



Rubin Galaxies Science Collaboration

Simona Mei (APC/IN2P3/Univ. Paris Cité)

LSST France - June 2024

Scientific goals



Co-chairs: Simona Mei and Sugata Kaviraj

Number of members: ~310 (new members are very welcome)

Core goal: perform extra-galactic science over ~90% of cosmic time

Advances expected from LSST:

- **Revolutionary statistics** across full spectrum of extra-galactic studies
- Vast **discovery space in the ‘low-surface-brightness’ regime** (e.g. dwarfs outside local group, intra-cluster light, faint galaxy outskirts, tidal features)
- **Statistical studies of rare and/or extreme objects** (e.g. starbursts, massive high-z systems) especially when combined with IR surveys
- **Intersection with computer science** will drive new technologies (e.g. machine learning) for big data astrophysics

Roadmap



Large Synoptic Survey Telescope Galaxies Science Roadmap

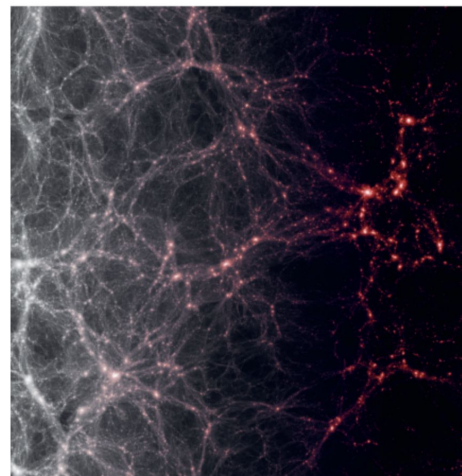
Robertson, Brant E.¹, Banerji, Manda², Cooper, Michael C.³, Davies, Roger⁴, Driver, Simon P.⁵, Ferguson, Annette M. N.⁶, Ferguson, Henry C.⁷, Gawiser, Eric⁸, Kaviraj, Sugata⁹, Knapen, Johan H.^{10,11}, Lintott, Chris⁴, Lotz, Jennifer⁷, Newman, Jeffrey A.¹², Norman, Dara J.¹³, Padilla, Nelson¹⁴, Schmidt, Samuel J.¹⁵, Smith, Graham P.¹⁶, Tyson, J. Anthony¹⁵, Verma, Aprajita⁴, Zehavi, Idit¹⁷, Armus, Lee¹⁸, Avestruz, Camille¹⁹, Barrientos, L. Felipe¹⁸, Bowler, Rebecca A. A.²⁰, Bremer, Malcolm N.²¹, Conselice, Christopher J.²², Davies, Jonathan²³, Demarco, Ricardo²³, Dickinson, Mark E.²⁴, Galaz, Gaspar²⁵, Grazian, Andrea²⁶, Holwerda, Borne W.²⁷, Jarvis, Matt J.²⁸, Kasliwal, Vishal^{29,30}, Lacerda, Ivan^{31,32}, Loveday, Jon³¹, Marshall, Phil³², Merlin, Emiliano²⁴, Napolitano, Nicola R.³³, Puzia, Thomas H.¹⁴, Robotham, Aaron³, Salim, Samir³⁴, Sereno, Mauro³⁵, Snyder, Gregory F.⁷, Stott, John P.³⁶, Tissera, Patricia B.³⁷, Werner, Norbert^{38,39,40}, Yoachim, Peter⁴¹, Borne, Kirk D.⁴², and Members of the LSST Galaxies Science Collaboration

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PHYSICS



Robertson +17, ArXiv:1708.01617

Robertson +19, Nature Rev. Phys, 1, 450

<https://tinyurl.com/lsstgalaxies>



Organisational structure

Working groups

Active galactic nuclei (James Mullaney)

Galaxy environment (TBD)

Galaxy morphology (Garreth Martin and Jeyhan Kartaltepe)

Low-surface-brightness science (Mireia Montes and Aaron Watkins)

SED-fitting and photometric techniques (Sam Schmidt and Rebecca Bowler)

Strong lensing (Aprajita Verma)

Survey strategy (H Ferguson, B Holwerda, B Robertson and D Burgarella)

Committee members and liaisons

In-kind operations managers - Brant Robertson and Pierre-Alain Duc

Contributions Evaluation Committee representatives - Manda Banerji and Brant Robertson

Survey cadence optimisation committee liaison – Louise Edwards

Rubin-Euclid WG - Manda Banerji

Data management liaison - Dan Taranu

Commissioning liaison - Lee Kelvin

DEI council – Manda Banerji



Current activities

- Management of in-kind contributions embedded within the SC:
 - Low-surface-brightness science (LSB optimized sky subtraction, detection of LSB structures)
 - Photo-z and SED fitting pipelines
 - Morphological parameter estimation pipelines
 - Distance measurements through SBF
 - Tools for cross-matching LSST with ancillary surveys (radio, IR etc)
- Regular activities: monthly telecons, face-to-face meetings, LSB WG challenges
- Publication policy
- MoU with other collaborations: DESC, AGN, etc.

LSST GSC

Home

∨ Working Groups

Members

Governance Documents

Technical Reports

Publications

∨ Active Projects

Apply for membership

Contact

LSST Galaxies Science Collaboration

The [Legacy Survey of Space and Time](#) (LSST) is a ground-breaking, 10-year optical survey of the entire southern sky, which will be carried out by the Simonyi Survey Telescope at the Vera C Rubin observatory. The project is jointly funded by the [National Science Foundation](#) (NSF) and the [US Department of Energy](#) (DOE). The LSST Galaxies Science Collaboration (LSST GSC) is a scientific organization charged with using LSST data to understand the formation and evolution of galaxies over cosmic time.

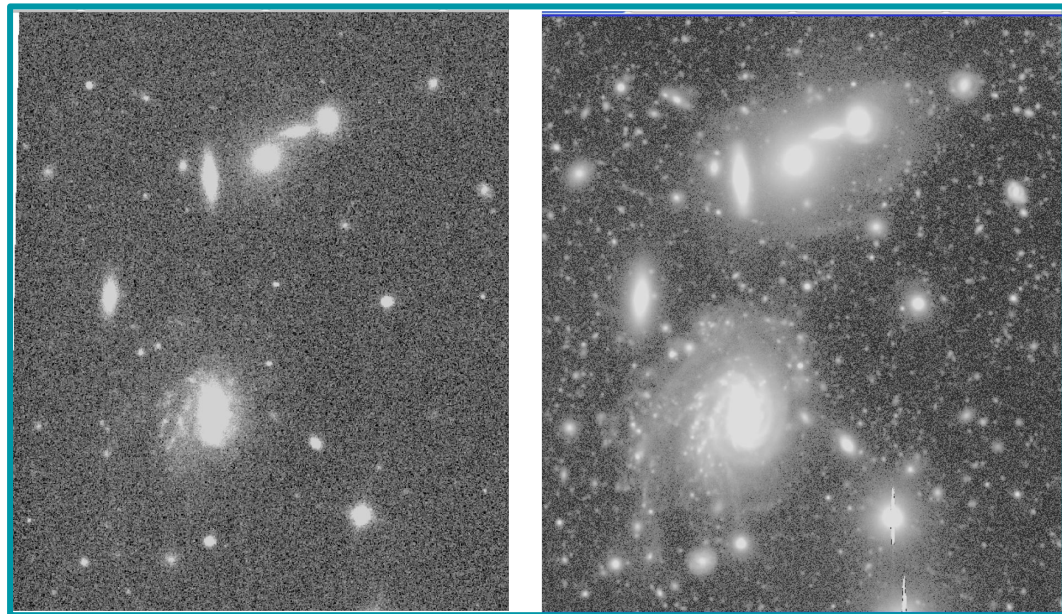
The LSST GSC is one of the original nine LSST Science Collaborations founded in 2006, and made important contributions to the [LSST Science Book](#) released in 2009. This detailed science case helped LSST become the top-rated priority for ground-based astronomical facilities in the [2010 Decadal Survey](#) and obtain NSF and DOE funding. [Scientists in the LSST GSC](#) will conduct a wide range of extragalactic research programs with LSST data, and will help the LSST Project develop critical data and software products that will enable astronomers from all over the world to conduct cutting-edge research programs of their own. Information about the organization and structure of the LSST GSC can be found in the [LSST GSC Charter](#).

[Sugata Kaviraj](#) and [Simona Mei](#) serve as the current Chairs of the LSST GSC. Previous LSST GSC Chairs were Manda Banerji, Brant Robertson, Michael Cooper and Harry Ferguson.

WP Low Surface Brightness



LSB studies and the associated infrastructure required to exploit LSST data.



g SDSS
 ~ 27 mag/arcsec²

g HSC
30.9 mag/arcsec²

- Meetings every other month (science talk + discussion)
- Slack channel: [#galaxies-lsb](#)
- LSB coordination group, to include SCs beyond Galaxies

Chairs: Aaron Watkins (U. Hertfordshire, a.watkins@herts.ac.uk)
Mireia Montes (IAC, mmontes@iac.es)

WP Low Surface Brightness



4 data challenges:

- Challenge #1: [How do LSST algorithms do at detecting LSB sources?](#) Led by Aaron Watkins
- Challenge #2: [What are the best ways to calculate distance for LSB galaxies?](#) Led by Harry Ferguson
- Challenge #3: [Do observers and simulators measure the same quantity of ICL?](#) Led by Sarah Brough
- Challenge #4: [What are the most critical observables/measurables in LSB tidal features that will constrain theory?](#) Led by Garreth Martin

3 paper published : Martin et al. 2022, Desmons, Brough et al. 2024 & Watkins et al. 2024

WP Low Surface Brightness



2 *A. Desmons et al.*

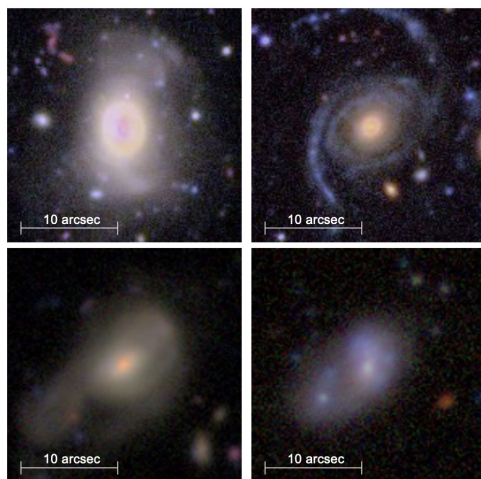
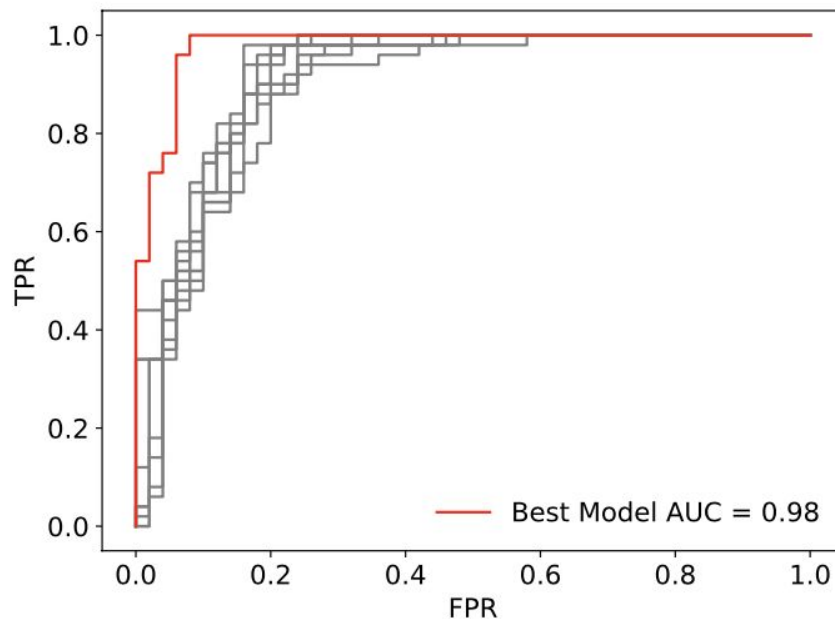


Figure 1. Example of galaxies with tidal features from HSC-SSP (*gri*-band cutout images). Top row from left to right: shells, stream. Bottom row from left to right: asymmetric halo, and double nucleus.



Desmons, Brough et al. 2024

Sample ~95% complete and 80% pure, against current models that give samples ~80% complete & pure



Morphology

Studies of galaxy morphology in the deep-wide era, addressing the challenges of LSST's extreme data-volume

Challenges:

Extreme data volumes and an evolving dataset: Billions of objects imaged at high cadence means significant computational challenges. Existing data processing methodologies (including citizen science) alone will be intractable. New methods needed for efficiently identifying and characterising galaxies and their sub-structures.

An unfamiliar, unexplored discovery space: Poorly understood biases. Unknown underlying populations. Leveraging LSST for the discovery of new classes of rare and/or faint objects.

Quarterly meetings with science talk and discussion began in July, so now is a great time to get involved and help shape the direction of the working group.

Members of the working group are involved in a number of complementary projects combining supervised/unsupervised machine learning and non-parametric structural measures.

Slack channel: [#galaxies-morphology](#)

Chairs: Jeyhan Kartaltepe (jeyhan@astro.rit.edu)
Garreth Martin (garrethmartin@kasi.re.kr)



WP Morphology

Members of the working group are involved in a number of complementary projects including:

- Quantitative morphologies – [ML models to efficiently and robustly predict structural parameters \(e.g. CAS, Gini-M20\) from imaging including unbiased predictions that are independent of resolution, noise etc.](#) – Leads: Liza Sazonova, Michael Balogh
- Hubble type and feature classification – [Automatic morphological classification of galaxies into detailed Hubble types with independent identification of morphological structures like bars, rings and merging features. Contrastive learning with supervised fine-tuning approach to account for imbalanced morphological distributions](#) – Lead: Antonio Vazquez Mata
- Unsupervised estimates of morphology – [Extremely fast and efficient classification of galaxies using fully unsupervised learning. Based on visual similarity by autonomously grouping objects with common morphology together into clusters, allowing for identification of broad morphological classes and the presence of other features](#) – Lead: Ilin Lazar

WP SED Fitting and Photo-z



The ramping up of the Rubin Photo-z Validation Cooperative may be an opportunity to kick-start engagement

- Working to investigate a number of potential PZ algorithms to determine which to implement as part of DM processing
- Opportunity to engage Galaxies-related in-kind contributions
- Potential to emphasize the needs of the Galaxies WG in Rubin-provided products, e.g. physical parameter estimates
- Beyond VC: plan for needs not covered by DM-provided catalogs
- Some details on the PZVC in DM tech note [DMTN-049](#)
- Link to [PZ Galaxies LOR](#) (Sept 2021)
- Installation of the Pasquet et al. (2019) in DESC/RAIL

Anyone interested in getting involved or leading Galaxies PZ projects, contact samschmidt@ucdavis.edu

Publication policy committee

Committee members: Sarah Brough, Pierre-Alain Duc, Nandini Hazra, Garreth Martin, Simona Mei (chair), Kanak Saha, Liza Sazonova

The publication policy has been discussed since last summer and we are writing the final document presenting it to the monthly telecons

Publication policy committee

The <u>LSST</u> Galaxies Publication and Presentation Policy	3
Publication and Presentation procedure	4
Private Documents and Presentations Internal to LSST	4
Private Documents and Presentations to Federal or Government Agencies	4
Public Communications or Presentations External to LSST	4
Pre-publication Scientific Projects	5
Definition of “Official” <u>LSSTGSC</u> project	5
Designation of “Official” <u>LSSTGSC</u> project	5
Scientific Publication Submission and Authorship Policy	6
Definition of “Official” <u>LSSTGSC</u> publications	6
LSSTGSC Official publication submission procedure	6
<u>LSSTGSC</u> Official In-Kind Contribution	7
<u>LSSTSGC</u> Official publication authorship policy	7
<u>LSSTSGC</u> Official publication timeline	8

Next meetings

Rubin Community Workshop, SLAC, July 22th-26th 2024

<https://project.lsst.org/meetings/rubin-2024/rubin-observatory-community-workshop>

LSST@Europe6, La Palma, September 16th-20th

<https://lsstdiscoveryalliance.org/event/lssteurope6-la-palma-spain/>

Do not hesitate to ask for membership and participate to our activities!