

Key Takeaways

- Local pattern speeds provide a unified dynamical test for bars and spirals.
- Many elongated structures in TNG50 early-type galaxies are genuine rotating bars, not merely static triaxial distortions.
- The apparent simulation–observation tension depends not only on baryon feedback physics, but also on sample selection, morphology definitions, and bar-identification criteria.

Motivation

Bars drive secular evolution, but the barred-galaxy census depends strongly on how morphology is defined.

- Bars and spirals redistribute angular momentum and reshape galaxies over cosmic time.
- In TNG50, elongated bar-like structures often appear in galaxies classified as early-type or dispersion-dominated.
- Shape alone cannot tell whether these systems host real bars or are simply triaxial bodies.

We therefore ask a dynamical question: do these structures rotate like bars?

Method

A unified local pattern-speed formalism

- Our method is based on a generalized integral form of the continuity equation over arbitrary closed loops.
- It gives a transparent local interpretation of all Tremaine–Weinberg-type measurements.
- It recovers radially varying pattern speeds, $\Omega_p(r)$, allowing bars and spiral structure to be separated when multiple patterns coexist.
- A genuine bar is expected to produce a nearly flat inner local Ω_p plateau.

This turns morphology into a dynamical test: a real bar should leave a coherent rotational signature, not just a geometric elongation.

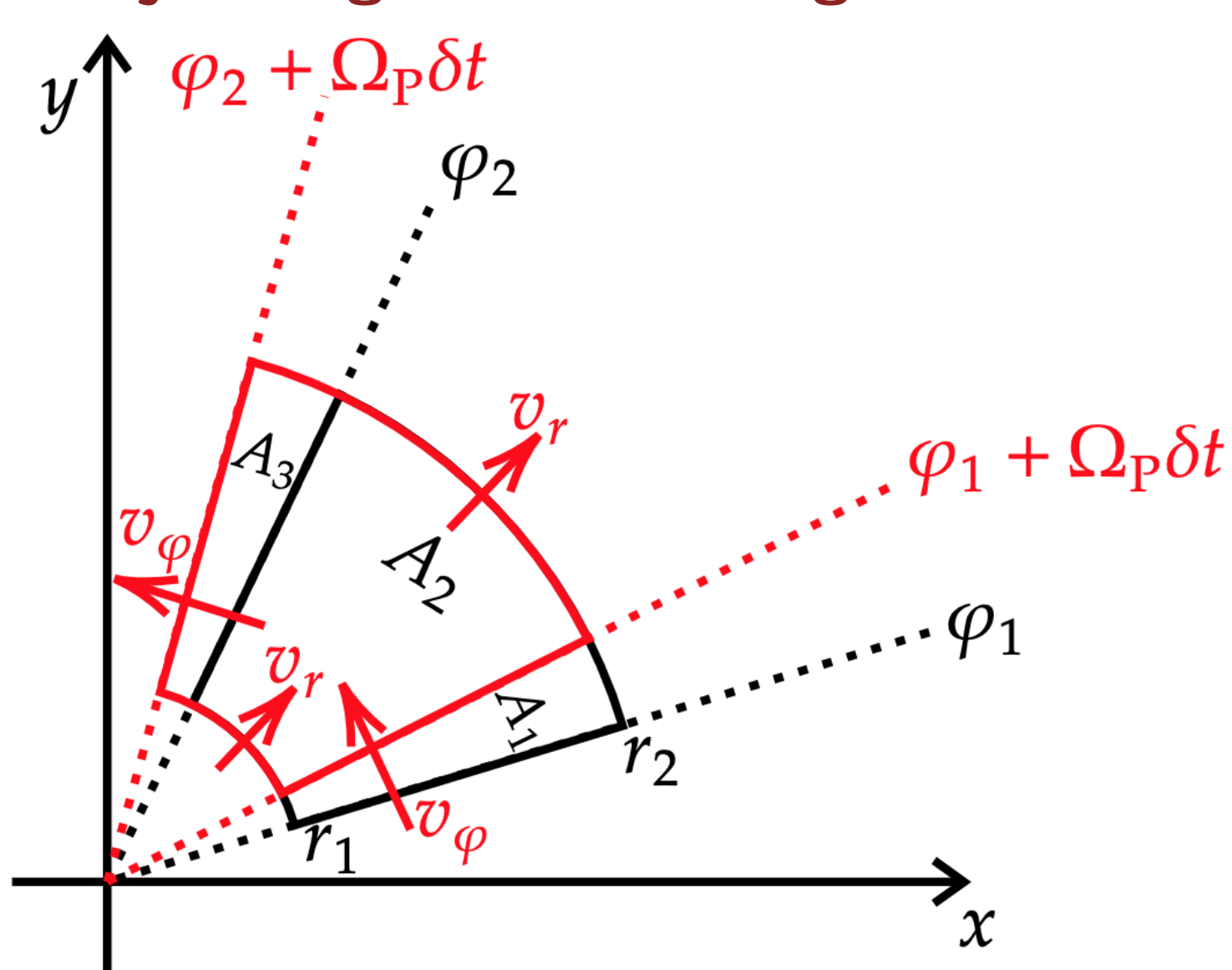


Figure 1: For a coherently rotating pattern, the mass mismatch between swept areas is exactly balanced by the net boundary flux, yielding a local geometric measure of Ω_p . This idea extends naturally to arbitrary closed loops (Du et al. 2026a).

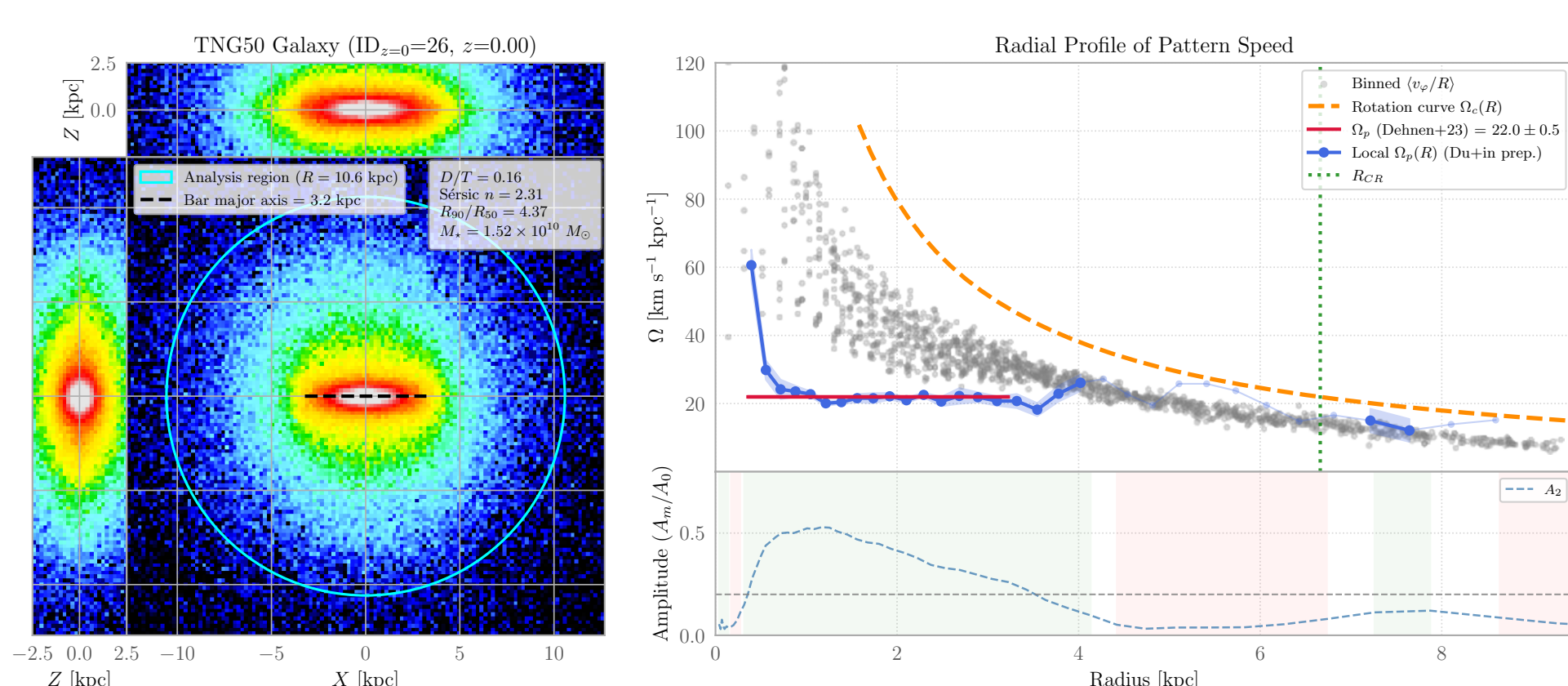


Figure 2: A flat inner local Ω_p plateau identifies a coherent bar-like pattern in a quenched early-type galaxy.

Main Result

Result: many TNG50 early-type “bar-like” structures rotate like genuine bars.

- Their local pattern-speed profiles show coherent plateaus, consistent with bar-like rotation over a finite radial range.
- Mock IFU maps show bar-associated kinematic signatures, including velocity distortions and σ -hollows.
- These systems are therefore difficult to explain as purely static triaxial ellipsoids or simple prolate rotators.

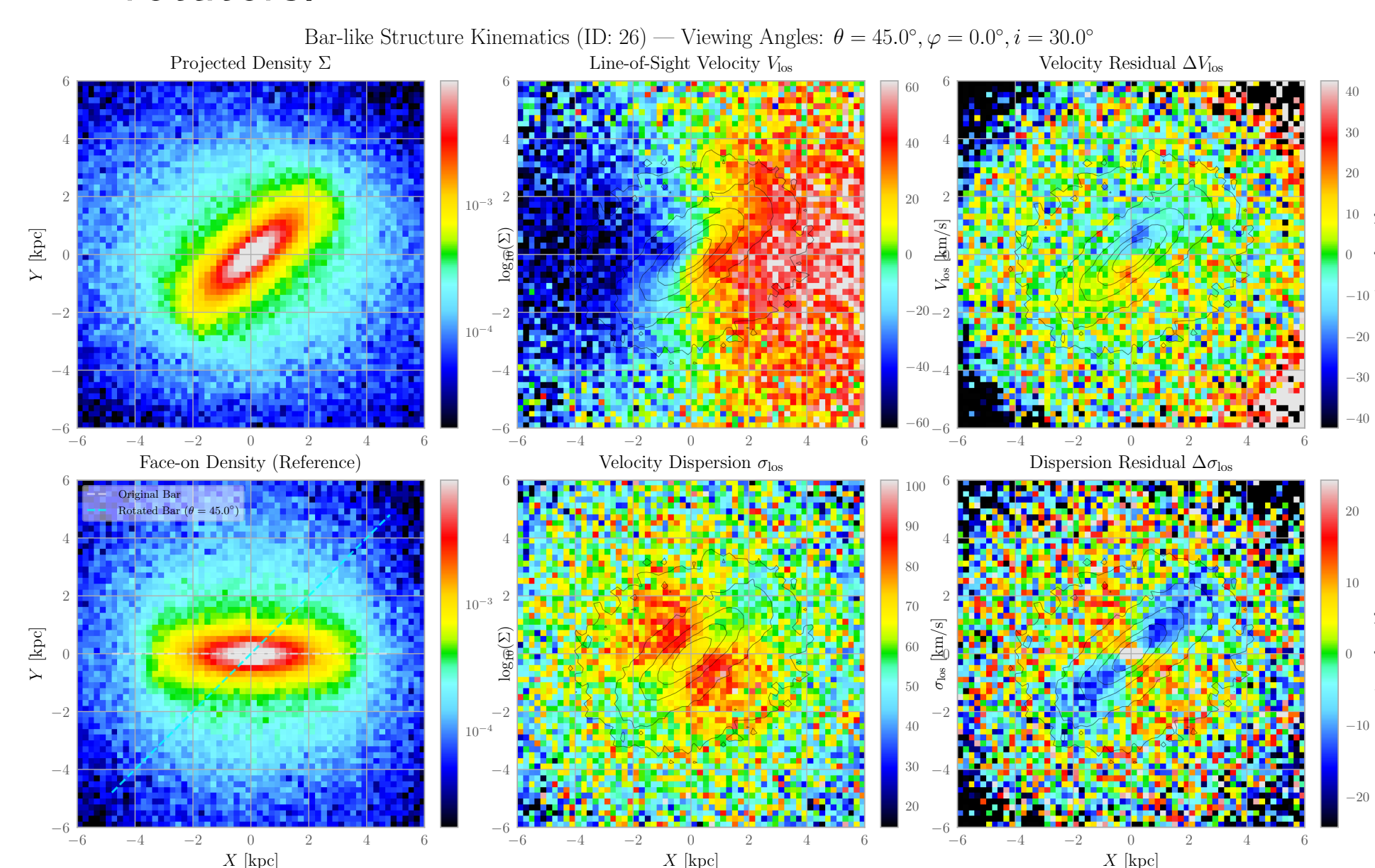


Figure 3: Bar-driven velocity distortions and σ -hollows reveal a dynamically genuine bar in this quenched early-type galaxy.

Evolutionary Interpretation

Present-day early-type bars are often longer and slower, but many likely descend from ordinary fast bars in more disc-like progenitors.

- Their progenitors were typically more gas-rich and dynamically colder at earlier times.
- After quenching, bars can survive while slowing down and lengthening through secular evolution.
- Relative to observations, TNG50 may retain too many Green Valley bars, hinting at tension in baryonic physics and/or quenching histories.

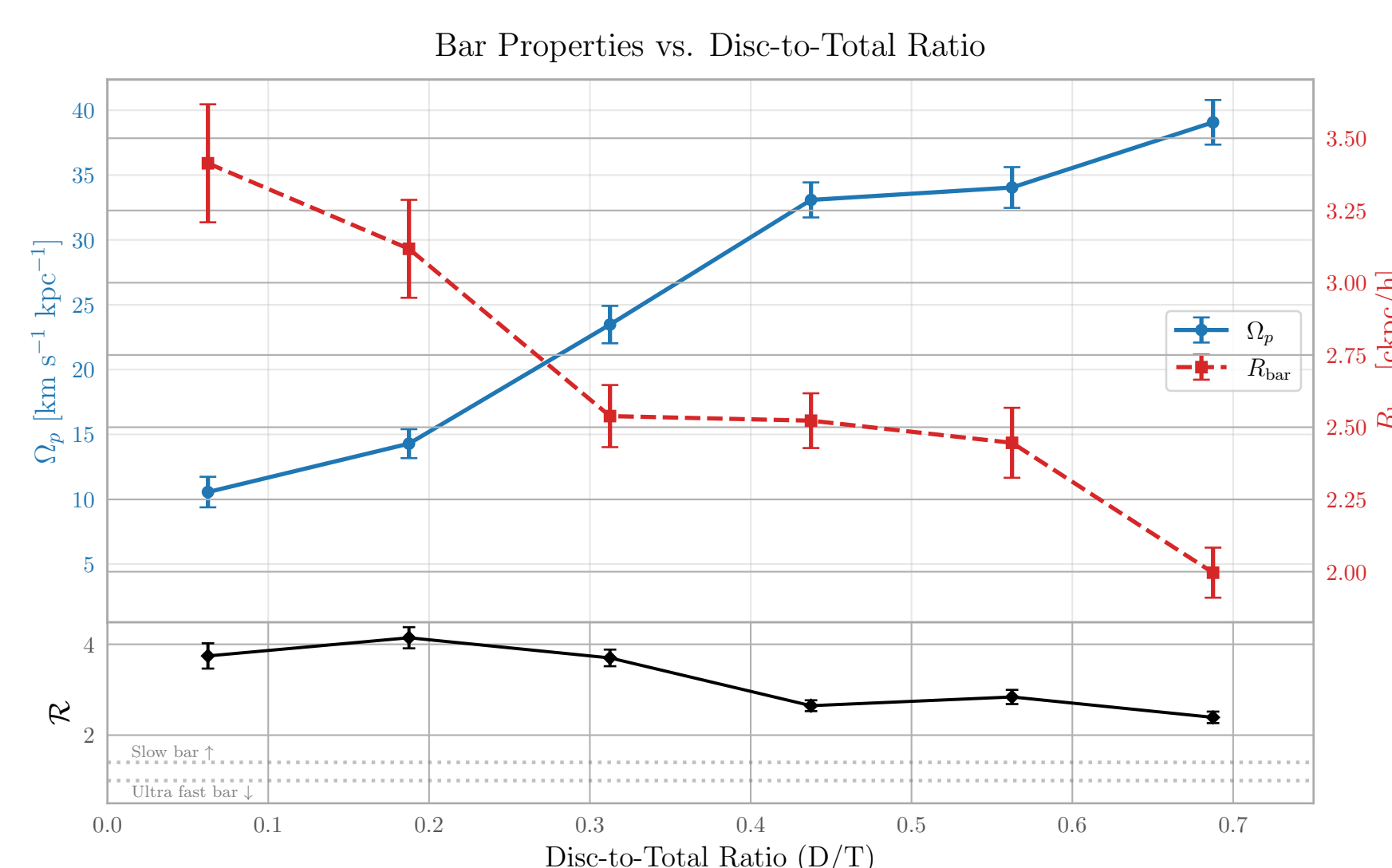


Figure 4: Bars in low-D/T systems are systematically longer and slower at $z \sim 0$. The large $\mathcal{R} \equiv R_{\text{CR}}/R_{\text{bar}}$ mainly reflects the bar-shortness tension reported by Frankel et al. (2022).

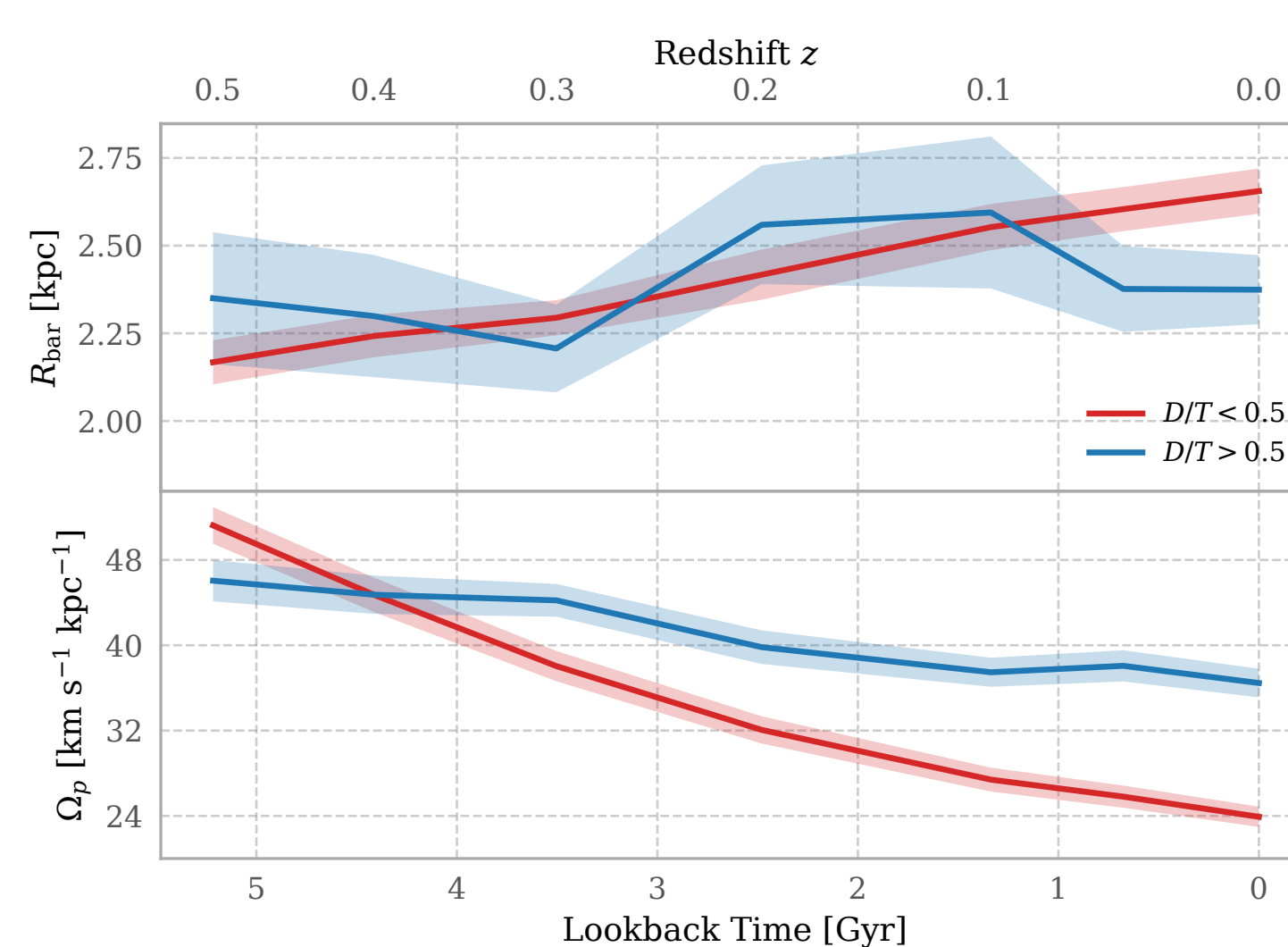


Figure 5: Many present-day slow, long bars likely evolved from faster bars in more disc-like progenitors through secular braking and bar growth after quenching.

Implications for Beyond Hubble

Morphological classification and galaxy dynamics must be connected.

- The simulation–observation discrepancy is not only a physics problem.
- It also depends on sample selection, morphology frameworks, and bar definitions.
- Disc-based pre-selection in simulations can naturally affect the inferred bar census.
- Classical Hubble-style thinking often assumes barred galaxies are discs *a priori* (e.g. Galaxy Zoo decision tree), whereas broader morphological frameworks allow more flexibility (e.g. CVRHS, Buta et al. 2015).
- Dynamical diagnostics provide a route beyond purely visual classification.

Summary

For observers:

- A measured bar fraction always depends on how a bar is defined and which galaxies enter the sample.

For theorists and simulators:

- Local Ω_p provides a morphology-agnostic dynamical classifier.
- IllustrisTNG may face a new “bar problem”: too many quenched or Green-Valley bars?
- Early-type bars may arise through long-term secular survival after quenching.

Ongoing Work

This poster is based on my two recent papers (check the QR code). Current projects include:

- environmental dependence of early-type bars
- analog-based case studies of bar evolution
- physical mechanisms of spiral structure

I would be very happy to discuss potential collaborations.

Can't catch me in person?

This is a later poster and the presenter may not be available on site.



Scan the QR code for a short walkthrough, PDF poster, related papers, and contact details.

References

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