

Measuring Galaxy Properties with JWST

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JADES: GOODS-S Field - Credit: NASA, ESA, CSA, B. Robertson (UC Santa Cruz), B. Johnson (Center for Astrophysics, Harvard & Smithsonian), S. Tacchella (University of Cambridge, M. Rieke (Univ. of Arizona), D. Eisenstein (Center for Astrophysics, Harvard & Smithsonian), A. Pagan (STScI)

Outline

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**Sample,
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Process**

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**Results &
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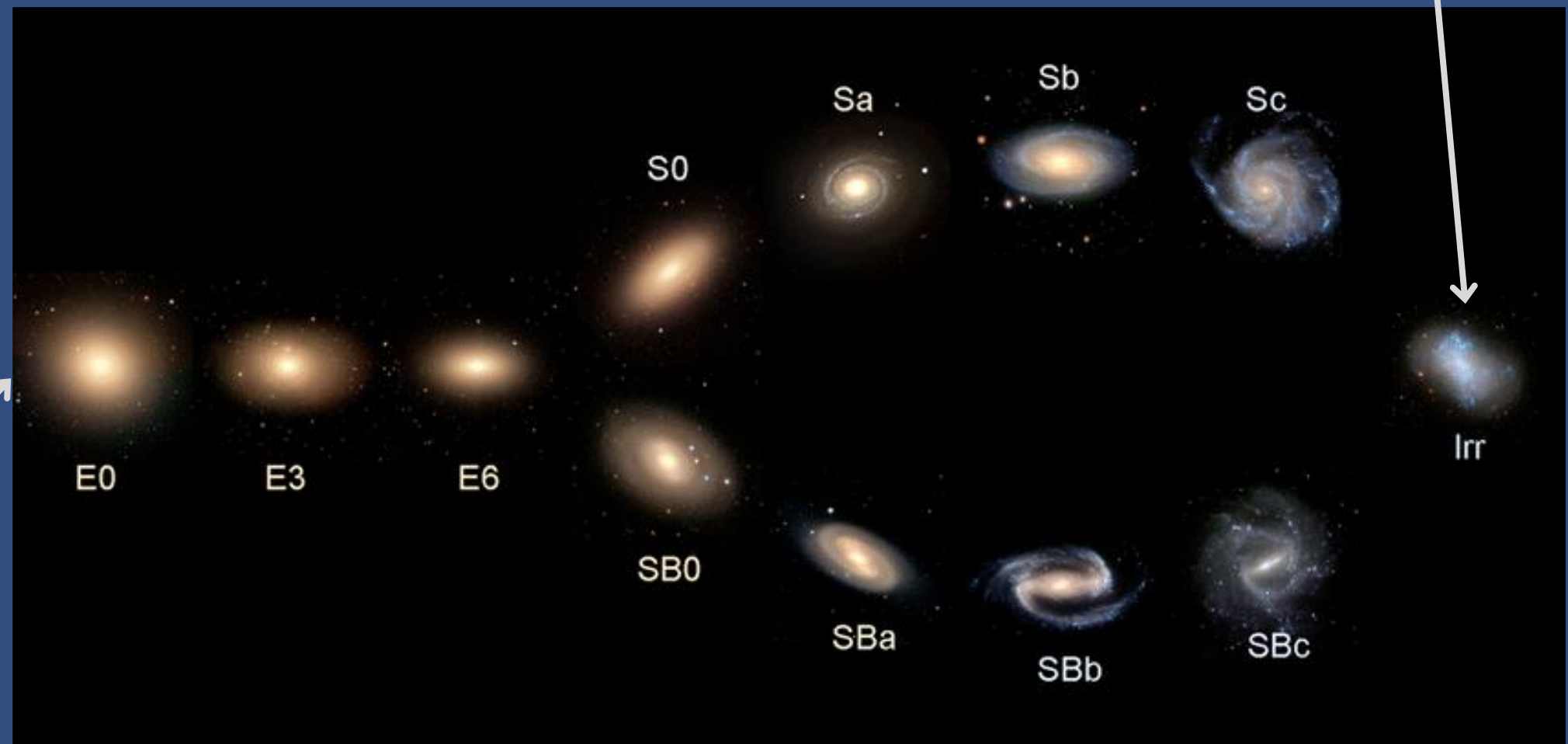
Motivations

- Range of galaxy types in the universe
 - We don't know how much they eat
 - eating = active galactic nucleus

Is there some correlation between a galaxy type and its active galactic nucleus (AGN) fraction?

Hungry?
(High AGN)

(Low AGN)
Full?



Cui, Yin & Xiang, Yongzhou & Rong, Kun & Feris, Rogerio & Cao, Liangliang. (2014). A spatial-color layout feature for representing galaxy images. 213-219. 10.1109/WACV.2014.6836098.

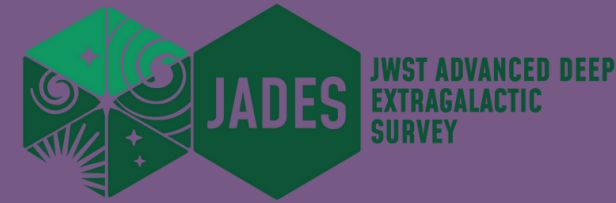
An artist's impression of a quasar, showing a bright, glowing orange and yellow accretion disk surrounding a central black hole. The background is a dark, starry space. The text "Sample, Data, & Process" is overlaid on the right side in a large, white, sans-serif font.

Sample, Data, & Process

Artist's impression of quasar J059-4351. Credit:
ESO/M. Kornmesser

Goal: Is there some correlation between a galaxy type and its active galactic nuclei (AGN) fraction?

How?



- **Sample** [Kirkpatrick+2012]
 - 151 dusty Mid-Infrared selected galaxies with $1 < z < 3$
 - AGN fraction from Mid-IR spectral decomposition
- **Data**
 - Need imaging from JWST NIRCам (~50 galaxies visible)
 - Using GOODS-N & GOODS-S fields from Grizli reduction of JADES data
 - Quantitative morphology analysis performed at the same rest wavelength of ~1 micron

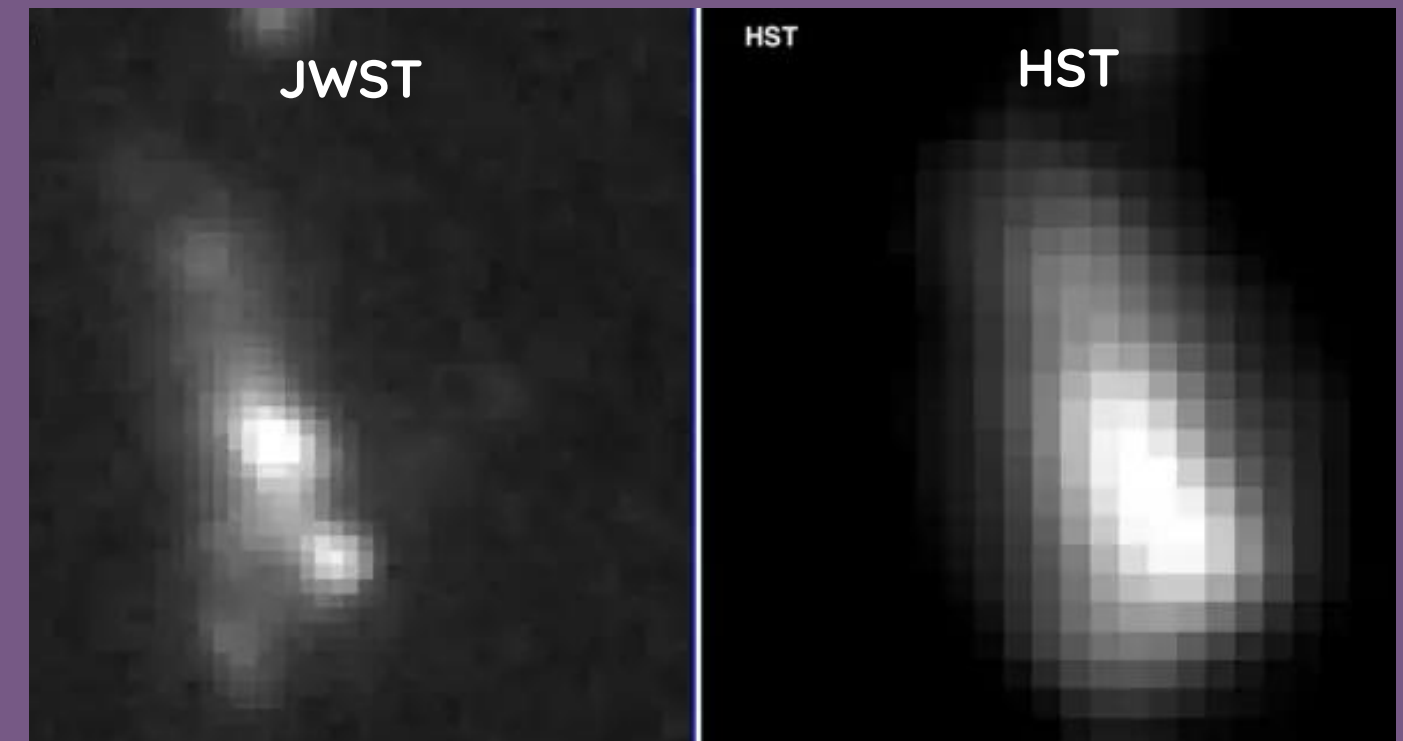


Image Credit: ARC Centre of Excellence for All Sky Astrophysics in 3 Dimensions (ASTRO 3D)

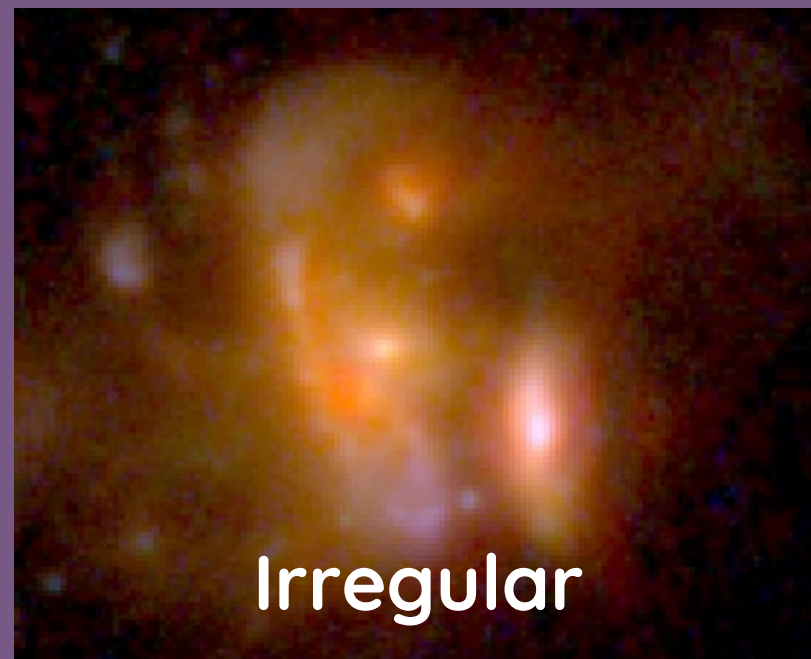
Goal: Is there some correlation between a galaxy type and its active galactic nuclei (AGN) fraction?

Visuals & Quantitative



Visual Morphology

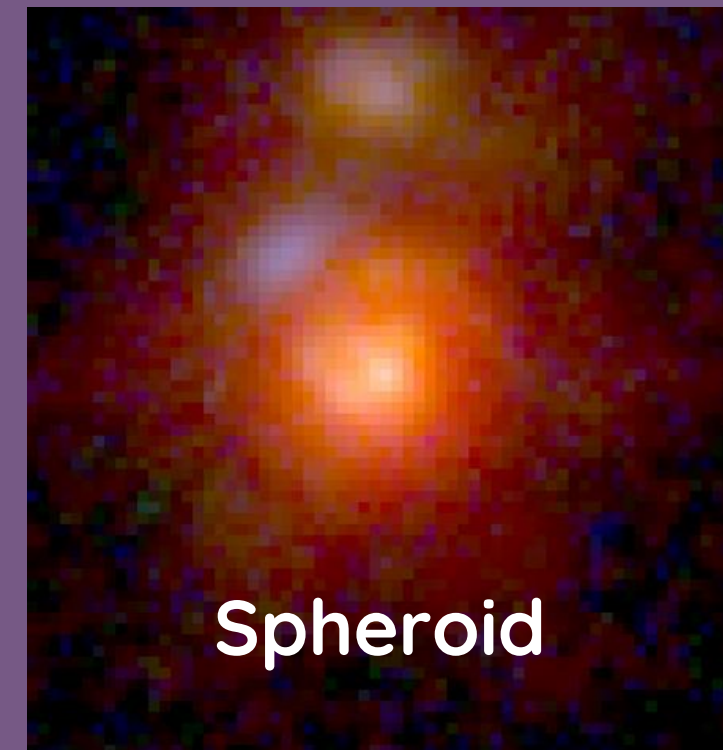
- Visual Classification Survey (21 responses)
- Multi-select: Disk, Spheroid, or Irregular
- Merger, Has Clumps, Spiral Arms



Irregular



Disk



Spheroid

Quantitative Analysis

- [Statmorph, [Rodriguez-Gomez+2019](#)]
- Asymmetry - higher values = more clumpy
- Concentration - high values = more central light
- Gini - smaller values = evenly distributed light
- M20 - more negative = noncentral concentration

Results!

Cartwheel Galaxy, ESO 350-40, AM0035-335

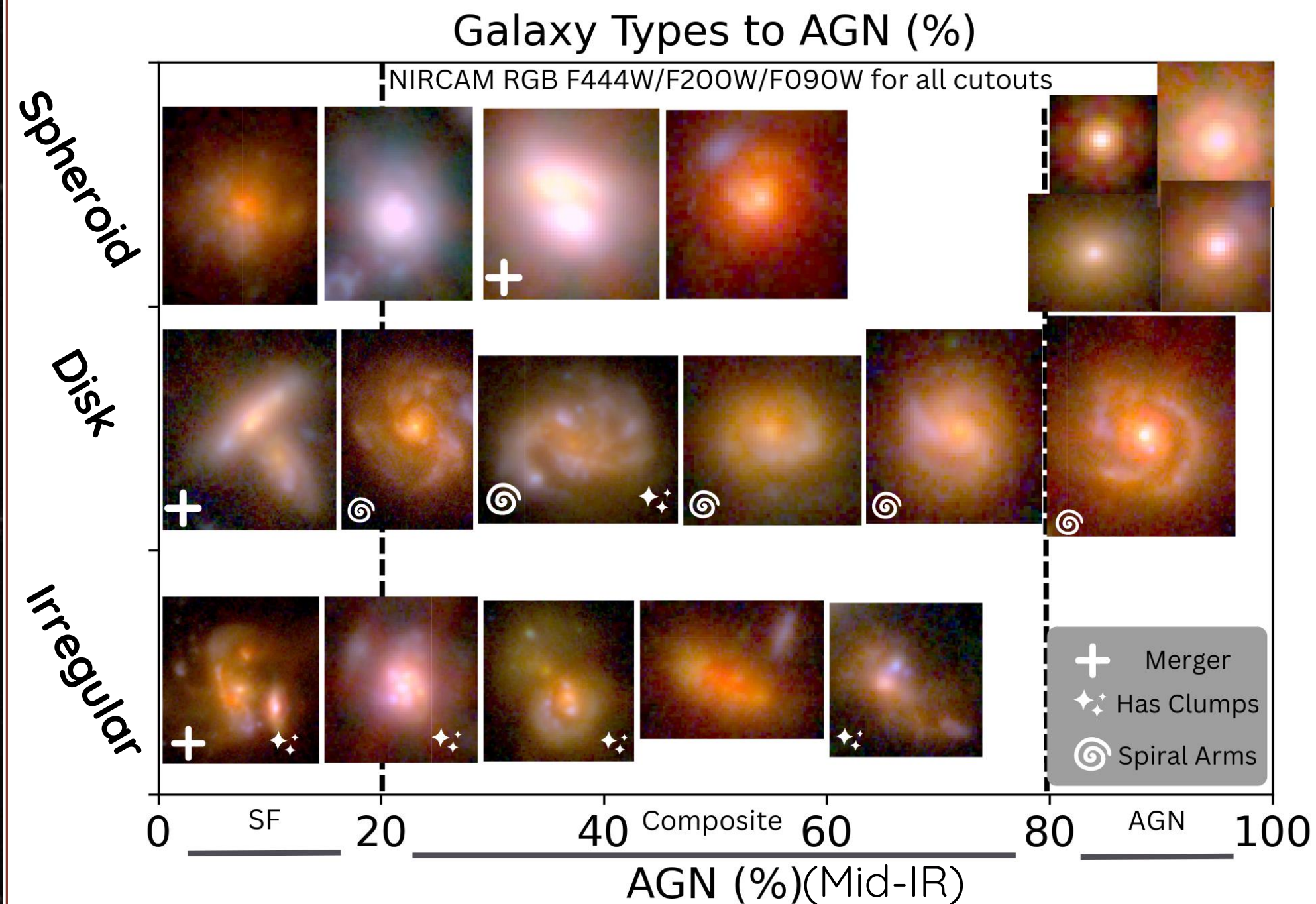
NIRCam: Red: F444W + F356W Yellow: F277W Green: F200W Blue: F150W + F090W

MIRI: Orange: F770W + F1000W + F1280W + F1800W

Image Credits: NASA, ESA, CSA, STScI, Webb ERO Production Team

Goal: Is there some correlation between a galaxy type and its active galactic nuclei (AGN) fraction?

Visuals vs AGN (%)



Key Takeaways

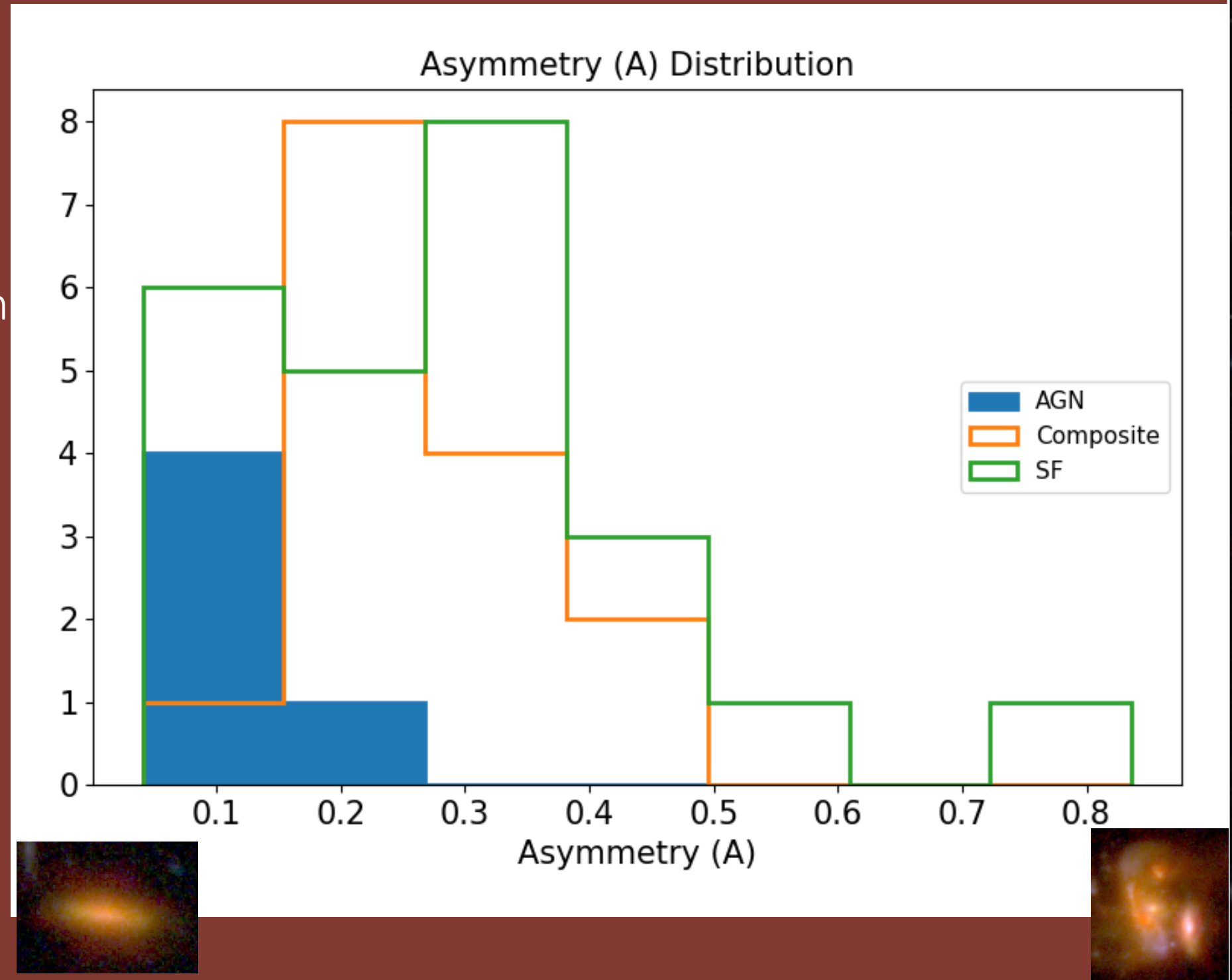
- Spheroids don't appear to evolve with AGN fraction
 - Most AGN are spheroids
- Disks get brighter in center as increase in AGN Fraction
 - Colors and structures same
- No irregulars contain strong AGN

Goal: Is there some correlation between a galaxy type and its active galactic nuclei (AGN) fraction?

Asymmetry and AGN

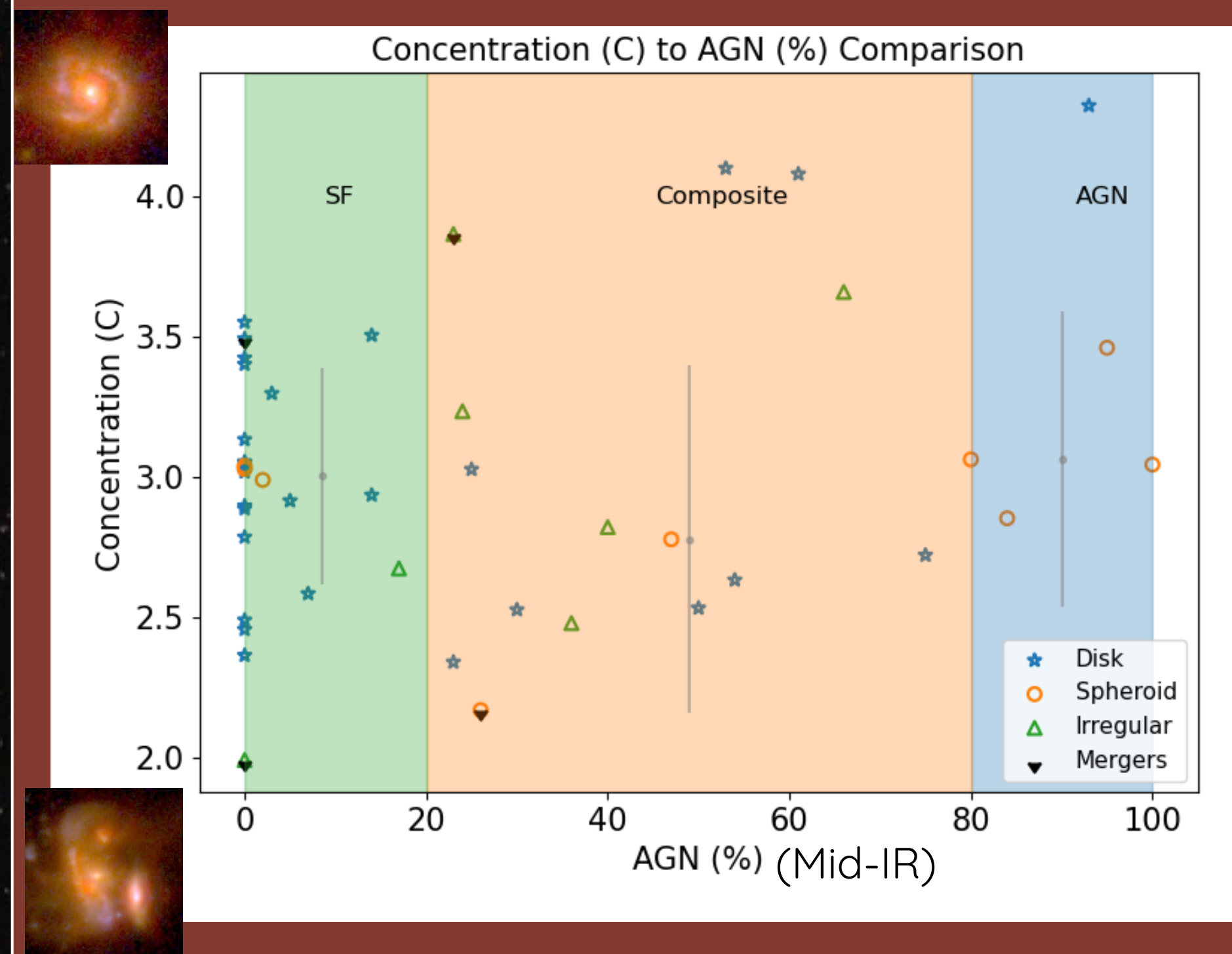
Key Takeaways

- Star-forming galaxies span full range of asymmetry values
- Asymmetry decreases with AGN fraction
 - AGN are symmetric/less clumpy than star-forming and composite
 - Consistent with [[Dodd+2021](#)]



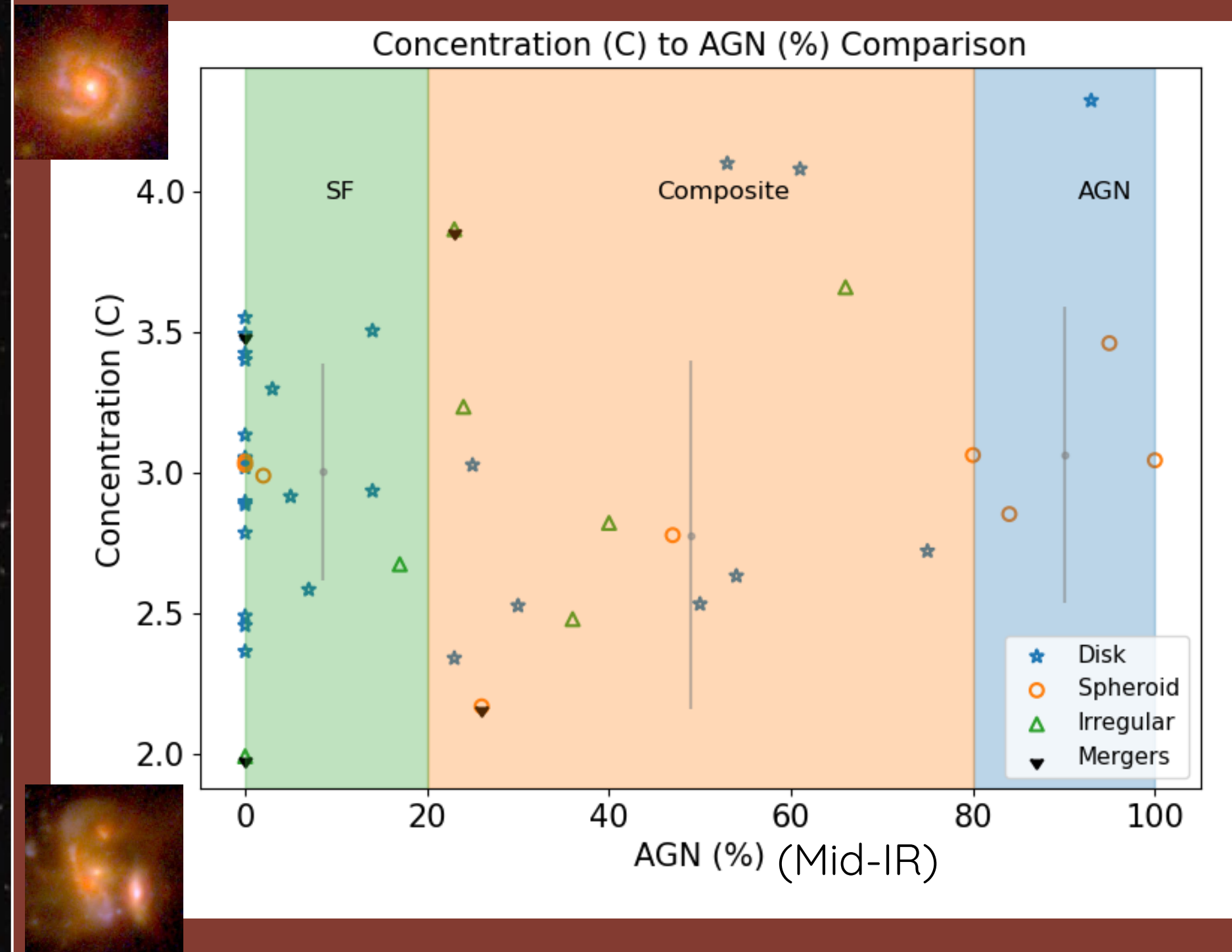
Goal: Is there some correlation between a galaxy type and its active galactic nuclei (AGN) fraction?

Concentration and AGN



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Concentration and AGN



Key Takeaways

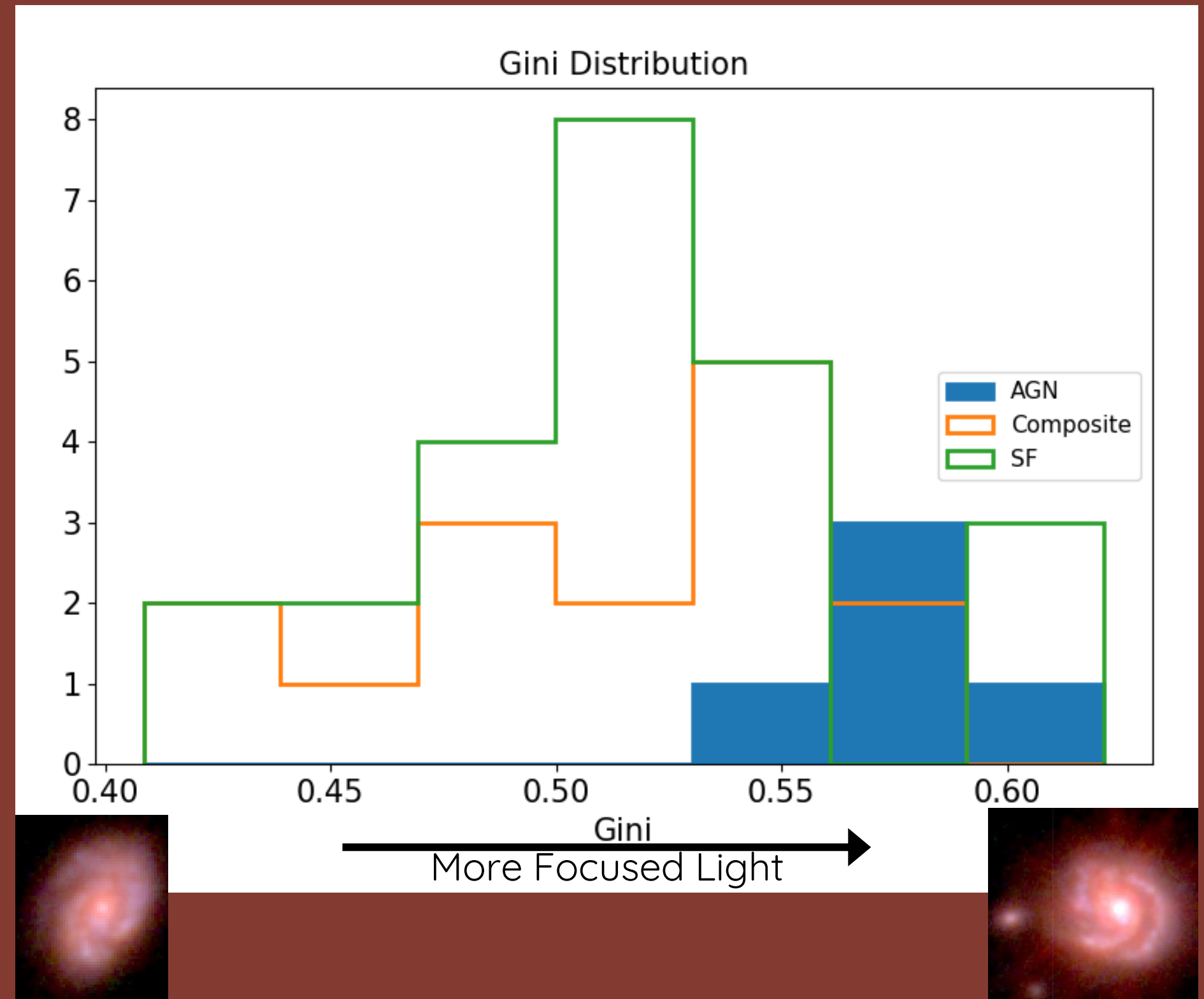
- Concentration remains roughly constant as AGN fraction increases
 - Especially for high AGN spheroids

Goal: Is there some correlation between a galaxy type and its active galactic nuclei (AGN) fraction?

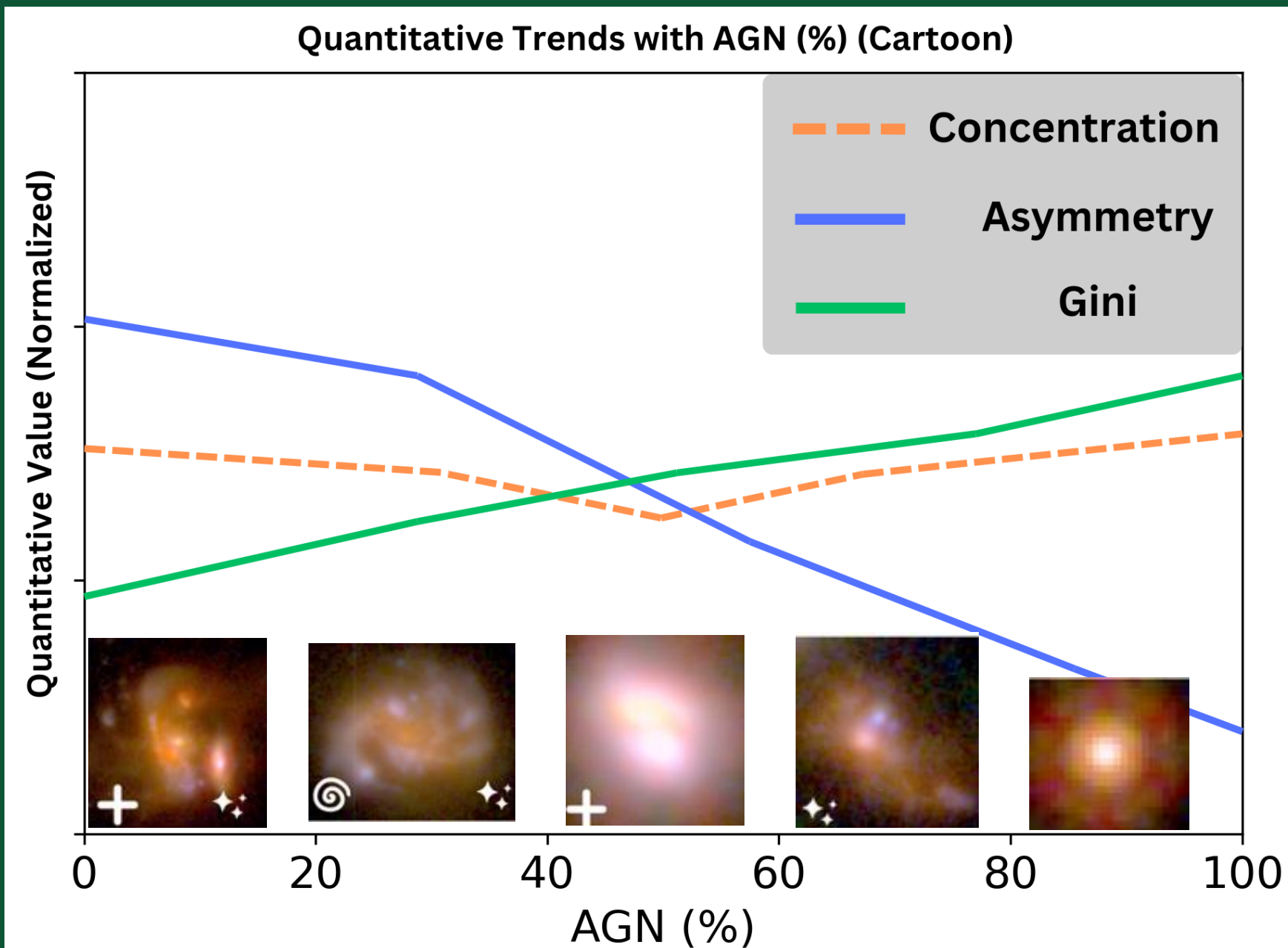
Gini and AGN

Key Takeaways

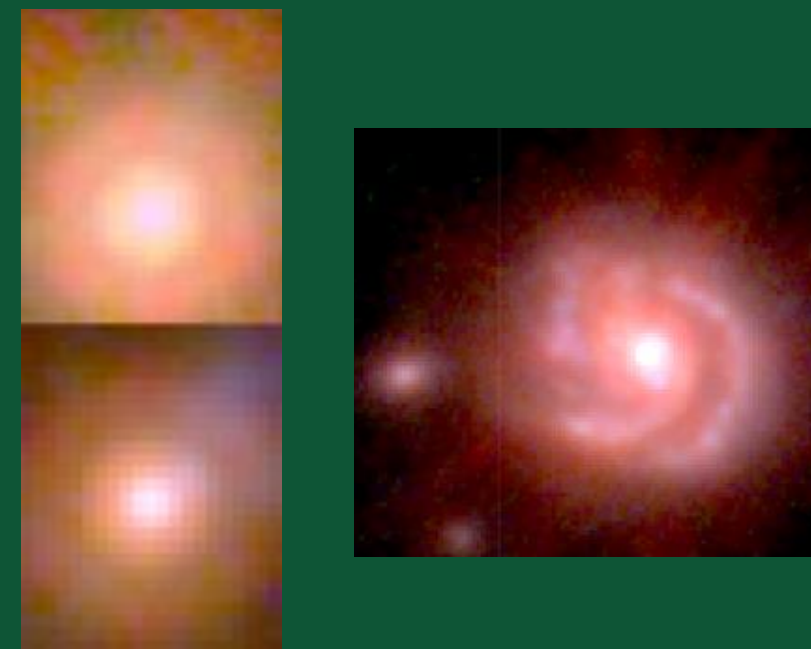
- Average Gini seems to increase with AGN fraction
 - AGNs are more likely to have most of their light in smaller regions than SF or Composites



Summary & Future

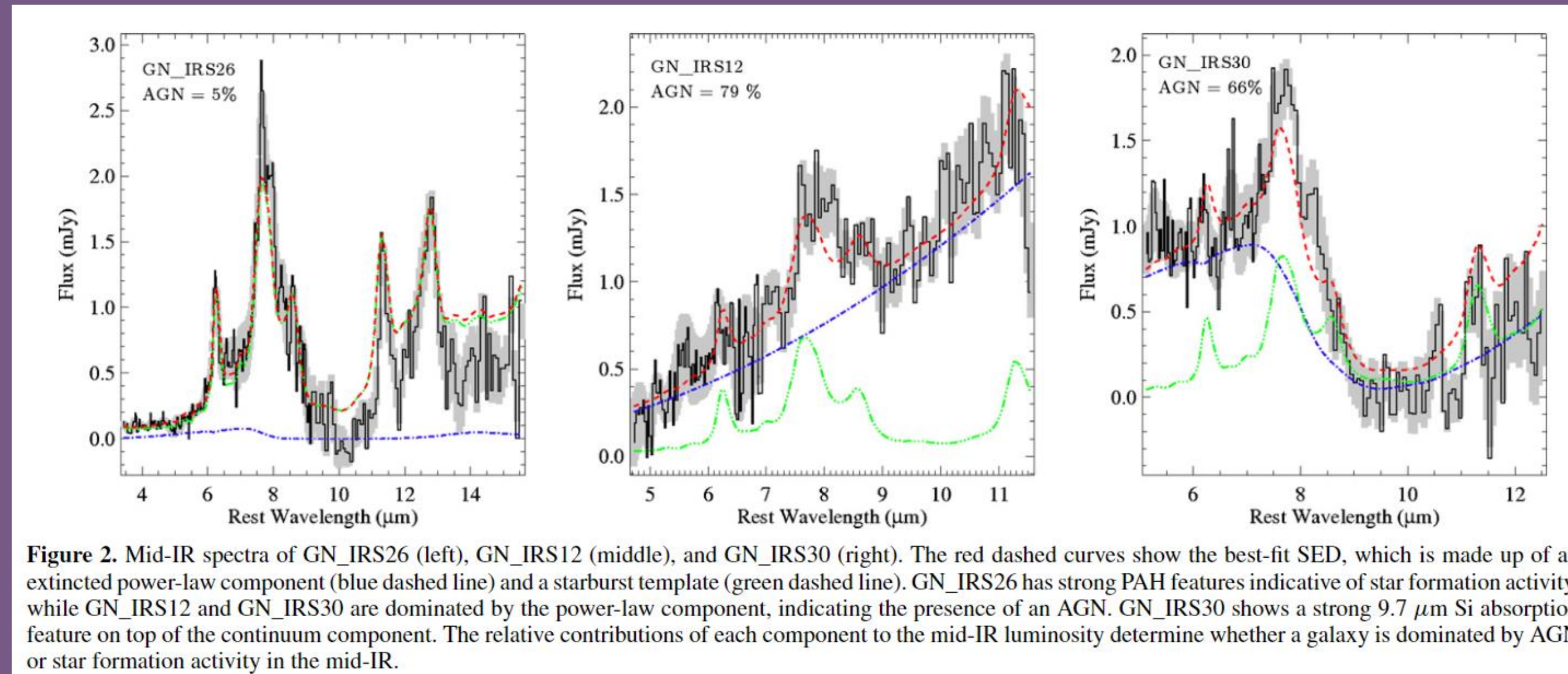


- Are high AGNs mainly spheroid because the nucleus obscures the outer structure?
- What fundamental process might prevent AGN from being irregular or merging?



Extra Slides

Data Sample: Spectral Fitting



Kirkpatrick et al. 2012

Data Sample: JADES & Grizli

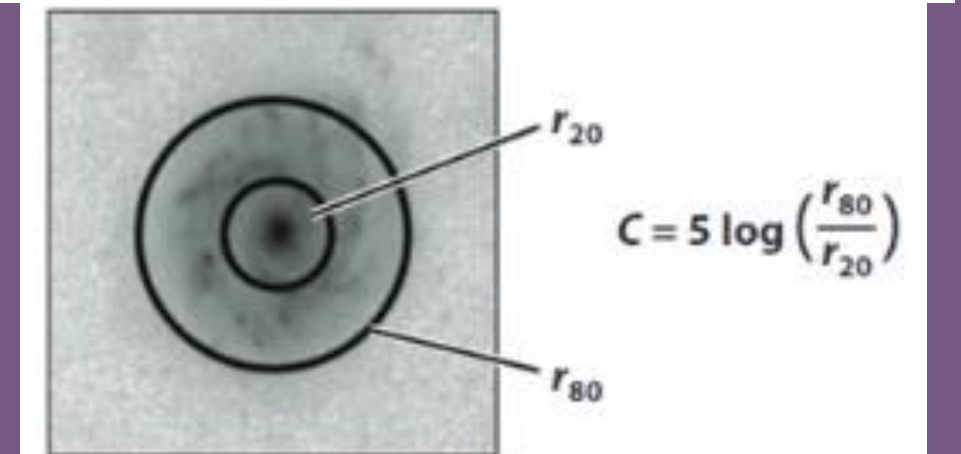
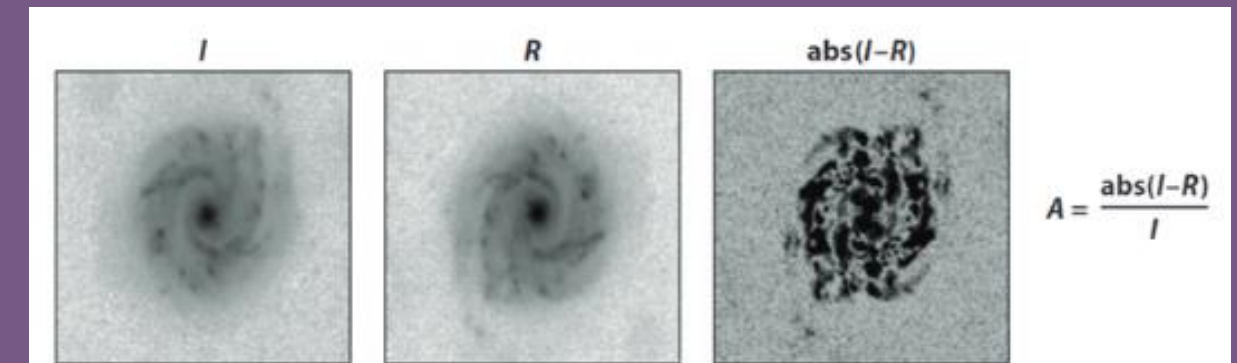
- [Data Reduction \[Grizli GN & GS\]](#)
- [JADES Survey Site](#) (Segmentation map & Viewer Images)
- [Kirkpatrick+2012 \[Sample data source\]](#)

Goal: Is there some correlation between a galaxy type and its active galactic nuclei (AGN) fraction?

Quantitative & Visuals

- Quantitative

- Asymmetry - Fraction of light in nonsymmetric parts of galaxy
- Concentration - Log Ratio of light in the outer 80% region of the galaxy compared to the inner 20%
 - focused on the center
- Gini - Disruption of light in the galaxy (not preferential towards the center)
 - High values = focused light
 - lower values = evenly distributed light
- M20 - Brightest 20% of the galaxy (non-central)



$$G = \frac{1}{|\bar{f}|n(n-1)} \sum_i^n (2i - n - 1) |f_i|$$

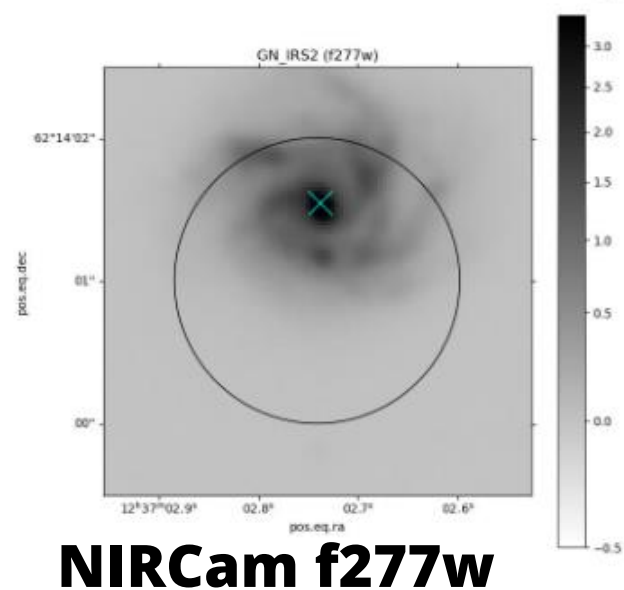
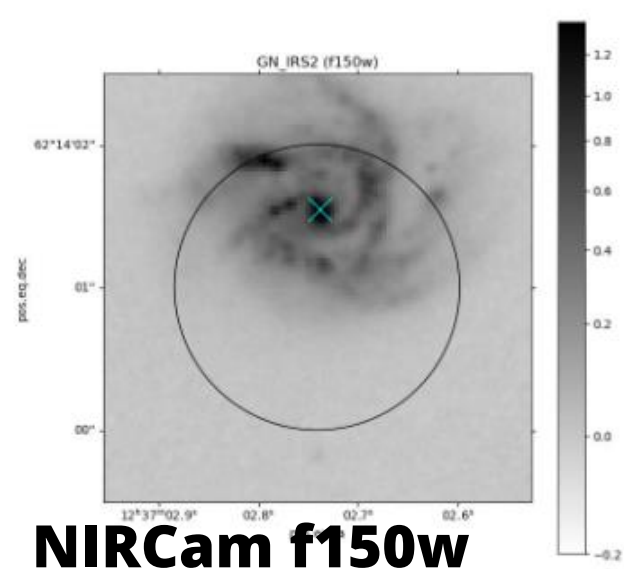
$$M_{20} = \log_{10} \left(\frac{\sum_i}{M_{\text{tot}}} \right) \text{ while } \sum i f_i < 0.2 f_{\text{tot}}$$

Goal: Is there some correlation between a galaxy type and its active galactic nuclei (AGN) fraction?

Quantitative & Visuals

GN_IRS2 *

GN - NIRCam R:>3.6um | G:2-3.4um | B:<2um
GS - NIRCam R:>3 um | G:2-3um | B:<2um

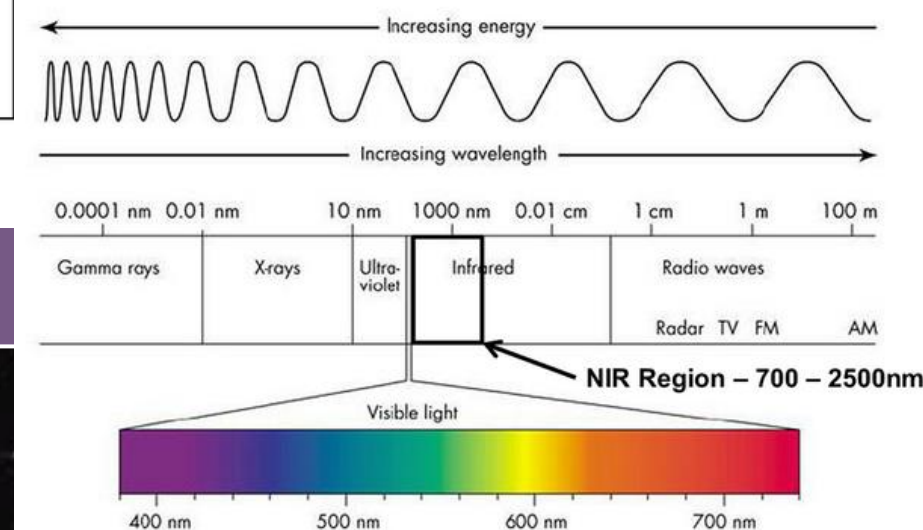
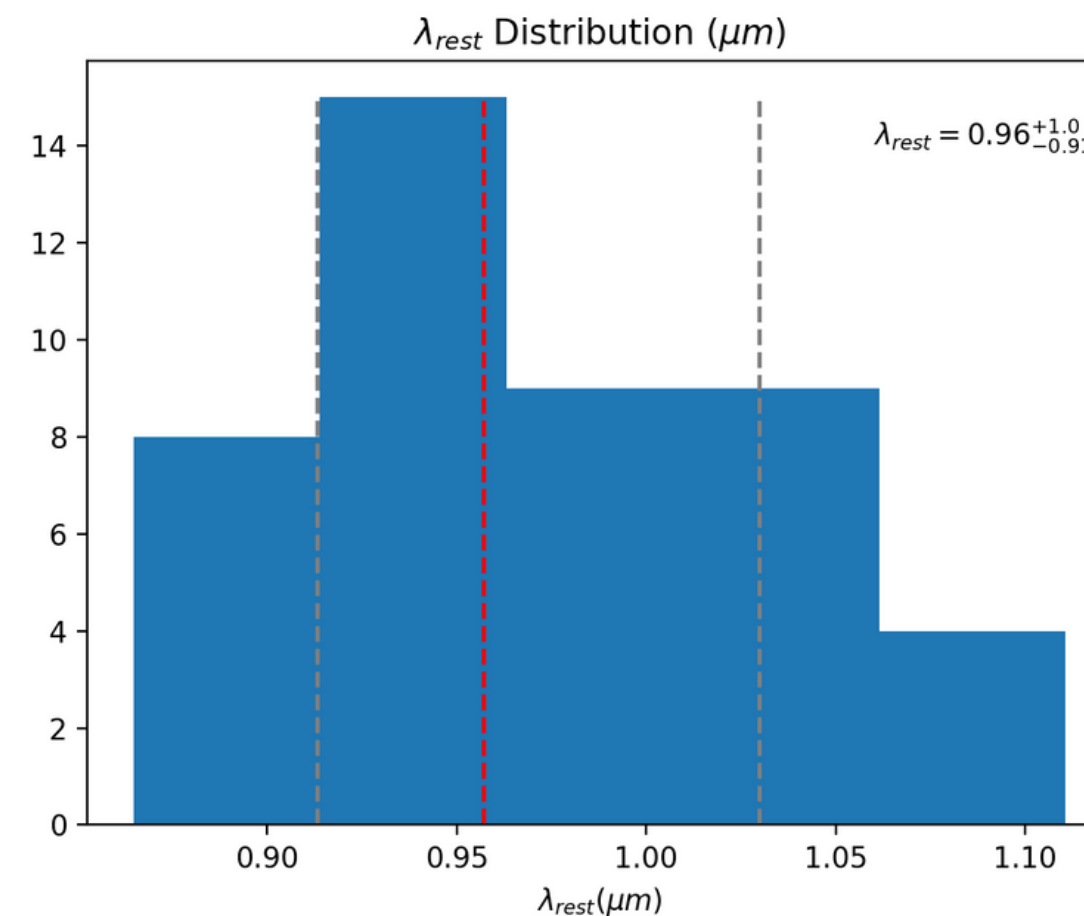
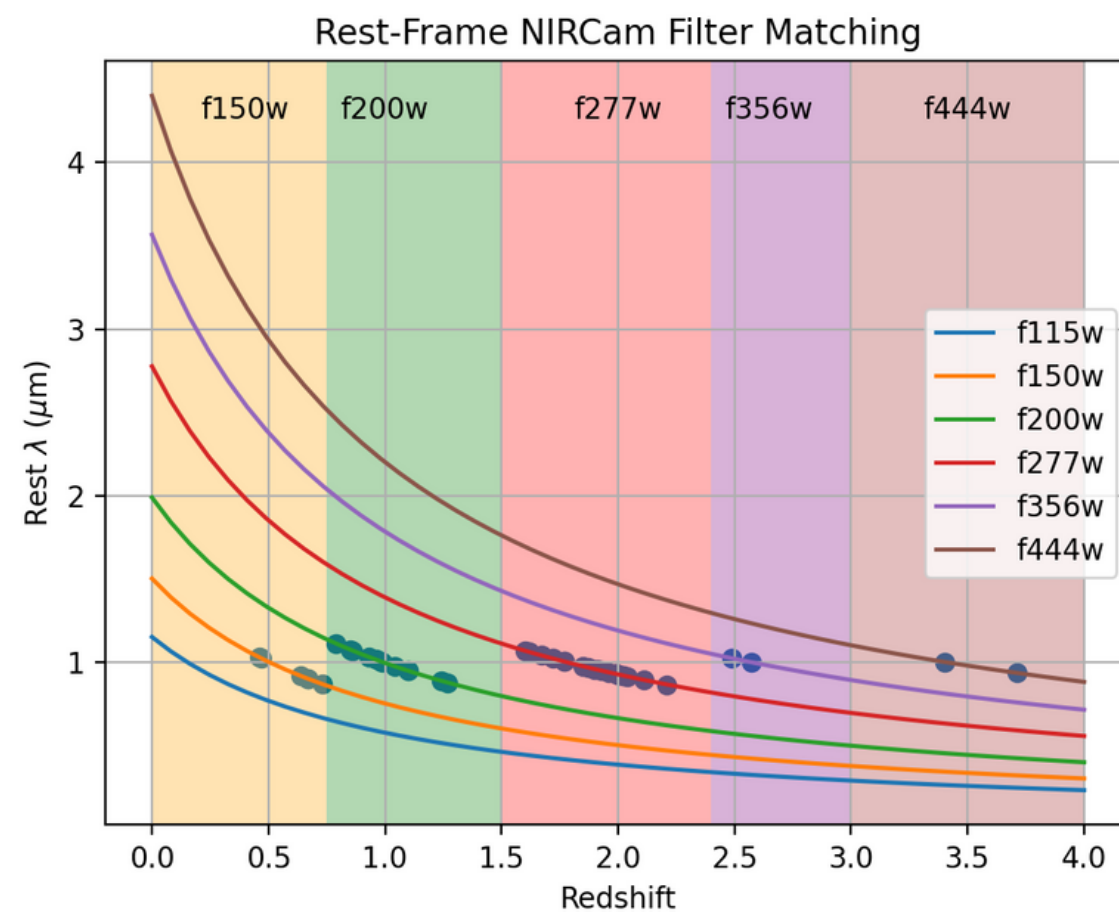


- ☐ Disk
- ☐ Spheroid
- ☐ Irregular
- ☐ Multiple Sources
- ☐ Has Clumps
- ☐ Spiral arms
- ☐ Appears to be a merger
- ☐ Check this if the morphology appears different for the wavelengths shown
- ☐ Other...

Goal: Is there some correlation between a galaxy type and its active galactic nuclei (AGN) fraction?

Process: Rest-Frame Light

- Make sure we're looking at the same light for each
- Probing Rest-Frame ~0.96 Micron or 960 nanometers

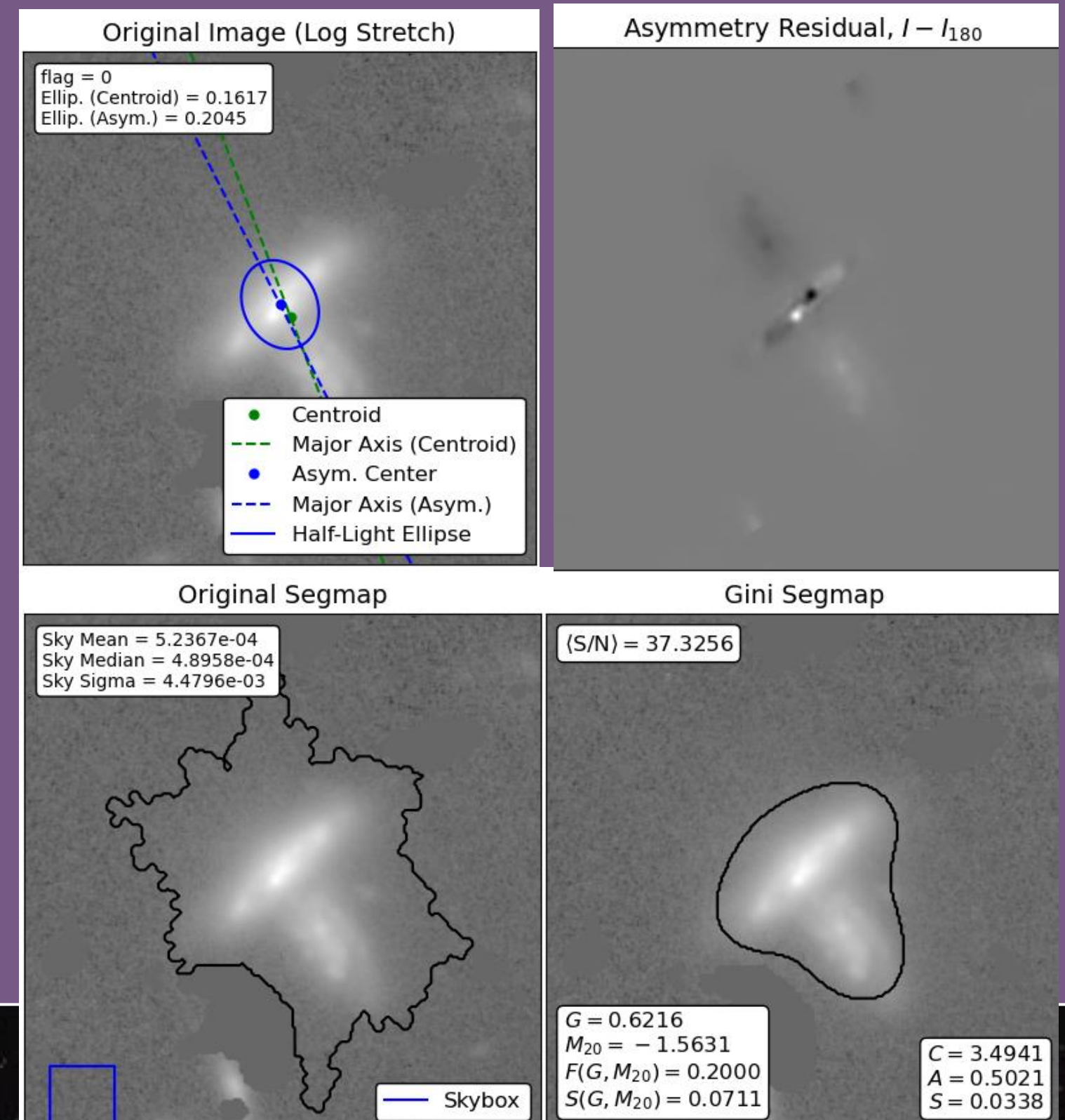


Goal: Is there some correlation between a galaxy type and its active galactic nuclei (AGN) fraction?

Process: Statmorph Configuration

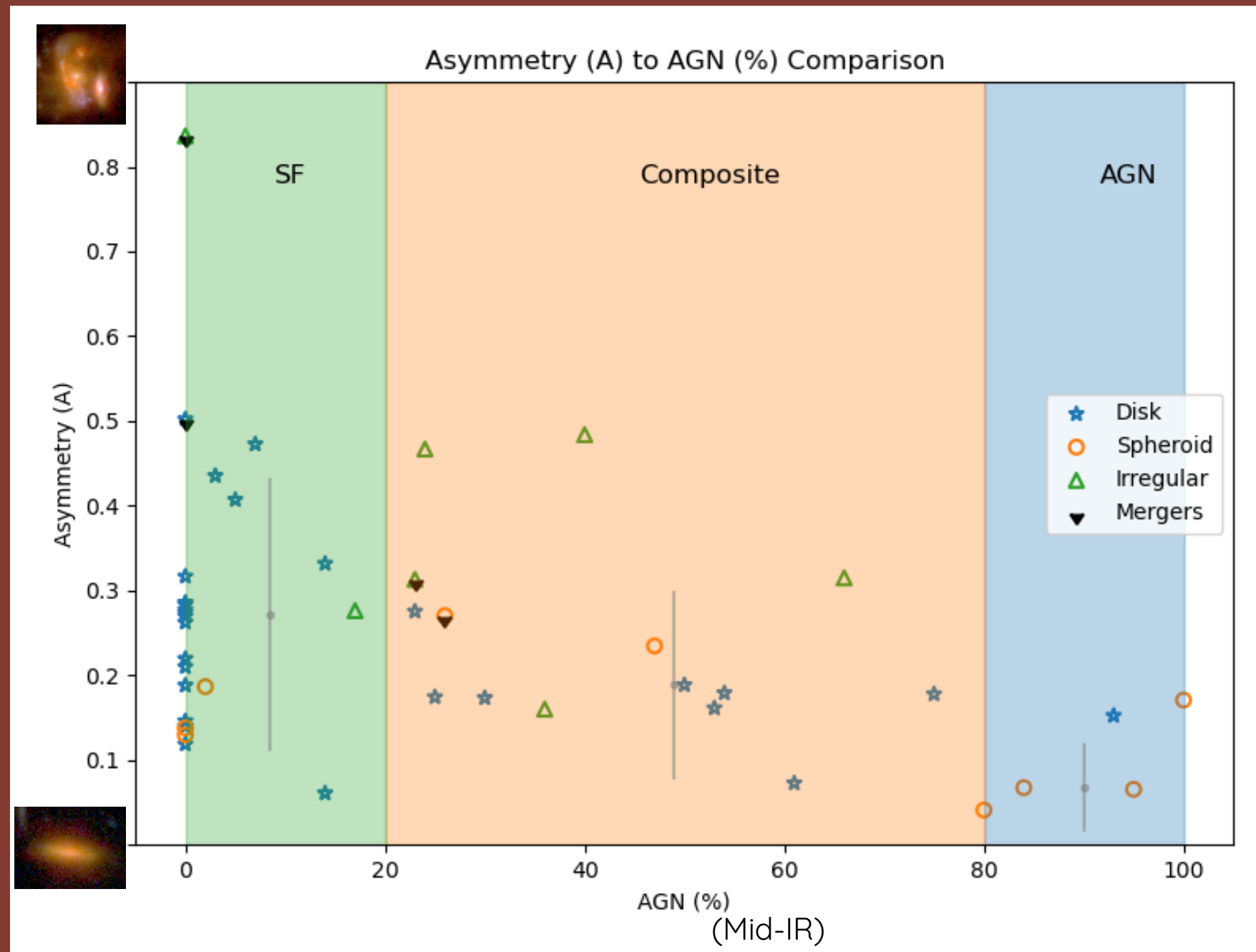
Configuration settings for statmorph

- Variable size of the cutout for galaxy (150-300 pixels) depending on the physical size of galaxy (Grizli)
- JADES segmentation image for the galaxy
- Weightmap from Grizli
- Skybox size = 32
- All sources $\text{flag} \leq 1$
- Manually looked through `make_figures` and `flag` output



Goal: Is there some correlation between a galaxy type and its active galactic nuclei (AGN) fraction?

Asymmetry and AGN

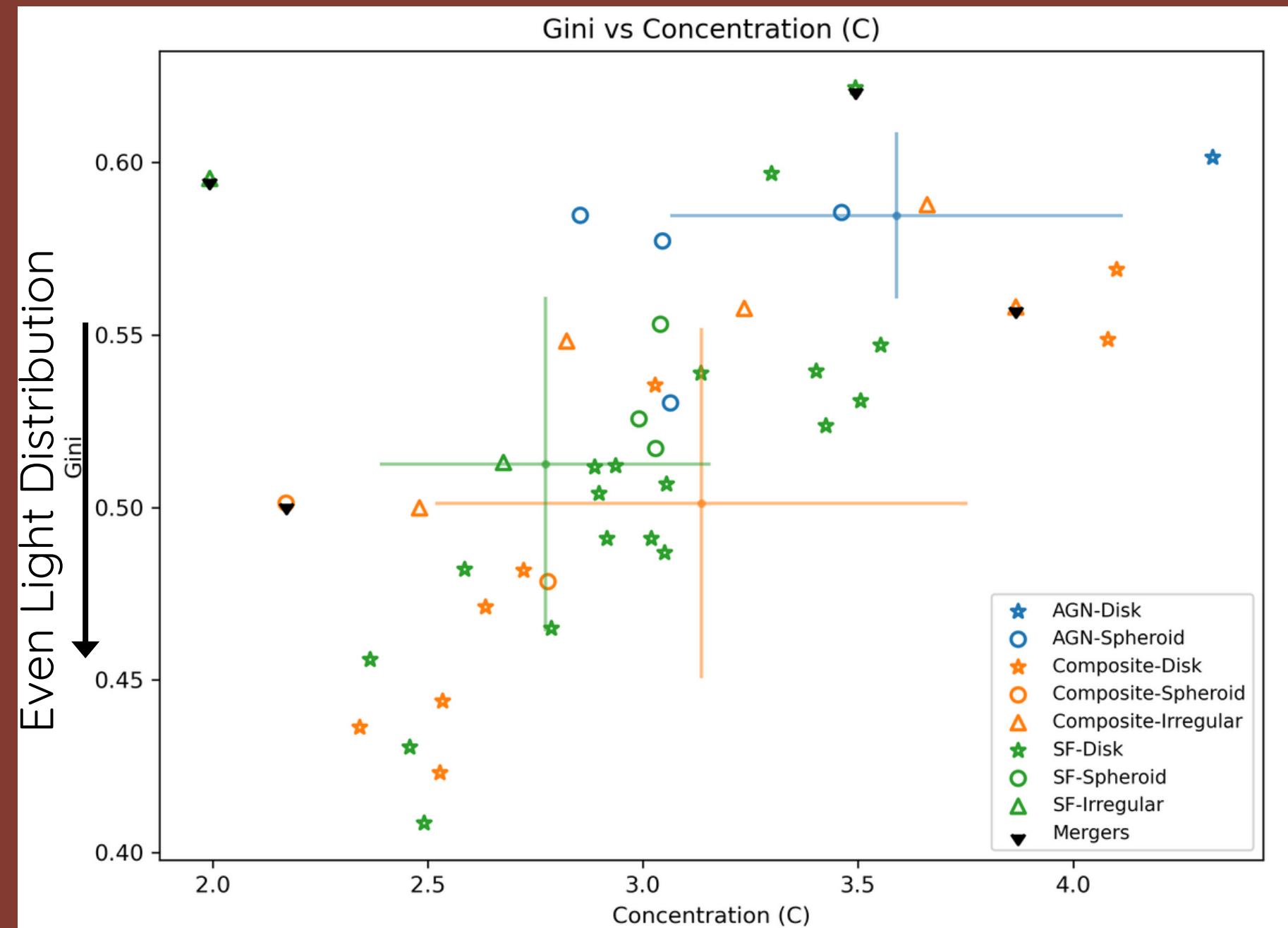


Key Takeaways

- Star-forming galaxies span full range of asymmetry values
- Asymmetry decreases with AGN fraction
 - AGN are symmetric/less clumpy than star-forming and composite

Goal: Is there some correlation between a galaxy type and its active galactic nuclei (AGN) fraction?

Gini & Concentration

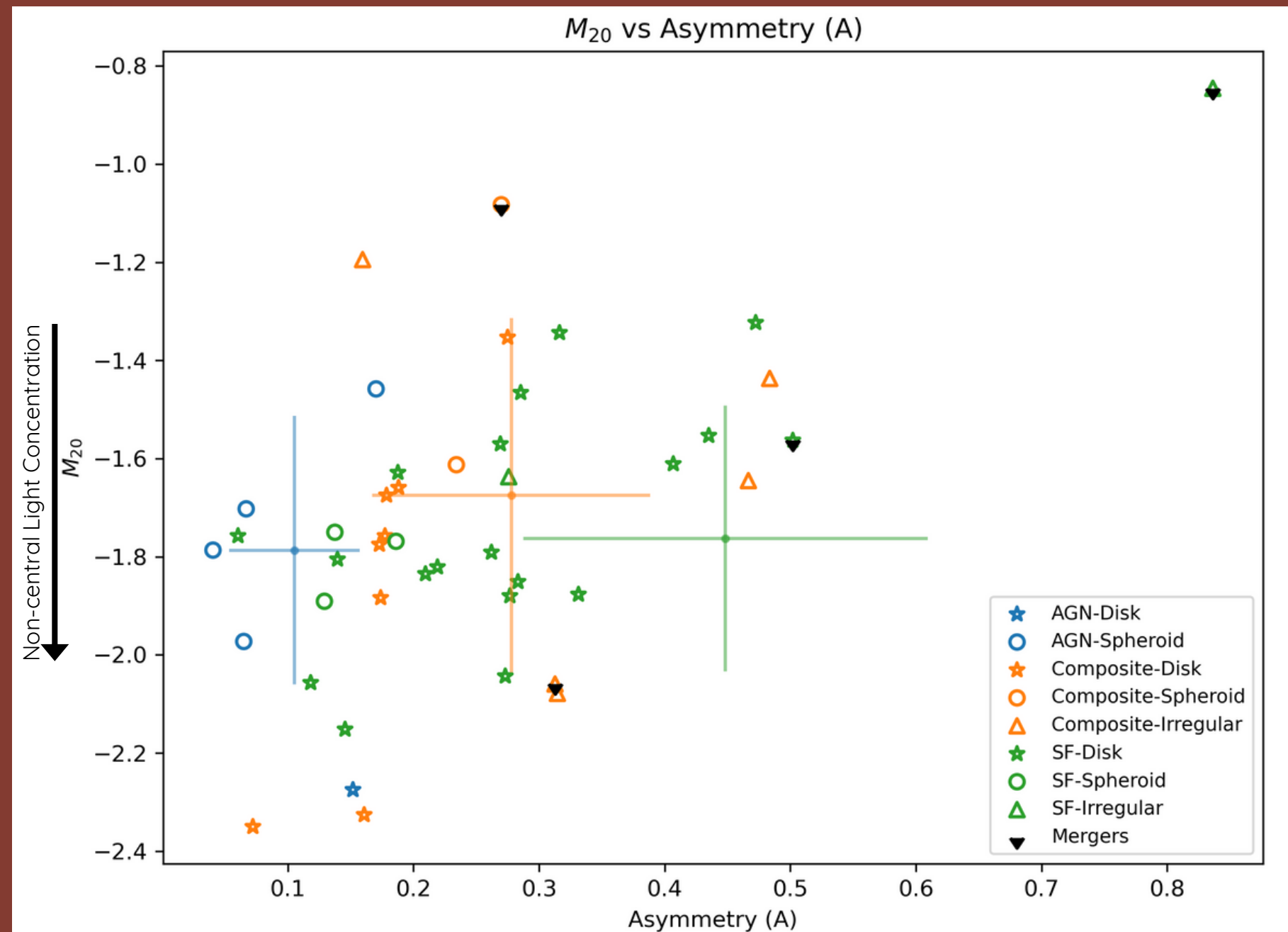


Key Takeaways

- AGNs have more focused light distribution
 - Because of the bright nucleus?

Goal: Is there some correlation between a galaxy type and its active galactic nuclei (AGN) fraction?

M20 & Asymmetry

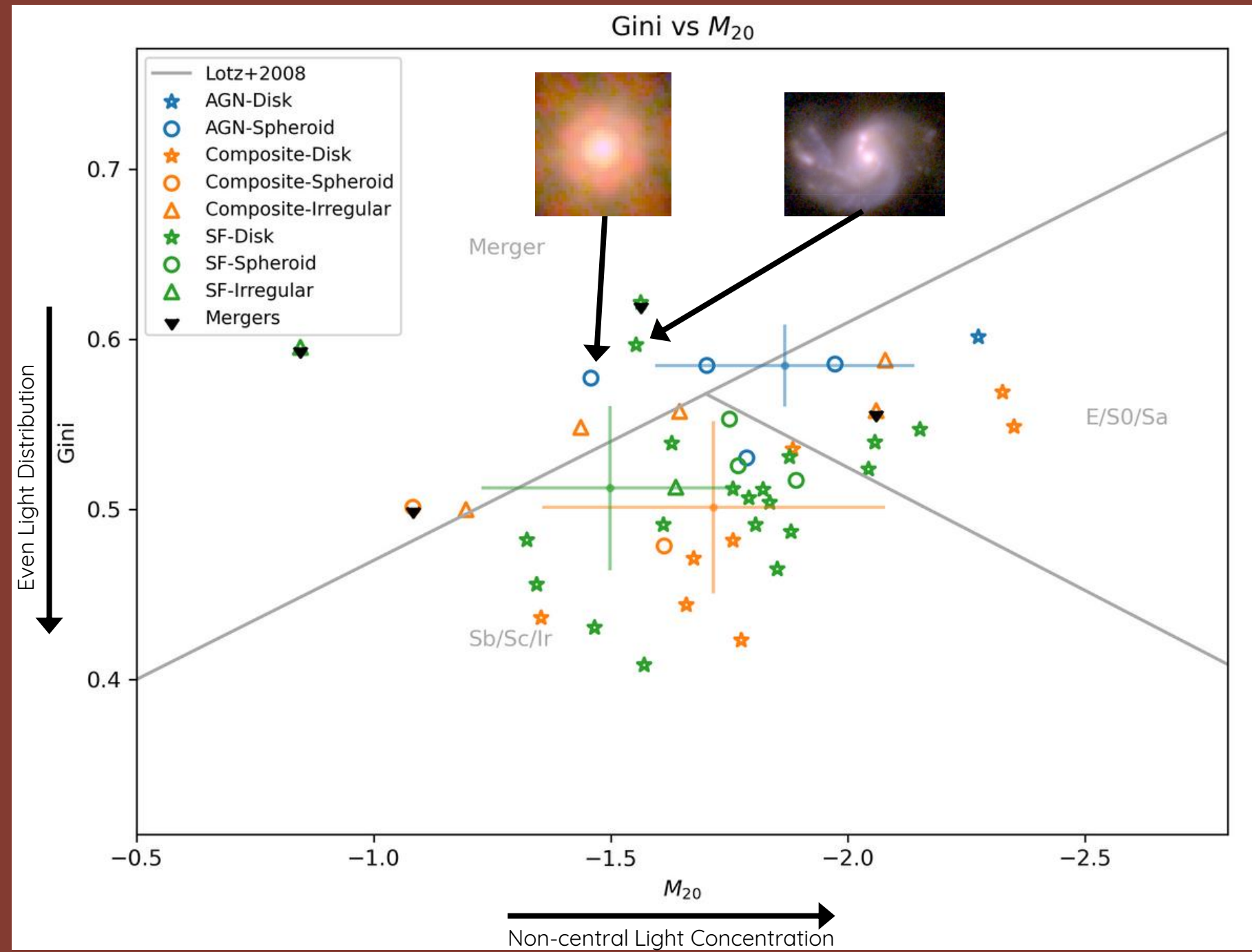


Key Takeaways

- AGN don't have preferential M_{20} values
- The light for SF, Composite, and AGN is distributed similarly
 - no distinct bright places of star formation or other activities
- AGN disks aren't special compared to SF or Composite (similar M_{20} values)

Goal: Is there some correlation between a galaxy type and its active galactic nuclei (AGN) fraction?

Gini/M20



Key Takeaways

- Visual mergers are (roughly) in agreement with the [\[Lotz+2008\]](#)
- AGN have more even light distribution than Star-forming and Composites
- Suggests (again) less clumps
- Smaller variation in Gini for AGN too

