The Angular Momentum Distribution in High Redshift Galaxies

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Contents

- The Hubble Sequence and Angular Momentum
- Adaptive Optics Sample

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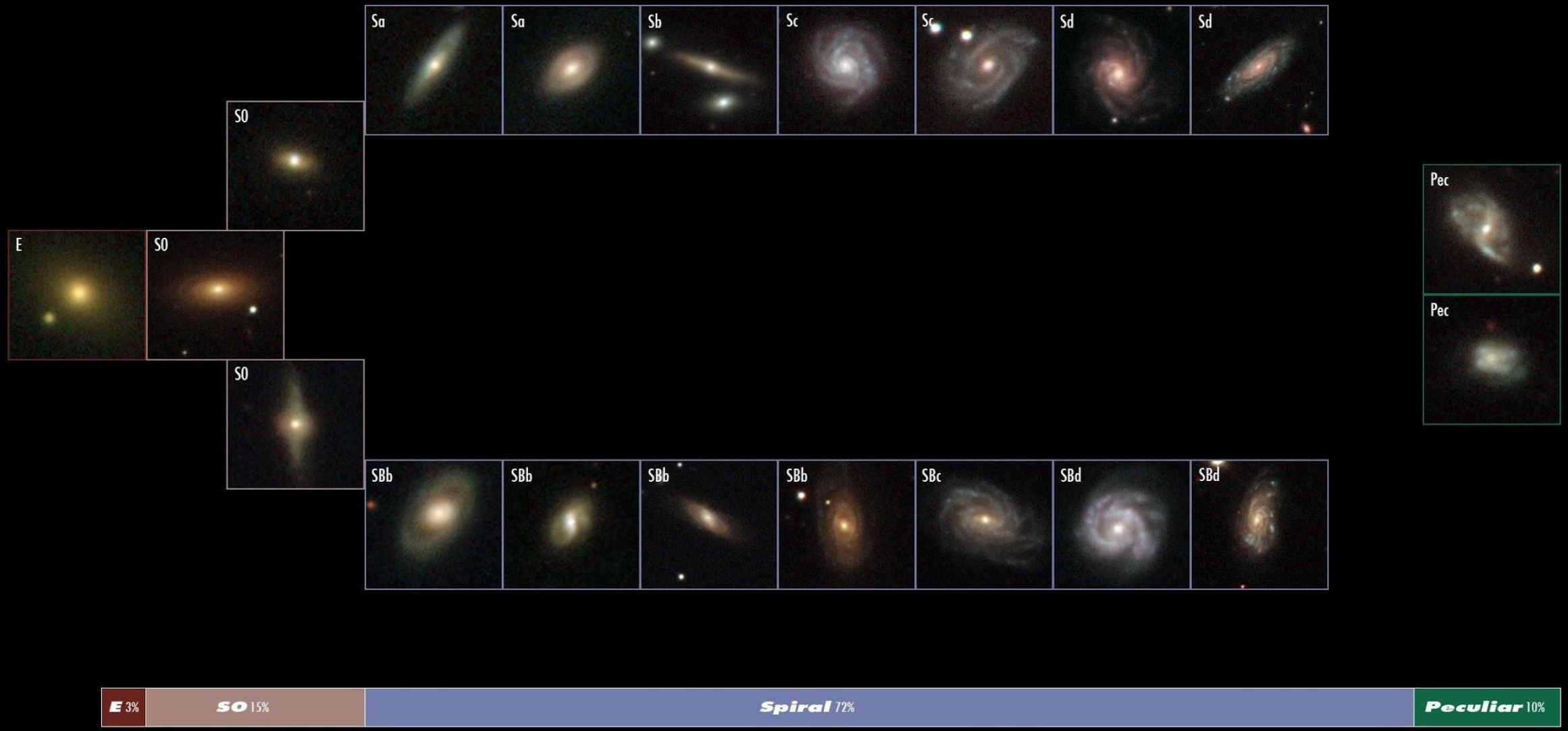
Local Galaxies



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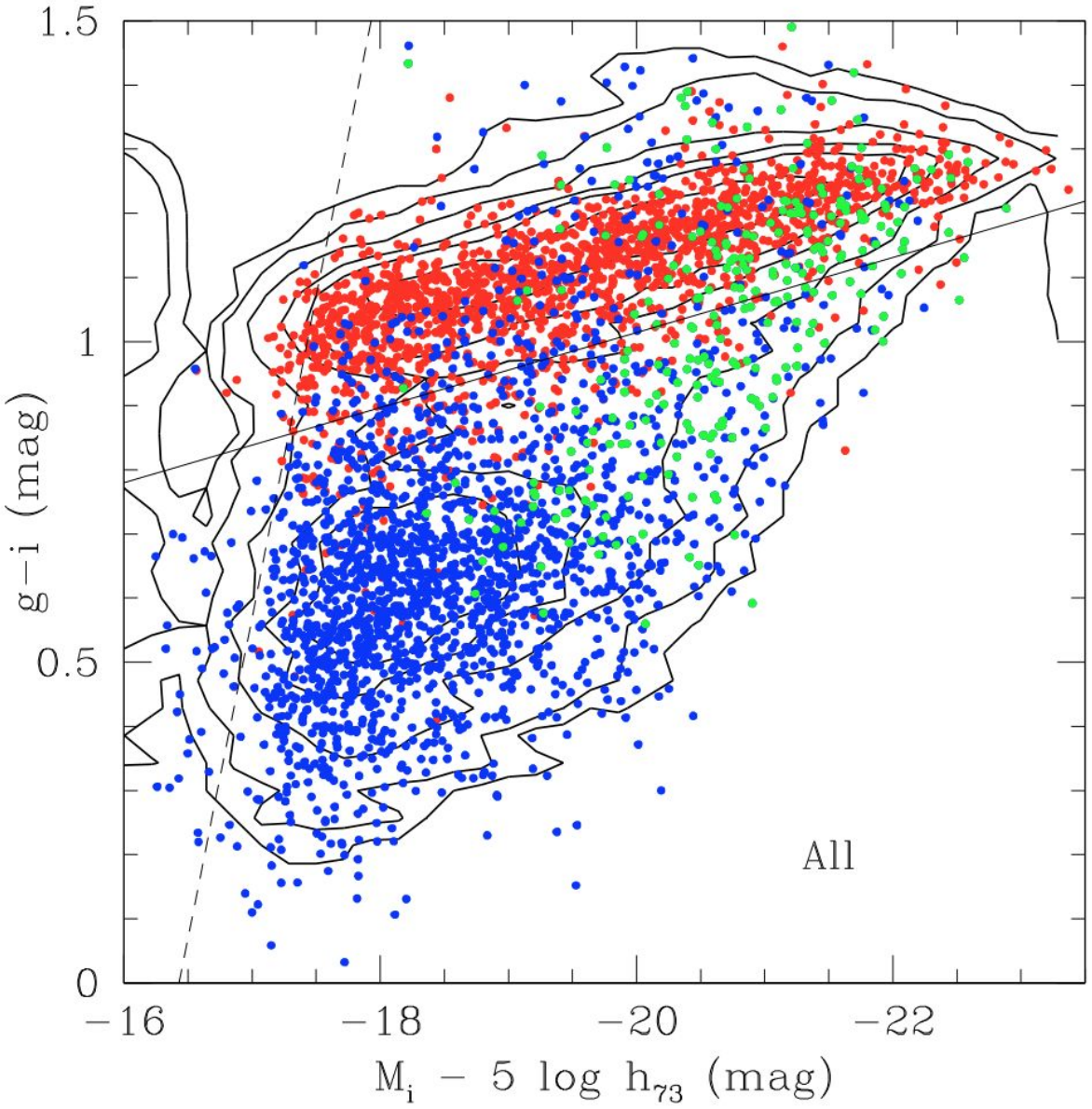
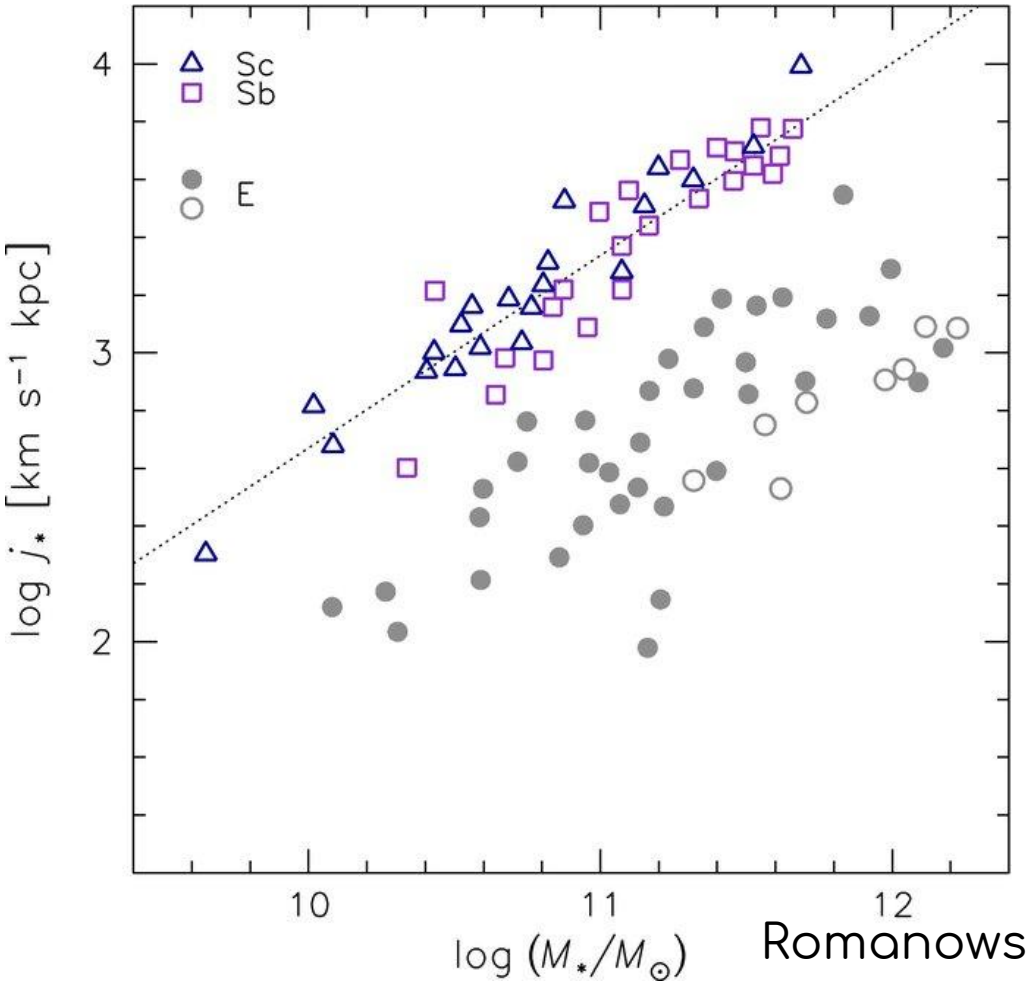
Colour Bimodality

- SDSS DR7 sample of ~4000 galaxies at z~0
  - red = early-type galaxies (E-S0) ;
  - blue = disk galaxies (Sbc-Im);
  - green = bulge galaxies (Sa-Sb).



Gavazzi et al 2010

Angular Momentum of Galaxy Disks



Romanowsky & Fall 2012

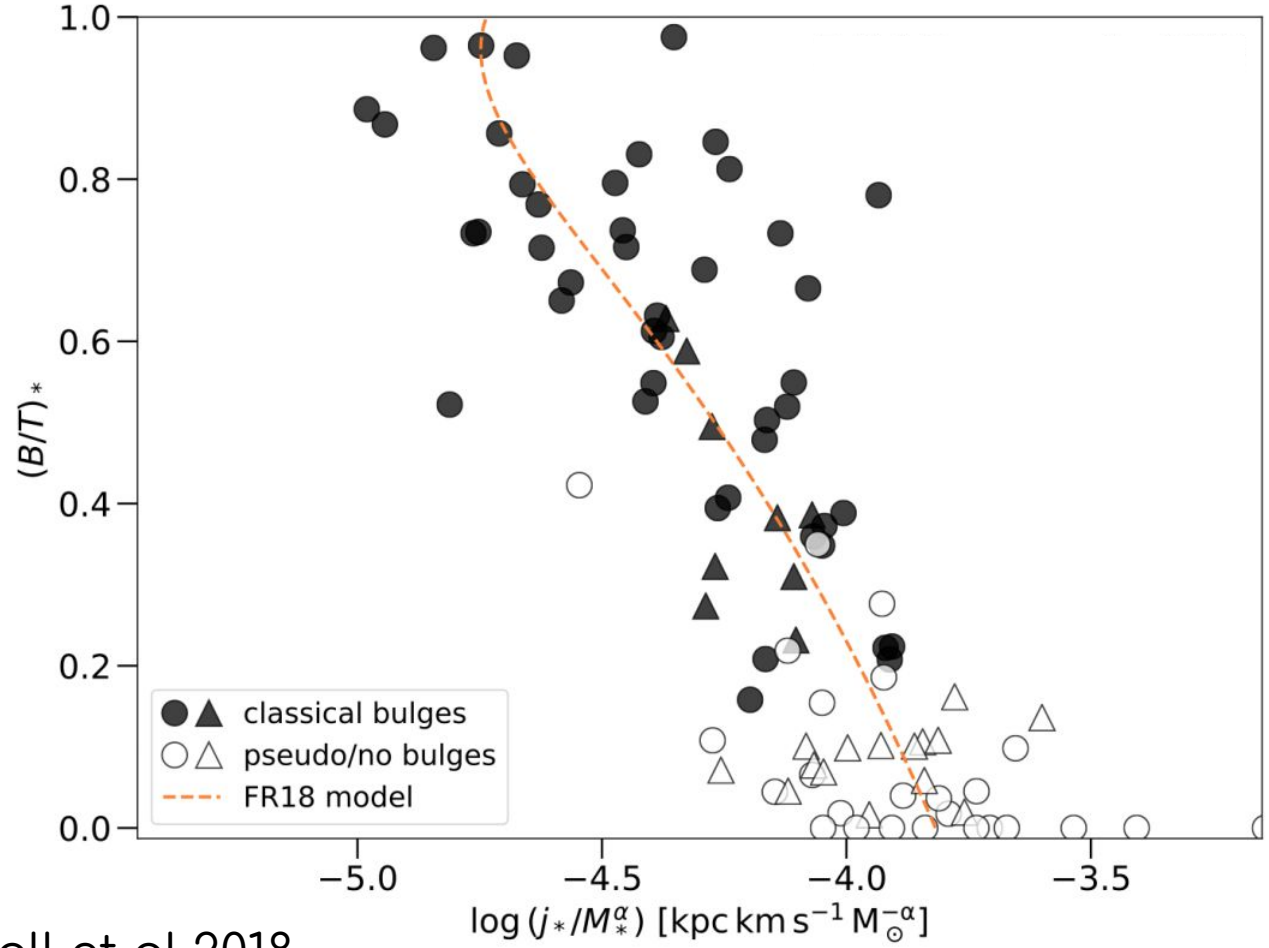
- True Specific Angular Momentum is given by;

$$\mathbf{j}_\mathrm{t} \equiv \frac{\mathbf{J}_\mathrm{t}}{M_\star} = \frac{\int_\mathbf{r} \mathbf{r} \times \bar{\mathbf{v}} \rho \, d^3\mathbf{r}}{\int_\mathbf{r} \rho \, d^3\mathbf{r}}$$

- For a exponential disk this simplifies to;

$$j_\mathrm{t} = 2 \, v_\mathrm{c} \, R_\mathrm{d}$$

Angular Momentum and B/T

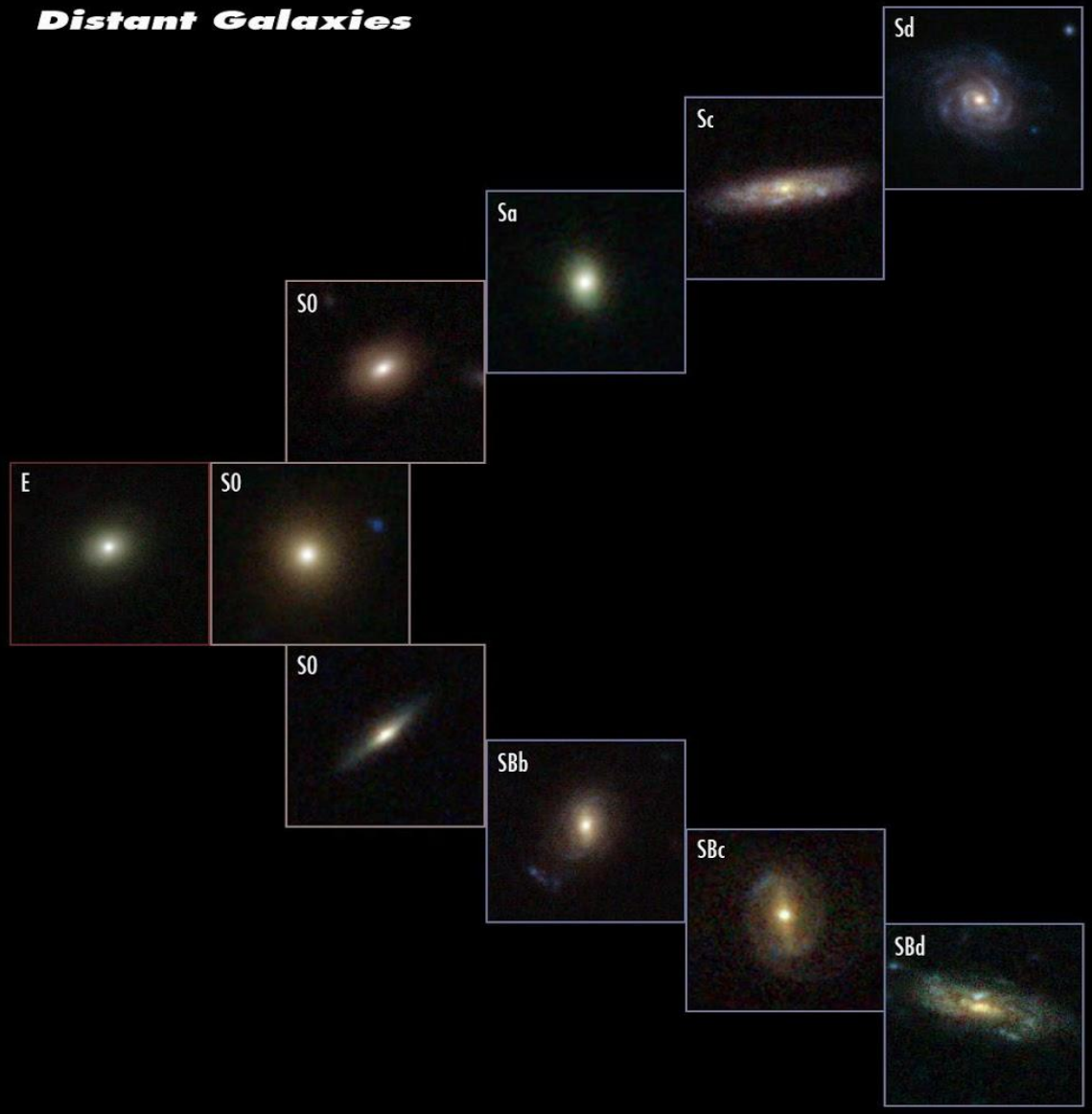


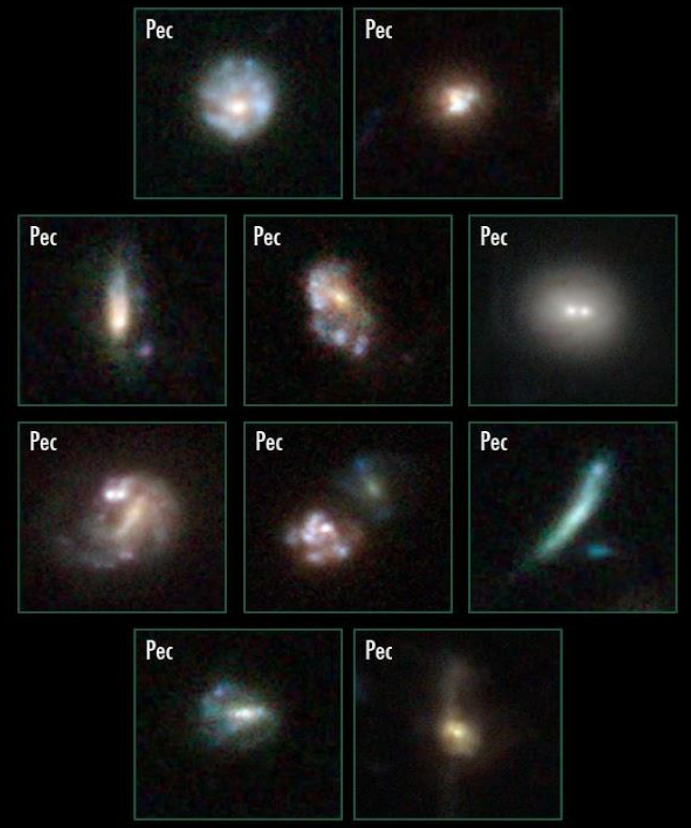
Fall et al 2018

Correlation between B/T and j^*/M^*?

Can we measure j_* at high redshift?

Distant Galaxies





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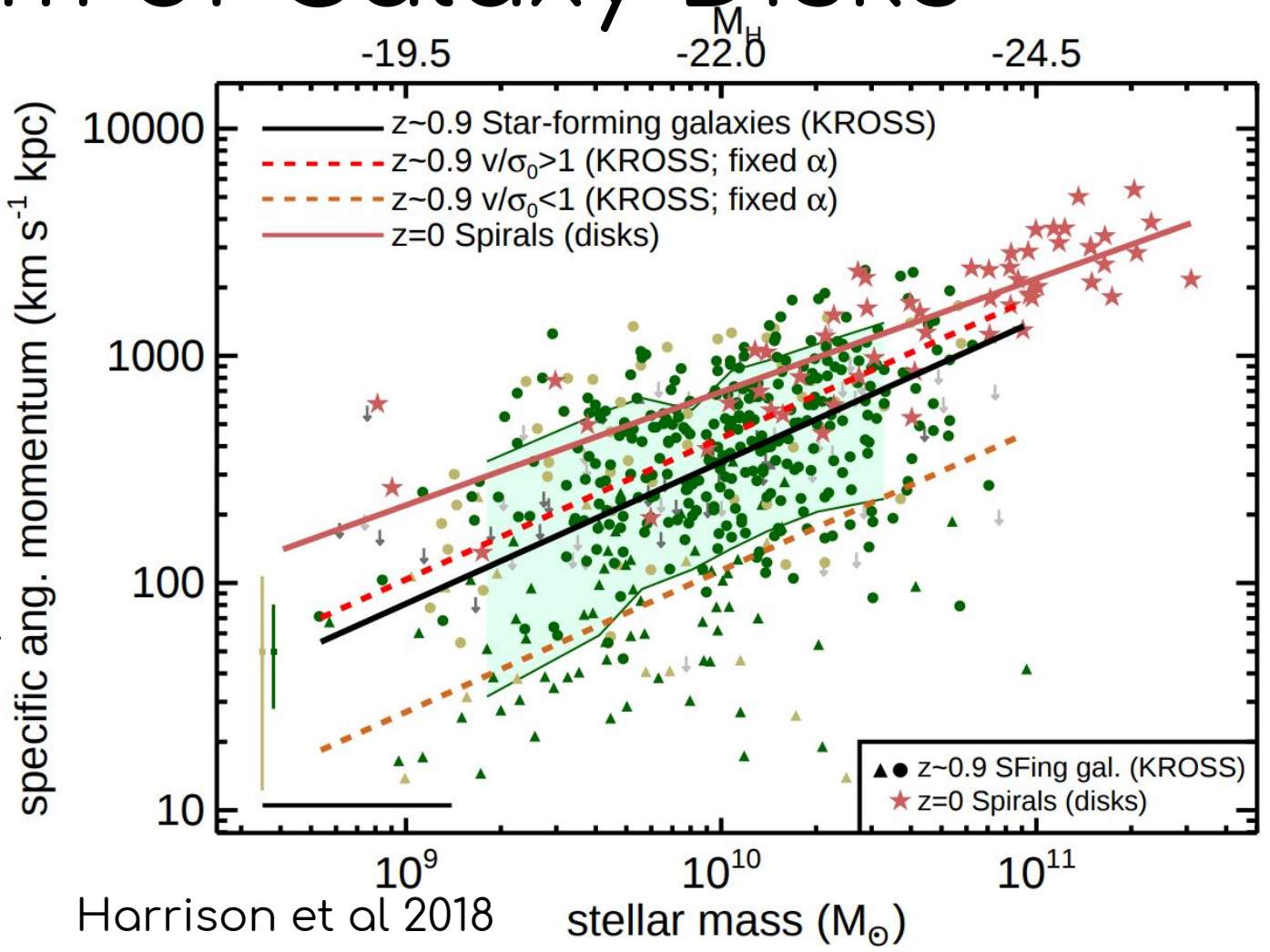
Angular Momentum of Galaxy Disks

=> Morphology and angular momentum evolve with redshift

=> What processes are driving this? What happens to the internal distribution of angular momentum with z?



Harrison et al 2018

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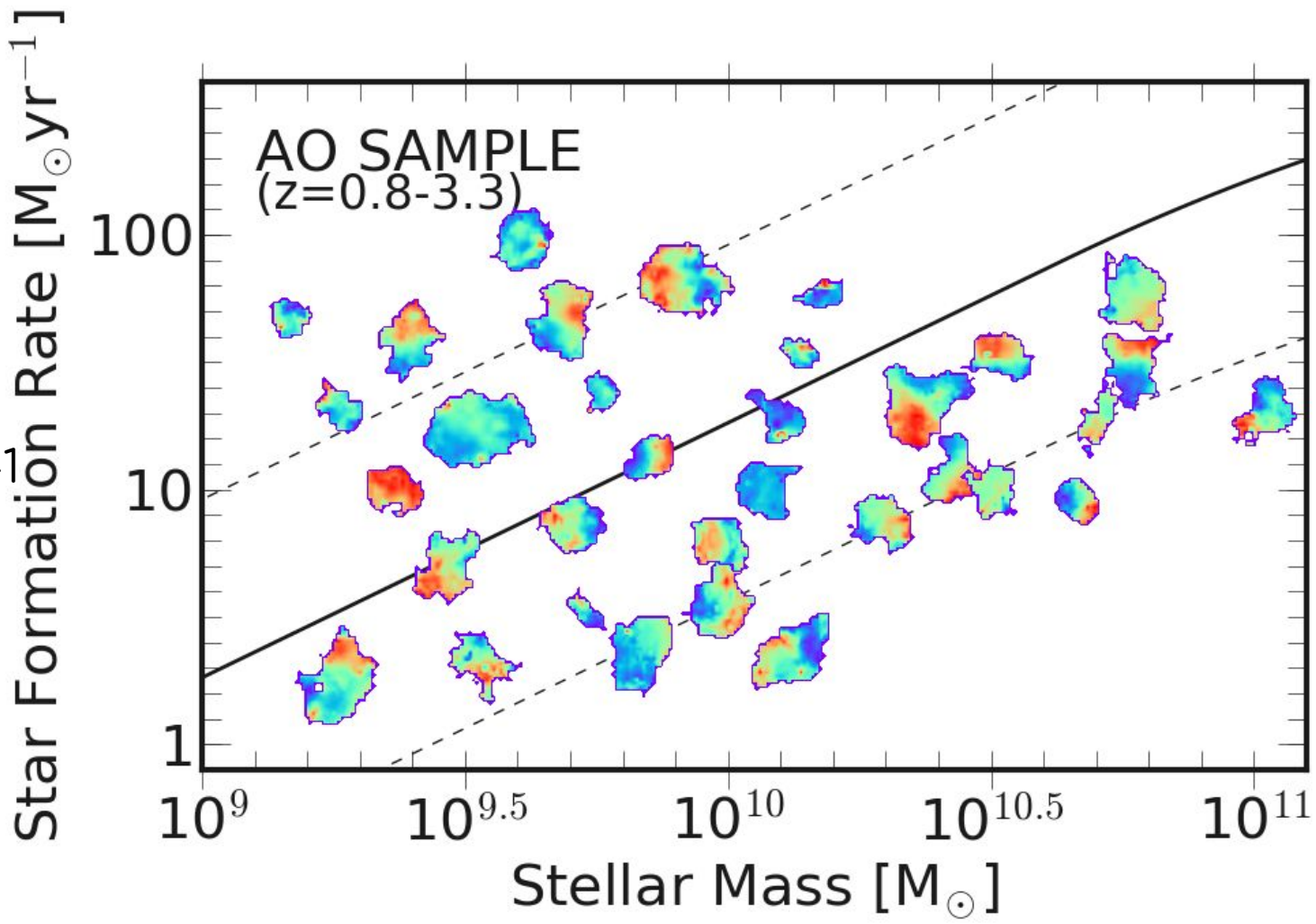
The Adaptive Optics Sample

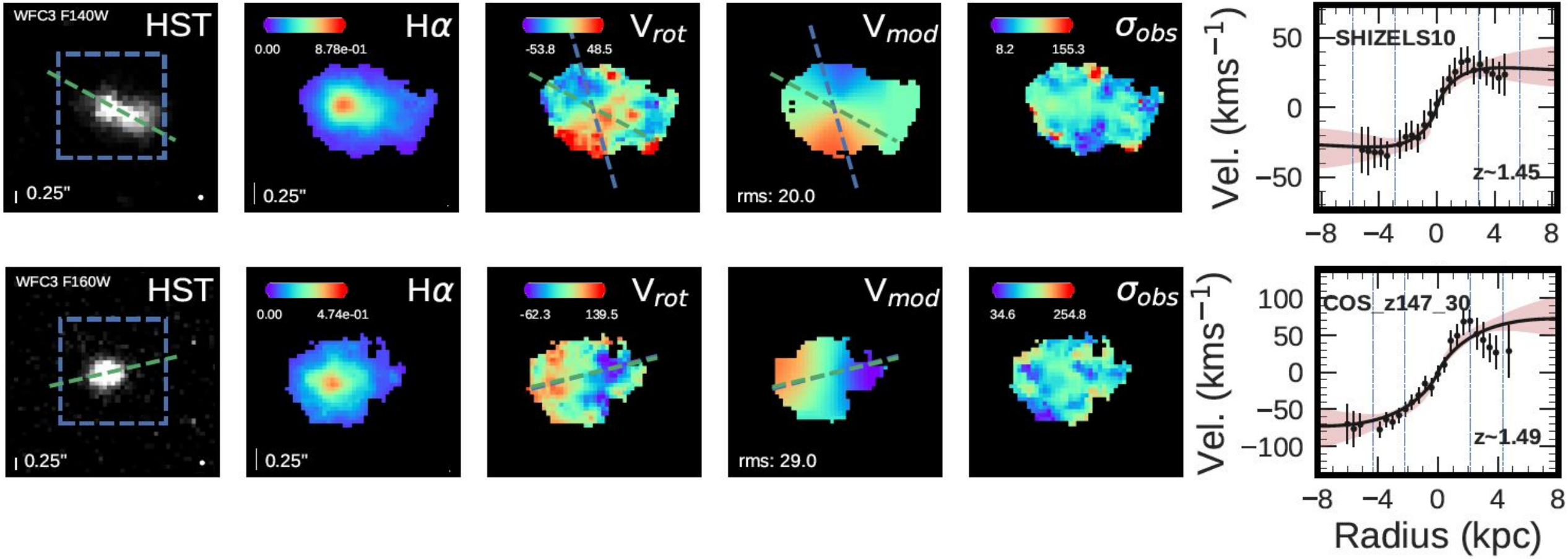
- 34 star forming main sequence galaxies from $0.8 < z < 3.33$
- Selected to be 25" from NGS to allow AO capabilities
- Using Hα and [NII] to trace star formation for $0.8 < z < 2.22$ and [OIII] for $z>3$ targets
- Ancillary photometric HST data for COSMOS and UDS K-band ground based for SA22 targets.

The Sample

- $\langle R_h \rangle = 0.''40 \pm 0.''06 \sim 4$kpc
- $\langle V_{2Rh} \rangle = 112$ kms^{-1} $\pm$ 30 kms^{-1}
- $\langle \sigma_{median} \rangle = 83$ kms^{-1} $\pm$ 6 kms^{-1}
- $\langle V_{2Rh}/\sigma_{median} \rangle = 1.07 \pm 0.06$



Kinematic Properties



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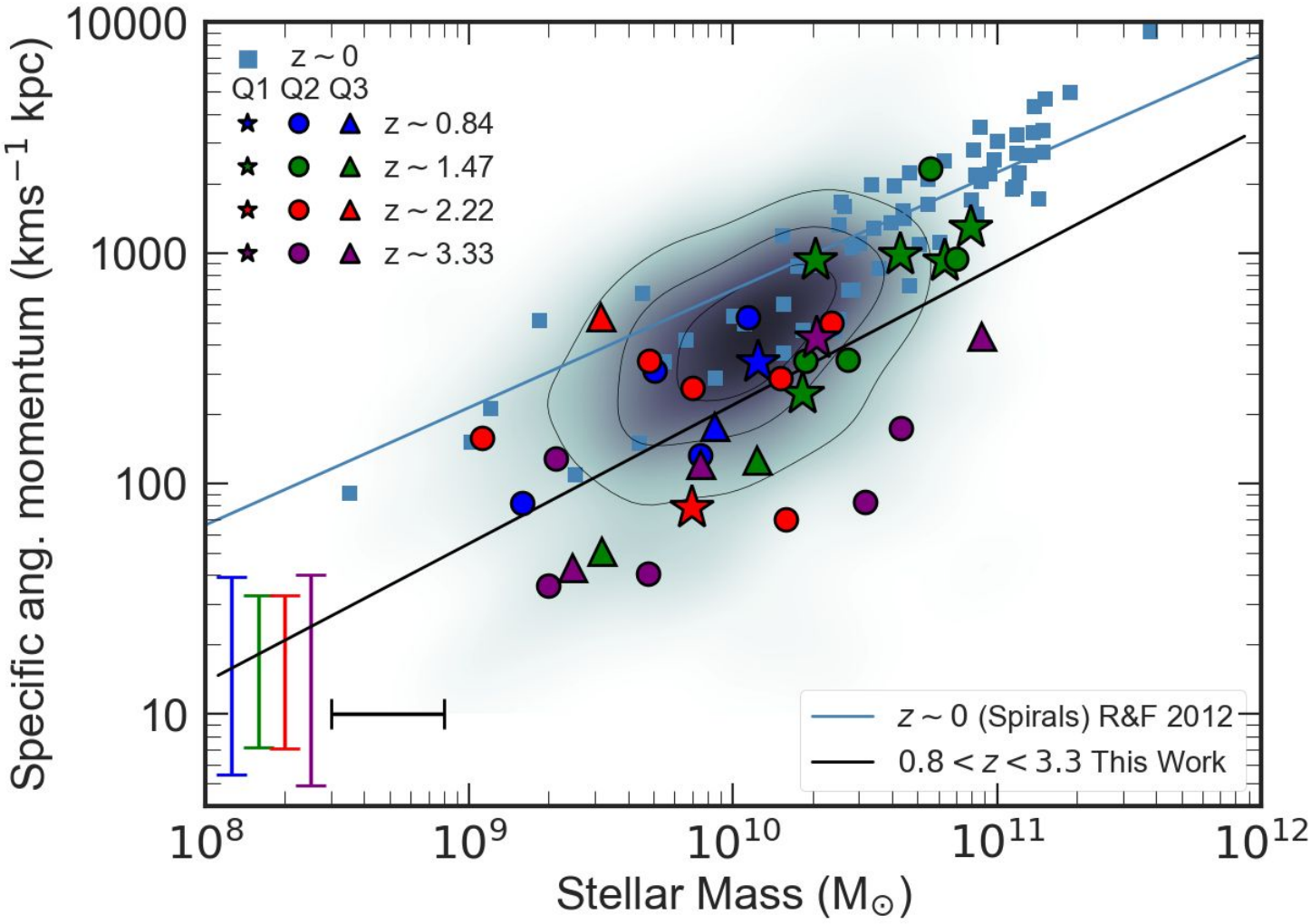
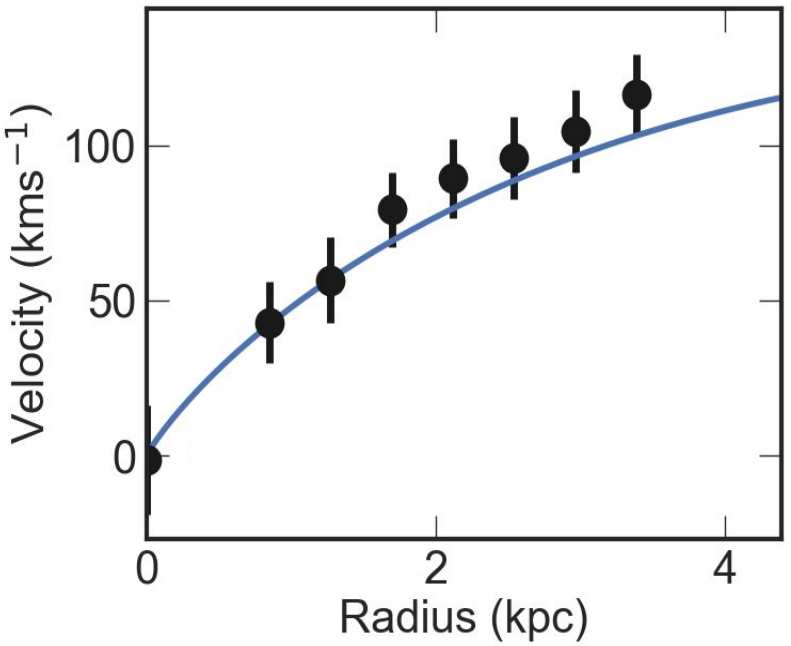
Specific Stellar Angular Momentum

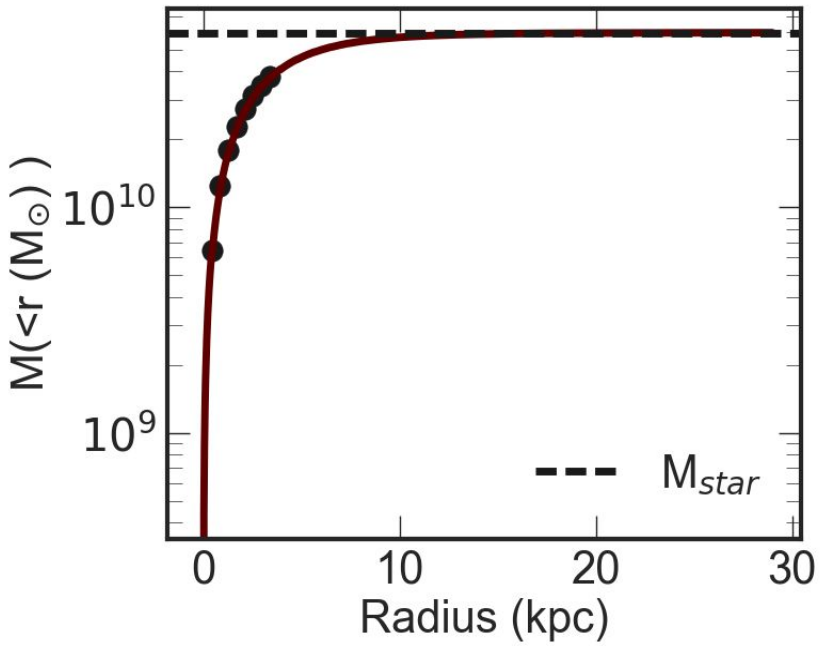
- Sample split into Q1, Q2 & Q3 targets
- Offset from z~0 sample
- Q1 align with KROSS, lowz

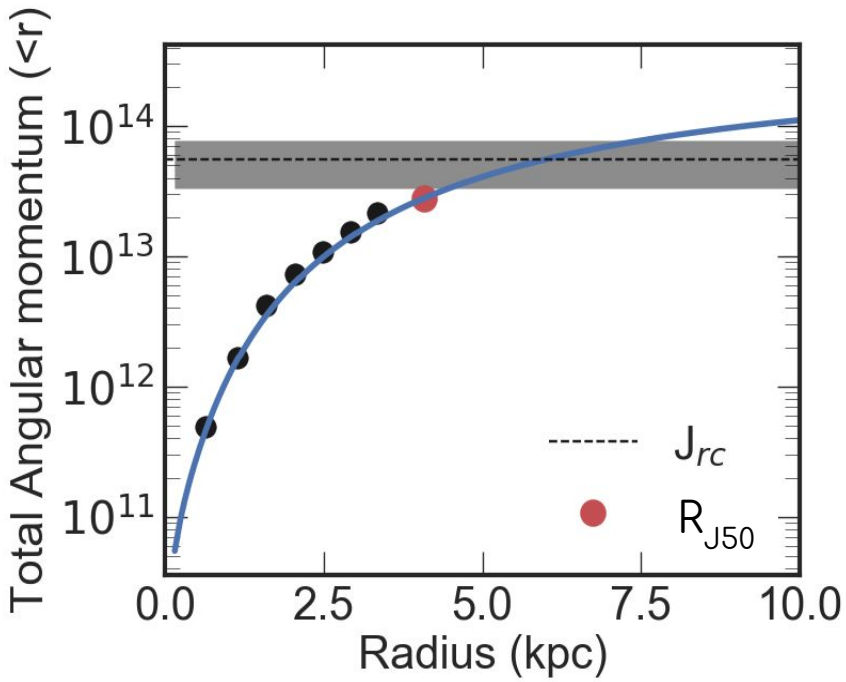
=> What about the internal distribution of angular momentum?



1D Total Stellar Angular Momentum



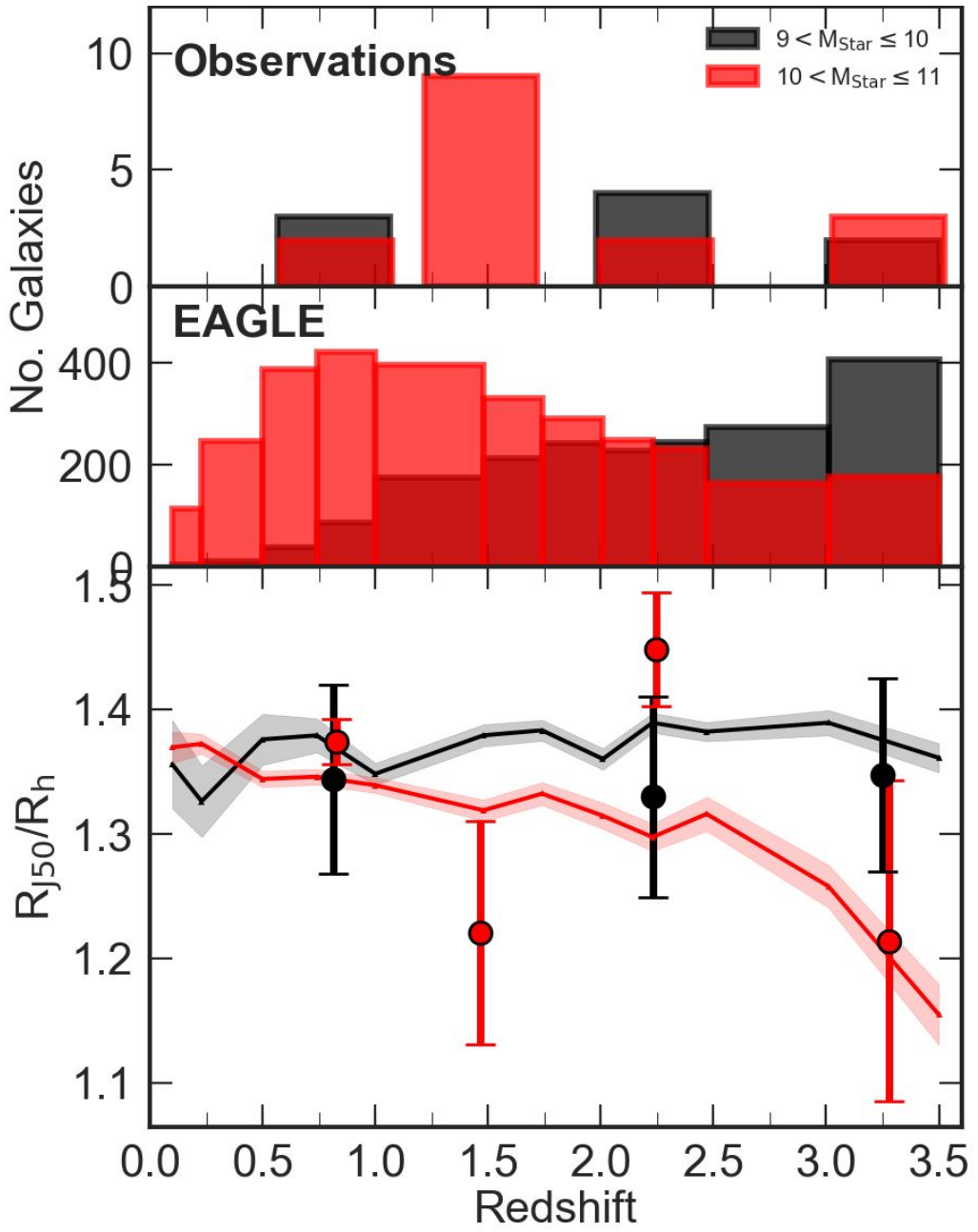




Fixed Mass Evolution

- Indication that higher stellar mass galaxies show an increase in R_{J50} with decreasing redshift
- EAGLE galaxies with $M_{star} \geq 10^9 M_\odot$ and SFR = 1-120$M_\odot yr^{-1}$ from z=0.1-3.5 indicate similar, more pronounced, trend

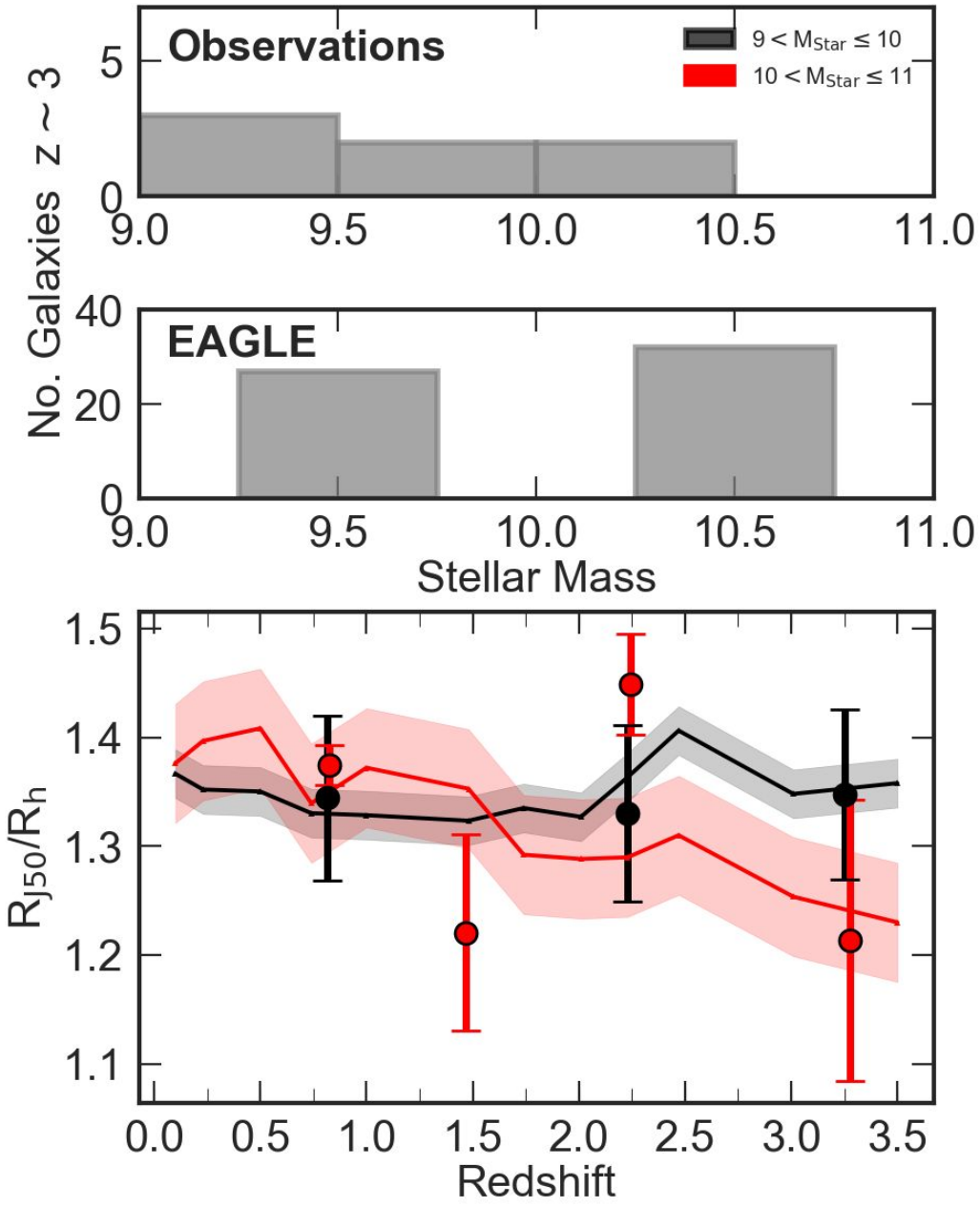
=> Average evolution of L^* galaxies, not the average angular momentum evolution in a galaxy



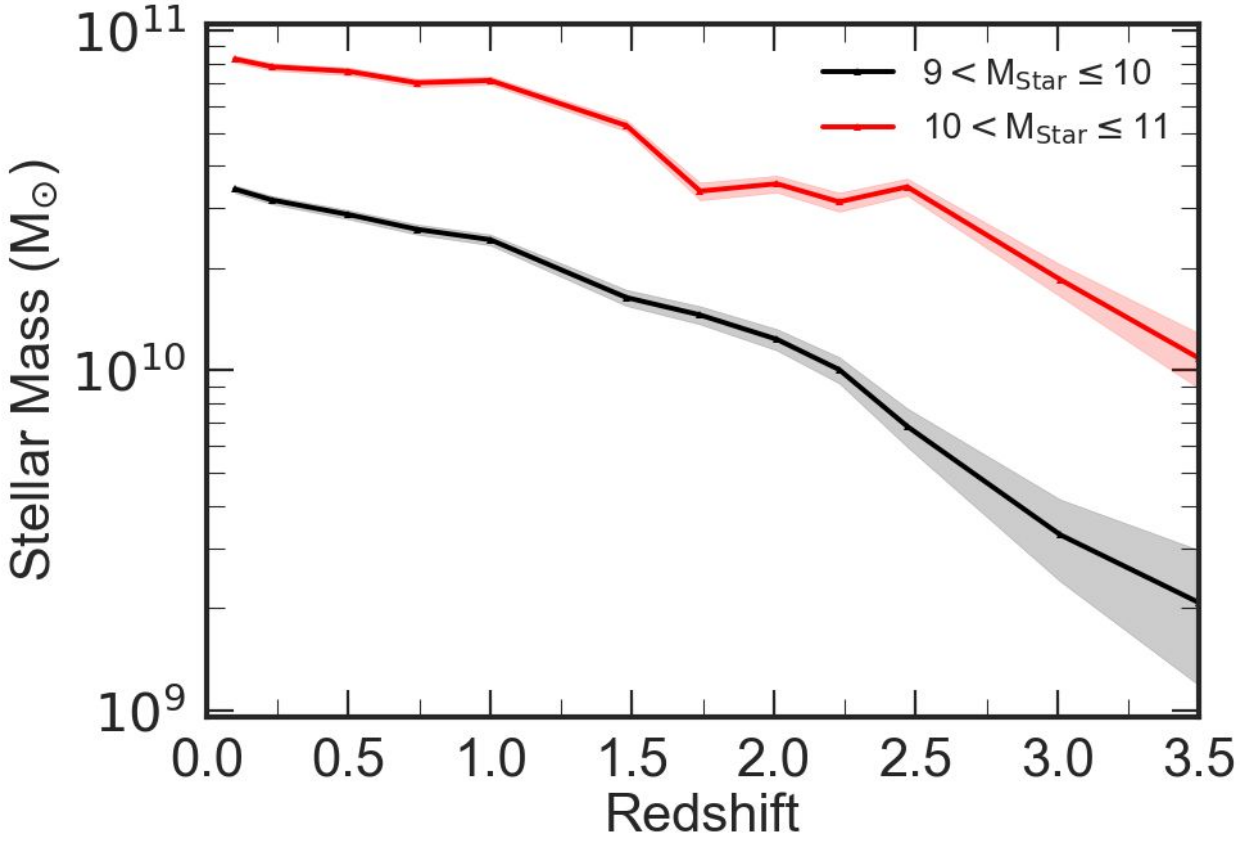
Evolving Mass Evolution

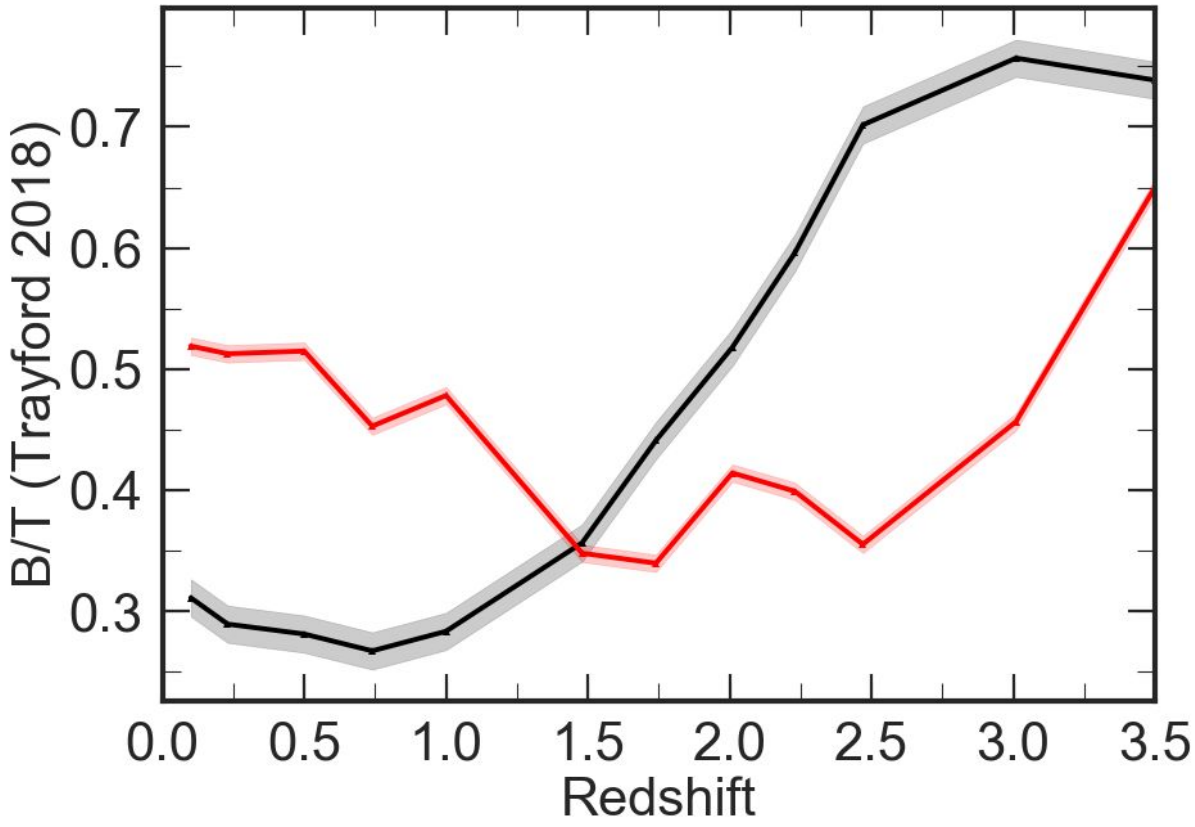
- Trace EAGLE galaxies of $M_{star} \geq 10^9 M_\odot$ and SFR= 1-120$M_\odot yr^{-1}$ at z=3.5 to z=0.1
- Higher stellar mass galaxies show a greater increase in R_{J50} with cosmic time.

=> The angular momentum in high stellar mass galaxies grows out / becomes less centrally concentrated with cosmic time



B/T and Stellar Mass Evolution





Summary

- Galaxy integrated properties evolve with redshift
- High z galaxies have lower specific angular momentum
- In AO sample and EAGLE high mass galaxies show an increase in R_{J50} with cosmic time, implying angular momentum becomes less concentrated as the galaxy evolves

=> Caused by feedback (outflows, accretion) and subsequent bulge formation