2-D DISTRIBUTION OF THE IONISED GAS OXYGEN ABUNDANCE IN CALIFA SPIRAL GALAXIES

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Background

- Distribution of chemical abundances crucial to understand the evolution of discs in spiral galaxies.

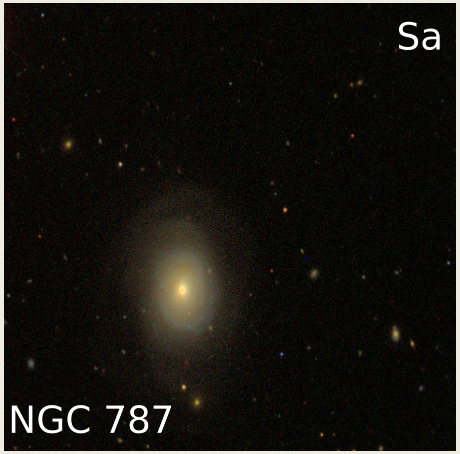
- Infall models of galaxy formation predict that spiral discs build up via accretion of material leading to an inside-out growth.
  - Inner parts form first followed by the formation of the outer parts.
  - Supported by observational studies presenting a radial decrease in the gas metallicity (e.g. Vila-Costas & Edmunds 1992; Zaritsky et al. 1994; van Zee et al. 1998; Bresolin et al. 2009; Rich et al. 2012).

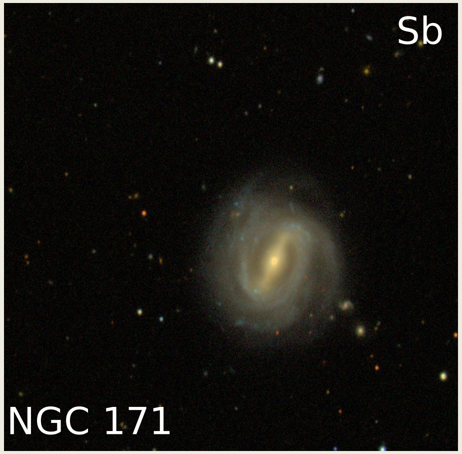
- Spectroscopic studies limited by statistics, either in the number of observed HII regions or in the spatial coverage of the disc.

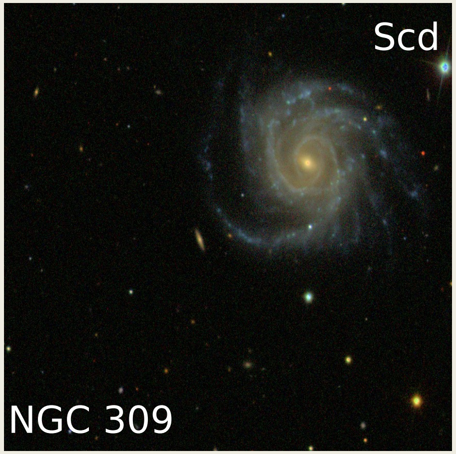
→ Integral Field Spectroscopy surveys

Sample

- **122 spiral galaxies** selected from the CALIFA mother sample following these criteria:
  - Morphological types between **Sa-Sdm**, including barred galaxies.
  - Face-on galaxies, with low disc inclination (**i < 60°**) .
  - Isolated galaxies, with no interaction.
  - Hα detected along different galactocentric distances with S/N > 4.







Analysis

Measurement of the emission lines

- We use Pipe3D to subtract the underlying stellar population (Sánchez et al. 2015, 2016) and measure the emission lines with a multi-component fitting using a single Gaussian function.

Selection of spaxels associated with SF

- Main emission line fluxes greater than 1σ.
- Under Kewley et al. (2001) demarcation line in BPT diagram and with EW(Hα) > 6 Å.

Measurement of the oxygen abundances

- O3N2 index: $$\mathrm{O3N2} = \log\left(\frac{[\mathrm{O\,III}]\lambda5007}{\mathrm{H}\beta} \times \frac{\mathrm{H}\alpha}{[\mathrm{N\,II}]\lambda6584}\right)$$
- 12+log (O/H) = 8.533 – 0.214 x O3N2 (Marino et al. 2013)

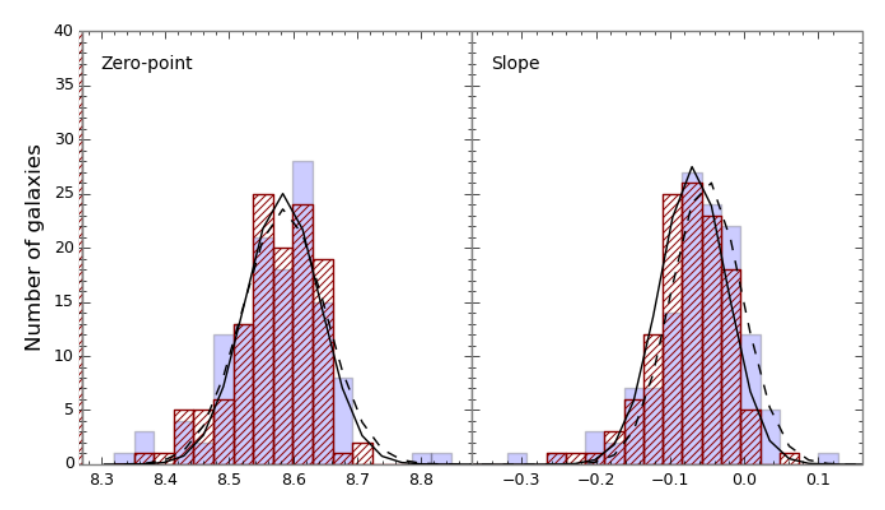
Oxygen abundance gradients

- Deprojected galactocentric distances normalised to the r_e.
- Radial range between 0.5 and 2.0 r_e.
- Error-weighted linear fit.

Results I

Spaxel-by-spaxel analysis equivalent to classical procedure of detecting HII regions, allowing to increase the number statistics and the spatial coverage

(Sánchez-Menguiano et al. 2016)



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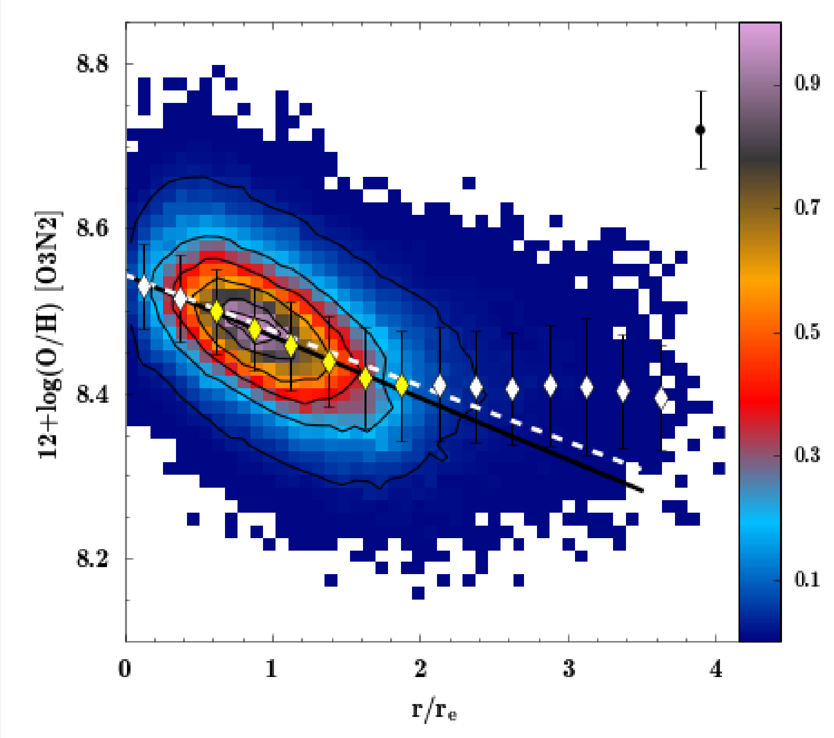
Results II

- Common abundance gradient up to 2 r_e.
- Flattening beyond ~ 2 r_e (48 galaxies).



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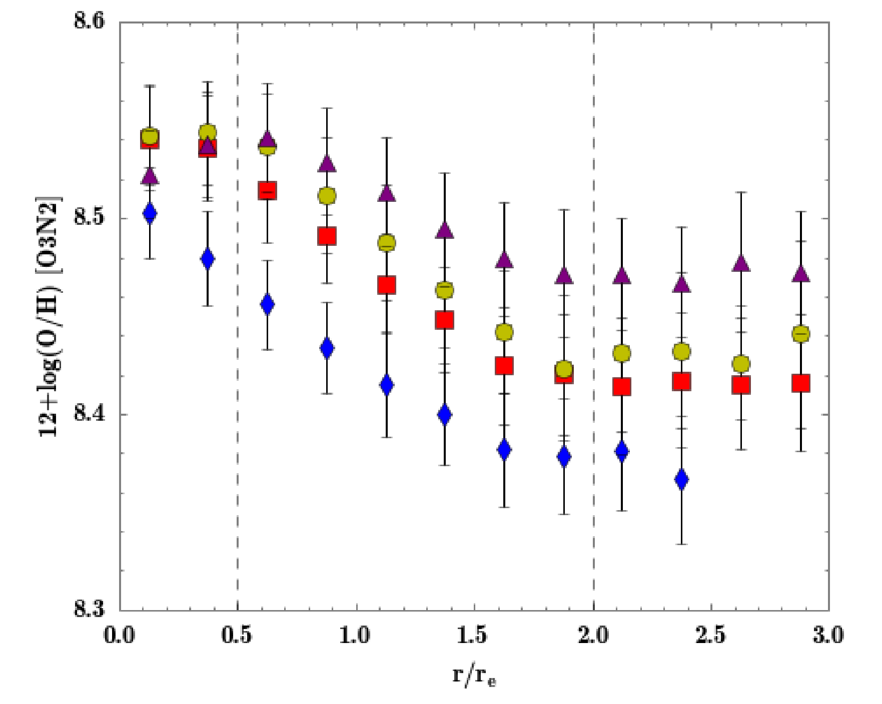
Results III

- Characteristic slope independent of the integrated stellar mass of the galaxies.
- Onset of the flattening located always around 2 r_e.
- Dependence of the inner drop with the integrated stellar mass of the galaxies.



High mass galaxies

Intermediate-high mass galaxies

Low-intermediate mass galaxies

Low mass galaxies

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Background

- Spiral arms: enhancement of star formation.
- If spiral structure is not always affecting the same material we should not expect differences in the chemical composition between the arm and inter-arm regions. If that's not the case, differences are expected.
- Flocculent and grand design galaxies may have a different origin that can be reflected in different ionization conditions of the HII regions (e.g. Elmegreen 1981).

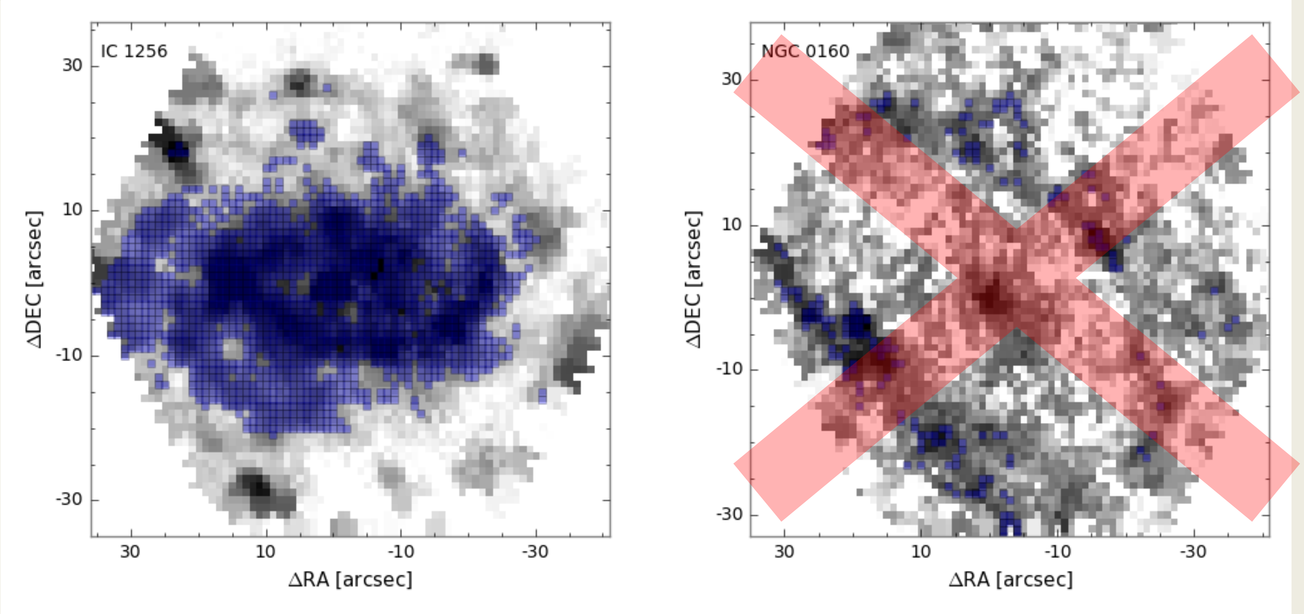
Is the gaseous content of spiral arms different to what found in the rest of the disc (inter-arm region)?

Is there any difference in the origin of the spiral arms of flocculent and grand design galaxies?

Sample

68 spiral galaxies selected from SM16, discarding those galaxies with:

- Gaseous emission not covering a continuous and wide area of the disc (fraction of non-isolated spaxels lower than 15 %).
- Gaseous emission not covering a substantial extension of both structures (less than 20 % of spaxels with gaseous information belonging to each of both structures).
- Untraceable spiral arms: not clearly defined over the gaseous disc.



Analysis spiral arm characterisation

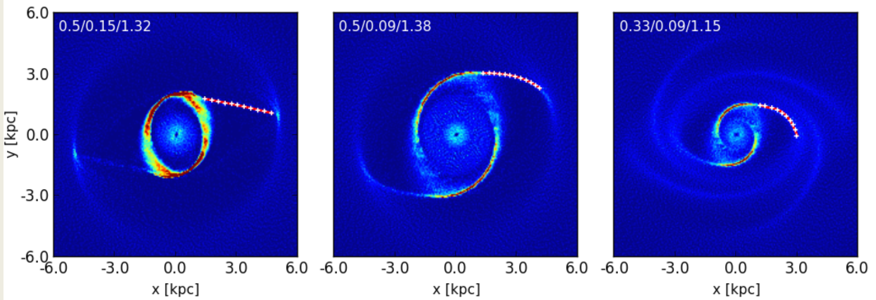
Arm classification

The classification was performed independently by 14 authors:

- 45 flocculent galaxies, with small and patchy spiral arms.
- 18 grand design galaxies, with long, symmetric and continuous arms..
- 5 unclear galaxies.

Arms tracking

- We visually trace the spiral arms on the SDSS *g+u* deprojected images using SAOImage ds9 and we interpolate the points using a cubic spline. We assign the spiral arms a width of 4 arcsec.
- Procedure already used in Sánchez-Menguiano et al. (2015) to trace dust lanes in galactic bars.



Arm-interarm abundance gradients

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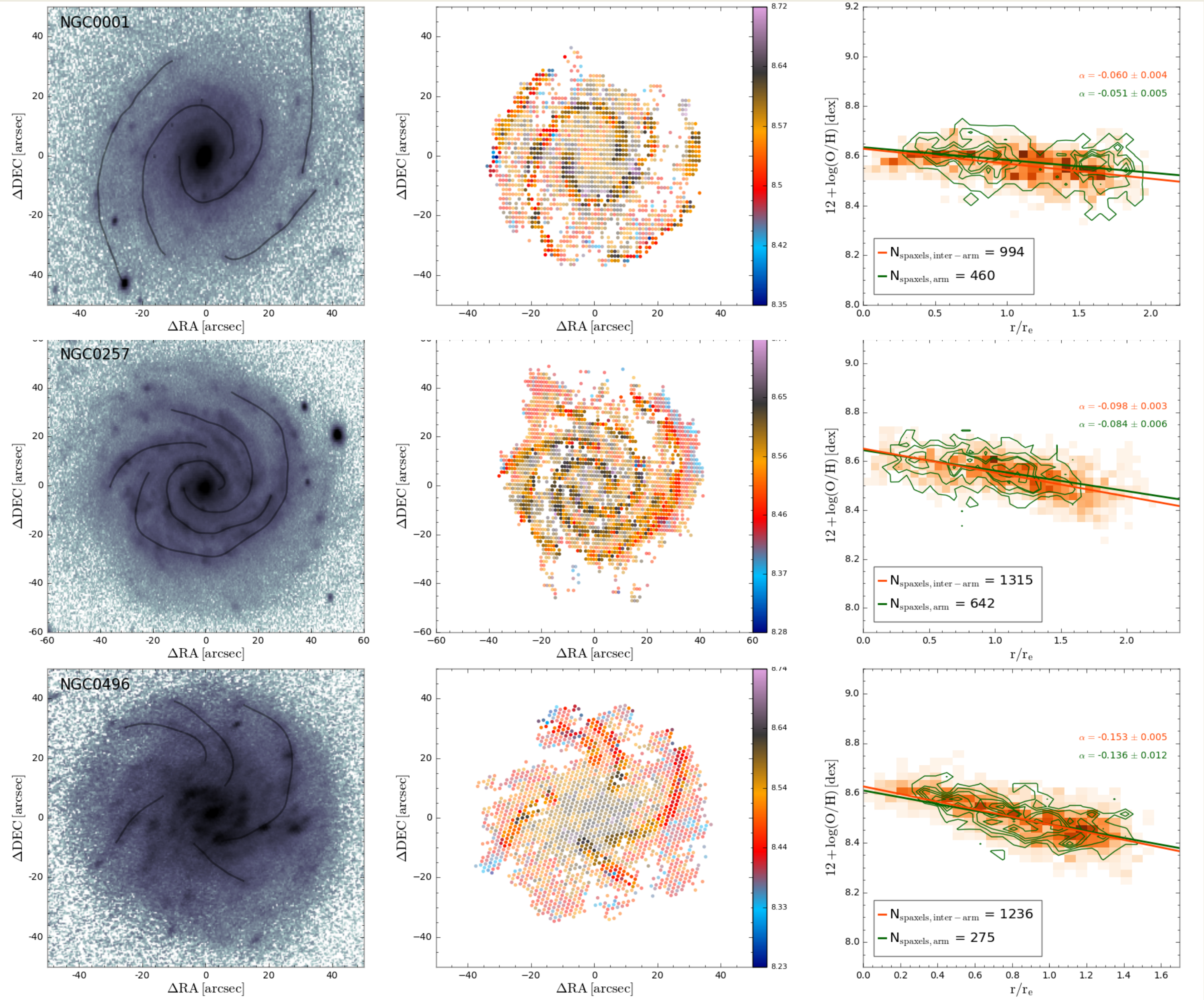

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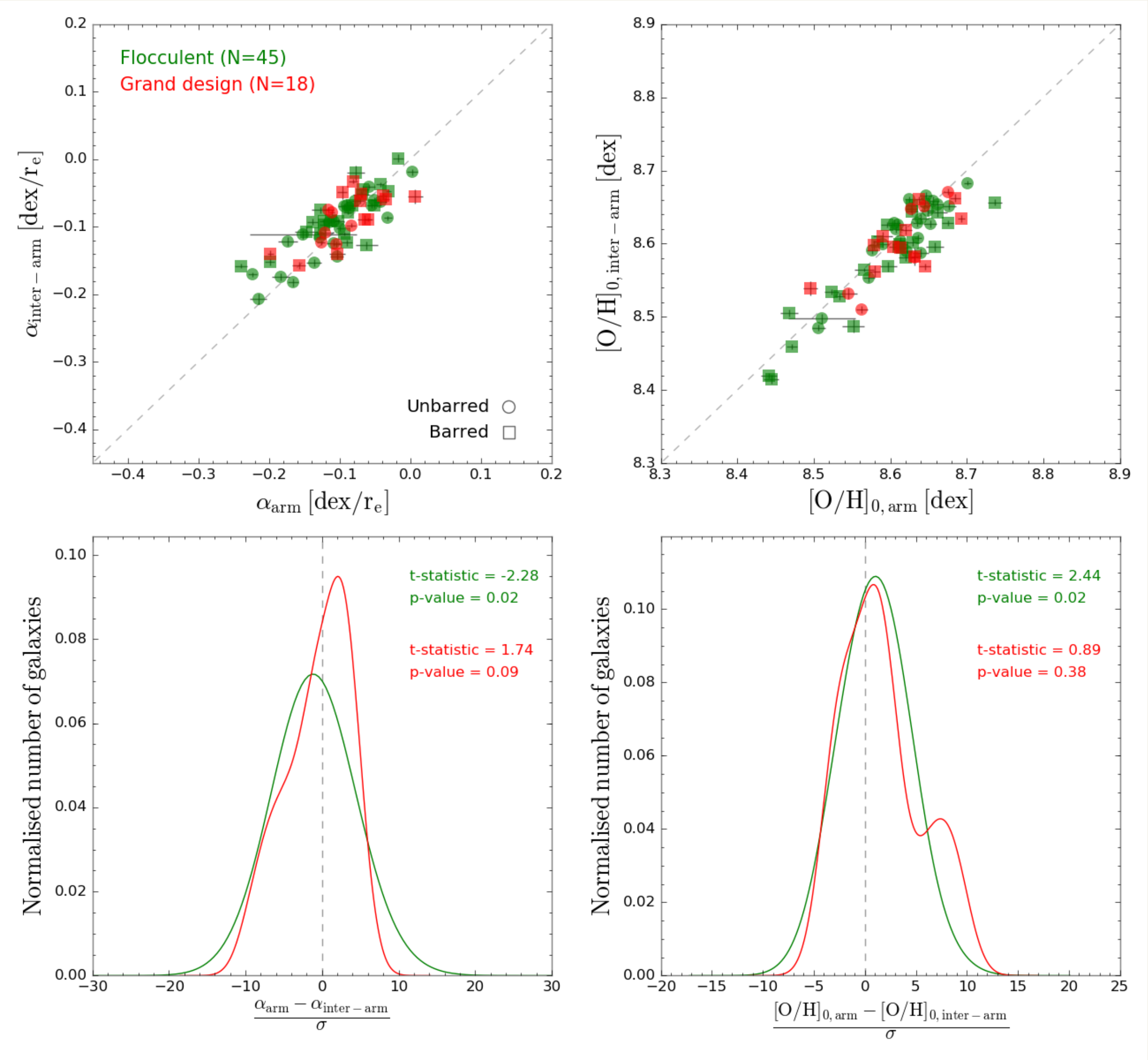
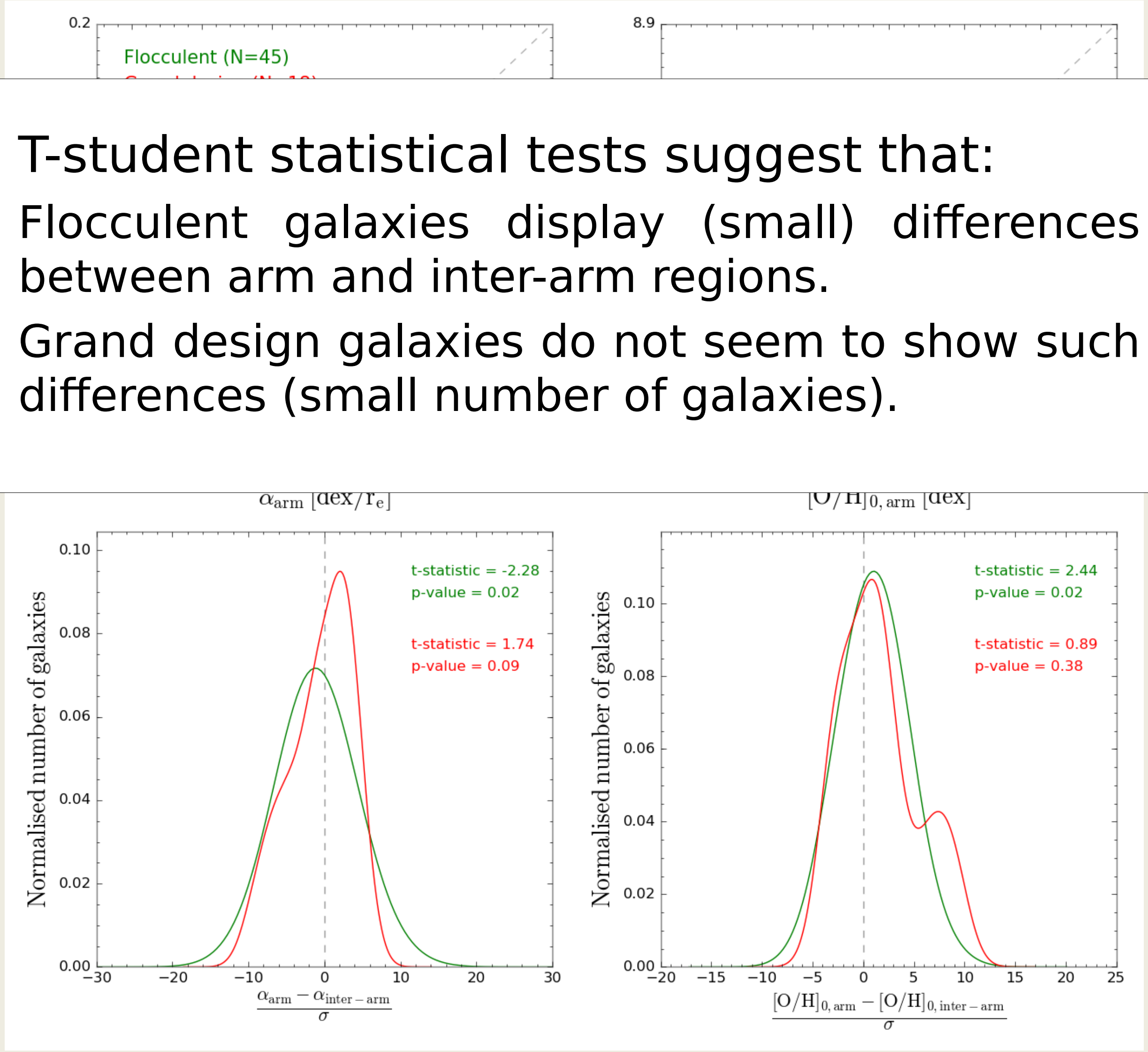
Results I



Results I

T-student statistical tests suggest that:

- Flocculent galaxies display (small) differences between arm and inter-arm regions.
- Grand design galaxies do not seem to show such differences (small number of galaxies).



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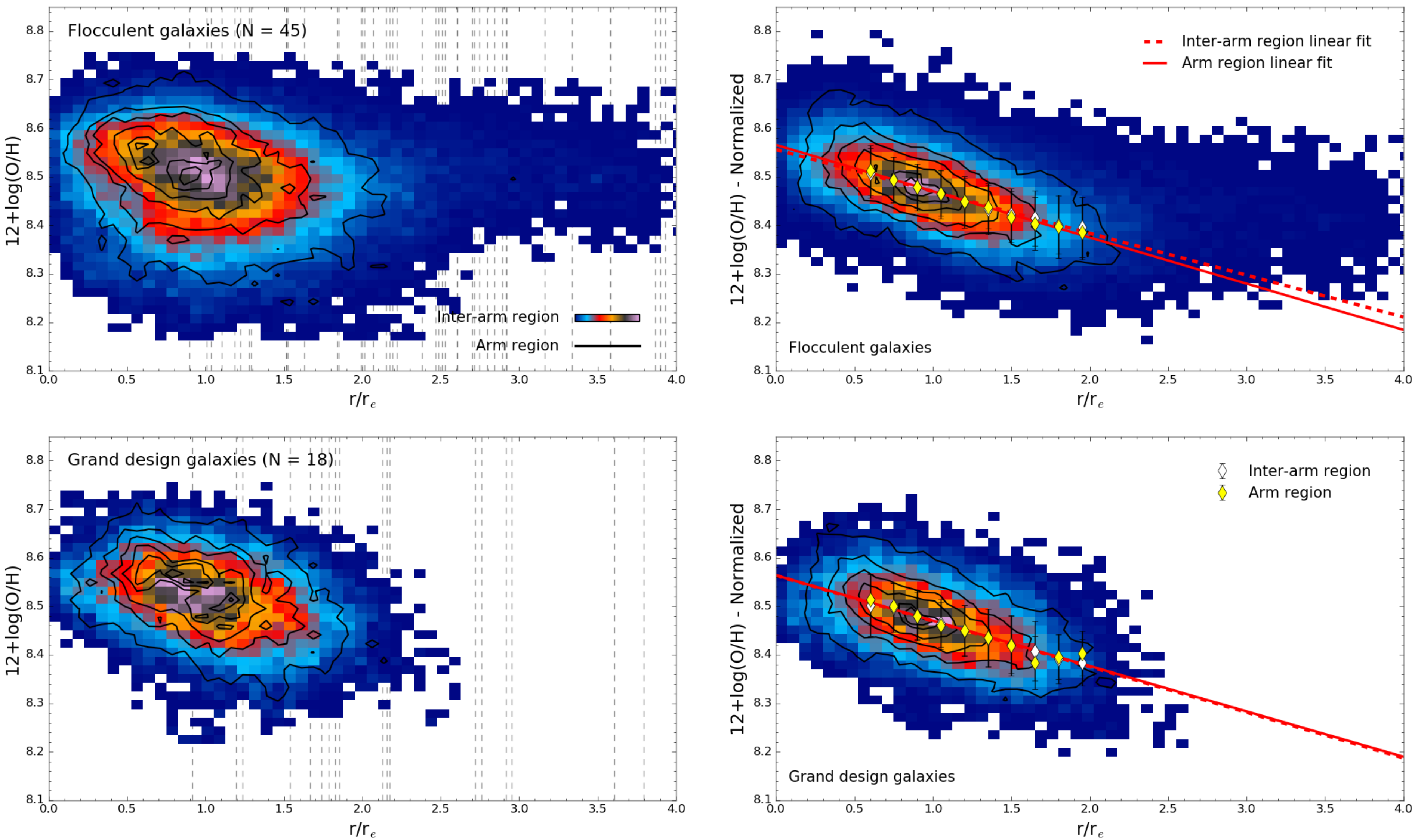
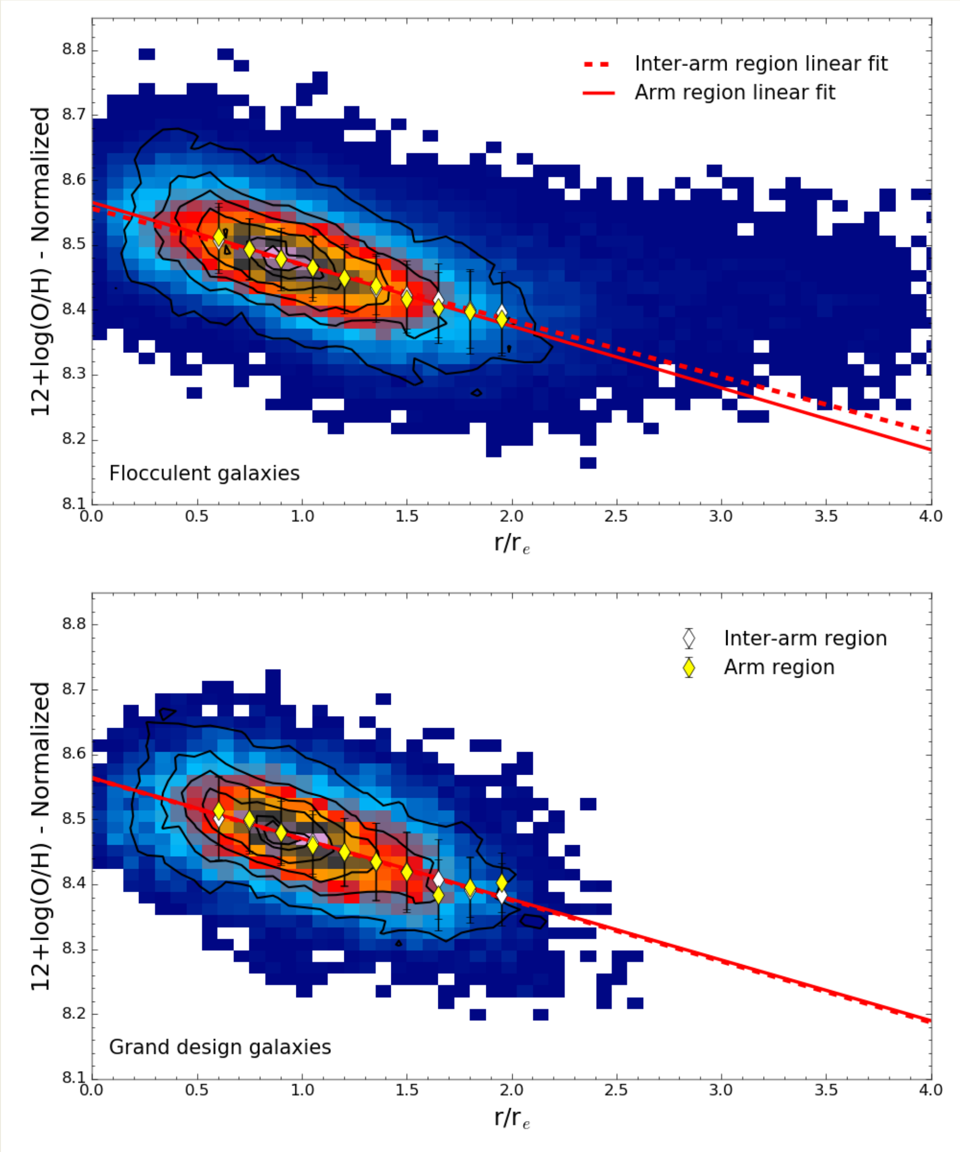
Results II



Results II

Same conclusions can be drawn when stacking all the abundance profiles for flocculent and grand design galaxies:

Small differences are only found for flocculent galaxies.



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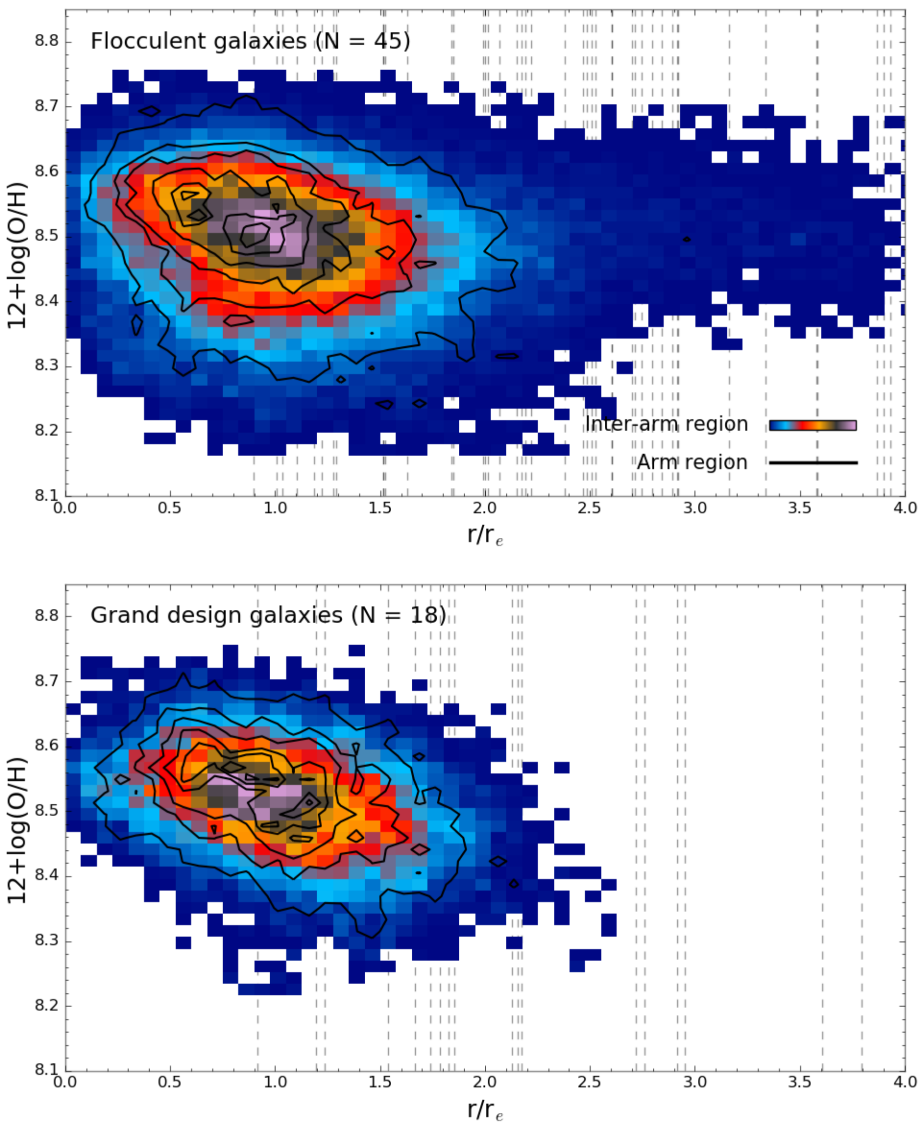
Results II



Ionised gas radial extension:

Presence of ionised gas at larger radii for flocculent galaxies compared to grand design systems although the extension of both discs is similar.

Conclusions

When analysing the abundance distribution of the entire disc we find:

- A common oxygen abundance gradient when normalising to r_e.
  - Slope independent of the integrated stellar mass of the galaxies.
- An universal flattening of the abundance beyond $2r_e$.
- A drop in the inner regions not observed for low mass galaxies.

When analysing arm-interarm abundance distributions we find:

- No significant differences, although flocculent galaxies hint subtle discrepancies (supported by statistical tests). This result suggests that:
  - The spiral structure is supported by a transient mechanism that affects the gas of the entire disc.
  - Processes shaping flocculent or grand design galaxies do not affect their chemical composition.
- The extension of the ionised gas for flocculent galaxies seems to be larger than in the case of grand design systems.
  - Further investigation is needed.

Thank you
for your attention

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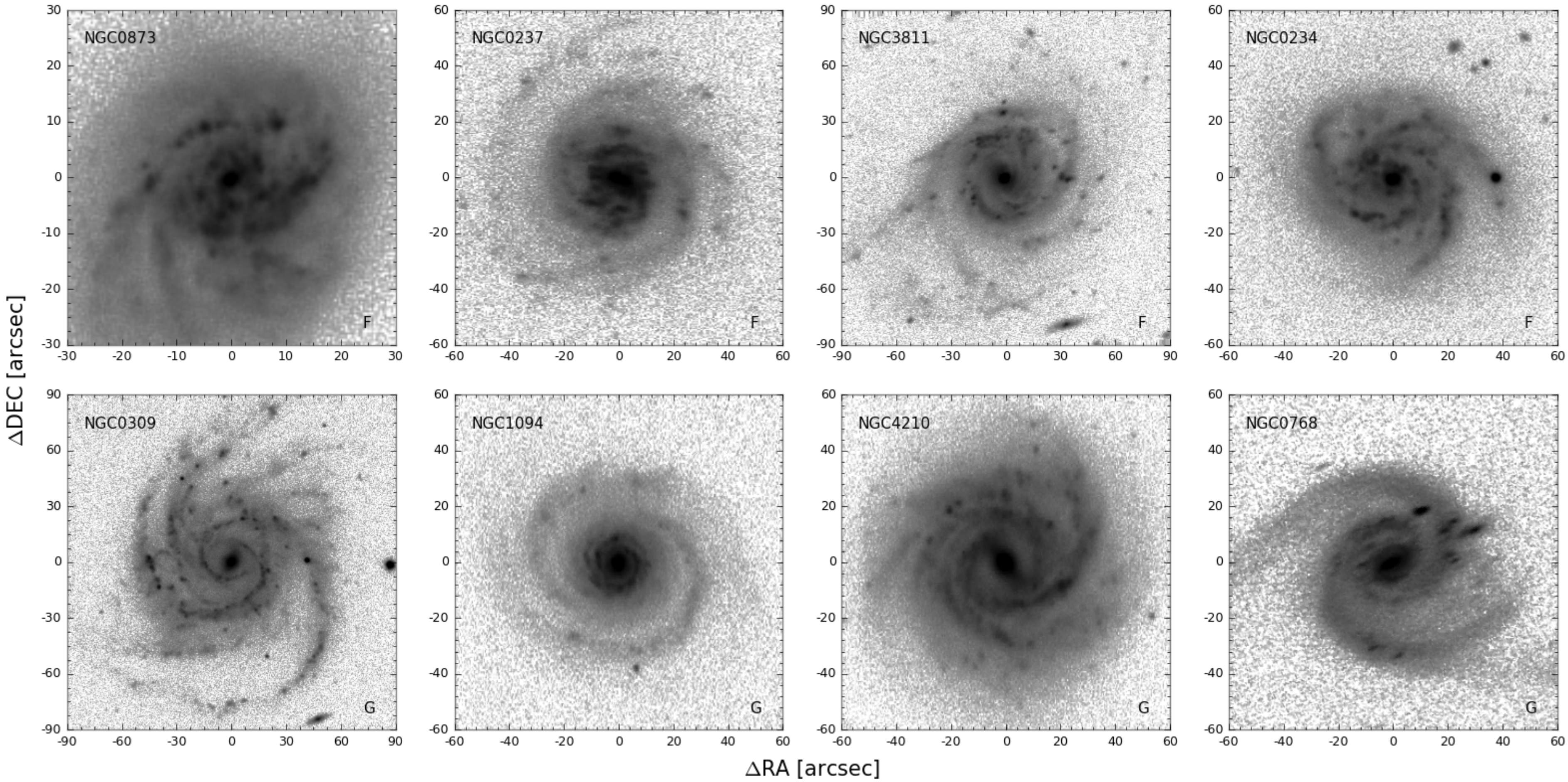
Arm classification

Flocculent galaxies



Grand design galaxies

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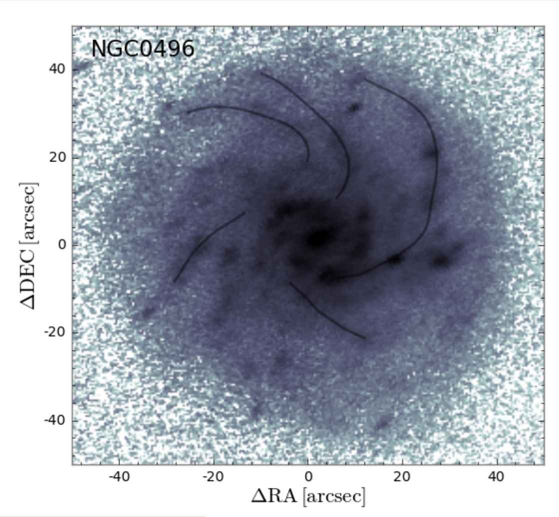
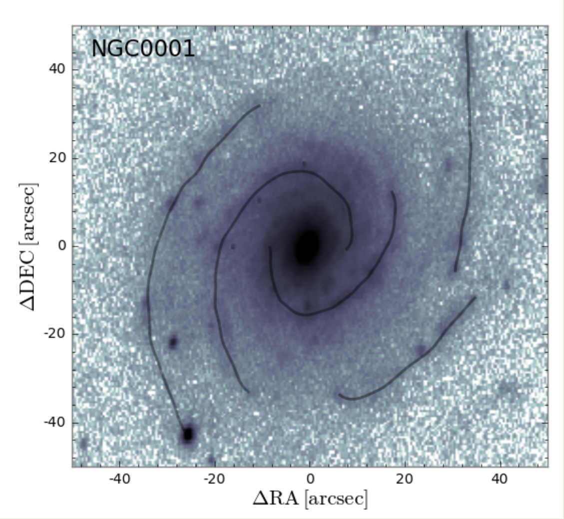
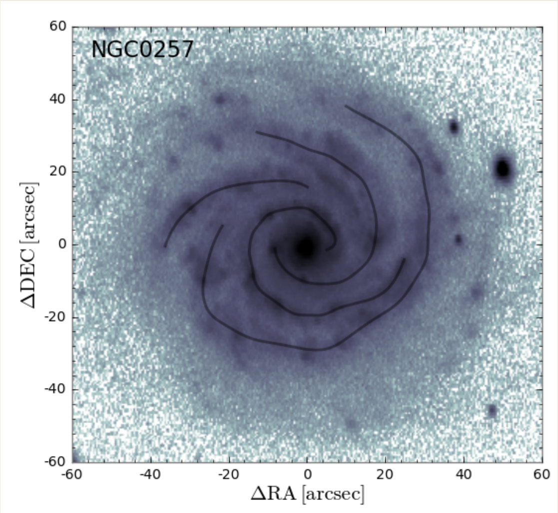
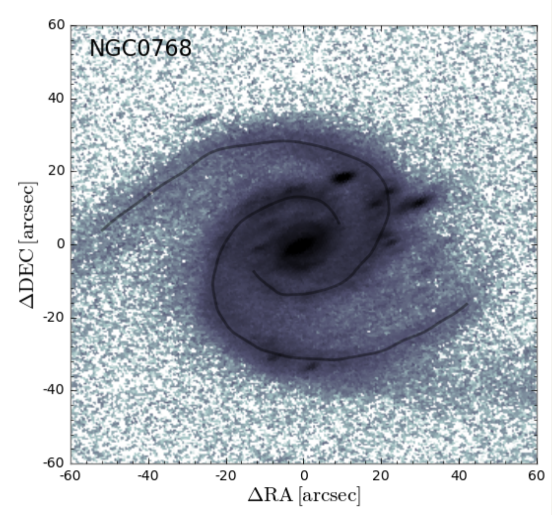
Arms tracking

Flocculent galaxies









Grand design galaxies

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Results II

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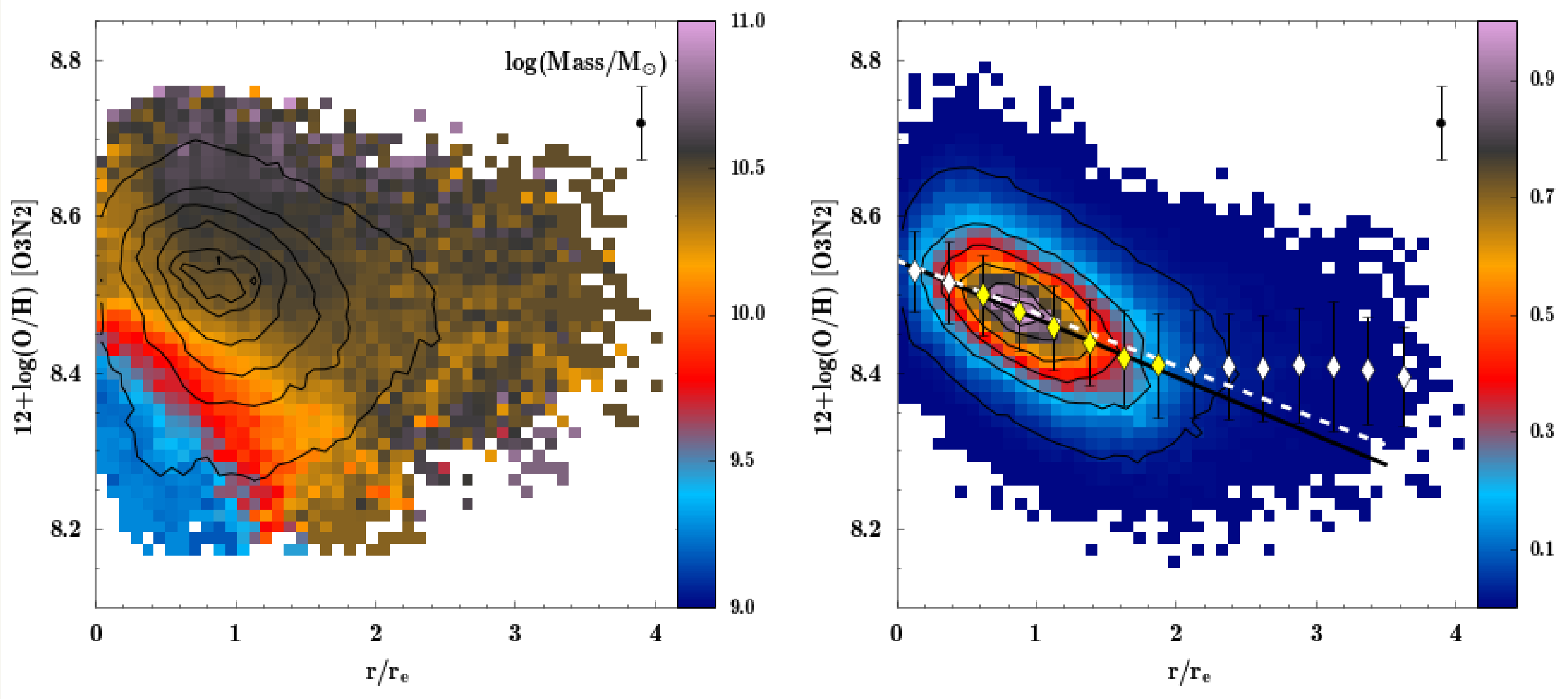

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