SUPA

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SEDmorph

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of
St Andrews

Merger, starburst, post-merger, post-starburst… red sequence?

Quantifying the morphology of tidally disrupted galaxies.

Milena Pawlik

Vivienne Wild (University of St Andrews),
Peter Johansson (University of Helsinki), Jakob Walcher (AIP, Potsdam)

Evolving Galaxies in Evolving Environments
Bologna, 19/09/2014

mp84@st-andrews.ac.uk

Motivation

- **Observations: first catalogue of peculiar galaxies in 1966 by Arp;**
- **Models: transition phase from blue-sequence to red-cloud galaxies**

(eg. Toomre & Toomre, 1972);

Galaxy mergers as one of the channels of galaxy evolution.

PROBLEM:
No strict criteria for sample selection.

mp84@st-andrews.ac.uk

Motivation

Starburst/post-starburst galaxies:

- **Observations: post-starburst spectral signatures in low-z galaxies likely caused by major mergers;**

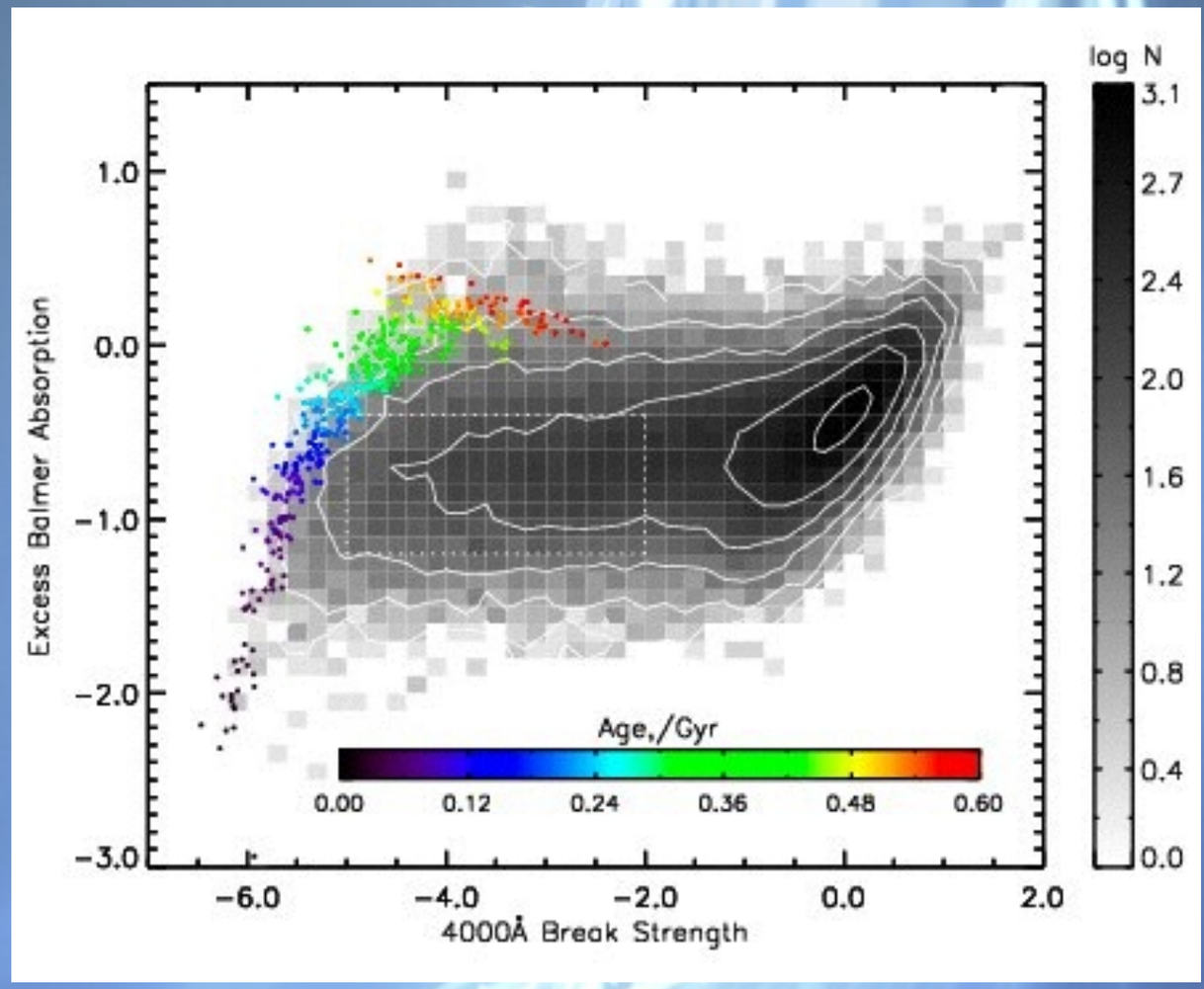
  (eg. Zabludoff et al, 1996)

- **Models: gas-rich major merger events can induce bursts of star formation;**

  (eg. Springel, Di Matteo & Hernquist, 2005)

- **Well-defined selection criteria: More robust and complete samples!**

  See: Wild et al, 2007



Wild et al, 2010

mp84@st-andrews.ac.uk

Aims of this work

Merger, starburst (SB), post-merger, post-starburst (PSB)…

- Quantify the morphology of spectroscopically-selected SB/PSB galaxies
- Need an automated method that could be applied to large galaxy samples!

- How does the morphology of galaxies change as they pass through their post-starburst phase?
- What fraction of SB/PSB galaxies show post-merger signatures?
- What is the role of galaxy mergers in the build-up of the red sequence and hence, the observed (local) galaxy bimodality?

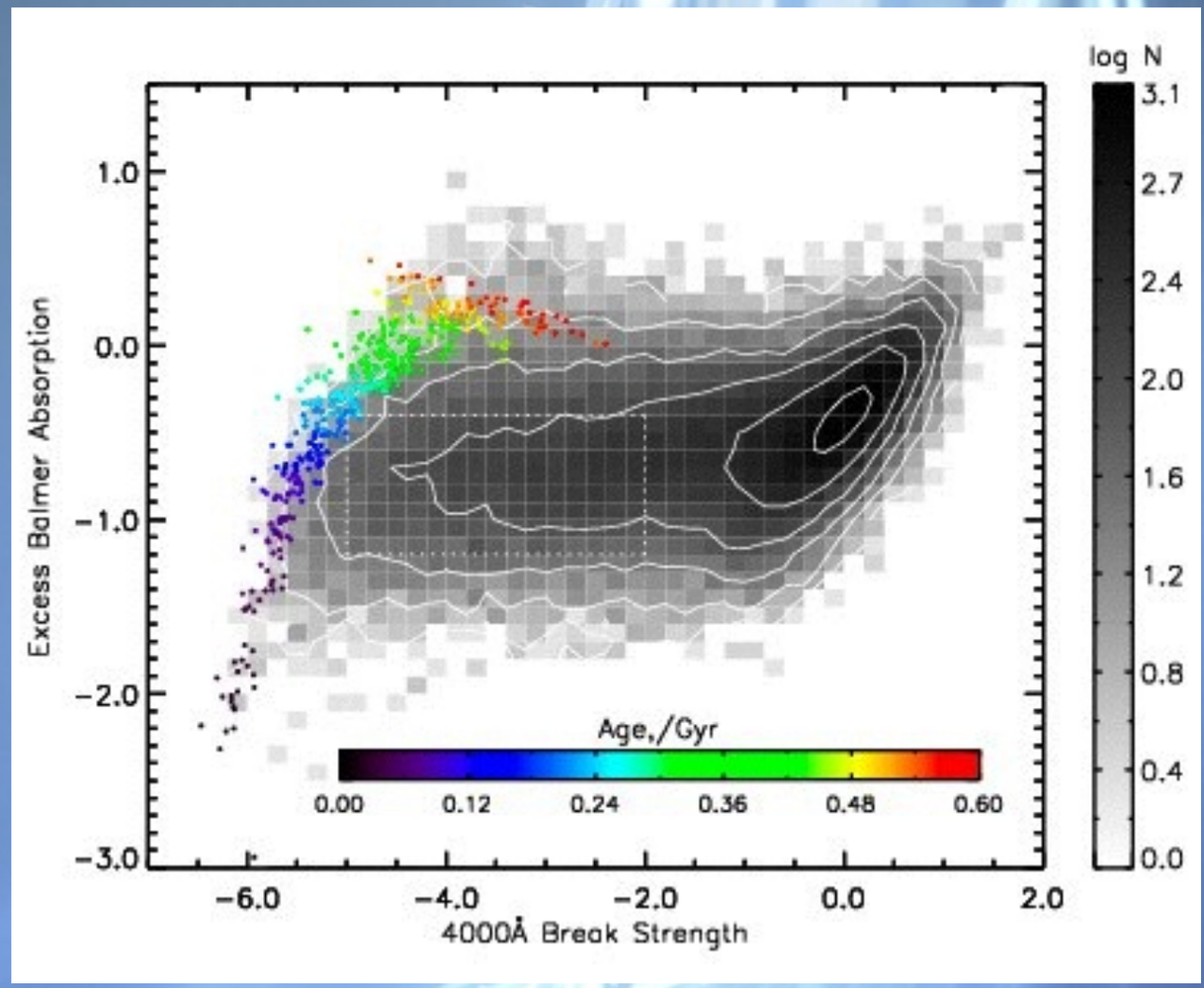
… red sequence?

mp84@st-andrews.ac.uk

The sample

For a detailed description of the sample selection process see:
Wild et al, 2010.

- **400 galaxies with a central starburst;**
- **starburst ages < 600 Myr;**
- **redshifts: 0.01 < z < 0.07;**
- **z-band stellar surface mass densities:**
  $\mu > 3 \times 10^8 M_{Sun}/kpc^2$
- **statistically complete (equal number of SB/PSB per unit age)**



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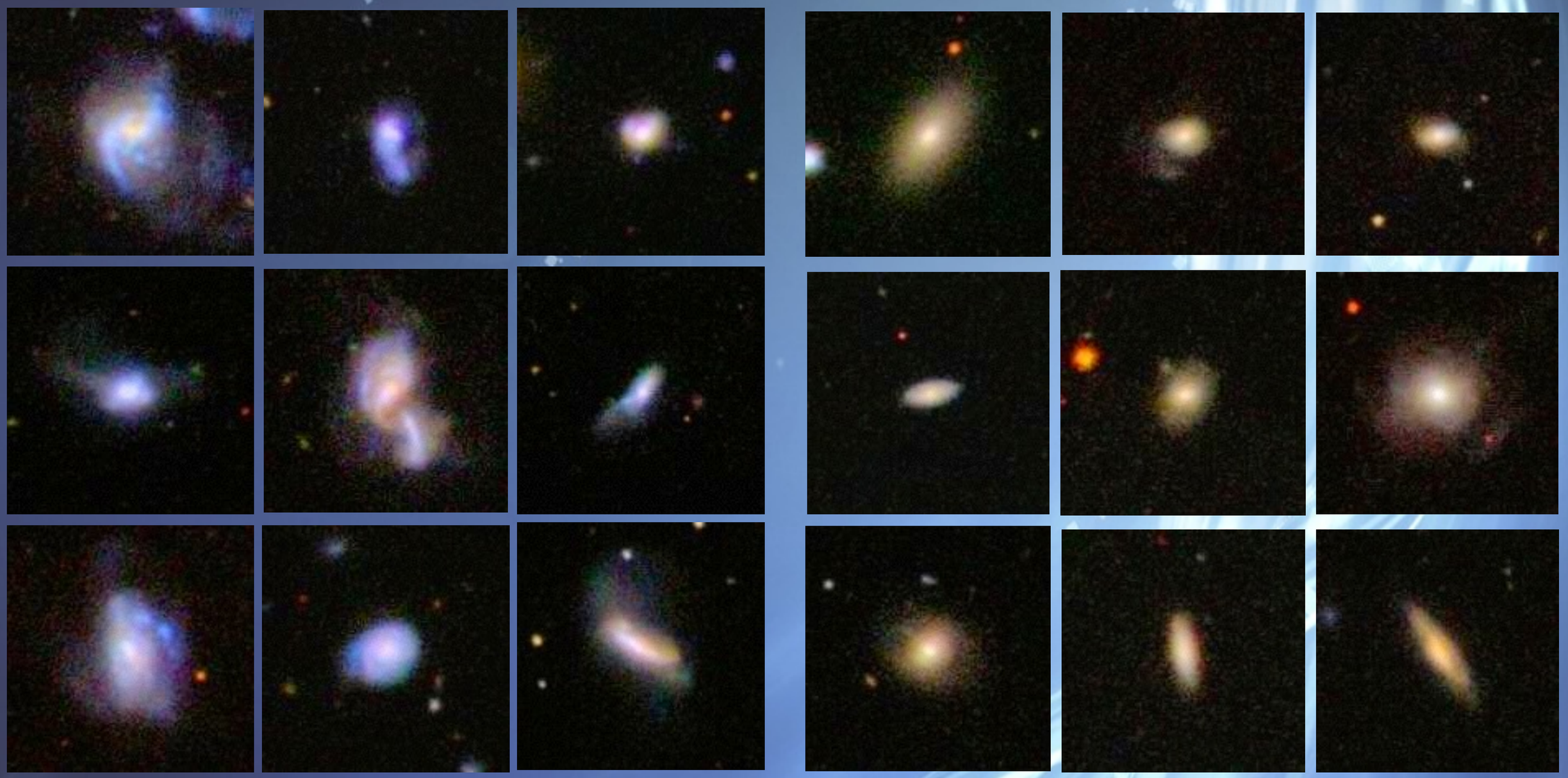
Visual inspection



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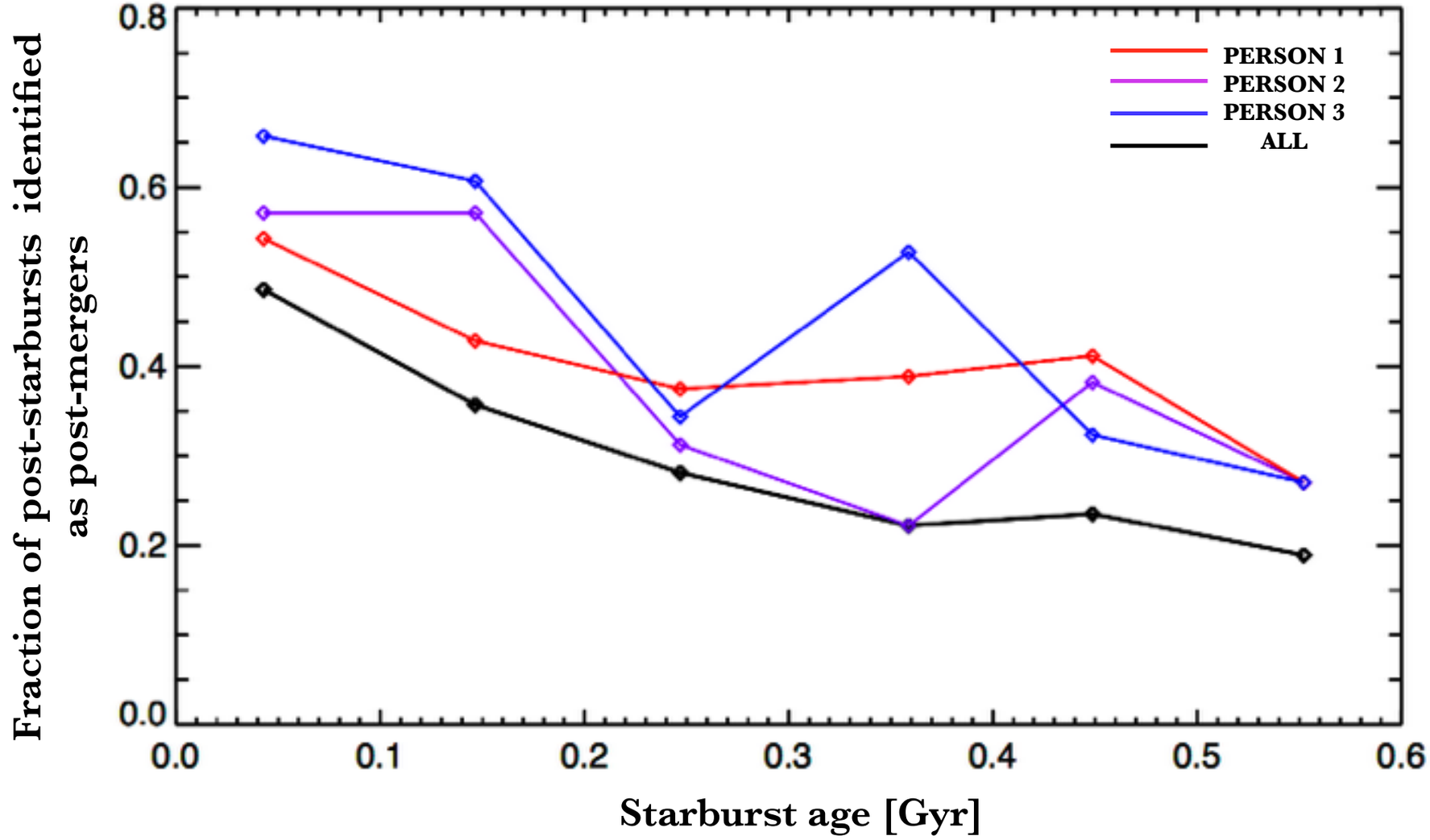

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Quantitative morphology

CONCENTRATION

Bershady et al , 2000
Conselice, 2003

ASYMMETRY

Conselice, Bershady & Jangren, 2000
Conselice, 2003

CLUMPINESS

Takamiya, 1999
Conselice, 2003

GINI INDEX

Lotz et al, 2004

M_{20} STATISTICS

Lotz et al, 2004

SERSIC INDEX

Sersic,1963

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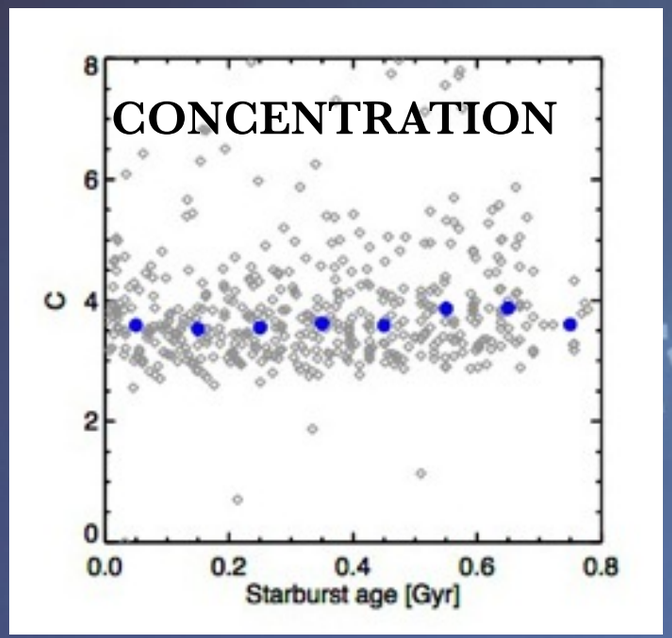
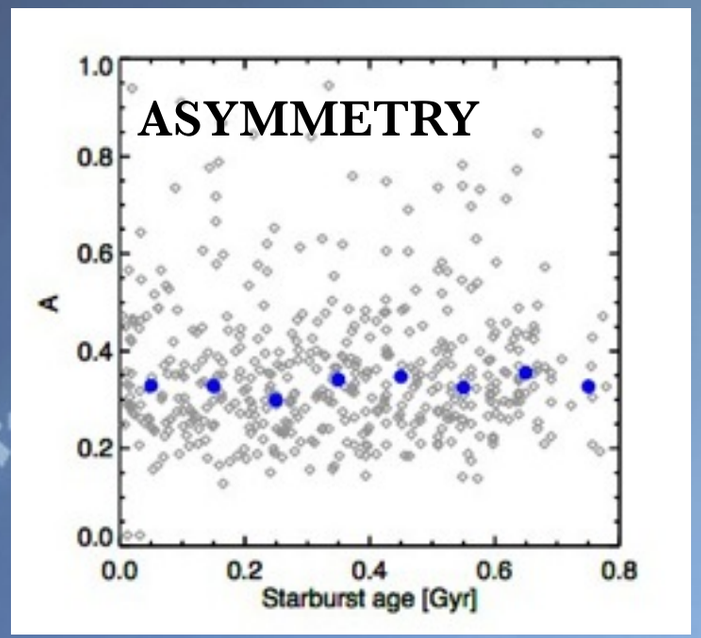
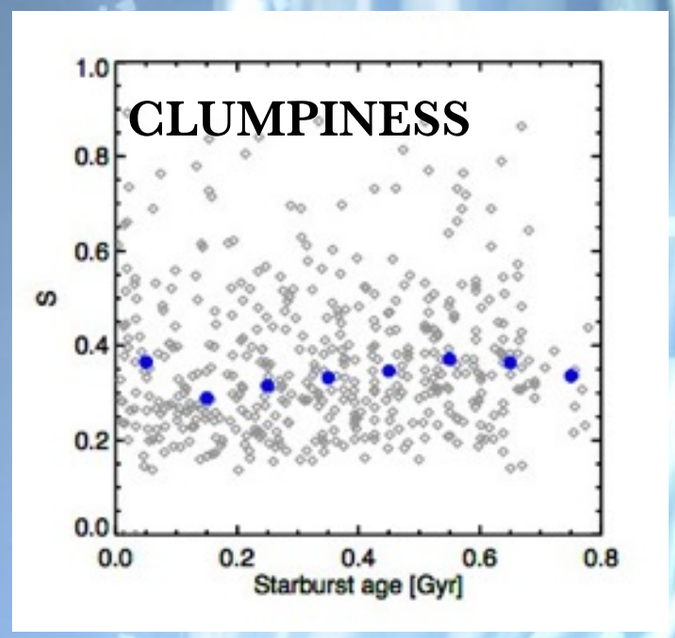
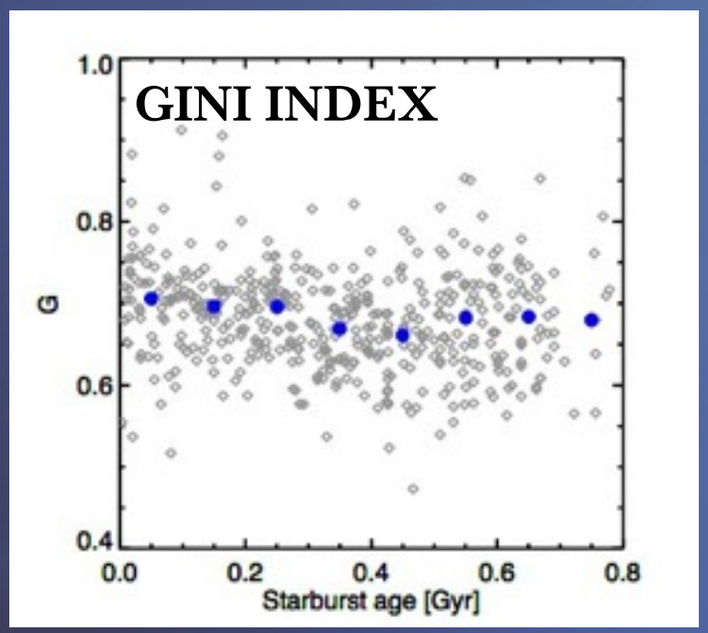
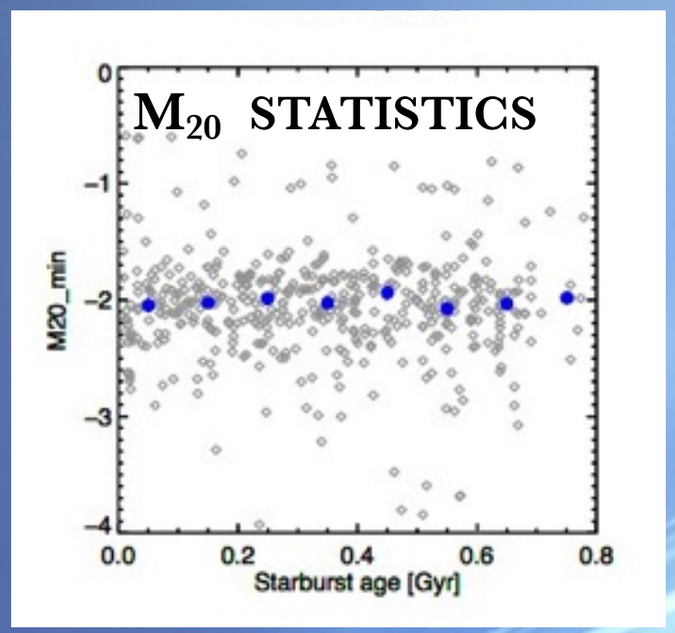
Quantitative morphology

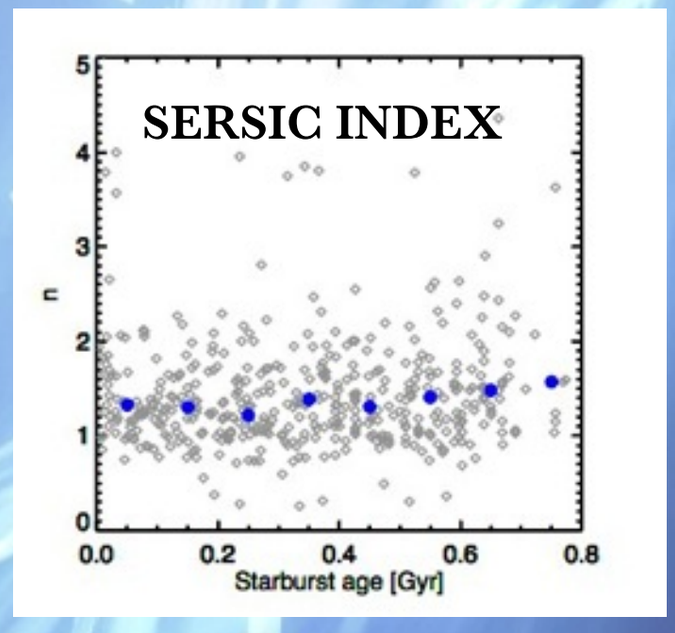












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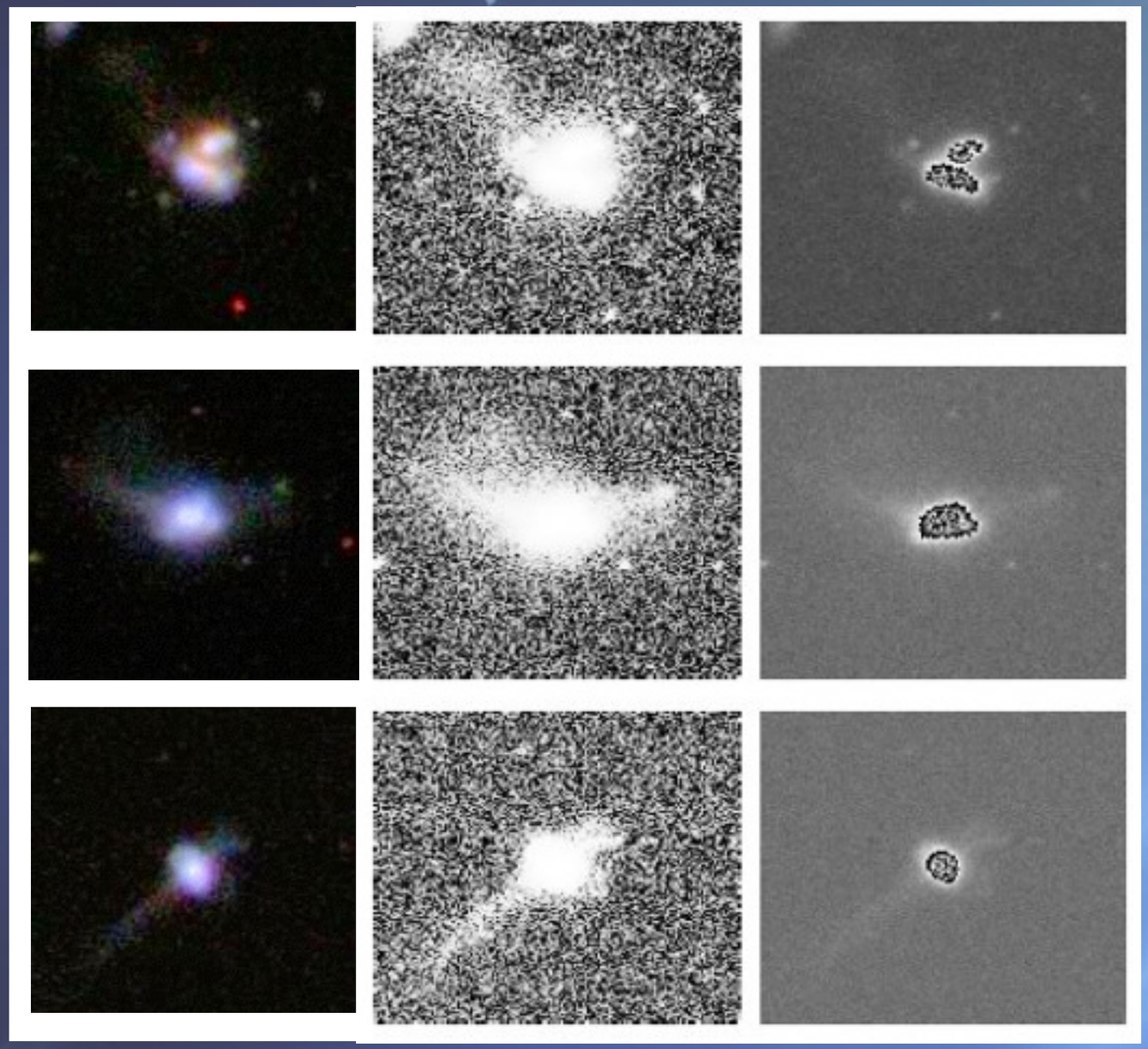
Why aren't the standard measures suitable?



- Tidal features much fainter than the central galaxy regions.
- Central regions less disrupted than the outskirts of galaxies.
- Standard morphology measures are highly sensitive to flux.

→ Parameters dominated by the signal from the brightest (central) regions of galaxies.

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The test sample

- **SB/PSB galaxies with highly-disrupted morphology, obvious tidal features;**

- **SB/PSB galaxies with moderately-disrupted morphology;**

- **SB/PSB galaxies with regular morphology;**

+ a control sub-sample of early- and late-type galaxies.

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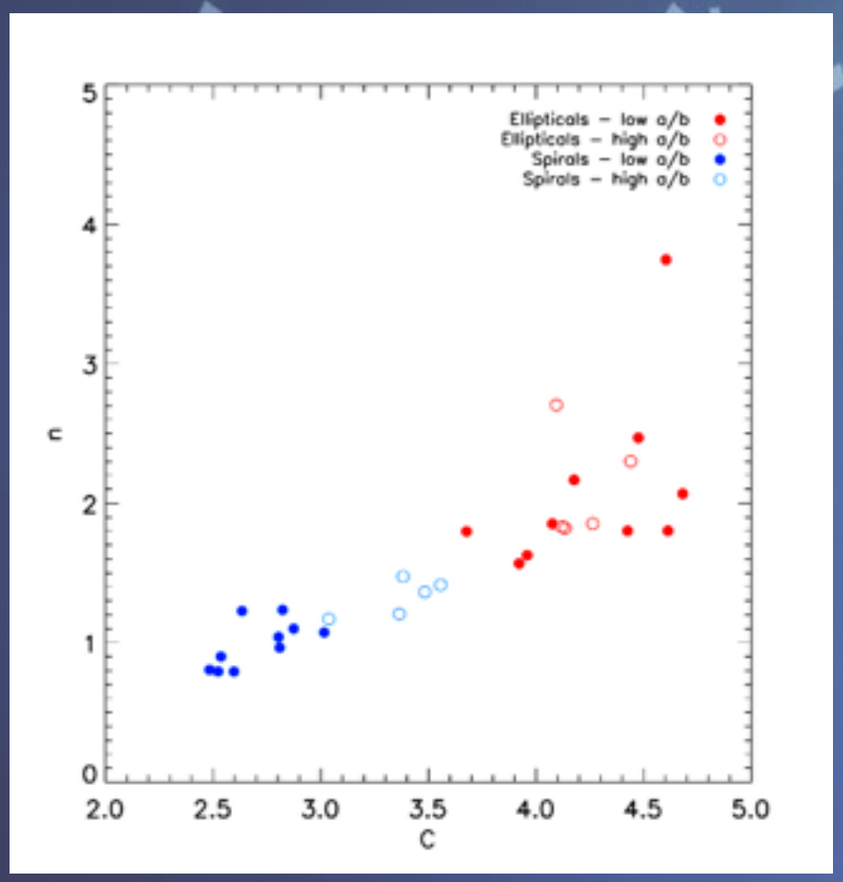
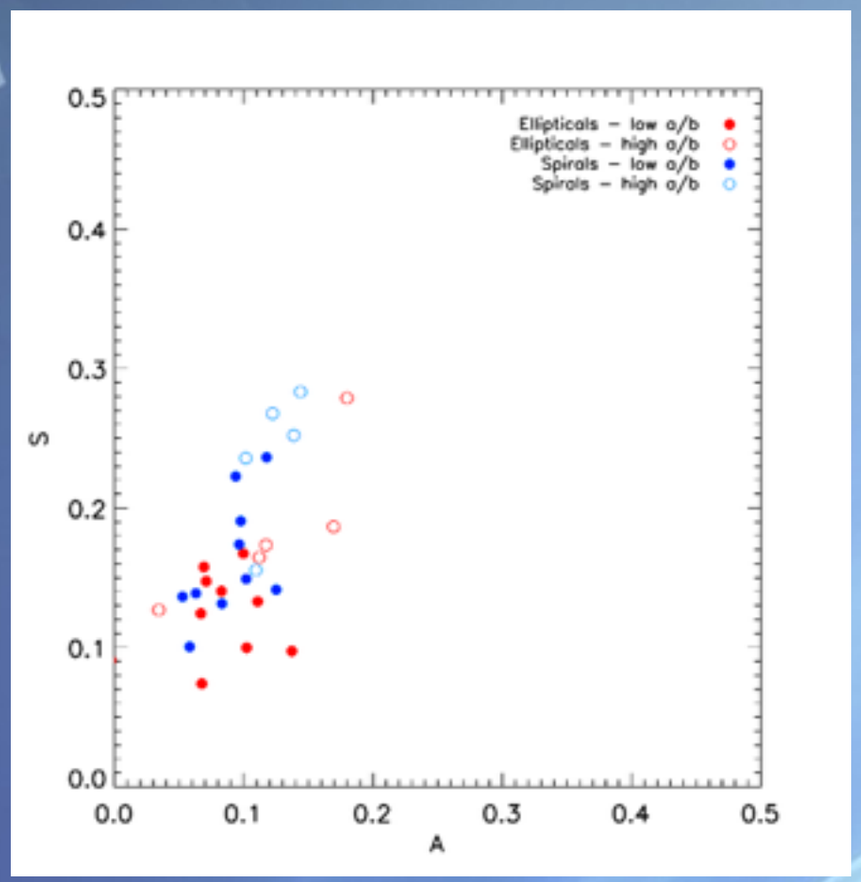
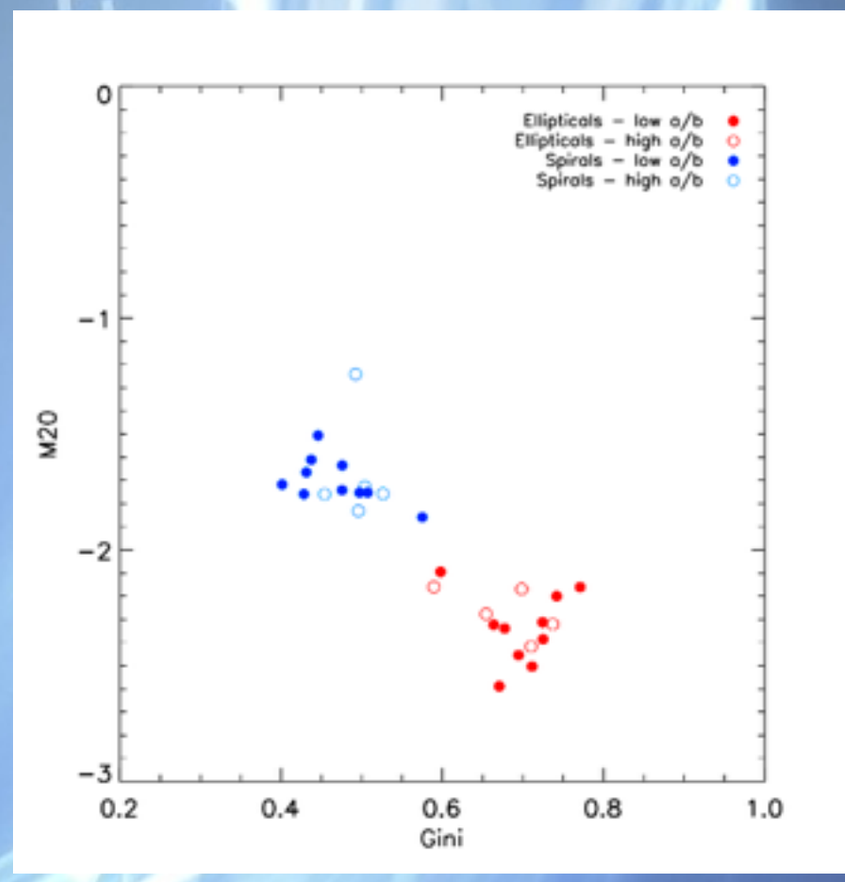
The test sample

Standard morphology measures







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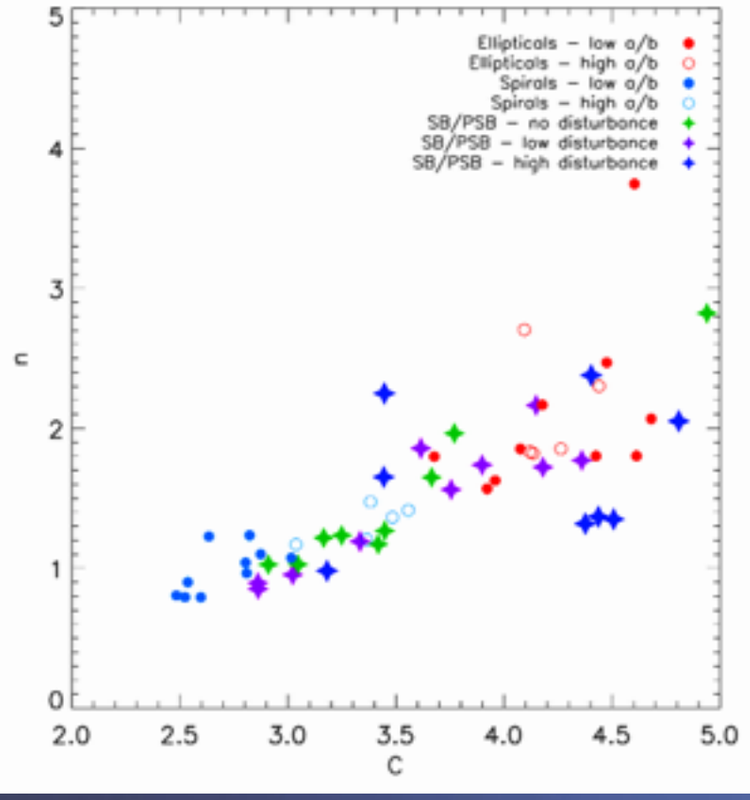
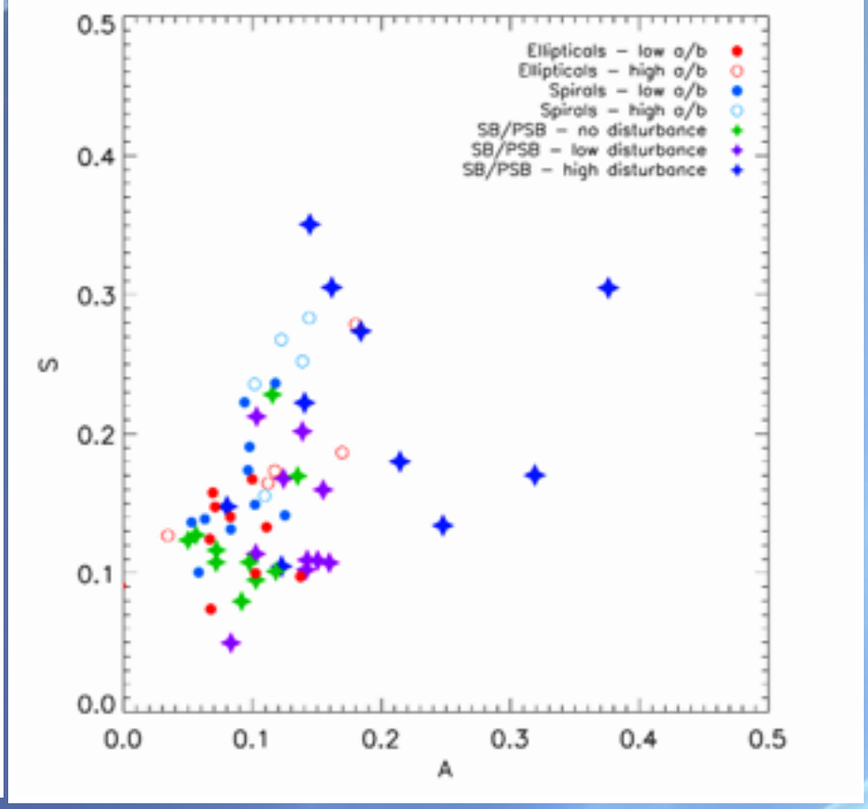
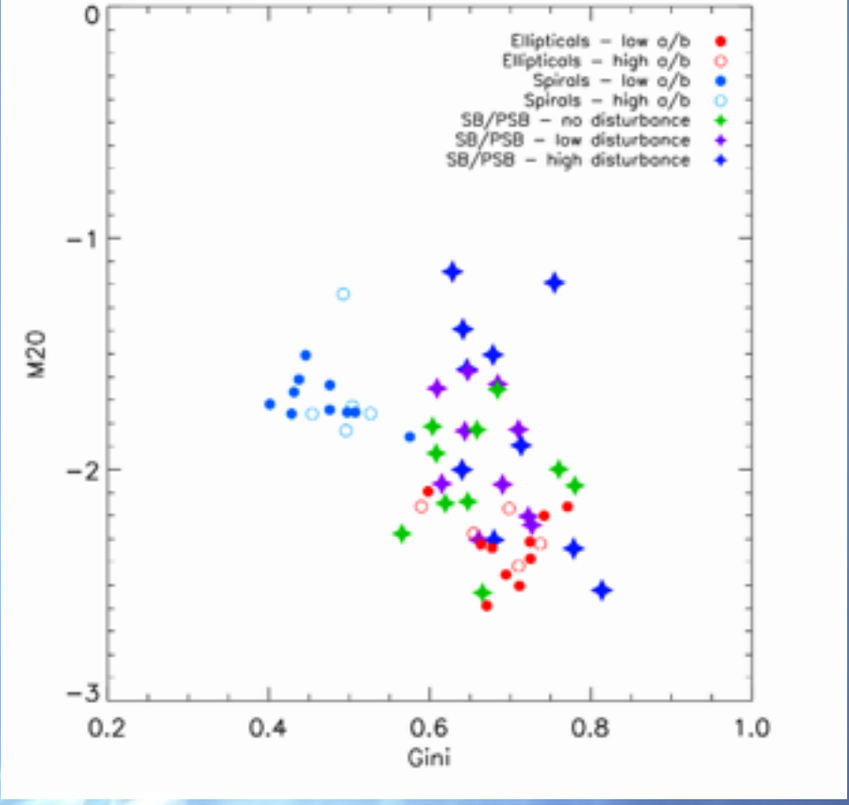
The test sample

Standard morphology measures







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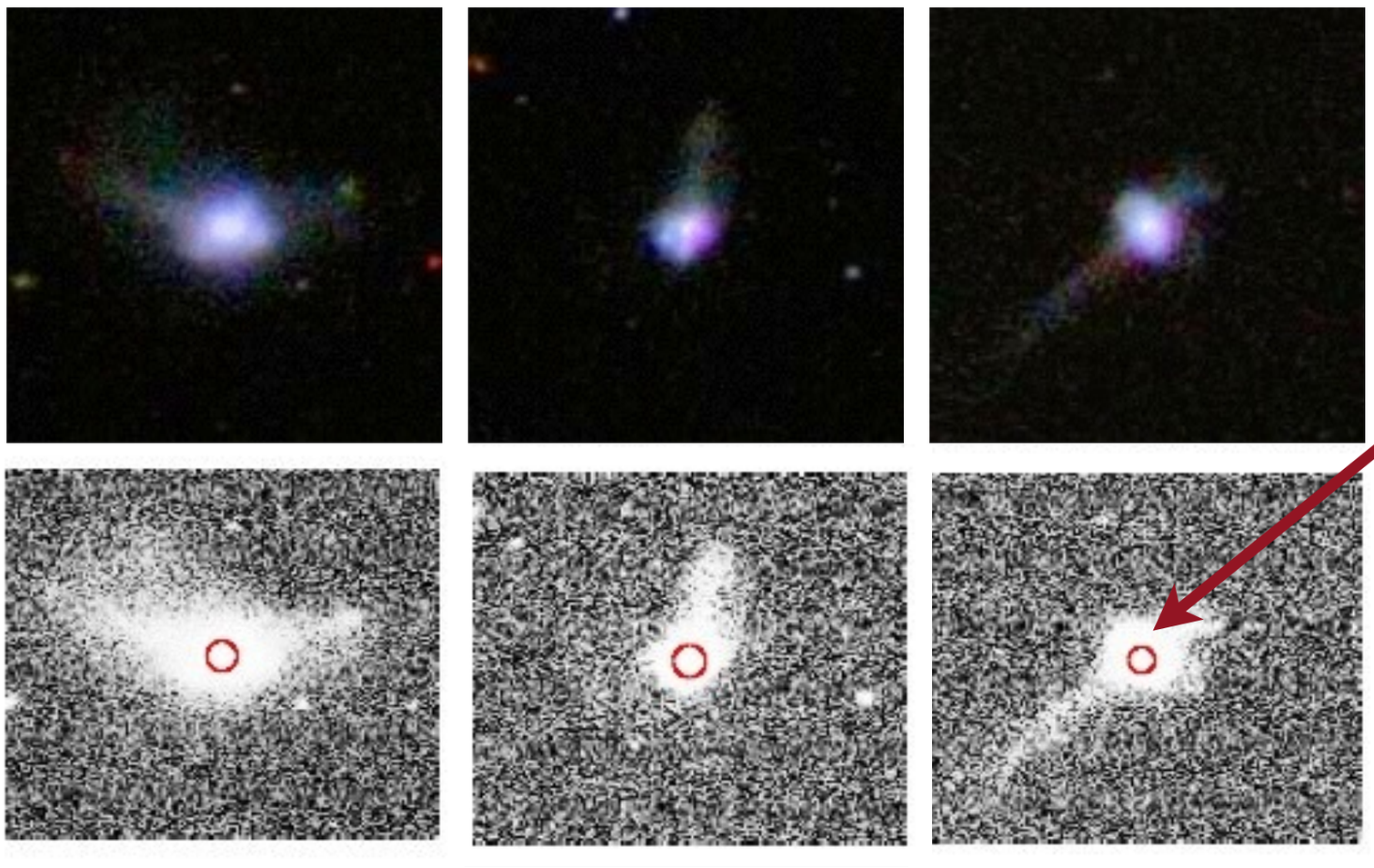
Probing the outskirts of galaxies

Outer asymmetry



$$A = \frac{\sum_{i,j} |I(i,j) - I_{180}(i,j)|}{\sum_{i,j} I(i,j)}$$

Cut out the central aperture containing 50% of the total light

Measure the asymmetry of the remaining outer region.

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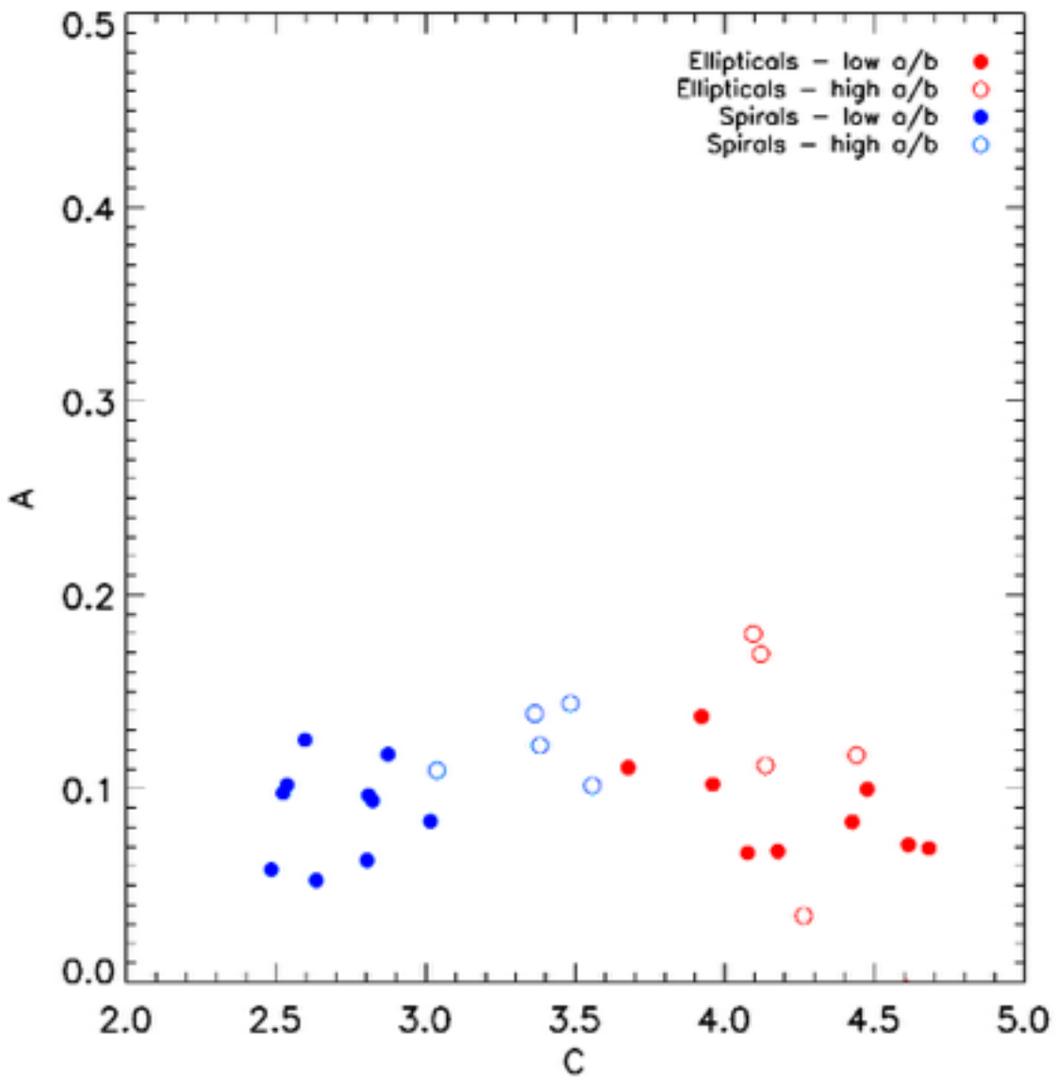
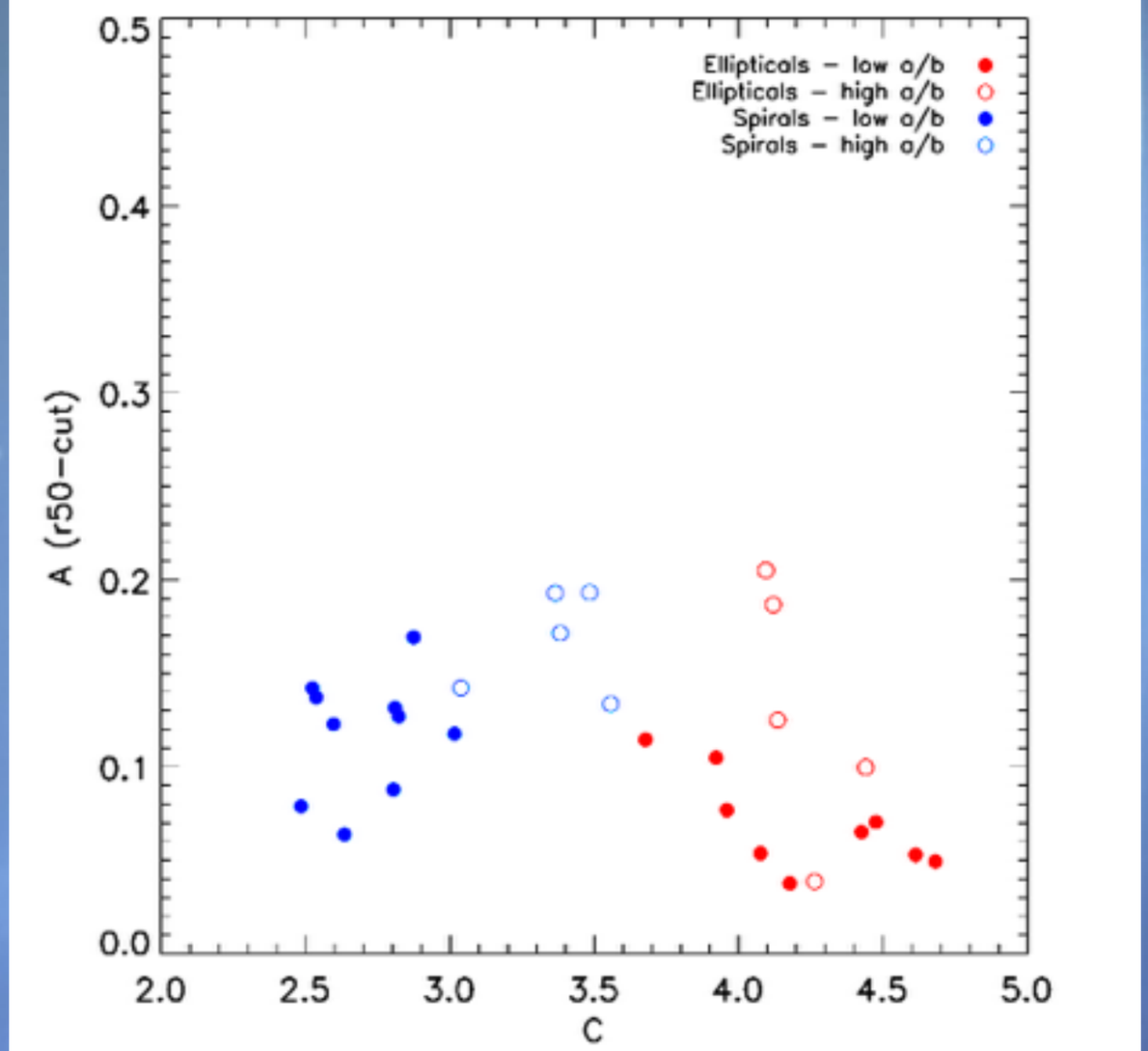
Outer asymmetry





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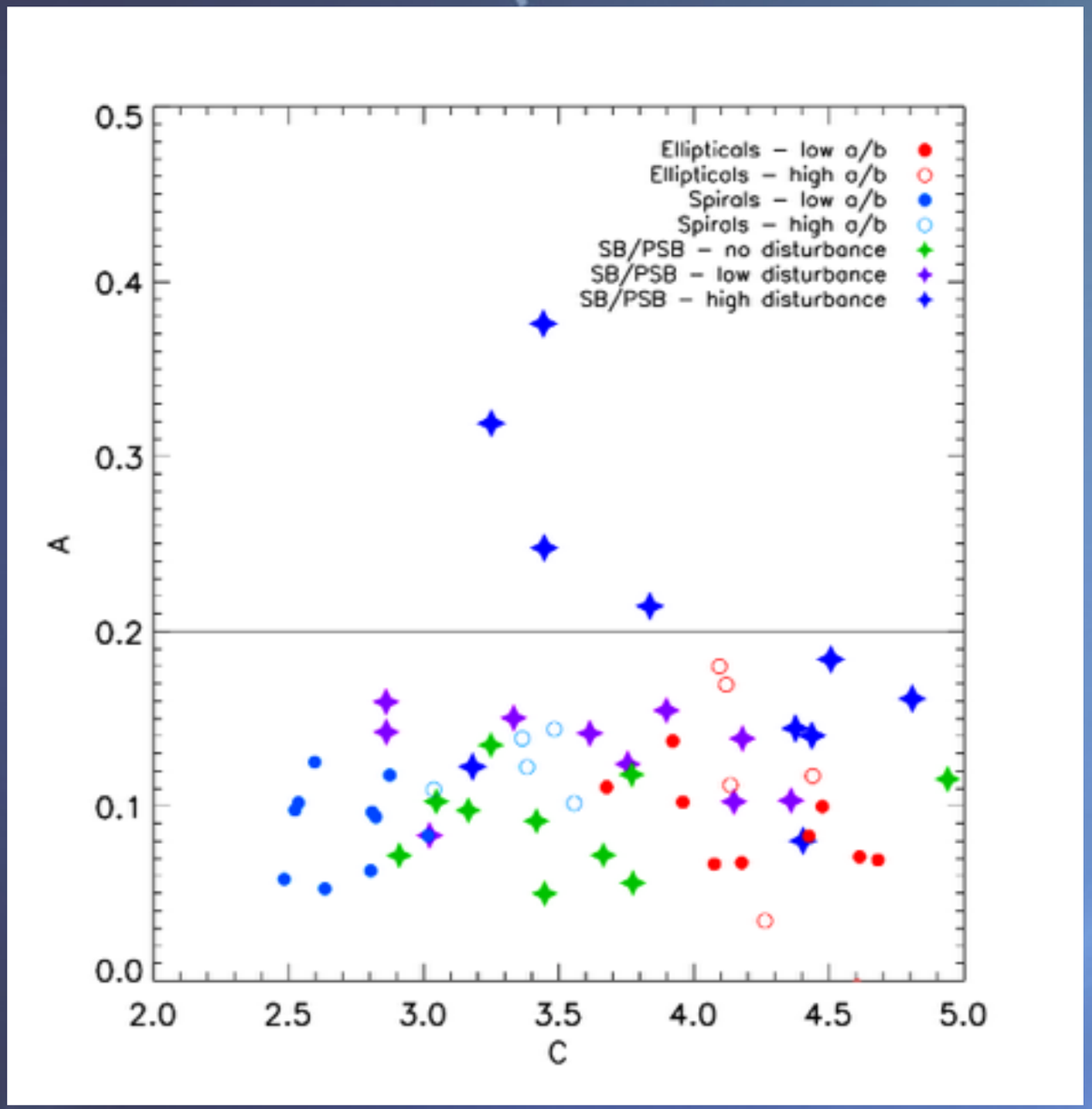
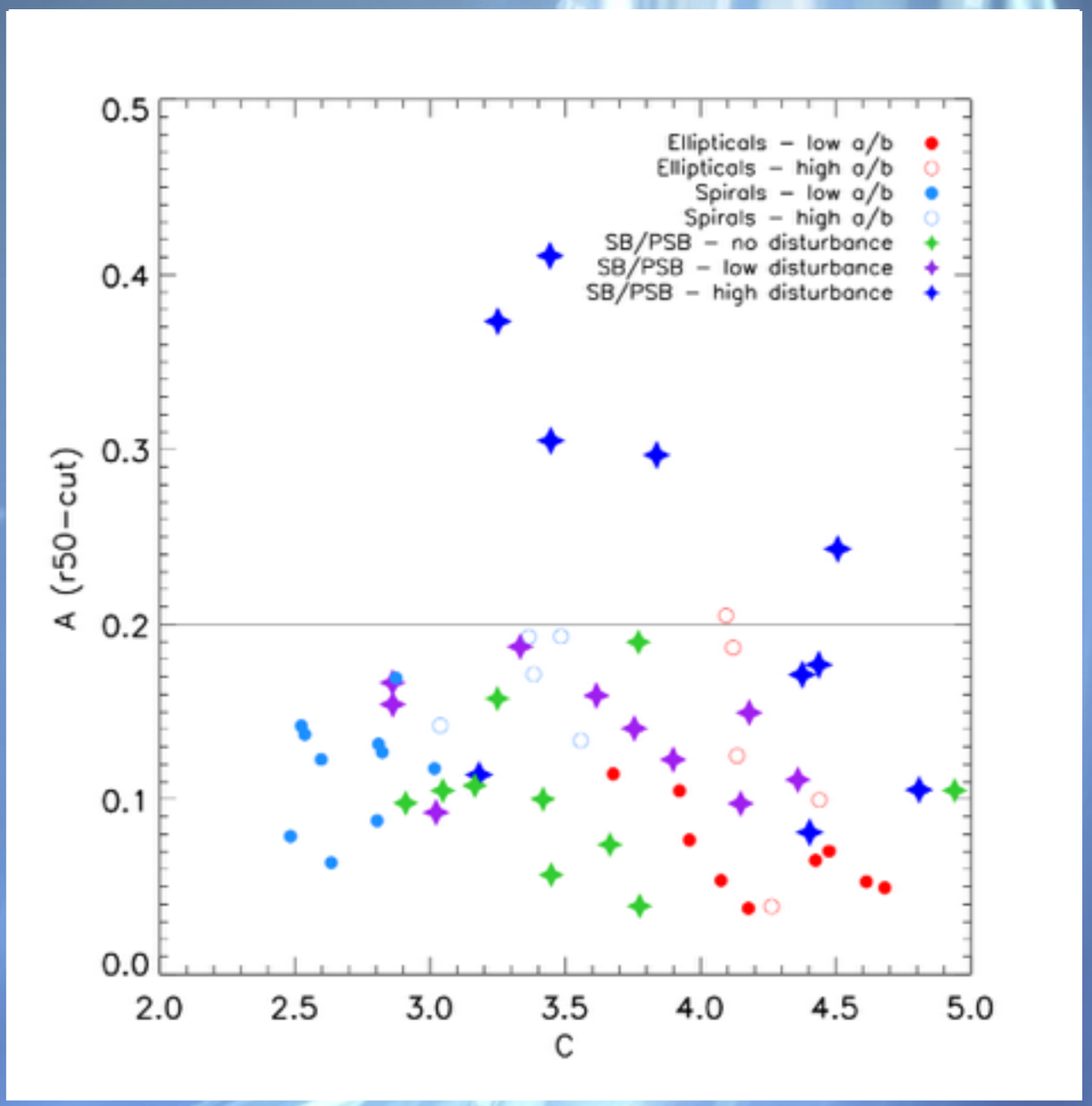
Outer asymmetry





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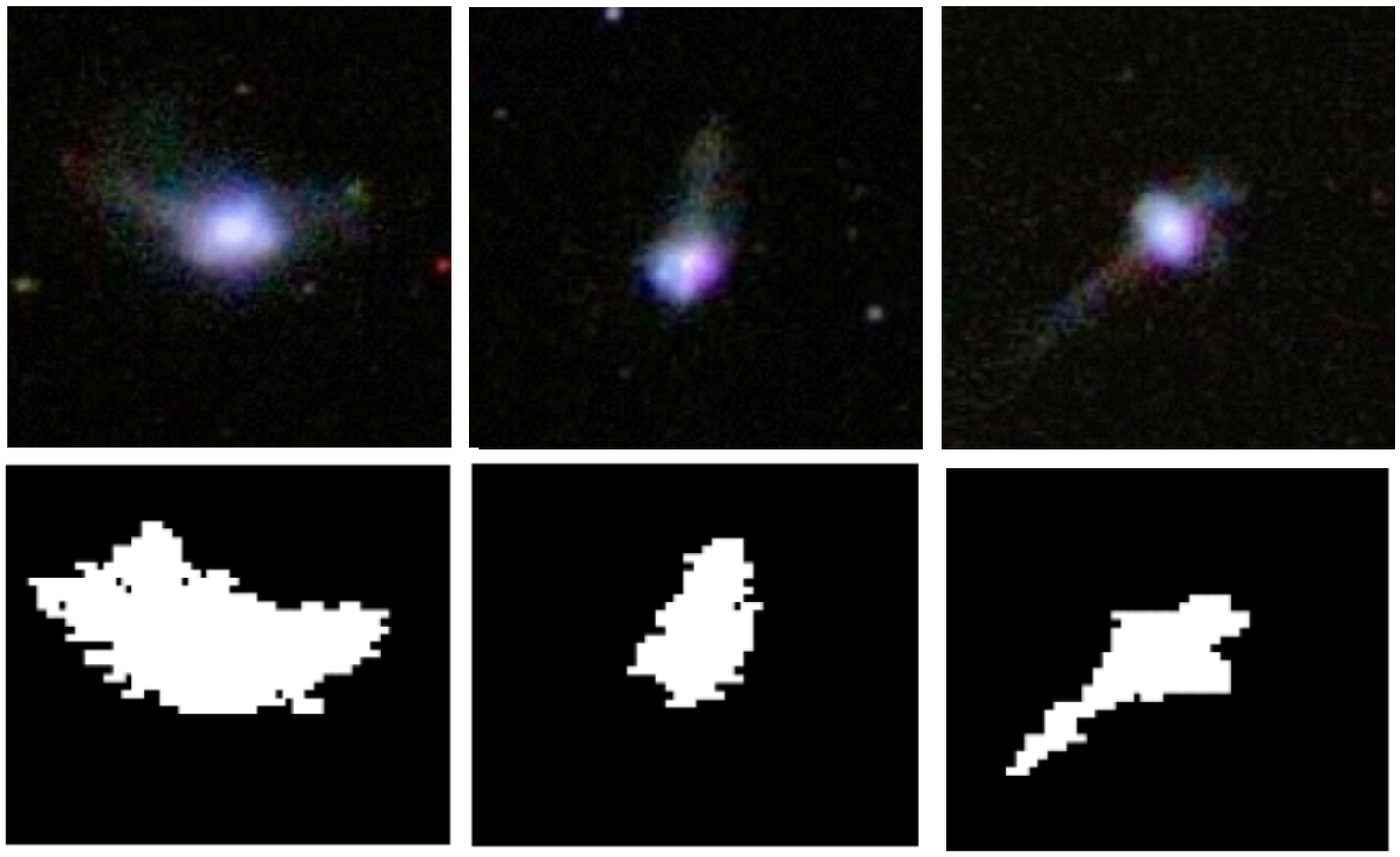
Probing the outskirts of galaxies

‘Shape’ asymmetry



$$A = \frac{\sum_{i,j} |I(i,j) - I_{180}(i,j)|}{\sum_{i,j} I(i,j)}$$

Remove the flux dependance completely!

Measure the asymmetry of the binary image of the galaxy detection mask.

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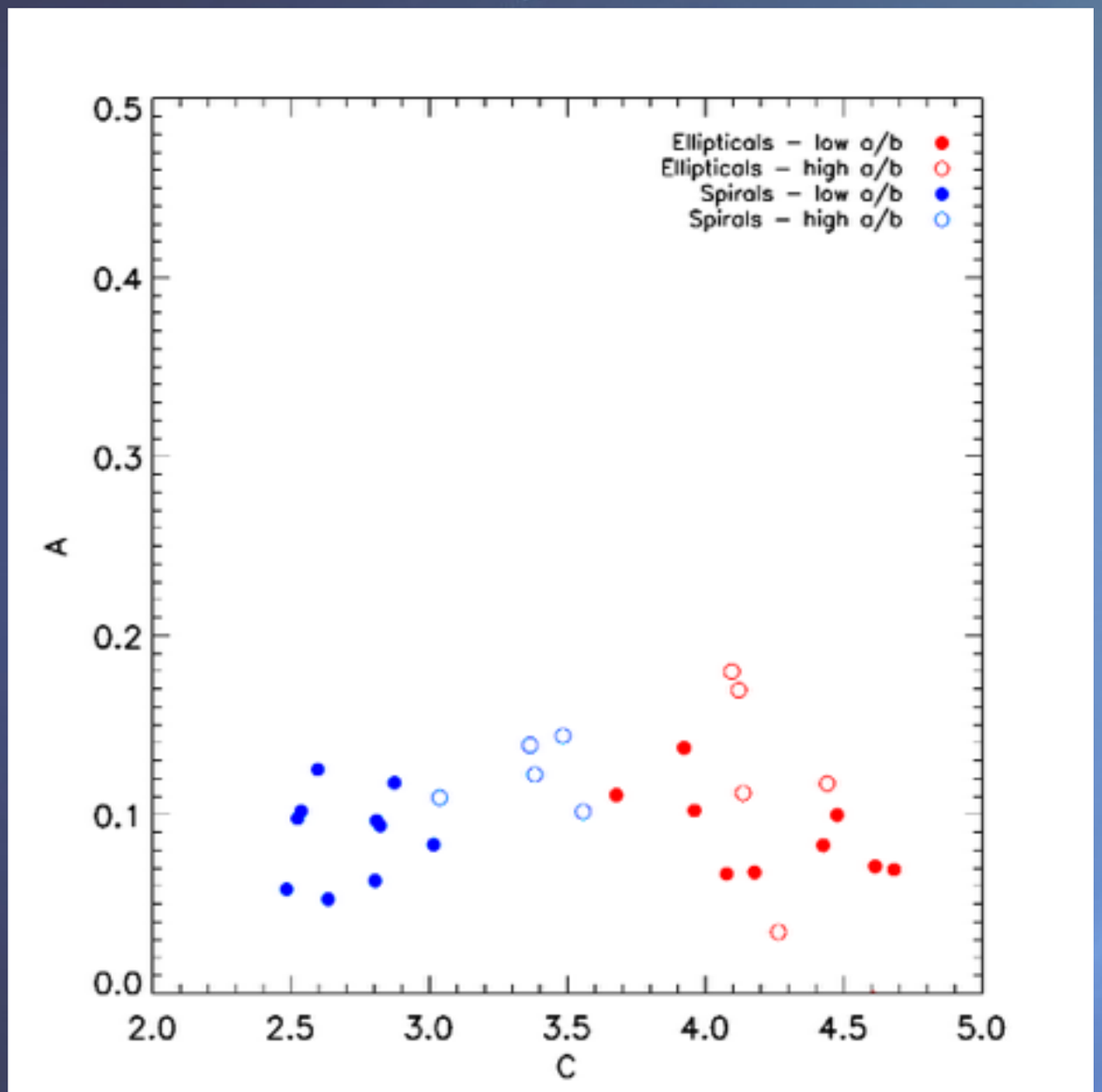
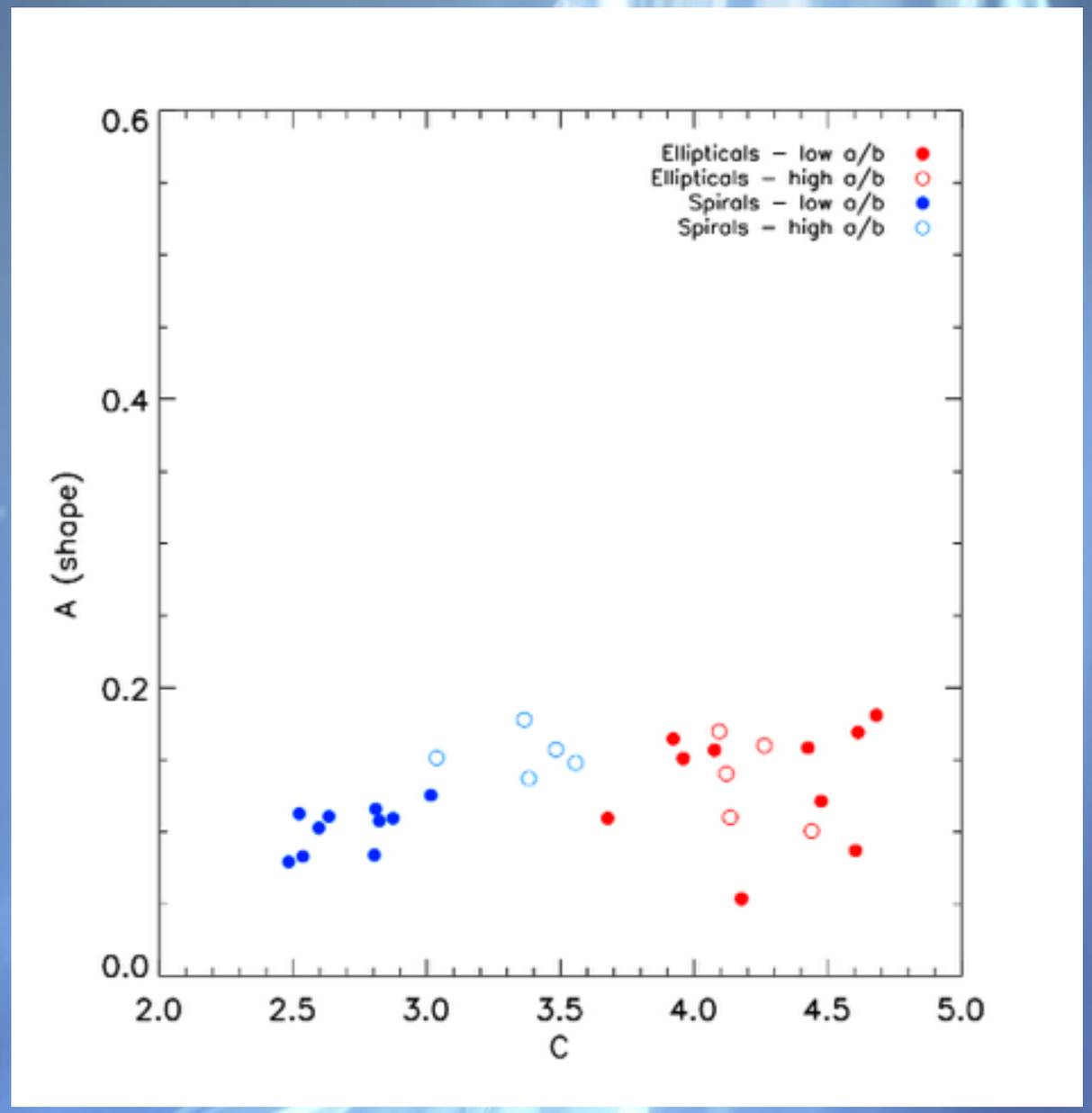
‘Shape’ asymmetry





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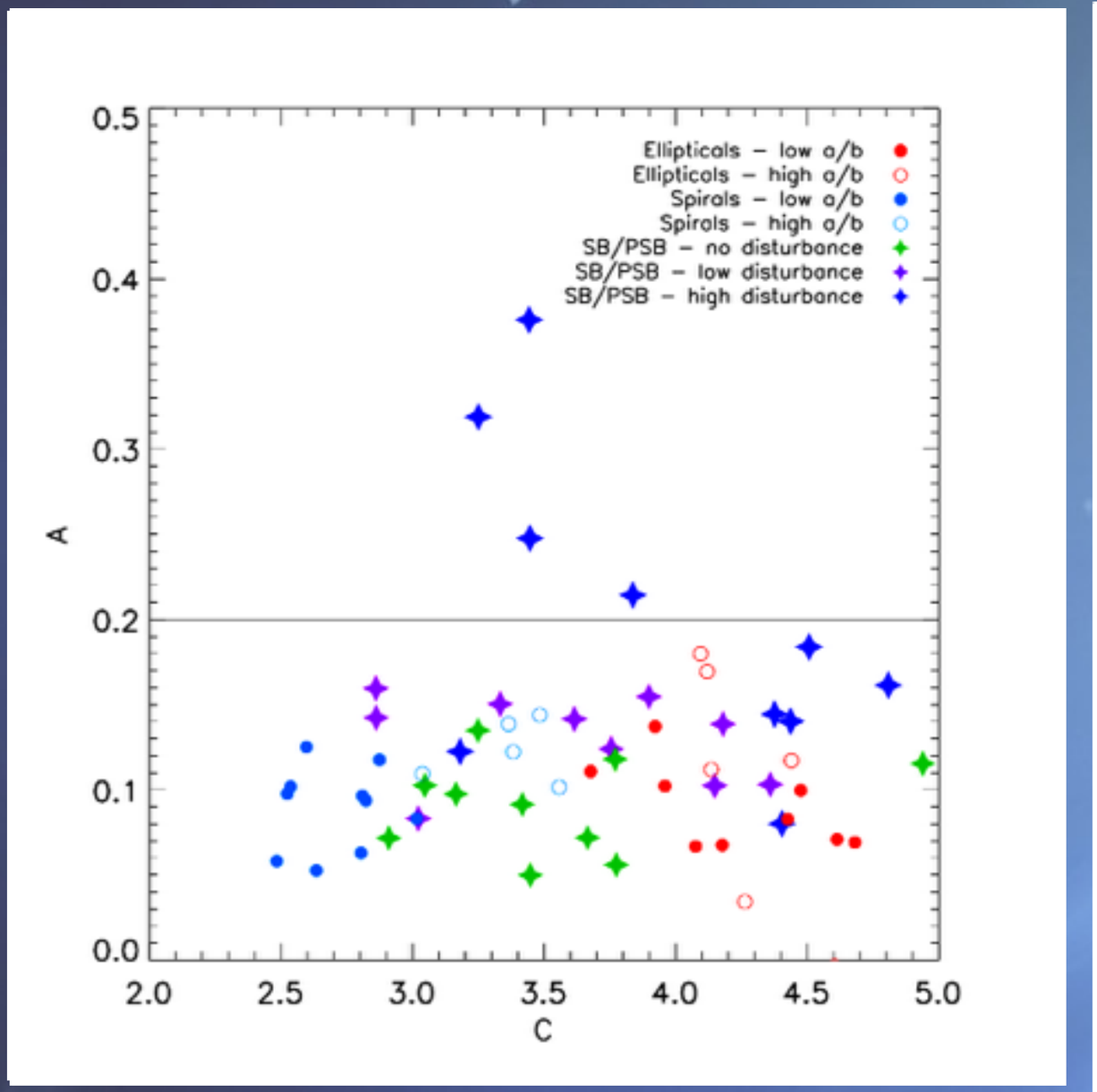

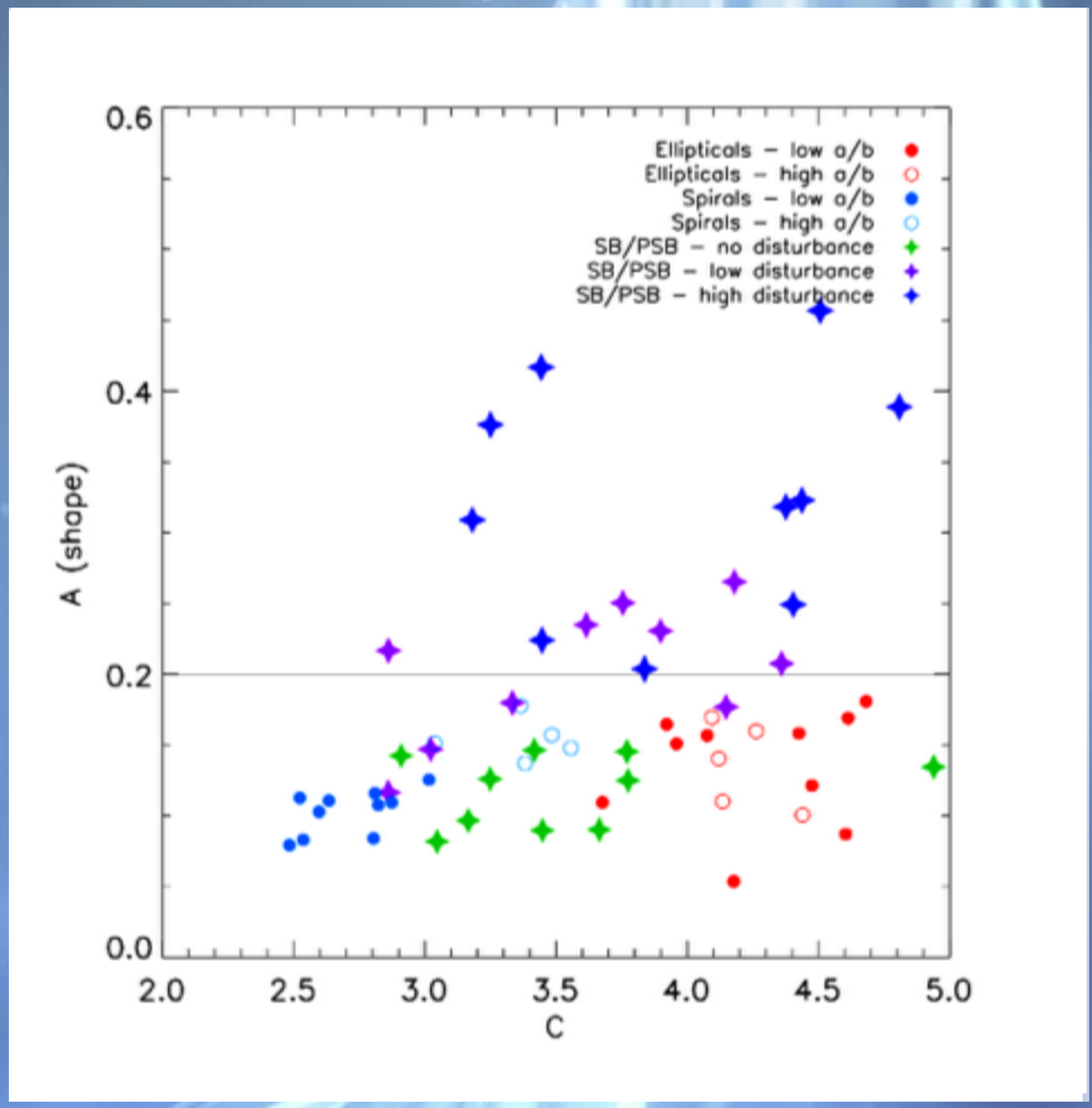

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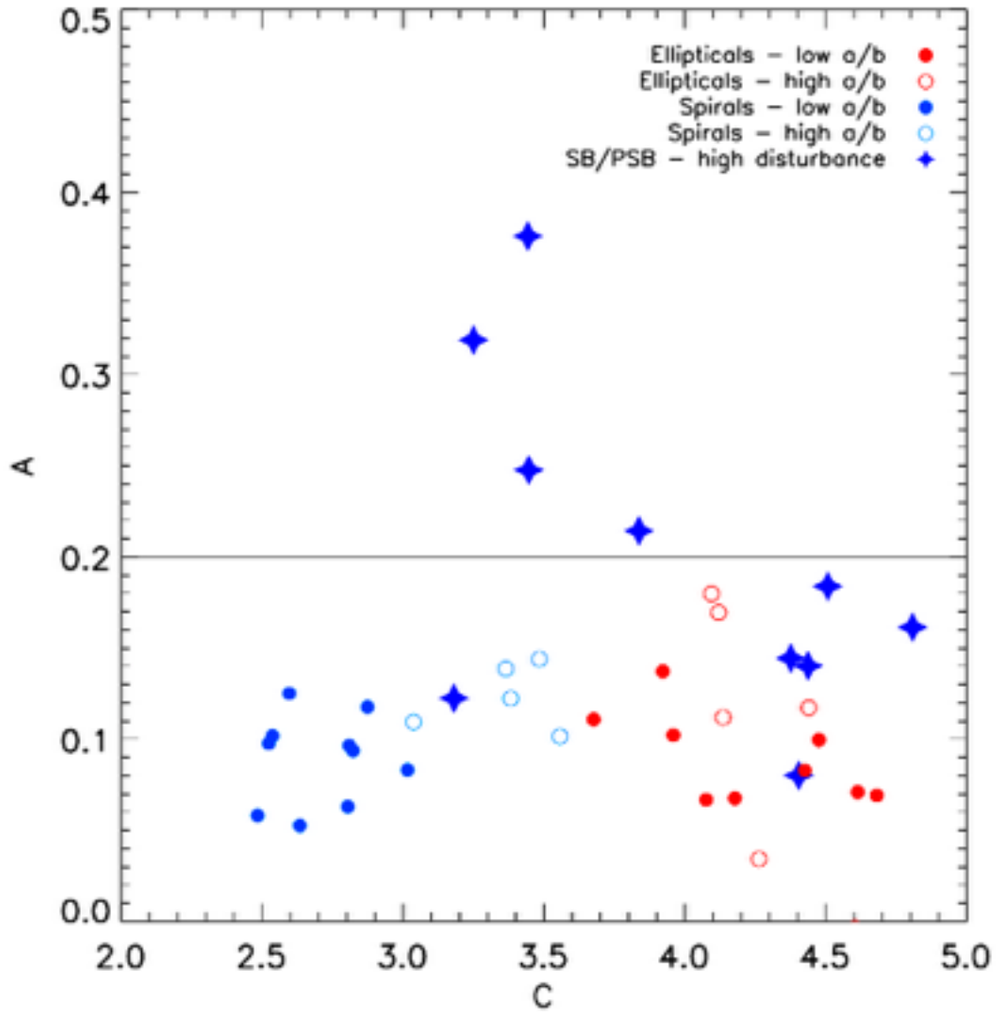

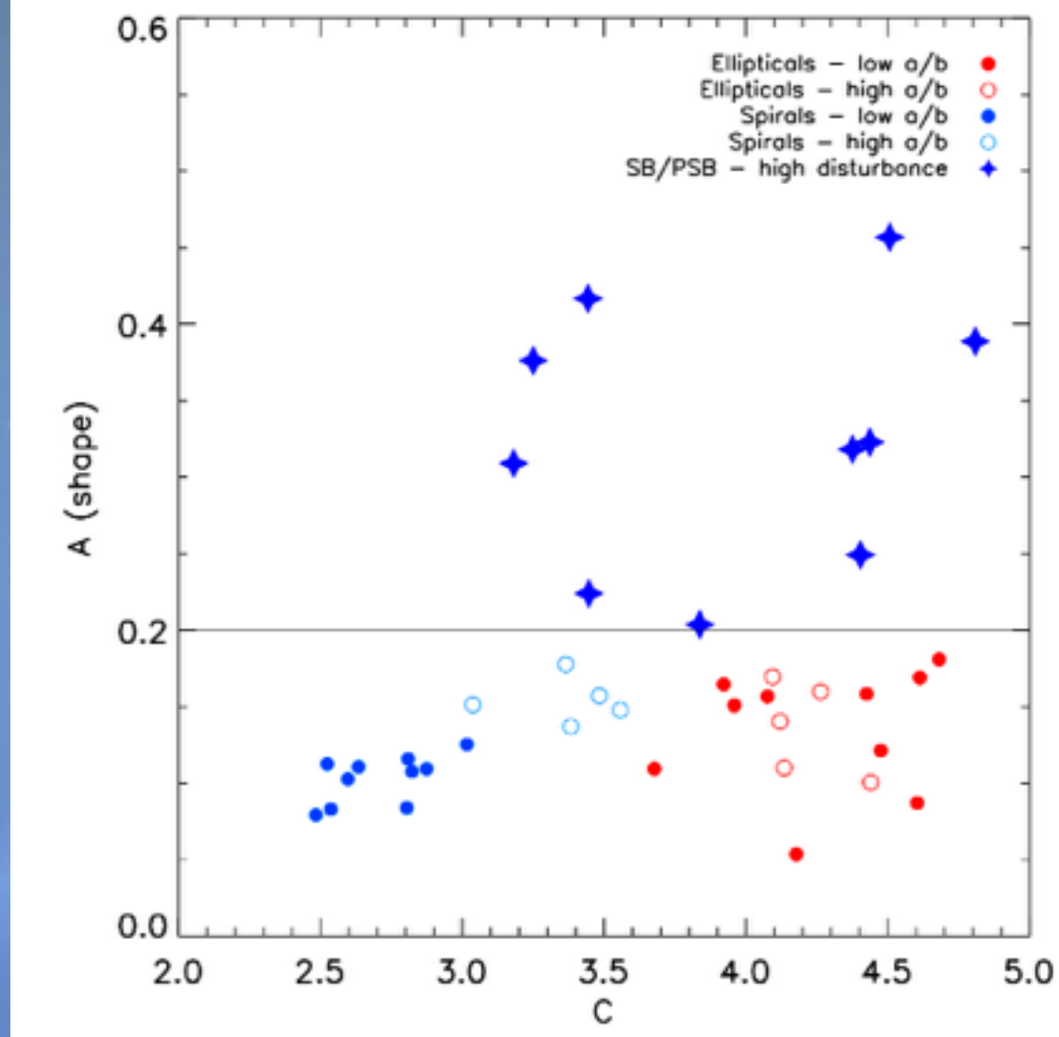

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Summary

- **Results of visual inspection of post-starbursts galaxies suggest that they tend to show less post-merger features as they get older.**

- **Standard morphology measures are not suitable for studying the tidal features of galaxies.**

- **'Shape' asymmetry provides a good way of separating galaxies with post-merger features from normal early- and late-type galaxies.**

- **Fully automated analysis allows for studies of large galaxy samples.**

mp84@st-andrews.ac.uk

Future work

- **Investigate the robustness of the 'shape'-asymmetry parameter at higher redshifts.**
- **Develop a method for measuring the internal structure of post-mergers.**
- **The new morphological measures will be used to study the evolution of the morphology of spectroscopically-selected galaxies passing through their post-starburst phase.**

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Future work

- Investigate the robustness of the ‘shape’-asymmetry parameter at higher redshifts.
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Thank you

mp84@st-andrews.ac.uk