

Galaxy Morphology Classification: Where Should We Draw the Line?

Katarina Baucalo^{1,2} & Ana Mitrašinović^{3,4}

¹Department of Astronomy, Faculty of Mathematics, University of Belgrade
²Petnica Science Center, Serbia
³Astronomical Observatory of Belgrade, Serbia
⁴Institute of Astrobiology, University of Crete, Greece
kataarina981@gmail.com



1 Motivation

- Detailed kinematic decompositions are **resource-intensive**: the 5-component catalog (t) (Zana+22) exists **only for TNG50**.
- A simple 2-component (disk, spheroid) **circularity catalog (c)** (Genel+15) exists for **every box and snapshot**, but is rarely used.
- When used, early and late types are split at an **ad hoc** $F_{\text{disk}} = 0.4$.

Are stellar circularities enough and what is the optimal threshold?

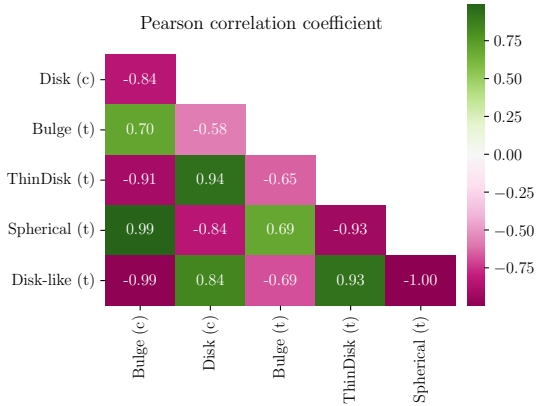
2 Data & method

- TNG100** galaxies at $z = 0$; validation in **TNG50**.
- Stellar orbital circularity and mass fractions within $10 R_{1/2}$, from catalog (c):

$$\epsilon = j_z / j_c(E) \in [-1, 1]$$
$$F_{\text{disk}} = f(\epsilon > 0.7) - f(\epsilon < -0.7)$$
$$F_{\text{sph}} = 2 f(\epsilon < 0)$$

Spheroid assumed symmetric around $\epsilon = 0$ (factor 2 in F_{sph} ; $\epsilon < -0.7$ correction in F_{disk}).

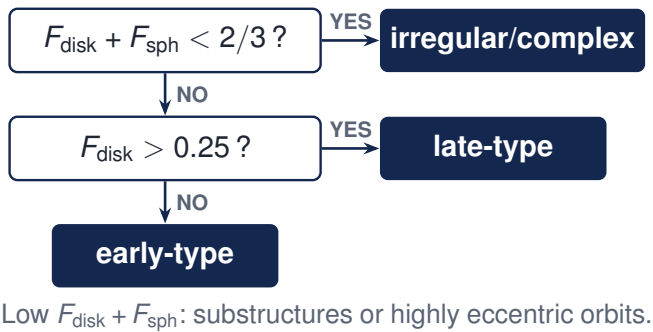
3 Is it physically meaningful?



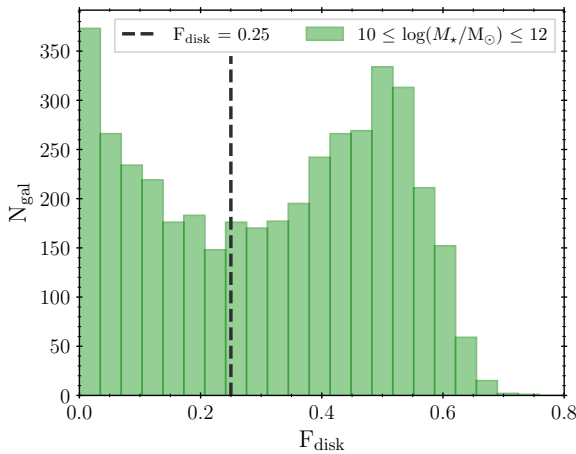
Pearson correlation between catalogs (c) and (t), TNG50.

- F_{sph} = **bulge + stellar halo** ($r = 0.99$).
- F_{disk} traces the **thin disk** ($r = 0.94$), and tends to underestimate it.

4 Classification scheme



5 Where to draw the line?



Non-irregular galaxies with $10 \leq \log(M_*/M_\odot) \leq 12$.

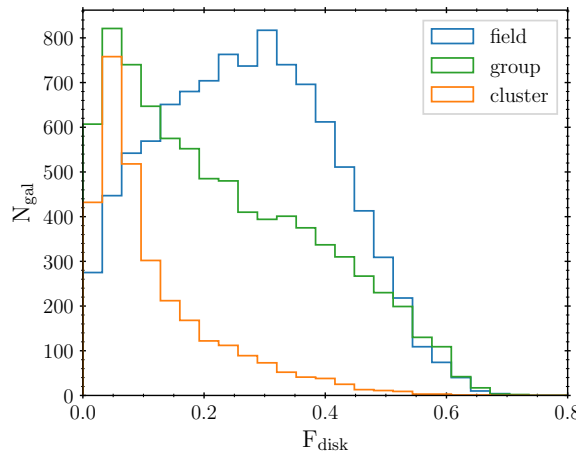
- All masses: **no bimodality** – dwarfs are spheroid-dominated.
- Intermediate-mass regime: **bimodality**, minimum at $F_{\text{disk}} \approx 0.225$.
- $F_{\text{disk}} = 0.4$ would exclude galaxies with substantial but not dominant disks.

threshold $F_{\text{disk}} = 0.25$

Take-away messages

- Circularities provide an **efficient, physically meaningful** proxy: $F_{\text{disk}} \approx$ thin disk, $F_{\text{sph}} \approx$ bulge + halo.
- The data-motivated cut $F_{\text{disk}} = 0.25$ (not 0.4) keeps galaxies with moderately prominent disks.
- Recovers the **morphology–density relation**; should work for any TNG box $\Rightarrow$ **ML baseline**.

6 Morphology & environment



$9 \leq \log(M_*/M_\odot) \leq 12$; environment from FoF host halo.

	field	group	cluster
late-type	45%	26%	4%
early-type	43%	44%	50%
irreg./complex	12%	30%	46%
N_{gal}	9921	8133	2983

late-type fraction: 45% $\rightarrow$ 26% $\rightarrow$ 4%