LSST:UK Galaxies science

Sugata Kaviraj
On behalf of the LSST:UK Galaxies collaboration

RAS Specialist Discussion Meeting
12 May 2017

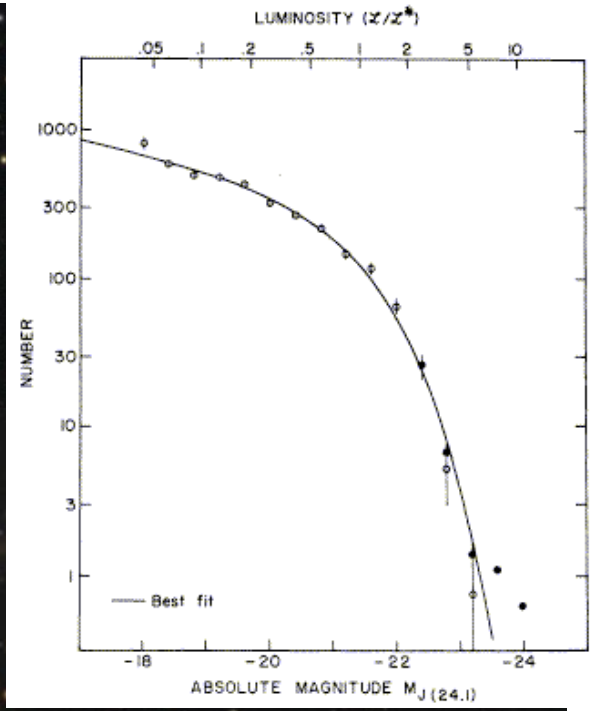
LSST:UK galaxies science

- Low surface-brightness Universe
- Simulations
- Morphological classification
- Photo-z pipelines
- Deblending algorithms
- High-redshift Universe
- Galaxy clusters
- Strong lensing

- ❖ UK momentum/leadership/niche
- ❖ Critical for enabling a broad spectrum of LSST science
- ❖ Some areas providing critical support for LSST Project

The low surface brightness Universe

Detection and characterisation of LSB objects

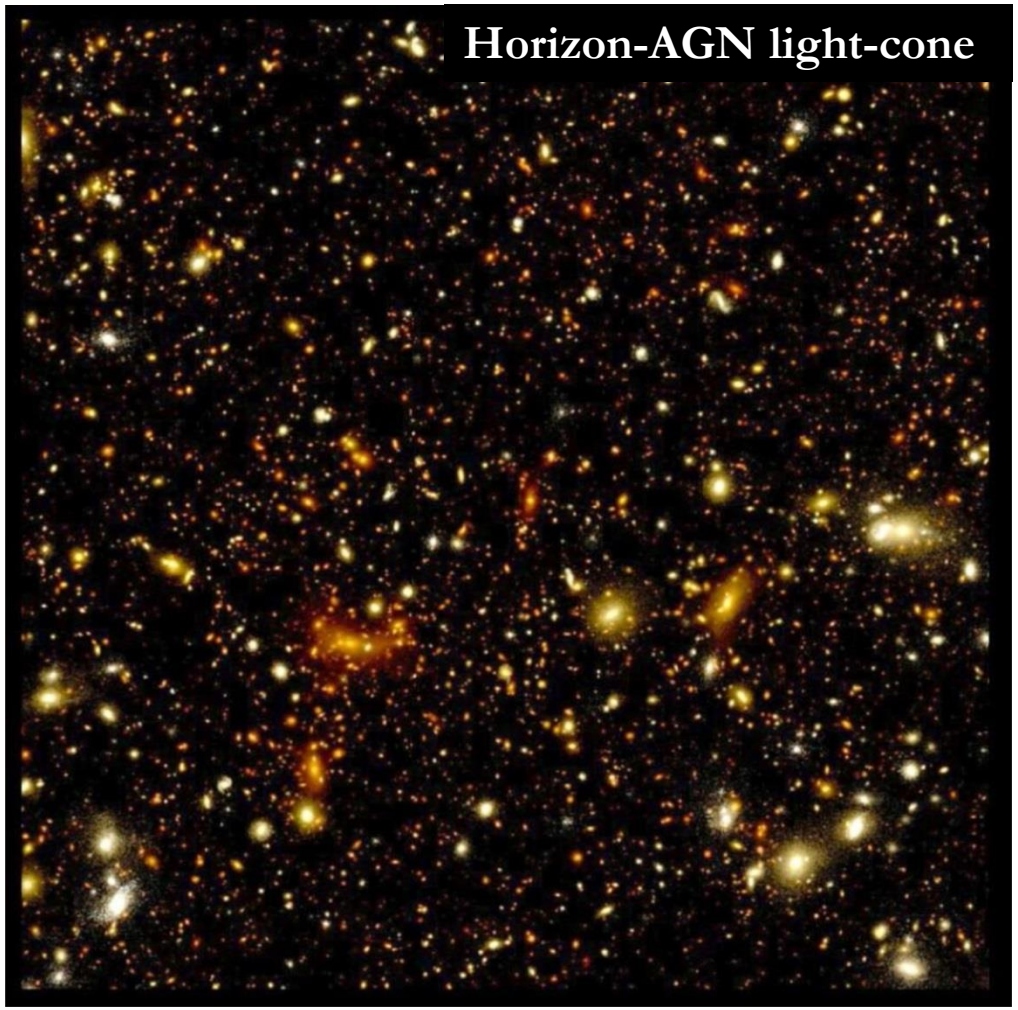


- Quantify role of merging in galaxy evolution
  - Detection of LSB tidal features
  - Characterisation of LSB tidal features
- Detection of LSB galaxies

Martin, Devriendt, SK, Laigle, Prole, Davies, Ferguson et al.

The low surface brightness Universe

Simulations: detection/characterisation of LSB tidal features



SK +17

- UK has strong simulation expertise:
  - Horizon
  - New-Horizon (mol. cloud scale resolution)
  - EAGLE
  - Illustris
- Full hydro sims in cosmological volumes (100 Mpc)

Martin, Devriendt, SK, Laigle, Prole, Davies, Ferguson et al.

The low surface brightness Universe

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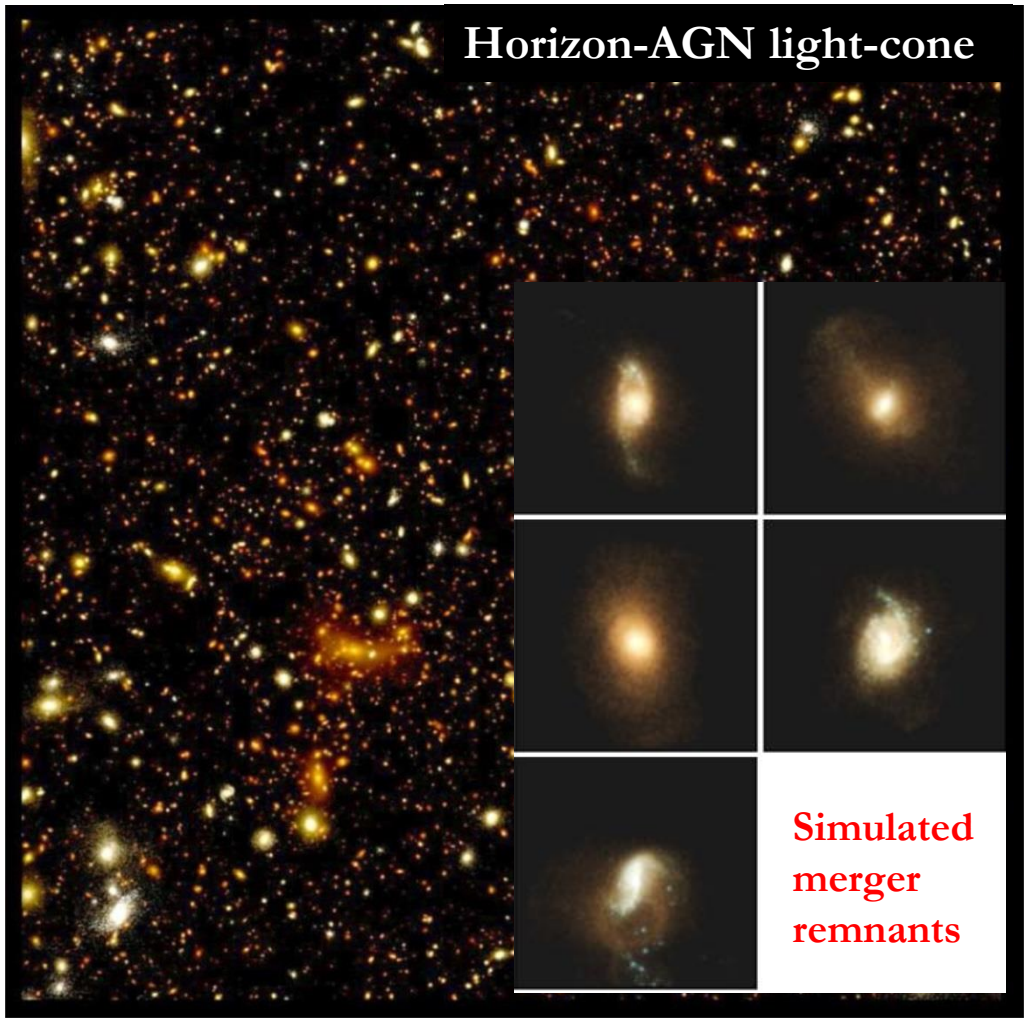

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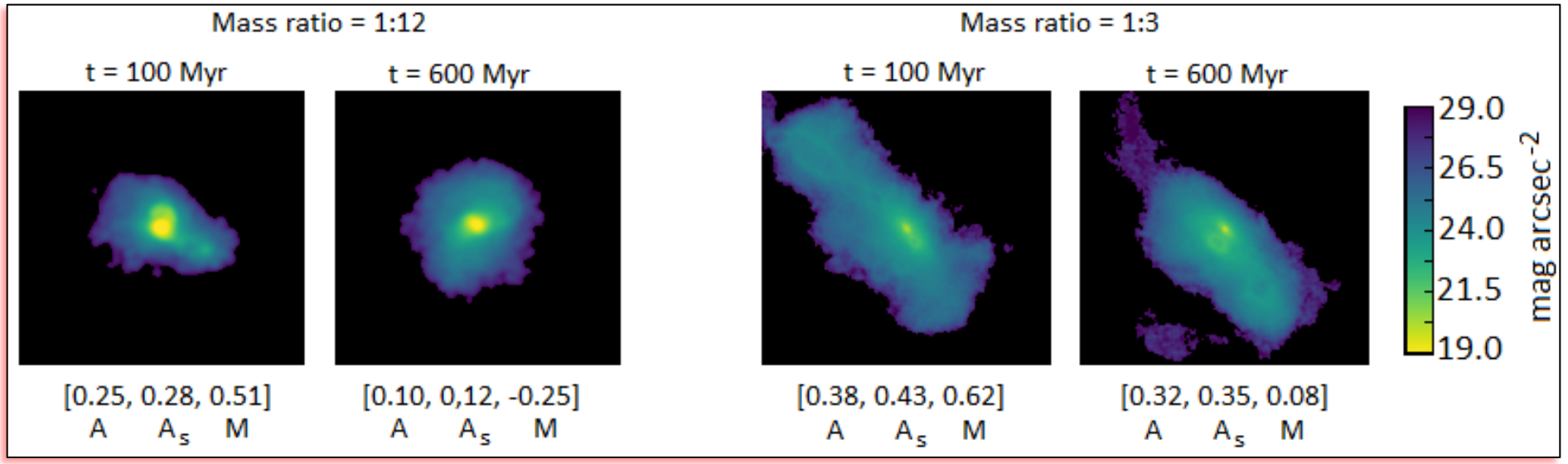
The low surface brightness Universe

Simulations: detection/characterisation of LSB tidal features



Algorithms can be built that use morphological parameters to:

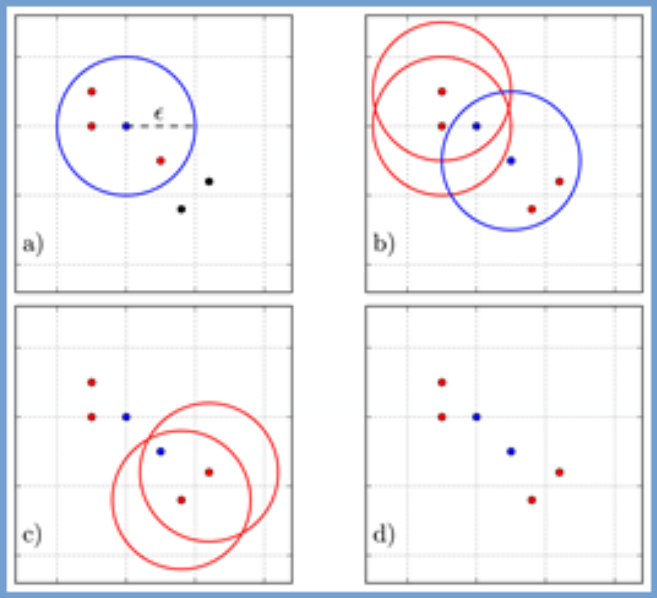
- Detect merger remnants
- Separate remnants based on their properties → characterise mergers

Martin, Devriendt, SK, Laigle, Prole, Davies, Ferguson et al.

The low surface brightness Universe

Detection of UDGs and LSB structures

- Use clustering algorithms (e.g. DBSCAN) to find Ultra Diffuse Galaxies
- Identifies over-densities of pixels over an arbitrary clustering scale length (ε)
- Train on simulations and precursor data (Prole +17)



- Number of enclosed LSB pixels counted for each LSB pixel
- A core point is formed when number of enclosed points is greater than η=3
- Clusters are composed of connected core points (blue)

Martin, Devriendt, SK, Laigle, Prole, Davies, Ferguson et al.

Galaxy morphology

Machine learning methods

Supervised or Unsupervised?

Supervised

Training data set consists of known galaxies + classifications

Spiral

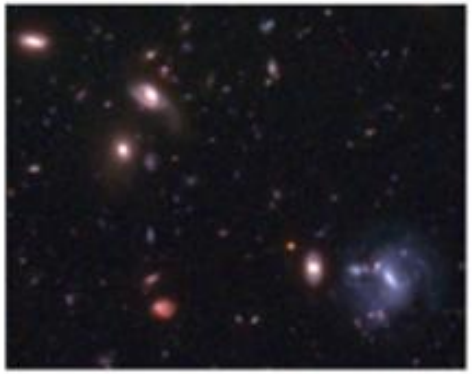
Elliptical

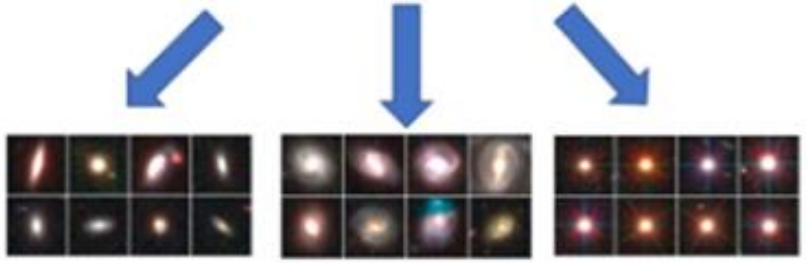
In use – predict the classification:

Elliptical or spiral?

Unsupervised

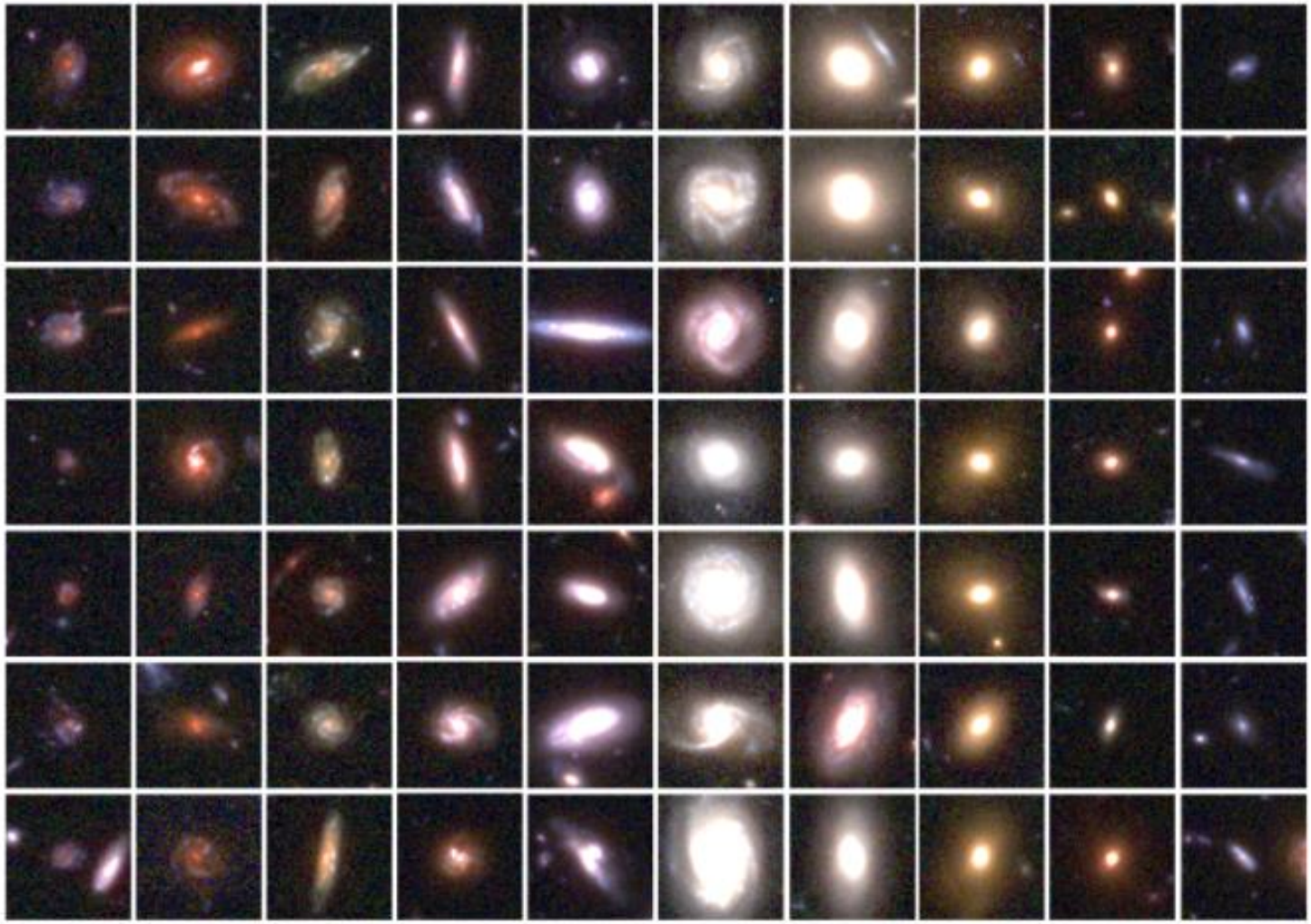
Training data set consists of FITS survey images. No classifications are used.





Galaxy morphology

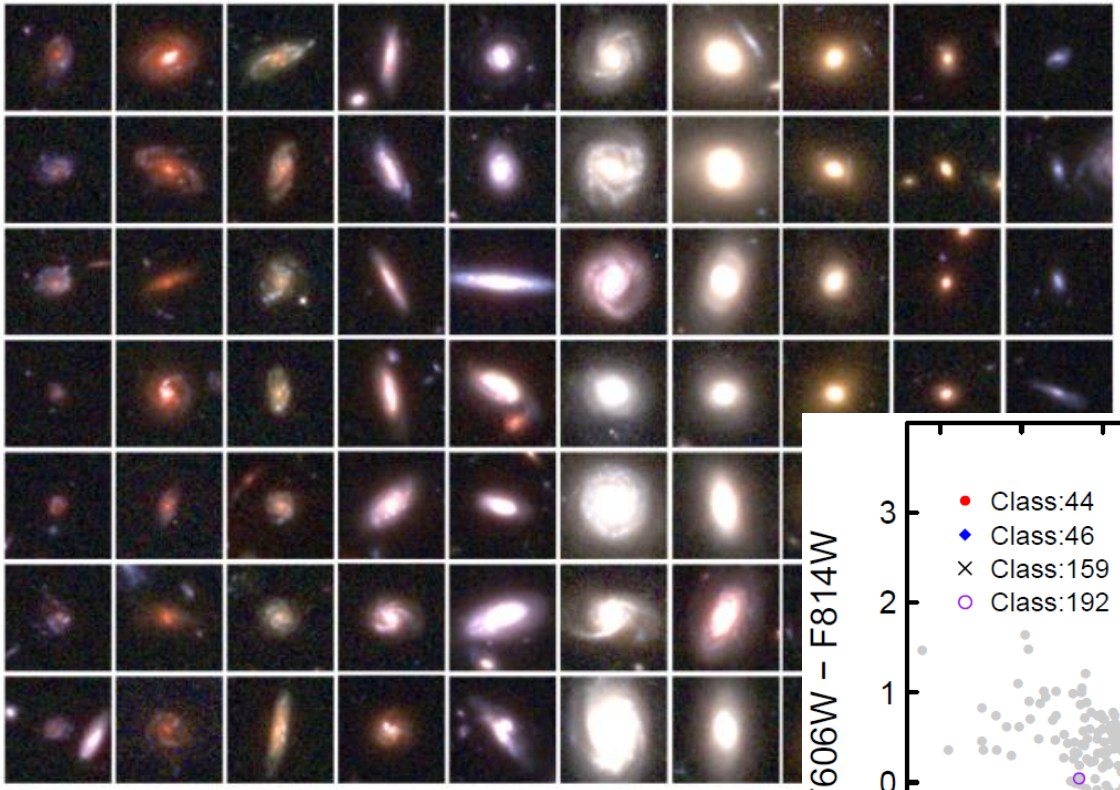
Machine learning methods



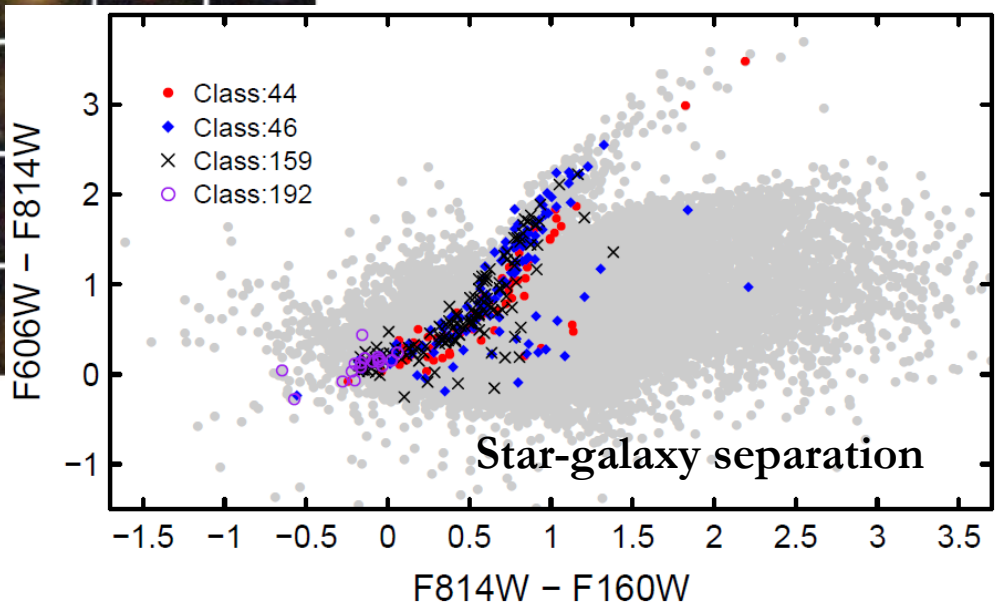
Hocking, Geach et al.

Galaxy morphology

Machine learning methods



- Feasibility tested on CANDELS (Hocking +17)
- Will be implemented on LSST and precursors



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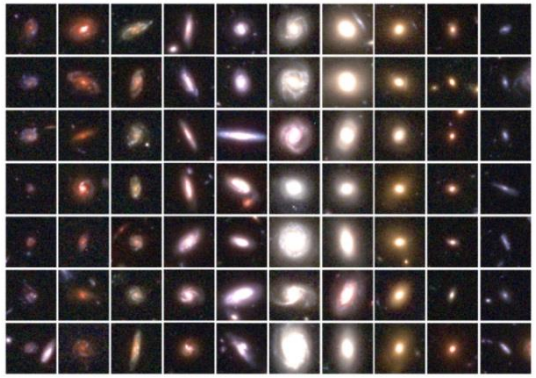
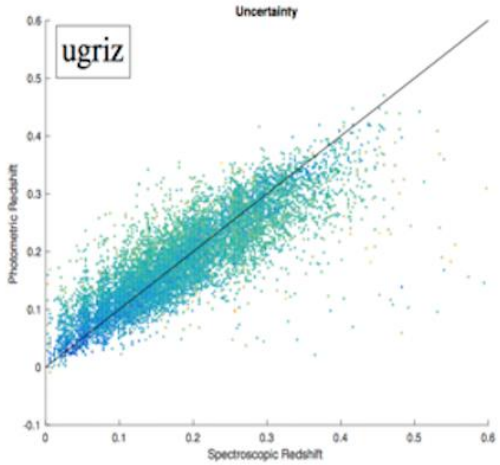
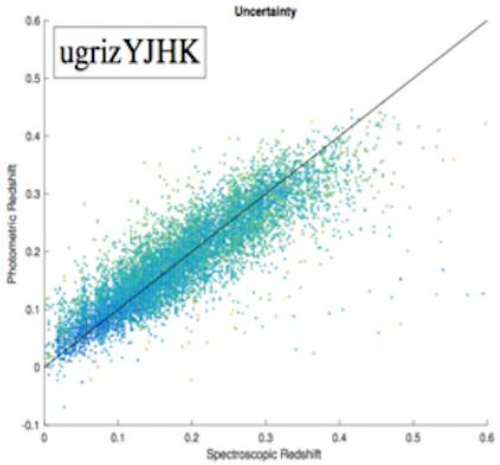
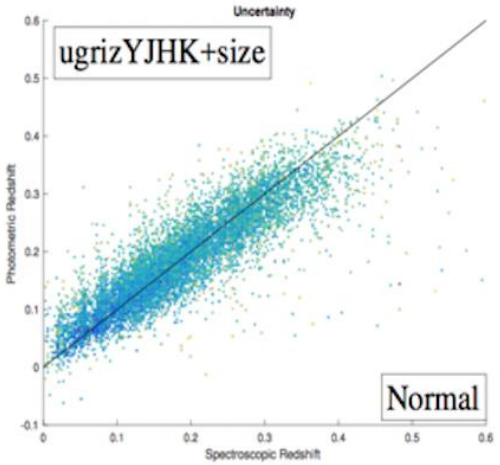


Input into photo-z pipelines…

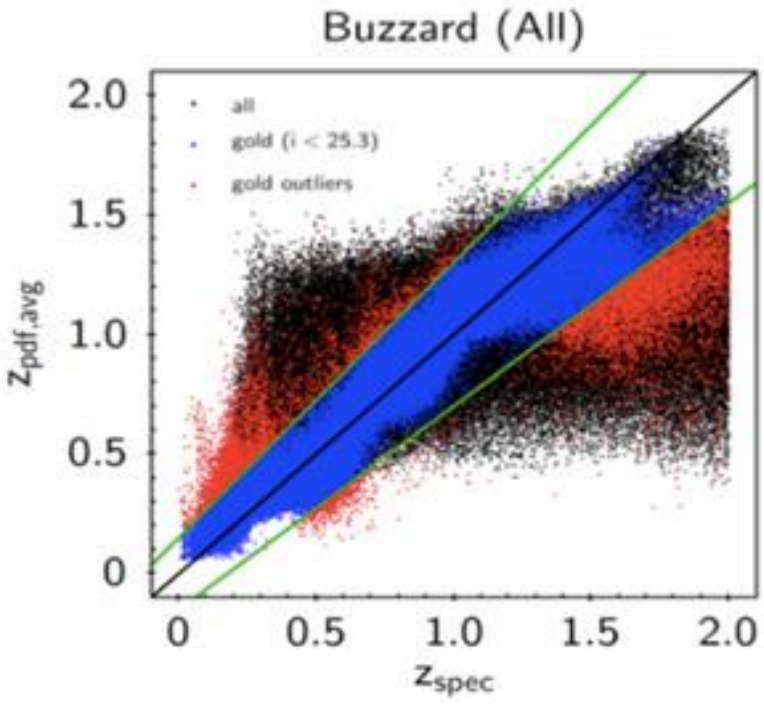






Hocking, Geach et al.

Photometric redshifts

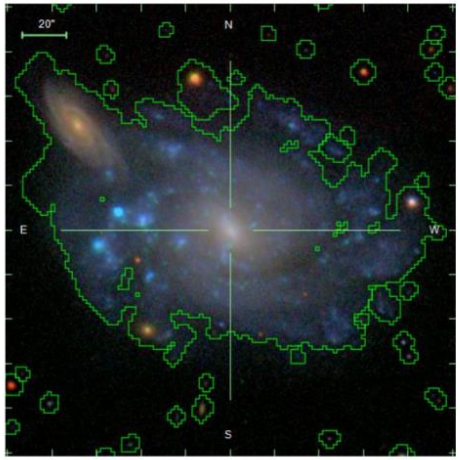


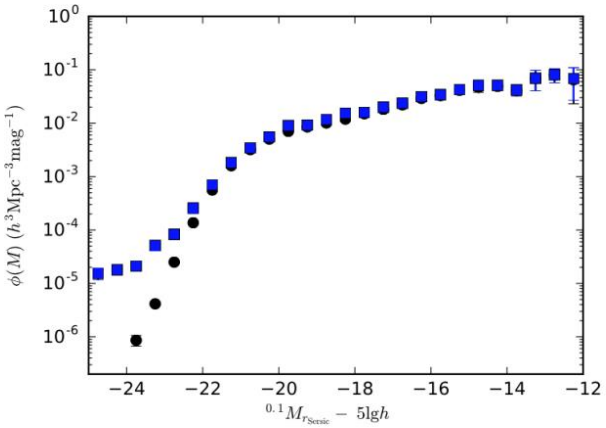
σ_{RMS}	= 0.1629	(GS 0.0853)
IQRσ	= 0.0710	(GS 0.0469)
η_{out}	= 13.1%	(GS 4.0%)
Bias	= 0.0075	(GS 0.0008)
MAD	= 0.0470	(GS 0.0309)

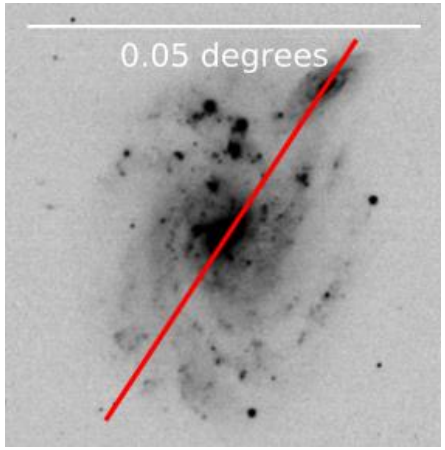
- Reliable Photometric Redshifts (PhZ) for billions of LSST galaxies are mission critical for galaxy evolution and cosmology studies
- UK heritage and leadership in PhZ: codes, imaging and spectroscopic surveys (MOONS, 4MOST ?)

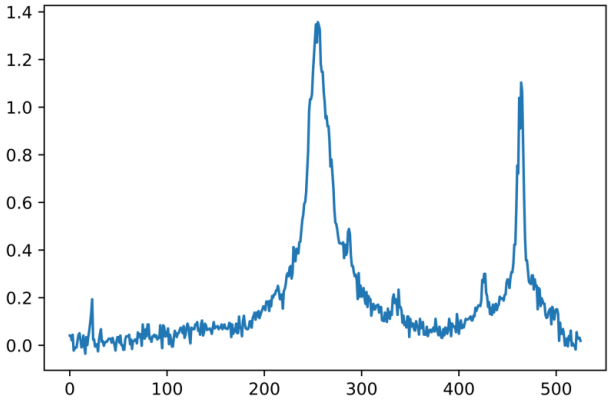
Lahav, Jarvis et al.

Deblending in deep surveys







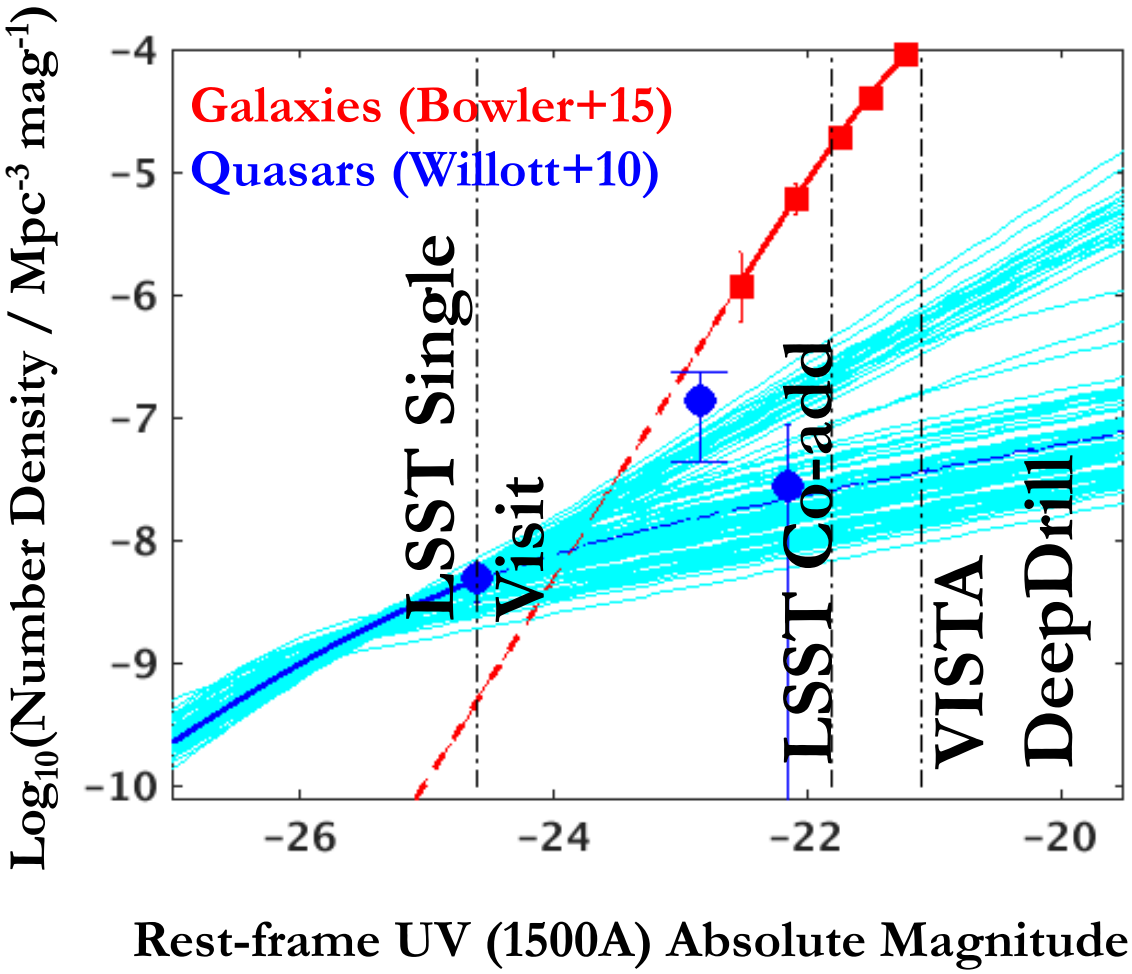


- Use MultiNest to use Bayesian inference to compare single Sersic fits to multiple Sersic fits
- Early stages- procedure works well for 1D
- Extend to 2D light distributions

Shirley, Loveday et al.

High-redshift Universe

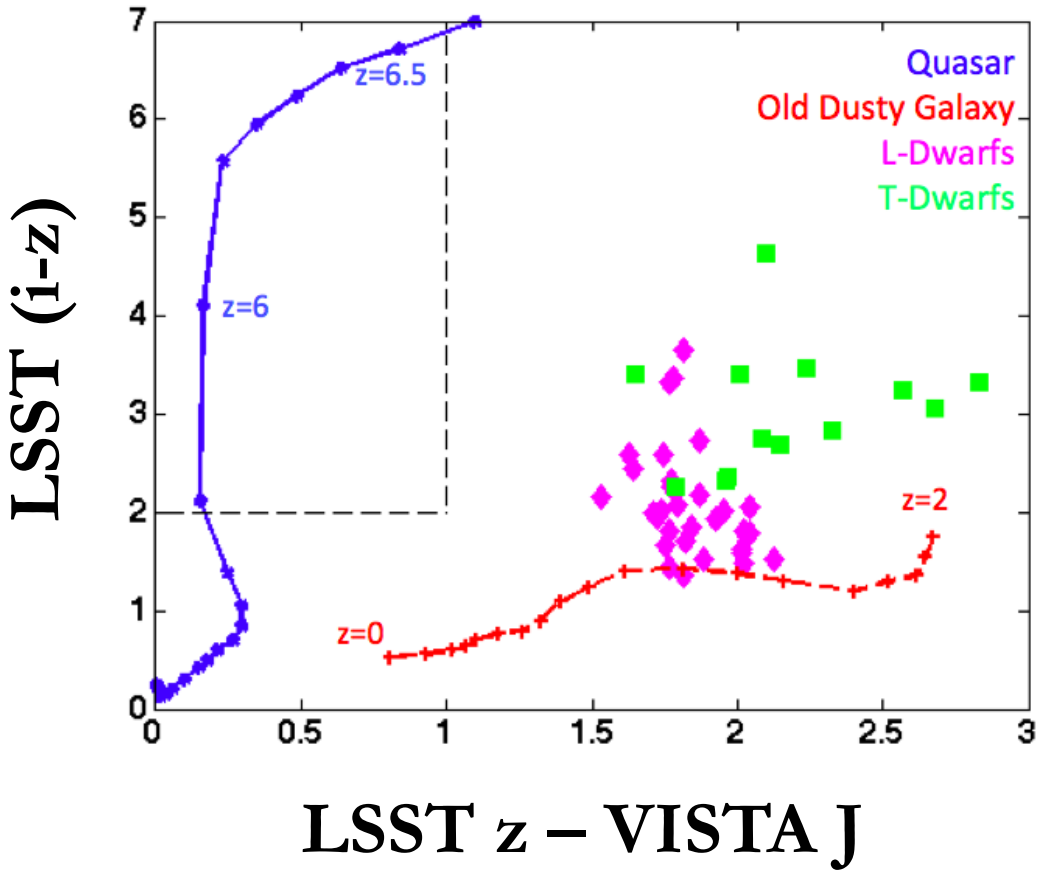
Redshift 6 luminosity function



- LSST will result in the discovery of unprecedented numbers of galaxies at z > 6 –most luminous and massive galaxies at these epochs
- Overlap between bright-end of galaxy LF and faint-end of QSO LF – both highly uncertain (dashed)

High-redshift Universe

Photometric selection of high-z galaxies



- Clean photometric selection of high-z galaxies will have to rely on combining LSST optical data with IR data e.g. from VISTA and Euclid

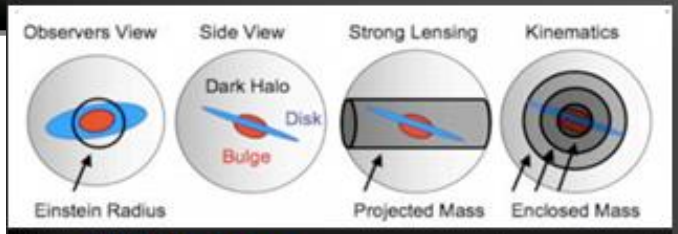
- Strong UK leadership in VISTA surveys in deep-drilling fields e.g. VIDEO (PI:Jarvis), VEILS (PI:Banerji) as well as Euclid

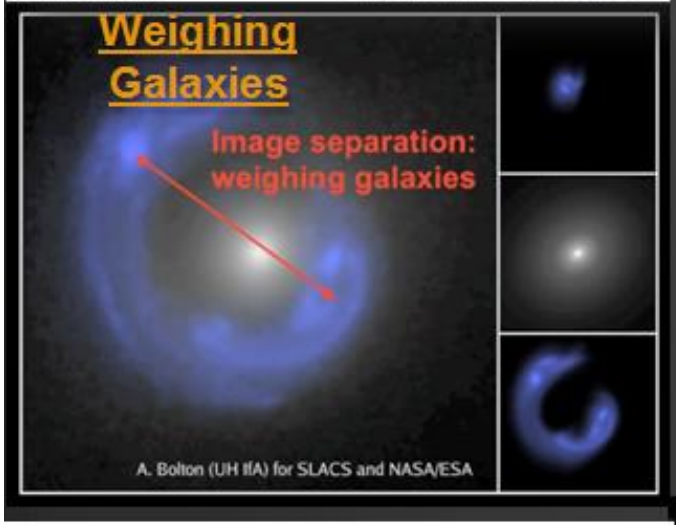
Galaxy clusters

- "Galaxy clusters" = clusters, groups, super-clusters, proto-clusters
- More information is available from the LSST:UK wiki:
  - https://lsst-uk.atlassian.net/wiki/pages/viewpage.action?pageId=9764897
  - White paper on the Galaxy Cluster Science Interests and High Level Requirements of the LSST:UK Community
    - Bremer, Collins, Edge, Hatch, Jauzac, Mann, Maughan, McCarthy, McGee, Romer, Smith, Stott, et al.
  - Report on Phase B Preparation Workshop, April 26-28, 2017
- Main science interests:
  - clusters at z>1: detection methods, galaxy evolution, scaling relations
  - cluster cores: intracluster light, active brightest cluster galaxies
  - strong+weak-lensing constraints on cluster mass and structure
  - hierarchical modeling of cluster scaling relations and (ultimately) cosmology

Point of Contact: Graham Smith, gps@star.sr.bham.ac.uk

Strong lensing science

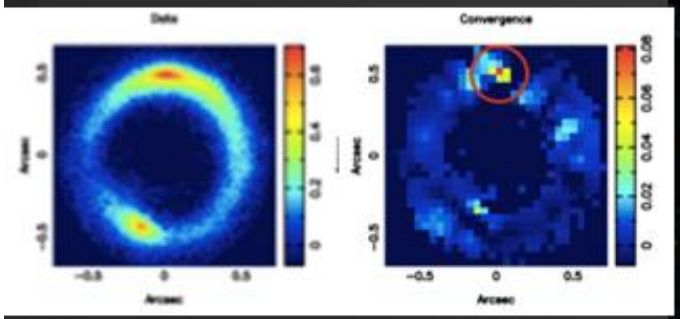




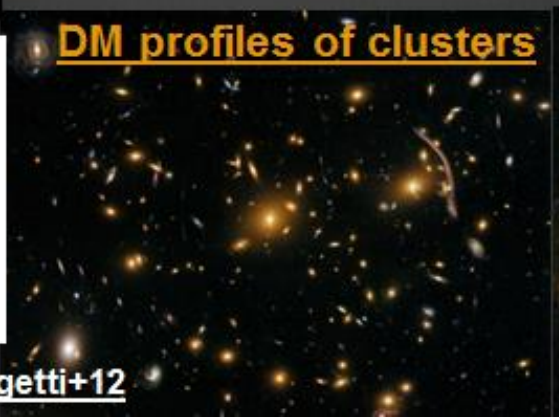
LSST will provide first statistical strong lensing studies
Number: 10^{4-5} gal-gal lenses, 8000 lensed QSOs,
Cadence: Lensed QSOs (3000 w time delays), 100 lensed SNe (see B. Joachimi's talk)

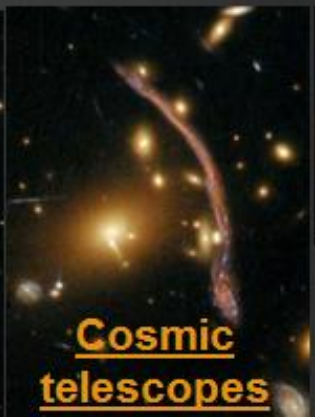
Multiple galaxy science goals e.g.

- Precision measurements of dark+visible matter
  - Accurate total masses for 10^{4-5} galaxies z<2
  - Dark matter substructure
  - Mass potentials of 100 clusters SL+WL
- Cosmic telescopes
  - Structures of 10^{4-5} high-z galaxies
  - AGN physics (incl. microlensing)
  - Properties of high-z AGN/SN host galaxies



DM Substructure Lagattuta+12, Vegetti+12





LSST:UK Galaxies science

Summary

- LSST:UK current efforts/interests in:
  - Low surface-brightness Universe
  - Simulations
  - Morphological classification
  - Deblending algorithms
  - Photo-z pipelines
  - Galaxy clusters
  - High-redshift Universe
  - Strong lensing

- ~80 strong LSST:UK Galaxies collaboration and growing. To join send me email: **s.kaviraj@herts.ac.uk**

- Perfect time to join the LSST:UK Galaxies effort
  - Precursor surveys already available (e.g. HSC, DES, DECaLS)
  - LSST commissioning data in 2020, survey proper in 2021