

JWST Reveals a Surprisingly High Fraction of Galaxies Being Spiral-like in the Early Universe

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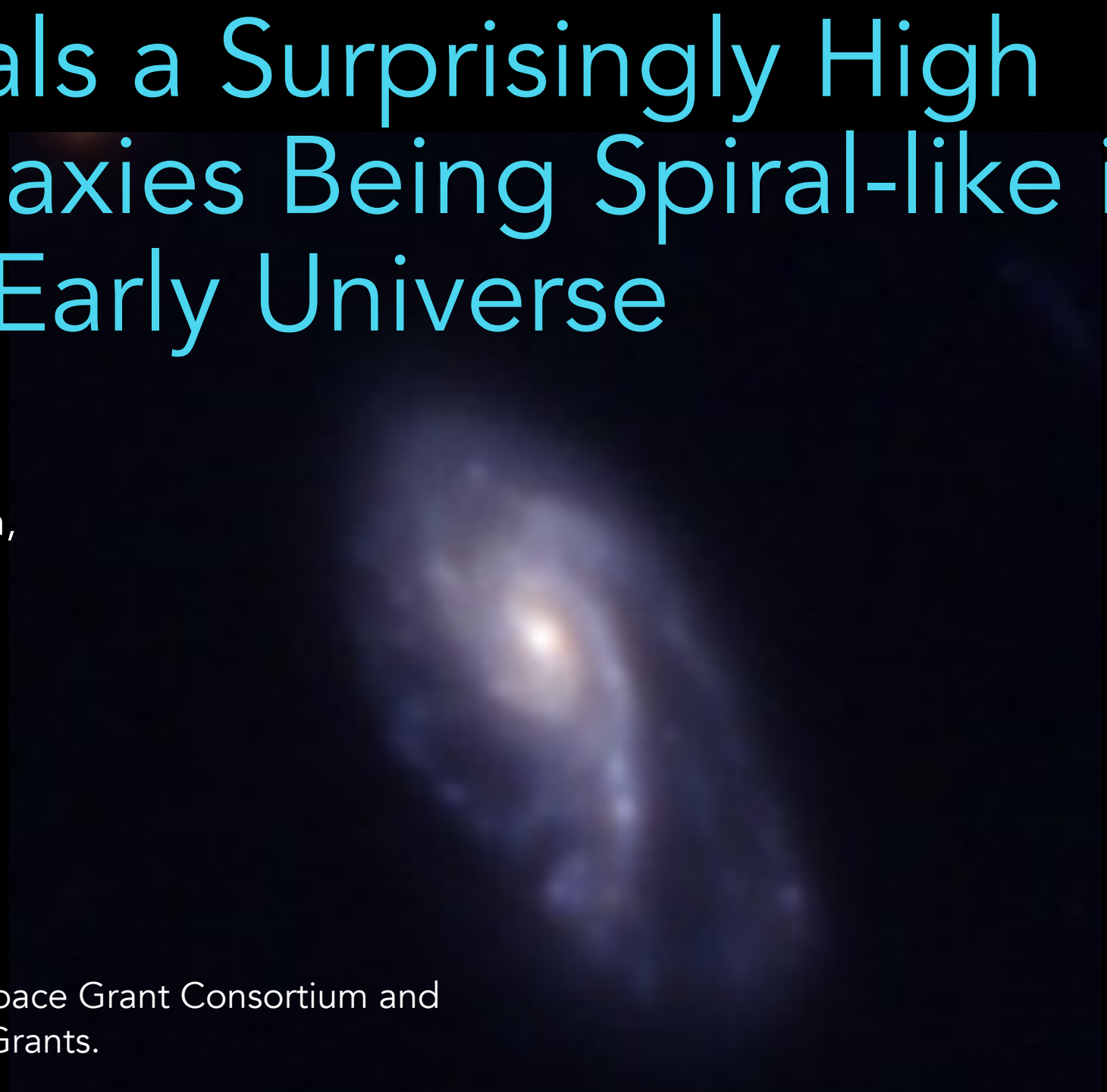
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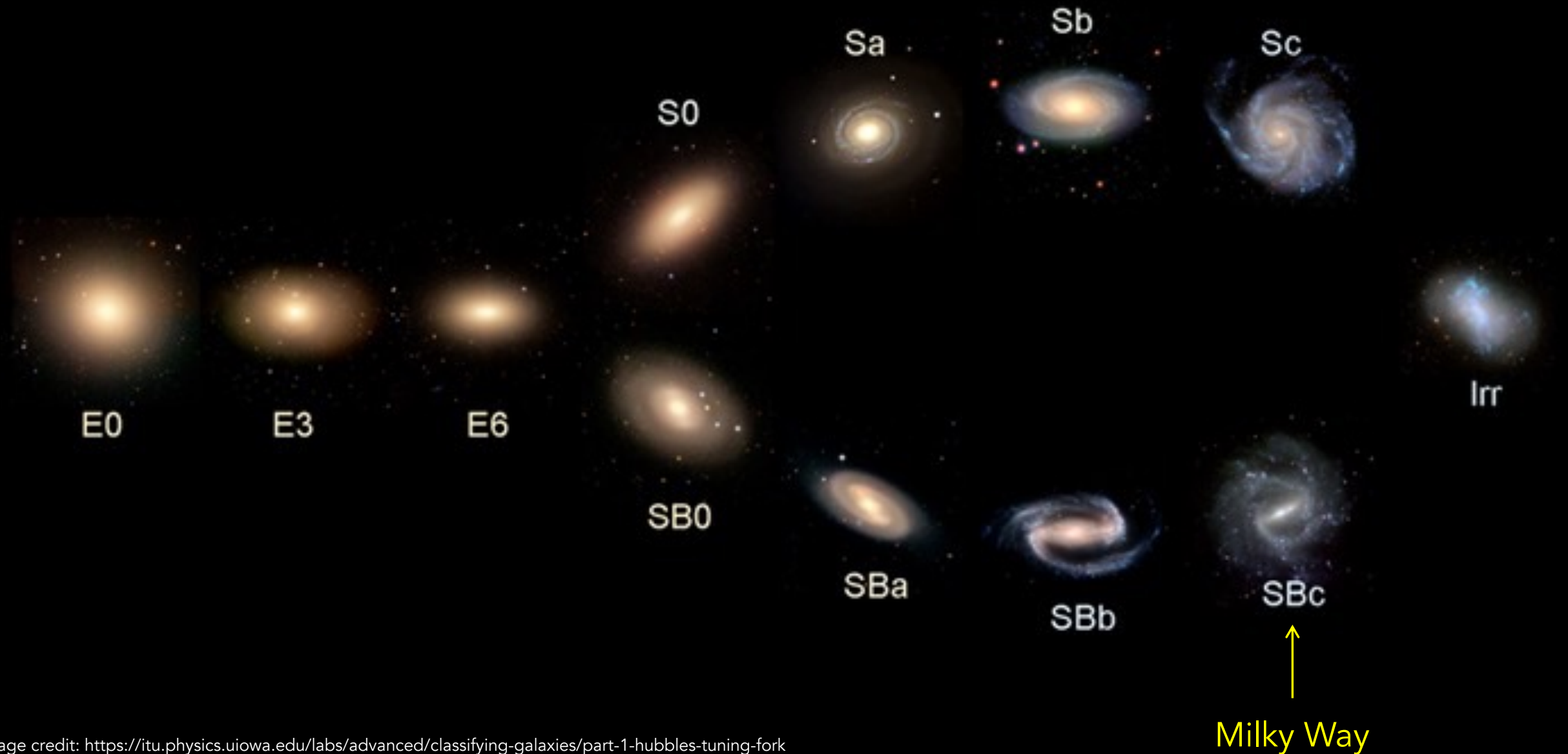
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Hubble's Galaxy Classification Scheme



Current Questions

- When do spiral galaxies first appear?
- What age is the Universe when the Hubble Sequence is established?

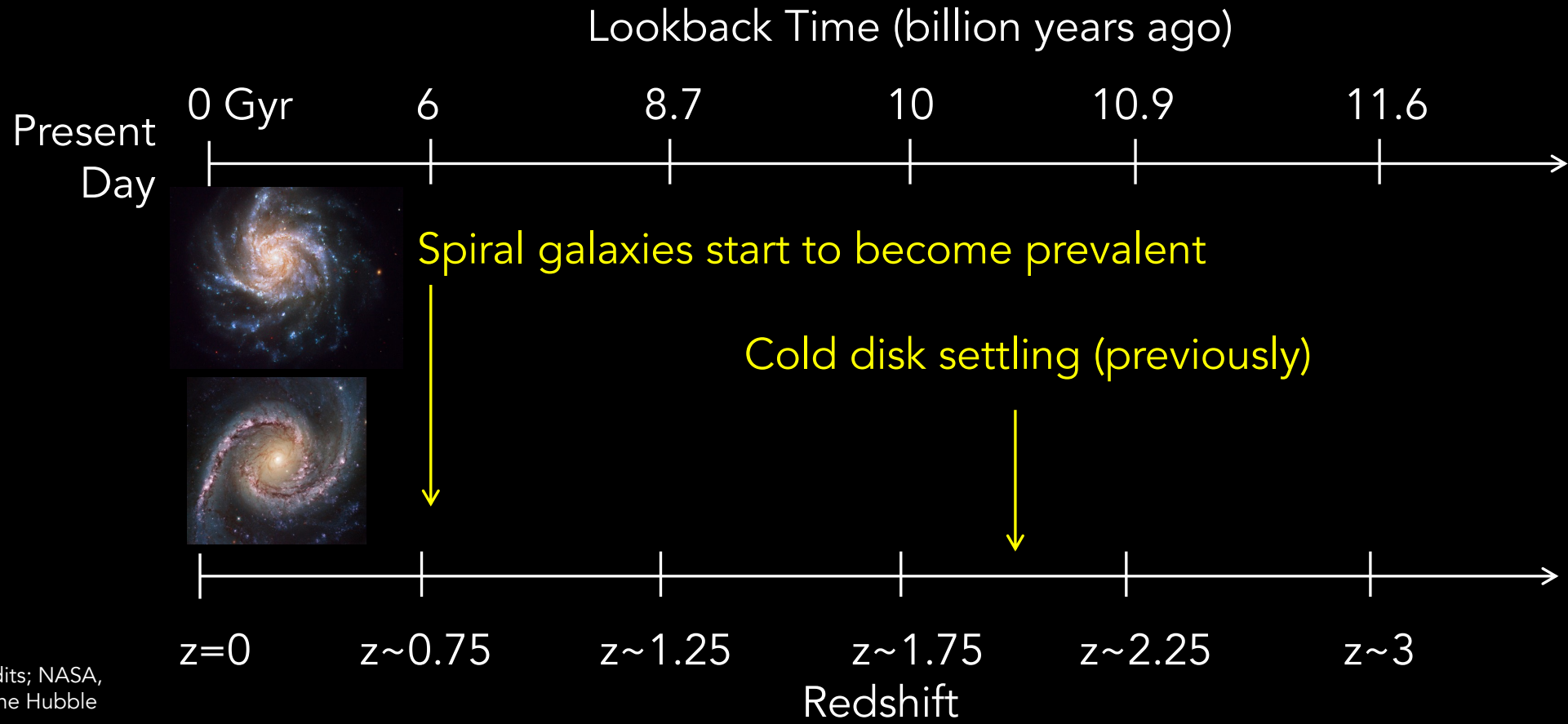
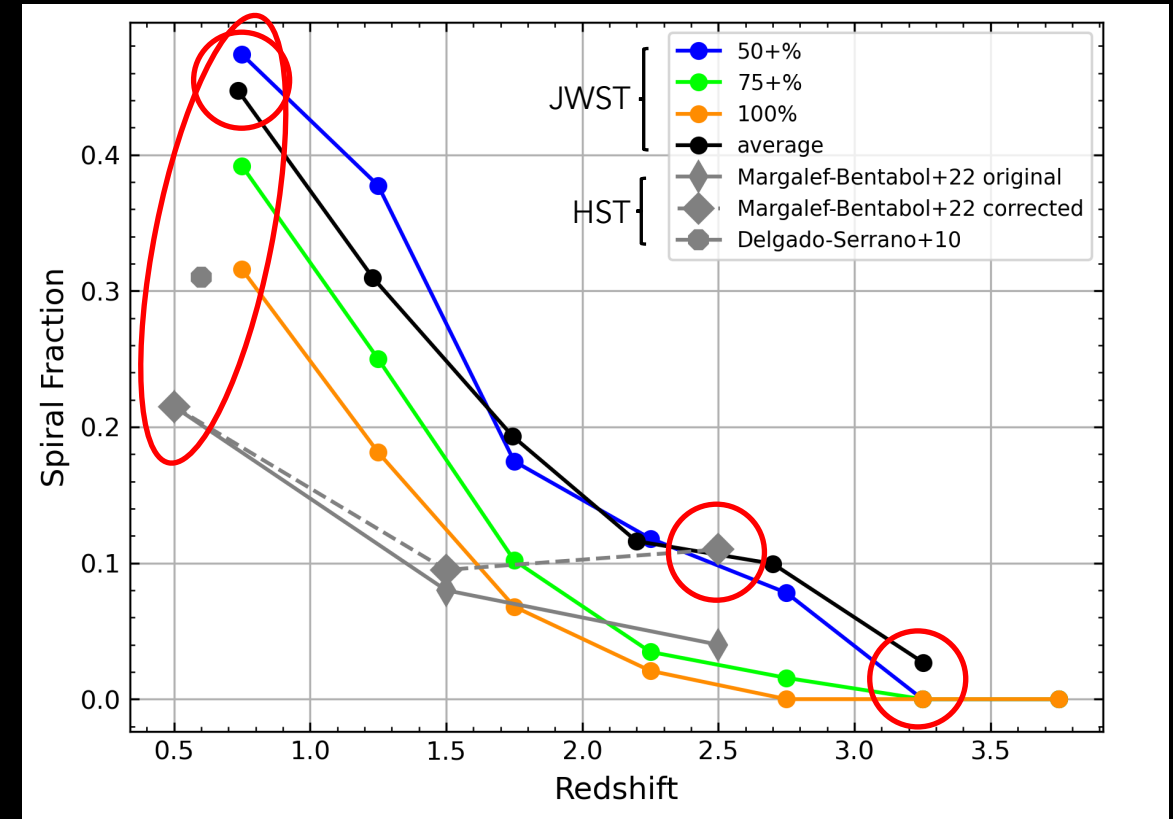


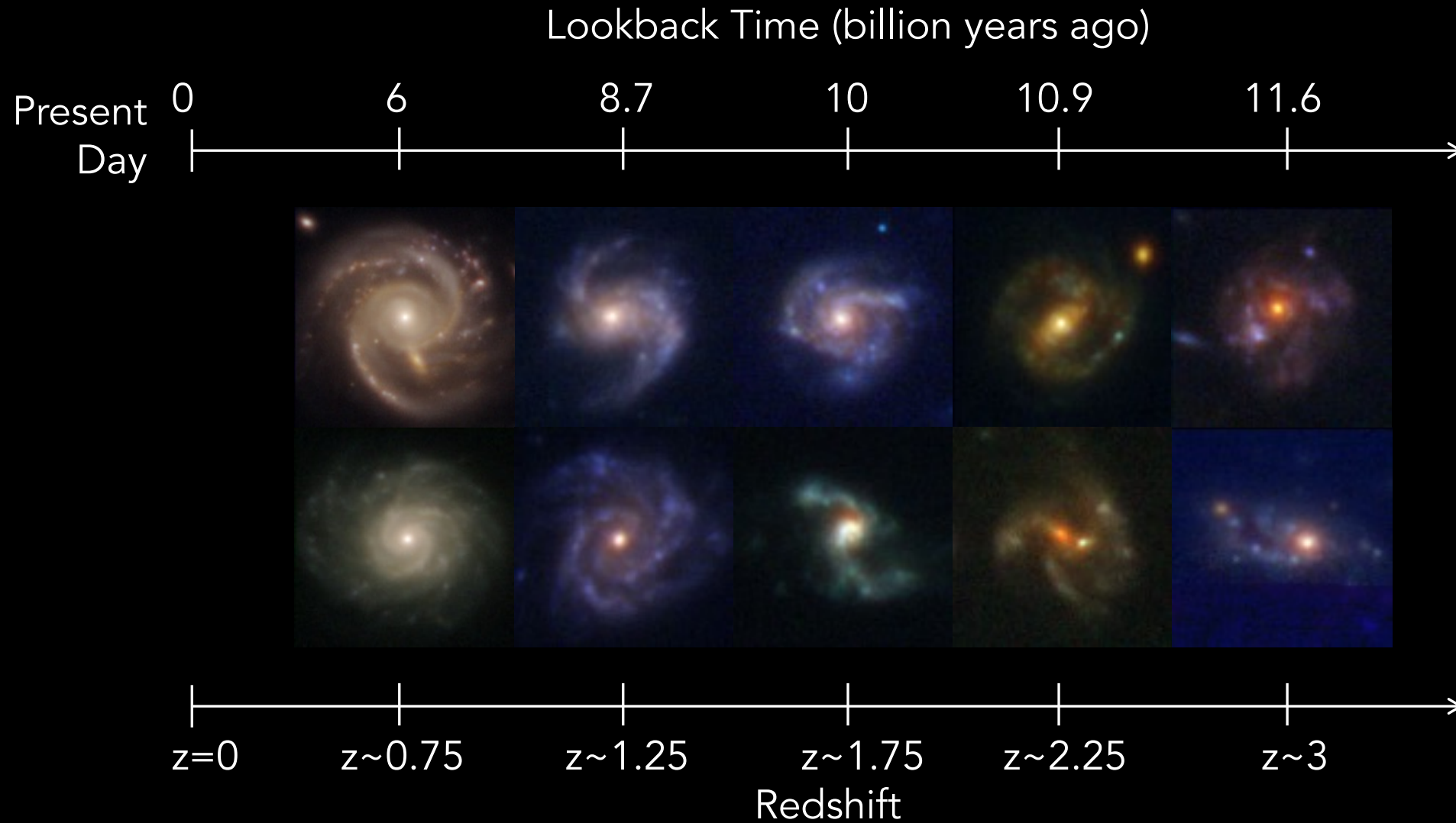
Image credits; NASA, ESA, and the Hubble Heritage Team

Spiral Inspection

- We visually inspected 873 high mass galaxies at $0.5 \leq z \leq 4$.
 - Was spiral structure present?
- A galaxy is spiral if it has 3 or more votes.
- Even without correcting for observational effects, JWST is already surpassing HST.

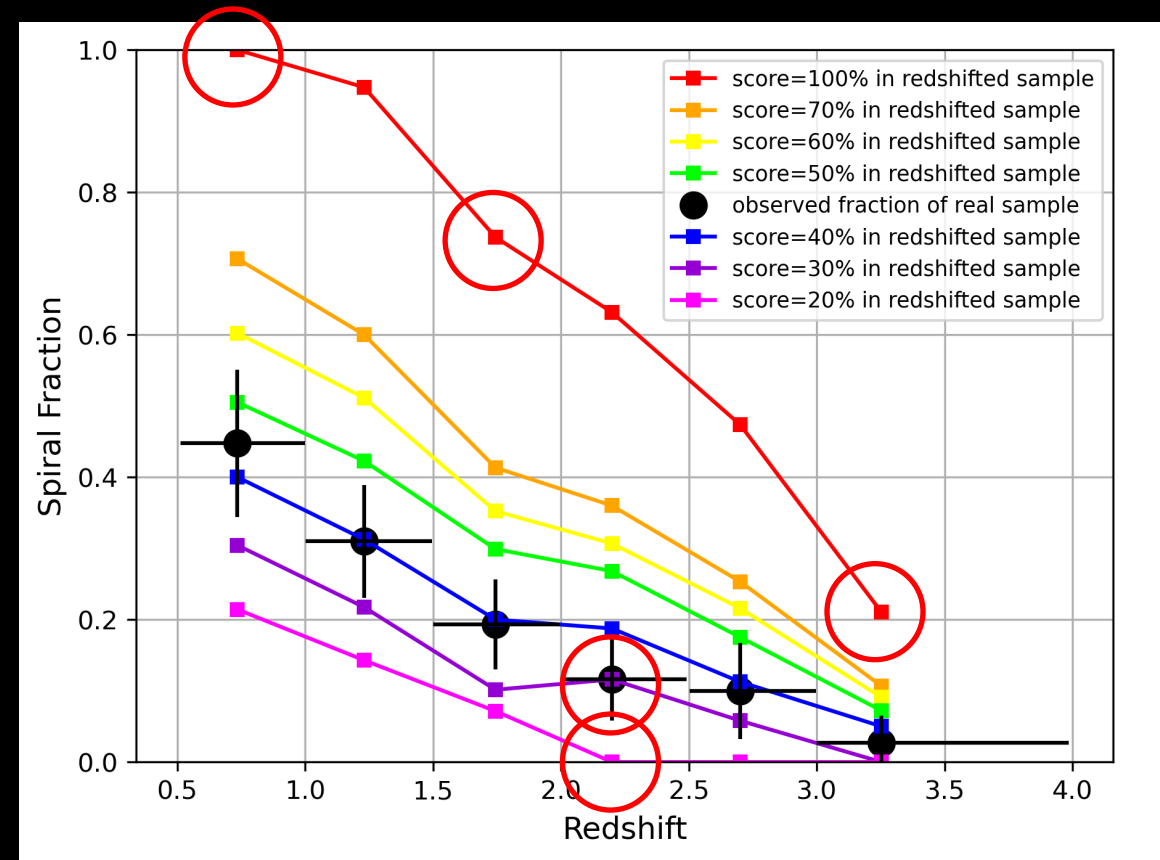
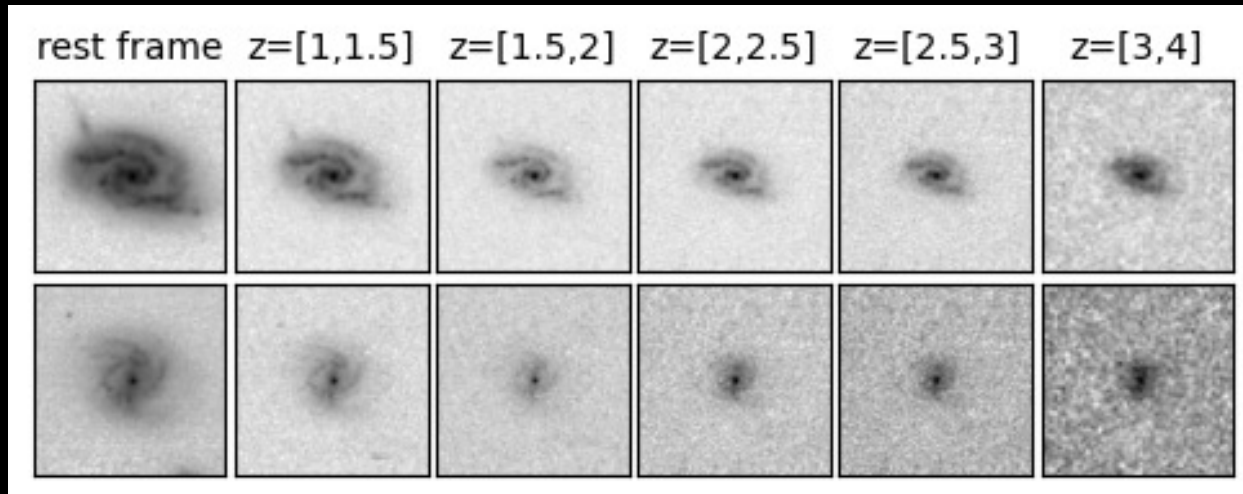


Spiral Galaxies

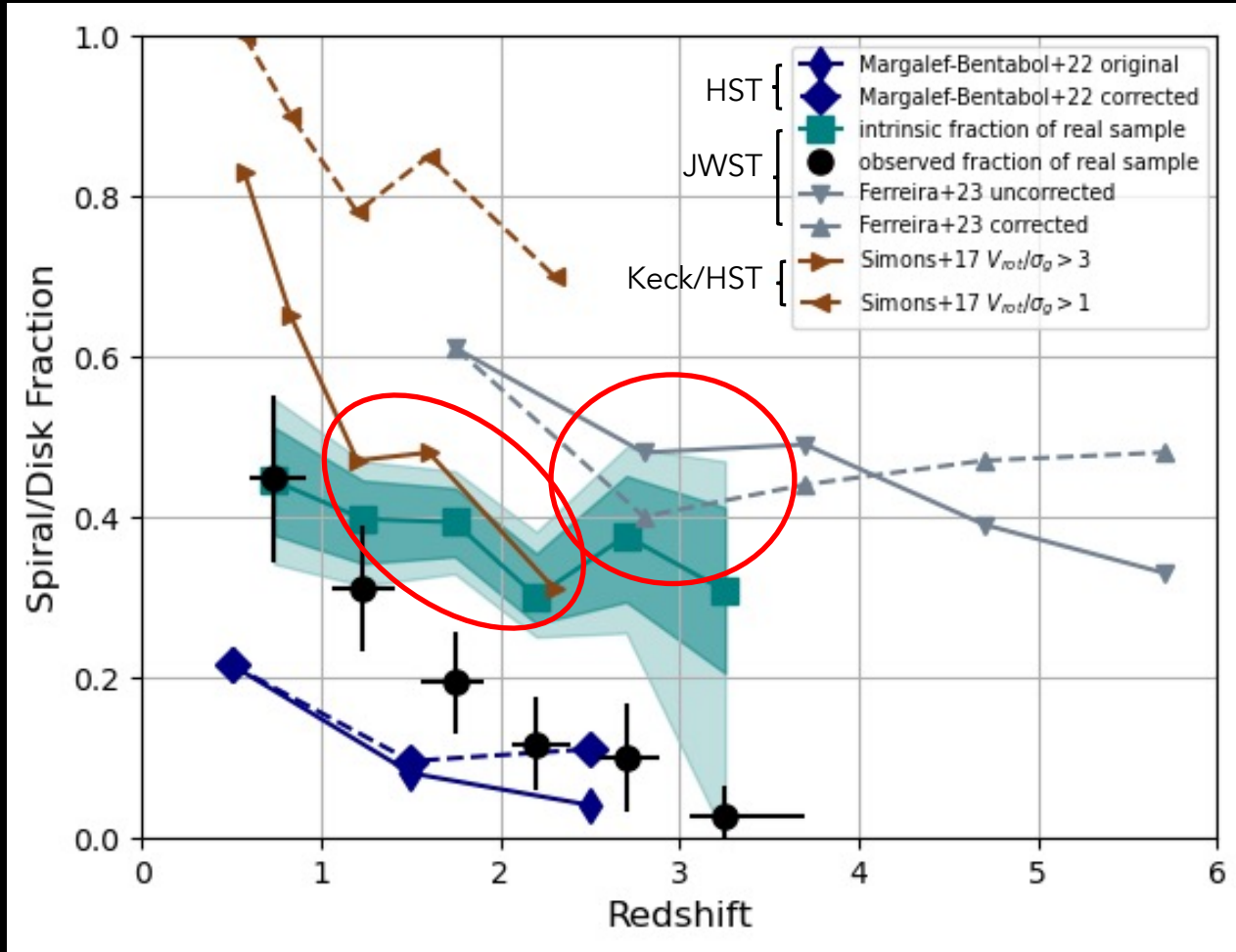


Mock High-z Results

- Simulations are used to correct for observational effects (e.g. flux, size, distance, and PSF).
- Black points are the true observed fraction of spiral galaxies.



Main Results



- Spiral galaxies surprisingly make up $\sim 30\%$ of galaxies at $z \sim 3$!
- The fraction of disk galaxies in the early universe is $\sim 50\%$.
- Spiral arms and cold, settled disks occur at the same cosmic time.

Summary

- JWST found 4x more spiral galaxies than HST had previously ~11 billion years ago!
- Spiral/Disk galaxies became prevalent when the Universe was ~2 billion years old.
- Galaxies settled early in cosmic time, bringing a new challenge to modeling galaxy formation.

Spiral galaxies start to become prevalent

