Mining Illustris and TNG for Major-Merger Galaxy Pairs

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Effect of Galaxy Interactions on SFR

- When galaxies get close enough, they exert tidal torques on each other
- Angular momentum in the galaxy increases and decreases
- Causes gas clouds inside the galaxy to compress
- Once the density of these clouds increases, molecules begin to form
- Molecular clouds radiate until they cool down
- When cloud becomes more massive than Jean's Mass, stars can form!

What is a Major-Merger? (Conceptually)

- A major-merger occurs when galaxies of roughly equal mass collide
- Major-mergers between spiral galaxies often lead to the formation of active galactic nuclei

Quantifying a Major-Merger Interaction

- **Observational Criteria:**
  - Radial separation $5 \leq r \leq 20\ kpc$
  - $\Delta K_s \leq 1\ mag$
  - $|v_1 - v_2| \leq 1000 km/s$

- Only using projected coordinates
- Mass ratio ≤ 2.5
- Numbers are chosen for dynamical purposes

Why turn to simulations?

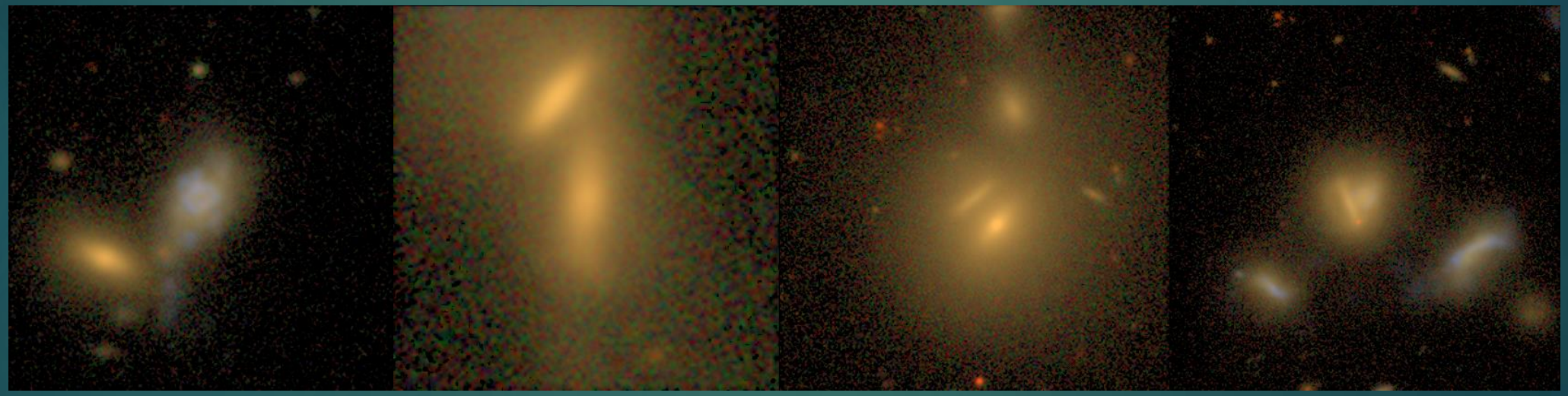
- Testing the accuracies of theories
- Understanding the history we can't observe
- Important to try to simulate a population

Illustris Project

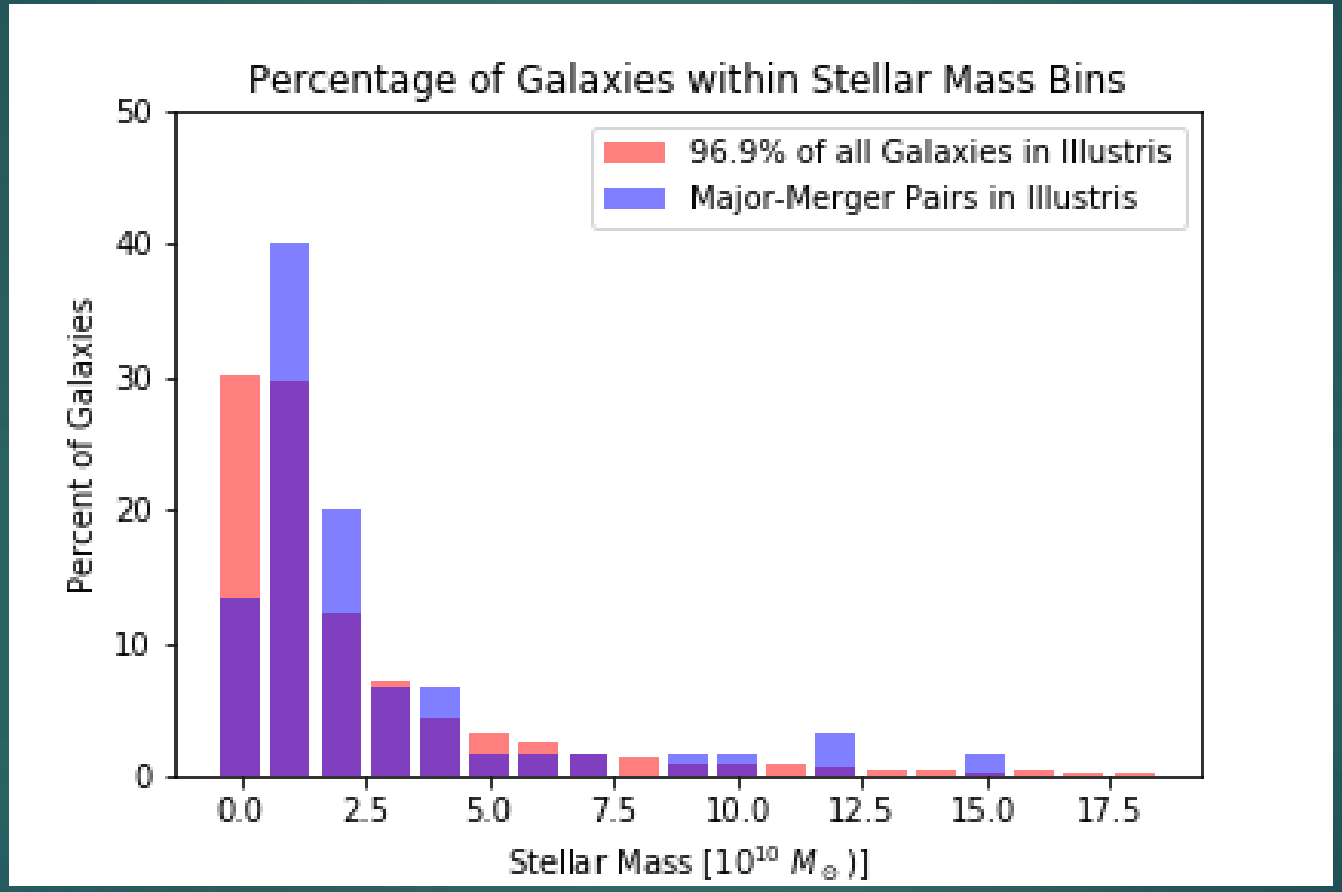
- Publicly accessible, large-scale set of hydrodynamic cosmological galaxy-formation simulations
- 4,366,546 galaxies
- Simulation volume of $(106.5\ Mpc)^3$
- Generated images for galaxies with stellar mass $\frac{M}{M_\odot} \geq 10^{10}$ using methods from Snyder et al 2015 and Torrey et al 2015

Mining Illustris for Major-Merger Pairs

- Used Python to search the data for major-mergers



Initial Histograms



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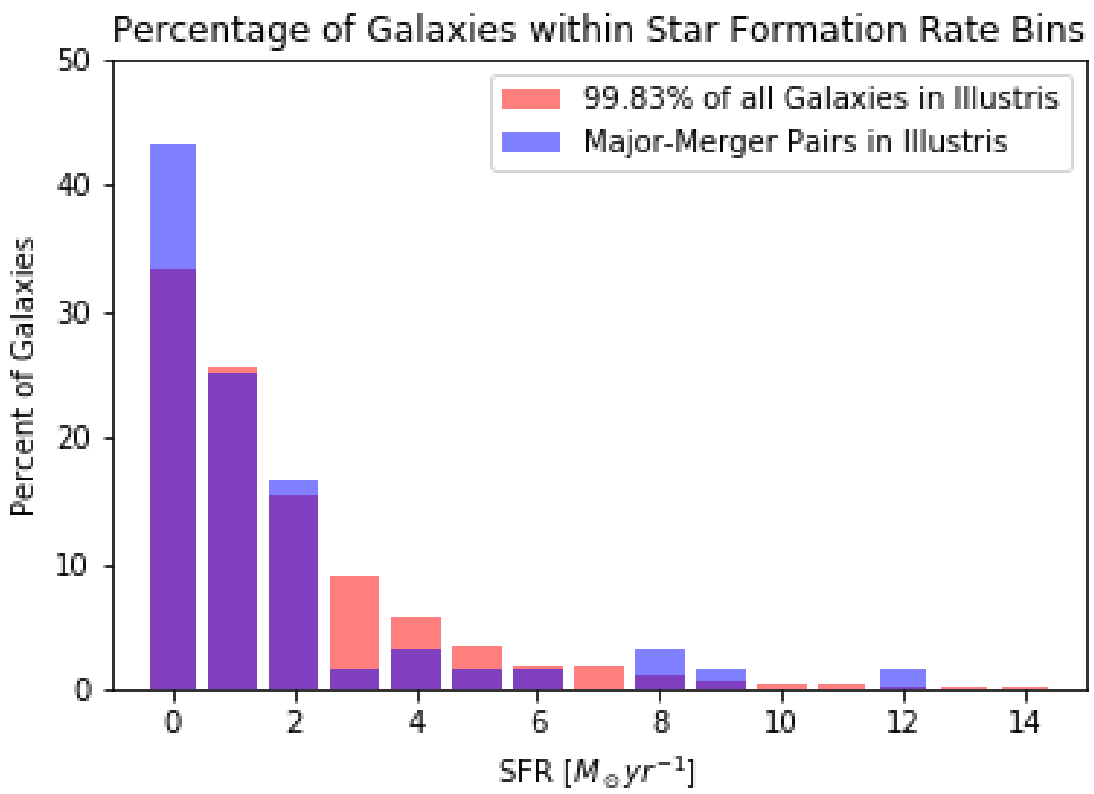

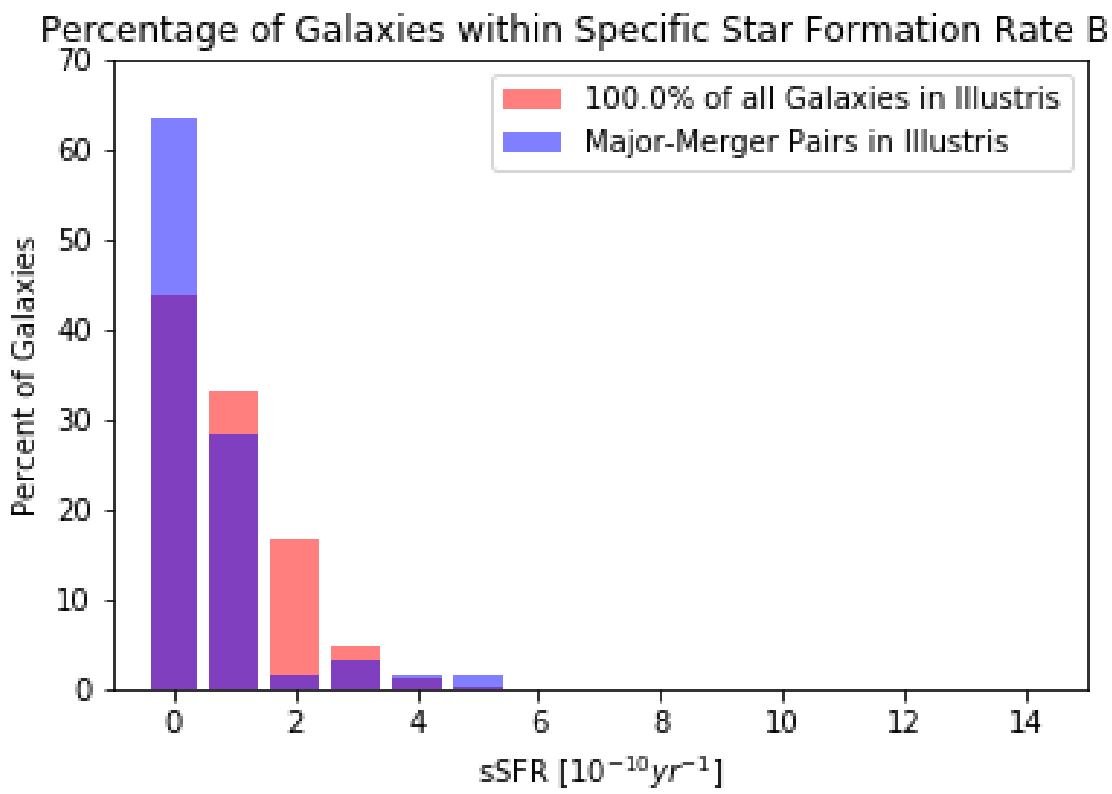

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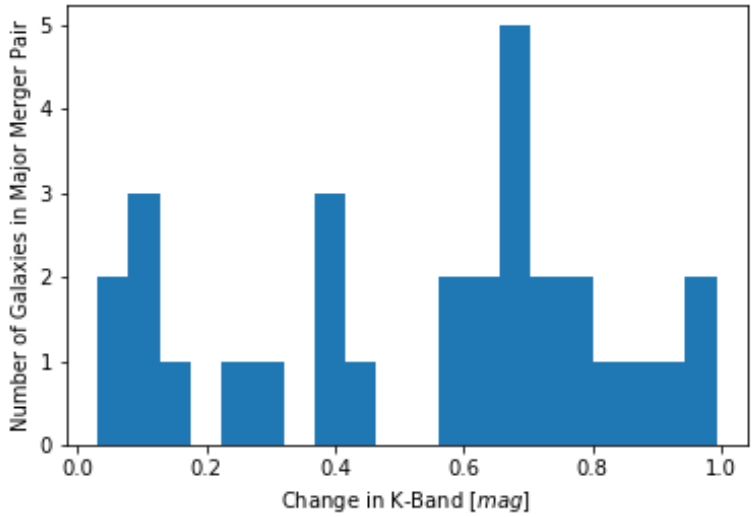
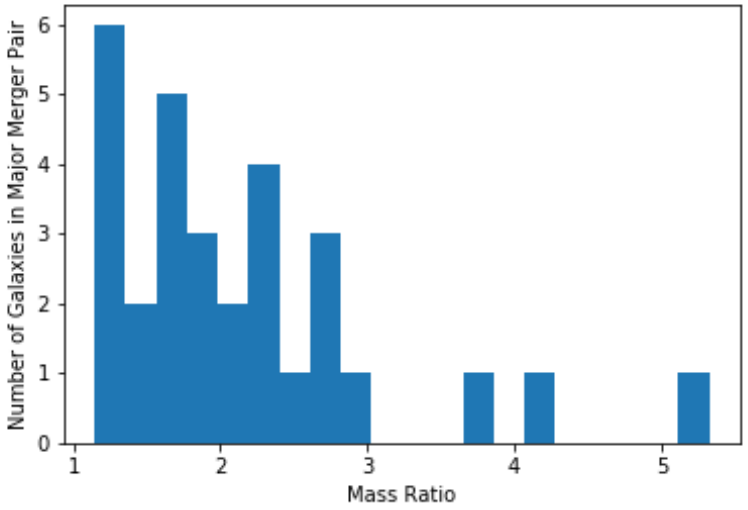
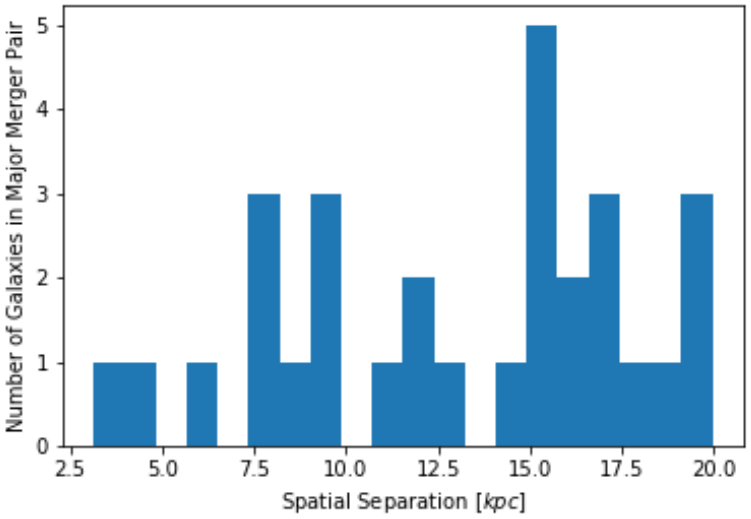
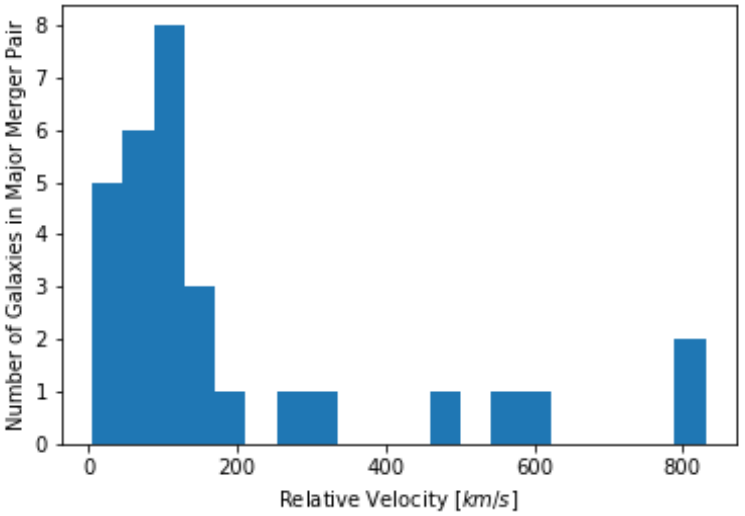








Kolmogorov–Smirnov (KS) test for Illustris galaxies

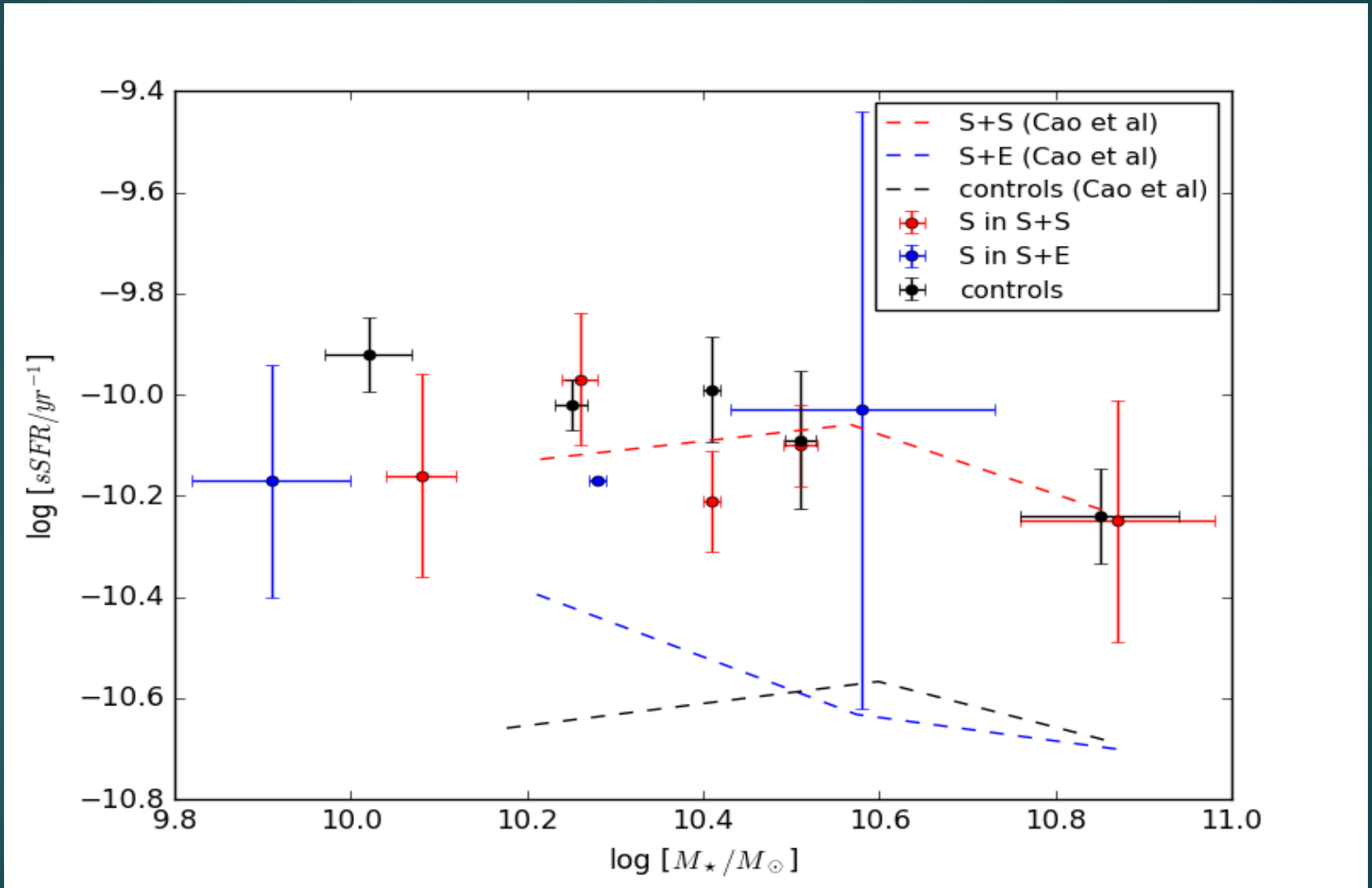
- Stellar Mass of pairs versus all galaxies with meeting mass criteria
  - P-value= 0.007
- SFR of pairs versus all galaxies with meeting mass criteria
  - P-value= 0.118
- sSFR of pairs versus all galaxies with meeting mass criteria
  - P-value=0.002

Morphology

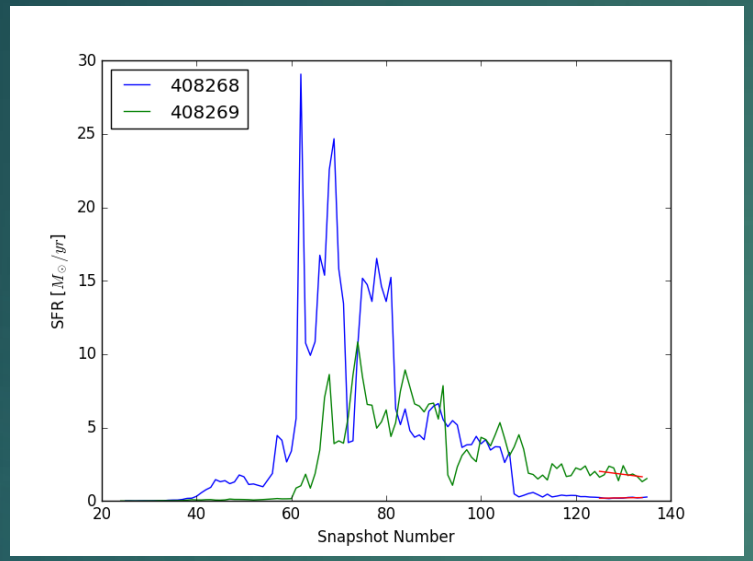
Morphologies of our simulated pairs:

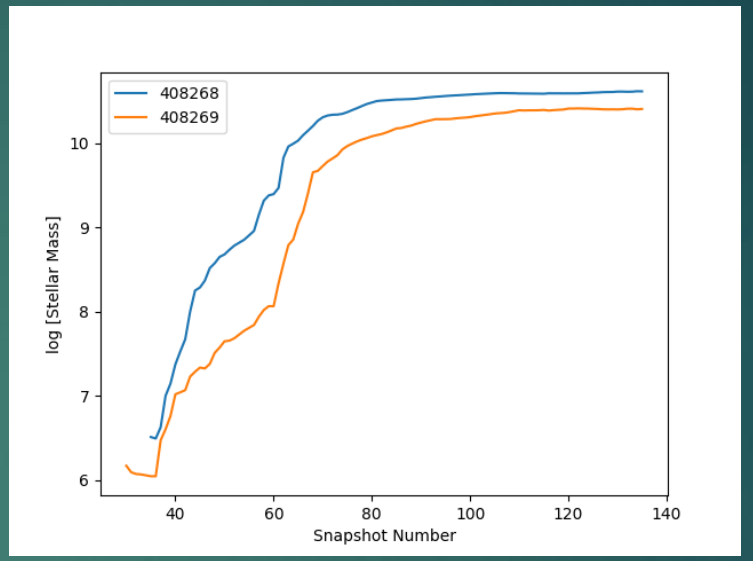
- Our galaxies were classified as 18 S+S pairs (60%), 9 E+S (30%) pairs, and 3 E+E pairs (10%).
- Xu et al.(2010) classified SDSS major merger pairs and found 15 S+S (32%), 12 E+S (25%), and 20 E+E (42%) pairs.
- This means that E+E pairs are underrepresented in Illustris while S+S are overrepresented

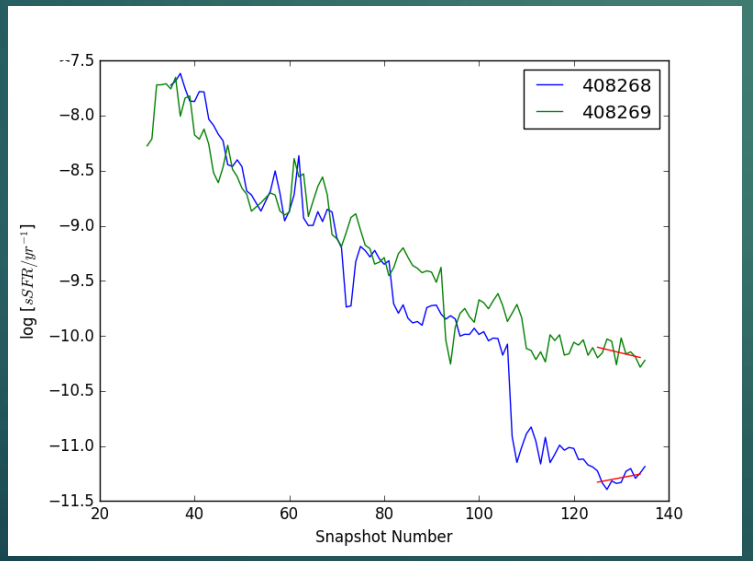
Comparison to Observations



Prepare for Pre-Pair History in Illustris!



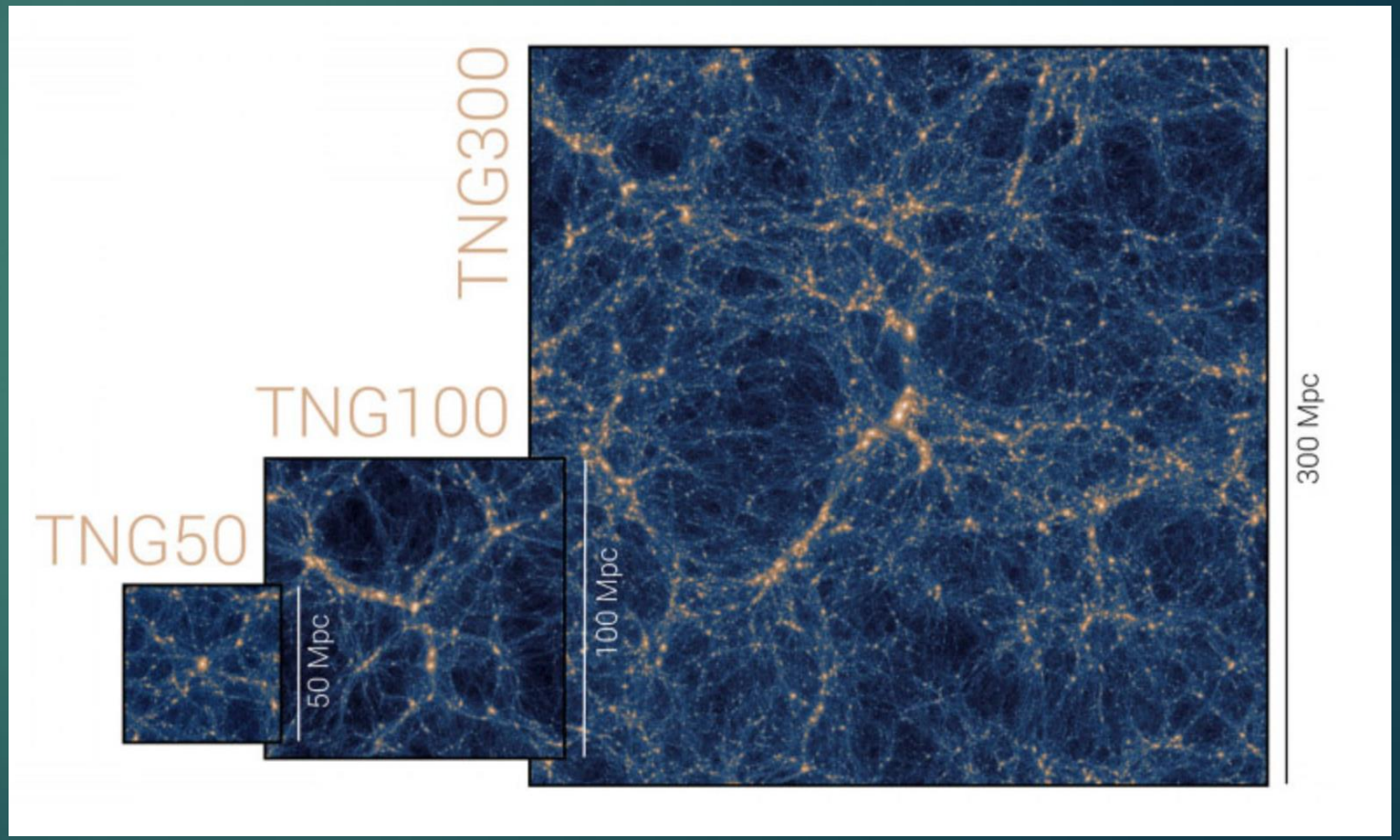




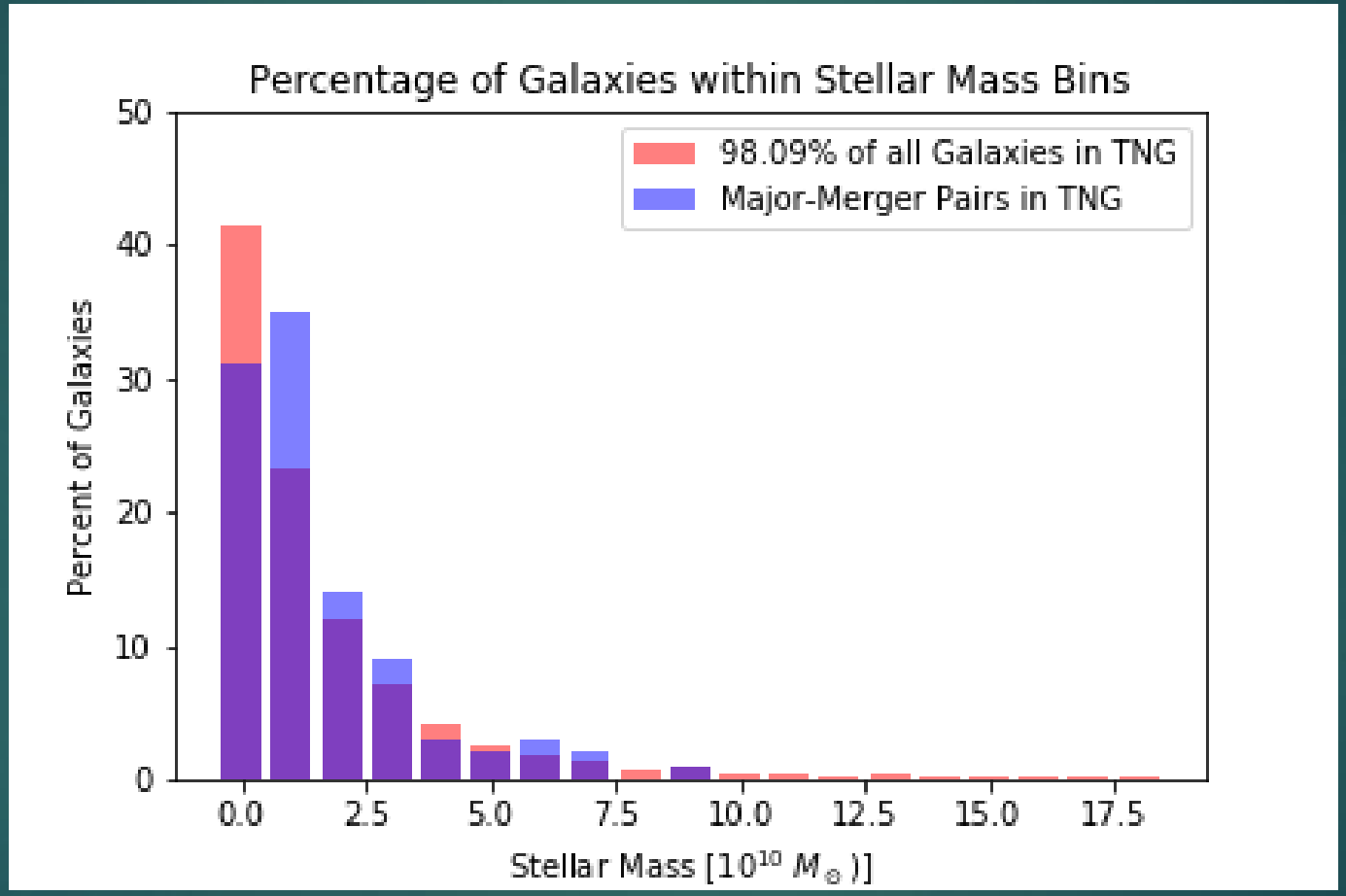
Plots of the time evolution of three quantities belonging to one S+E pair. The changes in SFR and mass both contribute to the changes in sSFR. In many of the S+E pairs, the E exhibited a large peak of SFR—likely due to its formation during a past merger. We can surmise that both the S and E galaxies had a similar sSFR during their early history, which diverges at the

IllustrisTNG

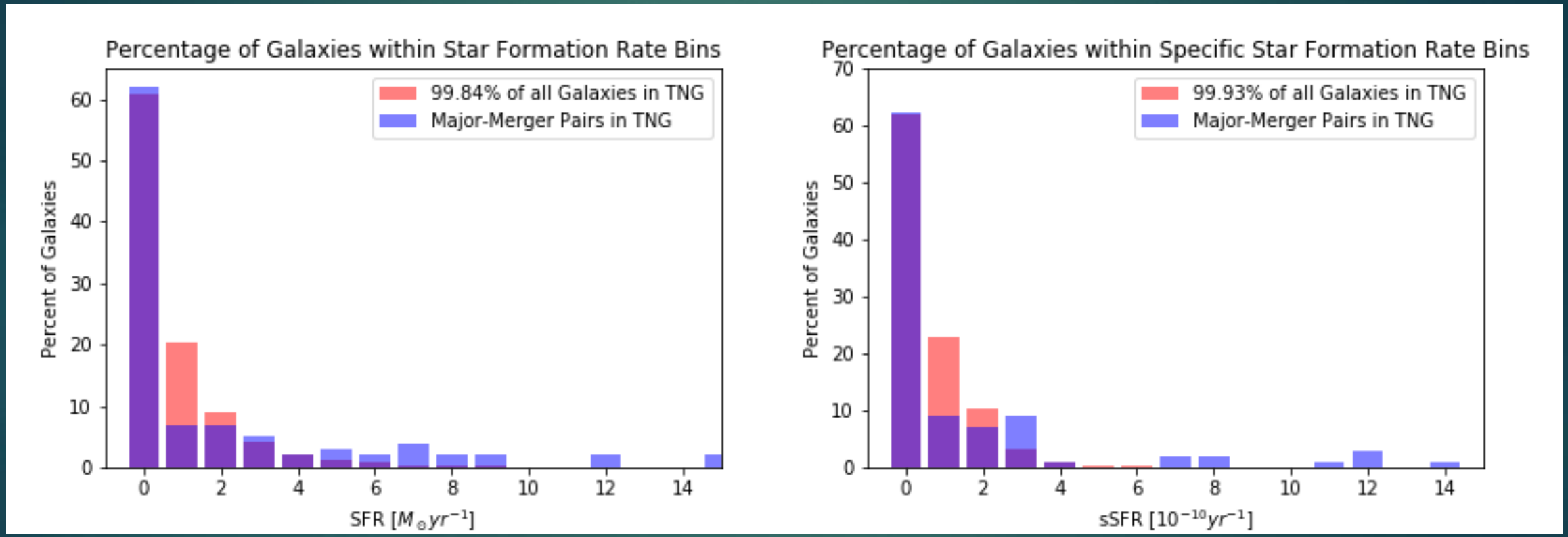
- Volume of $(302.6\ Mpc)^3$
- Springel et al. (2017)



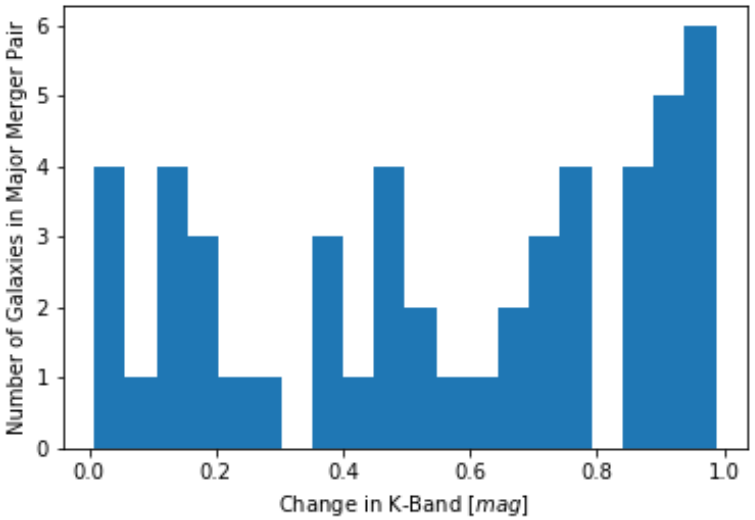
Some Initial Results

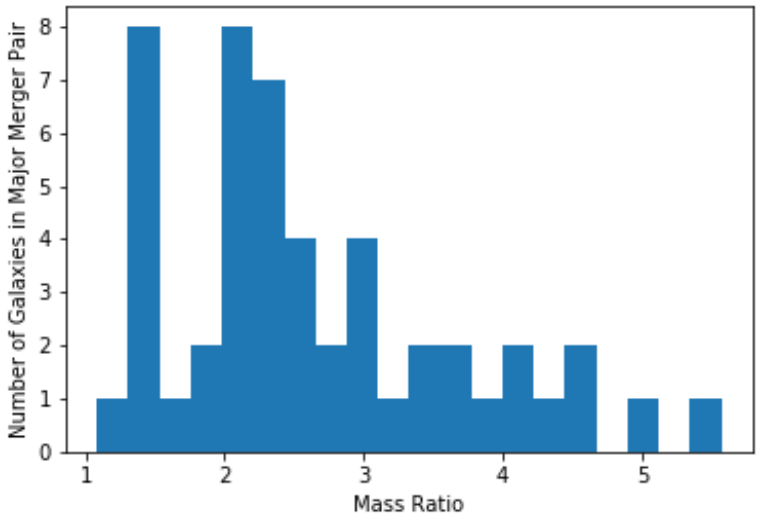


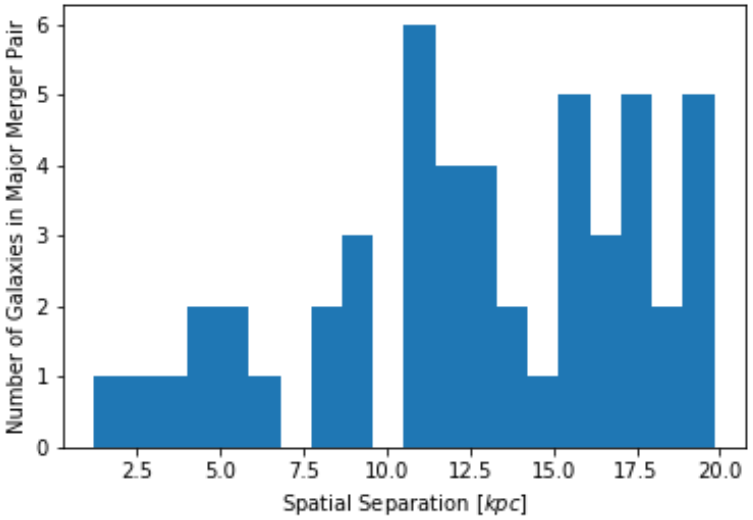
More initial results

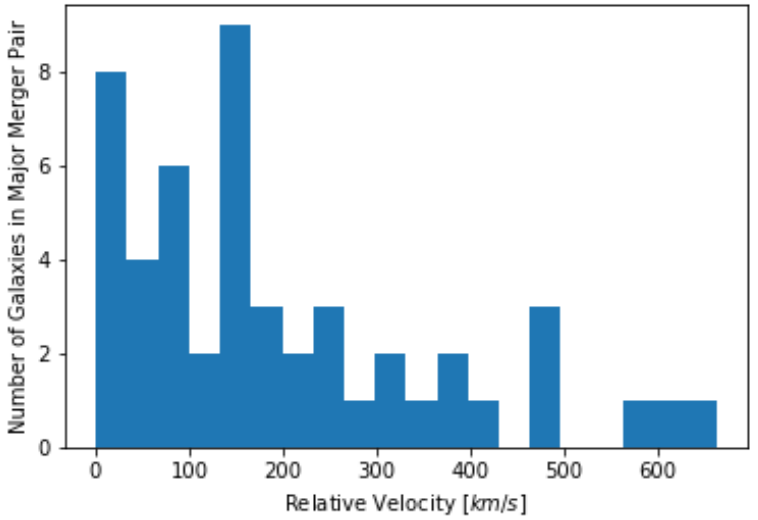


Initial Histograms









KS-testing

- Stellar Mass of pairs versus all galaxies with meeting mass criteria
  - P-value= 0.010
- SFR of pairs versus all galaxies with meeting mass criteria
  - P-value= 0.013
- sSFR of pairs versus all galaxies with meeting mass criteria
  - P-value=0.005

Future Work

- Classify morphologies in TNG
- Compare against observational data
- Plot the histories of pairs in TNG

References

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- Genel et al., 2014, MNRAS, 445, 175
- Rodriguez-Gomez et al., 2016, MNRAS, 458, 2371
- Rodriguez-Gomez et al., 2018, arXiv:1809.08239
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