VERA C. RUBIN OBSERVATORY

U.S. National Science Foundation | U.S. DEPARTMENT of ENERGY | Office of Science

Rubin Update

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NSF–DOE Vera C. Rubin Observatory

Rubin Operations have Begun!

Pre-operations has been in progress formally since 2019.

On October 25th “the keys to the Observatory” were passed from the Construction Team to the Operations Team.

Thus, the formal start of Operations has begun; the first night was October 26th. Our focus shifts from daytime to nighttime!

Update on Early Operations

Engineering Focus

Nighttime work on observation test sets. Small amount of FBS mode observing with LSST cadence to validate progress.

Improvements Realized

Implemented numerous improvements since the end of Science Verification (SV).

Isolating Final Tasks

Narrowing down remaining improvements to get to the start of the LSST.

Track Progress

Follow along at community.lsst.org.

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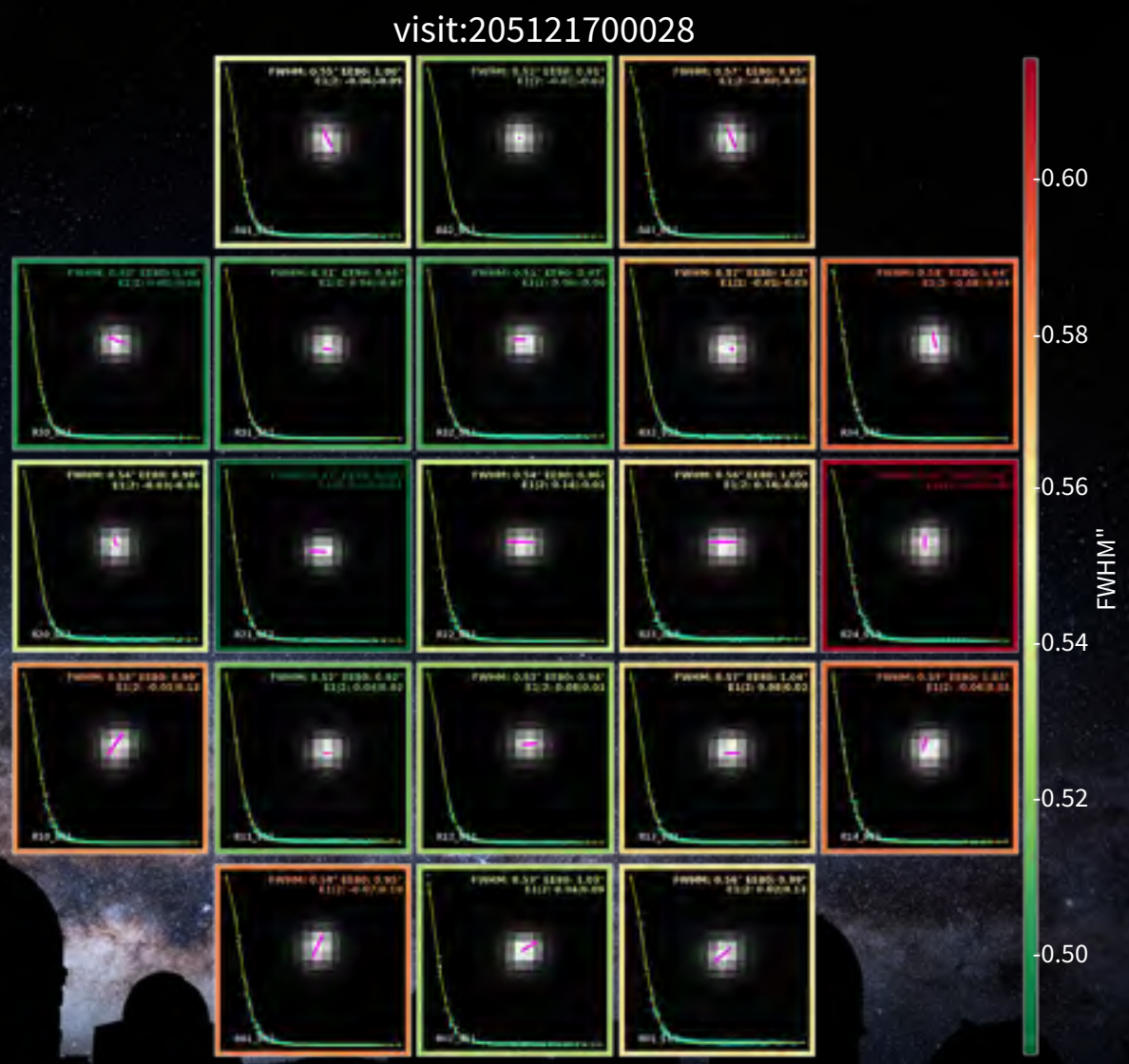
As-built System is Capable: Delivered Image Quality

Example visit from 17 Dec 2025

~0.58” PSF FWHM across full field of view

We are now in Early Operations and focused on Optimizing the system for reliable performance.



LSST Survey Performance is Driven by Rubin Observatory System Performance

For the next 10 years, Rubin Observatory will be fully dedicated to delivering the Legacy Survey of Space and Time (LSST)

Two key performance indicators of overall system performance described in Science Requirements Document (SRD) are monitored and updated on a continuous basis

1. **Delivered image quality** — characterizes the spatial resolution, a measure of the information content of the images
2. **Effective survey speed** — product of instantaneous etendue (ability to capture photons), source sensitivity, observing efficiency, and operational uptime

Delivered Image Quality

Delivered image quality characterizes the spatial resolution, a measure of the information content of the images.

Delivered image quality affects

- image depth (i.e., background counts contained within effective solid angle of PSF)
- star-galaxy classification
- astrometric precision
- galaxy shape measurements
- blending

Delivered image quality includes contributions from static optics, windshake, telescope tracking, charge diffusion in sensors, dome seeing, and atmosphere.

Effective Survey Speed

Effective survey speed is product of instantaneous etendue (ability to capture photons = effective area x field of view), observing efficiency, and system availability

normalized etendue: fE = fA * fS * fO * System Availability

fA: FOV area factor	—	total solid angle of all live science pixels
fS: sensitivity factor	—	defined for fiducial observing conditions and based on knowledge of throughput (optics) and sensor properties (QE, read-out noise)
fO: observing efficiency factor	—	rate of visits within scheduled observing time, including time intervals between visits for a nominal survey strategy (exposure time, slew time, readout time, filter exchange time)
System availability	—	accounts for weather losses as well as scheduled and unscheduled system downtime

All factors normalized by their nominal (design) value

System Performance Summary Diagram

Adopt criteria that allow start of the LSST if performance is in the **green "Start LSST" box more often than not**
(i.e., >50% of scheduled time in FBS-driven survey observing mode)

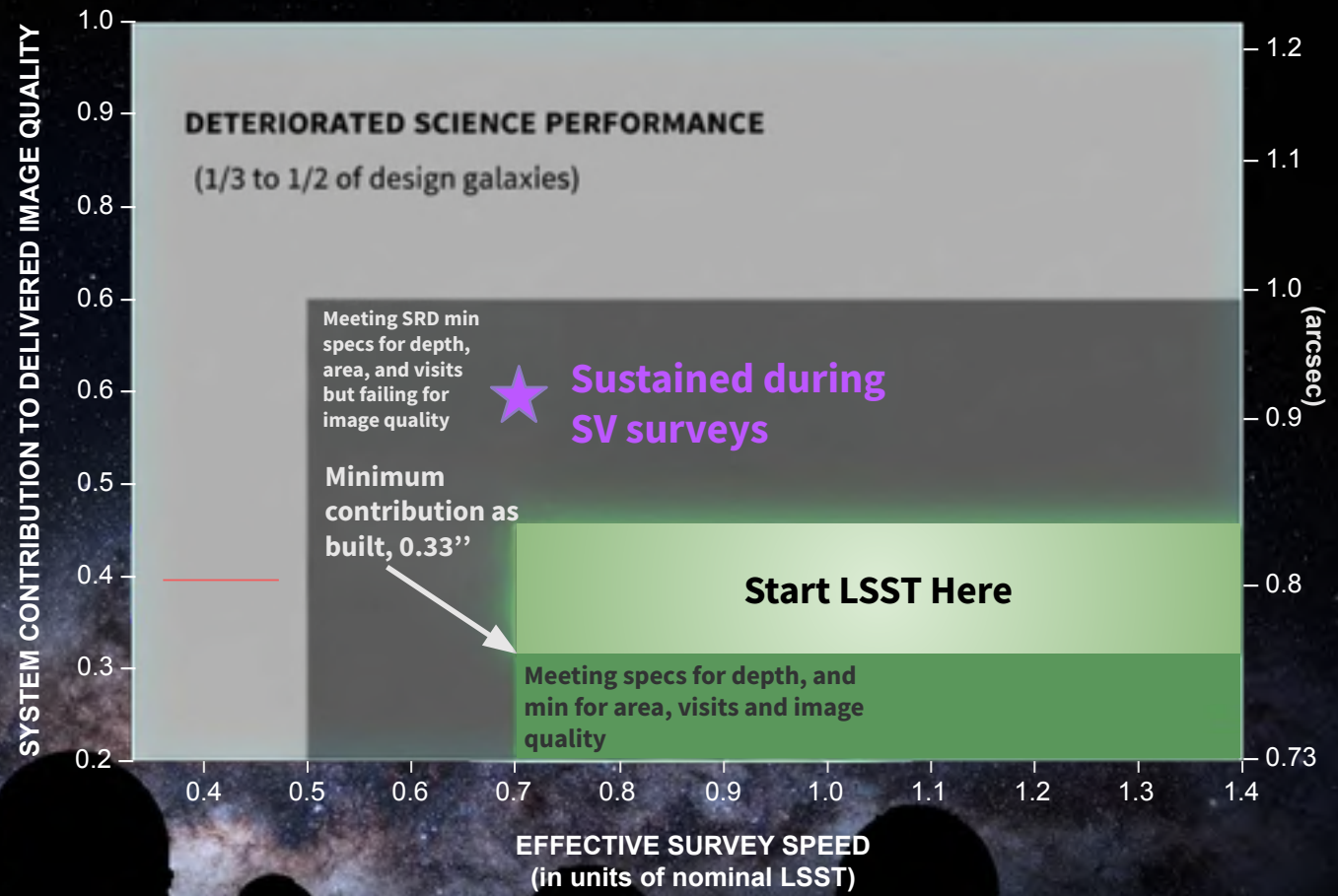


TABLE 1: Current f factor status

factor	Description	Sustained Performance in SV	Needed to Start LSST
sDIQ	System Contribution to the PSF FWHM	0.6"	0.45"
fA	FoV area factor	0.99	0.99
fS	Sensitivity factor	0.94	1.30
fO	Observing Efficiency	0.97	1.05
SA	System Availability (up and taking data)	0.75	0.75
fE	Normalized Étendue	0.68	1.01

RTN-093

Improvements in early OPS since end of SV

AOS

- 2-dimensional LUT for camera + M2 hexapods for elevation and physical rotator angle based on FEA + Zemax + laser + initial on-sky update (v20)
- 4 → 8 pairs of donuts used per corner wavefront sensor
- MTAOS improved control loop
- Improved accounting for intrinsic aberrations in WFS loop (including image heights)
- Better donut selection
- Initial stage of pointing model update and validated on sky Nov 22, 2025
- Intrinsic aberrations offset to apply best overall global focus

Thermal environment

- 6 louvers now available at night
- Thermal imaging of top end identifying heat sources, reduced air temp in top end
- Improved M1M3 thermal control, keeping specifically radial gradient and z gradient with spec (+/-0.1 C/m) more routinely; improved monitoring tools
- Nightly temperature forecast to improve M1M3 setpoints

System Contribution to Delivered Image Quality

Early Operations

Slight general trend towards more reliable system contribution to delivered image quality since resuming on-sky tests after the Sep-Oct engineering downtime 26 October

Constrained scheduler run since 11/26 (teal box) to check closed loop performance without filter changes, large rotations: image quality close to survey ready in these conditions.

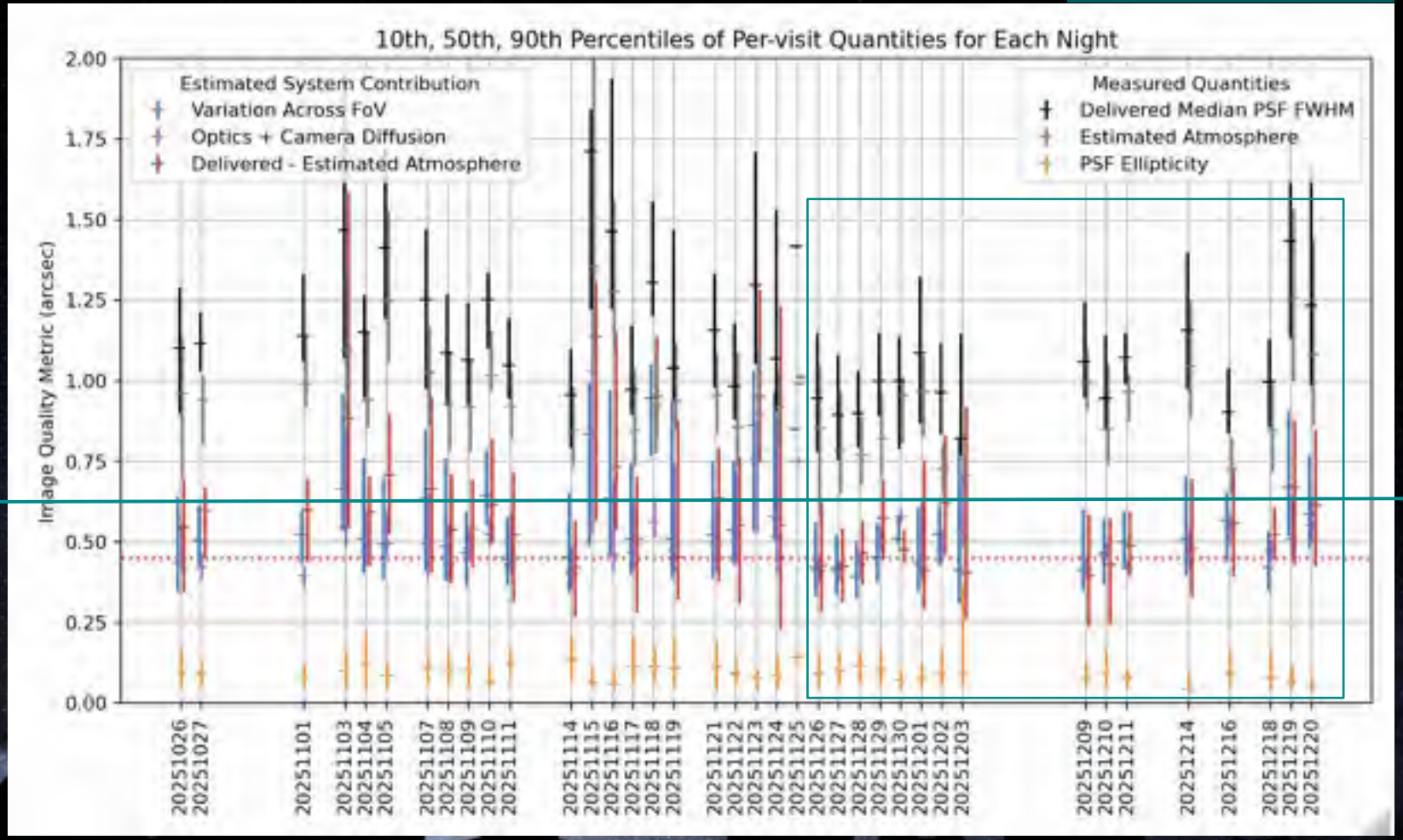
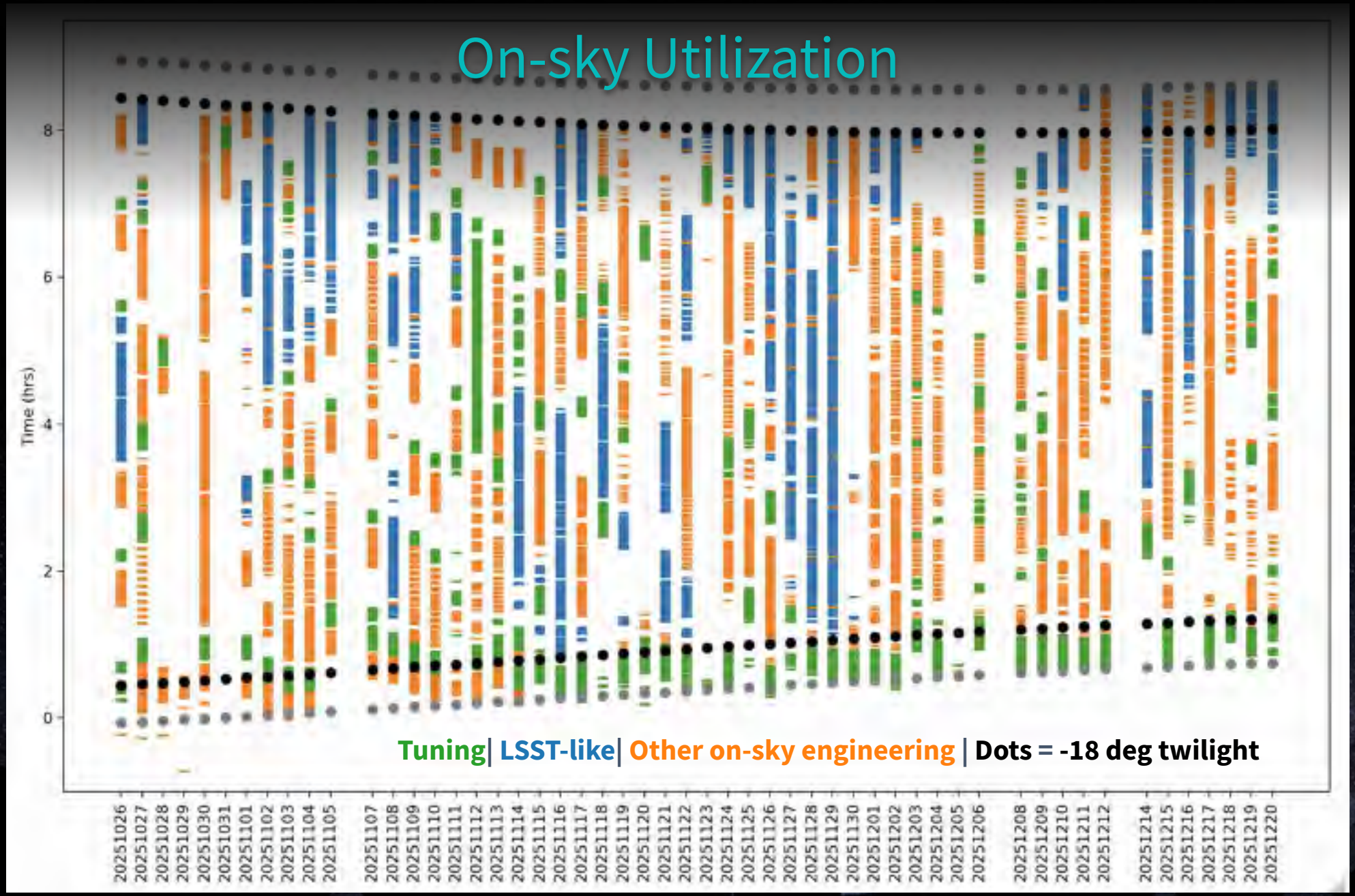


Figure credit: K. Bechtol

On-sky Utilization



What's next?

On sky in priority order:

- Filter look-up table (LUT)
- Full 22 DOF Az/Rot LUT
- Validated pointing model, including rotator
- N+2 AOS closed loop latency (i.e with processing time < 34 seconds)

In Dome:

- Thermal mitigations and improved cooling control at top end
- More louvers coming soon
- Working on system availability (reducing routine faults)
- Further refinements in M1-M3 thermal control

Four Science Areas

Milky Way Structure & Formation

Rubin will help us make the best map of our home galaxy yet.

Solar System Census

Rubin will show us millions of new asteroids and comets, and so much more.

Dark Matter & Dark Energy

Rubin is a brand new tool to help us learn more about their nature & behavior.

The Changing Sky

Rubin will bring the night sky to life, yielding a treasure trove of discoveries.

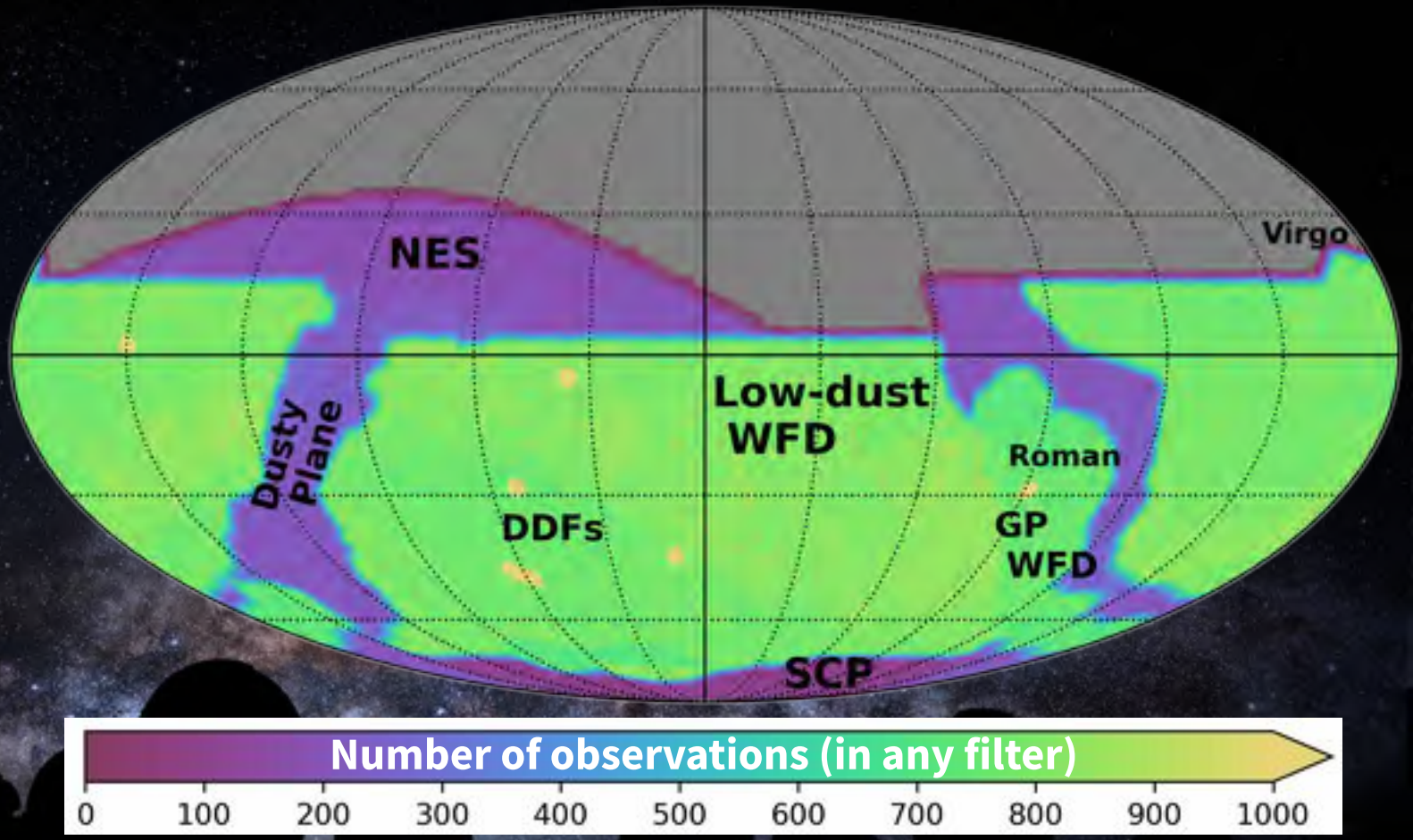
Legacy Survey of Space and Time (LSST)

Strategy:
Repeatedly scan the southern sky every ~3 nights for 10 years in 6 filters to simultaneously build time-series and deep all-sky images. **Optimizing the strategy for coverage and cadence is a community effort.**

Principal Components:

- NES: North Ecliptic Spur
- GP: Galactic Plane
- SCP: South Celestial Pole
- WFD: Wide-Fast-Deep
- Virgo Cluster
- DDF: Deep Drilling Fields

Baseline strategy version 5.0.



Data Preview 2 based on SV data obtained

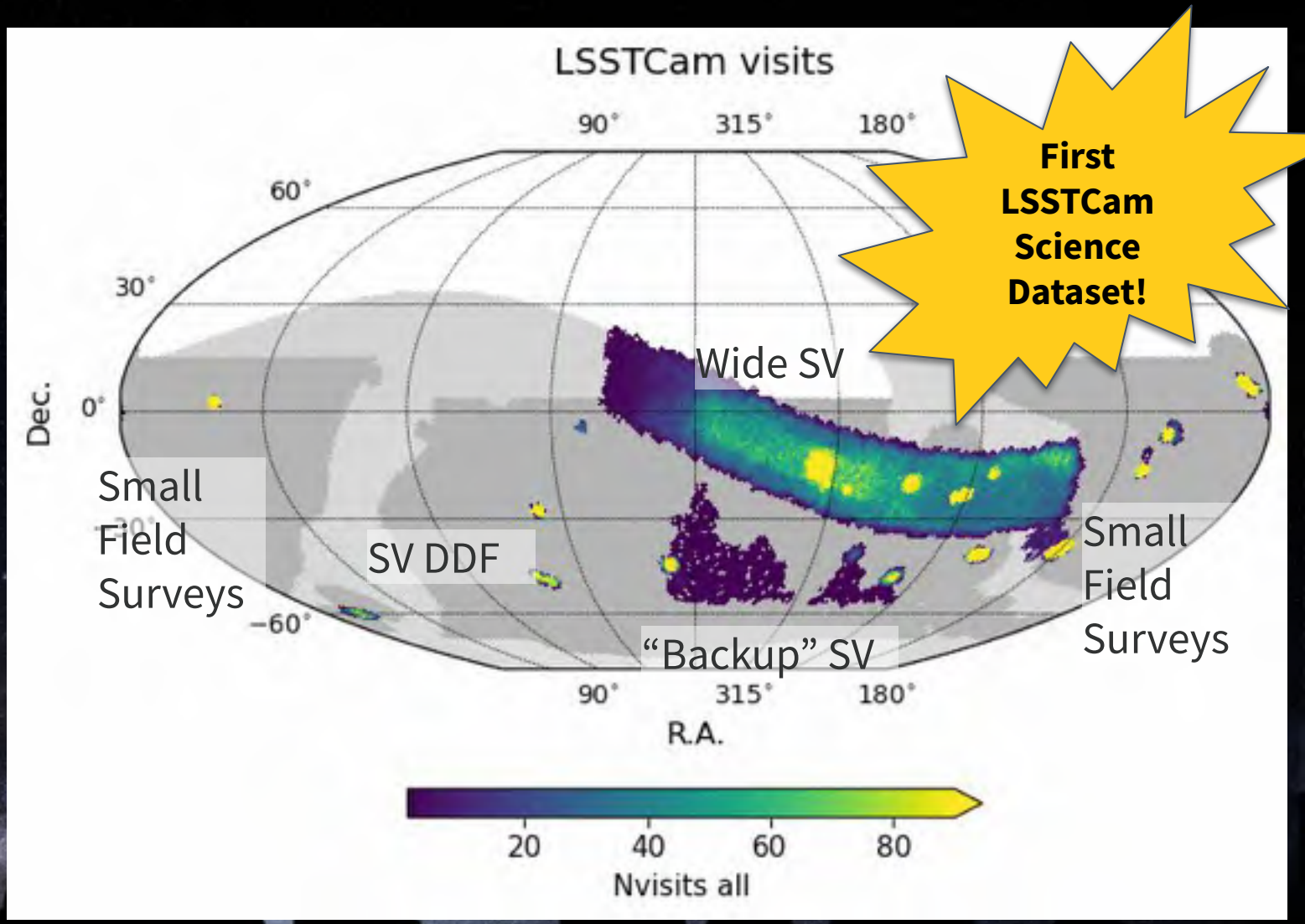
SV Surveys comprise interleaved **Wide** and **Deep** components

Total of **~22K visits** (~200x more than DP1, also ~1% of LSST) for Science Pipelines commissioning:

- ~13K visits within Wide SV area
- ~8K visits for small field surveys and Deep Drilling Fields (DDFs) within SV surveys

DP2 is WIDE, DDF, and Small Field in this image including First Look

We can add 10K more visits in the LSST footprint (including DDFs) from Nov-Dec that overlaps with the SV footprint.



Overview of "science program" visits at survey-strategy.lsst.io/progress

Data Preview 2

Pipeline freeze December, 2025.

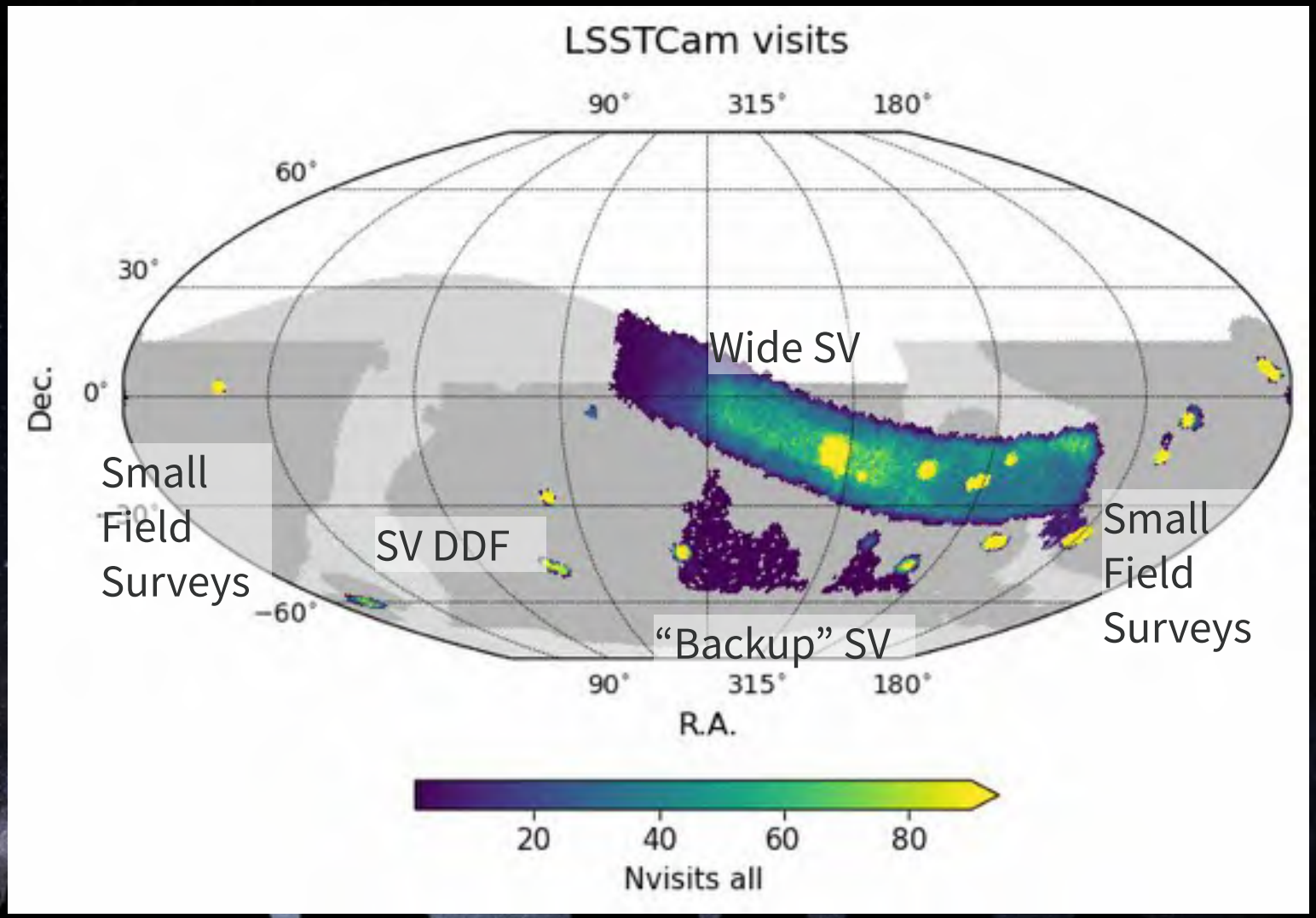
Pilot reduction runs begin with freeze.

Can add images up to January 9 if they fall in the SV “footprint” (includes DDFs).

January 9, start DRP

Release to community *July-Sept*.

RTN-11 v7.2



Overview of “science program” visits at survey-strategy.lsst.io/progress

Alerts

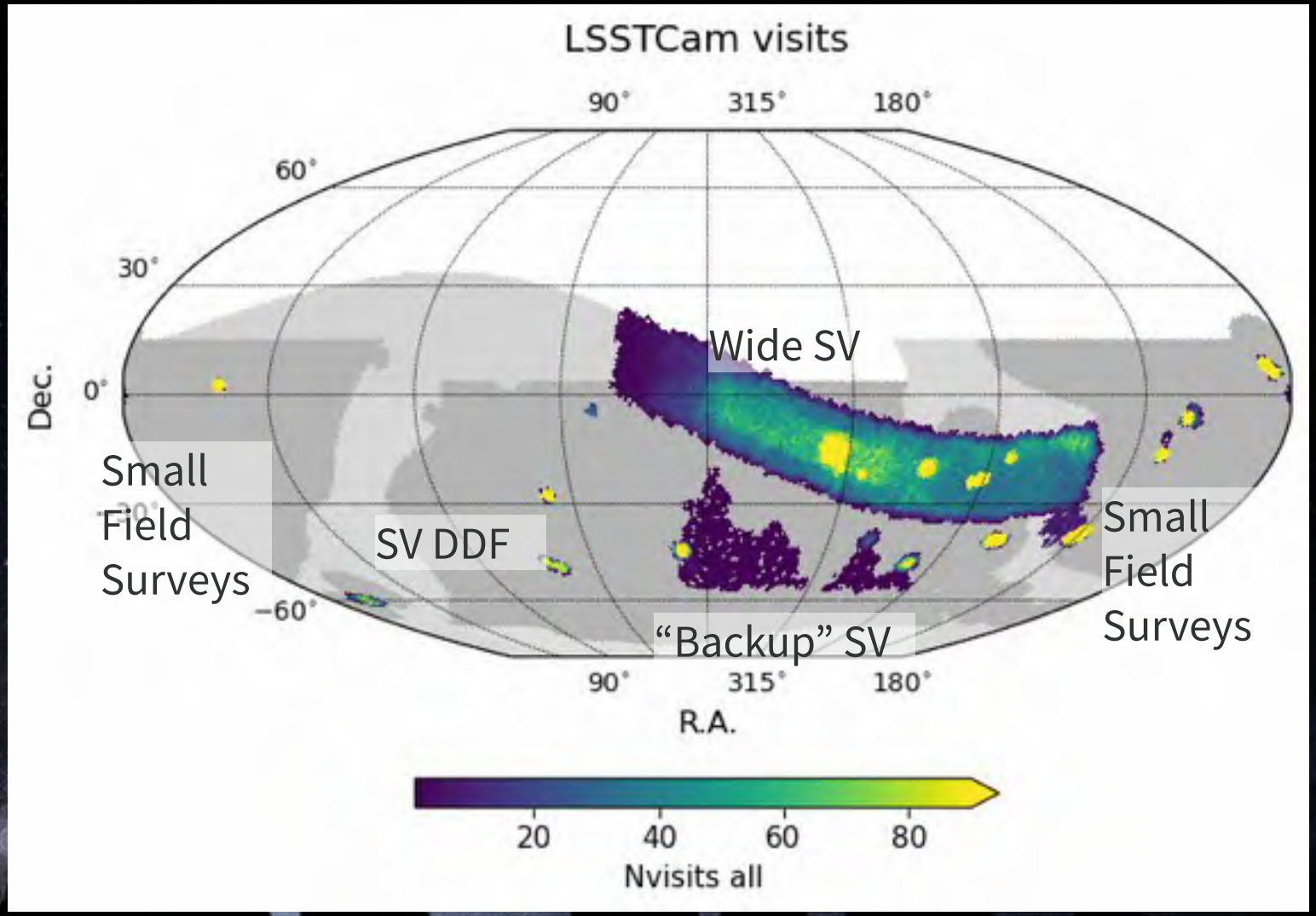
Alert generation is in good shape.

We will continue broker commissioning while we generate alerts in Nov-Jan during FBS/LSST mode. ~1000s of alerts/night

Most Wide SV templates are setting. Need to generate incremental templates in LSST footprint (DDFs already in place).

Small, but growing alert stream goes public at or near start of LSST. Timing TBD.

Solar System discoveries will be reported to the MPC.



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Supporting the Rubin science community

Who is "the Rubin science community?"

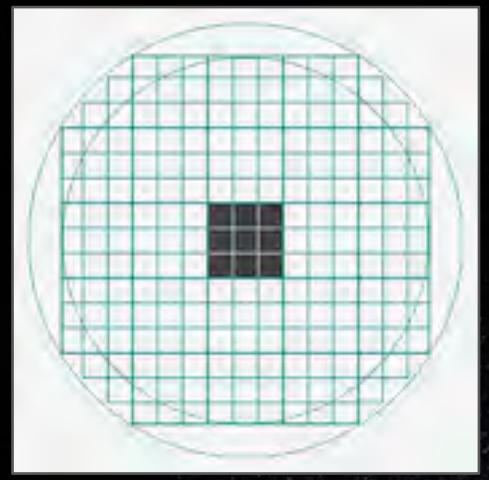
Everyone doing science with any of the Rubin data products.

Regardless of data rights, career stage, affiliation, location, etc.

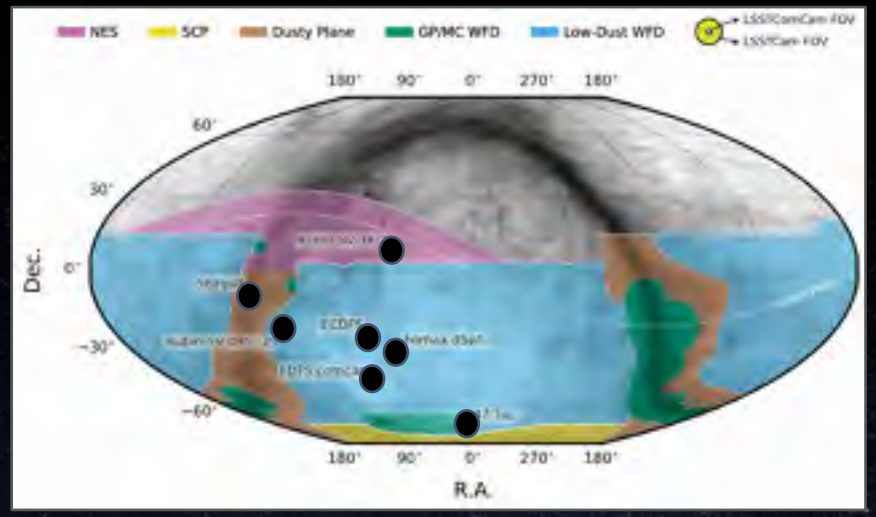
Rubin supports its science community by providing:

1. Science-ready data products ➜ **Data Preview 1 is now available: dp1.lsst.io**
2. A data access and analysis platform ➜ **Rubin Science Platform: ls.st/rsp-signup**
3. Learning resources and user support ➜ **Visit rubinobservatory.org to get started**

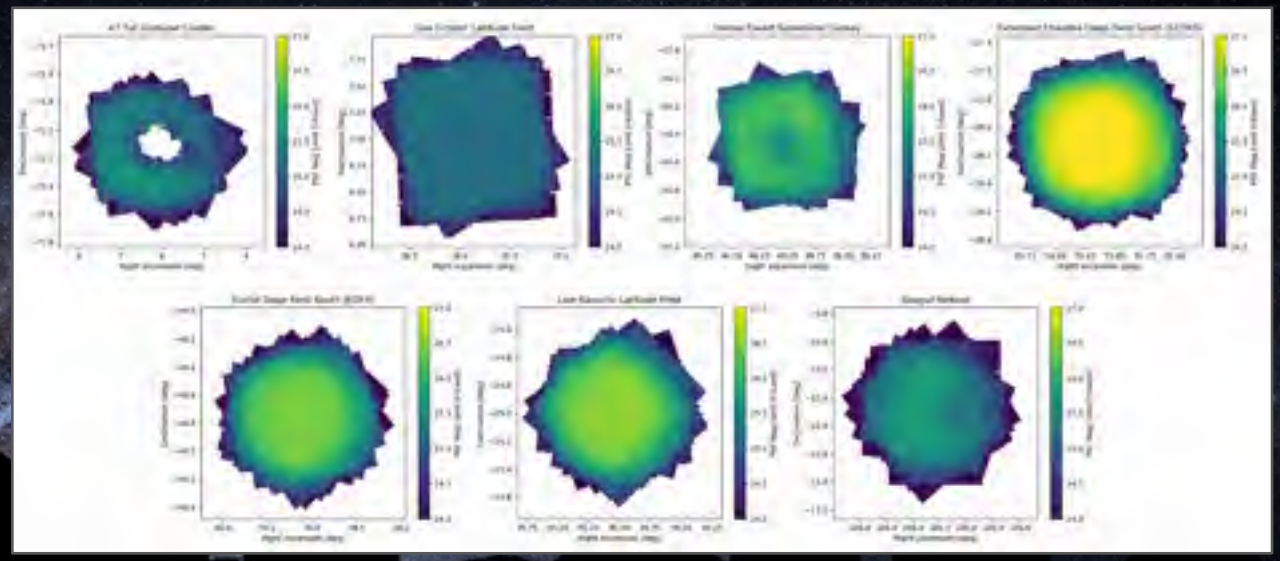
Rubin's Data Preview 1 (DP1), Available Now!



Data obtained with the LSST Commissioning Camera (**LSSTComCam**), a single "raft" of 9 CCDs, over 7 weeks between Oct 10 and Dec 11 2024.



Seven fields (left) to support a range of science goals. Observed with different cadences, filter combinations, and coadded depths (below).



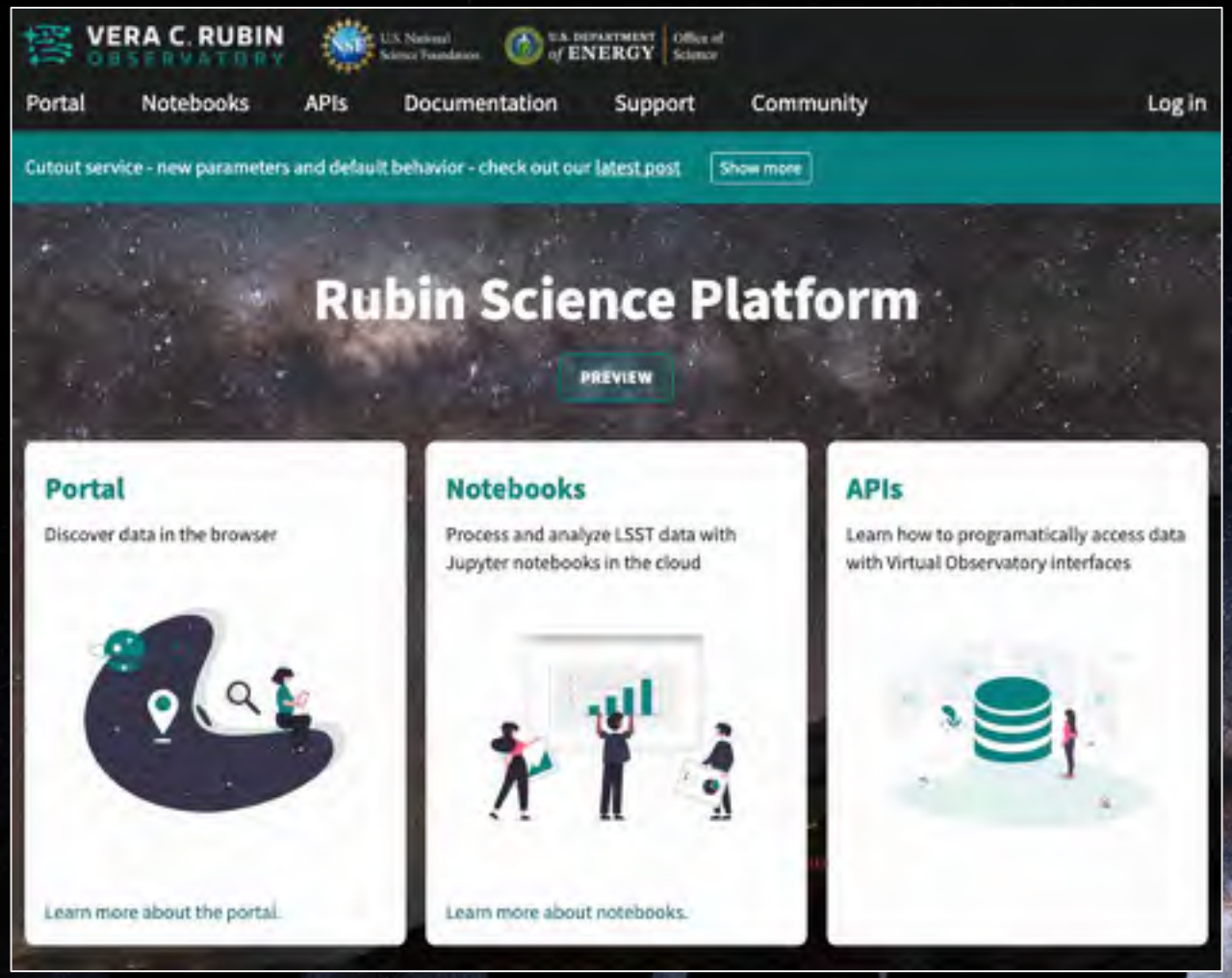
Available now.

DP1 is a small but *complete* preview: it includes most types of science-ready data products as future releases, but is equal to only about 100 images with LSSTCam.

Documentation: dp1.lsst.io

Paper submitted to ApJ

The Rubin Science Platform (RSP)



Web-based platform for Rubin data access and analysis.

Portal: Data discovery and visualization.

Notebook: Programmatic analysis in a maintained Python environment, with storage and compute.

API: Remote data access with IVOA standards.

Get your account:
ls.st/rsp-signup

Rubin learning resources

Documentation

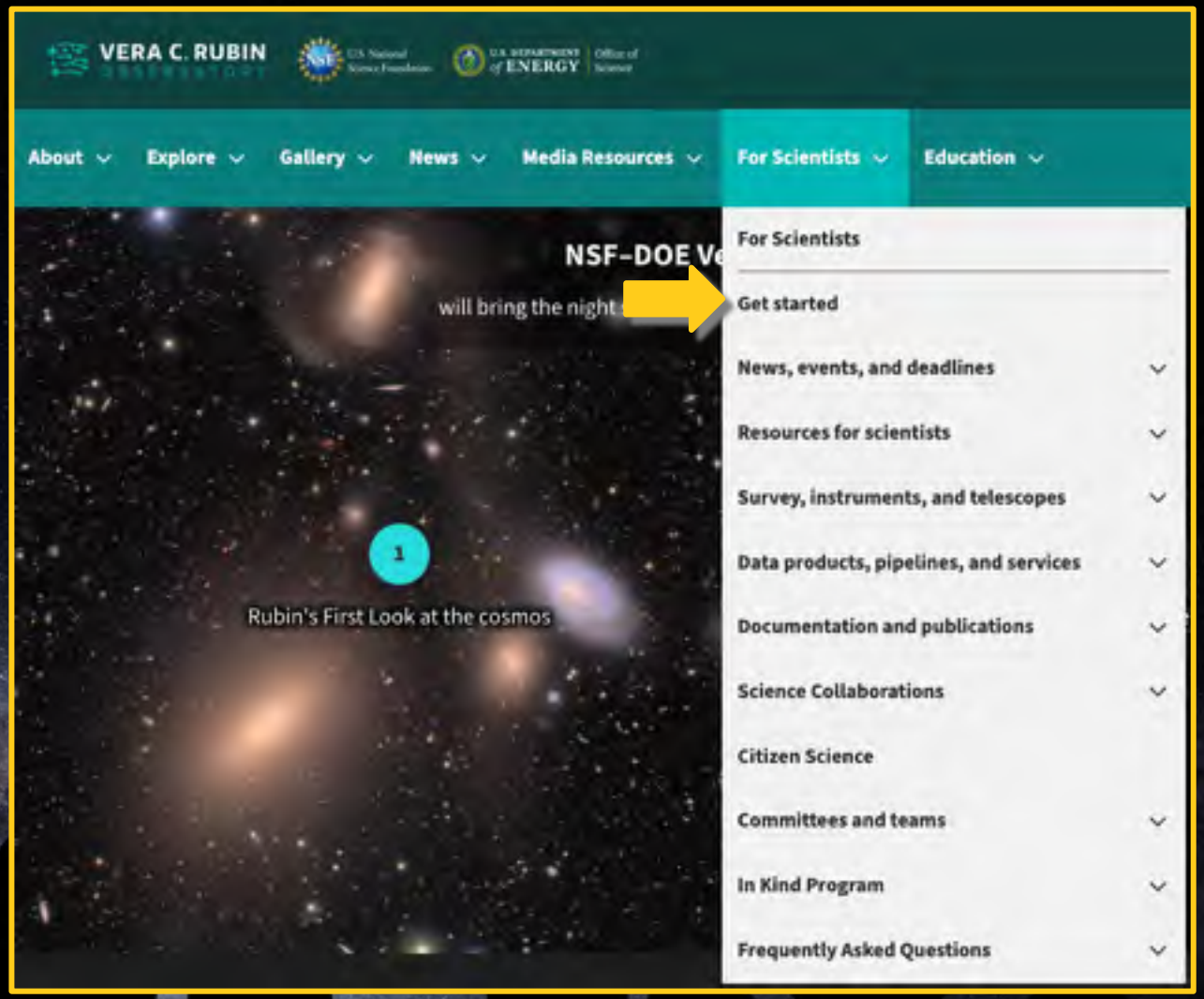
- **Website: rubinobservatory.org**
- Data release: dp1.lsst.io
- RSP user guides: rsp.lsst.io
- Technical docs: lsst.io

Tutorials

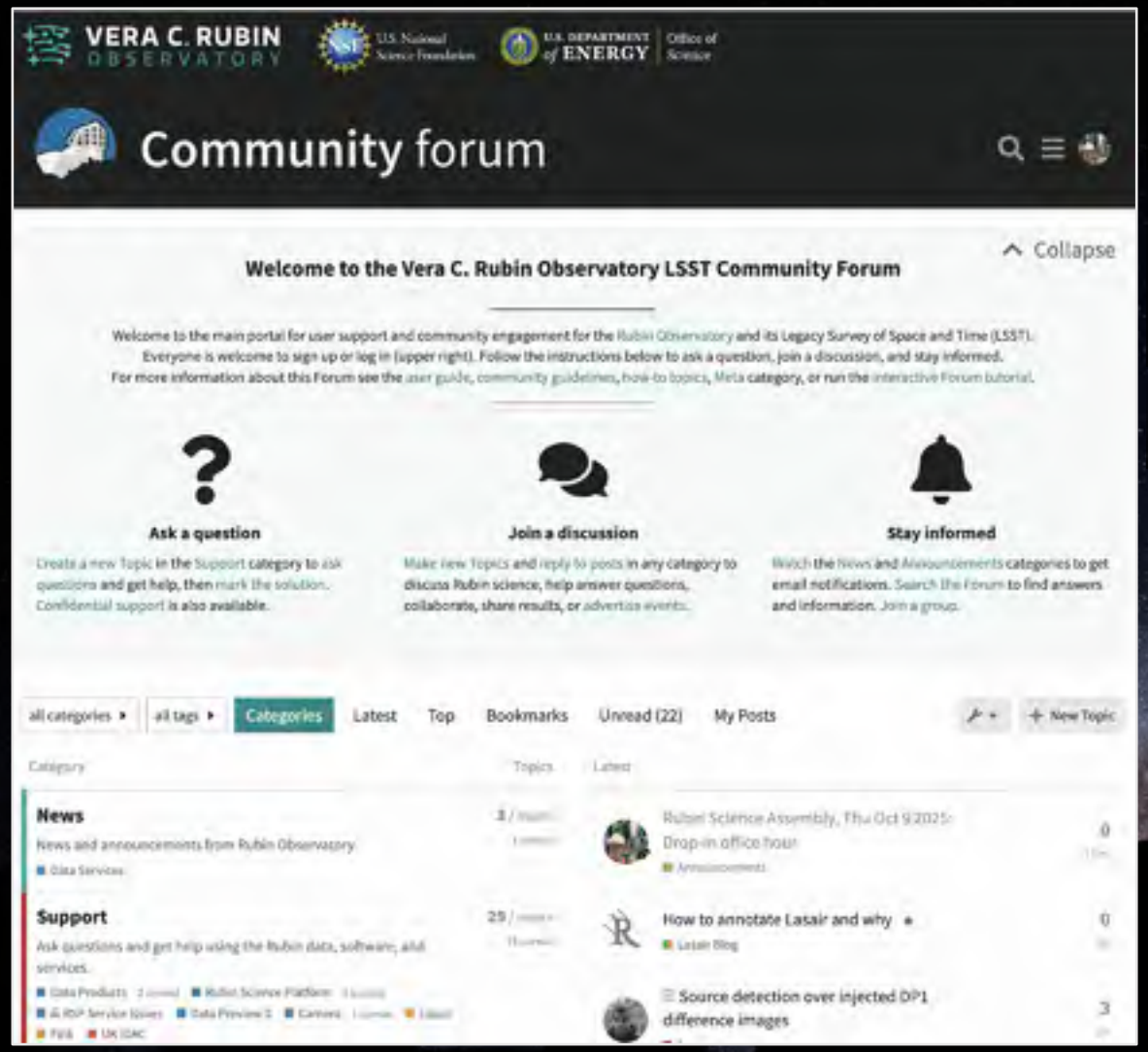
- step-by-step analysis demos
- executable Jupyter Notebooks

Events

- weekly virtual assemblies
- annual virtual data academy
- annual community workshop
- custom seminars by request



Rubin user support



Rubin Community Forum:
community.lsst.org

The Forum is a modern "helpdesk".

The ability to crowd-source solutions provides a scalable community support model for thousands of users.

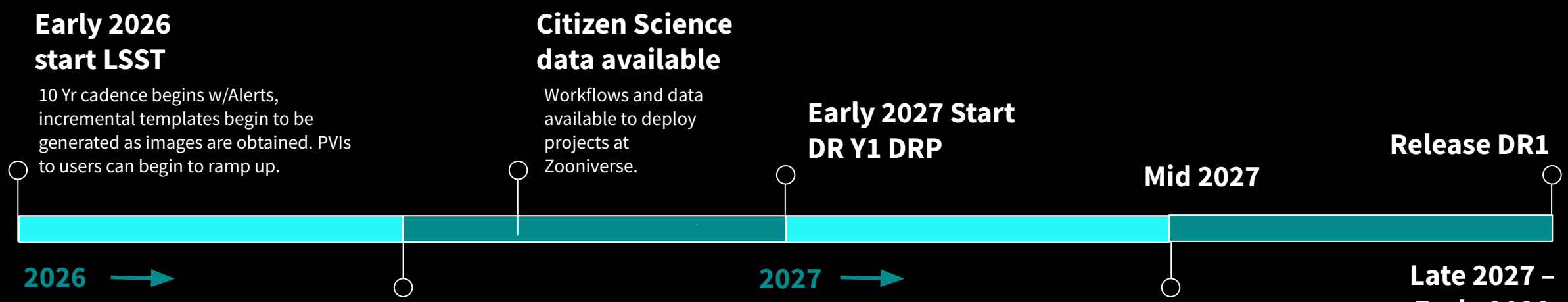
Have a question or a problem?

- Create a **new Topic** in the "**Support**" category.
- All Rubin-related questions belong here!
- Everyone is encouraged to ask: *students especially*.
- Rubin staff monitor all topics to ensure solutions.

Confidential support is also available (see banner).

Posting requires account creation and login; reading does not.

Rubin Y1-Y2 Timeline



Summary

Rubin Observatory is getting ready to start the 10-yr survey. Tremendous progress has been made this year by the Construction and Operations teams. Work remains for which we have appropriate plans.

The highest priority for the team in early operations is optimizing on-sky performance for the start of LSST.

Data Preview 2 is in work now and coming later this year.

Thank you to the community for your efforts!

A new record for IQ, December 17

visit:205121700028