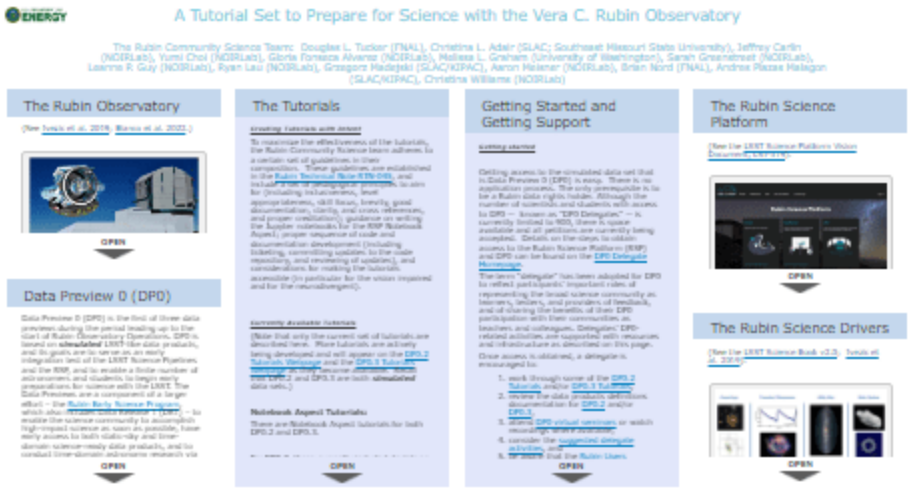
A Tutorial Set to Prepare for Science with the Vera C. Rubin Observatory



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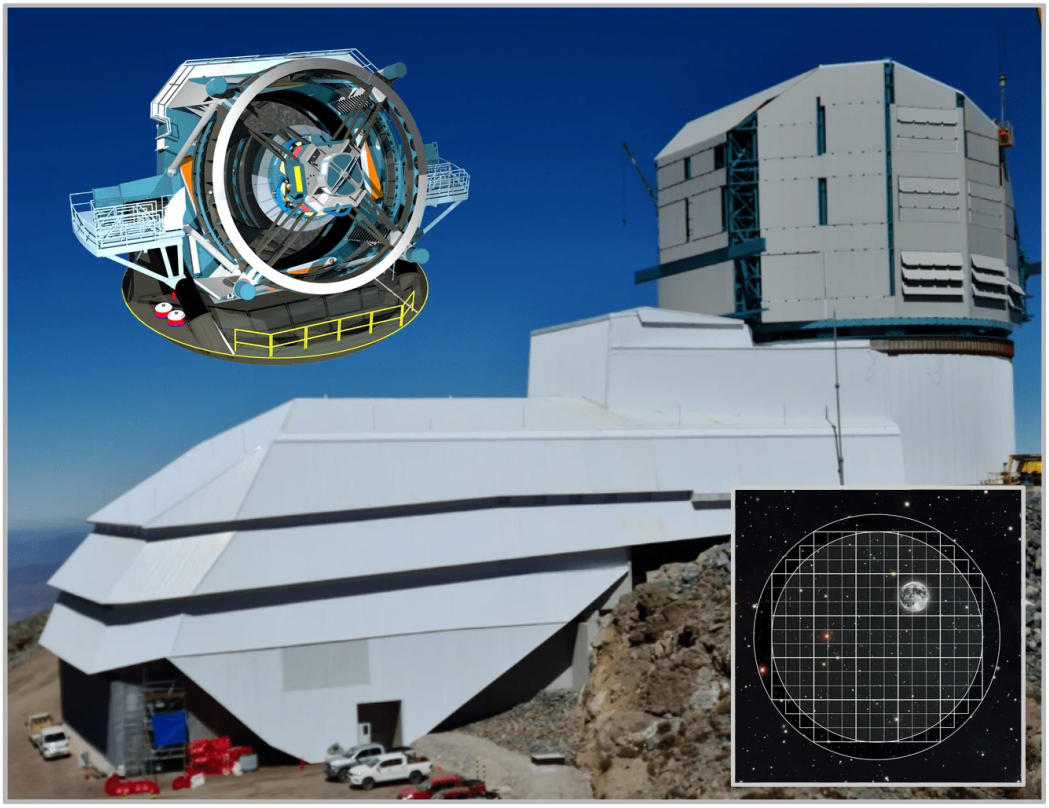
PRESENTED AT:

AAS 243 iPoster Sessions Sponsored by AAS PUBLISHING

THE RUBIN OBSERVATORY

(See Ivezic et al. 2019 (https://ui.adsabs.harvard.edu/abs/2019ApJ...873..111I/abstract); Bianco et al. 2022 (https://ui.adsabs.harvard.edu/abs/2022ApJS..258....1B/abstract).)

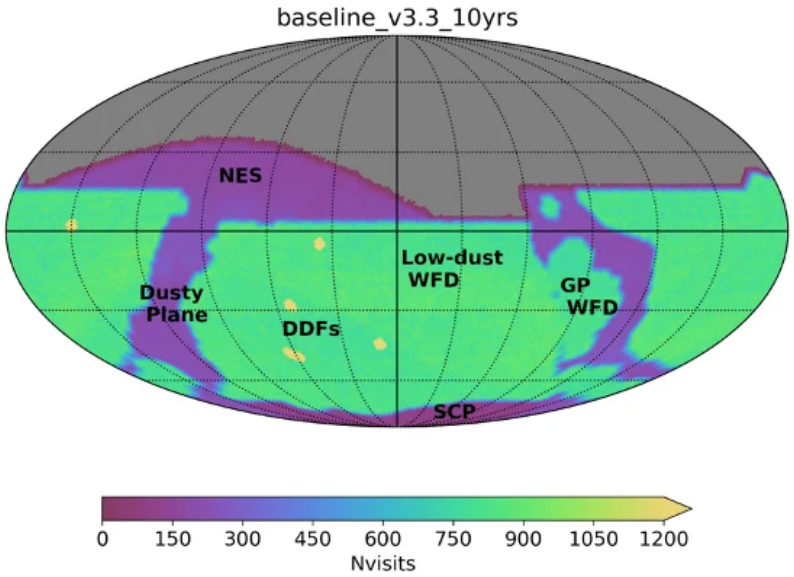


The Rubin Observatory (background image), with the Simonyi telescope (upper left inset) and an illustration of the field-of-view of the LSST camera (lower-right inset).

The *Vera C. Rubin Observatory*, currently under construction on Cerro Pachón in Chile, comprises the *Simonyi Survey Telescope* with a primary mirror with an effective diameter of 6.7 meters (full diameter of 8.4 meters), a 3.2 megapixel, 9.6 sq deg field-of-view camera with six optical-NIR filters (*ugrizy*), a fully automated data processing system, and an online public engagement platform.

Once construction and commissioning are complete, Rubin Observatory will execute the 10-year *Legacy Survey of Space and Time* (LSST):

- 18000 square degrees of the southern sky
- ~800 30-second visits to all areas in 10 years
- Single-image depths (point source; AB) of *ugrizy* = 23.2, 24.4, 23.9, 23.5, 22.9, 21.9 mag



Version 3.3 of the LSST 10-year baseline survey. The color bar indicates the number of visits for each region of sky. Note the locations of the Wide-Fast-Deep (WFD) Main Survey, the Deep Drilling Fields (DDFs), the North Ecliptic Spur (NES) survey, the Galactic Plane (GP) survey, and the South Celestial Pole (SCP) survey. For more information on survey observing strategy, please see PSTN-055, "Survey Cadence Optimization Committee's Phase 2 Recommendations" (https://pstn-055.lsst.io/).

[VIDEO] https://res.cloudinary.com/amuze-interactive/video/upload/vc_auto/v1704239881/aas/11-87-A1-A9-71-4E-95-83-55-D2-A8-C3-76-90-53-F0/Video/RubinVidDec2023_zrqqhw.mp4

Drone video footage of the Rubin Observatory at sunset in December 2023.

This video is available from the Rubin Observatory Canto photo and video gallery (https://rubin.canto.com/v/gallery/album/HDSNU?display=curatedView&viewIndex=2).

[VIDEO] https://res.cloudinary.com/amuze-interactive/video/upload/vc_auto/v1703205715/aas/11-87-A1-A9-71-4E-95-83-55-D2-A8-C3-76-90-53-F0/Video/Evening_on_Cerro_Pacho%CC%81n_1_ft24b2.mp4

Time-lapse video: An evening at Cerro Pachon from June 2023.

DATA PREVIEW 0 (DP0)

Data Preview 0 (DP0) is the first of three data previews during the period leading up to the start of Rubin Observatory Operations. DP0 is based on ***simulated*** LSST-like data products, and its goals are to serve as an early integration test of the LSST Science Pipelines and the RSP, and to enable a finite number of astronomers and students to begin early preparations for science with the LSST. The Data Previews are a component of a larger effort – the Rubin Early Science Program (https://www.lsst.org/scientists/early-science), which also includes Data Release 1 (DR1) – to enable the science community to accomplish high-impact science as soon as possible, have early access to both static-sky and time-domain science-ready data products, and to conduct time-domain astronomy research via Alert Production. More on the Early Science Program can be found in Rubin Observatory Plans for an Early Science Program (RTN-011) (https://rtn-011.lsst.io/).

The currently supported DP0 data collections are DP0.2 and DP0.3. The data set adopted for DP0.2 (https://dp0-2.lsst.io/ (https://dp0-2.lsst.io/)) is the 300 deg2 of simulated, LSST-like images and catalogs generated by the Dark Energy Science Collaboration (DESC) for their Data Challenge 2 (DC2; LSST DESC et al. 2021, ApJS, 253, 31 (https://ui.adsabs.harvard.edu/abs/2021ApJS..253...31L/abstract)). This data set is supplemented by DP0.3 (https://dp0-3.lsst.io/ (https://dp0-3.lsst.io/)) which is a catalog-only simulation of solar system objects.

A recent paper using DP0 is:

Ryczanowski et al. 2023, MNRAS, 520, 2547 (https://ui.adsabs.harvard.edu/abs/2023MNRAS.520.2547R/abstract)

THE TUTORIALS

Creating Tutorials with Intent

To maximize the effectiveness of the tutorials, the Rubin Community Science team adheres to a certain set of guidelines in their composition. These guidelines are established in the Rubin Technical Note RTN-045 (https://rtn-045.lsst.io/), and include a set of pedagogical principles to aim for (including inclusiveness, level appropriateness, skill focus, brevity, good documentation, clarity, and cross references, and proper creditation); guidance on writing the Jupyter notebooks for the RSP Notebook Aspect; proper sequence of code and documentation development (including ticketing, committing updates to the code repository, and reviewing of updates), and considerations for making the tutorials accessible (in particular for the vision impaired and for the neurodivergent).

Currently Available Tutorials

(Note that only the current set of tutorials are described here. More tutorials are actively being developed and will appear on the DP0.2 Tutorials Webpage (https://dp0-2.lsst.io/tutorials-examples/index.html) and the DP0.3 Tutorials Webpage (https://dp0-3.lsst.io/tutorials-dp0-3/index.html) as they become available. Recall that DP0.2 and DP0.3 are both ***simulated*** data sets.)

Notebook Aspect Tutorials:

There are Notebook Aspect tutorials for both DP0.2 and DP0.3.

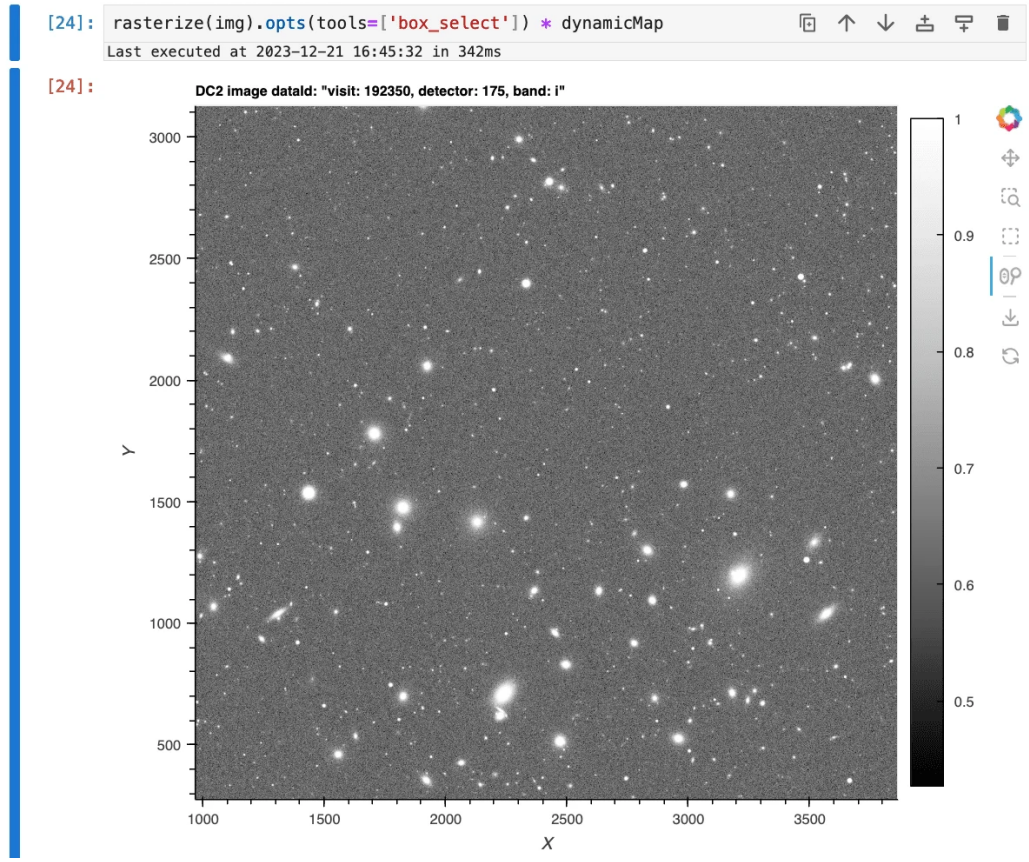
For DP0.2, these currently include tutorials on the following topics:

- TAP queries of the DPO0.2 catalogs
- image display and manipulation
- survey property maps
- queries of Butler repositories
- source detection
- interactive image and catalog visualization
- analysis of difference imaging sample
- creation of variable star light curves
- accessing the DP0.2 Truth tables
- creation of custom coadd images and sources
- analysis of deblender data products
- how to work with user packages
- analysis of point-spread data products

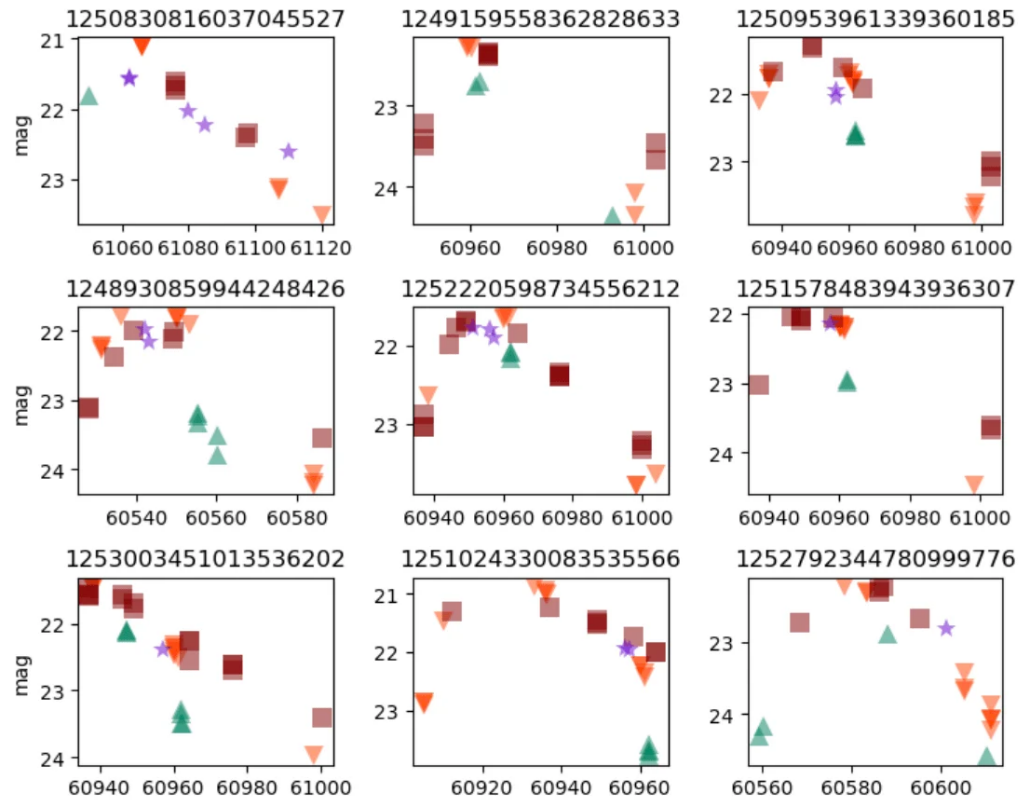
For DP0.3, these currently include tutorials on main belt asteroids, Trans-Neptunian Objects, and phase curves.

Both the DP0.2 and the DP0.3 notebook tutorials can be found on the DP0 Notebook GitHub Repo (https://github.com

/rubin-dp0/tutorial-notebooks).



Notebook Aspect: Screen shot from a Jupyter notebook session showoing an interactive plot of a detector image from DP0.2.



Notebook Aspect: A mosaic of light curves of a small selection of candidate SNe Ia identified in DP0.2.

Portal Aspect Tutorials:

As with the Notebook Aspect, there are Portal Aspect tutorials for both DP0.2 and DP0.3.

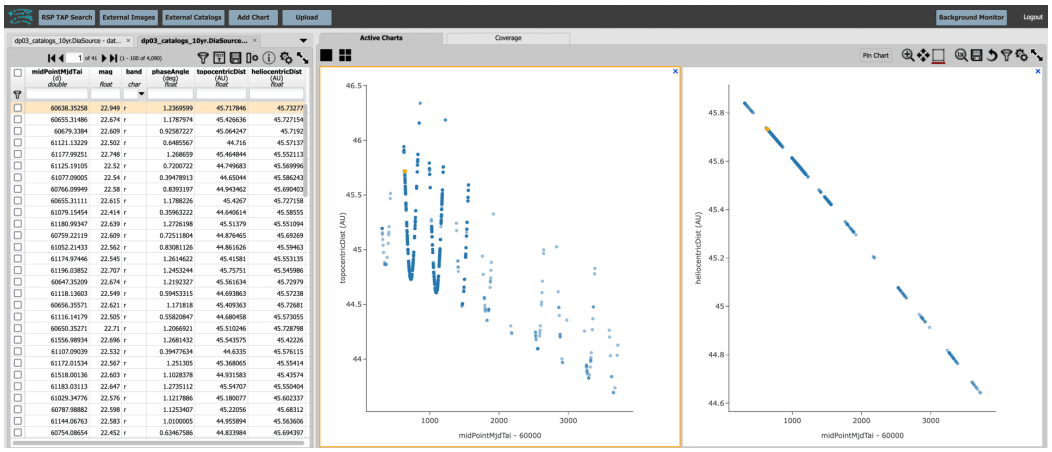
For DP0.2, these currently include tutorials for the following topics:

- creating a bright-stars color-magnitude diagram
- exploring a SNIa lightcurve
- viewing an SNIa host galaxy
- exploring extended object populations
- making multiband lightcurves using forced photometry.

For DP0.3, these currently include tutorials working with the following tables:

- the Minor Planet Center orbital parameters (MPCORB) table
- the solar system object (**`SSObject`**) table
- the solar system source (**`SSSource`**) table
- the difference imaging source (**`DiaSource`**) table for solar system objects

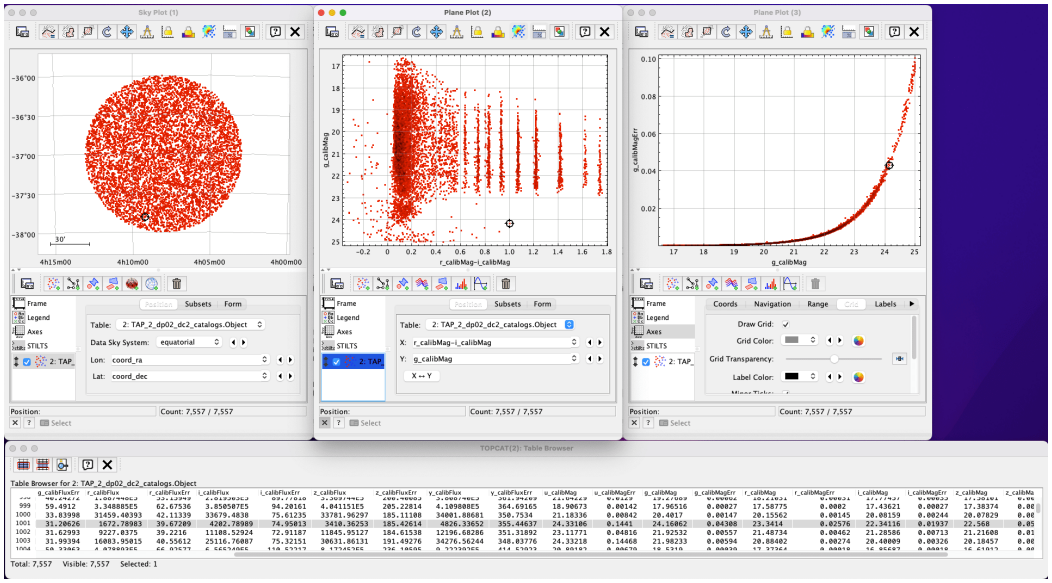
There is also a DP0.3 portal for the exploration of Trans-Neptunian Objects (TNOs).



Portal Aspect: heliocentric and topocentric distance of a TNO in the DP0.3 simulated data set.

API Aspect Tutorials:

Currently, there is just one API Aspect tutorial – a tutorial showing how to use TOPCAT to access the DP0.2 TAP service and then create a bright-stars color-magnitude diagram.



API Aspect: Multiple TOPCAT plots of bright stars in a 1-deg-radius circle near the cetner of the DP0.2 simulated data set.

GETTING STARTED AND GETTING SUPPORT

Getting started

Getting access to the simulated data set that is Data Preview 0 (DP0) is easy. There is no application process. The only prerequisite is to be a Rubin data rights holder. Although the number of scientists and students with access to DP0 -- known as “DP0 Delegates” -- is currently limited to 900, there is space available and all petitions are currently being accepted. Details on the steps to obtain access to the Rubin Science Platform (RSP) and DP0 can be found on the DP0 Delegate Homepage (https://dp0-2.lsst.io/dp0-delegate-resources/index.html).

The term “delegate” has been adopted for DP0 to reflect participants’ important roles of representing the broad science community as learners, testers, and providers of feedback, and of sharing the benefits of their DP0 participation with their communities as teachers and colleagues. Delegates’ DP0-related activities are supported with resources and infrastructure as described on this page.

Once access is obtained, a delegate is encouraged to:

1. work through some of the DP0.2 Tutorials (https://dp0-2.lsst.io/tutorials-examples/index.html) and/or DP0.3 Tutorials (https://dp0-3.lsst.io/tutorials-dp0-3/index.html),
2. review the data products definitions documentation for DP0.2 (https://dp0-2.lsst.io/data-products-dp0-2/index.html#dp0-2-data-products-definition-document-dpdd) and/or DP0.3 (https://dp0-3.lsst.io/data-products-dp0-3/index.html#dp0-3-data-products-definition-document-dpdd),
3. attend DP0 virtual seminars (https://dp0-2.lsst.io/dp0-delegate-resources/index.html#delegate-homepage-dp0-virtual-seminars) or watch recordings where available,
4. consider the suggested delegate activities (https://dp0-2.lsst.io/dp0-delegate-resources/index.html#delegate-homepage-delegate-activities), and
5. be aware that the Rubin Users Committee (https://www.lsst.org/scientists/users-committee) are delegate advocates.

Getting Support

The Rubin Community Forum (https://community.lsst.org/) is the best place for DP0 delegates to post topics related to scientific support. The “Support” category of the Community Forum is the place for Rubin Q&A.

Scientific support for DP0 includes questions about the DC2 simulated data set, the DP0 data products, and/or the application of the LSST Science Pipelines to the DP0 data set, as well as general discussion about DP0-related scientific analyses, or DP0 policies and guidelines.

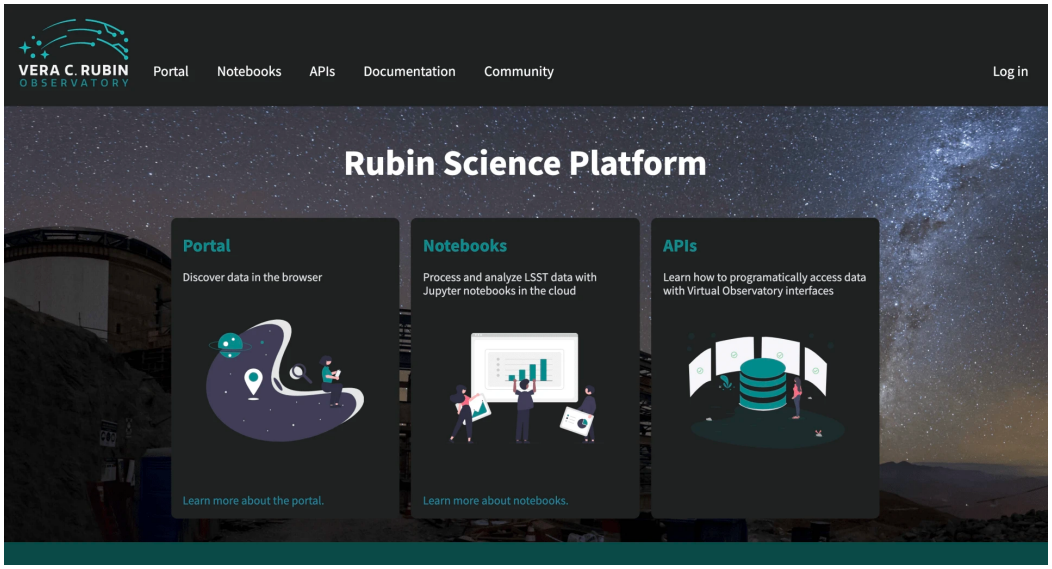
The DP0 subcategory is monitored by the Rubin Observatory Community Science team (CST) (https://community.lsst.org/g/CST). DP0 delegates are especially encouraged to post new topics and reply to others’ posts in this subcategory.

DP0 delegates can also also find support by attending DP0 virtual seminars (https://dp0-2.lsst.io/dp0-delegate-resources/index.html#delegate-homepage-dp0-virtual-seminars) or by watching the seminar recordings where available.

In addition, group requests for custom hands-on activities (virtual or in person) will be considered by the CST. Due to the limited resources, priority will be given to requests from scientists at small and/or underserved institutions (SUIs). Requests sent at least 6 weeks in advance are more likely to be accommodated. For more information on this option, please consult the “Custom virtual or in person seminars” section of the DP0 Delegate Resources webpage (https://dp0-2.lsst.io/dp0-delegate-resources/index.html#custom-virtual-or-in-person-seminars).

THE RUBIN SCIENCE PLATFORM

(See the LSST Science Platform Vision Document, LST-319 (https://lse-319.lsst.io/)).



The Rubin Science Platform login page.

With a final 10–year data volume including 60 PB of raw images and 15 PB of catalog data, a stable and robust software environment is essential. This environment, which includes the LSST Science Pipelines, is maintained by Rubin Data Management.

Another facet to the huge data data volume is that it will not be possible to download the entire LSST data set, and scientists will need a venue for **“next-to-the-data analysis”**.

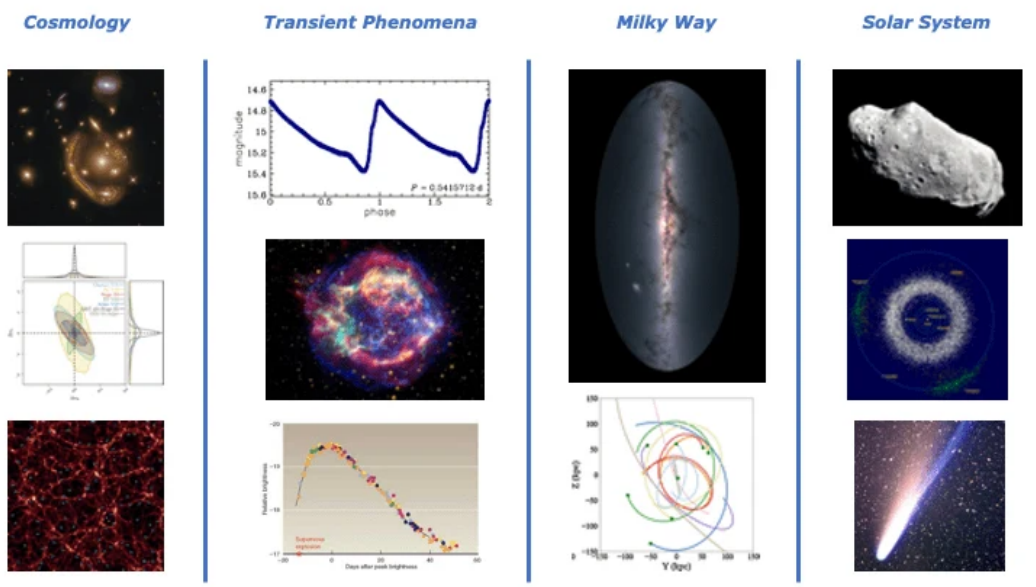
The **Rubin Science Platform (RSP)** is a set of integrated web-based applications and services running at the Rubin Observatory Data Access Centers (DACs).

The RSP will include tools to query, visualize, subset, and analyze the full LSST data archives in a stable software environment located “next-to-the-data”, along with storage space, compute resources, and remote access options.

There are three Aspects to the RSP: the Portal Aspect (provides exploratory analysis and visualization of the Rubin archive), **the Notebook Aspect** (provides in-depth “next-to-the-data” analysis and creation of added-value data products via Jupyter notebooks) and **the API Aspect** provides remote access to the Rubin archive via industry-standard APIs.

THE RUBIN SCIENCE DRIVERS

(See the LSST Science Book v2.0 (https://arxiv.org/abs/0912.0201); Ivezic et al. 2019 (https://ui.adsabs.harvard.edu/abs/2019ApJ...873..111I/abstract)).



Rubin Sciences Drivers: Cosmology, Transient Phenomena, the Milky Way, and the Solar System

The design of Rubin Obseratory and LSST is driven by four scientific areas of interest:

- **Cosmology:** Understand dark energy and dark matter, and the origin and fate of the universe, by studying gravitational lensing and large-scale structures across cosmic time.
- T**ransient Phenomena:** Understand evolutionary processes by studying how stars and compact objects (e.g., black holes) change brightness, interact, merge, and explode.
- **The Milky Way:** Understand the structure and evolution of our Galaxy's bulge, disk, and halo – and its satellites and tidal streams – by mapping the stars of the Milky Way.
- **The Solar System:** Understand the formation and evolution of our Solar System, and the risk of potentially hazardous asteroids, by making a full inventory of objects down to ~100 m scales.

TRANSCRIPT

ABSTRACT

In this poster the Rubin Observatory's Community Science team (CST) presents its current suite of tutorials, which are designed to help people make use of simulated data sets in preparation for the upcoming Legacy Survey of Space and Time (LSST). We will show examples of the tutorial contents, provide custom learning modules for different astronomical fields, and describe the online environment for data analysis (the Rubin Science Platform; RSP). We will also supply a checklist for how to obtain an RSP account and access the tutorials. All are welcome to drop by the poster or the Rubin booth in the exhibit hall with questions.