Galaxy Zoo:
the independence of morphology and colour

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Ivan Baldry, Mehri Torki, Chris Miller

Classifications by: Jonathan Rayers, Nigel Aspdin, Dean A Thomas, Jon'o Elson, Thomas H. Slone, John Furey, José Ignacio Crespo Anadón, Derek W Humphreys, Stephen Robert Hogan, Donald Clary, John Rice-Whetton and many more…

Outline

- Overview of the Galaxy Zoo project
- Bias corrections
- Reliability
- Morphology versus environment
  - Stellar mass dependence
  - Comparison with colour
  - Red spirals and blue early-types
  - (Real) morphology matters!
- Future directions

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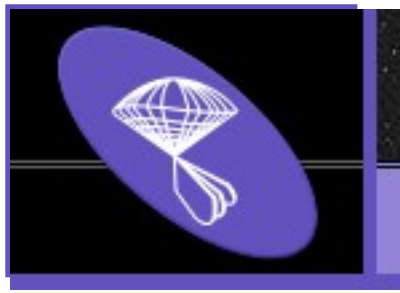
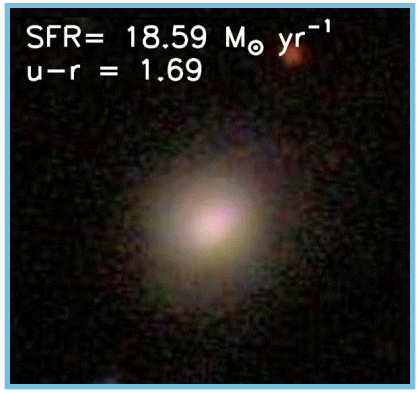
Aims

- Classify as many objects as possible from SDSS
- Find rare objects
- Cosmology with spiral spins
- Test morphology proxies
- Statistical studies with traditional morphology
- Public outreach





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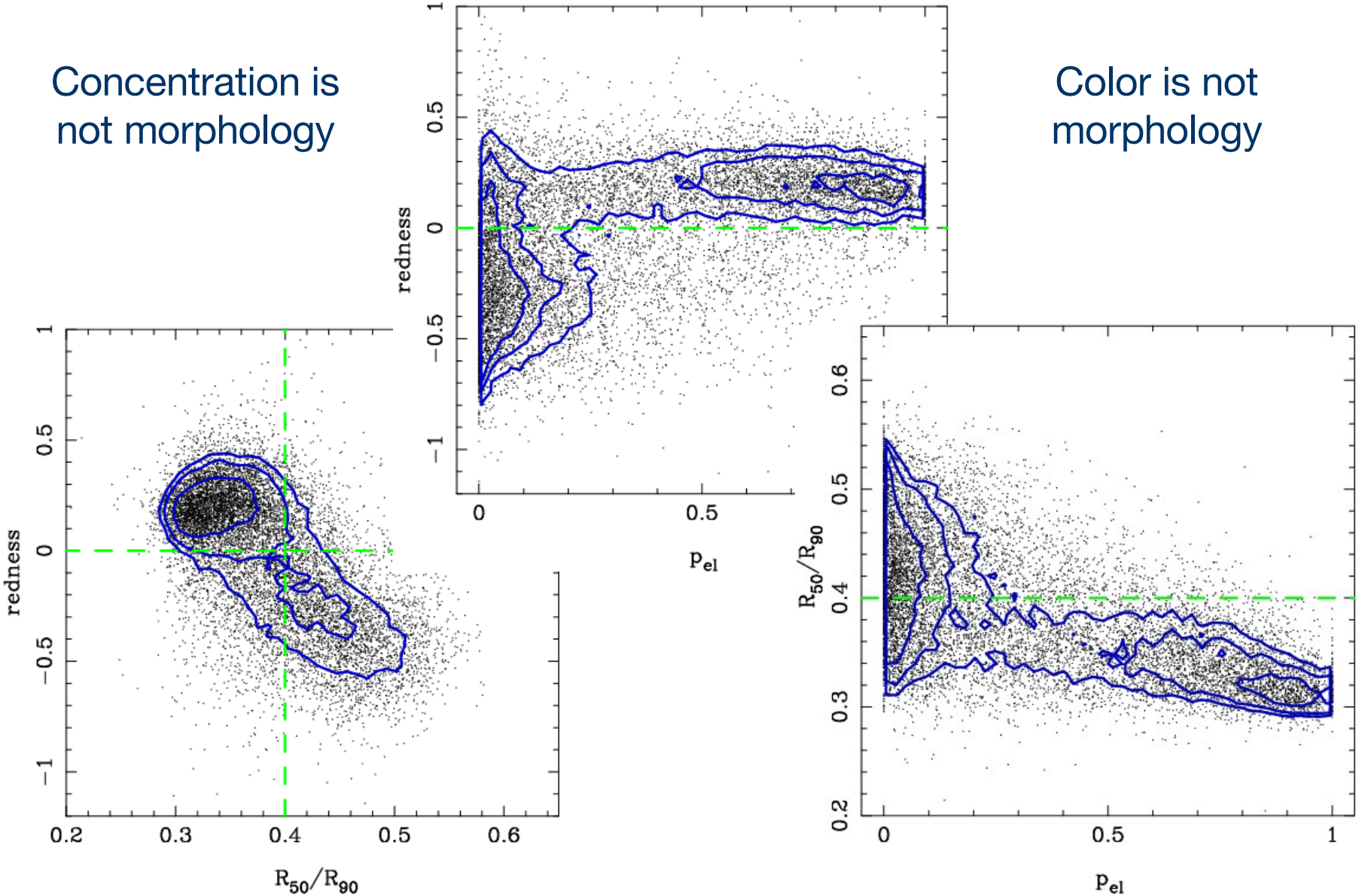
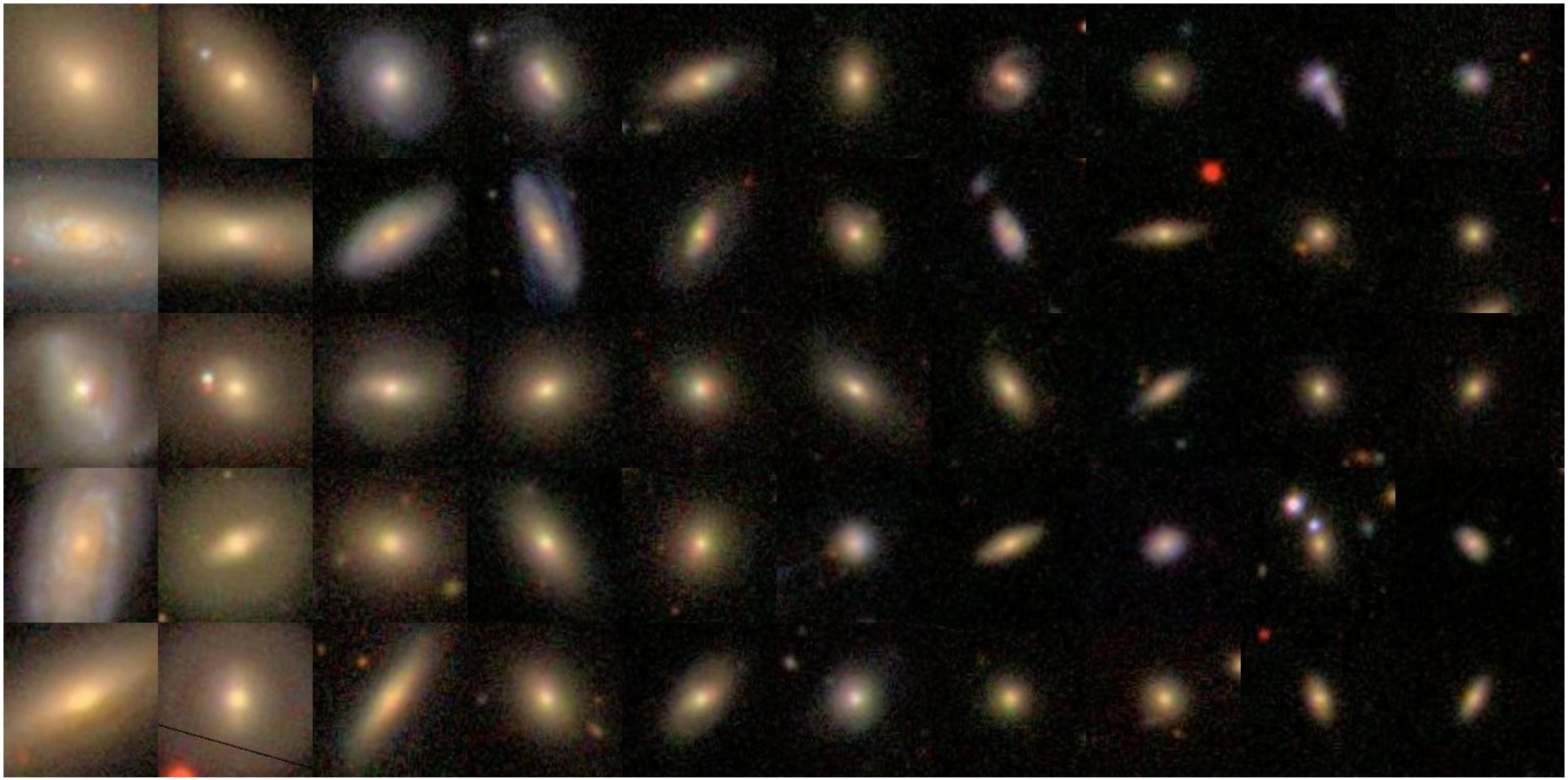
Why bother?

Concentration is not morphology

Color is not morphology



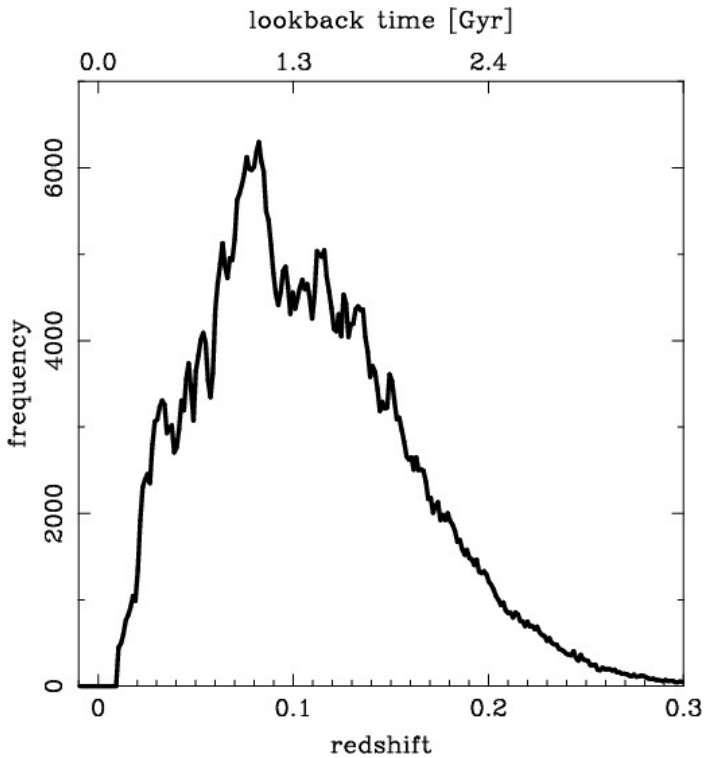
Feasibility



Typical ~L* galaxies: $M_r \sim -21.5$, $R_{50} \sim 5$ kpc

Sample

- SDSS DR6 Main Galaxy Sample (MGS) targets
  - r < 17.77, resolved above seeing
  - 738175 objects
- Any object with observed galaxy spectrum
  - not such a good idea?
  - 156481 objects
- Total: 893212 objects
- Extragalactic, MGS, with spectra:
  - 557681 objects



Website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GALAXY ZOO.org
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Galaxy Analysis
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LATEST NEWS: please do not be suprised if some of the galaxies you are shown look a little strange, or different to the original SDSS image. This is all part of our ongoing studies, and it is really important that you continue to classify the Galaxy Zoo image as normal (and not use the SDSS one). See the FORUM for more details and for the latest NEWSLETTER. Thanks!
Welcome to GalaxyZoo , the project which harnesses the power of the internet - and your brain - to classify a million galaxies. By taking part, you'll not only be contributing to scientific research, but you'll view parts of the Universe that literally no-one has ever seen before and get a sense of the glorious diversity of galaxies that pepper the sky.
Why do we need you?
The simple answer is that the human brain is much better at recognizing patterns than a computer can ever be. Any computer program we write to sort our galaxies into categories would do a reasonable job, but it would also inevitably throw out the unusual, the weird and the wonderful. To rescue these interesting systems which have a story to tell, we need you.
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Tutorial

Part 1B ... More Tricky Spiral or Elliptical Galaxies

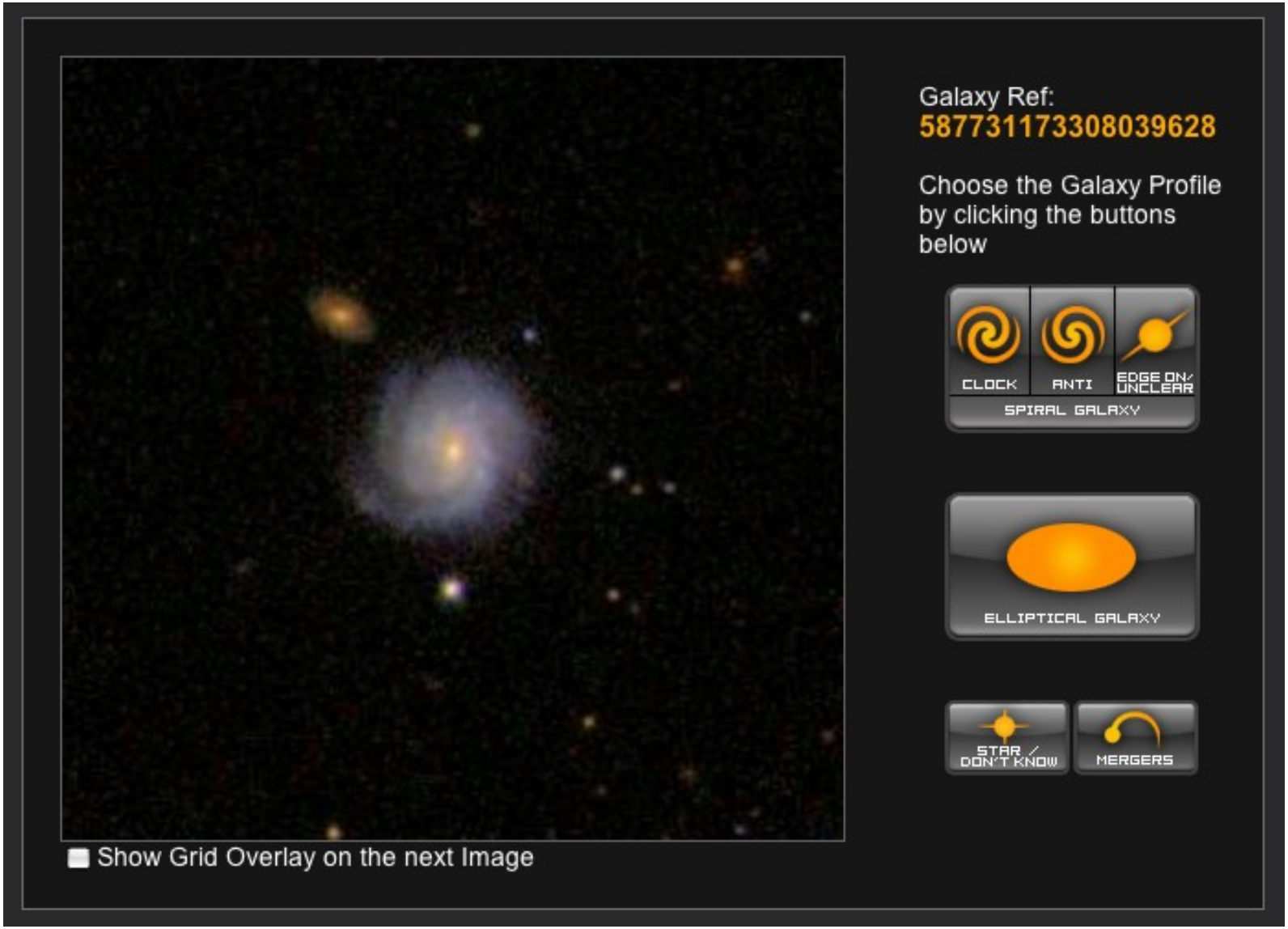
Some galaxies are a bit more tricky. As you noticed in the previous section, some spiral galaxies can look like ellipticals when viewed edge-on. Also, in some faint spiral galaxies, you have to look hard to see the spiral arms. Now, see if you can separate the genuine ellipticals from the spirals.

Try your hands at some!
Click the image to see if you're right.

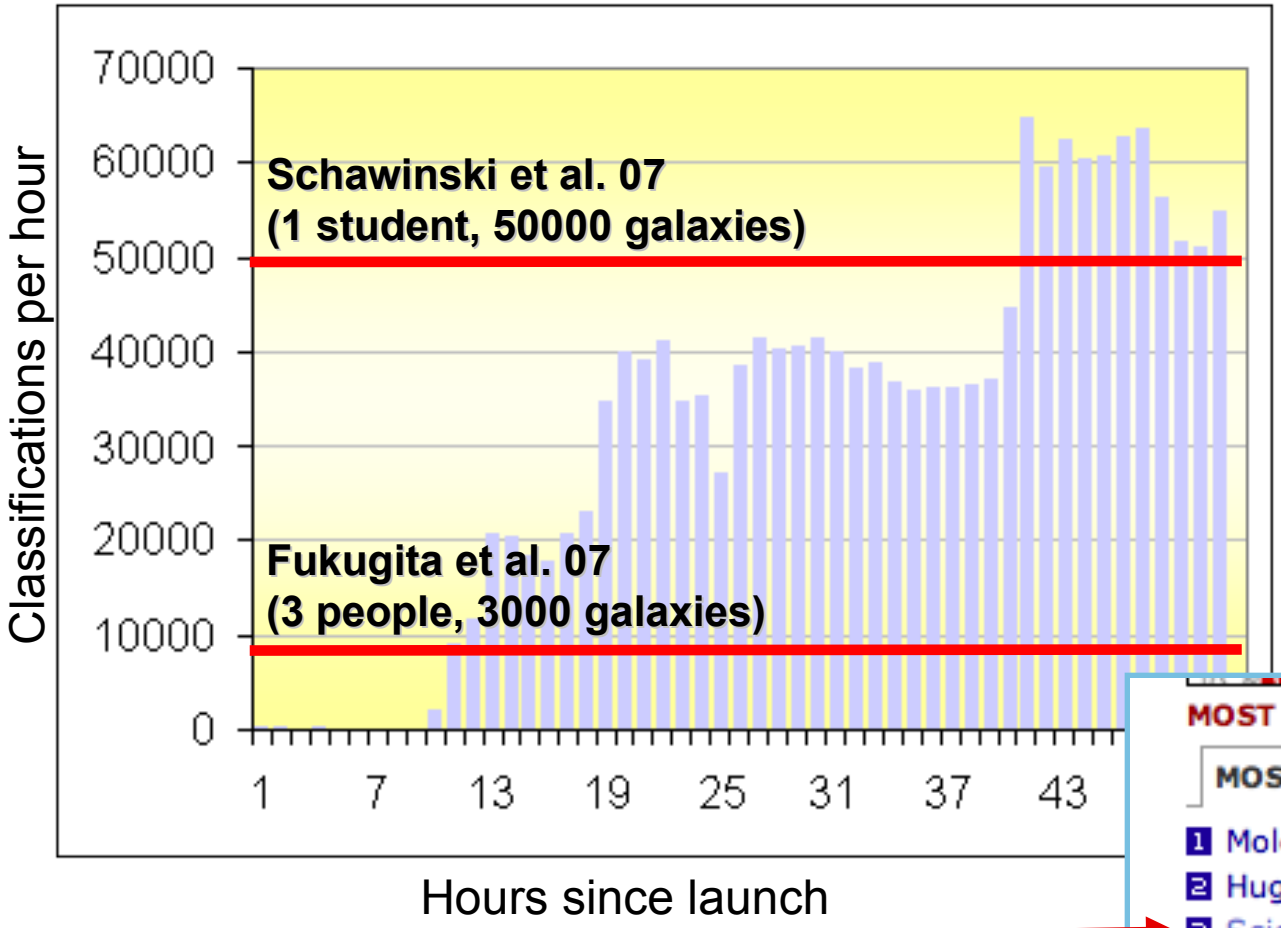
Part 1C ... Merging Galaxies

Sometimes, galaxies crash into each other, or come close. These are called merging galaxies. Merging galaxies are very interesting to astronomers because we think that large galaxies are built from mergers of small galaxies – if we see merging galaxies, we can see a snapshot of how that process happens. When you look for mergers, look for places where two galaxies appear to be merging into one. The galaxies should be close together, and you should be able to see some connection between them. In the trial or in your galaxy analysis, whenever you see this, click the button that says "Mergers".

Analysis


Galaxy Ref:
587731173308039628
Choose the Galaxy Profile by clicking the buttons below
CLOCK
ANTI
EDGE ON/ UNCLEAR
SPIRAL GALAXY
ELLIPTICAL GALAXY
STAR / DON'T KNOW
MERGERS
Show Grid Overlay on the next Image

Launch


Classifications per hour
70000
60000
50000
40000
30000
20000
10000
0
Schawinski et al. 07
(1 student, 50000 galaxies)
Fukugita et al. 07
(3 people, 3000 galaxies)
1
7
13
19
25
31
37
43
Hours since launch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3 Scientists seek galaxy hunt help
4 'My mother held me down'
5 Man flies to wedding a year early
Most popular now, in detail

Press

Economist.com

Communicating with the classifiers

www.galaxyzooforum.org - >7000 members

GALAXY ZOO.org

Official Galaxy Zoo Forum

Hello **bamford**

January 22, 2008, 06:51:54 PM

Show unread posts since last visit.
Show new replies to your posts.
Total time logged in: 18 hours and 46 minutes.

News: New Galaxy Zoo Forum is launched! (Note: this requires a separate registration)

Search

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Galaxy Zoo Forum

Welcome to Galaxy Zoo

	Threads to help you find your way around Galaxy Zoo	8 Posts 6 Topics	**Last post** by Alice in Galaxy Zoo FAQ Reference... on October 30, 2007, 05:43:16 PM

The objects

	Object of the Day The Galaxy Zoo team nominate their Object of the Day *Moderators: Alice, Edd, StuartA, bamford*	1759 Posts 150 Topics	**Last post** by jlowe in Re: Monday 21st January on **Today** at 05:21:57 PM
	Stunning sights! Post the most beautiful objects here. Remember to give the reference number. *Moderators: Alice, Edd, StuartA, bamford*	32845 Posts 1267 Topics	**Last post** by FermatsBrother in Re: Biggest cosmic train... on **Today** at 06:10:08 PM
	Weird and wonderful Post curiosities here. Please remember to include the reference number. *Moderators: Alice, Edd, StuartA, bamford*	36154 Posts 5545 Topics	**Last post** by helioprogenus in What's this magic lamp g... on **Today** at 06:03:45 PM

The site and the science

Communicating with the classifiers

www.galaxyzooblog.org - >30000 visitors so far, few hundred reads per day

ABOUT

GALAXY ZOO.org

Galaxy Zoo Blog

The official blog of the Galaxy Zoo project

JAN 21

Do galaxies care where they live?

Does where we live make a difference to the kind of person we are? This is a question that has been addressed many times by social scientists, and certainly with more refined thought than the following example, but it will serve our purposes.

Consider one person, Victor, living in a small countryside village, and another, Claire, who lives in the centre of a city. The nearest shops to Victor are many miles away. When he has a sudden biscuit craving and opens the cupboard to find, to his horror, that his wife finished off the last packet the previous evening, it is a great effort for him to travel to the shops to get another. Claire, on the other hand, has merely to stroll to the corner of her road to satisfy her craving for something crunchy. However, while Claire often finds herself nipping out for a packet of biscuits, Victor rarely has the need. He always makes sure he buys plenty of biscuits on his regular weekly shopping trip, and there is always the packet hidden at the back of the other cupboard that his wife hasn't noticed. Victor is very organised, while Claire clearly isn't, at least when it comes to biscuits. Does this have anything to do with where they live?

Of course, biscuit buying habits, although important, aren't the only thing one can say about an individual. Each person is complex and unique, imperfectly describable even by a very

SEARCH

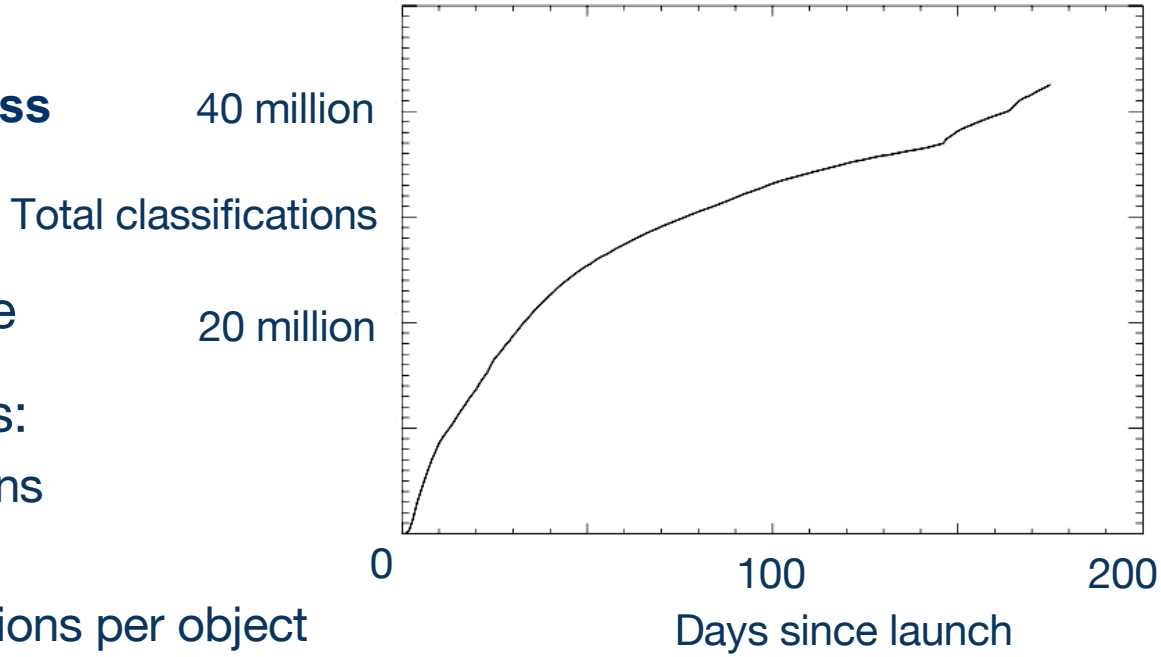
Go

CATEGORIES

- Anze
- Bill
- Chris
- Jordan
- Kate
- Kevin
- Steven

Classification database

Overview paper:
Lintott et al., MNRAS in press
arXiv:0803.3247



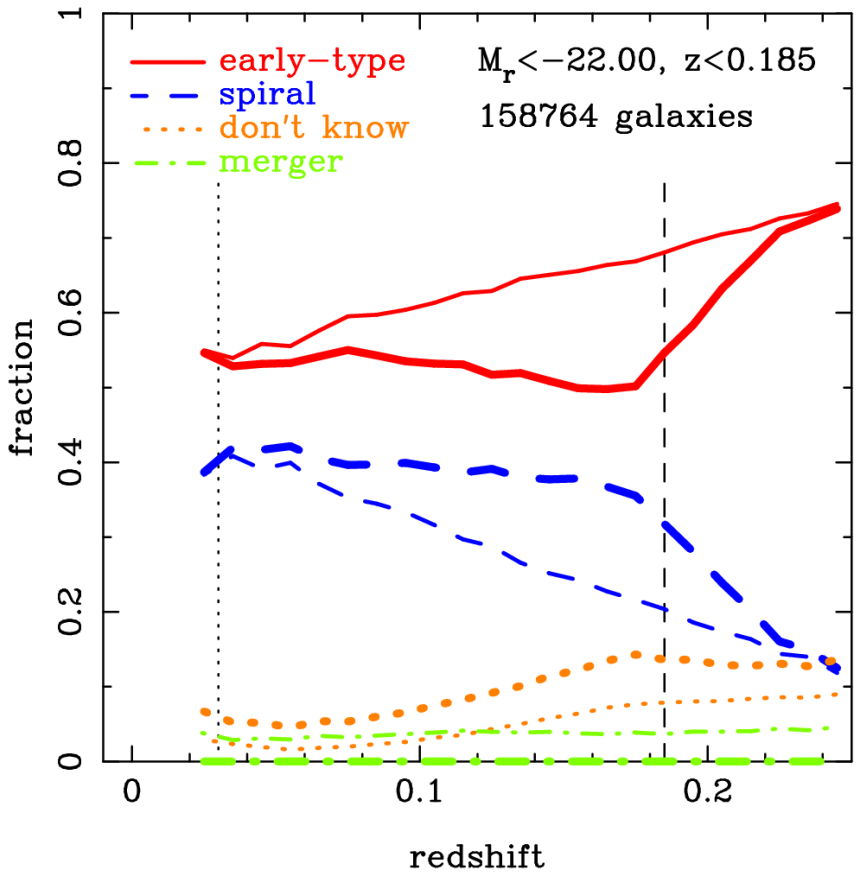
- 893212 objects in sample
- After 'cleaning' raw clicks:
  - 34,617,406 classifications
  - by 82,931 users
  - median of 33 classifications per object
  - >20 classifications per object for 98% of sample
- Roughly 3.3 continuous person-years!
- Most classifications are done by ~1/3 users who do 100 - 10,000 each
  - ~ few hours effort each
- Catalog public later this year
- Collaboration welcome now!

Combining classifications

- If we don't care about 'handedness' just combine spiral classes
- Raw morphological type 'likelihoods' p_{el}, p_{sp}, p_{mg}, p_{dk}
  - average classifications for each galaxy
    - all users equal, or
    - weight 'better' users
- Assigning types
  - work with likelihoods
  - threshold likelihoods
    - definite types
    - many uncertain

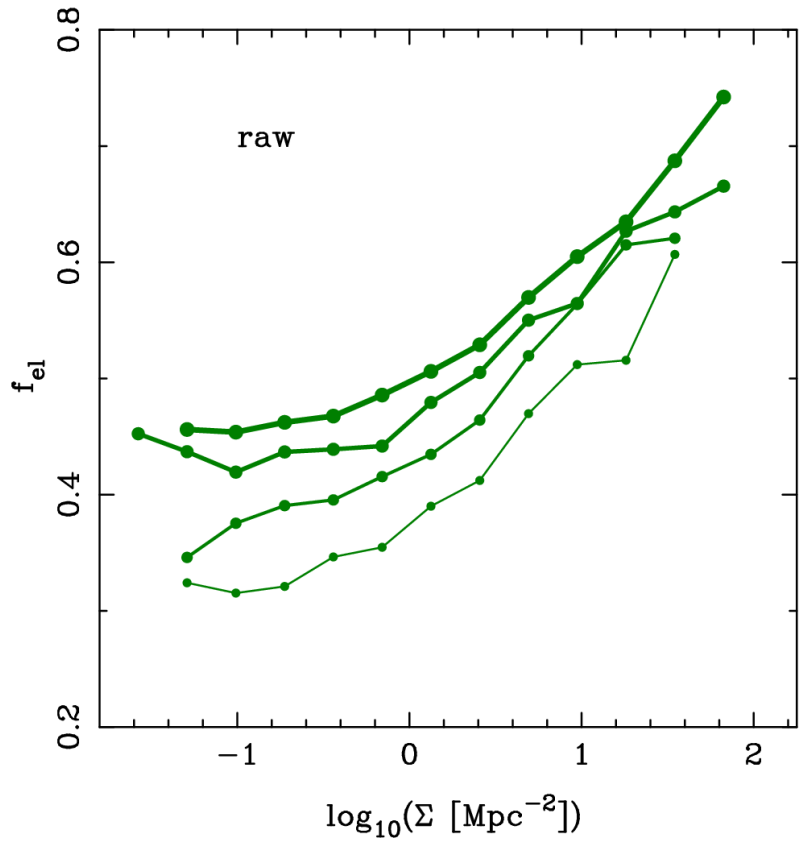
Classification biases

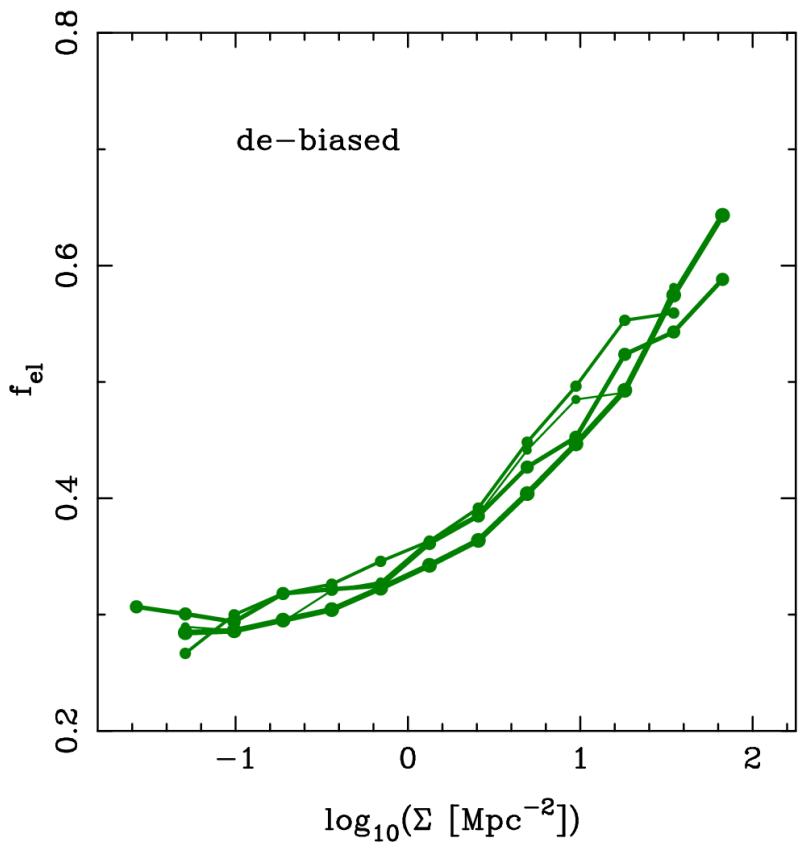
- Assume no redshift evolution
- Type fractions should be constant with z, in absence of sample selection effects - empirically determine bias correction versus luminosity, size, redshift



Correcting classification biases

" Morphology density relation corrected for redshift-dependent classification bias (z ~ 0.037, 0.051, 0.064, 0.078)

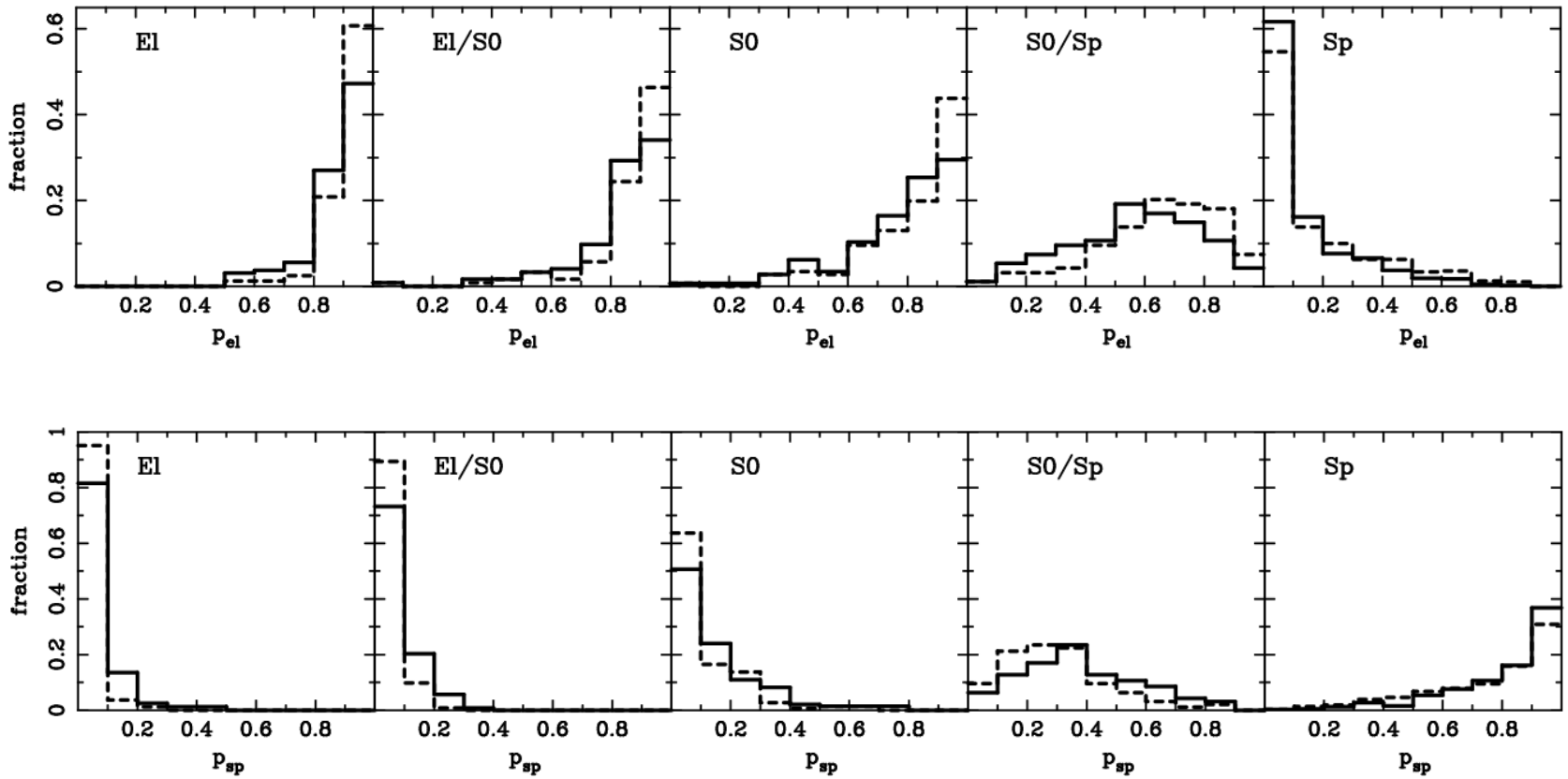




Comparison to other morphologies

Fukugita et al. 2007

S0 galaxies mostly classed as elliptical



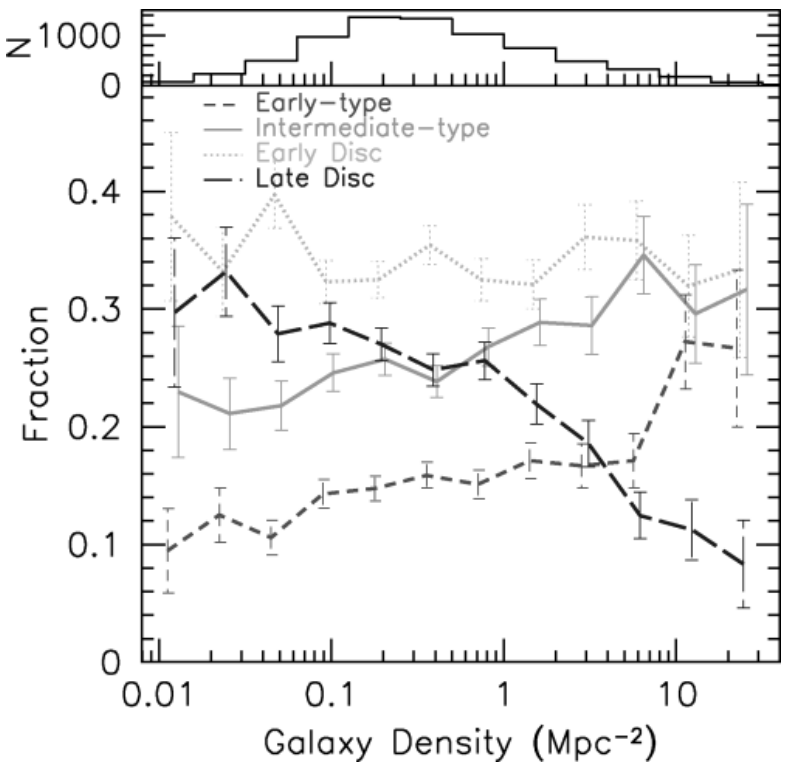
Current projects

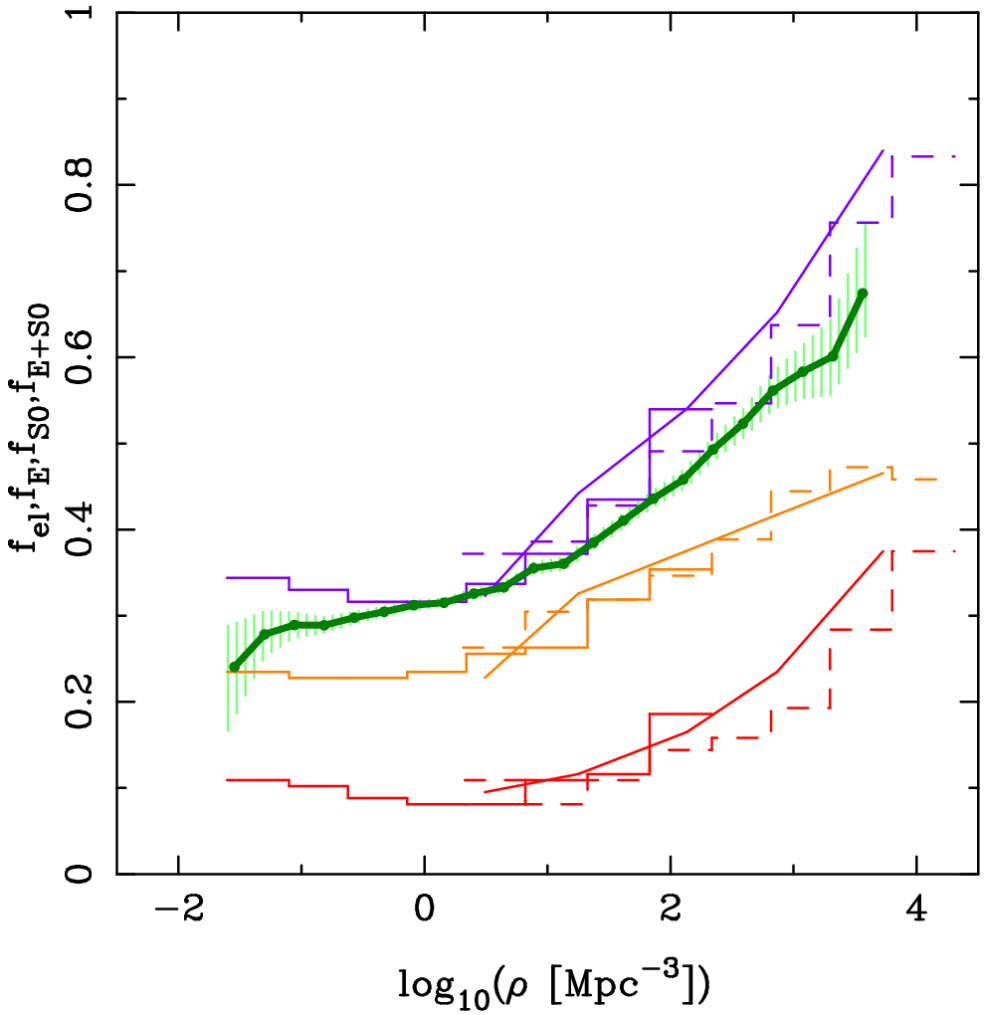
- Initial projects:
  - Spiral galaxy spins distribution
    Land et al., 2008, MNRAS, 388, 1686
    arXiv:0803.3247
  - Blue ellipticals
    Schawinski et al., MNRAS submitted
  - Morphology versus environment
    Bamford et al., MNRAS submitted
    arXiv:0805.2612
- Projects underway:
  - 2-point correlation function of spiral spins
  - Morphology-marked correlation functions
  - Mergers
  - Red spirals
  - More morphology versus environment
  - Comparison with semi-analytic models
  - Morphology-dependent colour-magnitude sequences
  - Morphology-dependent luminosity functions and galaxy bias
  - SFR and AGN fraction as a function of morphology and environment
  - Structural parameters of blue ellipticals
- Serendipitous projects:
  - Hanny's Voorwerp
    Lintott et al., MNRAS submitted
  - Overlapping galaxies - dust
  - Lenses
  - Ring galaxies
- Non-astronomy projects:
  - Zooites motivation study
  - The Zoo in a brain scanner

Morphology versus environment

- **Bamford et al., arXiv:0805.2612**

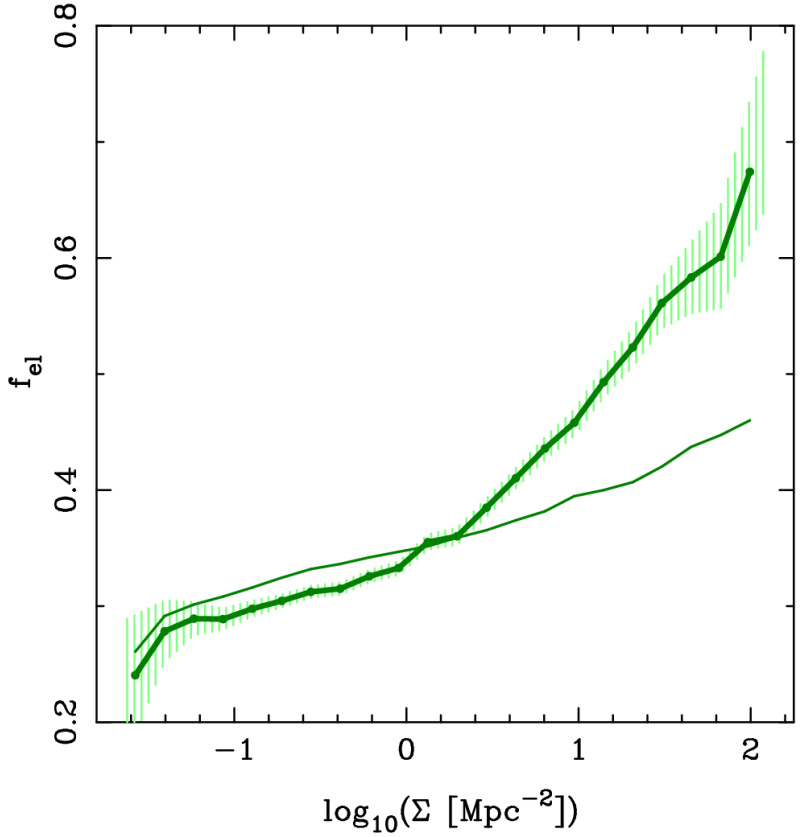
- Previous local work:
  - Dressler 1980
  - Postman & Geller 1984
  - Goto et al 2003

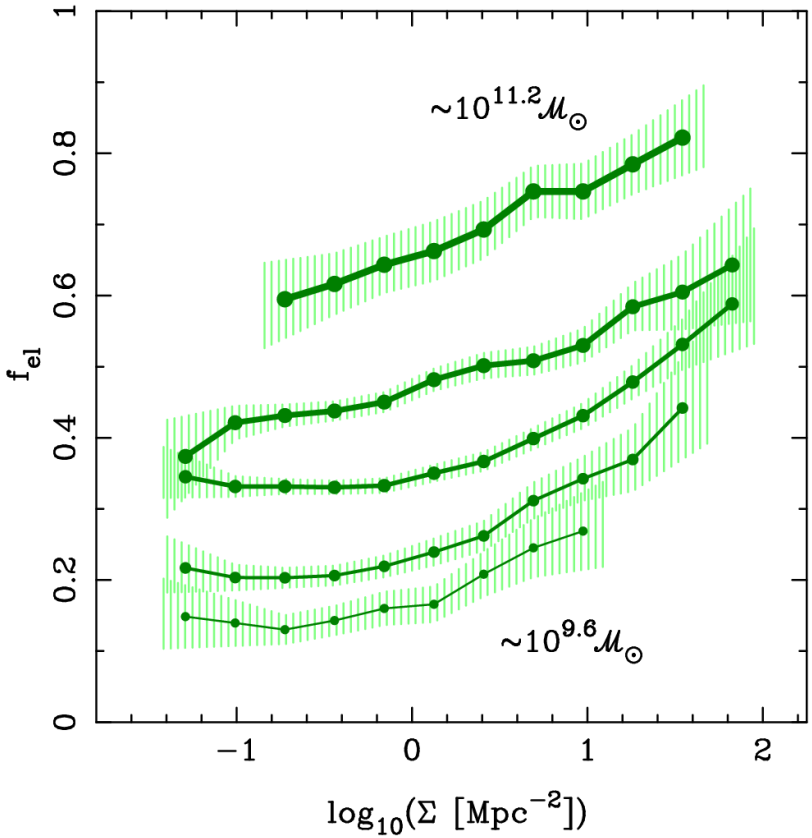




Morphology versus environment

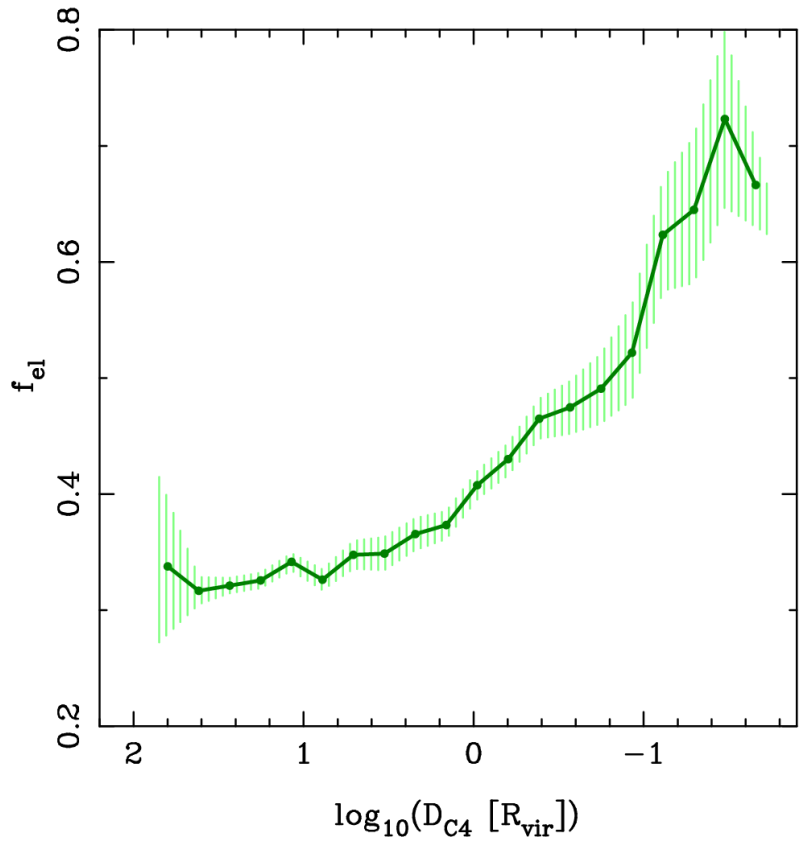
" Elliptical fraction versus local galaxy density and stellar mass

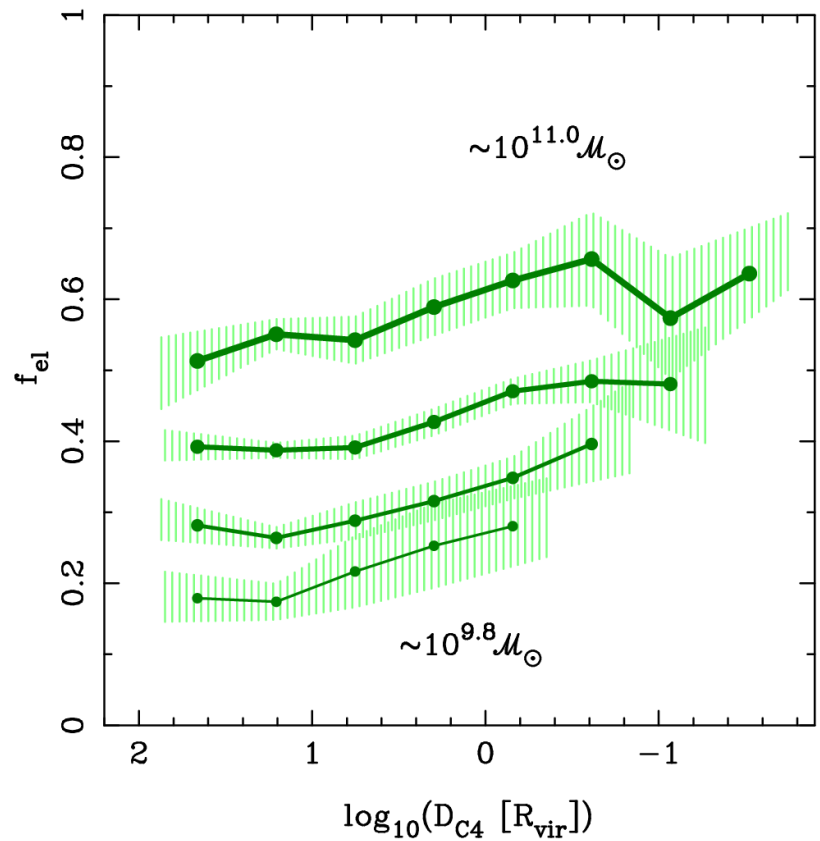




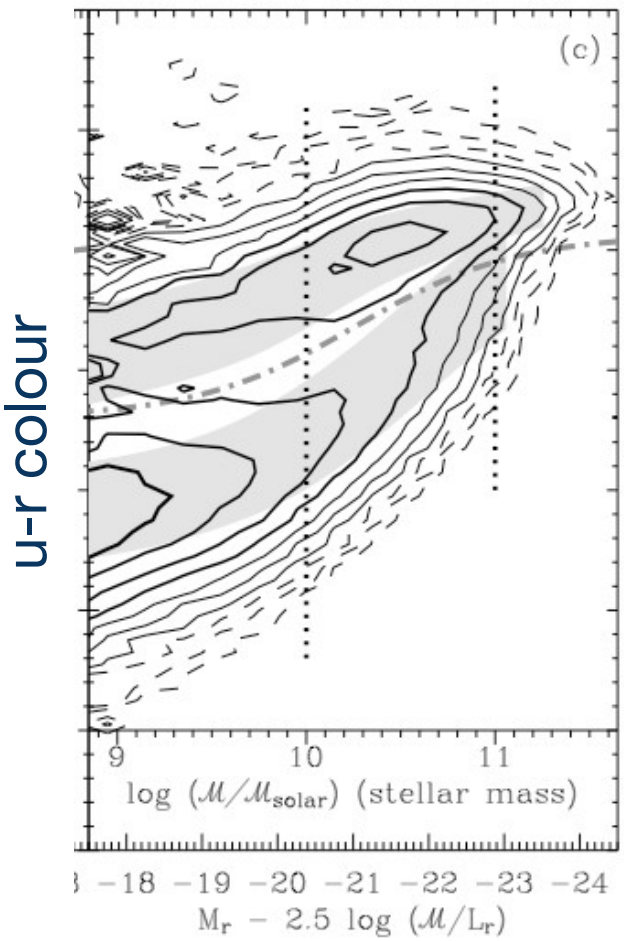
Morphology versus environment

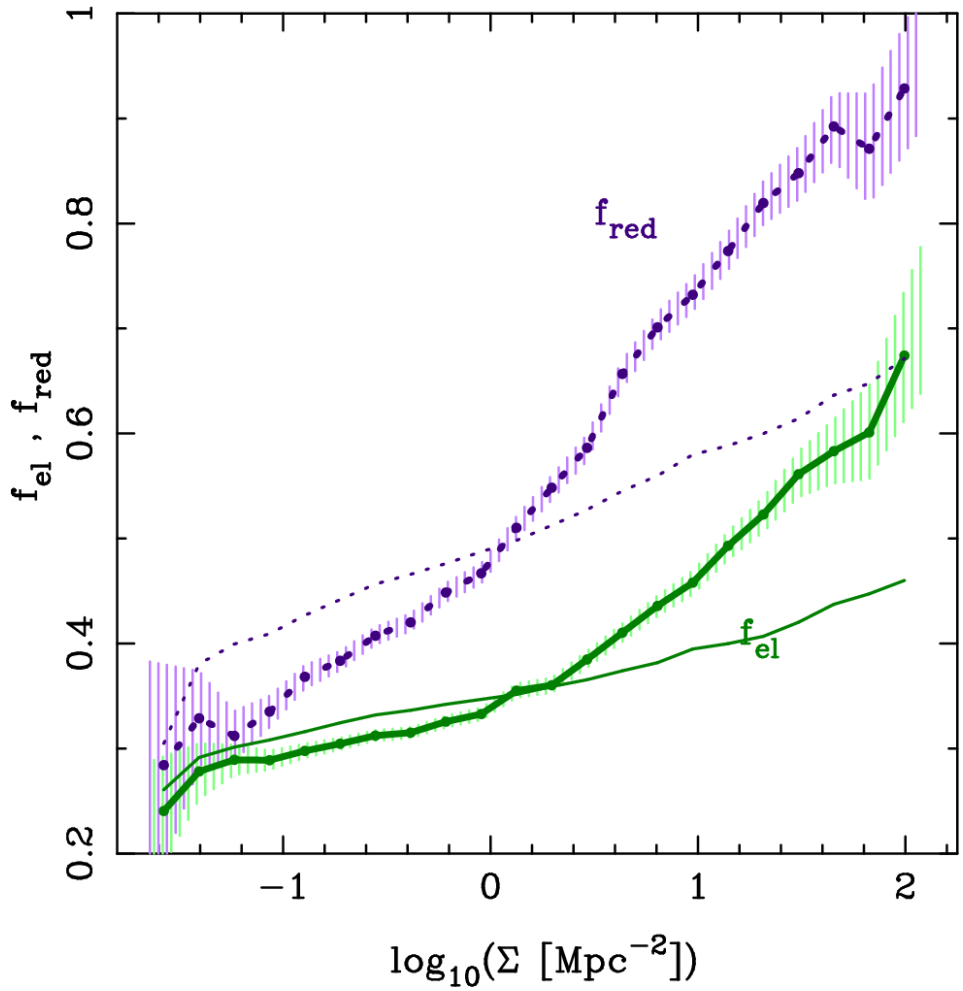
" Elliptical fraction versus distance to a C4 group and stellar mass





Morphology versus colour bimodality

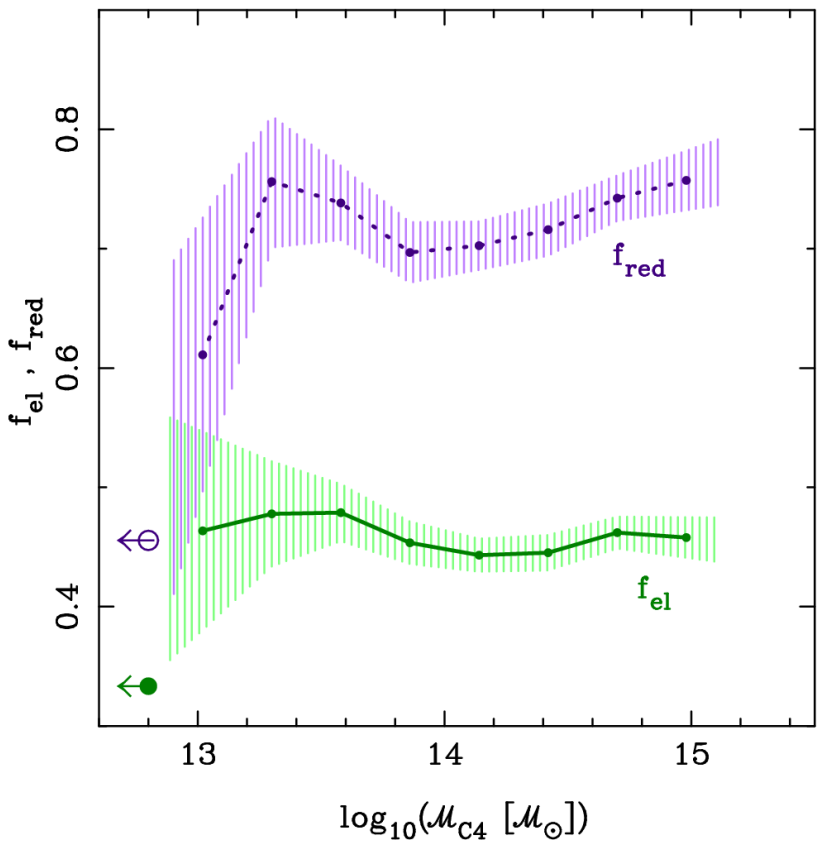




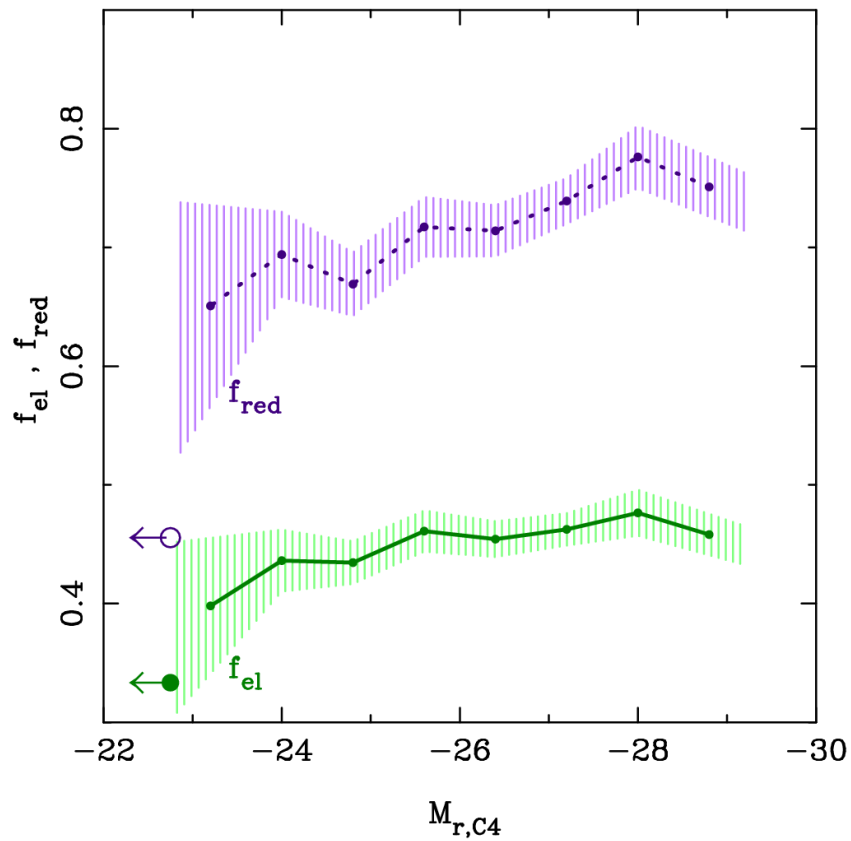
Morphology versus environment

" Little dependence of fractions on group mass

total mass

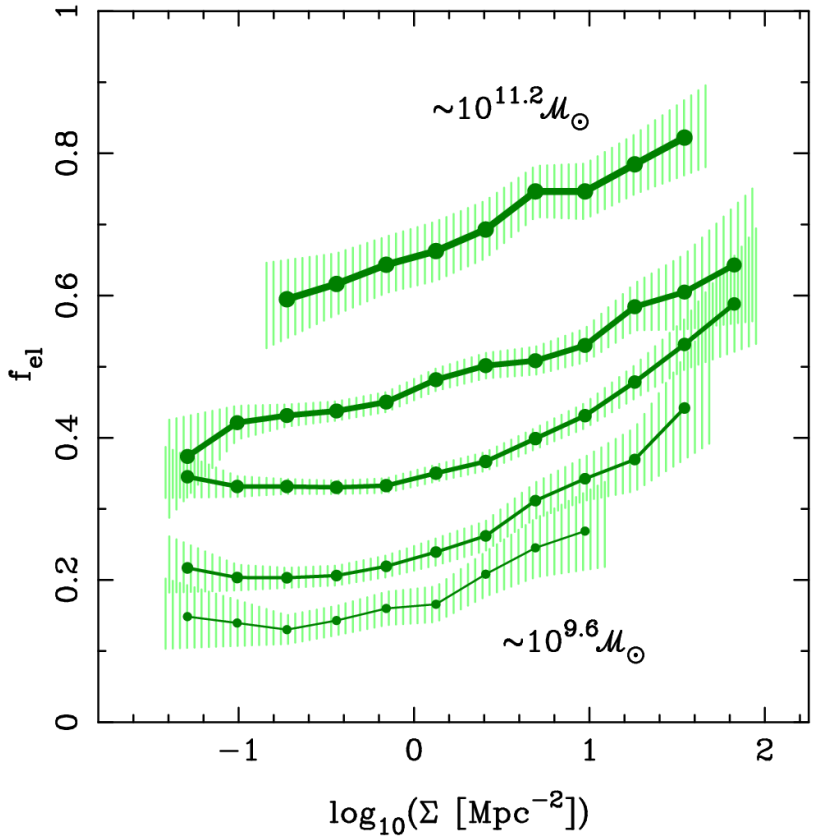


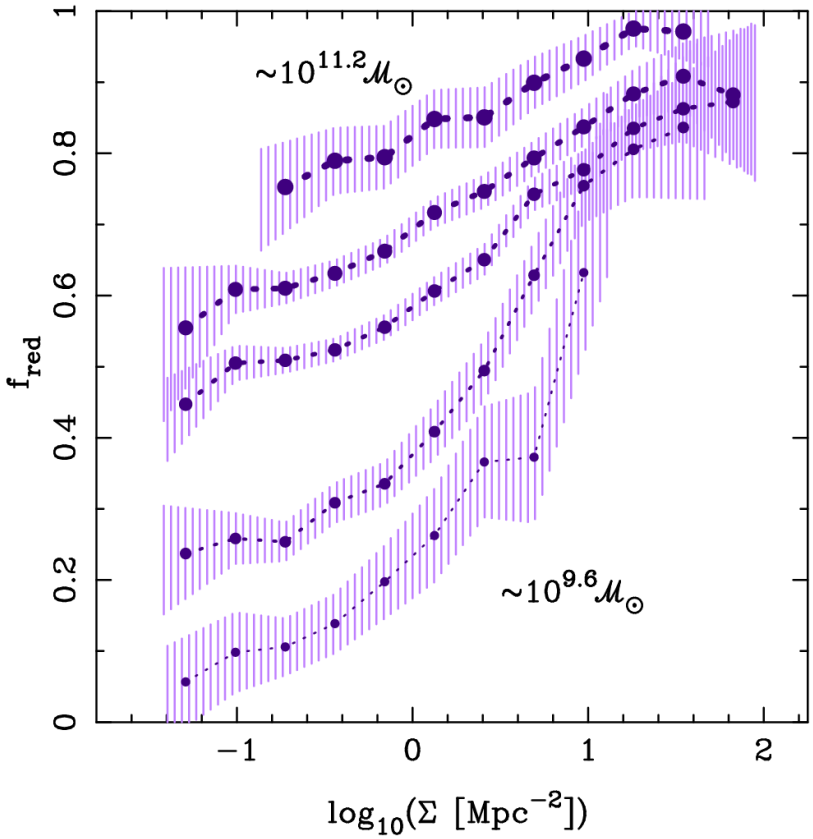
integrated luminosity



Morphology versus colour bimodality

" Comparison with colour

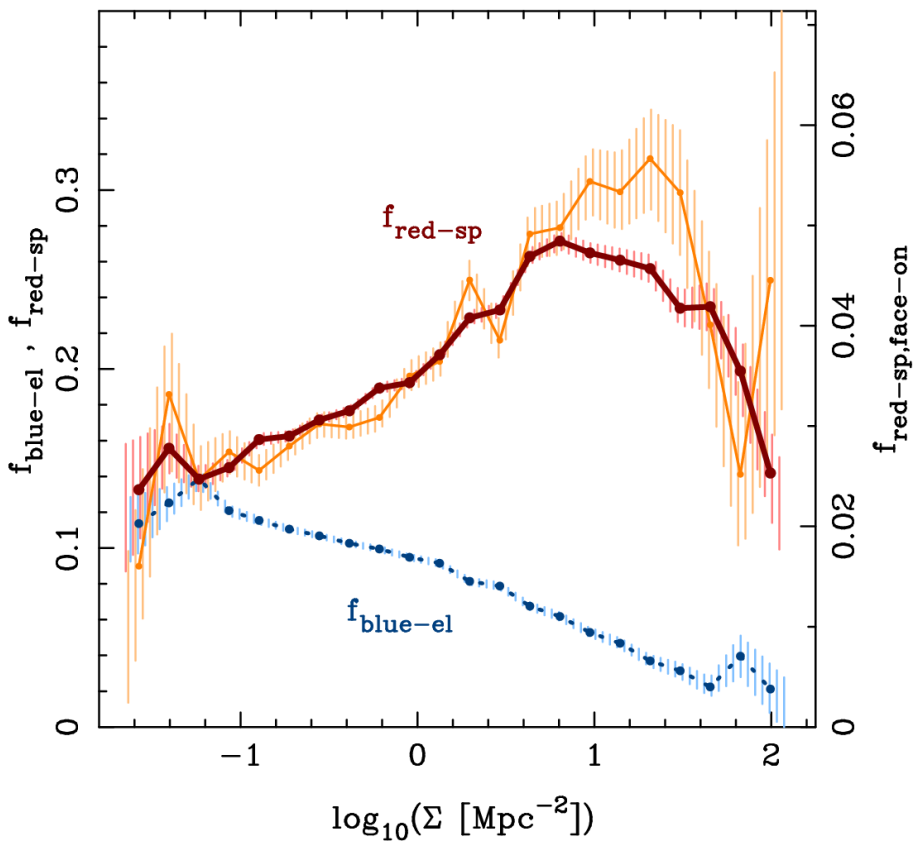




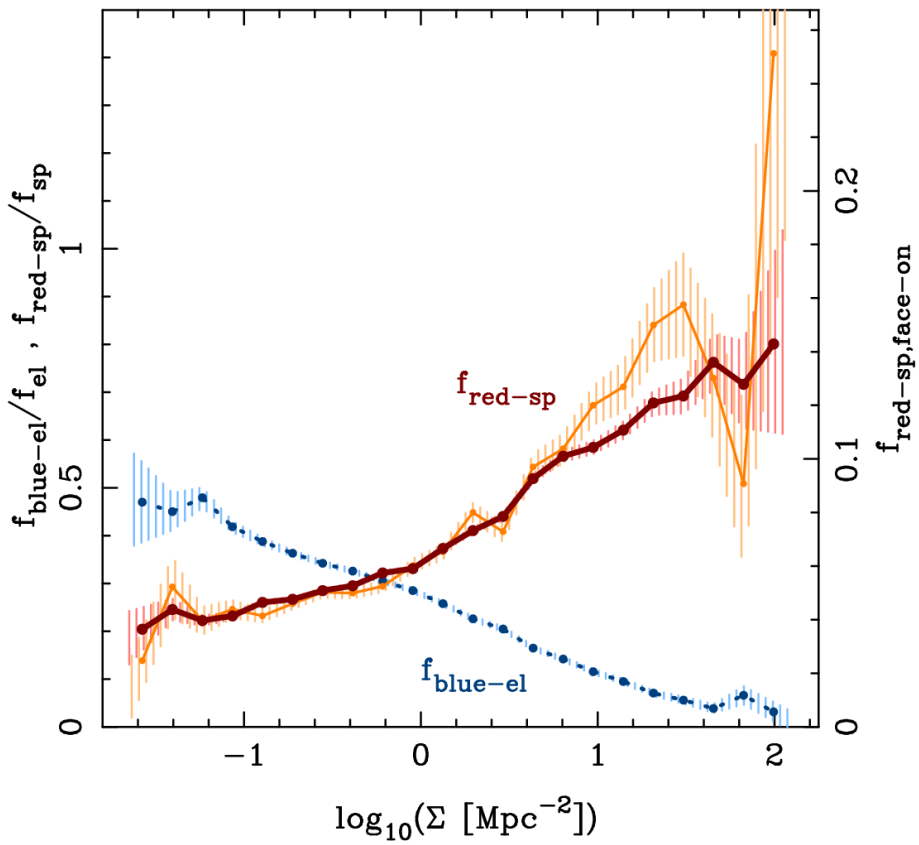
Red spirals and blue early-types

" Objects on opposite sides of morphology/colour bimodalities

fraction of all galaxies

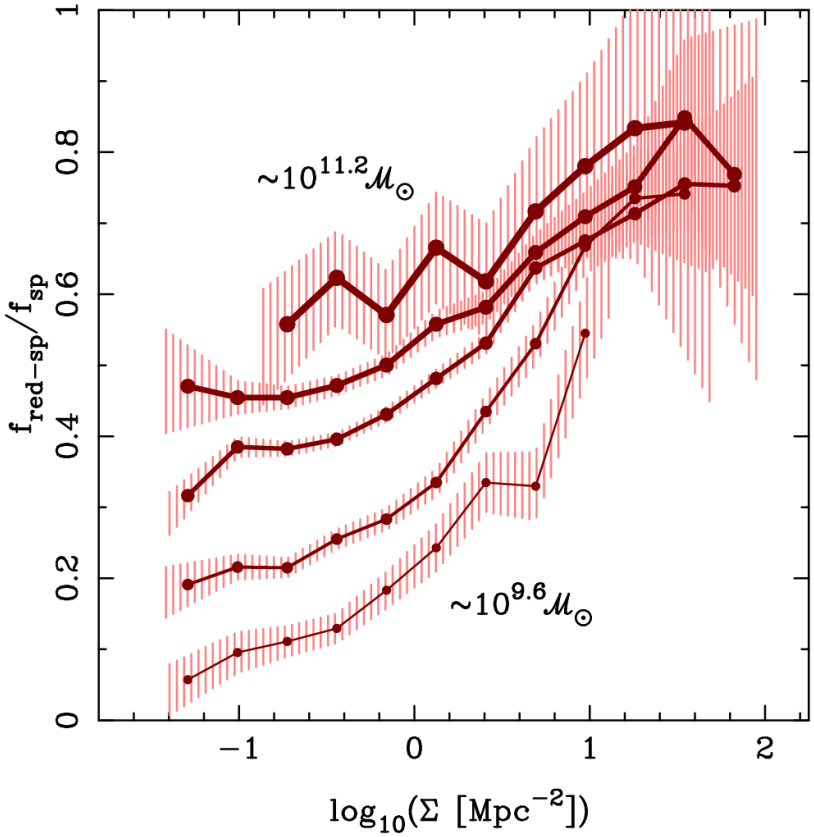


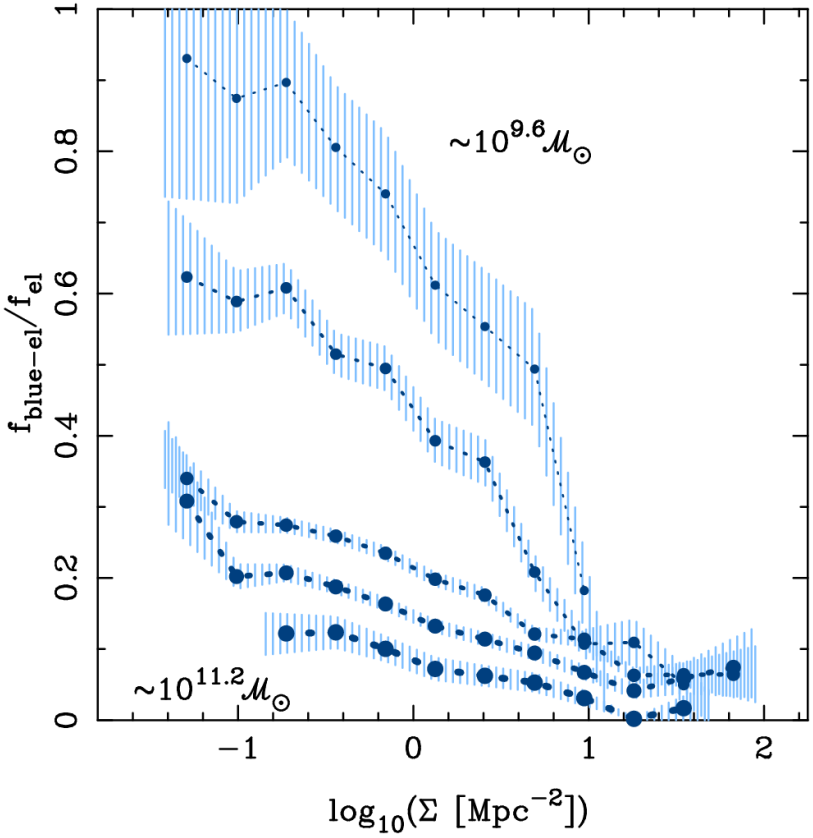
fraction of morphological type



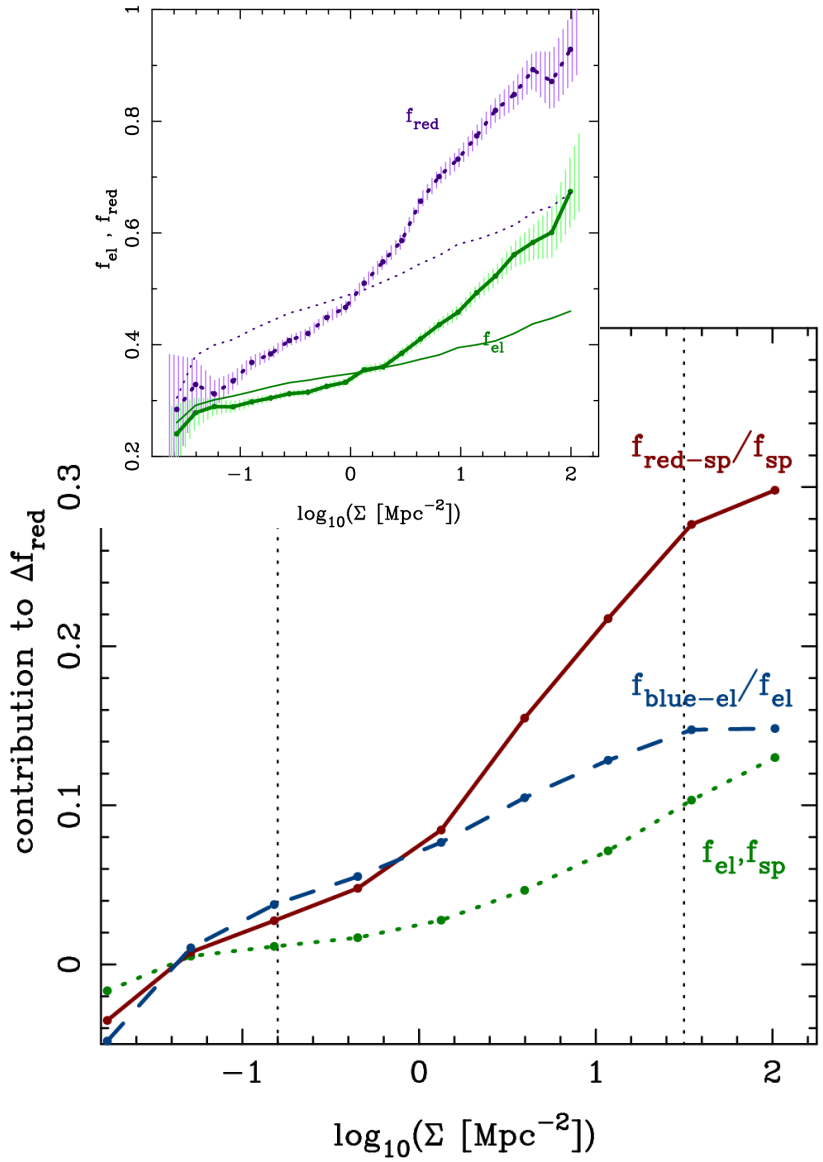
Red disks and blue ellipticals

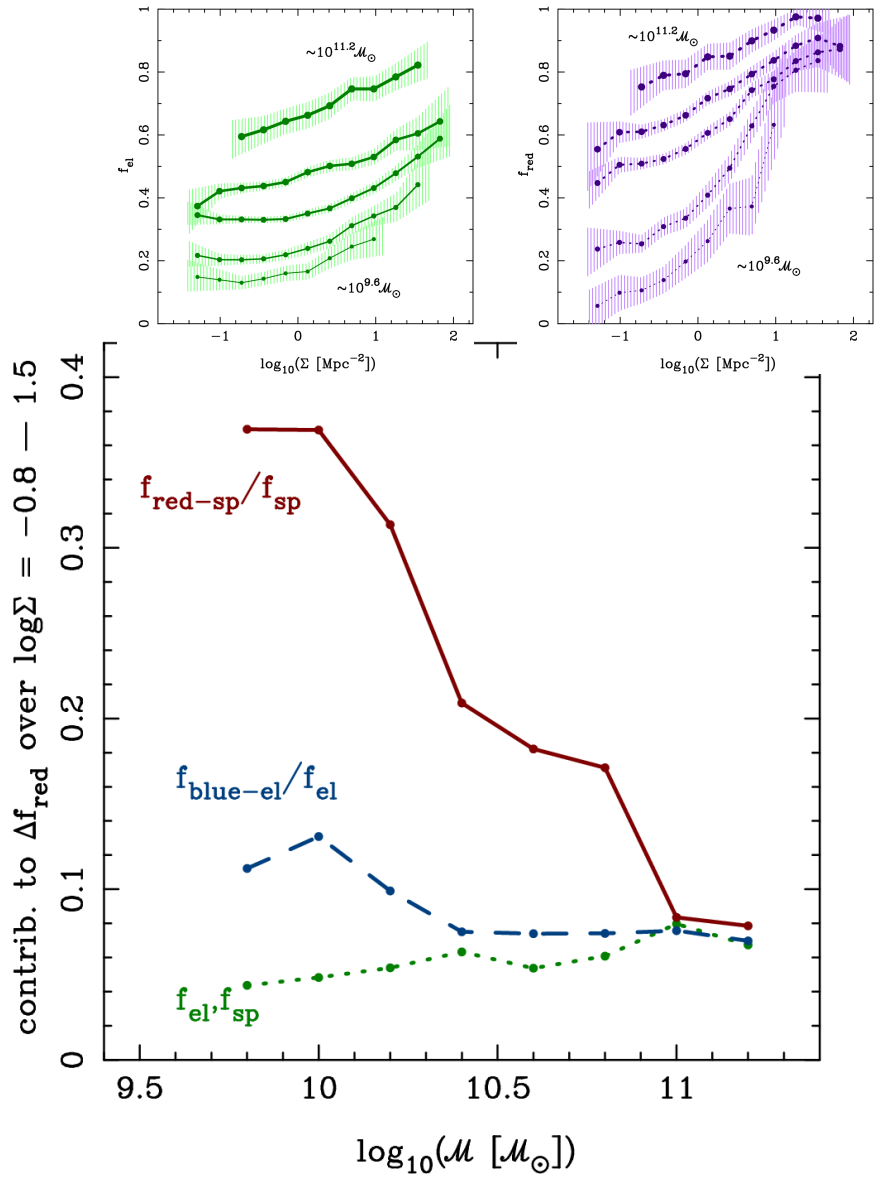
" Stellar mass dependence





Contributions to colour-environment





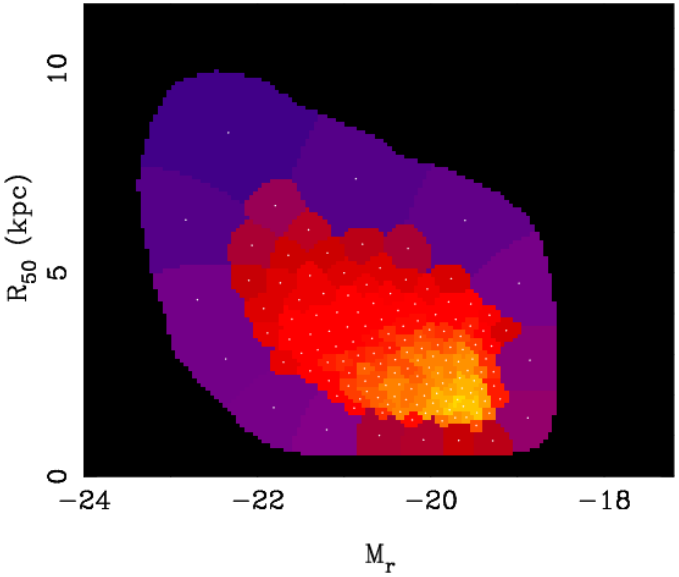
Morphology versus environment

Conclusions

- Morphology - density relation does exist at fixed stellar mass, but is weak
- Colour - density relation stronger, especially at fixed mass
- Morphology vs density and group distance show very similar behaviour
- Little dependence of group members on group mass
- Red spirals most common in outskirts of clusters / intermediate densities - combination of two competing environmental effects
- Blue early-types prefer voids
- Colour trends with environment are much stronger for lower mass galaxies
  - low mass ellipticals and spirals almost all blue at low densities, red at high densities
- Trends of morphology and colour vs environment **not** due to same processes
- Colour versus environment driven by occurrence of red spirals
  - Not just usual S0 population

The future of the Galaxy Zoo

- Lots to do with Galaxy Zoo 1 data - public soon!
- Galaxy Zoo 2
  - more detailed morphological classifications
  - conventional and comparative methods
  - refined SDSS sample
  - launching very soon!
- Galaxy Zoo 3
  - more datasets:
    - PanSTARS, HST, VST KIDS
    - higher quality imaging
    - greater depth



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