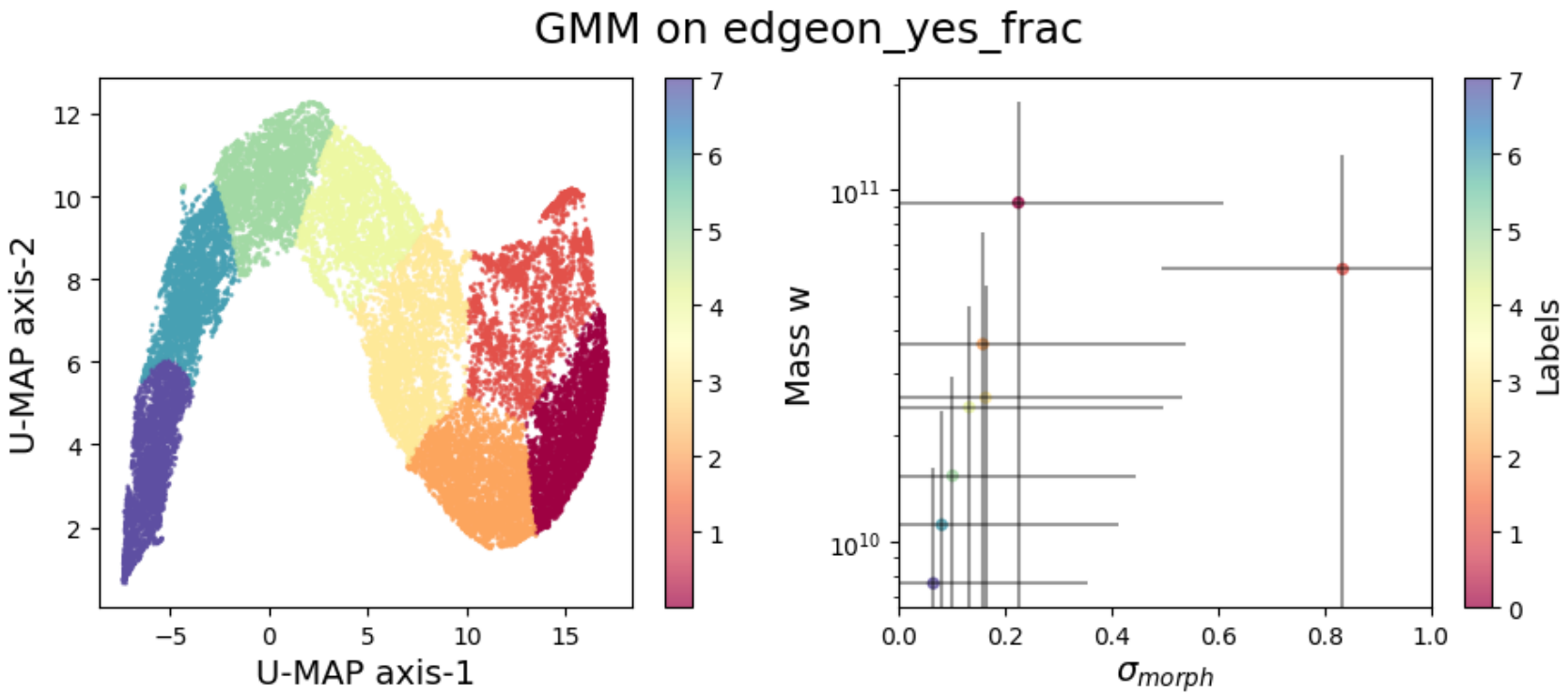




Step 2. Clustering

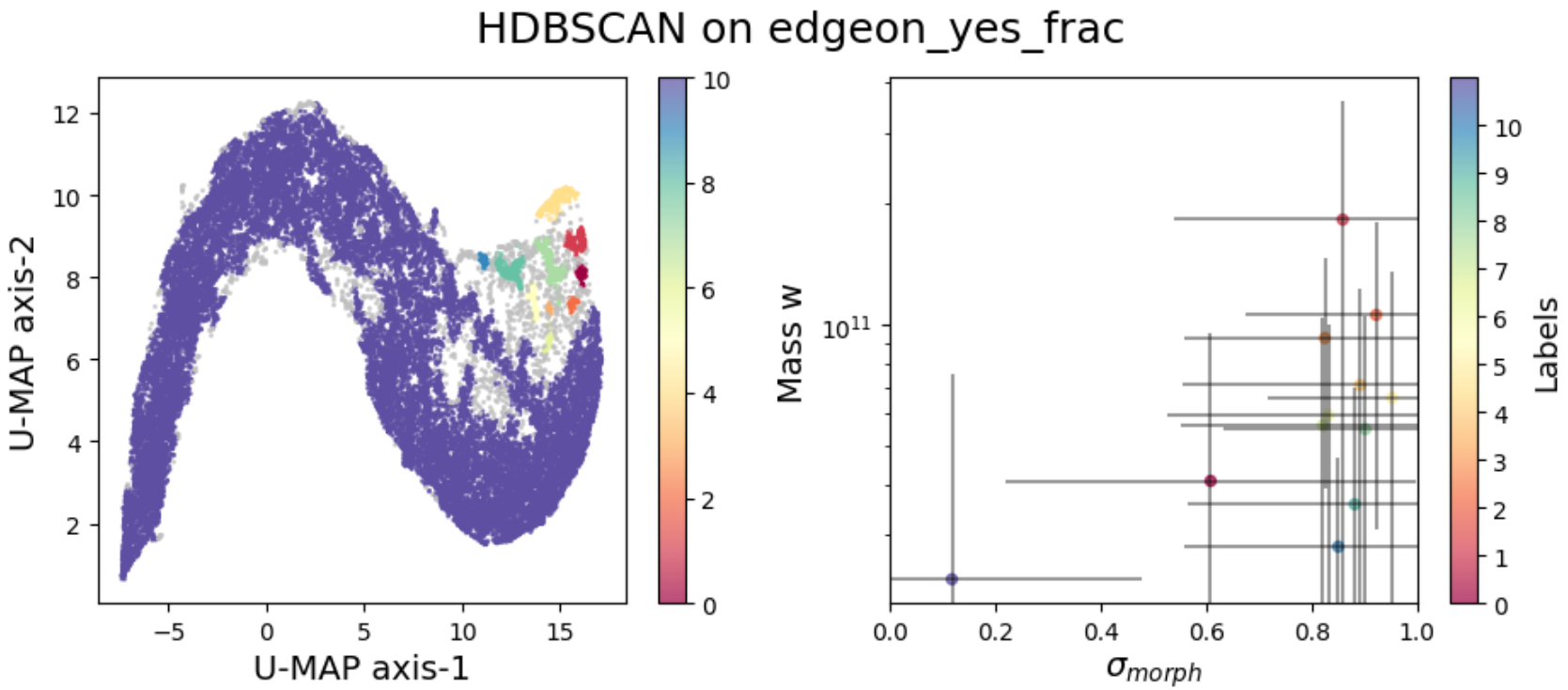
Gaussian Mixture Model (GMM)

Result on UMAP input



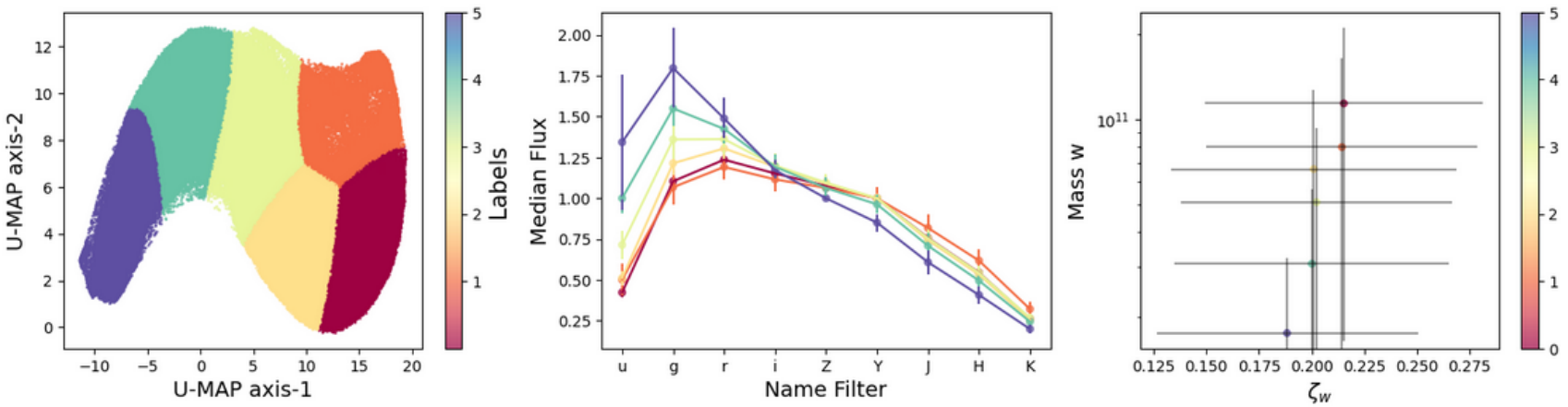
- Number of Clusters: input
- Internal Structure: attempts representing it through gaussian fitting

HDBSCAN Results



- Number of Clusters: according to the **Density**
- Presence of **Noise**: cluster -1
- Internal Structure: according to the **Density**

GMM physical meaning



bigger GAMA sample (without GZ values)

Conclusions

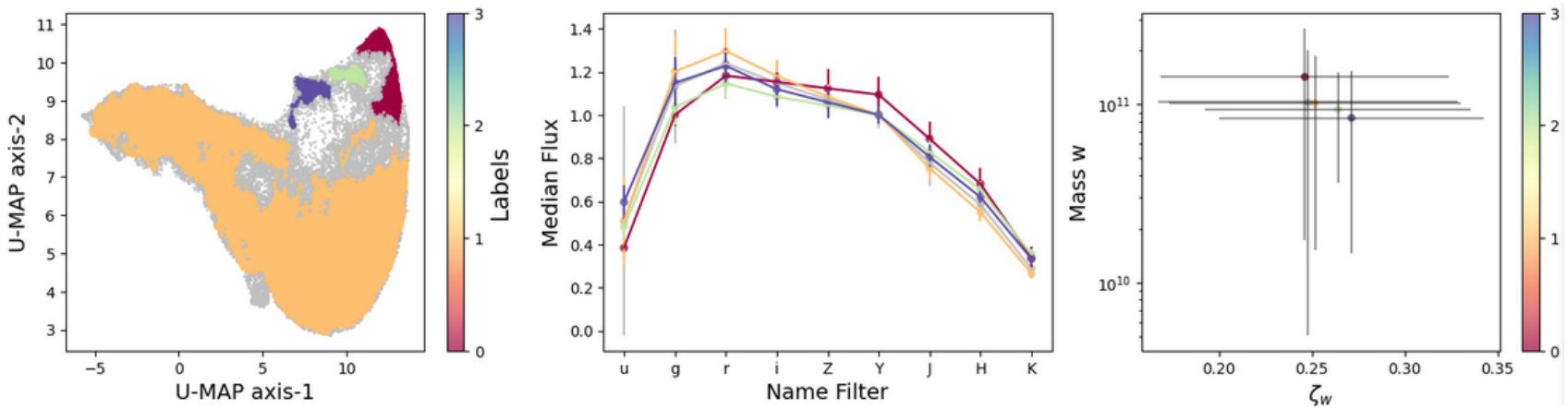
Future Work

- Find consistent cluster generation
- Control the **inherent stochasticity**
- Is it possible to reproduce known classifications?
- or to identify new classifications?

Thanks!

Take-home message

- Clustering on k-corrected colours is independent of redshift
- Mass and Morphology patterns "evolve" across UMAP embedding
- Clustering separates SEDs shapes



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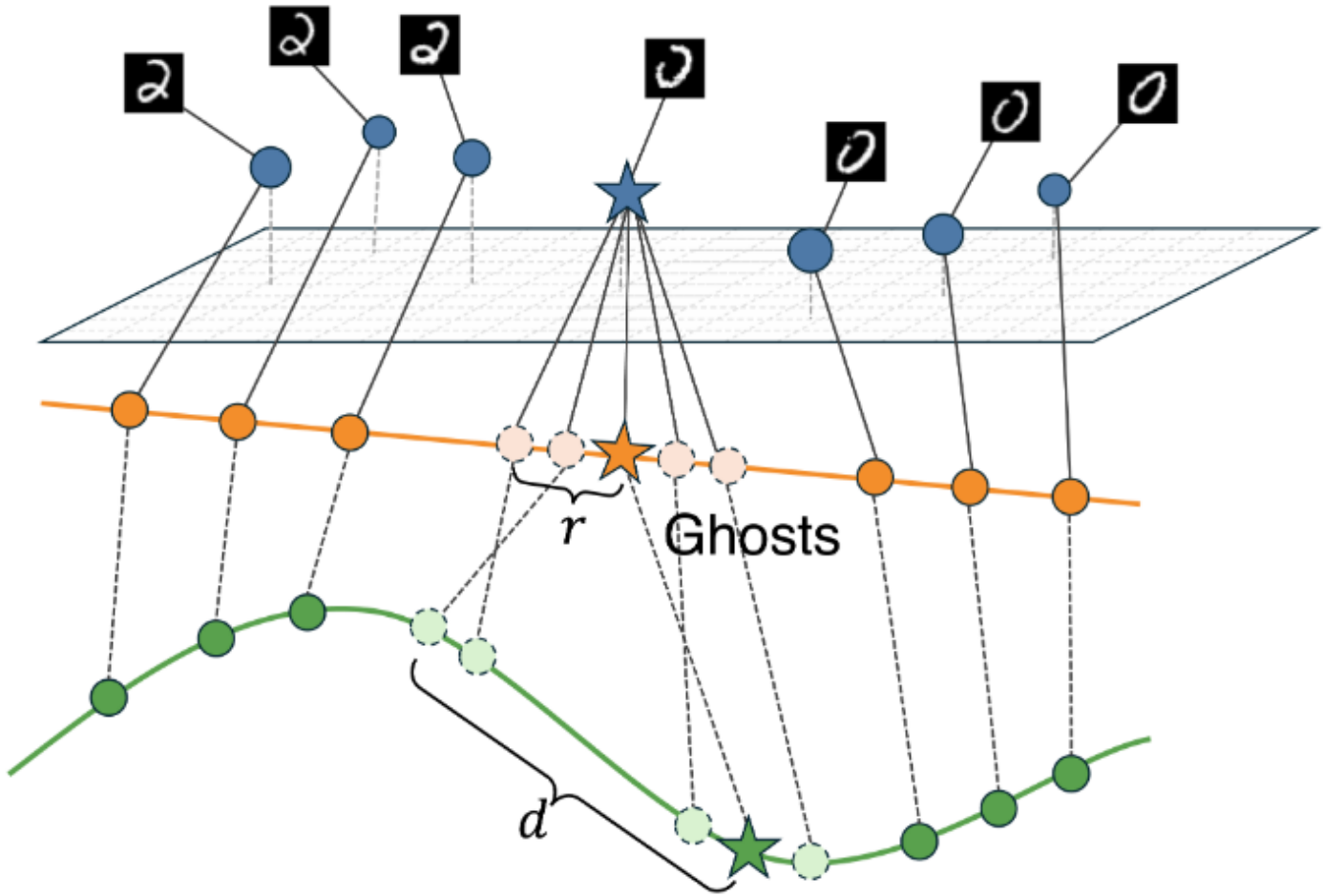
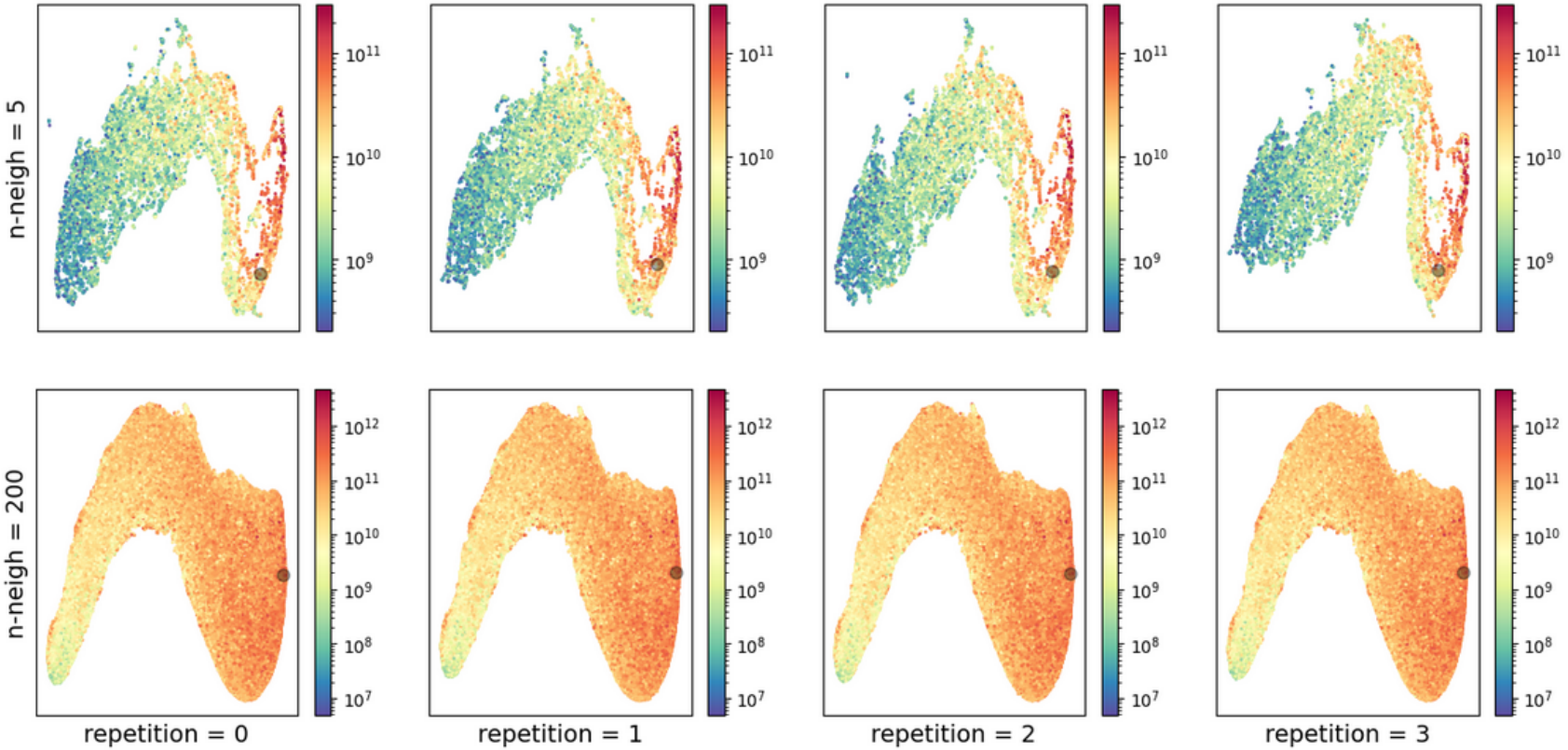
Stochasticity I
Appendix 1



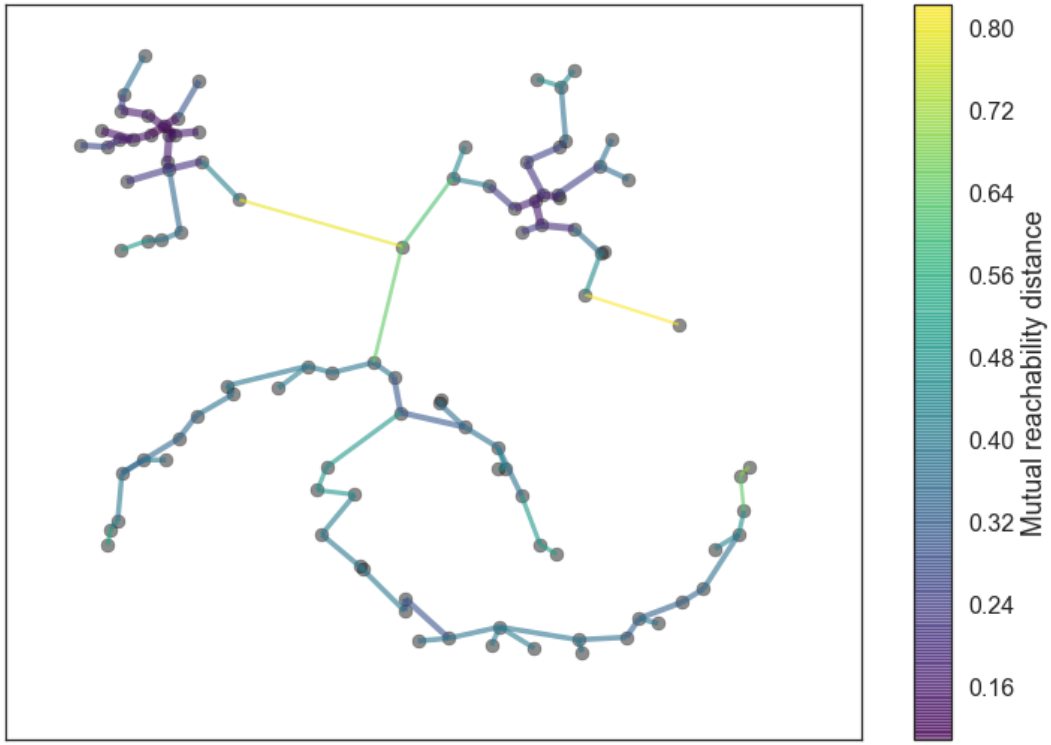
Stochasticity II
Appendix 1



the colour map is the galaxy mass

HDBSCAN I

Appendix 2

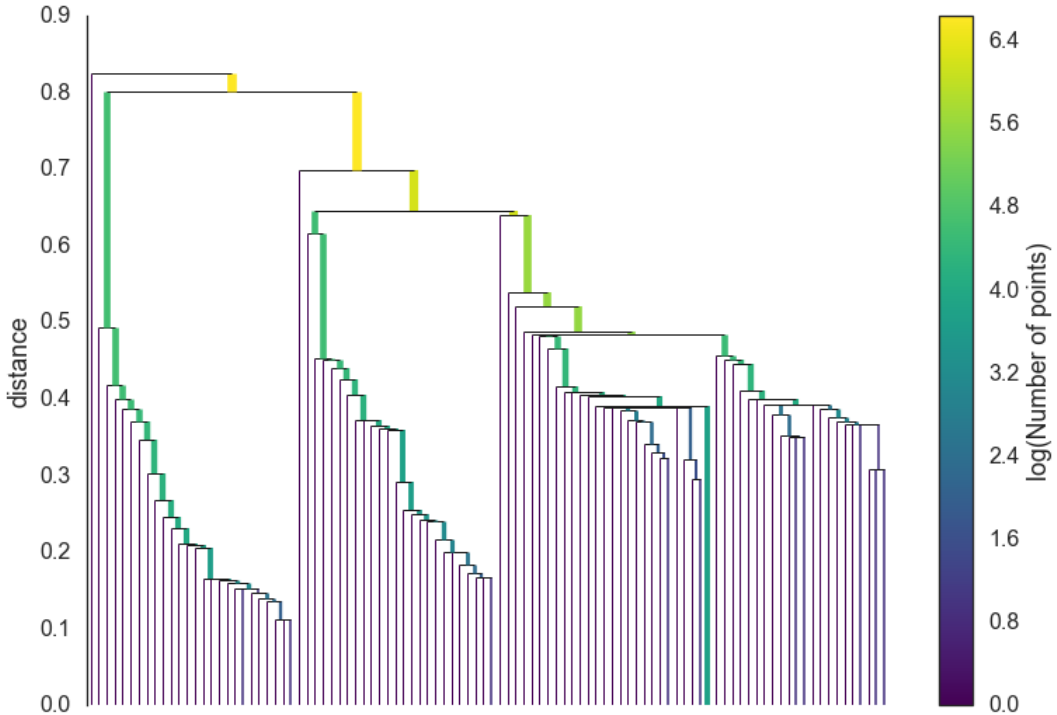


hdbscan.readthedocs.io

A (Mutual Reachability) Distance for each galaxy + Single linkage "skeleton" (Minimum Spanning Tree)

HDBSCAN II

Appendix 2

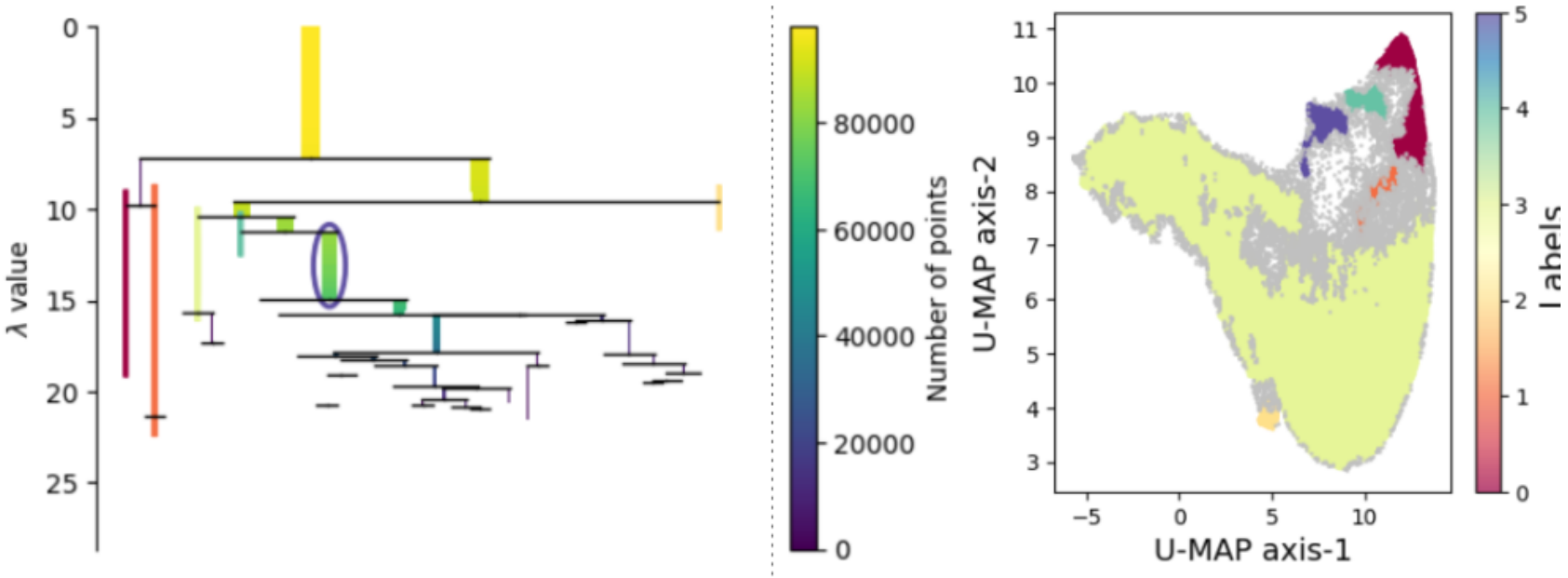


hdbscan.readthedocs.io

B Generate the cluster tree, cutting links in decreasing order

HDBSCAN III

Appendix 2



C Condense and select stable clusters

Noise = single-point clusters

HDBSCAN Results 2

Appendix 3