Synergies between Vera C. Rubin Observatory Legacy Survey of Space and Time (LSST) and WST

Sara (Rosaria) Bonito (she/her)
INAF - Osservatorio Astronomico di Palermo, Italy
rosaria.bonito@inaf.it

Rubin LSST and WST

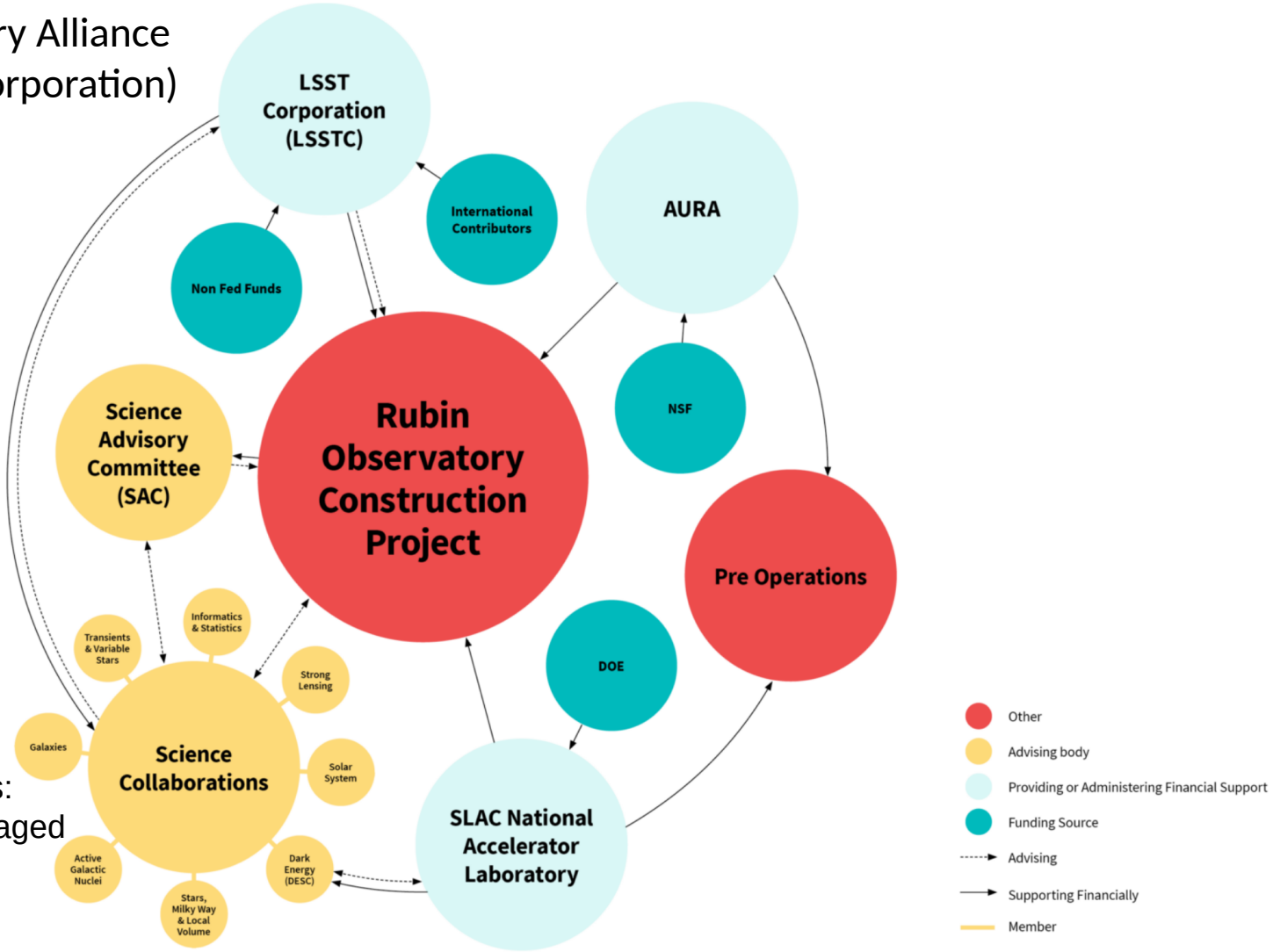
“While Rubin LSST will already have completed its first project phase, its next phases would likely consider and build on synergies with WST (Z. Ivezic January 2024, priv. comm.). Moreover, lessons learned as part of Rubin LSST ’s transients and variable stars science collaboration and from Rubin LSST ’s first phase would inform scheduling and planning of variable phenomena with WST”

The Wide-field Spectroscopic Telescope (WST) Science White Paper (Mainieri et al.)

Sara (Rosaria) Bonito – INAF – Osservatorio Astronomico di Palermo (Italy)

Rubin LSST Ecosystem

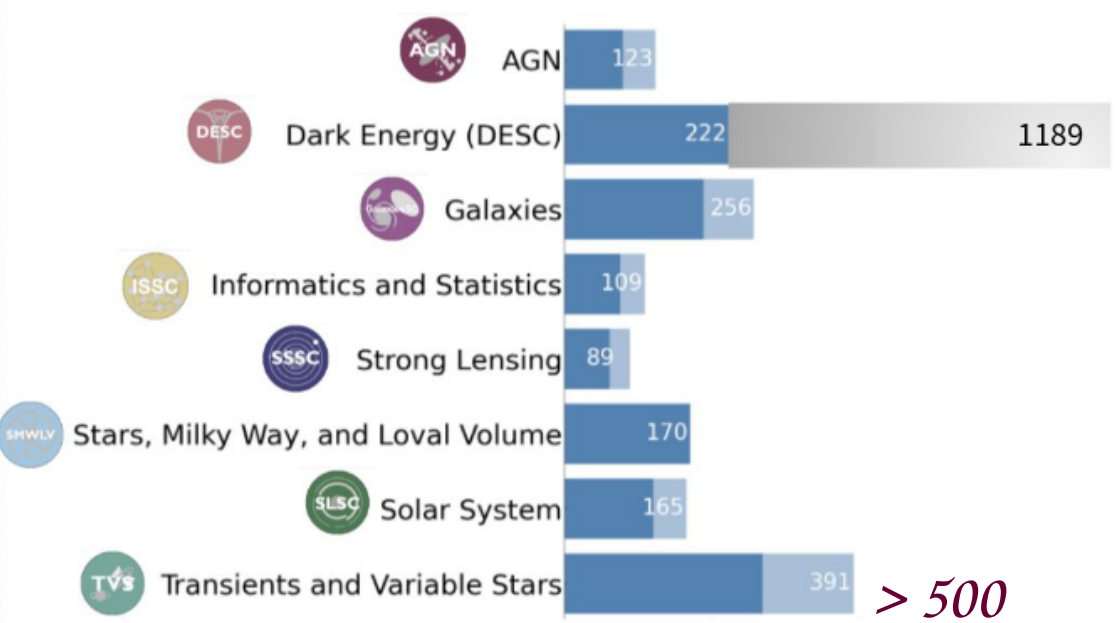
Discovery Alliance
(LSST Corporation)



Science Collaborations:
autonomous, self-managed
teams

- Understanding Dark Energy and the nature of Dark Matter,
- Cataloging the Solar System
- Exploring the Transient and Variable Sky
- Exploring the Milky Way Structure & Formation

Rubin LSST Science collaborations

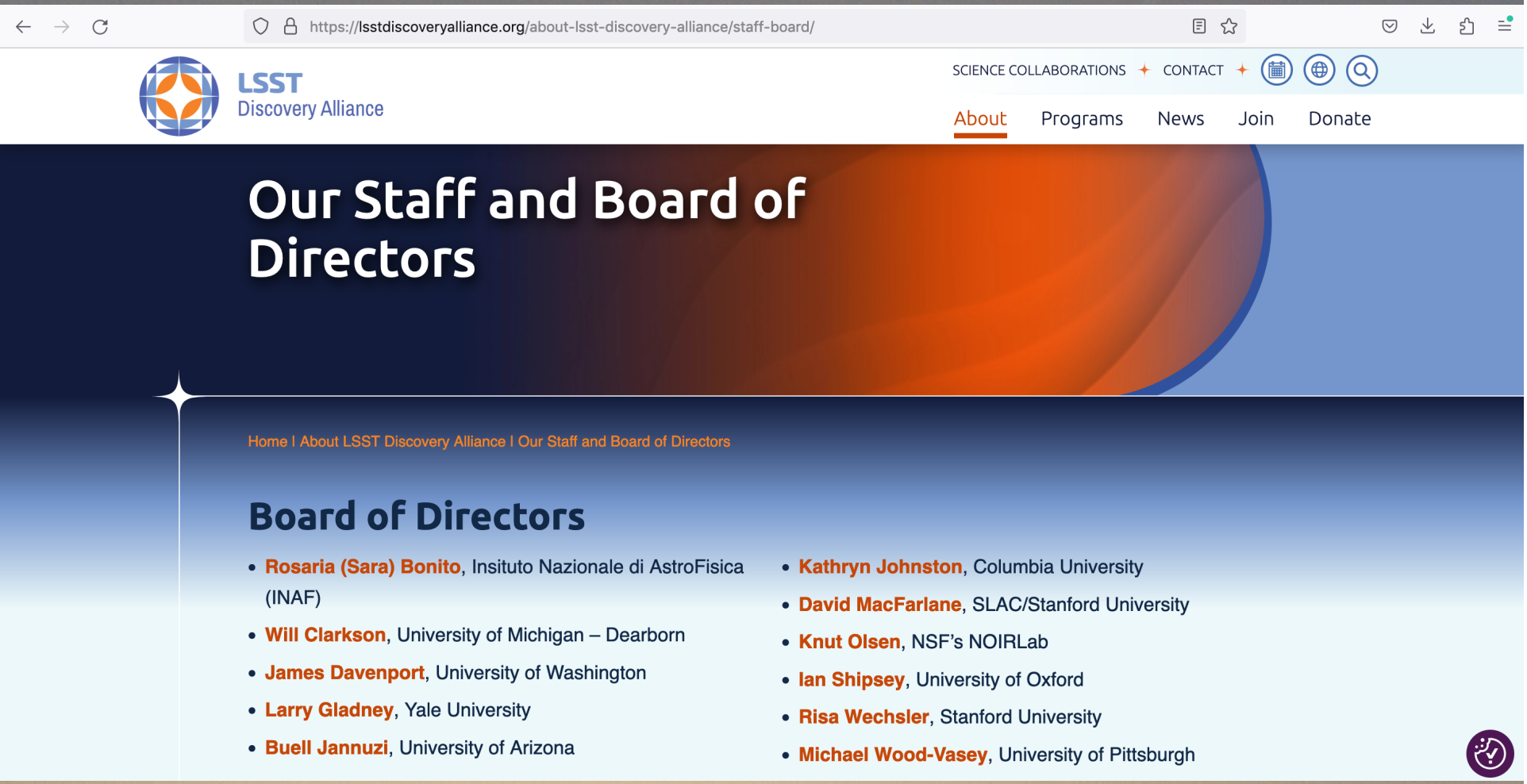


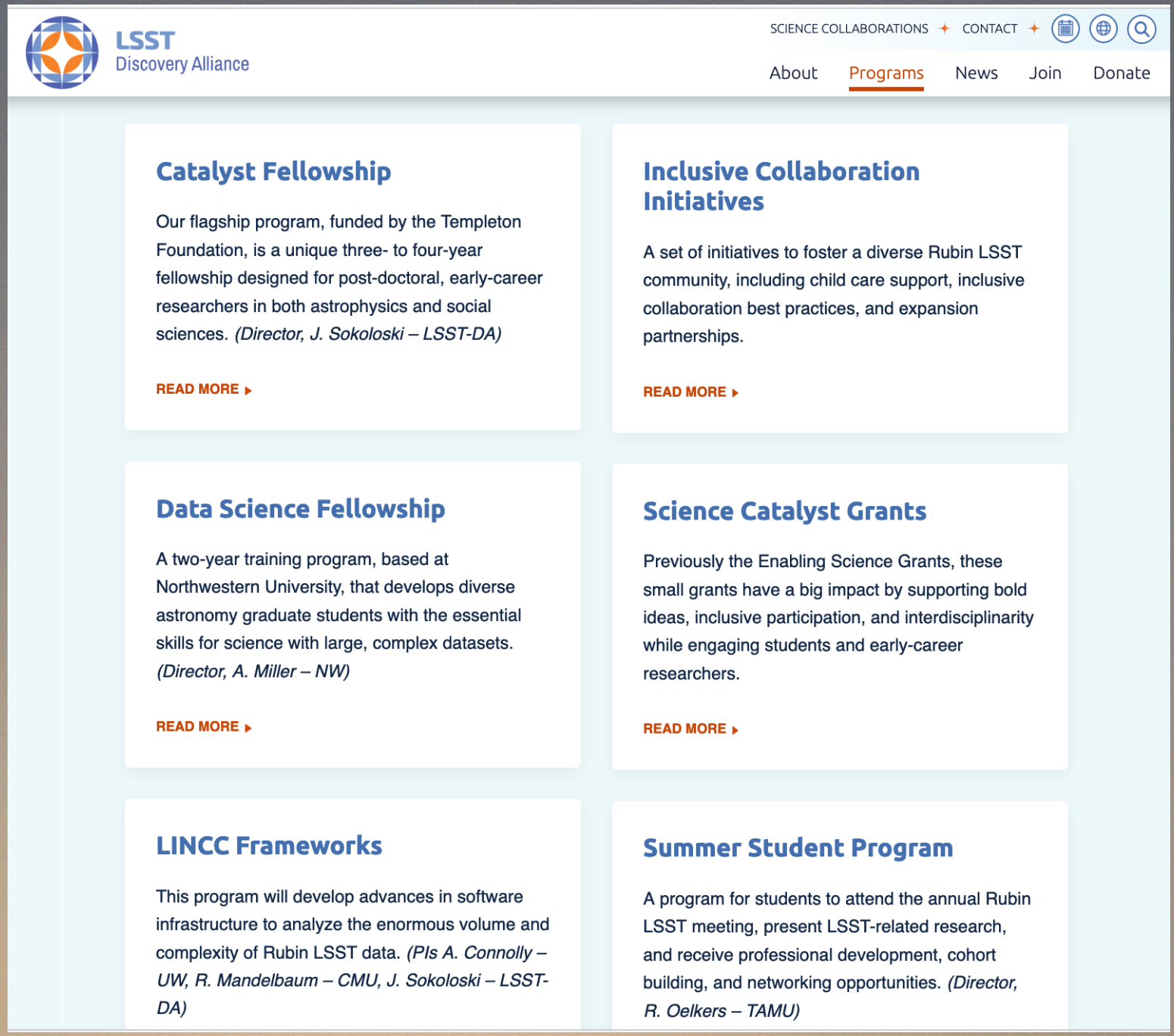
> 500

2000+ members, physicists, astronomers, data scientists, software engineers

Credit: FBianco TLoredo

LSST Discovery Alliance




LSST
Discovery Alliance
SCIENCE COLLABORATIONS
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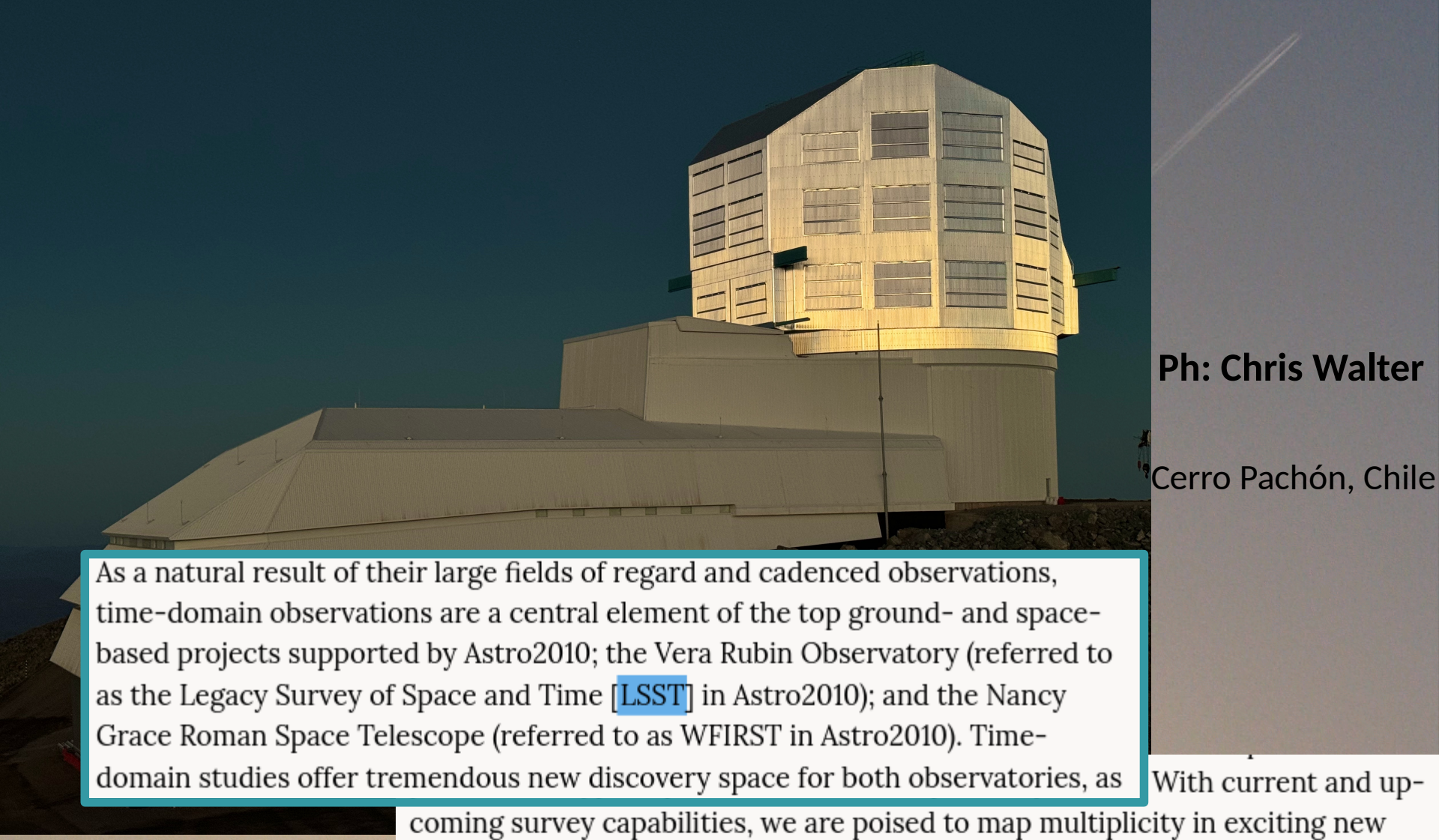
Catalyst Fellowship
Our flagship program, funded by the Templeton Foundation, is a unique three- to four-year fellowship designed for post-doctoral, early-career researchers in both astrophysics and social sciences. (Director, J. Sokoloski – LSST-DA)
READ MORE
Inclusive Collaboration Initiatives
A set of initiatives to foster a diverse Rubin LSST community, including child care support, inclusive collaboration best practices, and expansion partnerships.
READ MORE
Data Science Fellowship
A two-year training program, based at Northwestern University, that develops diverse astronomy graduate students with the essential skills for science with large, complex datasets. (Director, A. Miller – NW)
READ MORE
Science Catalyst Grants
Previously the Enabling Science Grants, these small grants have a big impact by supporting bold ideas, inclusive participation, and interdisciplinarity while engaging students and early-career researchers.
READ MORE
LINCC Frameworks
This program will develop advances in software infrastructure to analyze the enormous volume and complexity of Rubin LSST data. (PIs A. Connolly – UW, R. Mandelbaum – CMU, J. Sokoloski – LSST-DA)
Summer Student Program
A program for students to attend the annual Rubin LSST meeting, present LSST-related research, and receive professional development, cohort building, and networking opportunities. (Director, R. Oelkers – TAMU)

Ph: Chris Walter

Cerro Pachón, Chile

Sara (Rosaria) Bonito – INAF – Osservatorio Astronomico di Palermo (Italy)



Ph: Chris Walter

Cerro Pachón, Chile

As a natural result of their large fields of regard and cadenced observations, time-domain observations are a central element of the top ground- and space-based projects supported by Astro2010; the Vera Rubin Observatory (referred to as the Legacy Survey of Space and Time [LSST] in Astro2010); and the Nancy Grace Roman Space Telescope (referred to as WFIRST in Astro2010). Time-domain studies offer tremendous new discovery space for both observatories, as

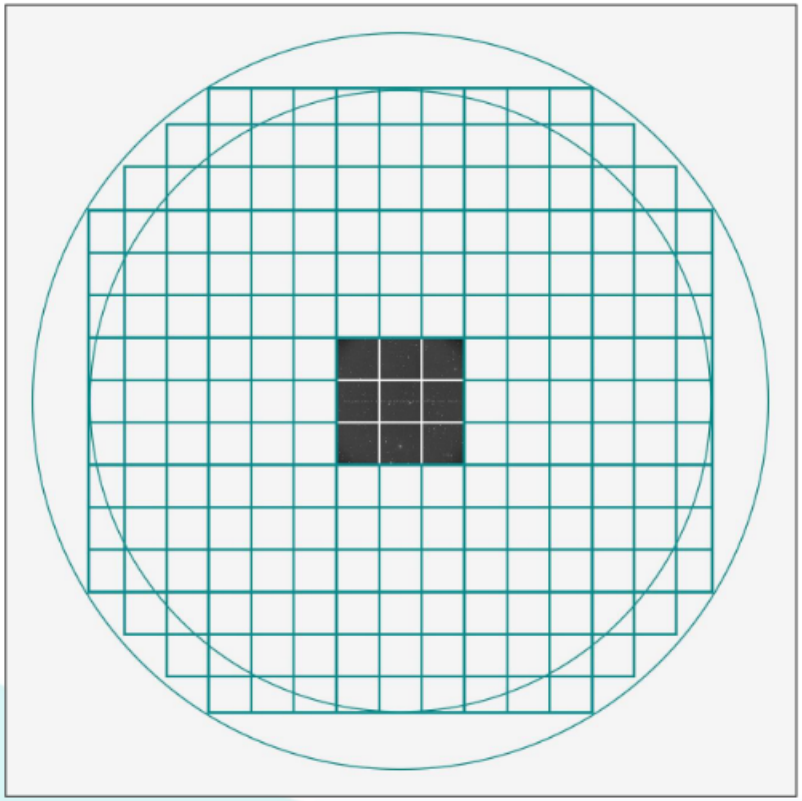
With current and up-coming survey capabilities, we are poised to map multiplicity in exciting new ways, using astrometry from Gaia, gravitational waves from LIGO and LISA, and synoptic photometry from the Zwicky Transient Facility (ZTF), Legacy Survey of Space and Time (LSST), TESS, and others. The addition of spectroscopic capabilities is crucial to the prospects for discovery and characterization.

Efforts in theory and computation need to go hand in hand with observations.

ComCam Engineering Test Image

https://noirlab.edu/public/images/ann25002a/
https://rubinobservatory.org/news/rubin-completes-comcam-tests

Announcements



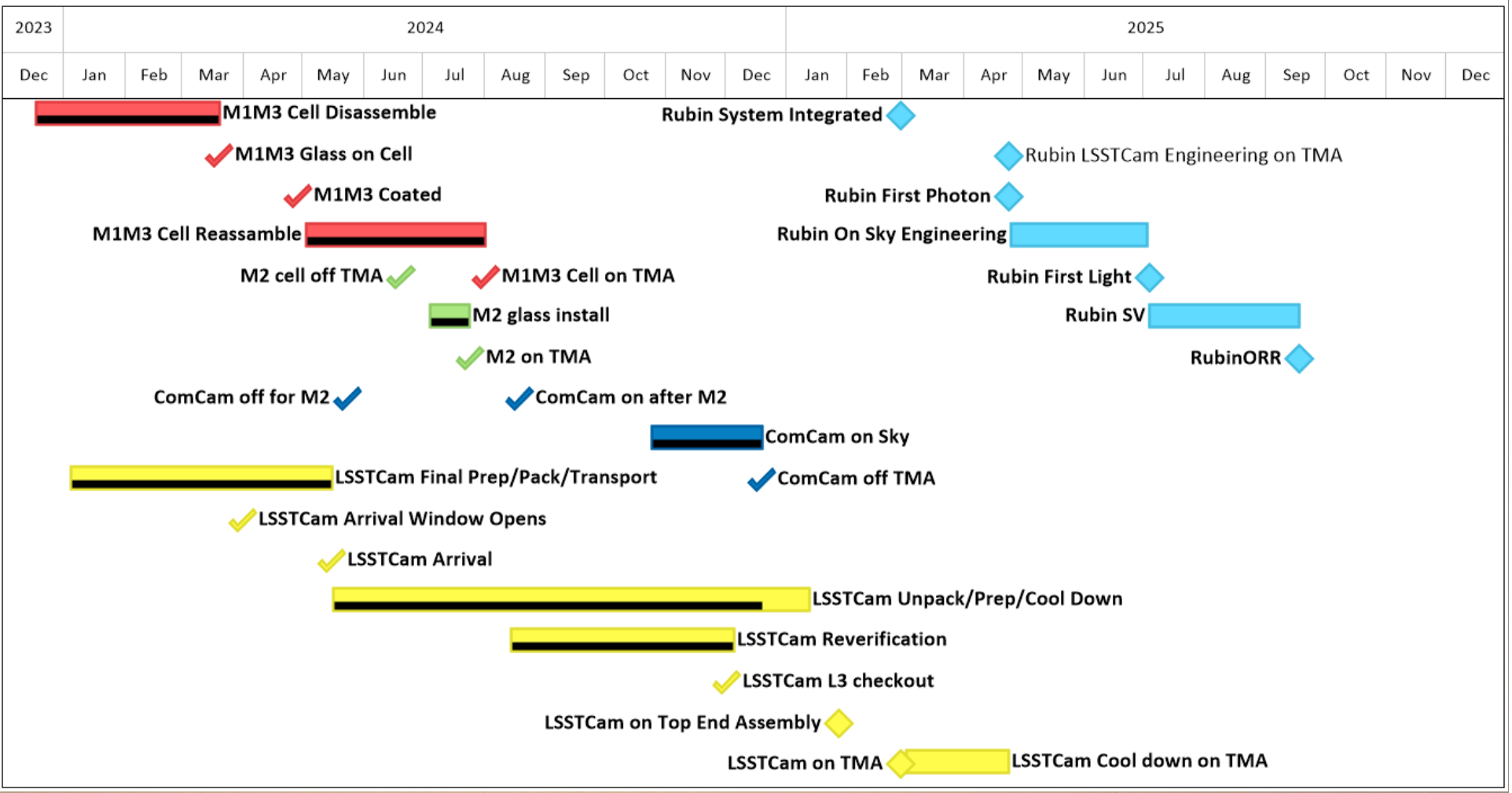
https://rubinobservatory.org/news/rubin-completes-comcam-tests

← A shareable ComCam image has been released.

From Rubin Science Assembly January 23°, Melissa Graham

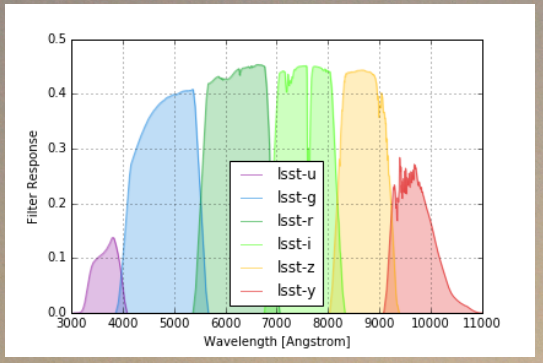
ls.st/dates

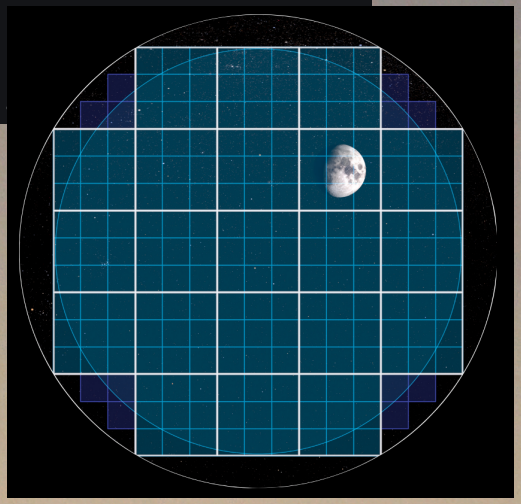
Rubin Key Activities December 2024



The New York Times

Vera Rubin Gets a Telescope of Her Own





VERA C. RUBIN OBSERVATORY
LEGACY SURVEY OF SPACE AND TIME

Decade-long, wide, fast, deep survey (optical)

8-meter class wide-field ground based telescope

Over 5 million images and catalogs with more than 37 billion objects and 7 trillion sources

Tens of billions of time-domain events will be detected and alerted on in real-time

Rubin Observatory Receives Two Guinness World Records for Its Camera and Lenses

The project is recognized for having the highest-resolution digital camera and the largest lenses in the world

21 October 2021

Each image spans 9.6 square degrees

Sara (Rosaria) Bonito – INAF – Osservatorio Astronomico di Palermo (Italy)

Telescope System:

- Etendue (AΩ) : 319 meter²degrees²
- Field of View : 3.5 degrees (9.6 square degrees)
- Primary mirror diameter : 8.4 m
- Mean effective aperture : 6.423 m (area weighted over FOV)
- Final f-ratio : f/1.234
- Camera weight : 6,746 lbs (3,060 kg)
- Mirror (M1+M3 glass mirror only) weight : 35,900 pounds (16,284 kg)

Imaging System:

- Pixel count : 3.2 Gpixels
- Focal plane : 189 4kx4k science CCD chips
- Pixel pitch : 0.2 arcsec/pixel
- Pixel size : 10 microns
- Filling factor : >90%
- Minimum exposure time : 1 sec

Throughput:

- 5-sigma point source depth: Single exposure and idealized for stationary sources after 10 years,
    - u : 23.9, 26.1
    - g : 25.0, 27.4
    - r : 24.7, 27.5
    - i : 24.0 , 26.8
    - z : 23.3, 26.1
    - y : 22.1, 24.9

(https://smtn-002.lsst.io : Calculating Rubin Observatory limiting magnitudes and SNR)

Site Stats:

- Median Atmospheric PSF with outer scale of 30m: 0.67" (Tokovinin)
- Site: El Penon, Cerro Pachon, Chile
- Site coordinates: latitude -30:14:40.68 longitude -70:44:57.90
- Altitude: 2647m
- Site observatory code: TBD
- Photometric time: 53% of night time (estimated)

Observation Properties:

- Standard visit exposures (expected) : 2 x 15 sec.
- Median (Mean) visit time : 39s (42.2s)
- Photometric accuracy : 10 mmag
- Astrometric accuracy : 50 mas
- Astrometric precision : 10 mas

Dataset properties:

- Nightly data size: 20TB/night
- Final database size (DR11) : 15 PB
- Real-time alert latency : 60 seconds

Data Releases:

- Survey duration : 10 years
- Number of Data Releases : 11
- Number of objects (full survey, DR11):
    - 20B galaxies
    - 17B resolved stars
    - 6M orbits of solar system bodies
    - Average number of alerts per night: about 10 million

LSST data products are organized into three main categories:

The LSST data products are organized into three main categories.

Prompt Data Products

Real Time Difference Image Analysis (DIA)

- A stream of ~10 million time-domain events per night (Alerts), transmitted to event distribution networks within 60s of camera readout.
- Images, Object and Source catalogs derived from DIA, and an orbit catalog for ~6 million Solar System bodies within 24h.
- Enables discovery and rapid follow-up of time domain events

Data Release Data Products

Reduced single-epoch & deep co-added images, catalogs, reprocessed DIA products

- Catalogs of ~37 billion objects (20 billion galaxies, 17 billion stars), ~7 trillion sources and ~30 trillion forced source measurements.
- 11 Data Releases, produced ~annually over 10 years of operation
- Accessible via the LSST Science Platform & LSST Data Access Centers.

User Generated Data Products

User-produced derived, added-value data products

- Deep KBO/NEO, variable star classifications, shear maps, etc …
- Enabled by services & computing resources at the LSST DACs and via the LSST Science Platform (LSP).
- 10% of LSST computing resources will be allocated for User Generated data product storage & processing.

You will get LSST data via the Rubin Science Platform

LSST Data Product Categories & DM Data Products & LSST Key Numbers

LSST Data Products: see http://ls.st/dpdd

by Željko Ivezić - Director of Rubin Observatory Construction

Rubin LSST@Europe 4 – Rome (Oct. 24-28, 2022)

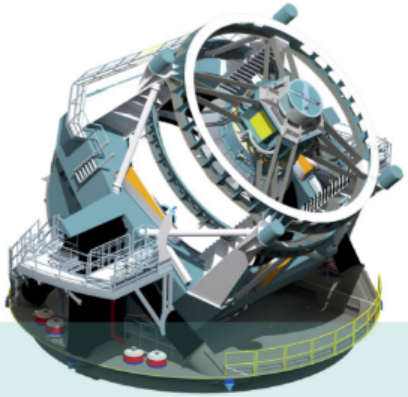
(Rubin LSST@Europe 4: organized in Rome with **LSST Corporation grants, PI: Bonito**)

Alert Production provides a world-public, near-real-time stream of LSST-identified transient, variable, and moving objects.

VERA C. RUBIN OBSERVATORY

Raw Data: 20TB/night

Sequential 30s images covering the entire visible sky every few days



LSST SCIENCE PIPELINES

Prompt Data Products

- Alerts incl. science, template and difference image cutouts — 60s — via Alert Streams
- Catalogs of detections incl. difference images, transient, variable & solar system sources — 24h — via Prompt Products
- Raw & processed visit images (PVIs), difference images — 80h — via Image Services

Data Release Data Products

Final 10yr Data Release:

- Images: 5.5 million x 3.2 Gpixels
- Catalog: 15PB, 37 billion objects

via Data Releases

Community Brokers

Rubin Data Access Centres (DACs)

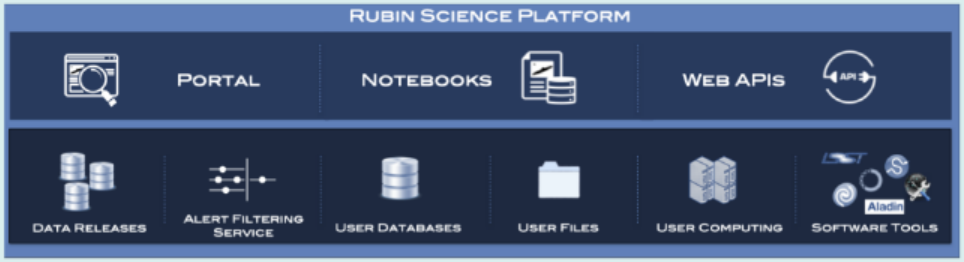
USA (USDF)
Chile (CLDF)
France (FRDF)
United Kingdom (UKDF)

Independent Data Access Centers (IDACs)

Access to proprietary data and the Science Platform require Rubin data rights

Rubin Science Platform

Provides access to LSST Data Products and services for all science users and project staff.



Credit: Leanne Guy

Rubin Science Platform

Portal

Discover data in the browser

Learn more about the portal.

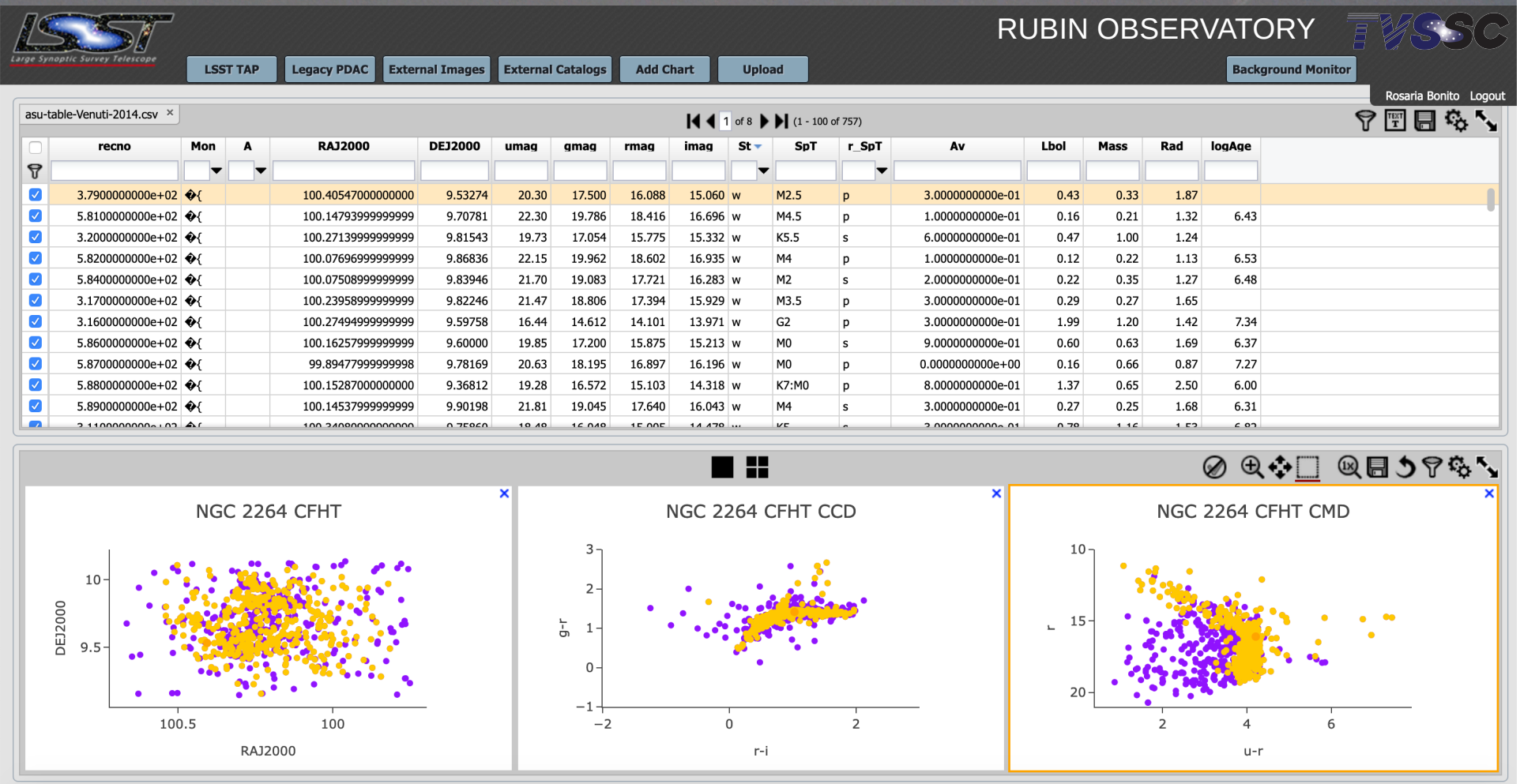
Notebooks

Process and analyze LSST data with Jupyter notebooks in the cloud

Learn more about notebooks.

APIs

Learn how to programatically access data with Virtual Observatory interfaces



Venuti et al. 2014

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File Edit View Run Kernel LSST Tabs Settings Help

/ notebooks / StackClubCourse /

Name	Last Modified
Session01	2 months ago
Session02	a month ago
Session03	17 days ago
Session04	2 months ago
Session05	2 months ago
Session06	17 days ago
testdata_cfht	Jul 27, 2020 8:07 PM
bokeh_NGC2264_CF...	9 days ago
bokeh_NGC2264_exa...	a month ago
bokeh_NGC6569_all_...	5 days ago
bokeh_NGC6569_exa...	a month ago
bokeh_NGC6569_exa...	22 days ago
bokeh_NGC6569_RRL...	5 days ago
bokeh_V1118Ori_exam...	17 days ago
bokeh_V1118Ori_exam...	20 days ago
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N19_withRRL.fits	5 days ago
README.md	2 months ago
RRall.fits	5 days ago
sara-2.ipynb	a month ago
sara-carina.ipynb	22 days ago

cluster.ipynb | DataInventory.ipynb | Exploring_A_Data_Repo.ipy | sara-exploring-data-repo-

Markdown git LSST

LSST Ca | cataloga | bokeh_ir | bokeh_h | afw_disp | matplotli | DataProc | IntroToD | bot_proc | intro-prc

Markdown git LSST

Stack Club Course Session 6: Data Products To Science

Owner(s): **Bryce Kalmbach** (@jbkalmbach)

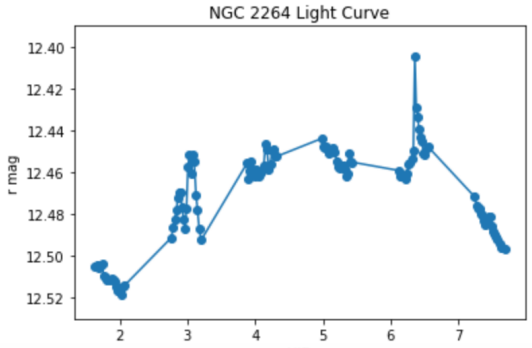
Last Verified to Run: **2020-06-11**

sara.ipyr | sara-car | sara-NG | sara-NG | sara-NG | sara-hol | sara-NG | sara-NG | sara-EX(| sara-EX(

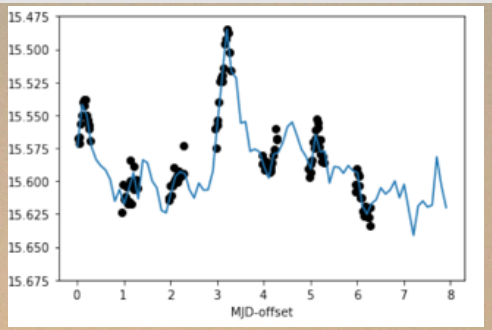
Code git LSST

```
plt.plot(HJD, r, marker='o')
plt.ylim(12.53,12.39)
plt.xlabel('HJD')
plt.ylabel('r mag')
plt.title('NGC 2264 Light Curve')
```

[10]: `Text(0.5, 1.0, 'NGC 2264 Light Curve')`



Bonito & Hartigan et al. 2018 (WP for Rubin LSST Cadence Optimization)



Bonito & Venuti et al. 2021

Bonito & Venuti et al. ApJS 2023

0 25 LSST | Idle Mode: Command Ln 1, Col 1 DataProductsToScience.ipynb

Sara (Rosaria) Bonito – INAF – Osservatorio Astronomico di Palermo (Italy)

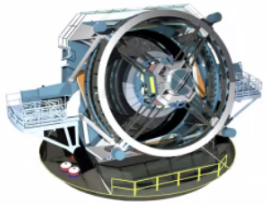
BIG DATA

Introduction to Alerts and Brokers

Rubin/LSST will provide detections of…

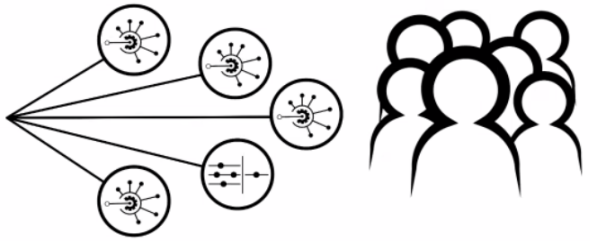
- Billions of stars and galaxies (*over 10-year survey*)
- Millions of transients, variables, and moving objects (*every night!*)

…***a data set of unprecedented volume and complexity.***



Difference Image Analysis (DIA)

In 60s, raw images are processed, a template is subtracted, and difference-image sources are detected, associated, characterized, and…



…distributed as ***alerts*** to ***brokers***, where they can be rapidly analyzed by users.

An alert contains data for a 5σ difference-image source, including astrometry, photometry, 12-month light curve history, and characterization parameters*.

*Alert contents: Section 3.5.1, ls.st/dpdd

Rubin Science Assembly March 6, 2025 Ryan Lau (Melissa Graham)

Brokers: access Rubin alerts in real time

Brokers are software systems that will ingest, process, and serve astronomical alerts from Rubin Observatory and other surveys to the broader scientific community.

Typical broker functionality includes watch lists, user-defined alert filters, cross-match with archival catalogs, classification (prioritization for follow-up observations) – through browser-based user interfaces.

The data in the alert packet is also available in the Prompt Products Database (PPDB) within 24 hours. The PPDB is accessible via the RSP.

Available now: several brokers are already processing ZTF alerts for users.

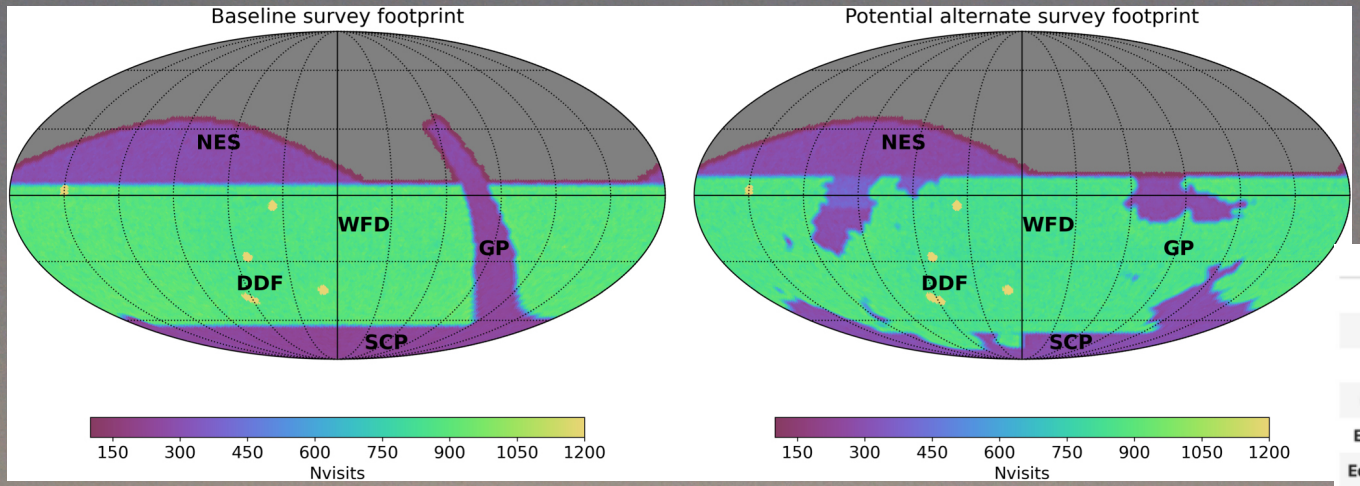
See www.lsst.org/scientists/alert-brokers for more information.

Full-Stream Brokers
- Alerce
- AMPEL
- ANTARES
- BABAMUL
- Fink
- Lasair
- Pitt-Google

Downstream Brokers
- SNAPS
- POI: Variables

Rubin LSST OpSim

Bianco et al. 2022, ApJS



from 2x15s to a single 30s gain in efficiency equivalent to ~7-9% of the survey time;

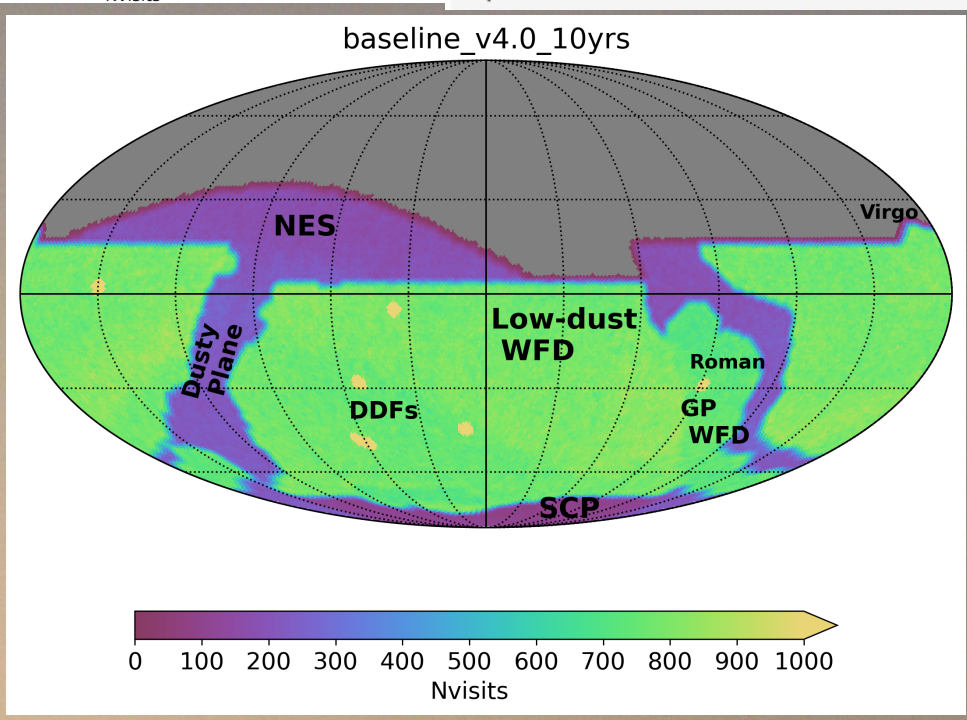
5 DDF pointings:
6-7% of overall survey time

	ELAISS1	XMM_LSS	ECDFS	COSMOS	EDFS_a	EDFS_b
RA	9.45	35.71	53.12	150.10	58.90	63.60
Dec	-44.00	-4.75	-28.10	2.18	-49.32	-47.60
Gal l	311.30	171.21	224.07	236.83	257.89	254.48
Gal b	-72.91	-58.77	-54.47	42.09	-48.46	-45.77
Eclip l	346.68	31.74	40.99	151.40	32.01	40.97
Eclip b	-43.18	-17.90	-45.47	-9.39	-66.60	-66.60

THE ASTROPHYSICAL JOURNAL
SUPPLEMENT SERIES

Peer Reviewed Survey Strategy Papers

21 published papers! 168 authors!



Survey Cadence Optimization Committee's Phase 3 Recommendations
The Rubin Observatory Survey Cadence Optimization Committee
PSTN-056
Latest Revision: 2024-10-01

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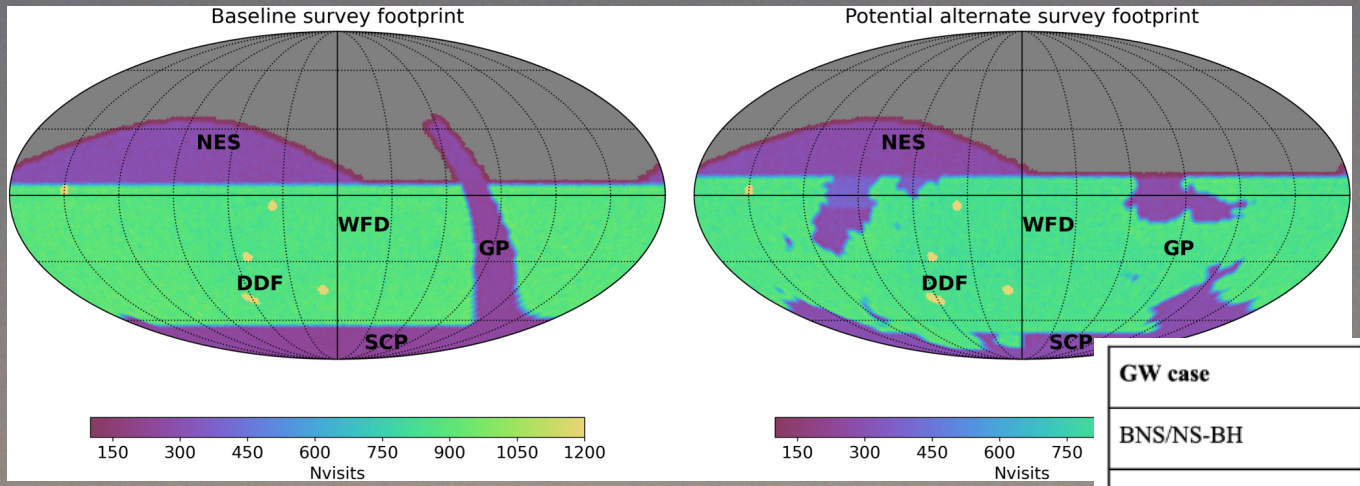
Rubin LSST OpSim

Bianco et al. 2022, ApJS



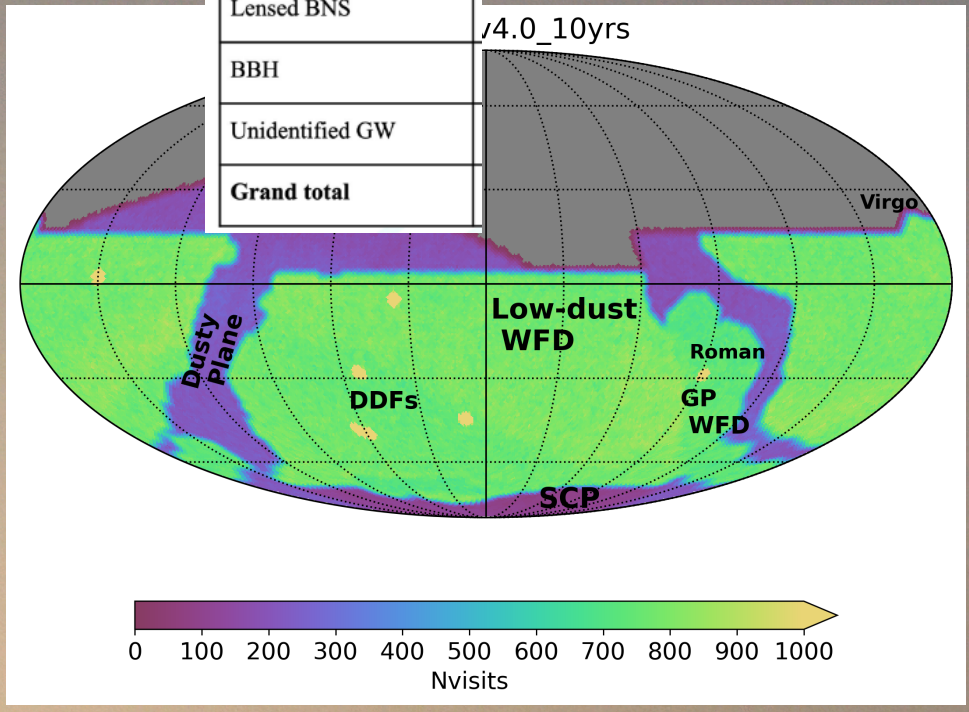
ToO

SCOC Rubin LSST + WST:

"together will unravel the population of BNS systems, the physics of neutron stars…"

GW case
BNS/NS-BH
Lensed BNS
BBH
Unidentified GW
Grand total

Galactic Plane (GP) inputs from the community (e.g. microlensing, star forming regions, …)



Survey Cadence Optimization Committee's Phase 3 Recommendations
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PSTN-056
Latest Revision: 2024-10-01

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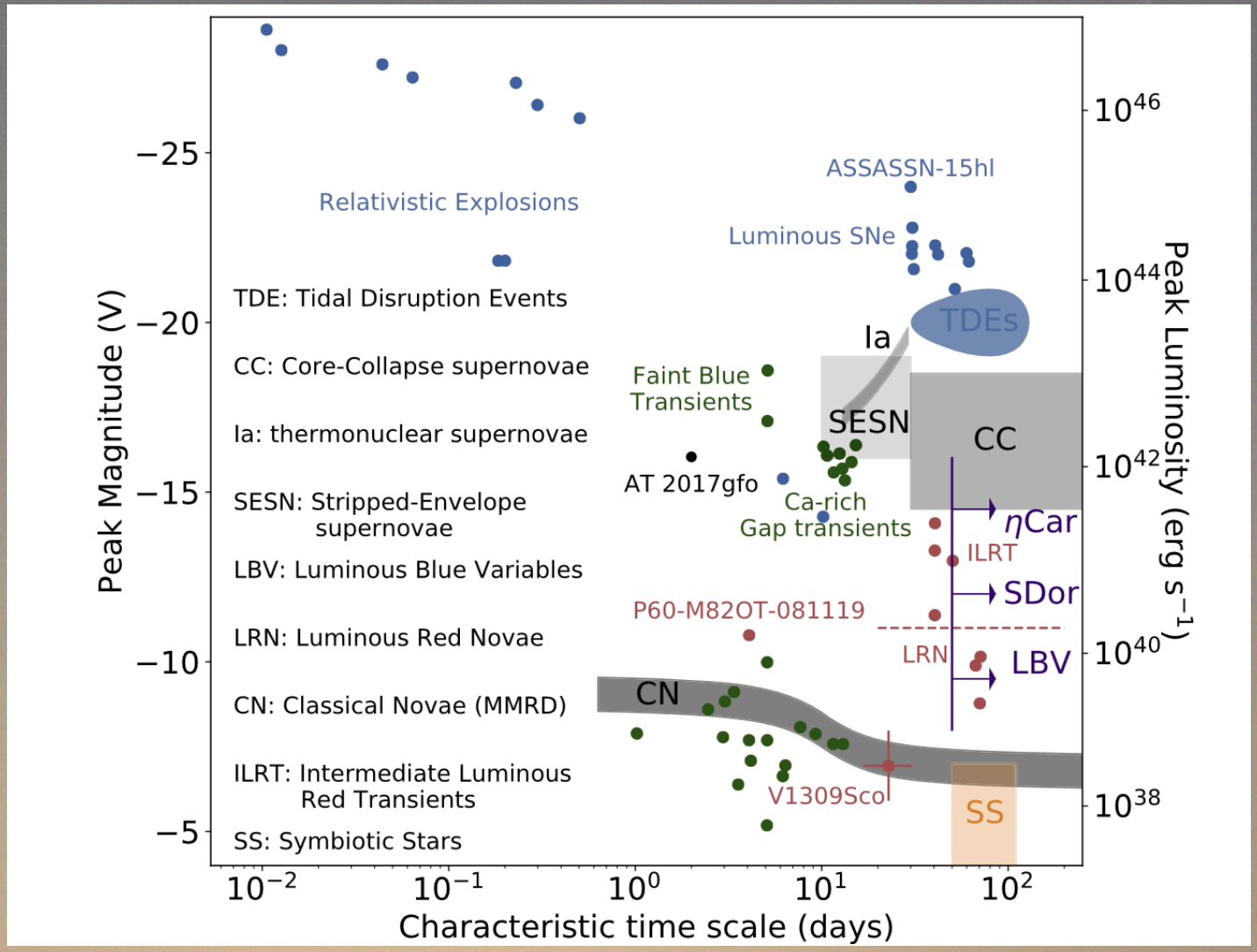
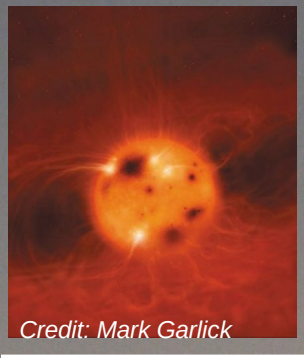
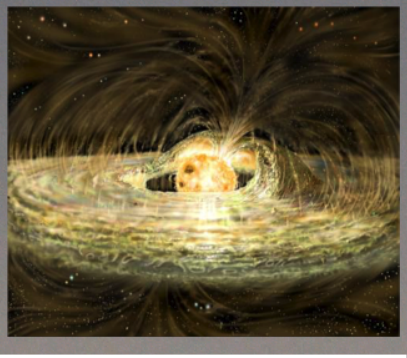
Rubin LSST Timescales



Ivezic et al. 2019

The photometric variability of young stars





Artist's impressions of the surface of a young star (left) and of a young star accreting from the circumstellar disk (right).

- *Young stars are intrinsically variable at all wavelengths and on any given timescale from hours to decades*.
- Although not necessarily the most intense, *the typically predominant variability is that observed over timescales of days to weeks* (corresponding to the timescales over which a young star completes a full rotation cycle around its axis).

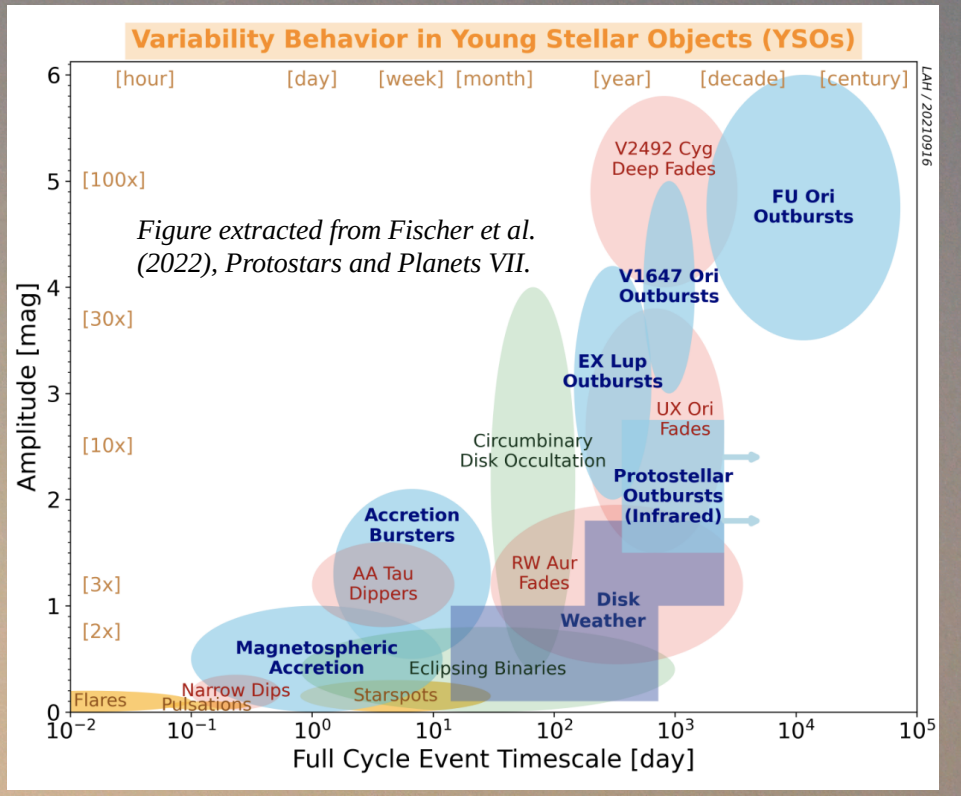
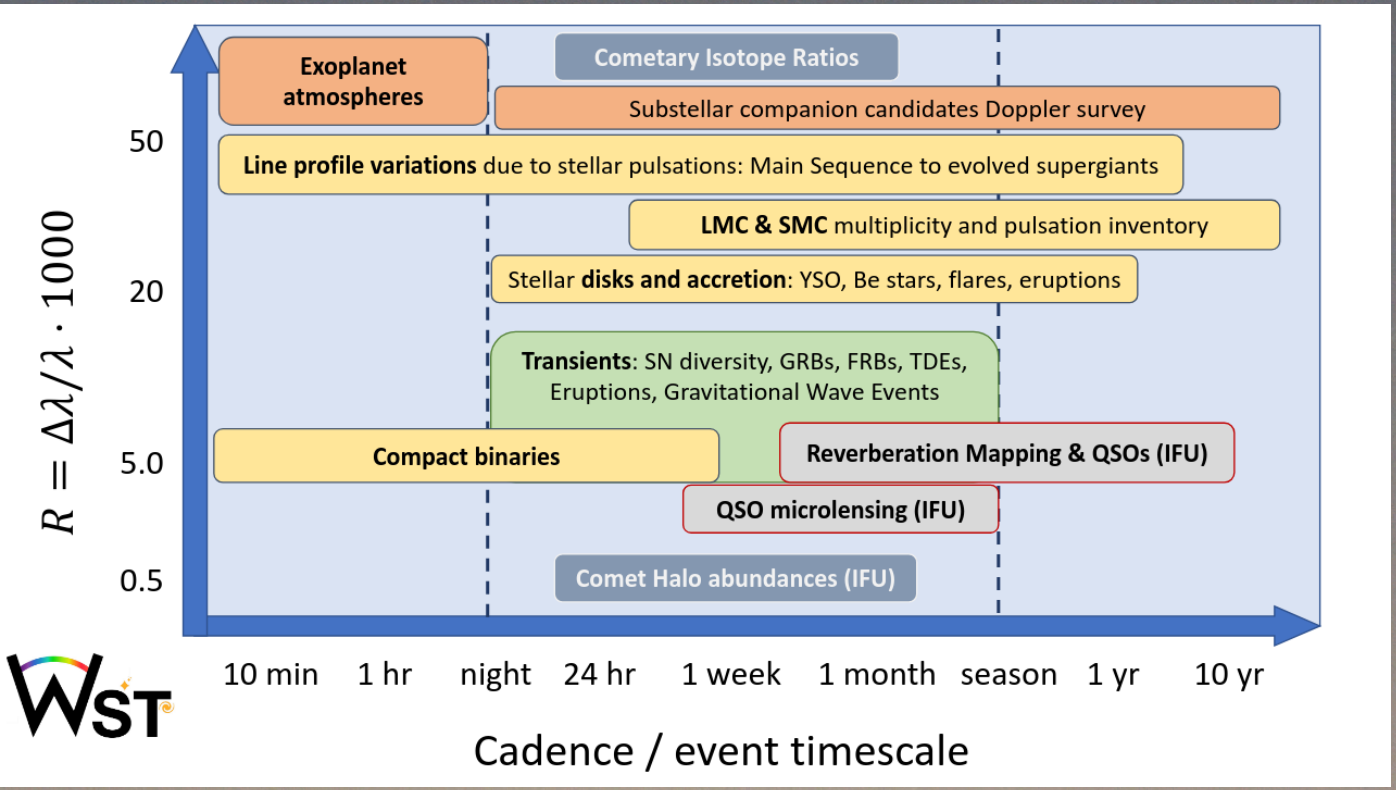


Figure extracted from Fischer et al. (2022), Protostars and Planets VII.

<u>Causes for day-to-week variability in young stars</u>:

- *Magnetic activity* -> flux modulation by starspots along the stellar rotation period (analogous to sunspots)
- *Star–disk interaction* -> variable emission from accretion shocks and variable mass load onto accretion columns
- *Star–disk geometry* -> varying visibility of different structures of the star-inner disk enviroment
- All abovementioned effects are typically blended in the specific variability behavior we observe for a given star

Courtesy of Laura Venuti



WP WST (https://arxiv.org/pdf/2403.05398) Figure 6: Sketch of time-variable phenomena that WST will observe alongside approximate indications of suitable spectral resolution and variability timescales

WST: spectroscopic information (precise radial velocities, metallicities, elemental abundances and other stellar properties, reaching distant and faint populations)

comprehensive local volume (D< 25 Mpc) IFS survey: will deliver spatially-resolved stellar and nebular spectroscopic data at exquisite resolution This will complement similar imaging campaigns undertaken...shortly with Rubin LSST

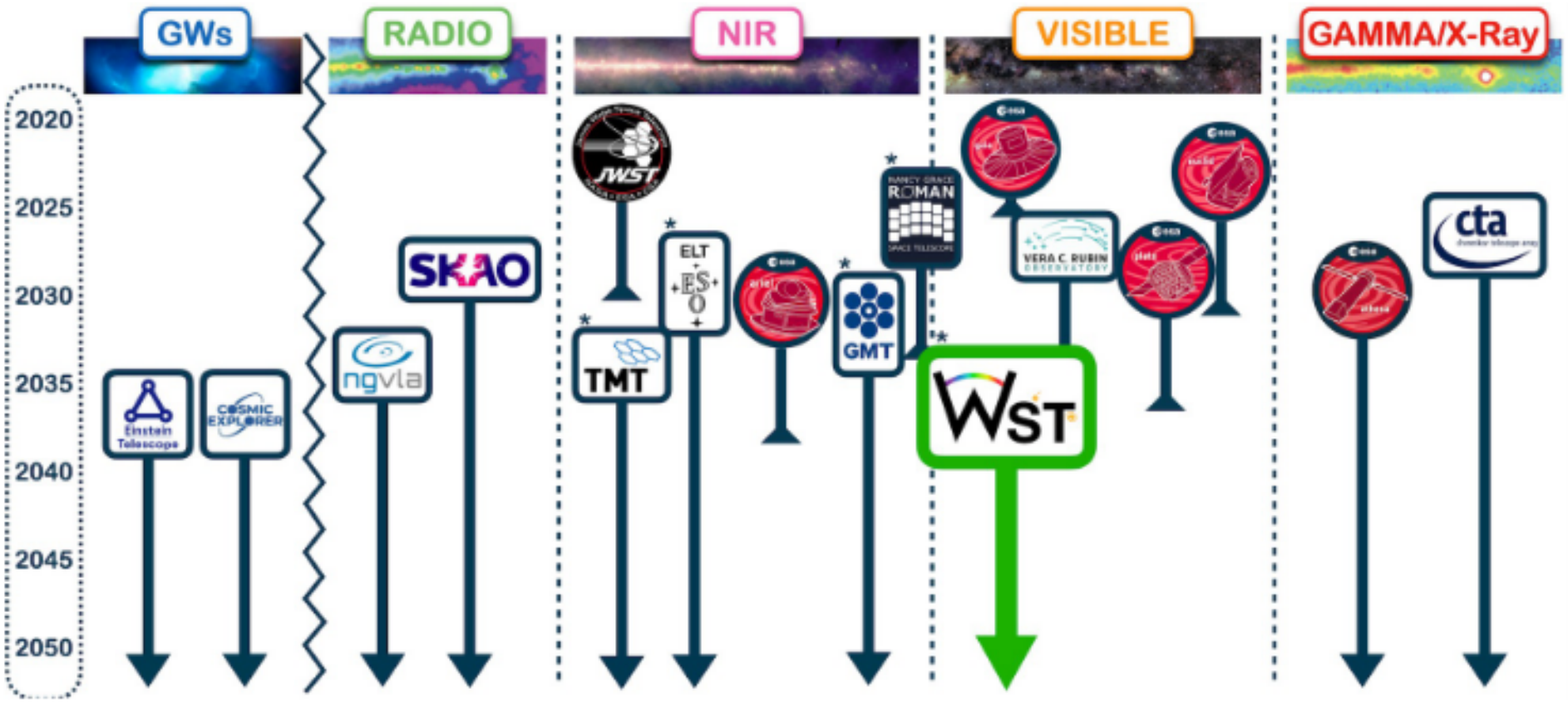
Astronomy has definitely entered in the era of big data volumes: major current and up-
coming facilities will provide astronomical data across the entire electromagnetic spectrum
at a rate never seen before. In particular over the next decade we expect a deluge of high-
quality imaging data from upcoming ground-based (e.g., Rubin LSST, SKA, CTA) and space
(JWST, Euclid, Roman Space Telescope, ATHENA) telescopes

ASTRONET Roadmap 2022-2035 for Astronomy

synergies between such new facility and other major astronomical capabilities (e.g. JWST, Rubin LSST, Euclid)

Decadal 2020 (US) + Long Range Plan (Canada): spectroscopy 10-m/Rubin LSST, Roman, ...

Rubin LSST & WST



WP WST (https://arxiv.org/pdf/2403.05398) Figure 4

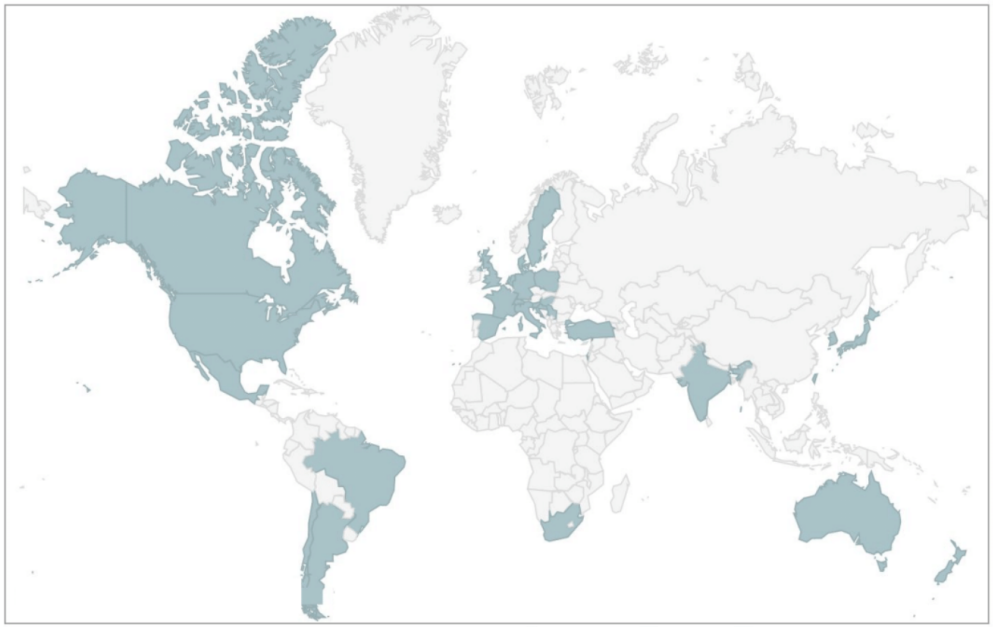
Najita et al. 2016, arXiv:1610.01661: Maximizing Science in the Era of LSST
"As a discovery machine and exploration portal for the astronomy and physics communities, LSST will enable many discoveries based on LSST data alone. At the same time, the scientific legacy of LSST will be richer and more diverse when supporting ground-based OIR resources are available to complement LSST data and follow up LSST discoveries"

Follow-up resources crucial for classification and characterization in particular for transient science

Sara (Rosaria) Bonito – INAF – Osservatorio Astronomico di Palermo (Italy)

In-Kind Program and Science Collaborations

There are 43 individual international teams (30 countries) providing 153 in-kind contributions to Rubin and the LSST science community in return for LSST data rights.



Diverse set and scope

- Observatory offsets/operations
- Telescope Time
- IDACs/SPC
- Datasets
- Software

WST

Cosmology
galaxy assembly, evolution, and enrichment
Milky Way
origin of stars and planets
time domain
multi-messenger astrophysics

- Understanding Dark Energy and the nature of Dark Matter,
- Cataloging the Solar System
- Exploring the Transient and Variable Sky
- Exploring the Milky Way Structure & Formation

Transients and Variable Stars Science Collaboration

https://lsst-tvssc.github.io/

CO-CHAIRS

Igor Andreoni

University of Maryland

NASA Goddard Space Flight Center

Sara Bonito

INAF

Osservatorio Astronomico di Palermo

CONTACT

Contact the co-Chairs for more information:

Igor Andreoni - andreoni at umd.edu

Sara Bonito - rosaria.bonito at inaf.it

https://youtu.be/MXQQzbC5HxY

INTERNATIONAL COLLABORATION

MEMBERS

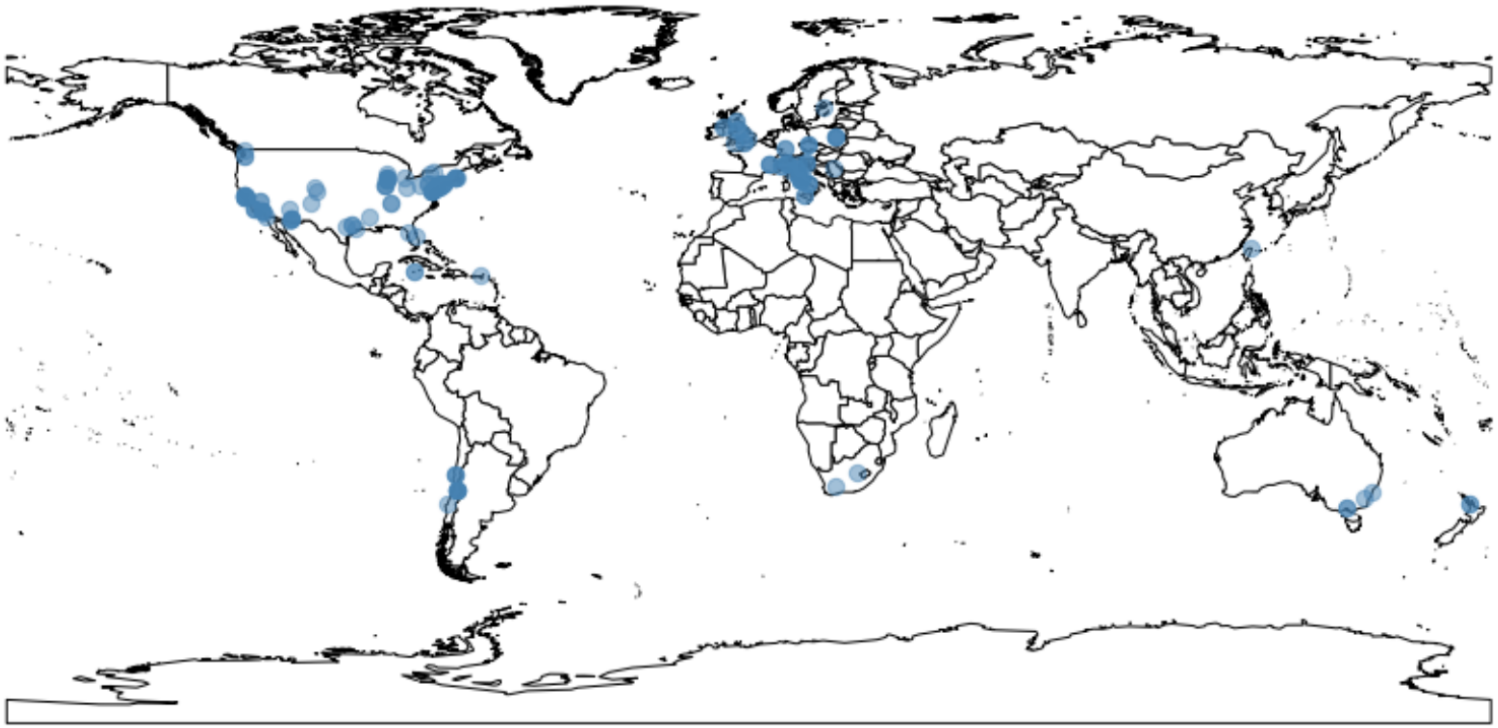
JUNE 2020

TVSSC

VERA C. RUBIN OBSERVATORY

TVS HAS OVER 400 MEMBERS IN 17 COUNTRIES WORLDWIDE

> 500



TVSSC

SUBGROUPS

JEDI: JUSTICE, EQUITY, DIVERSITY & INCLUSION

coordinators: Sara Bonito, INAF - Osservatorio Astronomico di Palermo

ANOMALIES AND TRUE NOVELTIES

coordinator: Federica Bianco, University of Delaware

CLASSIFICATION & CHARACTERIZATION

coordinators: Nina Hernitschek, Vanderbilt

DATA VISUALIZATIONS AND CHARACTERIZATIONS

coordinators: Sabina Ustamujic, Sally Macfarlane

FAST TRANSIENTS

coordinator: Shar Daniels, Unviersity of Delaware

SUPERNOVAE

coordinators: Fabio Ragosta, UW

TIDAL DISRUPTION EVENTS

coordinators: Sjoert van Velzen, Leiden Observatory

NON-DEGENERATE ERUPTIVE VARIABLES

coordinators: Sara Bonito, INAF

PULSATING VARIABLES

coordinators: Kelly Hambleton, Villanova

DISTANCE SCALES

coordinators: Marcella Marconi, INAF - Osservatorio Astronomico di Capodimonte Lovro Palaversa, Ruđer Bošković Institute

INTERACTING BINARIES

coordinator: Andrej Prsa, Villanova Paula Szkody, UW

MICROLENSING SUBGROUP

coordinators: Somayeh Khakpash, UDelaware

MULTIWAVELENGTH CHARACTERIZATION AND COUNTERPARTS

coordinators: Raffaella Margutti, NorthWestern

TASK FORCES

SURVEY STRATEGY TASK FORCE

Coordinator: Rachel Street

This task force coordinates work by TVS members relating to all aspects of survey strategy, in particular working on papers for the planned special edition publication of Cadence Notes. The group also coordinates with similar task forces from other Science Collaborations with overlapping science interests.

DATA PREVIEW 0 TASK FORCE

Coordinator: Sara Bonito

Vincenzo Petrecca

This task force is working on a range of projects undertaken for Data Preview 0, and serves as a forum for members to share their progress and troubleshoot issues. In the course of these projects, members will evaluate the functionality of the Rubin Science Platform for their science.

SOFTWARE TASK FORCE

Coordinator: Federica Bianco

All of the science that TVS will do during LSST will depend on having access to software tools capable of handling LSST data, the rate at which it is delivered, and interfacing with key services in the Rubin "ecosystem" such as alert brokers and the Rubin Science Platform. Rubin's recent call to solicit international in-kind contributions has resulted in a number of teams committing to providing software development effort to be guided by TVS towards software that will benefit our members. This task force will help to conceive and design software that needs to created from scratch or adapted for Rubin, and begin to work with international teams to oversee the development of that software.

CROWDED FIELDS PHOTOMETRY TASK FORCE

Coordinator: Massimo Dall'Ora

This task force will continue the productive collaboration started in previous years. It will continue to evaluate the quality of photometry that can be produced from Rubin data products in crowded star fields, and its application for variable star science. We suggest this task also focuses on writing a comprehensive report of their activities up to now.

COMMISSIONING TASK FORCE

Coordinator: Markus Rabus

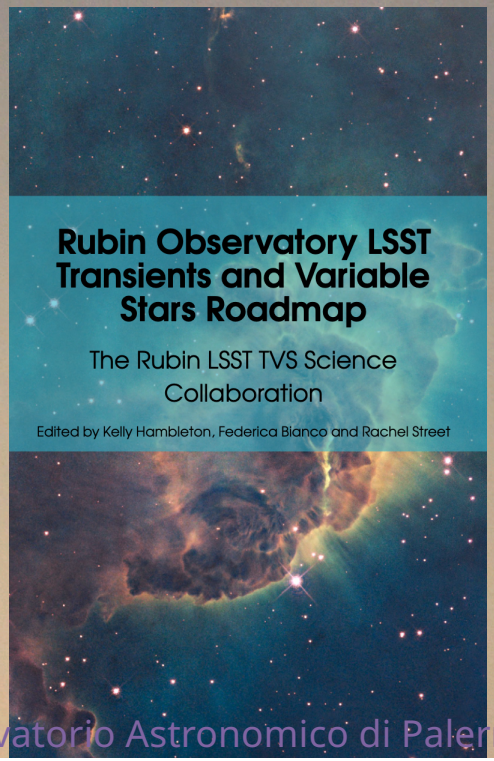
This task force will liaise with the Rubin commissioning staff, continuing to provide scientific input on activities and observations that benefit TVS science in the commissioning phase of the project.

TVS ROADMAP

https://doi.org/10.1088/1538-3873/acdb9a

(Peer reviewed paper, Hambleton et al., PASP)

Microlensing
Eclipsing Binary Stars
Cataclysmic Variables
Intermediate-Luminosity Optical Transients
Light Echoes of eruptions and explosions
EM counterparts of GW events
Neutron Star Binaries
Black Hole Binaries
Supernovae
Tidal Disruption Events



Young stellar objects
Pulsating Stars
Cepheids and RR Lyrae Stars
Long Period Variables
Brown Dwarfs
GRB
Blazars
Inclusion
Alert Brokers
SETI

VERA C. RUBIN OBSERVATORY

TVSSC

Sara (Rosaria) Bonito – INAF – Osservatorio Astronomico di Palermo (Italy)

TVS ROADMAP

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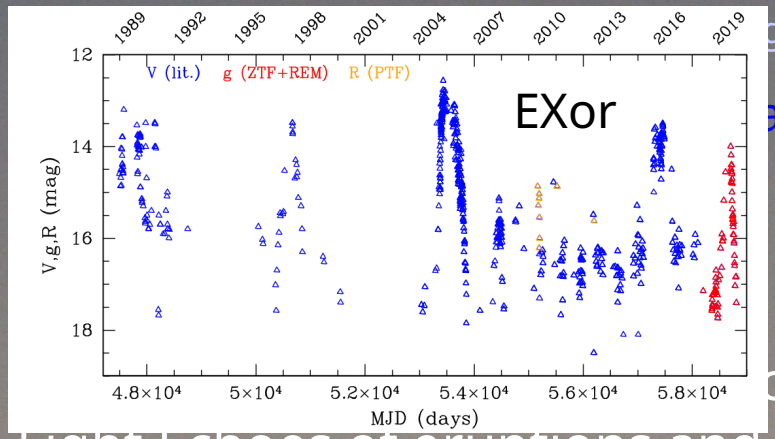

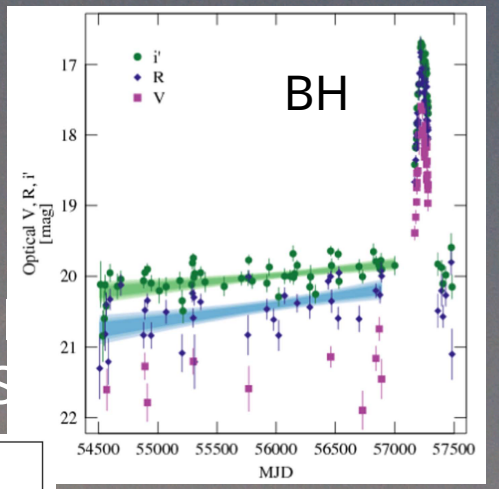

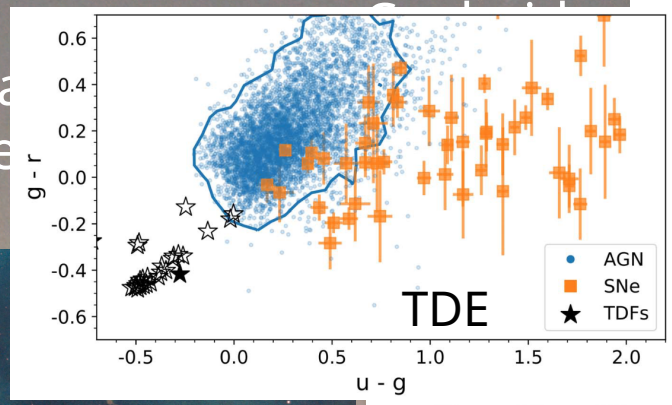

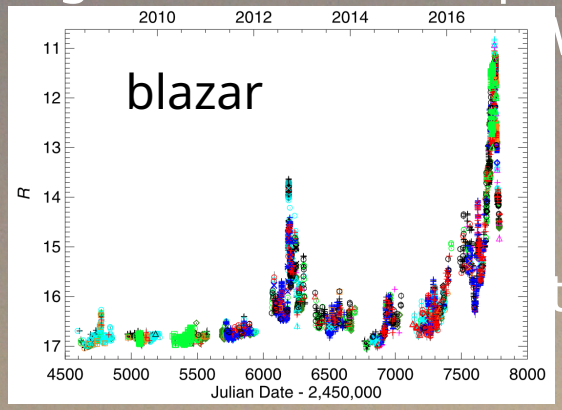

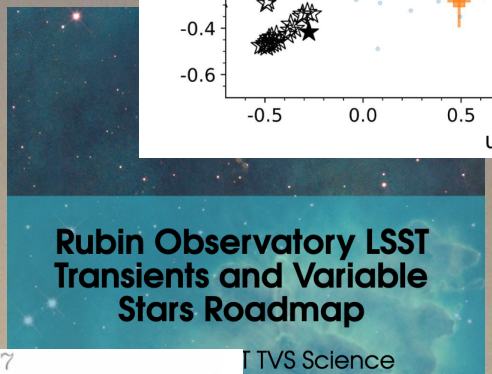

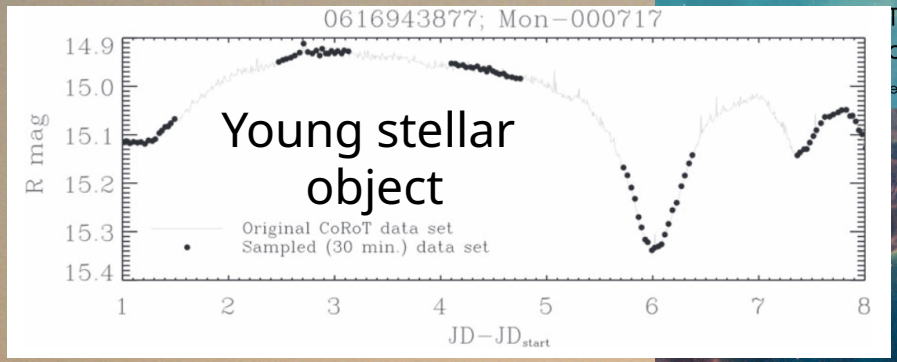

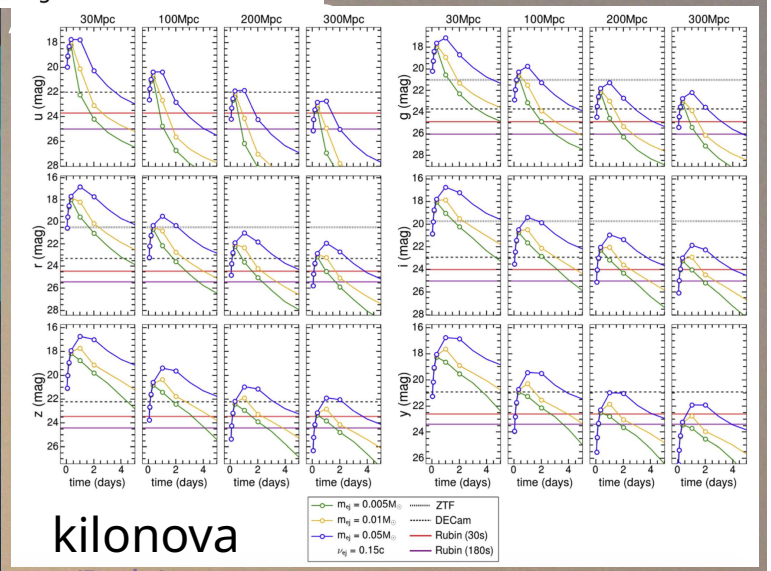

Sara (Rosaria) Bonito – INAF – Osservatorio Astronomico di Palermo (Italy)

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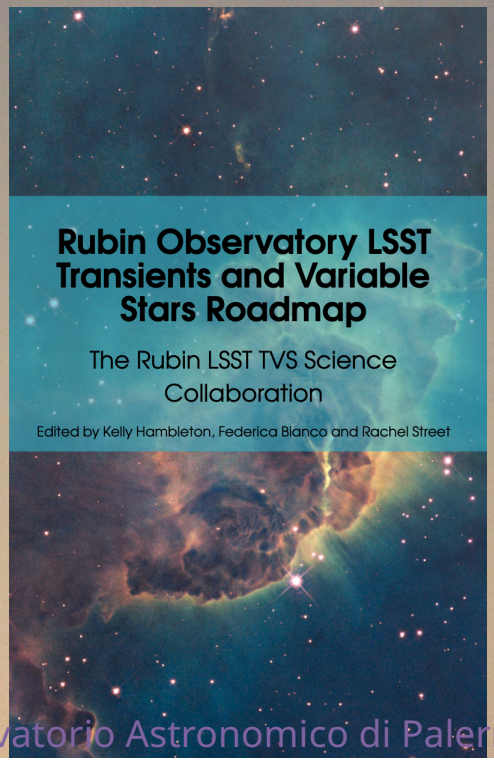


VERA C. RUBIN OBSERVATORY

Science roadmaps (e.g. TVS; SMWLV-Star clusters; DESC; AGN; SLSC in prep; Solar System; Galaxies)
(from Will Clarkson slides, April 2024)

Rubin LSST Survey Strategy Optimization

Preparing to Discover the Unknown with Rubin LSST: Time Domain - X. Li+ 2022 ApJS 258 2
Blazar Variability with the Vera C. Rubin Legacy Survey of Space and Time - C. M. Raiteri+ 2022 ApJS 258 3
The Impact of Observing Strategy on the Reliable Classification of Standard Candle Stars: Detection of Amplitude, Period, and Phase Modulation (Blazhko Effect) of RR Lyrae Stars with LSST - N. Hernitschek+ 2022 ApJS 258 4
Optimizing Cadences with Realistic Light-curve Filtering for Serendipitous Kilonova Discovery with Vera Rubin Observatory - I. Andreoni+ 2022 ApJS 258 5
Give Me a Few Hours: Exploring Short Timescales in Rubin Obs. Cadence Simulations - E. Bellm, ..., IA+ 2022 ApJS 258 13
Target-of-opportunity Observations of Gravitational-wave Events with Vera Rubin Obs. - I.Andreoni+ 2022 ApJS 260 18
The LSST Era of Supermassive Black Hole Accretion Disk Reverberation Mapping - A. B. Kovačević+ 2022 ApJS 262 49
Young Stellar Objects, Accretion Disks, and Their Variability with Rubin Observatory LSST - R. Bonito & Venuti+ 2023 ApJS 265 27
Light-curve Recovery with the Vera Rubin Observatory's LSST. I. Pulsating Stars in Local Group Dwarf Galaxies - M. Di Criscienzo+ 2023 ApJS 265 41
LSST Survey Strategy in the Galactic Plane and Magellanic Clouds - R. A. Street+ 2023 ApJS267 15
Rubin Observatory's Survey Strategy Performance for Tidal Disruption Events - K. BučarBricman+ 2023 ApJS 268 13
An Evenly Spaced LSST Cadence for Rapidly Variable Stars - E. Feigelson + 2023 ApJS 268 11
Rubin LSST Observing Strategies to Maximize Volume and Uniformity Coverage of Star-forming Regions in the Galactic Plane - L. Prisinzano + 2023 ApJS 265 39

Microlensing Discovery and Characterization Efficiency in the Vera C. Rubin Legacy Survey of Space and Time - N. S. Abrams, M. Hunterdmark et al., in review
Transient Dwarf Novae detection using the LSST Marais, Buckley et al., in review
Kilonova parameters estimation with LSST at Vera C. Rubin Observatory – Ragosta et al., accepted

Every Datapoint Counts: Stellar Flares as a Case Study of Atmosphere Aided Studies of Transients in the LSST Era - Clarke et al., in review

Sara (Rosaria) Bonito – INAF – Osservatorio Astronomico di Palermo (Italy)

Rubin LSST @ EAS

https://eas.unige.ch/EAS2025/session.jsp?id=SS5

Special Session SS5 25 June 2025

The Vera C. Rubin Observatory Legacy Survey of Space and Time: a European pathway from First Look to data flows

Aims and scope

Starting in 2025, the NSF-DOE Vera C. Rubin Observatory will conduct an unprecedented 10-year optical survey of the Southern Sky, the Legacy Survey of Space and Time (LSST). With its 3.2 Gigapixel camera (LSSTCam), Rubin Observatory will capture the entire visible sky every ~3 nights, delivering multi-color *ugrizy* images of unparalleled depth (r~24 mag; r~27 mag in 10-year stacks), and remarkable photometric and astrometric accuracy.

The survey is expected to characterise 20 billion galaxies, 17 billion resolved stars, 6 million orbits of solar system bodies, with an average number of real-time transient alerts of about 10 million per night. As Rubin Observatory will provide only general-use data products and analysis tools, the development of specialised tools and products is left to the expertise of the community, with the LSST Science Collaborations leading such effort. European scientists are already contributing to Rubin through a variety of in-kind contributions ranging from data and computing facilities to software development. With the imminent start of survey operations and the first science-grade LSSTCam images planned to be released in June 2025, as part of Rubin's 'First Look' event, this session is an opportunity to engage with the wider community and prepare European astronomers for the first data release.

Programme

This session will focus on three main aspects:

- **The Rubin Observatory ecosystem and the role of the Science Collaborations.** We will address the science enabled by the 10-year Legacy Survey of Space and Time including the four key science pillars: probing dark energy and dark matter, cataloguing the solar system, investigating the transient and variable optical sky, and mapping the Milky Way. The role of LSST Science Collaborations and the European contributions in shaping LSST science will also be discussed.
- **Early science with public alerts and synergies with other surveys.** We will focus on early science with public alerts, including transient, variable and moving objects, how LSST alert data will flow to the end user, what services are offered by various data access facilities, i.e. 'community alert brokers', and the synergies with photometric, spectroscopic, and time-domain surveys (Gaia, Euclid, Roman, 4MOST, ASAS-SN, ZTF).
- **Doing science with Rubin-LSST, together.** We will discuss strategies and actions to promote diversity, equity and inclusion, improving data accessibility, education and public outreach within the Rubin community and international collaborations. We will also explore opportunities to engage with Rubin LSST, including research collaborations, data access, and participation in upcoming initiatives.

Scientific organisers

- Giada Pastorelli (she/her, co-Chair), University of Padova, Italy
- Matthew Temple (he/him, co-Chair), Durham University, UK
- Federica Bianco (she/her), University of Delaware, USA
- Sara (Rosaria) Bonito (she/her), INAF - Osservatorio Astronomico di Palermo, Italy
- Helmut Dannerbauer (he/him), Instituto de Astrofisica de Canarias, Spain
- Giulia De Somma (she/her), INAF - Osservatorio Astronomico di Capodimonte, Italy
- Dragana Ilic (she/her), University of Belgrade - Faculty of Mathematics, Serbia
- Andjelka Kovacevic (she/her), University of Belgrade - Faculty of Mathematics, Serbia
- Nicolas Lodieu (he/him), Instituto de Astrofisica de Canarias, Spain
- Katarzyna Małek (she/her), National Center for Nuclear Research, Poland
- Ilaria Musella (she/her), INAF - Osservatorio Astronomico di Capodimonte, Italy
- Vincenzo Petrecca (he/him), Università di Napoli Federico II, Italy
- Róbert Szabó (he/him), Konkoly Observatory, HUN-REN CSFK, Hungary
- Michele Trabucchi (he/him), University of Padova, Italy

-

First Light Event

Vera C. Rubin Observatory Legacy Survey of Space and Time (LSST)
“First Look Event", Palermo, June (July) 2025
INAF Direzione Scientifica grants (PI: Bonito)

Media: e.g. **Netflix**, **National Geographic**, Chile newspapers and many more
Soliciting expression of interest from international media incl Spanish for Chile
Educational: e.g **Smithsonian**, Masterclass - ongoing
Speakerpool & requests for interviews
Resulting from momentum building - Media contact volunteers **(INAF: Bonito, Dall’Ora, Tramuto, Rodeghiero, ...)**
Connecting with **Influencers** - EPO outreach to content creators
(Ranpal Gill’s talk, Rubin Community Workshop 2024, see also Rubin Observatory Youtube channel)

SKY SUBTRACTION AND Hα + [NII]

NGC 2264

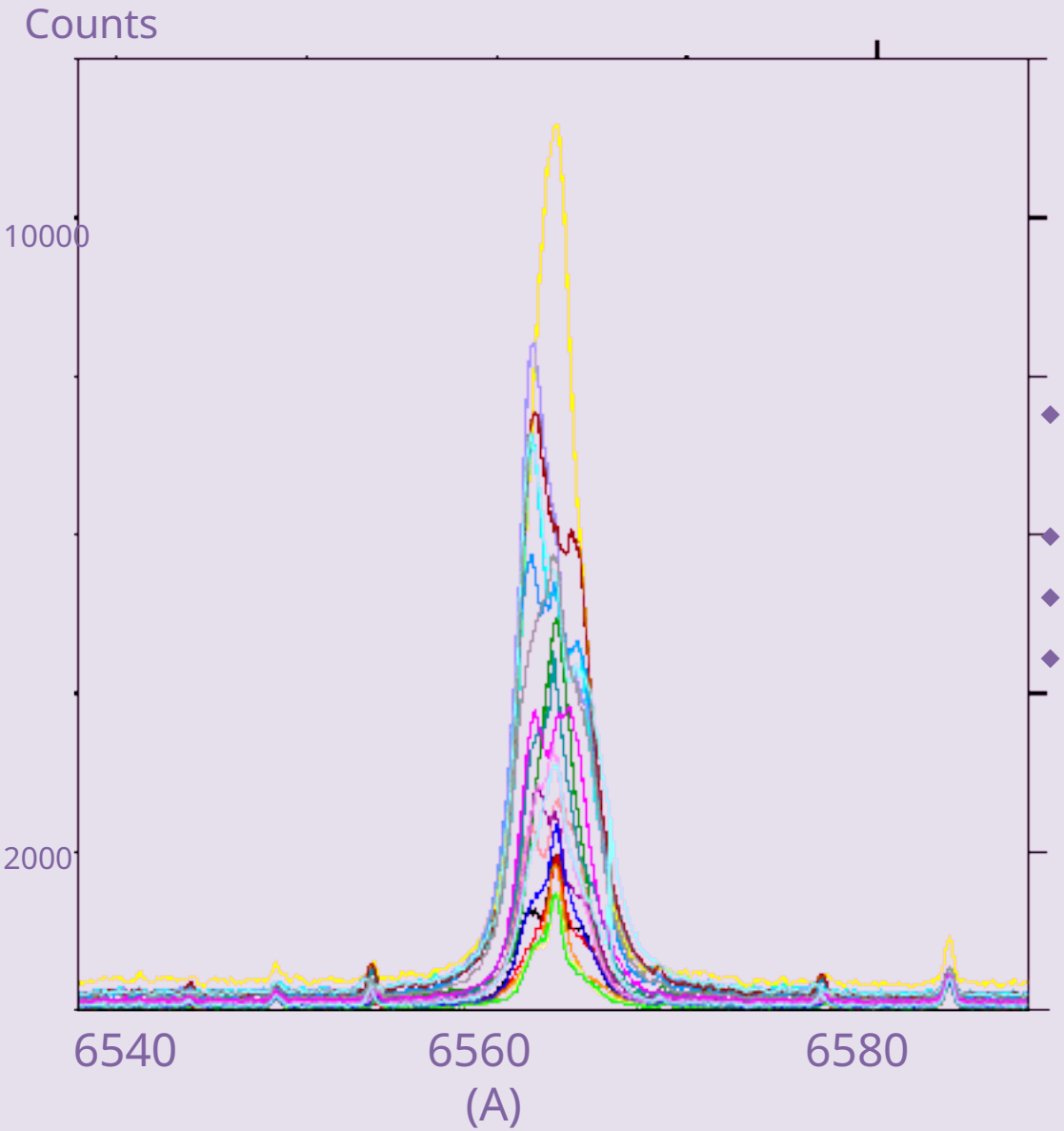
- GES spectrum
- Original spectrum
- SKY spectrum

OHαNA-method

(Bonito et al. 2020)

Sara (Rosaria) Bonito – INAF – Osservatorio Astronomico di Palermo (Italy)

VARIABILITY



- Multiple spectra (2 – 20; 60% with 20 spectra)
- Variation in the peak intensity
- Variation in the line profile
- Variation in the plasma speed

(Bonito et et al. 2020)