



# The effects AGN Contributions of the Morphological Parameters of Their Host Galaxies in lower and higher redshift

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## ABSTRACT

The presence of Active Galactic Nuclei (AGN) can significantly influence the morphological classification of galaxies, particularly at intermediate and high redshifts where observational limitations further complicate structural measurements. This study investigates how different levels of AGN contribution affect six widely used non-parametric morphological parameters under COSMOS-like conditions down to redshift  $z \approx 2$ . We use a sample of more than 2000 local, non-active galaxies with reliable visual morphological classifications. To simulate the presence of an AGN, we add an unresolved central point source contributing between 5% and 75% of the total galaxy flux. The galaxies are then artificially shifted to fainter magnitudes to reproduce the observational depth, resolution, and noise typical of the COSMOS field. For each simulated image, we remeasure the morphological parameters and assess how they deviate from their original values. Our results show that the combined effect of increasing redshift, decreasing magnitude, and AGN contribution has the strongest impact on galaxy morphology, with spiral galaxies being noticeably more affected than early-type systems. All concentration-based parameters exhibit substantial changes when the AGN contributes more than 25% of the total flux and when galaxies appear fainter than magnitude 23. Among all parameters, the GINI coefficient proves to be the most stable against both AGN contamination and redshift degradation, followed by the moment of light (M20), the Conselice–Bershady concentration index (CCON), and finally the Abraham concentration index (CABR), which is the most sensitive. When using morphological parameters to classify high-redshift active galaxies, we find that a combination of CABR, CCON, and asymmetry provides the best discrimination between morphological types. A secondary but still effective combination is CABR with the GINI coefficient. These results provide insights into the reliability of morphological diagnostics in AGN host galaxies and offer guidance for future morphological studies in deep extragalactic surveys.

## AGN effects on morphology at lower and higher z

- ◆ Morphology is used to study the properties of AGN host galaxies, their connection with AGN and their evolution.
- ◆ The effects of AGN on morphological parameters and classification at  $z \sim 0$  were studied more detailed in Getachew et al., (2022).
- ◆ AGN contribution may also affect the morphological classification of their host galaxies, in the best-case scenario, limited contributions are made (Gabor et al., 2009, Cardamone et al., 2010, Pierce et al., 2010, Trump et al., 2015).
- ◆ \*We studied how different contributions of AGN to the total optical light, varying between 5% and 75%, affect the 6 commonly used morphological parameters: CABR, Gini coefficient, CCON, M20 moment of light, ASYM index, and SMOOTH.

\* We found that most morphological parameters are affected by the presence of an AGN when its contribution to the total galaxy light is above 25%, with late-type galaxies being more affected than Early-types.

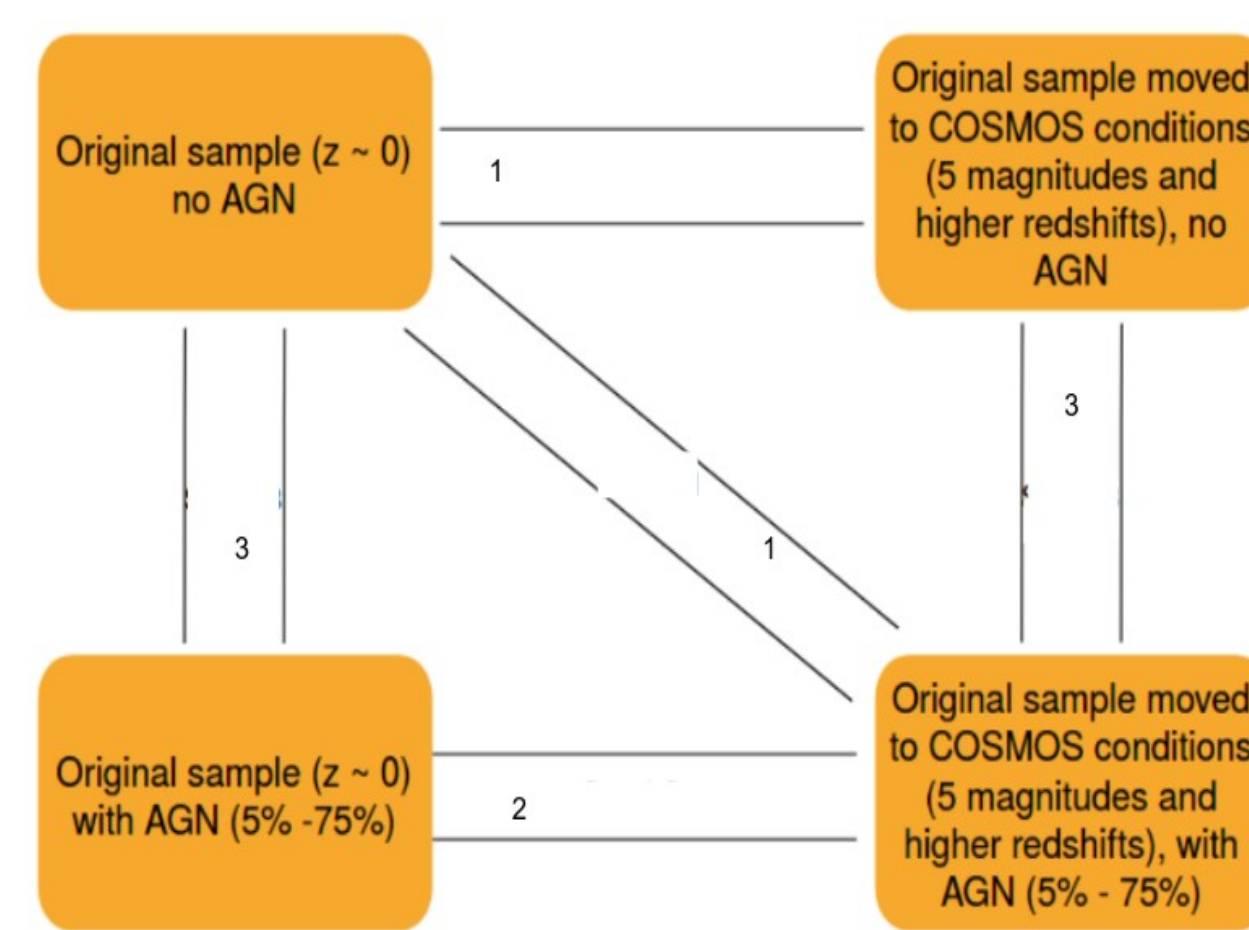
\*In this study, AGN contributions from 5% to 75% were artificially added to non-active local galaxies with known morphology

\*These galaxies were then placed into redshift and magnitude distributions resembling those observed in the COSMOS survey (Scoville et al., 2010)

## Data and sample selections

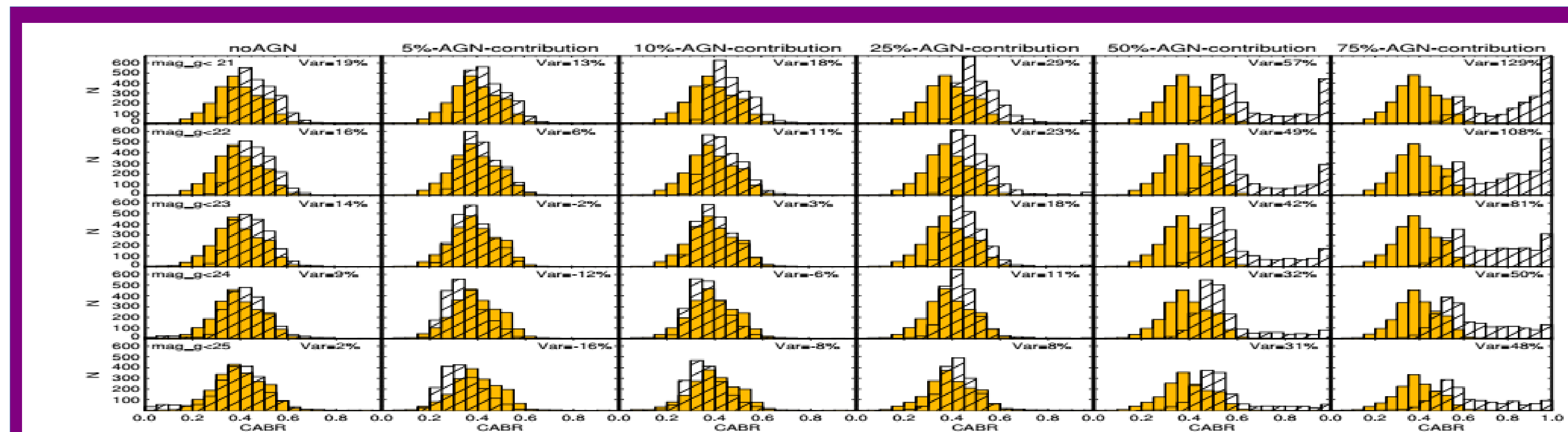
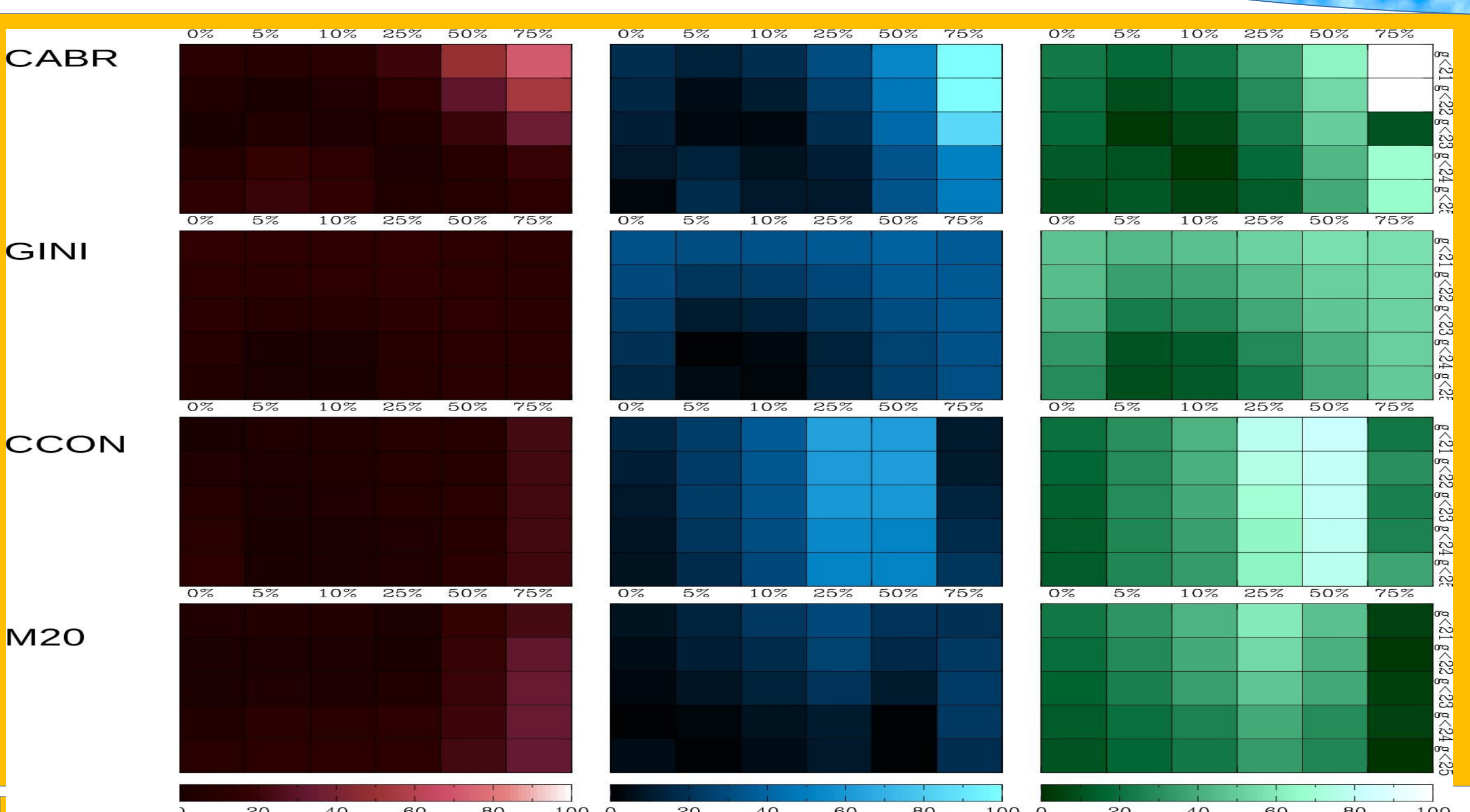
- ◆ We use a total sample of 2301 local, non-active galaxies, randomly selected from the initial sample of ~14000 galaxies with available visual morphological classification (T-type) from Nair and Abram (2010).
- ◆ Galaxies were selected as non-active using the BPT-NII diagram (Baldwin 1981) and emission line ratios using fluxes from the MPA-JHU SDSS DR7 catalog.
- ◆ The final local sample used in this work contains 2251 galaxies, of which 471 are early-types (elliptical and lenticular, with  $T\text{-type} \leq 0$ ), 891 early-spirals ( $0 < T\text{-type} \leq 4$ ) & 889 late-spirals ( $4 < T\text{-type} \leq 8$ ).

## Methodology and analysis



- \*The galSVM code is optimized for classifying faint sources. Previous studies showed that using various magnitude limits improves classification (Pović et al., 2013; Pintos et al., 2016).
- \*This study analyzes the effect of AGN on the morphological parameters of galaxies with different brightnesses and redshifts.
- \*Five magnitude limits are considered, from  $F814W \leq 21$  to  $F814W \leq 25$ , using the HST/ACS F814W photometric band.
- \*Local galaxies are re-sampled and convolved to match the COSMOS spatial resolution.

## RESULTS: AGN effects on morphology



- > This Fig shows comparison of CABR values for the original sample at  $z \sim 0$  without AGN (filled histograms) and the simulated sample (open histograms) at higher redshifts and fainter magnitudes (21 to 25, top to bottom rows). Includes scenarios without AGN (first column) and with AGN contributions from 5% to 75% (second to last columns)..
- > With a total sample of galaxies up to magnitude  $\leq 22$ , AGN impact dominates.
- > CABR increases on average from ~10%-20% with 5%-10% AGN contribution to >100% with 75% AGN contribution
- > At magnitude  $g < 23$  and above, magnitude/redshift has a larger impact on CABR compared to AGN, but only for AGN contribution  $< 25\%$  (variations from  $< 10\%$  to 20%).
- > For 50% and 75% AGN contributions, CABR shifts significantly higher (from  $> 30\%$  to 80%), with AGN being the dominant factor and components

## CONCLUSION

- We quantify the impact of AGN on four morphological parameters (CABR, GINI, CCON, M20) using the COSMOS field as an example, a prominent deep survey.
- Local galaxies from the SDSS survey, with known morphology, have AGN contributions ranging from 5% to 75% added to their centers.
- These galaxies are then shifted to intermediate redshifts and fainter magnitudes (21 to 25 in the g-band), aligning with the characteristics of galaxies in the COSMOS field.
- If the AGN contribution to the total galaxy flux is 50% or more, it dominates the impact on all morphological parameters compared to the effect of magnitude/redshift across all morphological types.

- ◆ In Fig shows the summary describes the changes in four parameters CABR, GINI, CCON, and M20
- ◆ When comparing an original sample at redshift  $z \sim 0$  with no AGN added, to a simulated sample under COSMOS conditions.
  - ✓ Early-type galaxies show smaller variations in CABR, indicating less impact from AGN and magnitude/redshift effects.
  - ✓ Late-spiral galaxies exhibit the largest CABR variations, highly sensitive to AGN contributions:
    - ✓ 25% AGN: 35%-14%
    - ✓ 50% AGN: 63%-39%
    - ✓ 75% AGN: 165%-66%
  - ✓ These changes occur from magnitude  $g < 21$  to  $g < 25$ .