Science Collaborations Reports

LSST Project and Community Workshop 2019
Tuesday 9:30-10:30 : SSSC, Galaxies, AGN, TVS
Wednesday 9:30-10:30: SMWLV, ISSC, DESC, SL

Large Synoptic Survey Telescope

SSSC Report

LSST Project and Community Workshop 2019
Presenter: Henry Hsieh (Planetary Science Institute)

SSSC Co-Chairs: Meg Schwamb (Queen's Univ. Belfast), David Trilling (Northern Ariz. Univ.)

Large Synoptic Survey Telescope

What LSST Can Do For Solar System Science

Expected LSST Yields

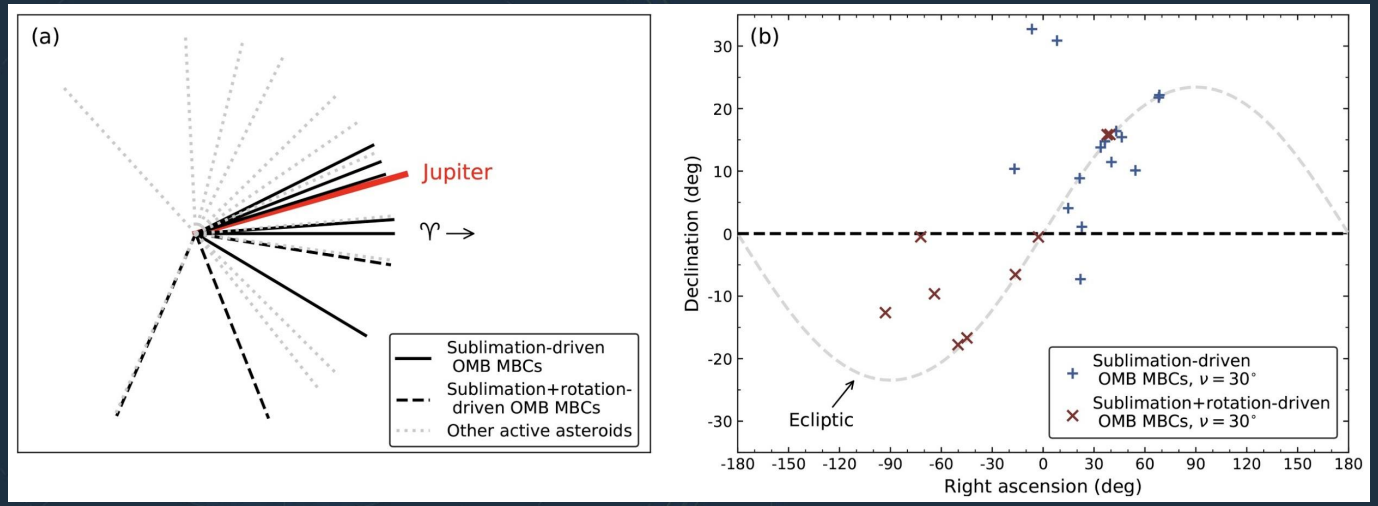
	Currently Known	LSST Discoveries	Median number of observations	Observational arc length
Near Earth Objects (NEOs)	~14,500	100,000	(D>250m) 60	6.0 years
Main Belt Asteroids (MBAs)	~650,000	5,500,000	(D>500m) 200	8.5 years
Jupiter Trojans	~6,000	280,000	(D>2km) 300	8.7 years
TransNeptunian + Scattered Disk Objects (TNOs + SDOS)	~2,000	40,000	(D>200km) 450	8.5 years
Interstellar Objects (ISOs)	1	10	?	?

ugrizy photometry *From the LSST Science Book / Lynne Jones*

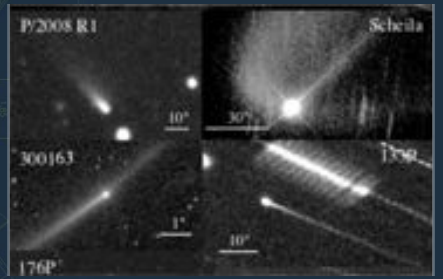
Uncertainties in the size distribution for most solar system populations leads to large uncertainties in the total number of objects LSST is expected to discover after 10 years.

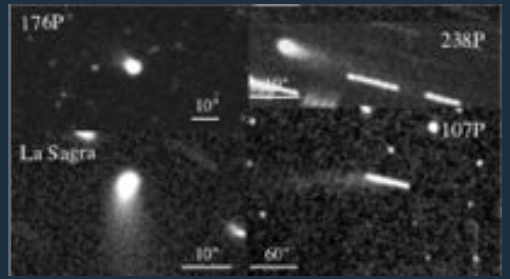
What LSST Can Do For Solar System Science

Explore the Populations of Main Belt Comets and Active Asteroids



Adapted from Kim et al. (2018) by H. Hsieh





Jewitt (2012)

What LSST Can Do For Solar System Science

Explore the Origin of Sedna's Strange Orbit and Test the Existence of Planet 9

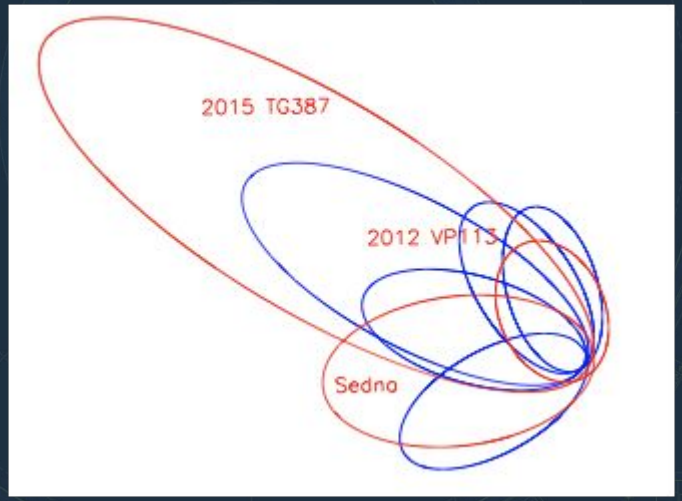


Image Credit: S. Sheppard

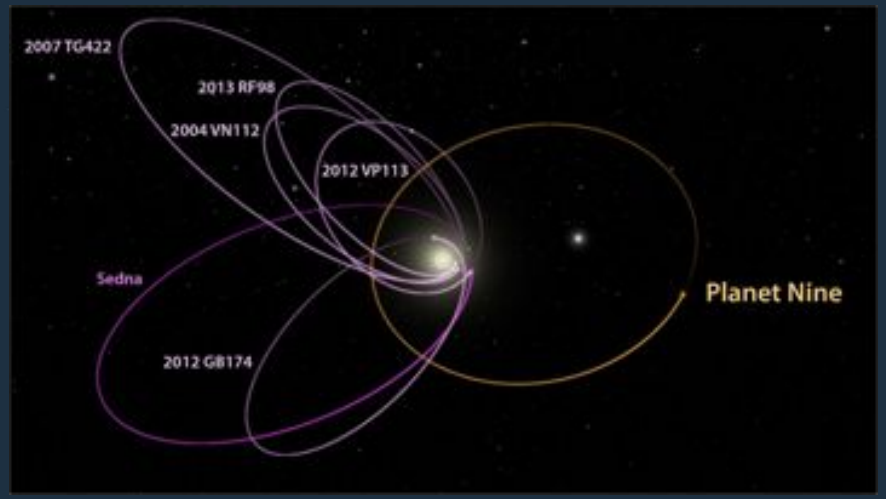
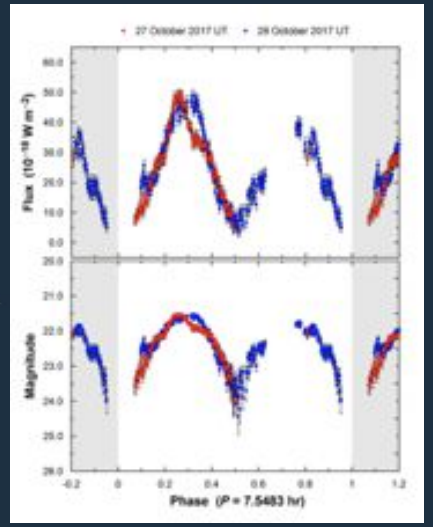


Image Credit: R. Hurt/JPL-Caltech

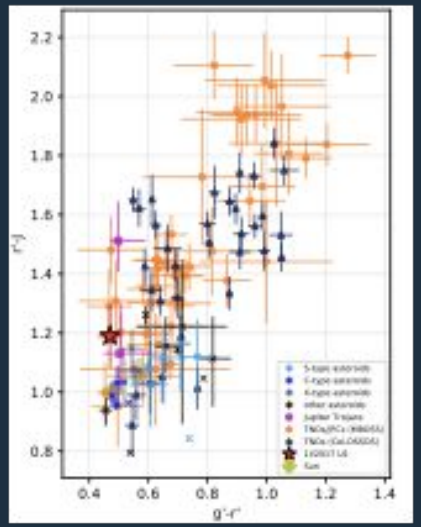
What LSST Can Do For Solar System Science

Identify and characterize interstellar objects

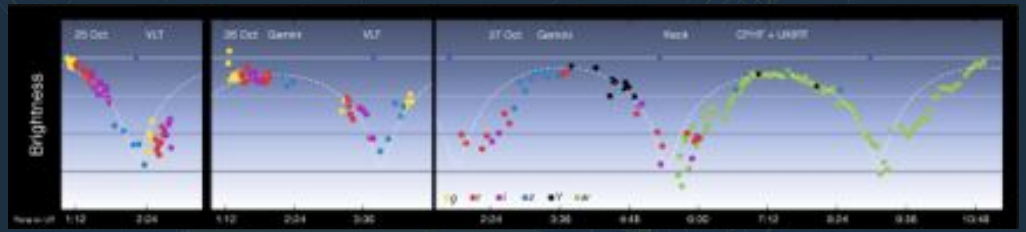
Credit: NASA/JPL-Caltech



Drahus et al. (2018)



Bannister et al. (2017)



Meech et al. (2018)

Meech et al. (2018)

A Software Roadmap for Solar System Science with the Large Synoptic Survey Telescope

Megan E. Schwamb[1], Henry Hsieh[2], Michele T. Bannister[3], Dennis Bodewits[4], Steven R. Chesley[5], Wesley C. Fraser[3], Mikael Granvik[6,7], R. Lynne Jones[8], Mario Jurić[8], Michael S. P. Kelley[9] +Show full author list

Published 2019 March 15 •

Research Notes of the AAS, Volume 3, Number 3

The 8.4 m Large Synoptic Survey Telescope (LSST) will provide an unprecedented view of the Solar System (Ivezić et al. 2008; LSST Science Collaboration et al. 2009). LSST will detect millions of asteroids and tens of thousands of distant Solar System bodies, within approximately 16 and 24.5 mag (in *r*-band). Over a ten year period, most of these minor planets will receive hundreds of observations divided between 6 filters (*ugrizy*). What specifically LSST project will deliver for Solar System detections will soon be updated in the LSST Data Products Definition Document (DPDD; Jurić et al. 2013). A preliminary version of the new LSST Solar System data products schema is available at http://ls.st/ssd and http://ls.st/oug.

The LSST Solar System Science Collaboration (SSSC; http://www.lsstsssc.org) produced a science roadmap (Schwamb et al. 2018) which outlines the collaboration's highest ranked research priorities utilizing LSST. To achieve these science goals, the SSSC has identified crucial software products and tools that will be required but will not be provided by the LSST project. These will have to be developed by the SSSC and the broader planetary community. To spur this effort, we present below this list of LSST community software development tasks.

1. Community Software Utilities Needed During Year 1 of LSST Operations

1. Tools to extract cutouts from raw, reduced, and deep-stacked LSST images at locations where a specified orbit is predicted to appear, accounting for the uncertainty in the orbital parameters.

Schwamb et al. (2019): RNAAS, 3, 3

Maximizing LSST Solar System Science: Approaches, Software Tools, and Infrastructure Needs

Henry H. Hsieh[a,b], Michele T. Bannister[c], Bryce T. Bolin[d,e], Josef Ďurech[f], Siegfried Eggl[d], Wesley C. Fraser[g], Mikael Granvik[h,i], Michael S. P. Kelley[j], Matthew M. Knight[j], Rodrigo Leiva[k], Marco Micheli[l,m], Joachim Moeyens[d], Michael Mommert[n], Darin Ragozzine[o], Cristina A. Thomas[p]

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Abstract. The Large Synoptic Survey Telescope (LSST) is expected to increase known small solar system object populations by an order of magnitude or more over the next decade, enabling a broad array of transformative solar system science investigations to be performed. In this white paper, we discuss software tools and infrastructure that we anticipate will be needed to conduct these investigations and outline possible approaches for implementing them. Feedback from the community or contributions to future updates of this work are welcome. Our aim is for this white paper to encourage further consideration of the software development needs of the LSST solar system science community, and also to be a call to action for working to meet those needs in advance of the expected start of the survey in late 2022.

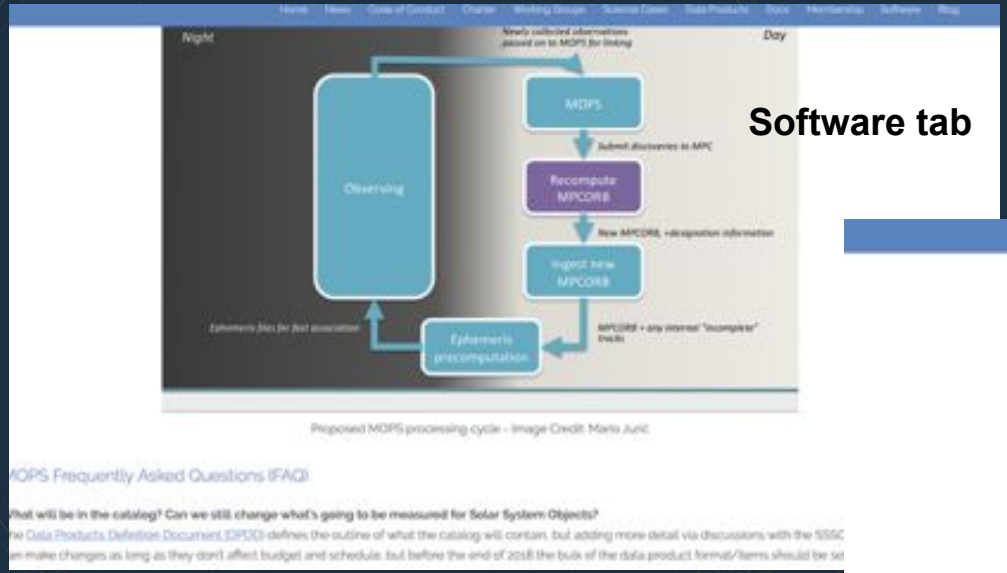
Hsieh et al. (2019): https://arxiv.org/abs/1906.11346

Active SSSC Efforts

- Planning yearly sprints to get SSSC members together to collaborate and work on projects
- Preparing for commissioning, science data, and follow-up (identifying and attempting to address tools/software/infrastructure needs now in order to be able to maximize Solar System science later)
- Writing metrics for future cadence decisions
- Efforts by individual SSSC members or small groups to perform preparatory work (e.g., developing software to address personal scientific interests, working with LSST-like surveys like ZTF, writing proposals to request funds from NASA or NSF for LSST-related work, etc.)

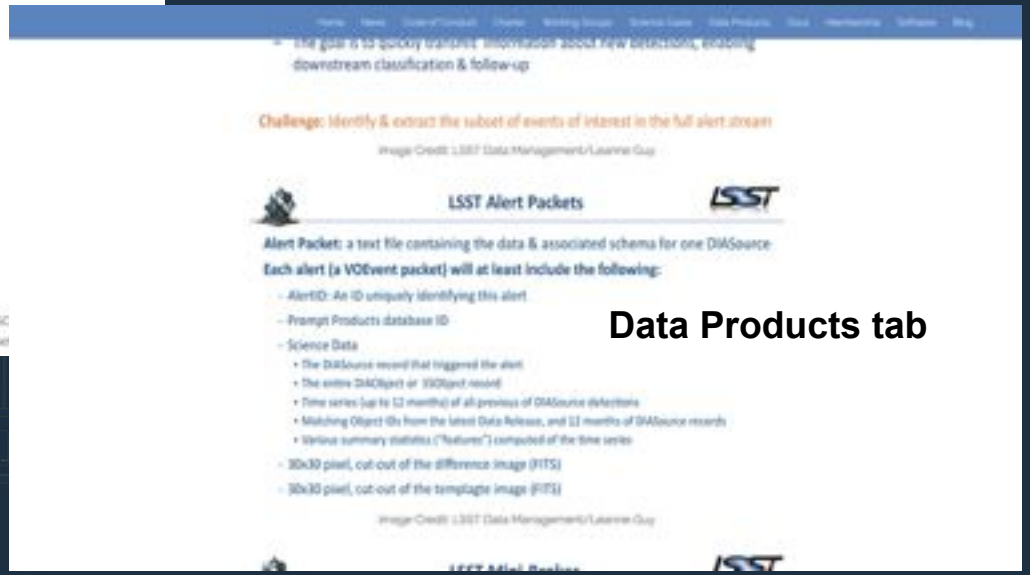
Mario Jurić is the SSSC liaison to the commissioning team, in addition to other roles as LSST Solar System Data Products owner, DM Liaison to the SSSC, and commissioning team member

Active SSSC Projects: Documentation



Software tab

The SSSC Website has the latest information on Solar System Data Processing & Products and Alert Stream Information



Data Products tab

Many thanks to LSST Project team members for providing content!

http://www.lsstsssc.org

Future SSSC Activities

The SSSC at LSST2019

Tuesday, 11:00am-12:30pm, Presidio I
Preparing to Do Solar System Science with LSST

Tuesday, 1:30pm-3:00pm, Presidio I
Solar System Science Pipeline, Infrastructure, and Cadence Optimization Needs

SSSC LSST Workshop at EPSC-DPS

Getting Ready for LSST:
5+ million small bodies, 1+ billion observations

Thursday September 19, 2019 1:30–3:15pm
EPSC-DPS Joint Meeting 2019
Geneva, Switzerland
Open to all EPSC-DPS attendees

Future SSSC Activities

Funding for sprints (e.g., travel support) and salary for preparatory activities is crucial right now. Very few SSSC members are funded to work on LSST preparatory tasks, and many key or potentially interested members are soft-money researchers. It is also hard to get funding to organize workshops to gather collaboration members or for members to attend PCWs.

The SSSC was awarded LSSTC Enabling Science funding in 2018 for our first readiness sprint: had ~25 attendees with diverse backgrounds and career levels. Half of attendees were supported in some capacity. Spawned several white papers.

In 2019, no new LSSTC funding was received for the second readiness sprint (unsuccessful LSSTC Enabling Science Grant): ~10 people attended / less diverse group in terms of background and career stages.

US$10,000-20,000 could make a big difference for the SSSC to get things done & reach the broader Solar System community, but how do we find funding for foundation-building activities? Substantive preparatory work is similarly critical but will require more funds.

Galaxies Science Collaboration Report

LSST Project and Community Workshop 2019

Presenter: Sugata Kaviraj, Hertfordshire

Large Synoptic Survey Telescope

GalaxiesSC

Galaxies SC - Science Overview

- LSST will study the evolution of galaxies, AGN, groups/clusters in unprecedented detail across 95% of cosmic time

- It will open up unexplored regimes e.g. the low surface brightness (LSB) Universe
+ LSB galaxies (incl. dwarfs) dominate the galaxy number density
+ LSB structures e.g. merger-induced tidal features and intra-cluster light constrain our theoretical paradigm

- Provide optical counterparts for *all* future surveys at other wavelengths (e.g. the SKA)

- Convergence of LSST data and cosmological simulations will transform our understanding of the physics of galaxy evolution

- Revolutionary advances expected in our understanding of galaxy evolution via LSST

Galaxies SC - Science Overview

Core aims:

…to organize the science effort within the LSST Galaxies community

...to produce high-level data products that are essential for LSST exploitation

…to influence the scientific direction of LSST by providing input to the Project (e.g. on commissioning survey fields)

Membership drawn mainly from the US, Chile, France, UK and Australia

Regular telecons, GSC topics are featuring heavily in recent international conferences e.g. IAU Symposium 355 (low-surface-brightness Universe), LSST@Asia and many others

Galaxies SC - Science Overview

arXiv: 1708.0161

Large Synoptic Survey Telescope Galaxies Science Roadmap

Robertson, Brant E.[1], Banerji, Manda[2], Cooper, Michael C.[3], Davies, Roger[4], Driver, Simon P.[5], Ferguson, Annette M. N.[6], Ferguson, Henry C.[7], Gawiser, Eric[8], Kaviraj, Sugata[9], Knapen, Johan H.[10,11], Lintott, Chris[4], Lotz, Jennifer[7], Newman, Jeffrey A.[12], Norman, Dara J.[13], Padilla, Nelson[14], Schmidt, Samuel J.[15], Smith, Graham P.,[16], Tyson, J. Anthony[15], Verma, Aprajita[4], Zehavi, Idit[17], Armus, Lee[18], Avestruz, Camille[19], Barrientos, L. Felipe[14], Bowler, Rebecca A. A.[4], Bremer, Malcolm N.[20], Conselice, Christopher J.[21], Davies, Jonathan[22], Demarco, Ricardo[23], Dickinson, Mark E.[13], Galaz, Gaspar[14], Grazian, Andrea[24], Holwerda, Benne W.[25], Jarvis, Matt J.[4,26], Kasliwal, Vishal[27,28,29], Lacerna, Ivan[30,14], Loveday, Jon[31], Marshall, Phil[32], Merlin, Emiliano[24], Napolitano, Nicola R.[33], Puzia, Thomas H.[14], Robotham, Aaron[5], Salim, Samir[34], Sereno, Mauro[35], Snyder, Gregory F.[7], Stott, John P.[36], Tissera, Patricia B.[37], Werner, Norbert[38,39,40], Yoachim, Peter[41], Borne, Kirk D.[42], and Members of the LSST Galaxies Science Collaboration

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Nature Rev. Phys., 2019, 1, 450

ROADMAP

Galaxy formation and evolution science in the era of the Large Synoptic Survey Telescope

Brant E. Robertson[1,2], Manda Banerji[3], Sarah Brough[4], Roger L. Davies[5], Henry C. Ferguson[6], Ryan Hausen[1], Sugata Kaviraj[7], Jeffrey A. Newman[8], Samuel J. Schmidt[9], J. Anthony Tyson[9] and Risa H. Wechsler[10]*

Abstract | The field of galaxy formation and evolution synthesizes the physics of baryons and dark matter to describe the origin of systems such as the Milky Way and the enormous diversity of the galaxy population. The broad variation in possible formation histories and the wide range of cosmic environments make large statistical samples of galaxies essential for identifying the important physical mechanisms that govern their formation. Starting in the early 2020s, the Large Synoptic Survey Telescope (LSST) will provide an unmatched dataset for galaxy evolution studies by observing the entire southern sky in ultraviolet, optical and near-infrared wavelengths, producing multi-epoch digital images over a 10-year nominal mission that when summed will provide the deepest, wide-angle view of our Universe ever assembled. Here, we discuss the importance of LSST for deepening our understanding of galaxy formation and evolution over cosmic time. We present some outstanding problems in the field that LSST will address, and we present a roadmap of some preparatory research efforts required to make effective use of the LSST dataset for galaxy formation science.

Astronomy has moved into an era of large digital images of the sky from which enormous datasets including both the photometric properties of galaxies (photon flux in each of multiple bands, locations on the sky and redshift) and their structural characteristics (size and morphology) are measured. Compared with previous astronomical surveys, the Large Synoptic Survey Telescope (LSST) will provide a breakthrough in terms of the combined survey area and depth, the telescope mirror area and field of view (the étendue) and comparable advances in the quality and uniformity of the data processing and public access to the data[1]. A primary motivation for LSST has been to constrain cosmological parameters, including the energy density and possible time evolution of dark energy, through the weak gravitational lensing and angular clustering of galaxies[2]. This Roadmap discusses how LSST will also contribute to galaxy formation and evolution science, complementing the dark energy science that LSST will perform, and outlines some of the areas of active research that may influence how extragalactic astronomers can leverage the unprecedented dataset that the telescope will provide[3].

The features of LSST designed to help to optimize the survey for constraining dark energy will also enable its dataset to serve as a central driver for discoveries in galaxy formation physics. We provide an overview of the LSST facility and data relevant to understanding extragalactic science. Broadly, the important characteristics of LSST include a Wide–Fast–Deep (WFD) survey covering the entire southern sky in multiple bands from the ultraviolet to the near-infrared, with sufficient depth and imaging quality to reveal the detailed photometric and structural properties of billions of galaxies, and a complementary set of Deep Drilling Fields (DDFs) probing several times deeper than the main survey and covering areas ~10–100 times larger than any previous surveys at similar depth. LSST will probe the rarest environments where the highest matter overdensities or lowest underdensities may substantially affect the galaxy formation process. The image quality and depth will allow for a detailed understanding of how the process of galaxy formation establishes the full range of galaxy morphologies. The vast area of LSST will enable searches for the brightest and most massive galaxies and supermassive black holes (SMBHs) that cosmological structure formation can generate. LSST will thereby open up new lines of inquiry regarding galaxy formation, impossible to address with existing datasets, and may also lead to the resolution of long-standing puzzles in extragalactic science.

*e-mail: brant@ucsc.edu

https://doi.org/10.1038/s42254-019-0067-x

x

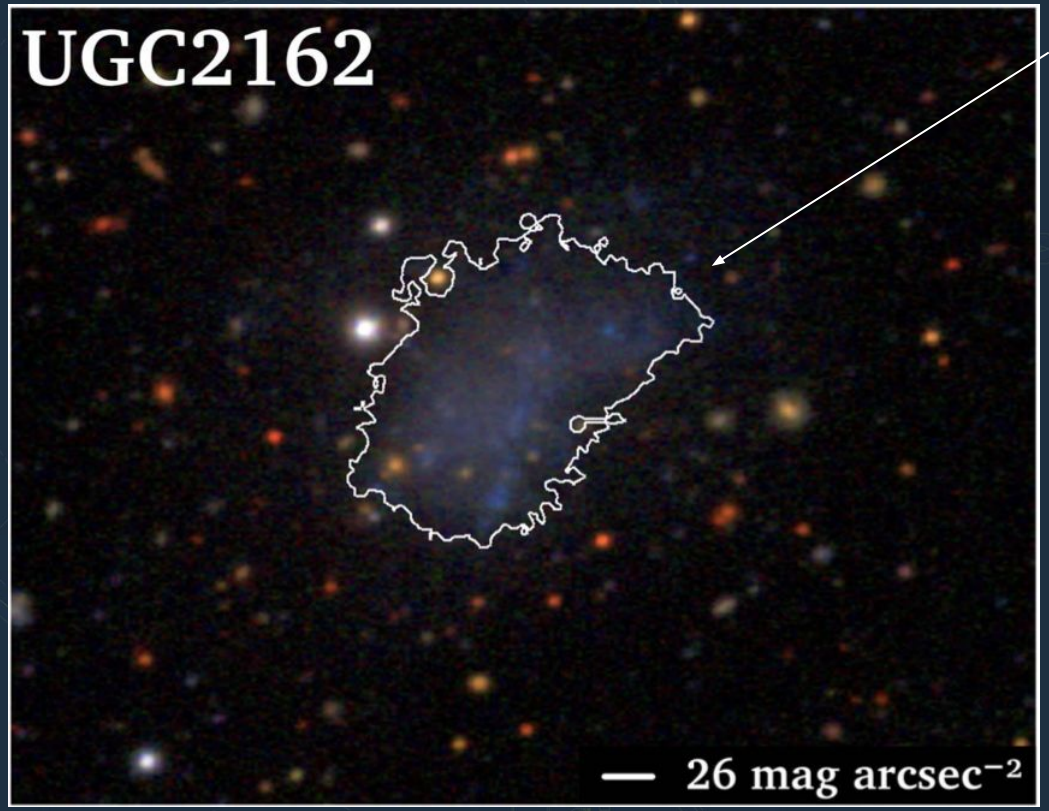
Galaxies SC - Active Projects

Some highlights (not exhaustive!):

- Low-surface-brightness (LSB) science
- Machine learning techniques
- Cosmological simulations
- Photometric redshifts

Galaxies SC - Active Projects

Low-surface-brightness science



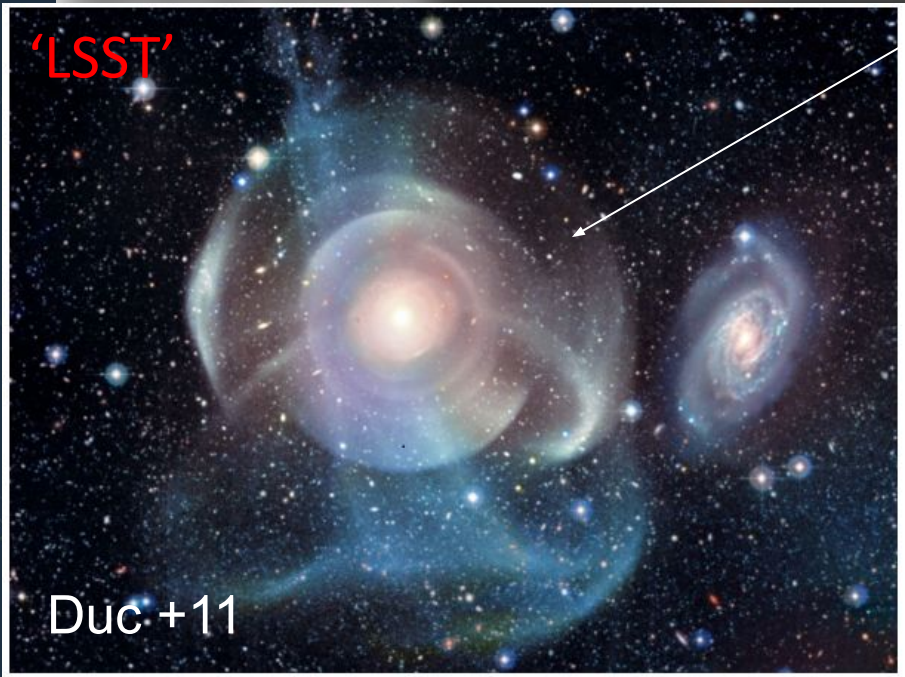
LSB galaxies

Trujillo +17

Galaxies SC - Active Projects

Low-surface-brightness science

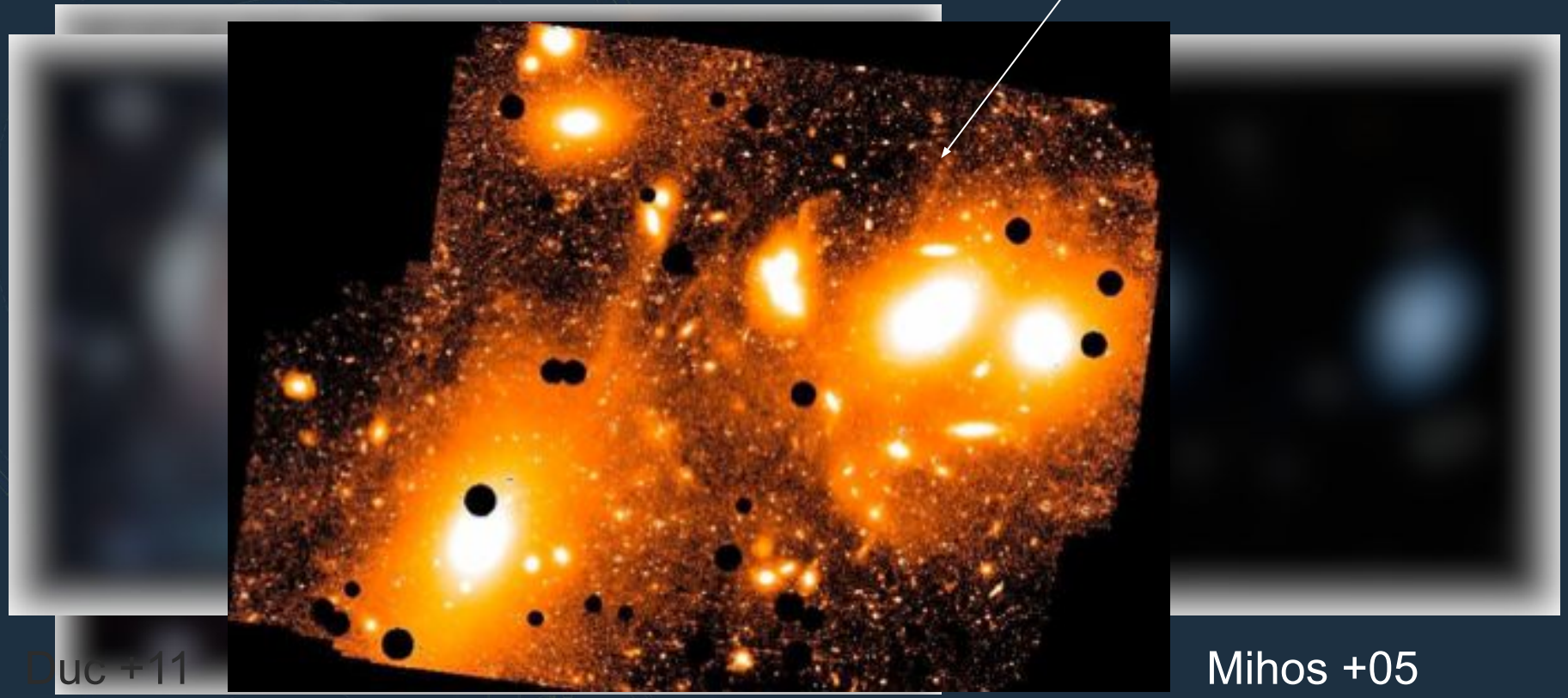
LSB tidal features



Galaxies SC - Active Projects

Low-surface-brightness science

Intra-cluster light

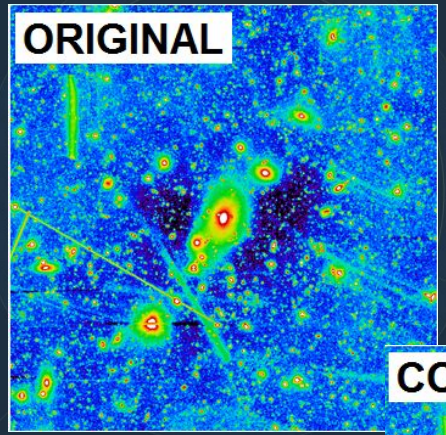


Duc +11

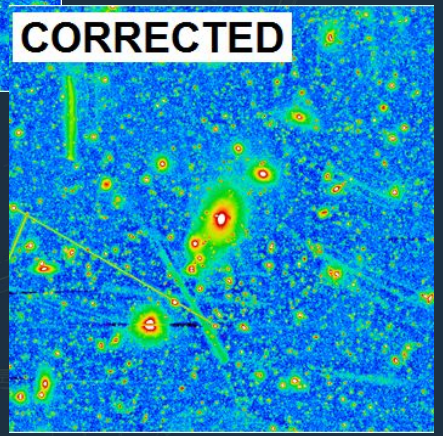
Mihos +05

Galaxies SC - Active Projects

Low-surface-brightness science



XCS 35 in HSC-SSP Deep DR1 i-band reduced through the current LSST pipeline. Sky over-subtraction is visible around bright and extended sources.



- Fit 2D Sersic models to sources
- Characterise the expected flux in the wings
- Residual between model and science map used to define over-subtraction threshold
- Values below threshold added back

Kelvin et al. in prep

Galaxies SC - Active Projects

Machine-learning techniques

- Unprecedented data volumes from LSST (20 TB per night) – automation needed

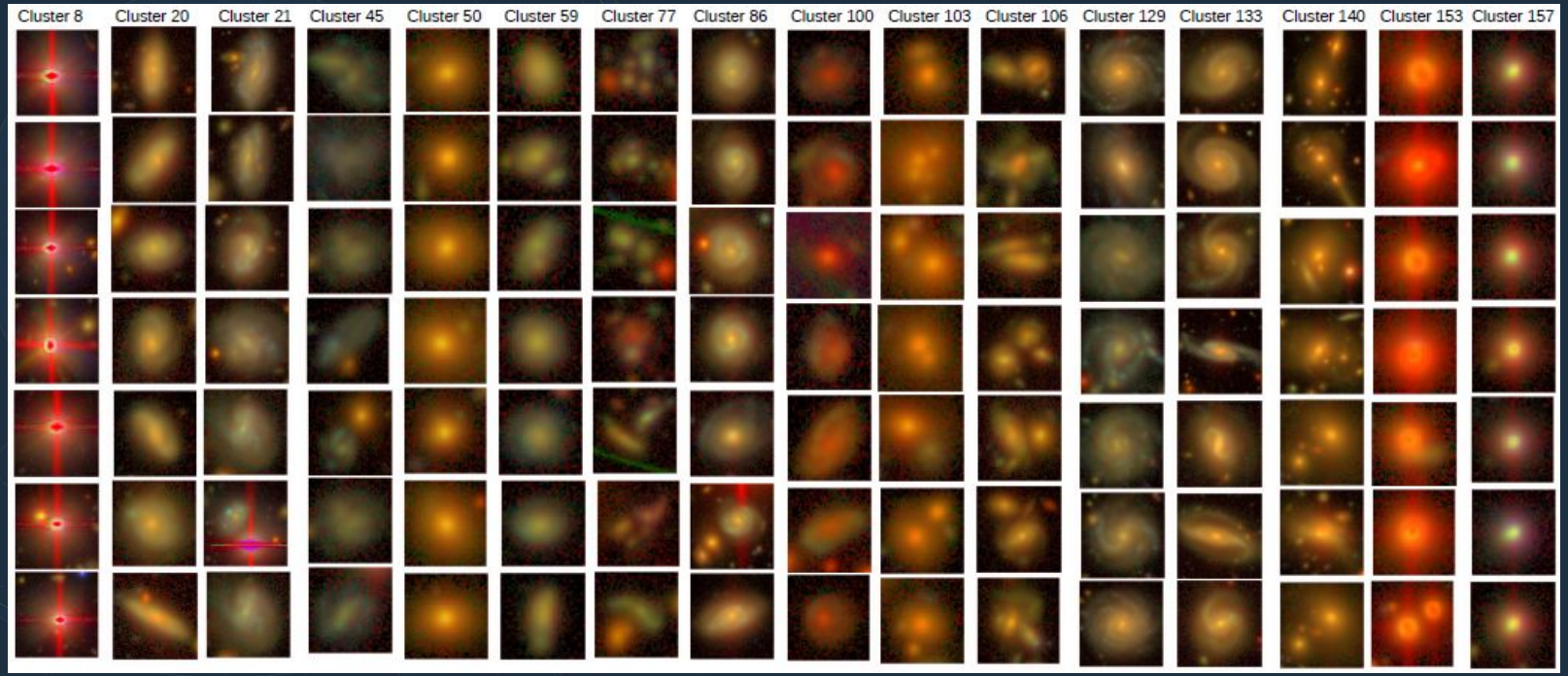
- Machine learning will be essential: growing convergence between astrophysics and computer science

- Example: Galaxy morphological classification
+ Morphology is a fundamental parameter, also a key prior for photo-z pipelines and transient light curve classifications
+ Visual classification intractable, automation essential
+ LSST's short cadence is an extra hurdle – repeatedly producing training sets for supervised techniques may be impractical

- Solution: *Unsupervised* machine-learning + visual benchmarking

Galaxies SC - Active Projects

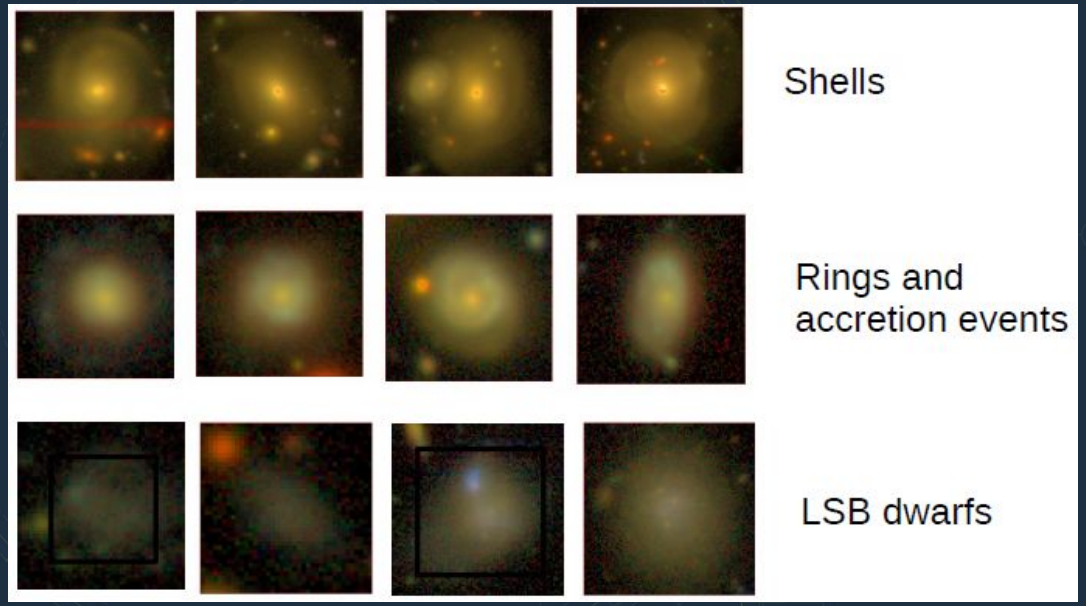
Machine-learning techniques



Implementation on HSC Ultradeep (~LSST 10 year): Martin et al. submitted

Galaxies SC - Active Projects

Machine-learning techniques



Can ‘auto-detect’ rare objects e.g. shells

But...further development required for successful analysis of LSB/faint galaxies

Galaxies SC - Active Projects

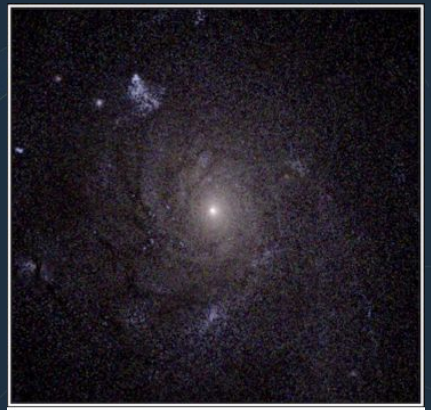
State-of-the-art simulations

Recent advent of hydro-dynamical simulations in cosmological volumes

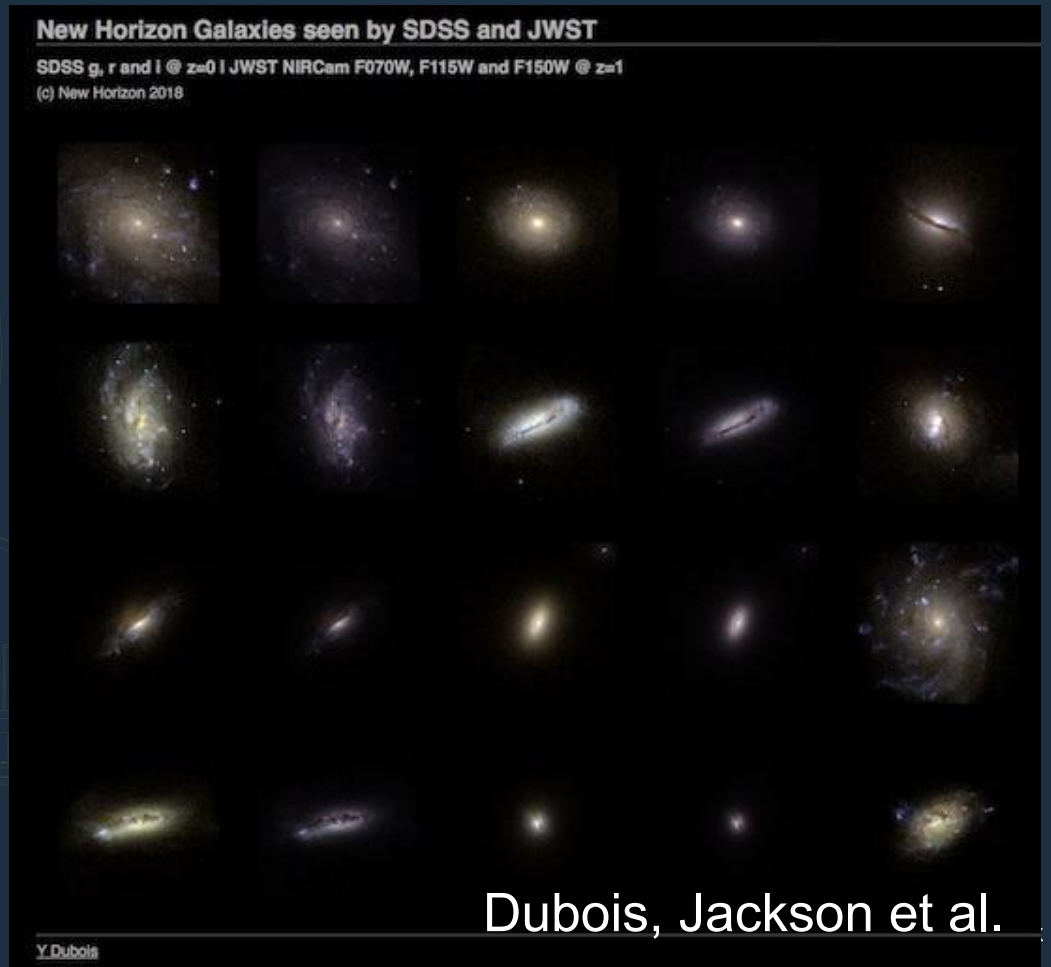
But previous generation lacks the mass/spatial resolution to resolve low-mass galaxies and LSB structures (e.g. tidal features)

Galaxies SC - Active Projects

State-of-the-art simulations



LSST gri

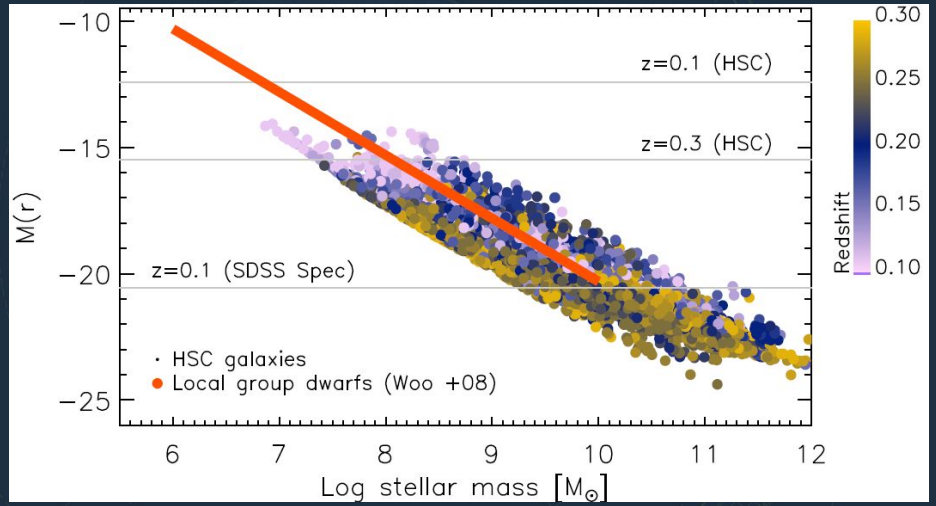


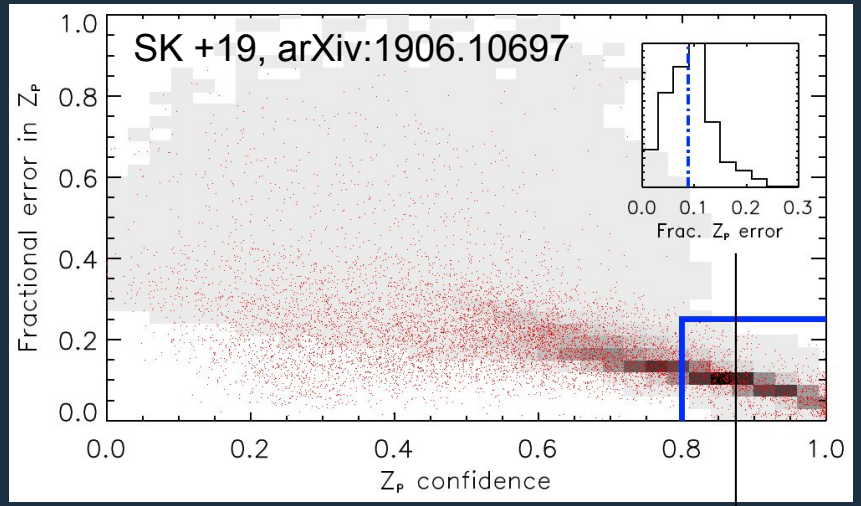
Dubois, Jackson et al.

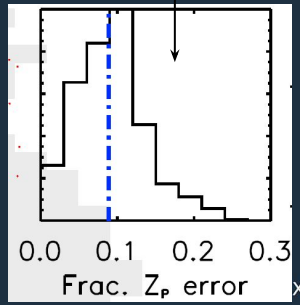
High resolution simulations e.g. New Horizon, Illustris TNG-50 and others will be important theoretical counterparts for LSST

Galaxies SC - Active Projects

Photometric redshifts







- Physical parameters (M*, SFR) require redshift information
- Spec-zs will not be available for most LSST detections (e.g. dwarf galaxies)
- Investment in photometric redshifts is essential
- HSC-SSP DR1 suggests that <10% accuracy is possible in dwarf regime

Galaxies SC - Main Issues & Challenges

Data rights

- Key preparatory work being performed by non-US participants
- Loss of data rights will impact SC preparedness significantly

Commissioning surveys

- Need area and depth that enables the SC to test its infrastructure
- Particularly important for low-surface-brightness science

Scaling up and integration of pipelines for LSST

Preparatory pipelines are not yet optimized for LSST data volumes
Help from Project will be needed to integrate user-generated software into LSST stack

Lack of funding has generally hampered preparatory activities

Galaxies SC - The Future

- Many GSC activities (e.g. LSB, machine-learning, simulations, photo-z) have cross-SC potential

- Best way to get involved is to join the collaboration, membership has increased rapidly in the last 6 months

- Galaxies SC session on Thursday 15 Aug @ 15:30 in Coronado 1 - please come along if you are interested!

AGN Science Collaboration Report

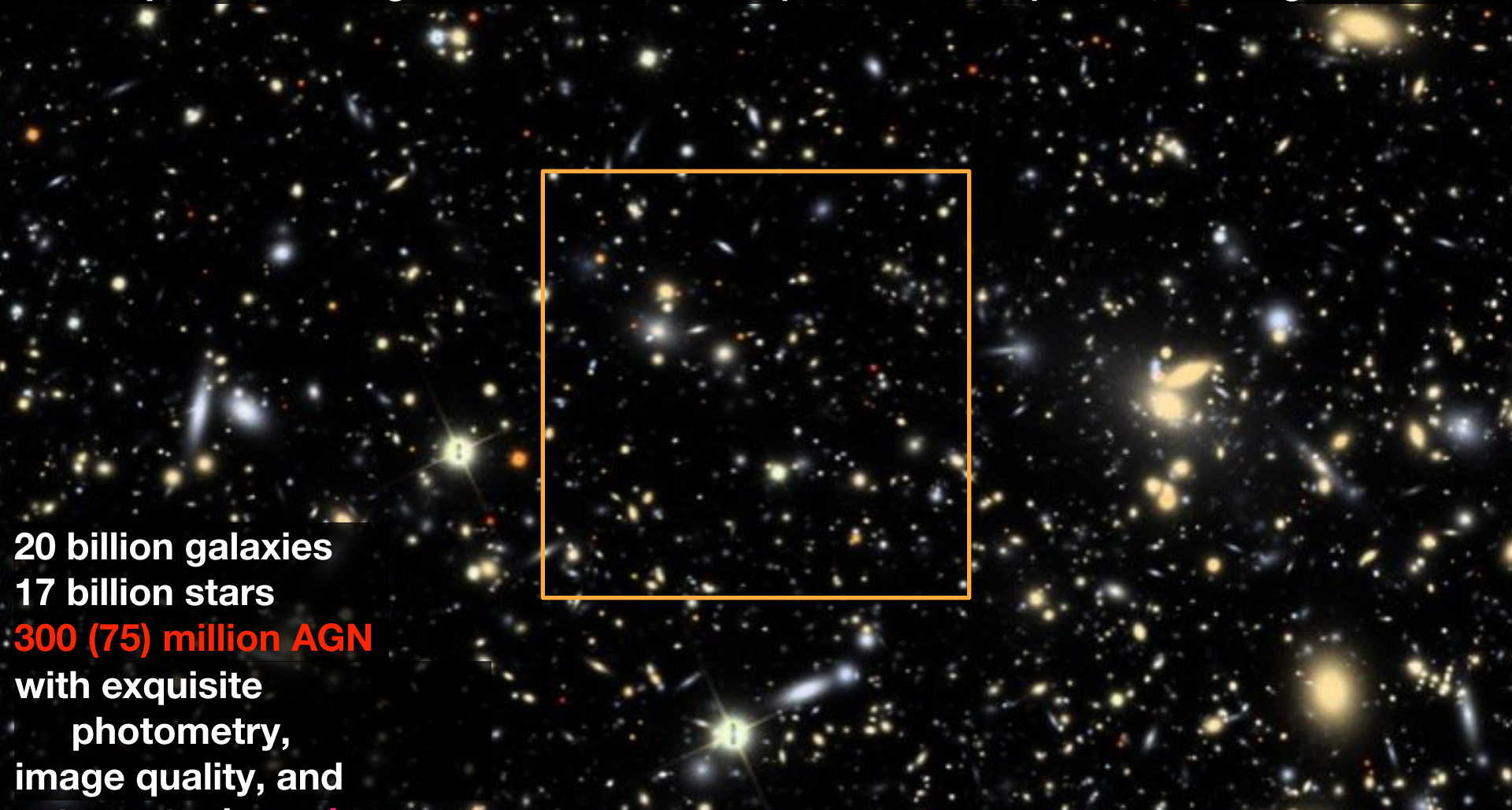
(Supermassive Black Hole Studies with the LSST)

LSST Project and Community Workshop 2019

Presenter: Franz Bauer (Instituto de Astrofísica, Pontificia Universidad Católica de Chile / MAS)

Large Synoptic Survey Telescope

Full-depth LSST image simulation vs UDF (~11.5 arcmin^2) => 18,000 deg^2 of this…



20 billion galaxies
17 billion stars
300 (75) million AGN
with exquisite
photometry,
image quality, and

Science Overview - AGN Selection/Demographics

Multi-color selection in *ugrizy* from z = 0-7.5

- Ultraviolet excess below z ~ 2.5
- Lyman-a forest at high redshifts
- Works best when $L_{AGN} > L_{Host}$

Multi-λ (radio-to-X-ray) selection

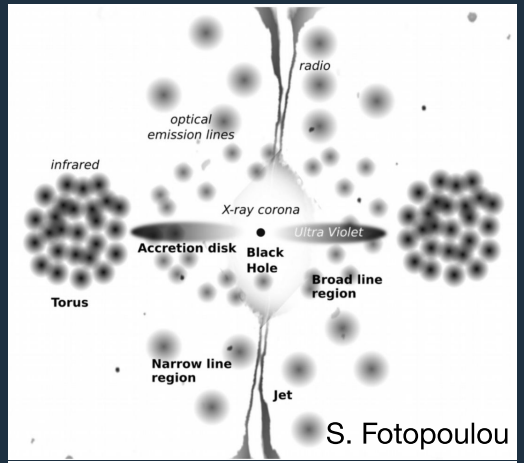
- LSST + MeerKAT/ASKAP + WISE + Euclid/WFIRST + eROSITA/XMM + …

Variability

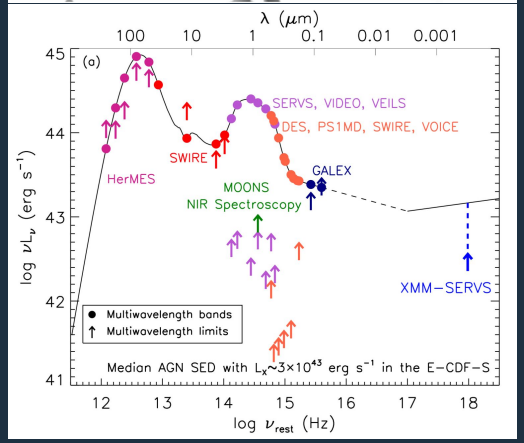
- 55-185 samplings per band over 10 yr
- Highly effective complement to color selection
- Works best when $L_{AGN} > L_{Host}$

Astrometry (Lack of proper motion and differential chromatic refraction)

- Can reach ~1 mas yr^{-1} at r ~ 24 over 10 yr
- Will help minimize confusion with stars
- Strong emission lines will induce astrometric offsets at high airmass



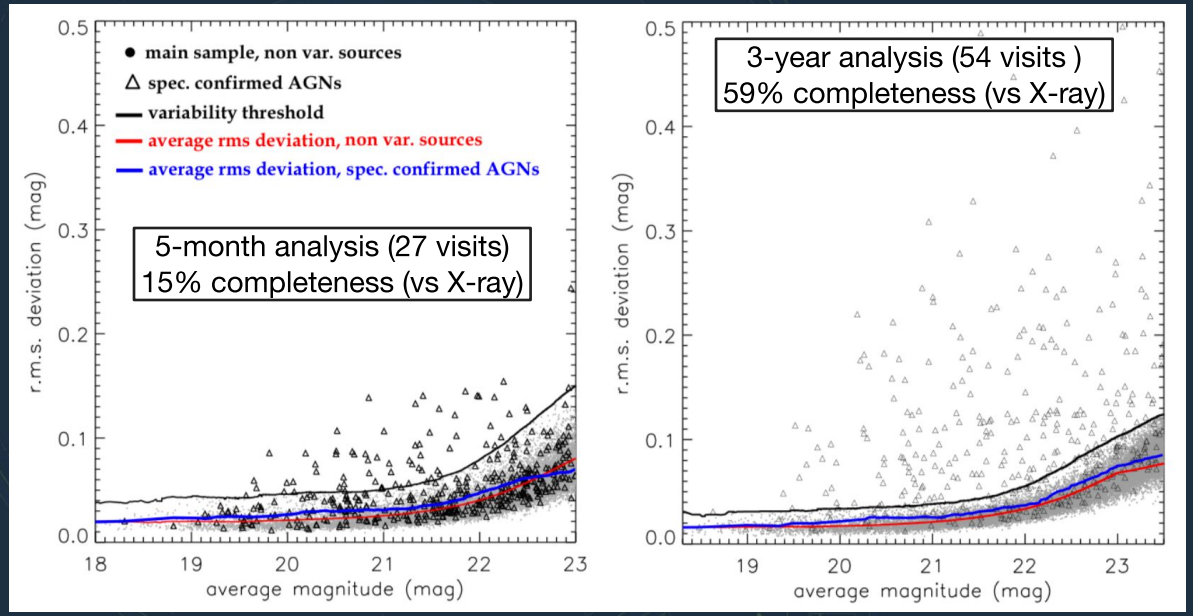
S. Fotopoulou



Color, variability, multi-λ provide different/unique slices through AGN population.

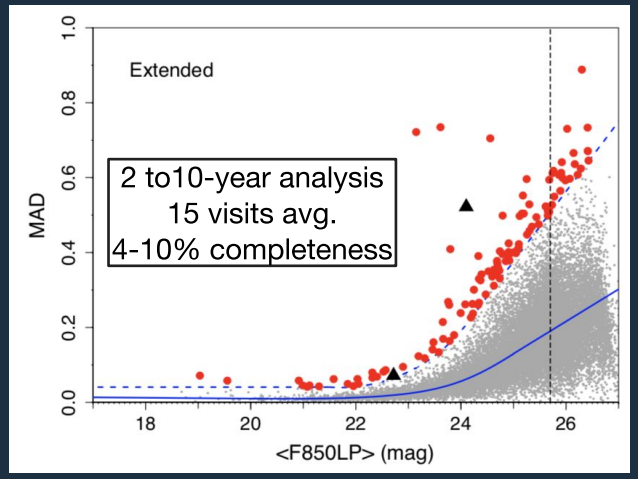
Science Overview - AGN Selection/Demographics

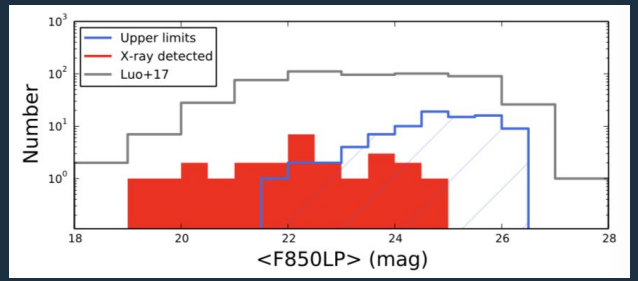
De Cicco+19: VST r-band



=> 256 deg^{-2}, or 4.6 million in 18000 deg^{-2}

Pouliasis+19: HST z-band

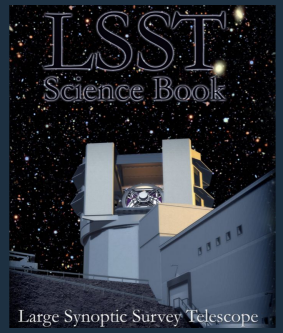




=> 2000 deg^{-2}, or 36 million in 18000 deg^{-2}

LSST should be better due to longer baseline, more/deeper epochs, more bands, ...

Science Overview - Example AGN Investigations



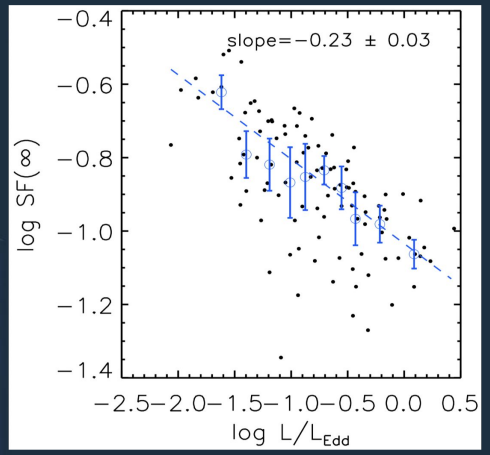
For more info:
agn.science.lsst.org

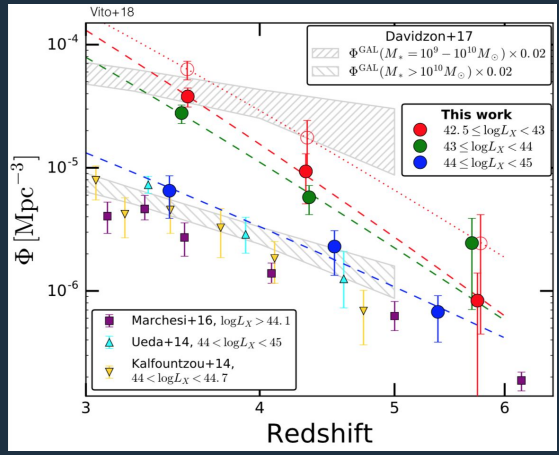
Nightly LSST SMBH Science

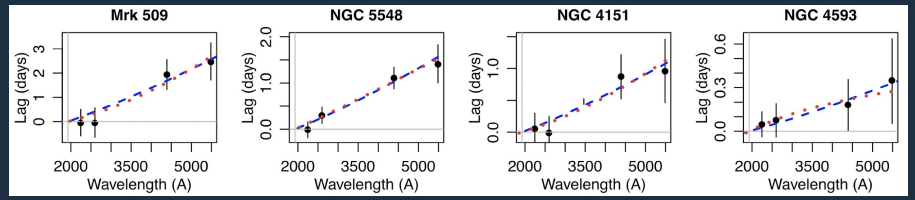
- Monitoring of ~ 75 million AGNs (5+ million variability-selected).
- Discovery of ~ 50 large AGN flares (e.g., blazars and accretion-disk instabilities).
- Discovery of ~ 3 stellar tidal disruption events.
- Discovery of ~ 0.1 strong quasar microlensing events.
- Binary SMBH inspirals and mergers?

Longer-term Statistical Studies

- Massive Statistical AGN Variability Studies
- LSST+Time-Domain Spectroscopy synergies
- Accretion-Disk Structure with LSST
- Small-Separation Binary SMBHs
- Transient Fueling of Dormant SMBHs
- LSST High-Redshift AGN Selection and Constraints on SMBH Seeds







The AGN Science Collaboration (SC)

Currently with 57 members:

- Monthly telecons, breakout meetings at AAS/EWASS/etc.
- New members welcomed from the LSST consortium.
- Some recent challenges owing to the revised LSST funding model and data policy - details still being determined…
- Presently working as loose confederation, but revising membership and organization structure to become a hard-core collaboration as LSST construction proceeds => tiered membership model similar to TVS to help motivate / incentivize project work

Country	Number of Members
USA	37
Chile	7
United Kingdom	6
Italy	3
Poland	2
Germany	1
Serbia	1
Australia	1
Canada	1

AAS 2017 Winter (Grapevine, TX, USA)

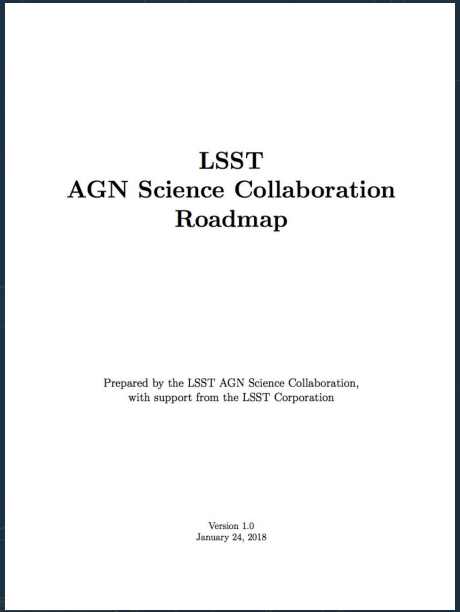
Chile-LSST 2017 (Santiago, Chile)

UK AGNs and Galaxies Meeting 2017 (Cambridge, UK)

AGN SC Roadmap

Living document to describe and prioritize critical AGN science goals …

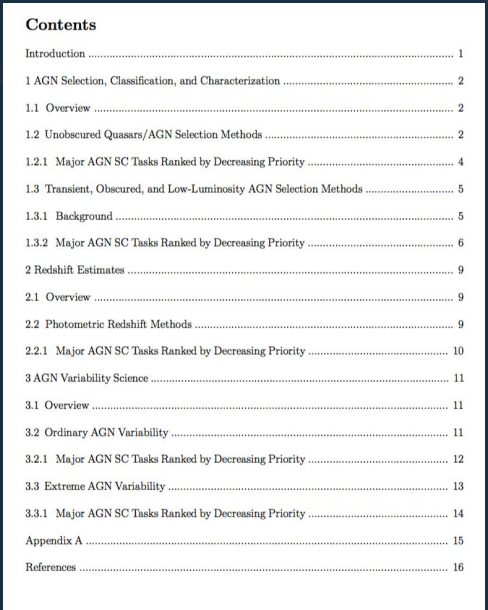
- MUCH work needed on basic AGN selection, analysis of LSST simulations, detailed science planning, and pooling of follow-up/synergistic observational resources.
- LOTS of cross-collaboration work to be done! (ProJect, DM, DBLD, GALSC, DESC, TVS, ISSC, other, …)



LSST
AGN Science Collaboration
Roadmap

Prepared by the LSST AGN Science Collaboration,
with support from the LSST Corporation

Version 1.0
January 24, 2018



Contents

For more info: agn.science.lsst.org

AGN SC Roadmap

Selection, Classification, and Characterization

- Establish public training/test sets to benchmark different selection algorithms (i.e., a "data challenge" sample). Building up "truth tables" in DDFs via multi-λ selection.
- Determine what "color" and host/nuclear separation/deblending mean in LSST context. How deep into $L_{AGN} \lesssim L_{Host}$ can we go to detect LLAGN? (GALSC, DM)
- Generate realistic catalog-level simulated data. (DESC)
- Explore different machine learning techniques. (ISSC)
- Test the effects of different cadence schemes on selection. (PJ)
- Work with (and simulate) asynchronous light curves for variability selection, performing such analysis in the context of difference imaging. (TVS, DM)

AGN SC Roadmap

Redshift Estimates

- Establish public training/test sets to benchmark different selection algorithms. Establish follow-up plan to enhance.
- Determine what info is useful/critical: colors, fluxes, variability, DCR, multi-λ, etc. (DM, GALSC, ISSC, other)
- Identify best methods (empirical, SED fitting, …) and accuracy per source type. Can we do ID and photo simultaneously? Compare the results to independent galaxy photz's. (ISSC, GALSC)
- Test the effects of different cadence schemes on photz's. (PJ)
- Produce/store photo probability distribution functions (PDFs). Develop QSO luminosity function and clustering algorithms that work with PDF photz data. (ISSC)

AGN SC Roadmap

AGN Variability Science

- Simulate AGN light curves for range of SMBH masses, Eddington ratios, redshifts, cadences to see how well variability and photometric/BELR reverberation mapping properties are recovered. (DESC, DM DBLD? ISSC? TVS?)
- Assess how well rare extreme and periodic signals can be detected for realistic AGN light curves. (ISSC, TVS)
- Develop/study how host-subtraction techniques might impact, e.g., TDE and binary SMBH discovery. (DM, GALSC, TVS)
- Feed results from commissioning and early DRs back into AGN selection/classification algorithms. (brokers, ISSC)

AGN SC Roadmap

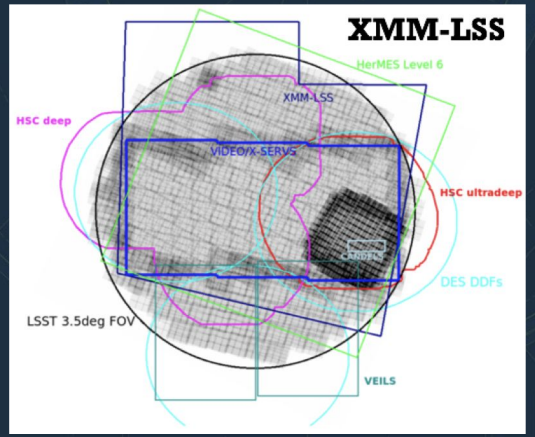
AGN Follow-up

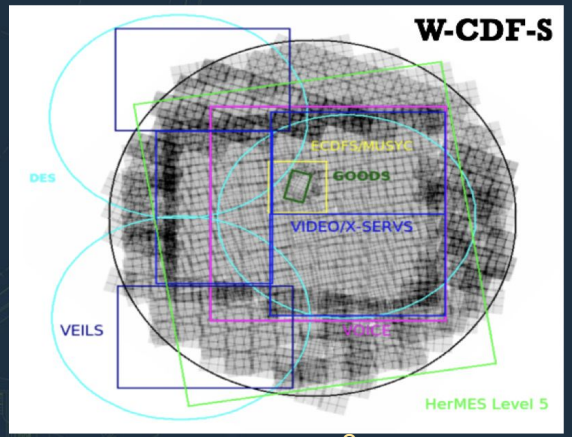
- Work with brokers to efficiently/reliably classify AGN for various follow-up programs. (brokers)
- Develop strategy to trigger (mostly rapid photometric / spectroscopic) follow-up observations of AGN variability events (transient AGN, blazar flare, microlensing, CLQs, …) for both classification and deeper science goals. (other)
- Develop strategy to target rare/outlier/high-z AGN for both classification (reinforce ML techniques) and deeper science goals. (other)
- Develop strategy for precursor and concurrent massive spectroscopic RM monitoring on long timescales. (other)

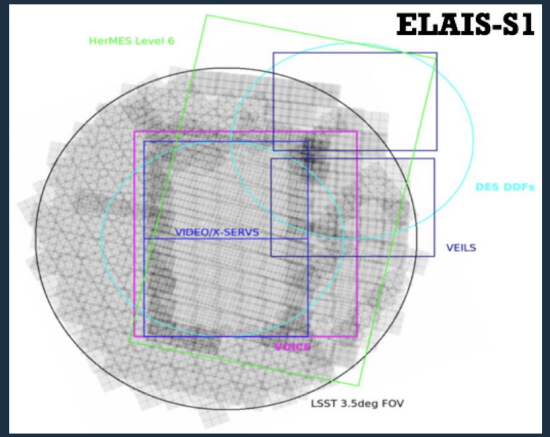
Two successful approaches to date…

- The lack of LSST science funding (US, Chile) has posed MAJOR challenges for LSST AGN science preparation - “creativity” needed!
- 1st approach has been to bootstrap our way along:

  Deep Fields + Stripe 82 (in hand) => Pan-STARRS + ZTF (on-going) => DES + HSC => LSST
- 2nd approach has been to gather key multi-wavelength data for DDFs; e.g., Spitzer+XMM-Newton now; SDSS-V BHMapper, 4MOST-WAVES/TIDES, VLT-MOONS, Subaru-PSF, MeerKAT, ASKAP, LMT, …soon?







PI: M Lacy => completing 38 deg^2 of Spitzer coverage (gray shading).

PI: N. Brandt => 12 deg^2 of XMM coverage (blue boxes)

The Future

Progress has been slow due to variety of factors:

- Lack of dedicated LSST-related funding / human resources
- "LSST not yet a reality" mindset
- Inertia needed to work at inter-SC level.
- Uncertainties and limitations surrounding data rights/access.

Looking to have initial multi-tiered static+temporal training sets available in Fall 2019.

Begin ML (data challenge) process on archival and ongoing ZTF datasets, hopefully scaling up to LSST-level data over next 2 years.

Transients and Variable Stars SC Report

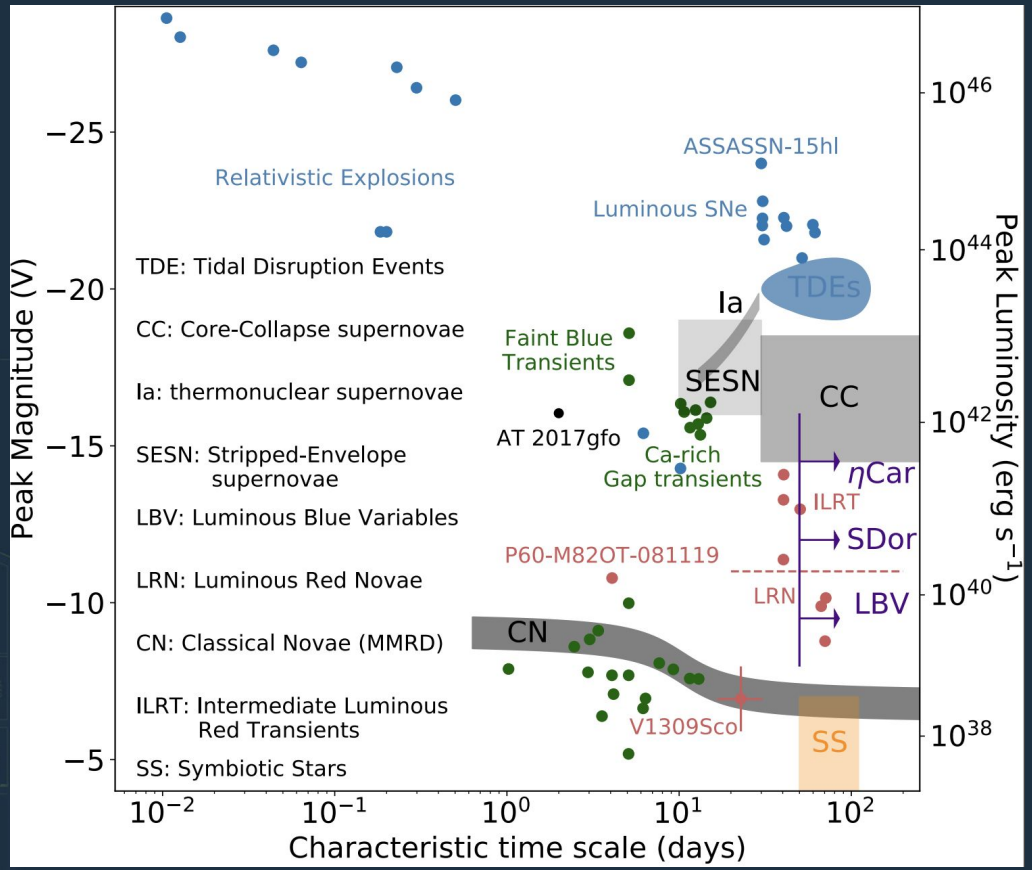
LSST Project and Community Workshop 2019

Presenter: Federica Bianco (University of Delaware)
TVS Co-Chair: Rachel Street (Las Cumbres Observatory)

Large Synoptic Survey Telescope

Science Overview

Phenomenology and physics of phenomena that evolve in time: Galactic, Extragalactic, Geometric, Physical, all energy scales, all time scales



Ivezic+ 2019

http://ls.st/lop

Science Overview

How will LSST make a difference?

Event Rate

Increase size of events:
e.g. SN subclasses

Build statistical samples of rare events:
e.g. TDE, Kilonova

Precursors of transients:
e.g. LBV

Faint Magnitude

High redshift and evolution:
e.g. SN subclasses

Improved event distribution
e.g. microlensing across galaxy

Dense+long-term multi-color time series

Improved characterization of variables and transients:
e.g. pulsating variable + magnetically active stars characterization

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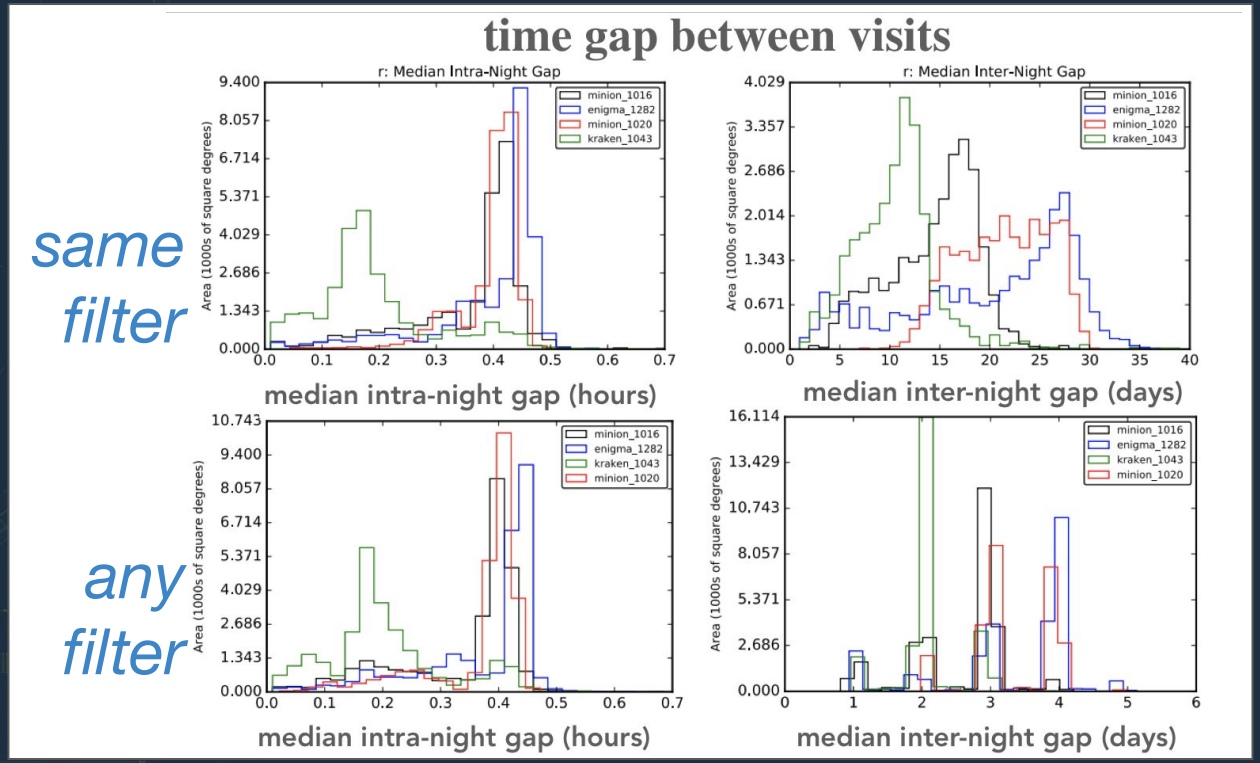
Science Overview

Extremely sensitive to observing strategy



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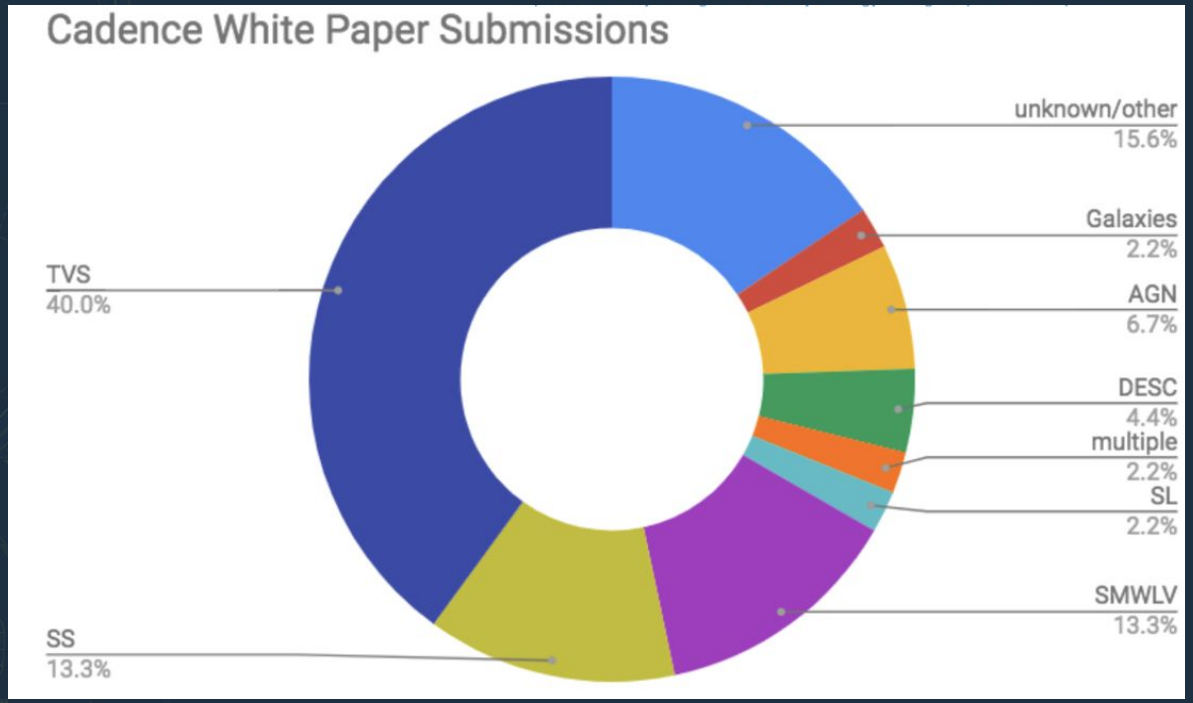
Science Overview

Extremely sensitive to observing strategy

- Aliasing
- Coobserving (e.g. WFIRST)
- Colors information
- Filter selection
- Lightcurve density
- Lightcurve persistence
- Field selection (e.g. galactic plane)
- Exposure (e.g. inter-image time scales)



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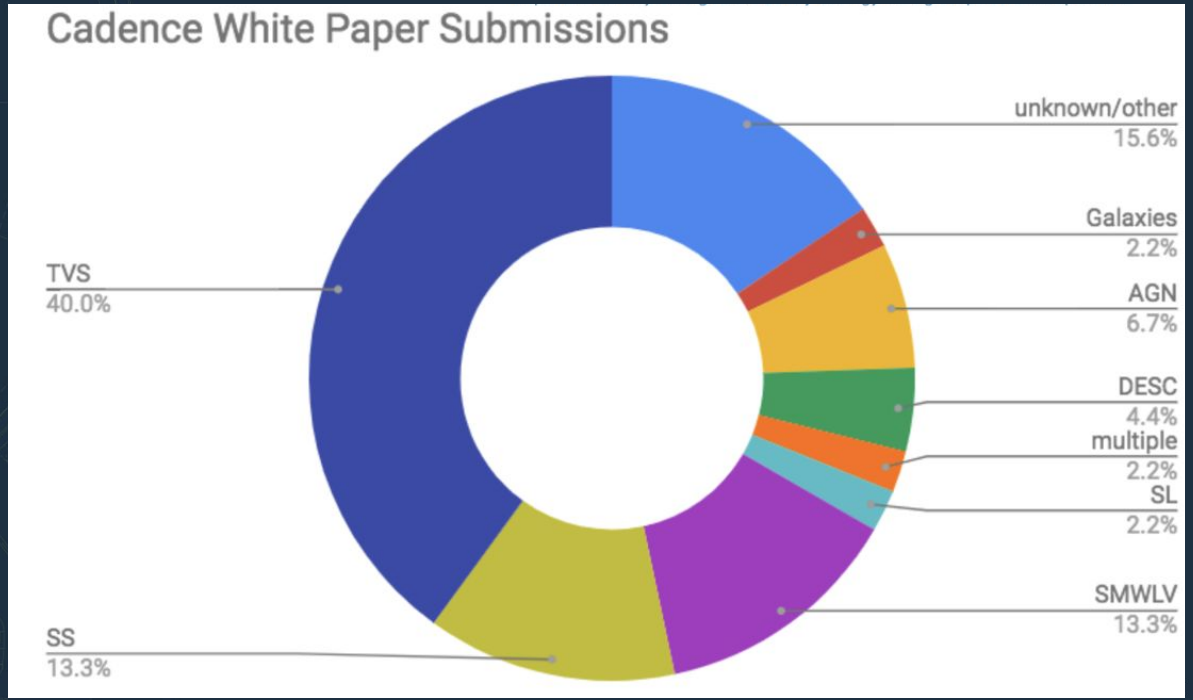
Science Overview

Extremely sensitive to observing strategy

- ToO to follow up GW alerts (Margutti et al 2018)

Thursday 11AM
LSST-LIGO Synergy
T. Tyson
Coronado I



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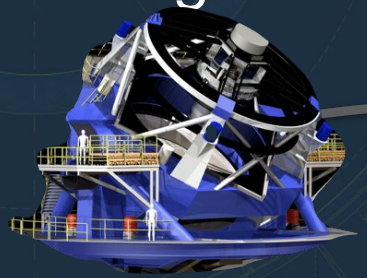
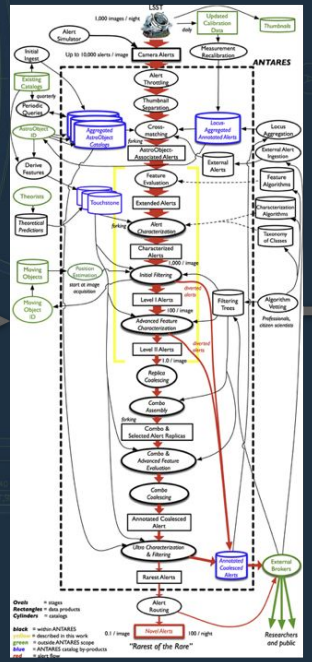
Science Overview

Largely dependent on follow-up, coobserving, and synergistic data collection/mining





Broker services

Target & Observation Manager Systems

Observing facilities

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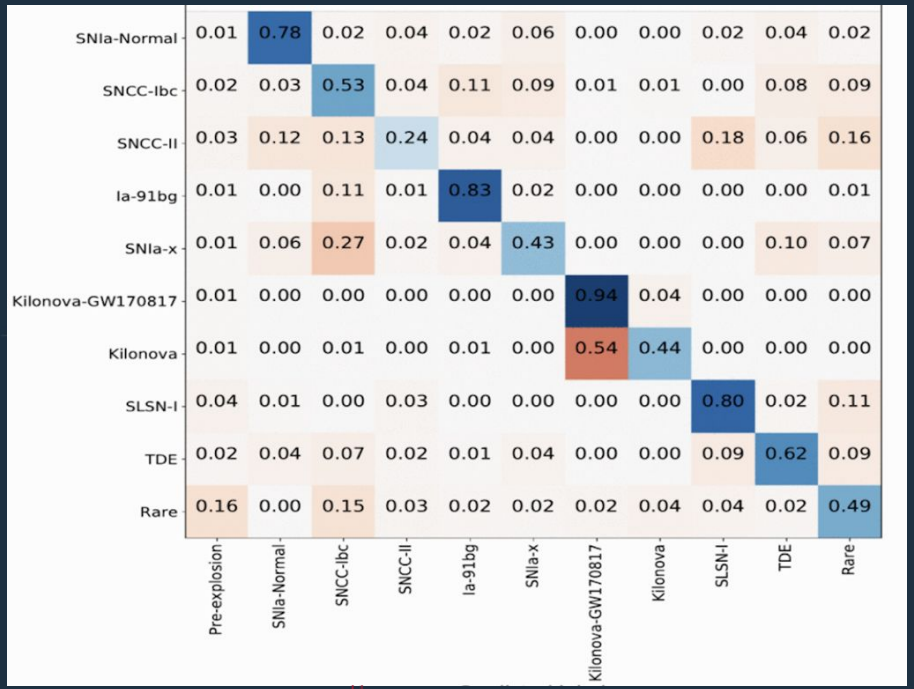
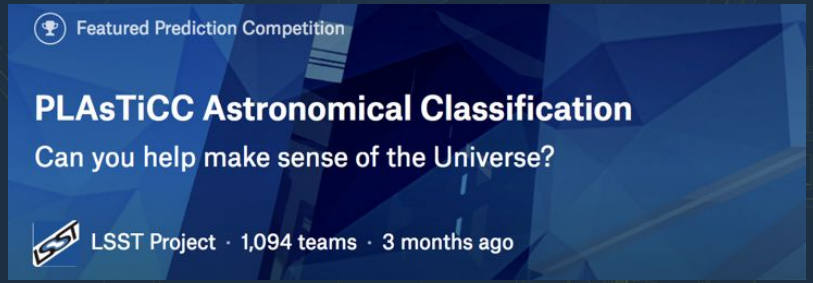
Science Overview

Largely dependent on follow-up, coobserving, and synergistic data collection/mining





kaggle

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SC Overview

Co-chairs:

Federica Bianco (me)
University of Delaware
(mostlly) extragalactic transients

Rachel Street (also here)
Las Cumbres Observatory
(mostlly) microlensing

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SC Overview

organized into 15 subgroups (Active | Inactive)

Extragalactic

Fast Transients (M. Drout)

Supernovae (*M. Graham*)

Tidal Disruption Events (S. vanVelzen)

Blazars

Distance Scale

Methodologies

Cosmological

Classification/Characterization

Galactic

Interacting Binaries (A. Prsa)

Magnetically Active Stars (R. Egeland)

Microlensing (*R. Street*)

Transiting Exoplanets (*M. Lund*)

Pulsating Variables (K. Hambelton)

Non-degenerate Eruptive Variables (S. Bonito)

Galactic

Multiwavelength Characterization & Counterparts (R. Margutti)

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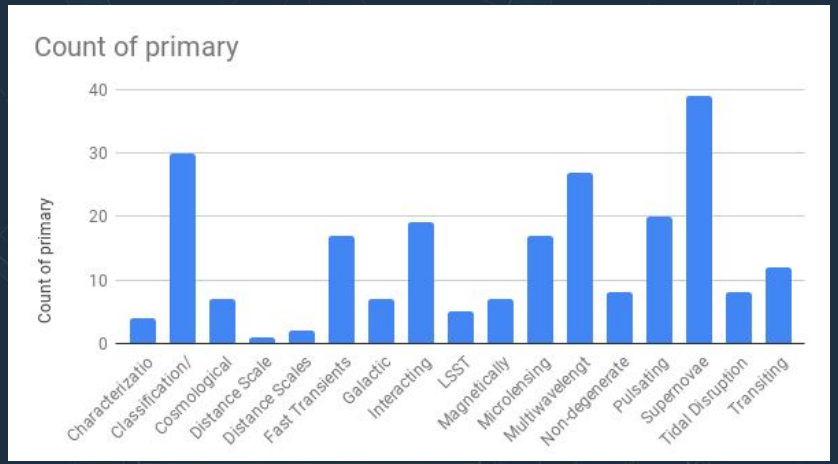
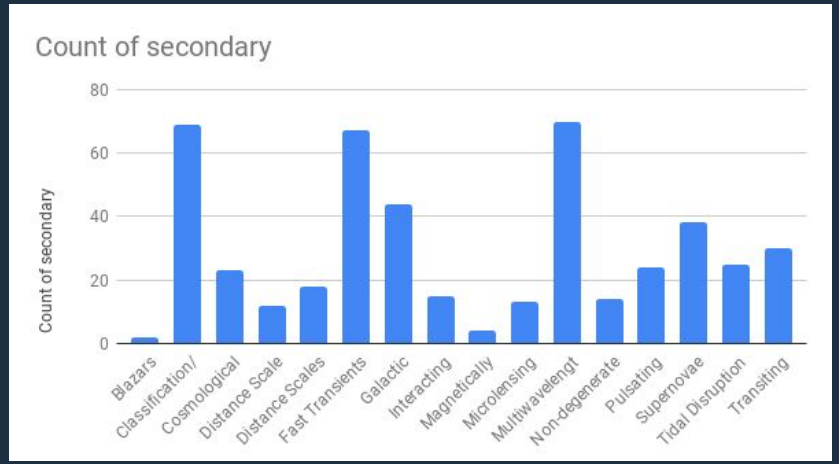
SC Overview

Each TVS members can be affiliated with 1 primary and up to two secondary subgroups





TVS Task Forces 2018

Task-oriented groups that attract cross-disciplinary support from subgroups

DDF and Minisurvey proposals planning

14 TVS-led LSST Cadence White Papers
Hackathon workshop to foster collaborations and design metrics

Stellar variability in crowded fields

Created metrics to evaluate DM performance for variable stars in crowded fields
Tested photometric analysis software using DECam data on the Galactic Bulge
So productive, now **extended to 2019**

TVS roadmap

V1.0 of a roadmap towards TVS science with **LSST being finalized**

Brokers

Characterize the functionality needed from a community-broker interface
Work continuing in 2019

TVS Task Forces 2019

Task-oriented groups that attract cross-disciplinary support from subgroups

MAF Task Force

Generating Metrics for the 14 TVS-led LSST Cadence White Papers

Stellar variability in crowded fields

Testing the LSST photometric pipeline in crowded and extremely crowded fields

Science Platform and Stack club

Catching up with stack club and testing the LSST science platform for TVS needs

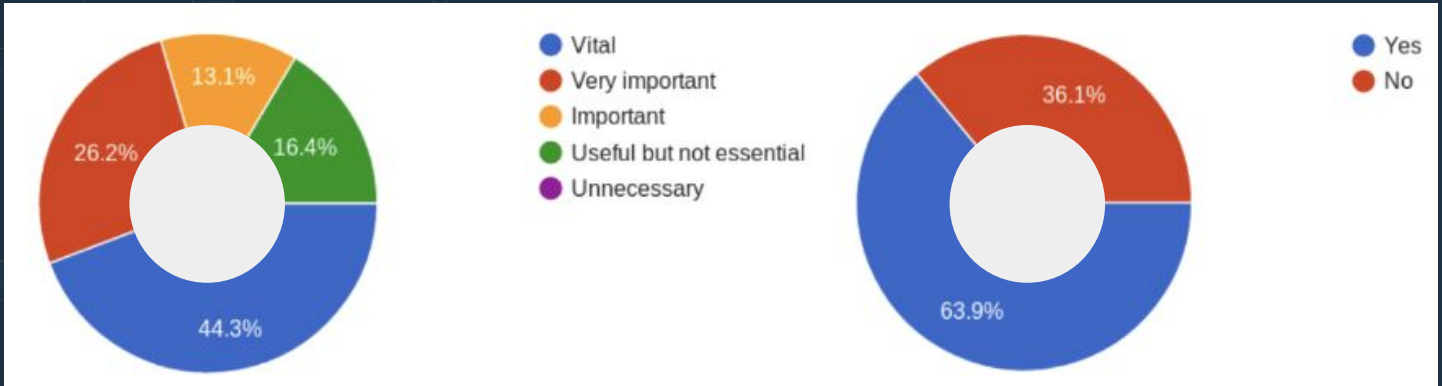
Commissioning

Generating a commissioning plan for LSST

Broker Requirements Survey - 2018

Task Force conducted two parallel surveys of broker functionality:

- Community requirements on data content, dissemination, tools and
- Developer constraints



How important is it that brokers classify your transients

Can you define a simple selection criteria that would trigger notifications (e.g. Dmag > 1)

http://bit.ly/TVSBrokersReq

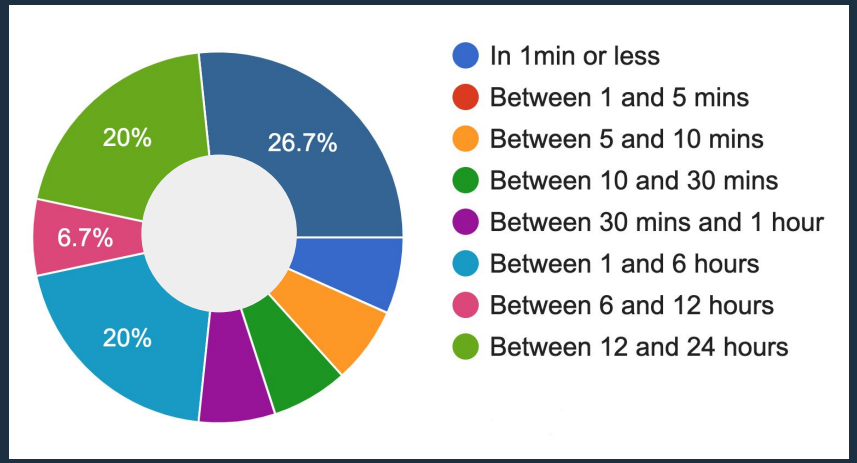
Broker Requirements Survey - 2019

Broker developers need more information!

Technology used at broker depends strongly on how quickly users need access to new alerts. LSST is capable of delivering alerts in 60 sec but that puts strain in the system. *Are <5min alerts scientifically motivated?*

T>5min - current technology
T~1min - alternative technologies needed

How fast do you *really* need alerts?
Have your say at: https://ls.st/7vb



Active Projects

Suggested time: ~4 minutes

Summarize the current activities, such as:

- building tools for analysis (e.g., ML classification)
- compiling precursor data sets (e.g., spec-z catalogs)

Building Analysis Tools

TVS Roadmap

Variable part finished.
Transient in progress
Expected publication winter 2019

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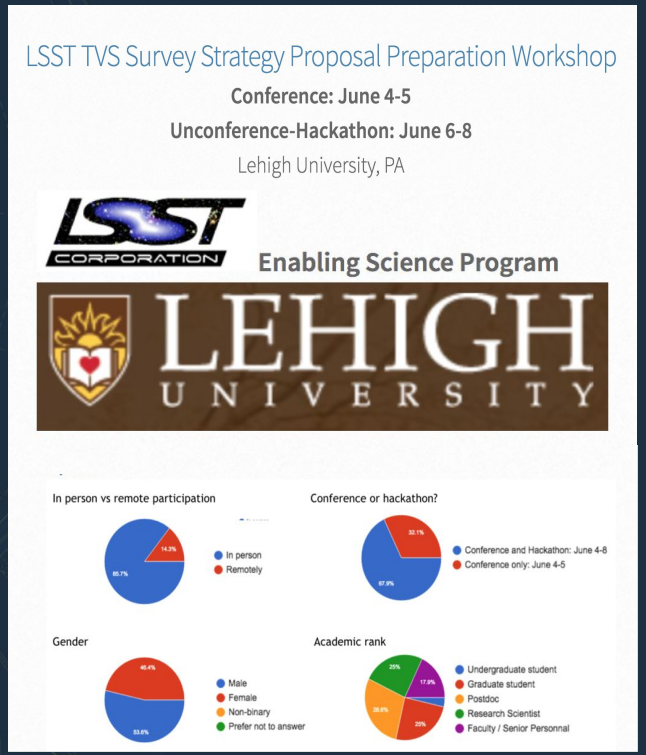
TVS meetings: recent



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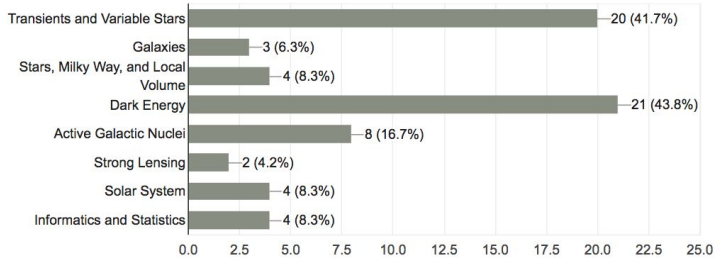
TVS meetings: recent

LSST Cadence Hackathon at the Flatiron Institute

September 17, 18, 19, NYC

Which Science Collaboration(s) are you a member of

48 responses



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LSST - Large Synoptic Survey Telescope - Special Programs Workshop

8-10 October 2018
Palazzo dei Normanni
Palermo, Italy

TVS meetings: upcoming

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TVS meetings: upcoming

De-blending with Scarlet
Naples, Italy
October 7-9

https://indico.ict.inaf.it/event/889/

Supernovae across SCs
April 2019
University of Illinois

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TVS meetings: upcoming

TVS parallel session : Preparing to do Transient and Variable Star Science with LSST

Friday 9-10:30
Presidio I

9:00 - 9:10 Rachel Street
TVS introduction
9:10 - 9:30 Melissa Graham
Overview of TVS Roadmap
9:30 - 9:45 Markus Rabus
Updates from TVS Task Forces
9:45 - 10:00 Markus Rabus
Plans for commissioning+discussion
10:00 - 10:15 Rachel Street
TVS requirements for brokers
10:15 - 10:30 Federica Bianco
MAF and survey cadence proposals

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Code of Conduct, Charter, Publication Policy

The LSST Transients and Variable Stars Science Collaboration Code of Conduct

Guiding Principles:

All members participate and contribute on equal terms.

The social climate within which all research, collaboration and interactions are conducted will be respectful and professional.

All members can expect that their contributions will receive fair and appropriate credit in all forums.

The default expectation is that research will be conducted openly and be accessible in a timely manner to all members. Exceptions should be rare and well justified.

Reading and agreeing to this policy *is a condition for membership* to the LSST Transients and Variable Stars Science Collaboration.

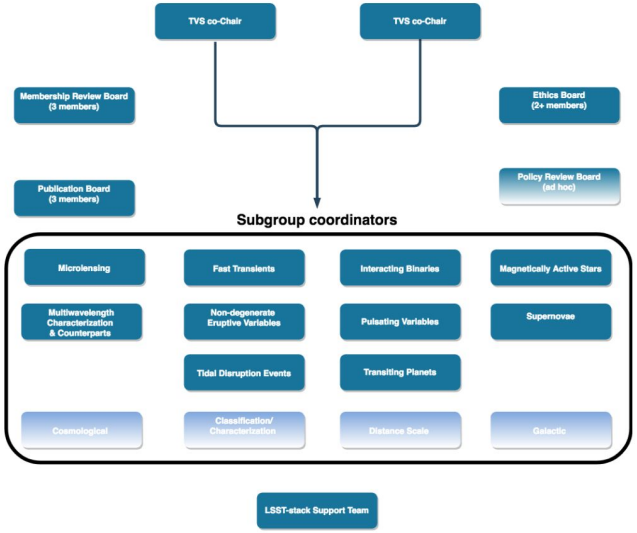
Code of Conduct, Charter, Publication Policy

The LSST Transient and Variable Stars Science Collaboration Charter

Version information: v 0.1 prepared by Federica Bianco (TVS co-Chair) in June 2018 edited by Rachel Street (TVS co-Chair) July 2018

This document describes the governing and managing structure of the Large Synoptic Survey Telescope (LSST) Transients and Variable Stars Science Collaboration (TVS SC, also referred to here as "the Collaboration").

The TVS SC organizational structure as of August 2018.



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Code of Conduct, Charter, Publication Policy

The LSST Transient and Variable Stars Collaboration Science Collaboration
Publication Policy

Reading and agreeing to this policy *is a condition for membership* to the LSST Transients and Variable Stars Science Collaboration.

There are two primary goals for this policy:

- To protect the intellectual property of TVS members and provide a trusted, supportive environment in which they can share ideas and expertise, and.
- To maximize the quality and ensure the validity of TVS publications by taking full advantage of the scientific and technical expertise within the collaboration.

Reading and agreeing to the TVS Publication Policy is a condition for membership and the Publication Policy should be reviewed by all applying for membership before submitting their application.

This publication policy covers

- peer-reviewed publications (journal articles),
- white papers,
- conference contributions (oral and posters),
- theses, dissertations, projects,
- data releases,
- software tools, and
- documentation relating to TVS data products and software.

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variable Universe and

Matthew Penny
12:20 PM Aug 13

Add header

3:01 PM Aug 8
Resolve

Science

Giacomo Vianel...
2:20 PM Jul 19
Resolve

Is there going to be a formal policy for advertising projects before they reach the paper stage? Failing to do so might result in multiple people working on the same thing within the TVS group, and discovering it only very late in the process

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Intra-collaboration agreement

LSST DESC Dark Energy Science Collaboration

LSST TVS Science Collaboration

LSST DESC & LSST TVS SC Coordination: the PLAsTiCC Project

Inter-Collaboration Agreement

LSST DESC and LSST TVS, October 24, 2018

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Main Issues

Suggested time: ~4 minutes

Describe the unknowns, the worries, the obstacles, etc. that this science collaboration is currently facing.

Could include, for example:

- particular aspects of the survey strategy (cadence, exposure times, LEO sats, area, etc.)
- data rights (international collaborations, shared tools, authentication, etc.)
- understanding the data products
- evaluating computational needs
- identifying platforms for tool-building
- etc.

I.e., of the SC's current activities, what is working well, and what isn't? Where is progress being made and where is it stalled? (A set-up for the next slide topic, which is future needs).

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TVS: Main Issues

Factors inhibiting members from contributing actively

- <u>Lack of funding for preparatory work towards science with LSST</u>
- Lack of access to LSST-oriented platforms such as LSP
  - Understood that these are in development.
- “LSST is in the future” mindset
- Concerns over future access to LSST data
- Awaiting determination of observing strategy to gauge level of interest?

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The Future

Suggested time: ~1 minute

With this final slide, an opportunity to communicate:

- needs and expectations to the Project
- potential inter-SC projects
- ways for Project/Community involvement

Great deal of concern from international members of TVS about whether they will be able to continue to contribute to the project

- Need to rapidly establish guidelines about future contributions
- Great potential for international contributions to data platforms and tools

Would like to foster greater inter-SC communication and collaboration

- Pan-SC Task Forces?

Project/Community partnerships for e.g., observing strategy, evaluating in-kind contributions, determining optimum use of LSST computing resources dedicated for community use.

TVS: Main Issues

Great deal of concern from international members of TVS about whether they will be able to continue to contribute to the project

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- Pan-SC Task Forces?
  - Established annually at PCW meeting, reporting via LSSTC Science Collaboration Committee?

Endorse Project/Community partnerships

- E.g., for observing strategy
- evaluating in-kind contributions,
- determining optimum use of LSST computing resources dedicated for community use.