



Survey Strategy Updates

Lynne Jones (SST) and Federica Bianco (SCOC chair)

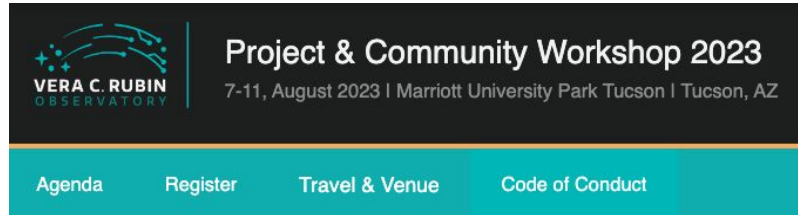
Peter Yoachim (SST)

Members of the SCOC

**Timo Anguita, Franz Bauer, Louise Olivia Violet Edwards,
Saurabh Jha, Rachel Mandelbaum, Adam Miller,
Knut Olsen, Colin Slater, Steven Smartt,
Jay Strader, Rachel Street, Kat Volk**



Reminder - Code of Conduct




Harassment and unprofessional conduct (including the use of offensive language) of any kind is not permitted at any time and should be reported to:

- Andrew Connolly (ajc@astro.washington.edu),
- John Franklin Crenshaw (jfc20@uw.edu), and/or
- Alysha Shugart (ashugart@lsst.org).

Rubin Observatory adheres to the principles of kindness, trust, respect, diversity, and inclusiveness in order to provide a learning environment that produces rigor and excellence.



full code of conduct



Handshakes OK
Fold Here

Elbow/Fist Bump OK
Fold Here

I Need My Space
Fold Here

Wear a mask if you want to!

Check name-tags for these contact comfort level stickers.

Use the confidential email rubin2023-covid@lists.lsst.org to request a test, report your test results, or ask questions.



If someone is wearing a pin like this, and it indicates a low social battery, please give them their space or offer to restart the conversation at a later time.

If you feel unsafe at any time send an email to rubin2023-helpline@lists.lsst.org

Reminder - Virtual Participation



Virtual participants should be muted when they're not speaking.



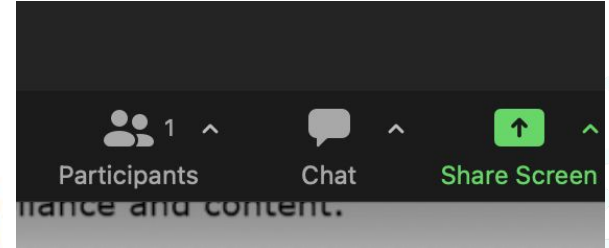
In-person participants should speak into the room microphone(s), or the chair should repeat all questions into the microphone, so that the virtual participants can hear what is said.



In the Rubin2023_PCW Slack Space, all participants can use the session's channel for Q&A and discussion.



The channel name convention is, **#day3-wed-1400-survey-strategy**



In Zoom, use the chat to:

- request to unmute to ask a question, or
- type your question so someone can speak it aloud.

The Zoom “raise hand” feature is generally harder for moderators to track, and is not preferred, but may be used at the discretion of the session chair.

Outline of session

- Introduction to the SCOC and SST
- V3.2 Baseline Survey Strategy
 - Evolution in the baseline from v2.0
 - Specific updates in v3.2
- Current SCOC activities (remaining questions)
 - Filter loading/swaps with lunar cycle
 - Galactic Plane and Magellanic Clouds coverage
 - DDF strategy
 - Survey Uniformity
 - ToO Options
 - Early Science
 - Responding to Commissioning (snaps, throughputs and filter balance)
- Future SCOC plans
 - The SCOC during Operations

Please ask questions on the slack channel
#day3-wed-1400-survey-strategy

Survey Scheduling Team



Lynne Jones
Aerotek/Rubin
Lead Scheduler Scientist



Peter Yoachim
University of Washington
Scheduler Scientist

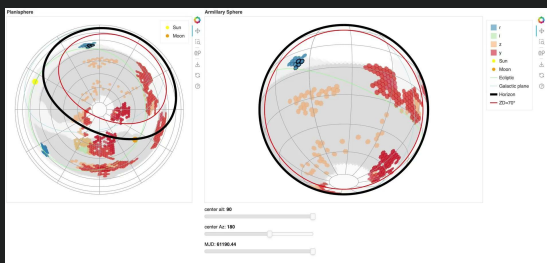


Eric Neilsen
Fermilab
Scheduler Scientist

Building the ‘brain’ of the scheduler (the FBS)
Evaluating survey strategy options
Building the tools to monitor survey progress during operations



Future member
Bryce Kalmbach
Currently Rubin commissioning;
will become Scheduler Scientist



The Survey Cadence Optimization Committee

<https://www.lsst.org/content/charge-survey-cadence-optimization-committee-scoc>



Committee Members:

- **Timo Anguita**, Universidad Andres Bello, Chile (Strong Lensing SC liaison)
- **Franz Bauer**, Universidad Católica, Chile (AGN SC liaison)
- **Louise Olivia Violet Edwards**, Cal Poly, SLO (Galaxies SC liaison)
- **Saurabh Jha**, Rutgers University (DESC liaison)
- **Rachel Mandelbaum**, CMU (DESC liaison)
- **Adam Miller**, Northwestern University (TVS SC liaison)
- **Knut Olsen**, NSF's NOIRLab (SMWLVL SC liaison)
- **Colin Slater**, University of Washington (TVS SC liaison)
- **Steven Smartt**, Oxford University (DESC liaison)
- **Jay Strader**, Michigan State University (SMWLVL SC liaison)
- **Rachel Street**, Las Cumbres Observatory (TVS SC liaison)
- **Kat Volk**, University of Arizona, Planetary Science Institute (SSSC liaison)

Non-voting Committee Members:

Lynne Jones, Rubin Observatory, ex officio

Federica Bianco, Rubin Observatory, Chair (ISSC liaison)

The Survey Cadence Optimization Committee

<https://www.lsst.org/content/charge-survey-cadence-optimization-committee-scoc>



The SCOC meets (at least) monthly

The SCOC has liaisons in each Science Collaboration: their job is to establish and maintain bilateral communication

Monthly office hour on the last monday of the month at 7 Pacific - [ls.st/scocofficehour](https://www.lsst.org/lsst/scoc/officehour)

Monthly meeting minutes available on community
<https://community.lsst.org/t/public-scoc-meeting-minutes>

Workshops held annually in November

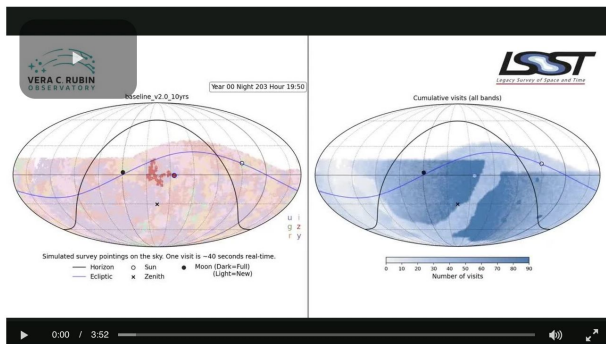
https://iopscience.iop.org/journal/0067-0049/page/rubin_cadence

18 published papers! 168 authors!! And counting!

THE ASTROPHYSICAL JOURNAL
SUPPLEMENT SERIES

Rubin LSST Survey Strategy Optimization

PI: Federica Bianco



The Vera C. Rubin Observatory's Legacy Survey of Space and Time (LSST) will provide unprecedented data that will be made available to all US and Chilean scientists and to international member scientists for a diverse range of astrophysical investigations, from cosmology to solar system studies and from stellar astrophysics to transients to galaxy evolution. In any synoptic survey such as this one, the choice of cadence—the pattern in which the telescope moves across the sky and periodically revisits each field—is of vital importance in maximizing the scientific utility of the data. Yet, identifying the optimal cadence for a broad range of scientific goals is a challenge. As part of the survey design and characterization process, Rubin Observatory involved the LSST science community by soliciting Cadence White Papers and Cadence Notes. Peer-reviewed journal articles describing scientific investigations that motivate and support these notes are published in this focus issue as a record of the factors which influenced survey design, and for guidance for future surveys that may confront many of the same issues faced by Rubin Observatory.

FAQ:

Does the focus issue still accept submissions?

YES! The focus issue is open for submissions that are published on a rolling basis. When we release the final survey strategy before operations we will close the issue with an SCOC led paper. Until then you can submit!

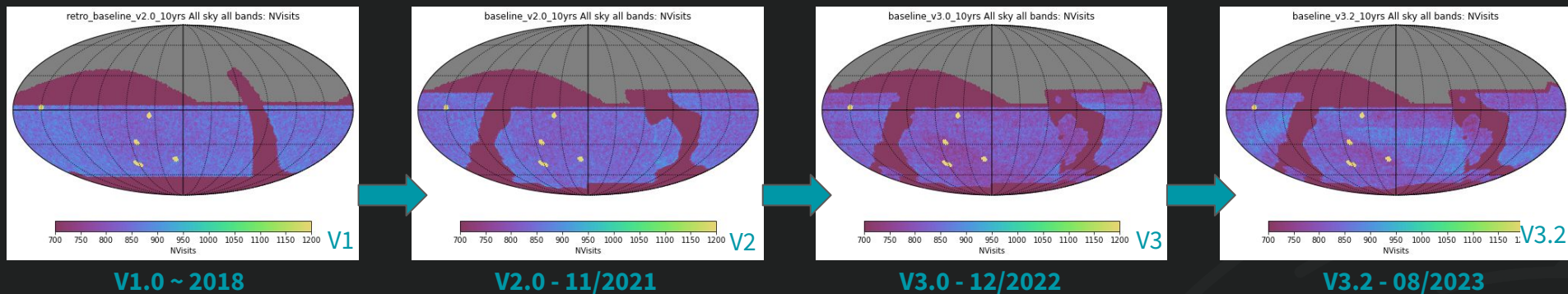
How do I submit a paper?

- Submit as a normal paper through normal ApJS;
- Use the “instrumentation lab astrophysics, software, data” track
- Include a cover note that says this “To be considered for the ApJS Rubin Cadence Focus Issues”.

Thanks to Chris Lintott (ApJS editor) for his vision and support!
Many papers were supported by a HSF grant to the SCs (PI Street)



Baseline Survey Strategy Evolution

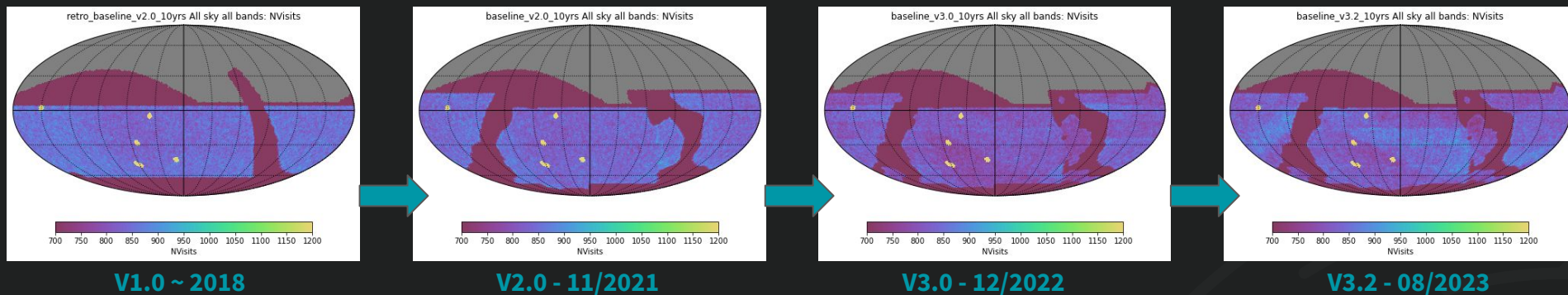


The last five years have brought changes!

Improvement of footprint for extragalactic science, improvement of cadence on short timescales, resulting in general improvements in science metrics. Overall # of visits per pointing has dropped as visits are directed other than traditional WFD.

We are now at v3.2 of the baseline survey strategy.

SCOC Recommendations so far



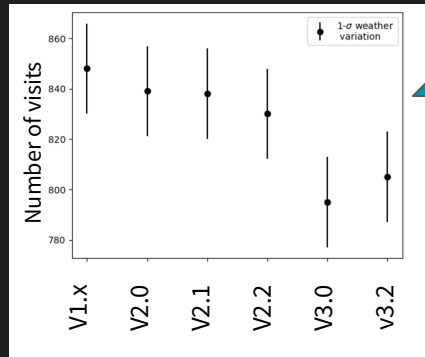
Previous SCOC recommendations on survey strategy are described in [PSTN-053](#) (Phase 1 recommendations) and [PSTN-055](#) (Phase 2 recommendations).

Highlights from these recommendations include

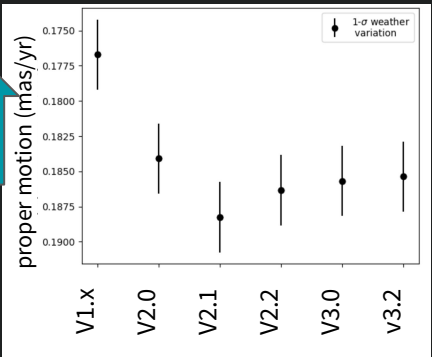
- Change in footprint coverage, including increase in low-dust area (v2, v3)
- Using a rolling cadence: 2 'bands' (4 regions) (v2)
- Increasing time spent on DDFs (v3)
- Adding one early microsurvey (near-sun twilight microsurvey) (v3)
- Adding a small fraction of revisits at multi-hour (2-7hr) intervals within some nights (v3)



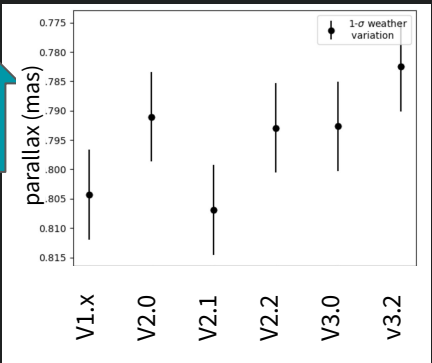
Baseline Survey Strategy Evolution



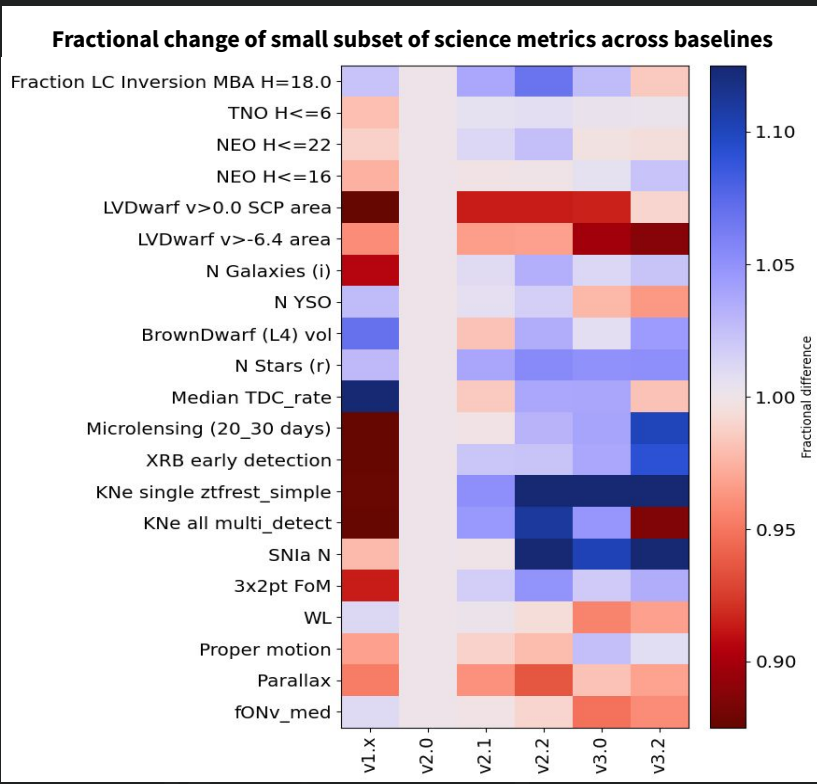
better



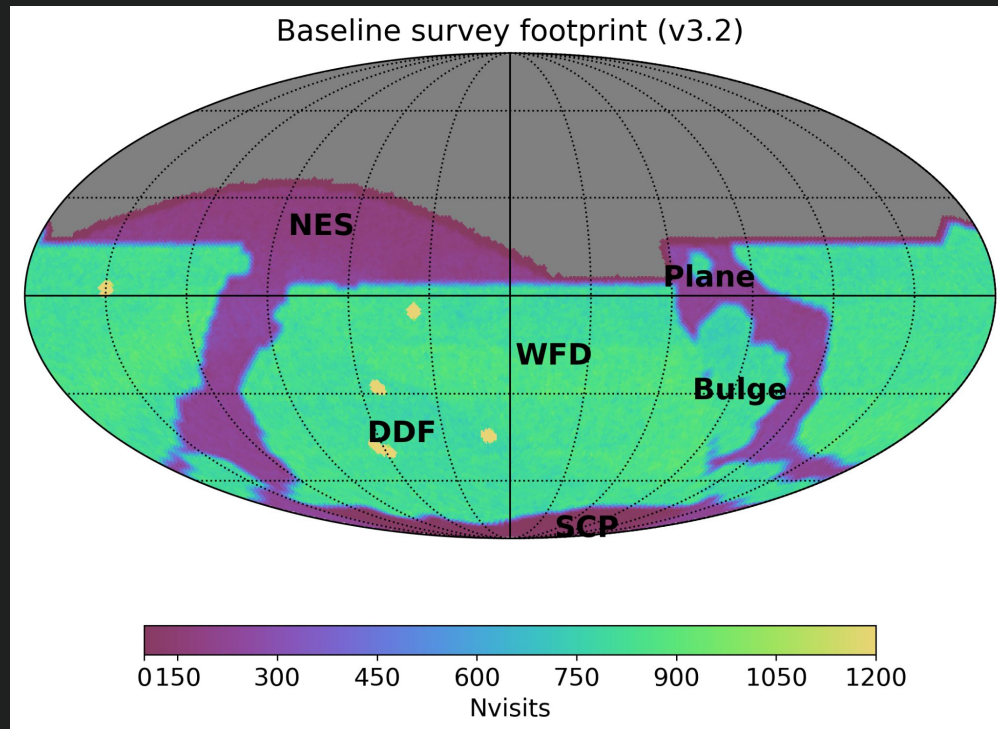
better



Core SRD metrics across baselines, with error bars based on simulations using different weather histories. (measured in 'WFD' area, median values)

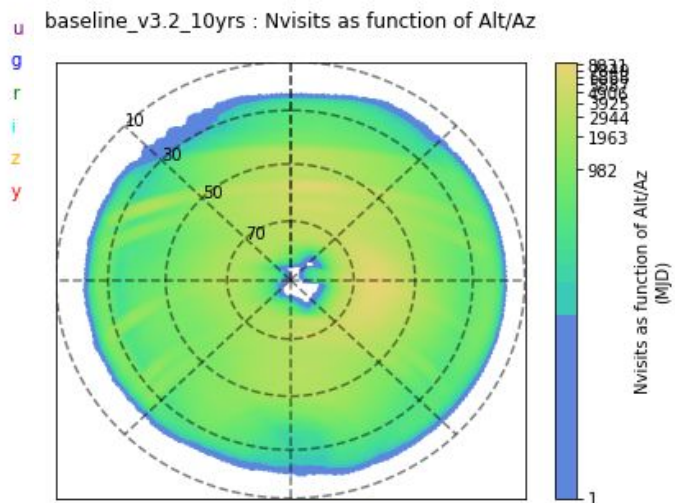
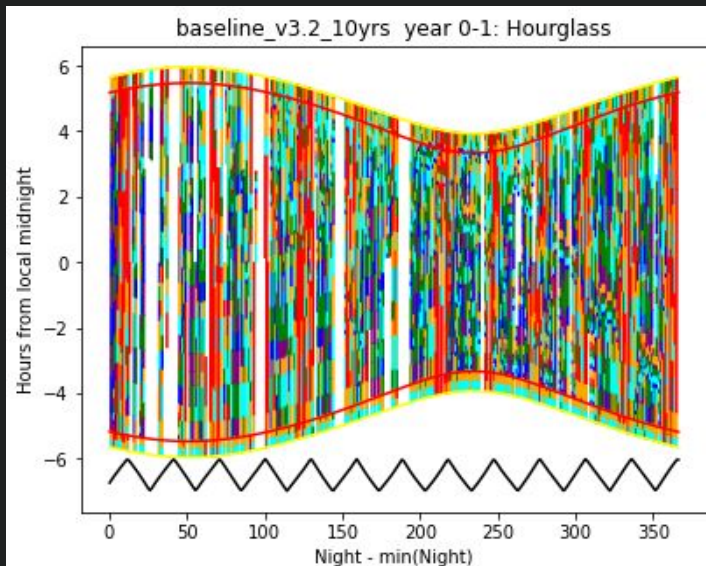
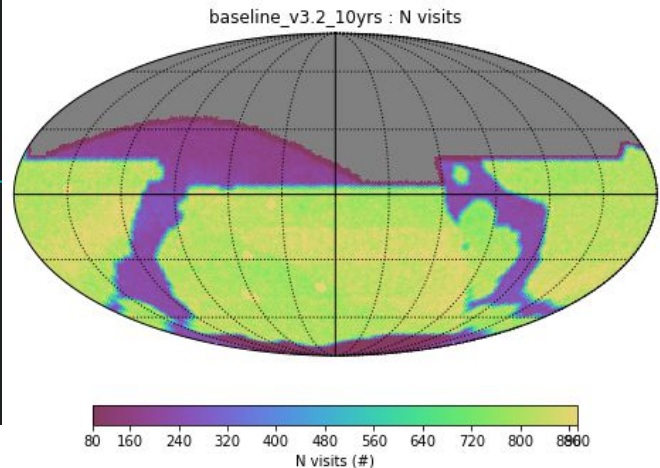


V3.2 Baseline - Peter Yoachim



Overview

- 10 years, 2.1 million visits



Breakdown of Observing Modes

Survey Mode	Percentage of Exposure Time	Note
Pair_33	74%	Paired observations in neighboring filters (e.g., $r+i$)
Pair_15	10%	Paired observations with 15 min gap
DDF	6.7%	Deep Drilling Fields
Long Gaps	3.8%	Paired observation, plus a third observation 3-7 hour later
Greedy	3.9%	Filler greedy algorithm
Near sun quads	1%	1x15s exposures in twilight, mainly for inner solar system objects

V2.0 -> V3.2

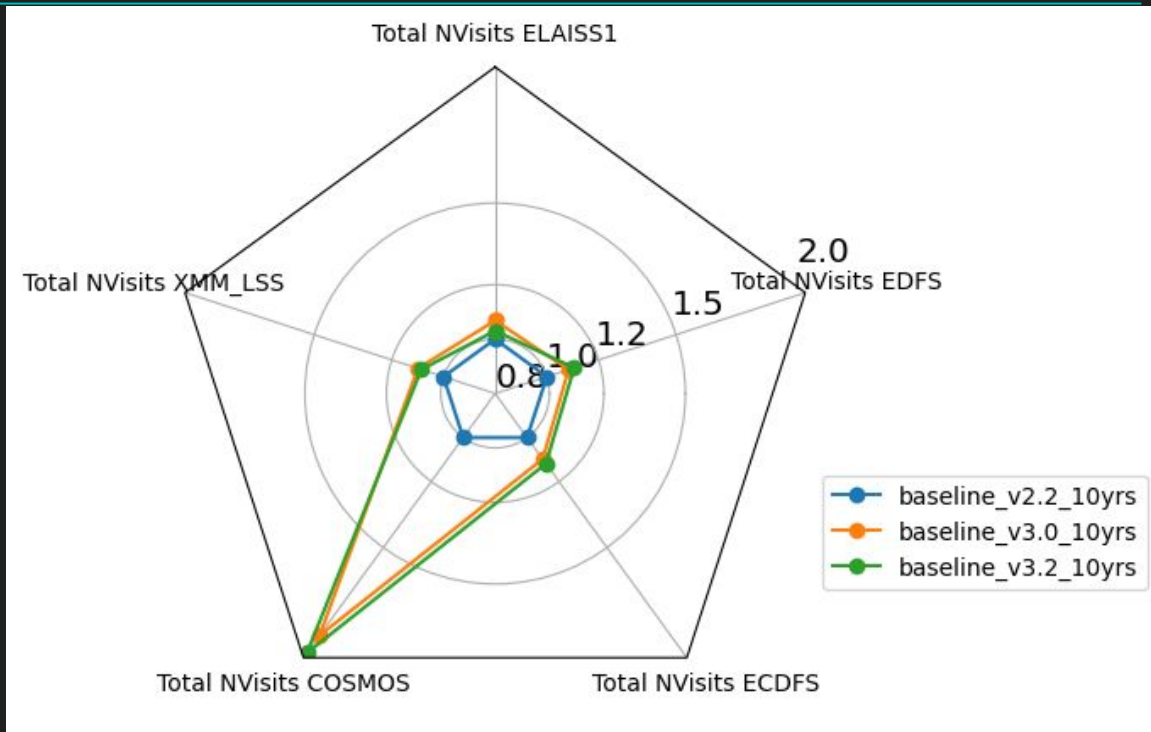
- V3.0 increased DDF time and added early 10-year depth coverage for COSMOS field (PSTN-055 recommendations 2.6.2)
- V3.0 introduced near-sun twilight microsurvey (PSTN-055 recommendations 2.7.2); *v3.2 updated this near-sun survey to be even nearer to the sun*
- V3.0 adds triplets (3-7 hour gaps - PSTN-055 recommendations 2.4.2); *v3.2 updates gap implementation*

V3.0 -> V3.2:

- Update start date to May 1, 2025
- Update footprint to include small Euclid swath
- Keep z filter loaded at all times, swap out y in dark time
- Improved u and g coverage in the 1st year
- Other minor bug fixes

DDF coverage

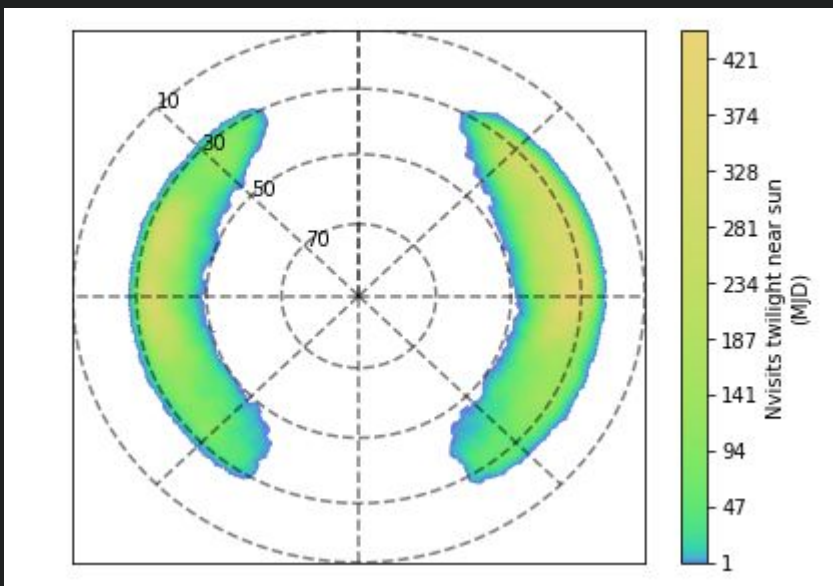
V3 increases overall time spent in DDFs, and adds early 10-year depth coverage in COSMOS (PSTN-055 phase 2 recommendation 2.6.2-2 and 2.6.2-3)



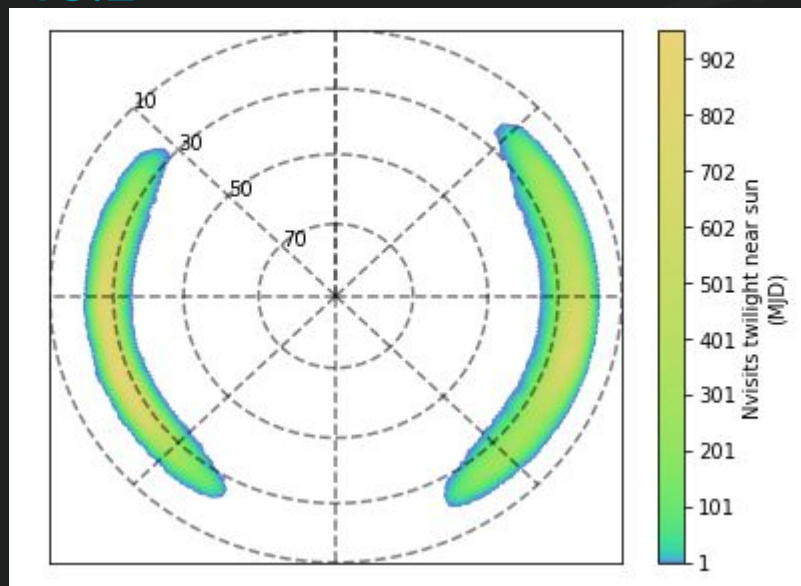
Near-sun Twilight Microsurvey (v3.0 -> v3.2)

Alt/az distribution of near-sun twilight observations (~1% of exposure time)

v3.0

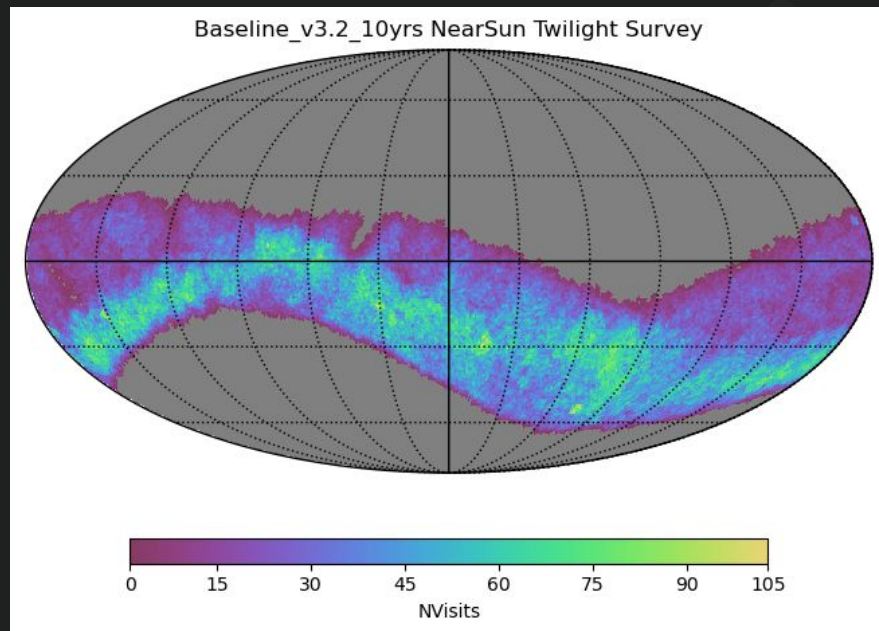
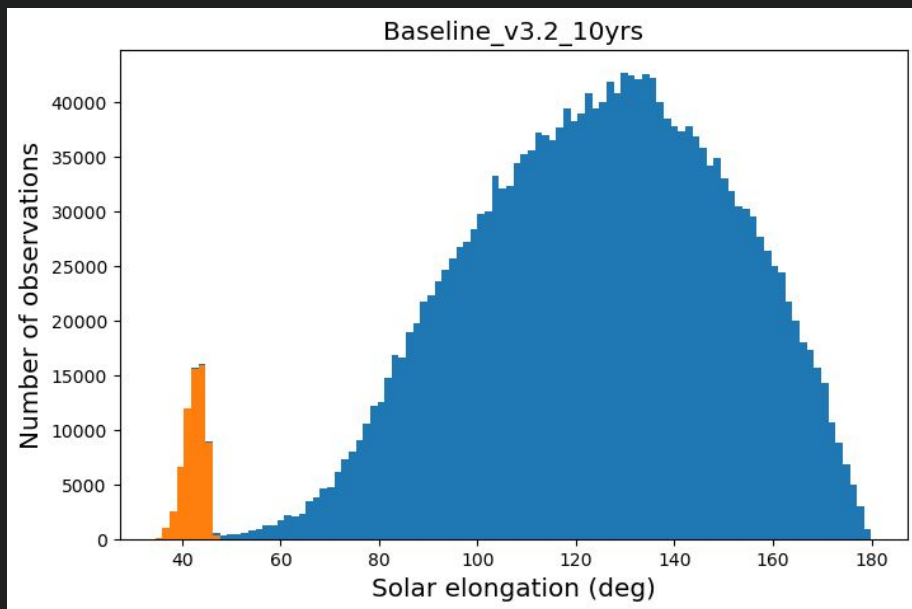


v3.2

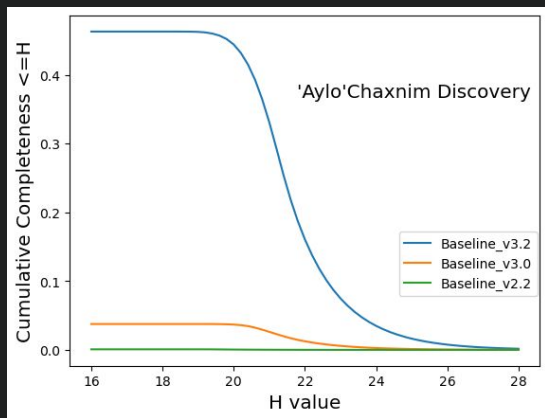


Near-sun Twilight Microsurvey

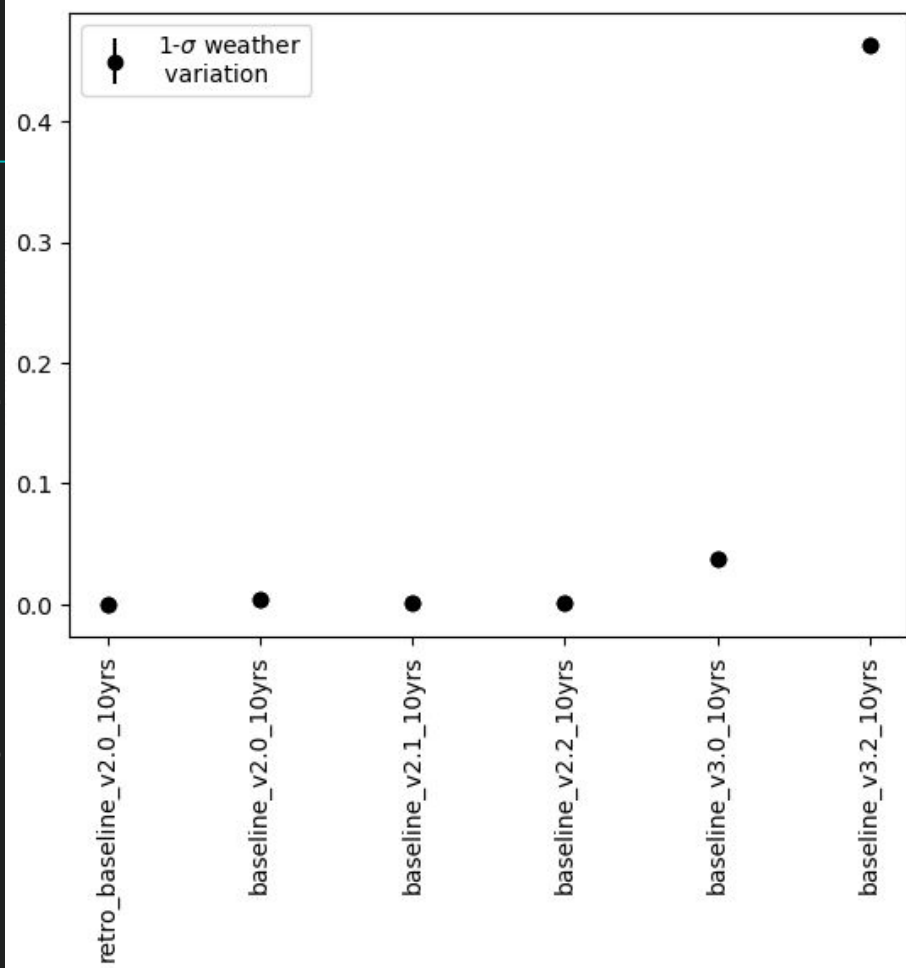
Goal: Improve recovery of interior-to-Earth asteroids
([PSTN-055](#) phase 2 recommendations 2.7.2)



This V3.2 update is probably the biggest impact on all science metrics, going from detecting ~4% of objects interior to Venus to over 40% of objects with $H \leq 20$



'Aylo'Chaxnim Completeness $H \leq 20$

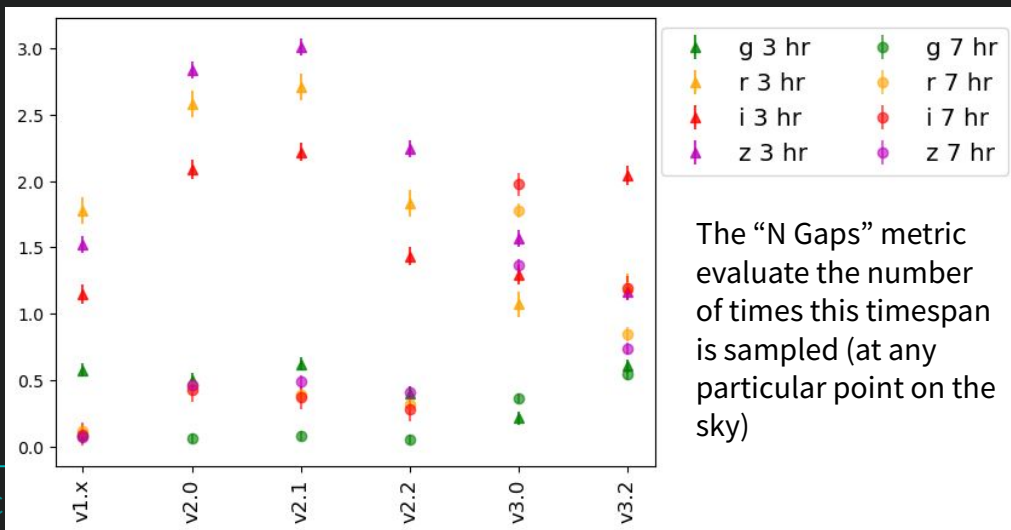


Intra-night triplets

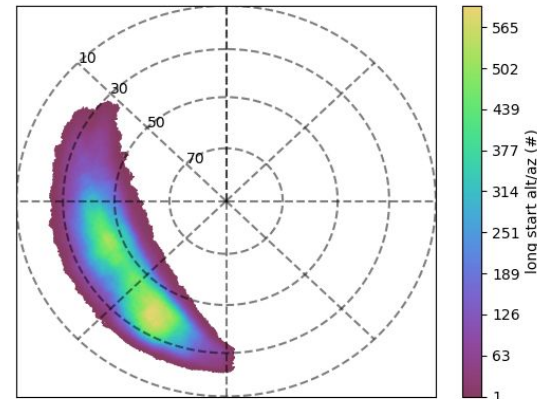
Return for a 3rd visit to match an earlier pair (repeat in one of the same filters - *griz*)

Triplet spacing between 2-7 hours

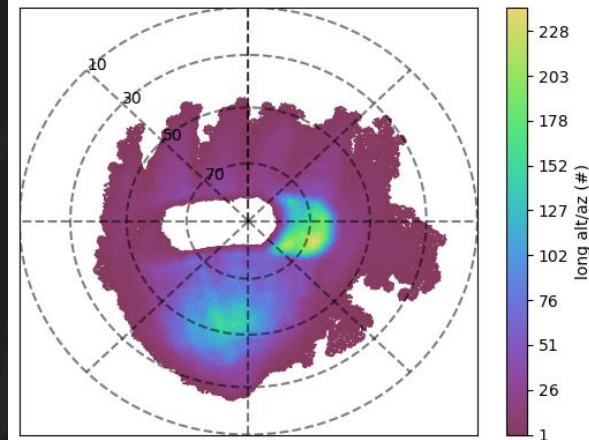
V3.0 and v3.2 have equivalent # of triplets, but v3.2 more even between 2-7 hours, one 'set' of triplets per nights



baseline_v3.2_10yrs note like blob_long%: long start alt/az



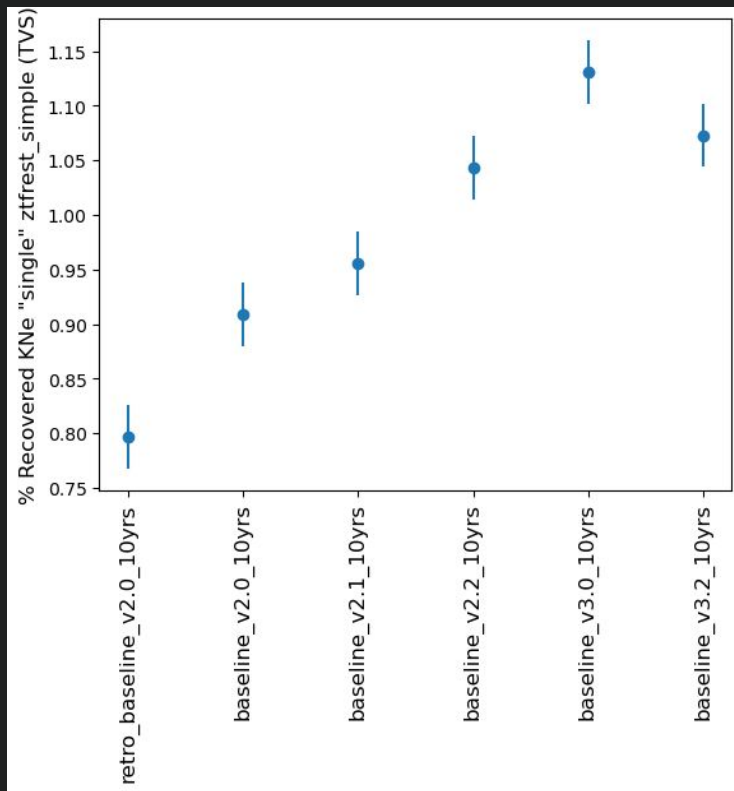
baseline_v3.2_10yrs note long: long alt/az



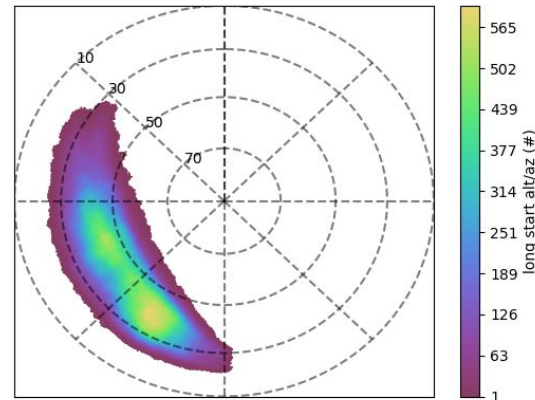
Intra-night triplets

Sampling 3-7 hour timescales. V3.2 shows small drop in KNe (but we are always in the low %-recovery regime with KNe).

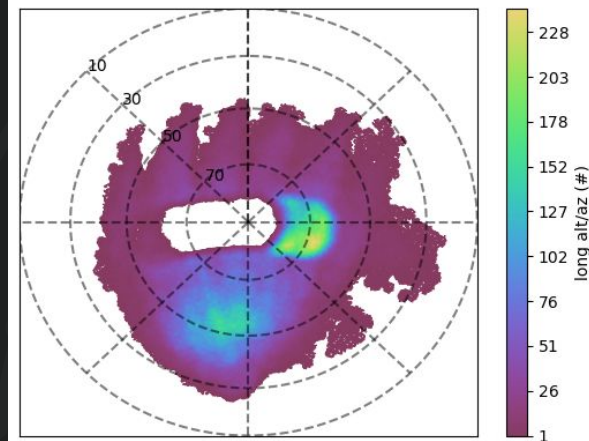
We are sampling 3-7 hours, but more targeted science metrics would be helpful.



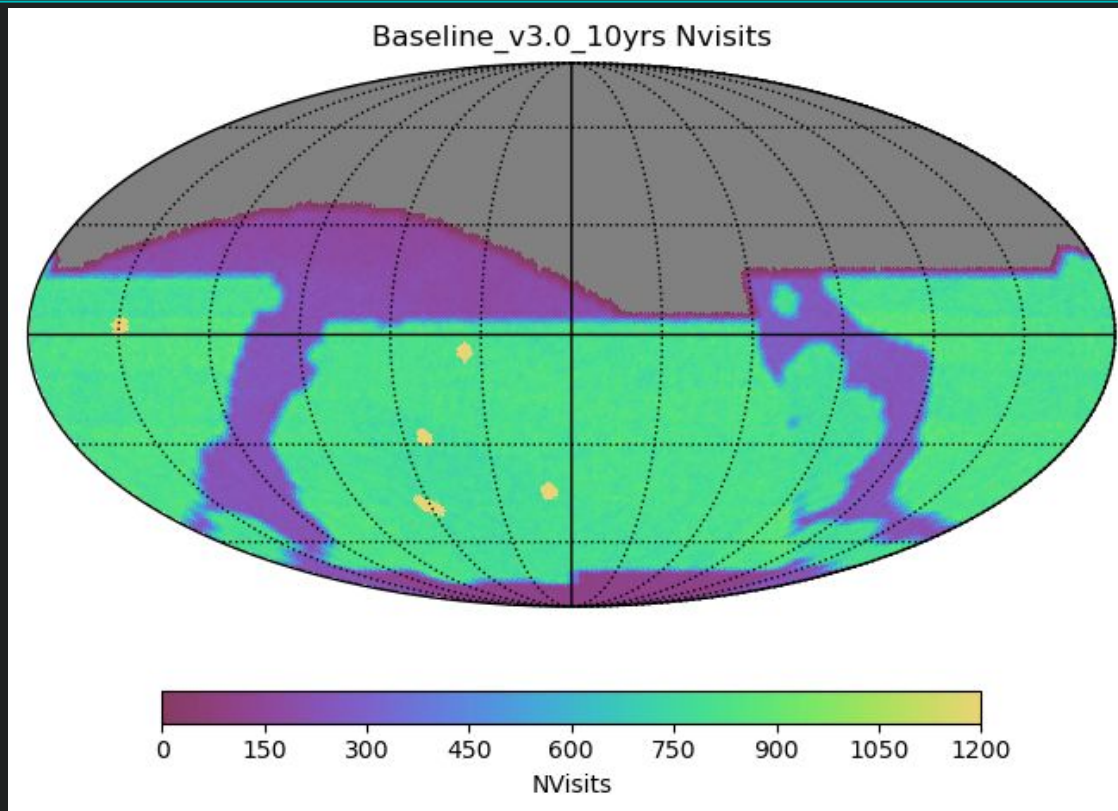
baseline_v3.2_10yrs note like blob_long%: long start alt/az



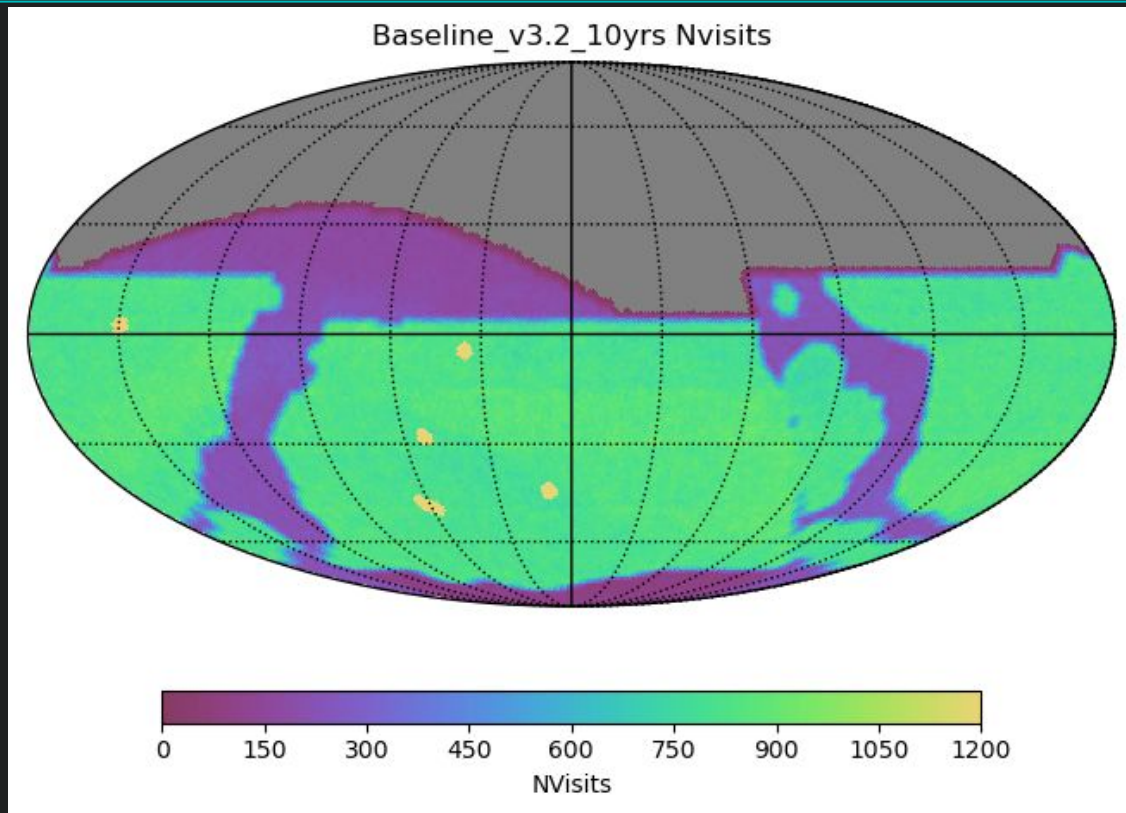
baseline_v3.2_10yrs note long: long alt/az



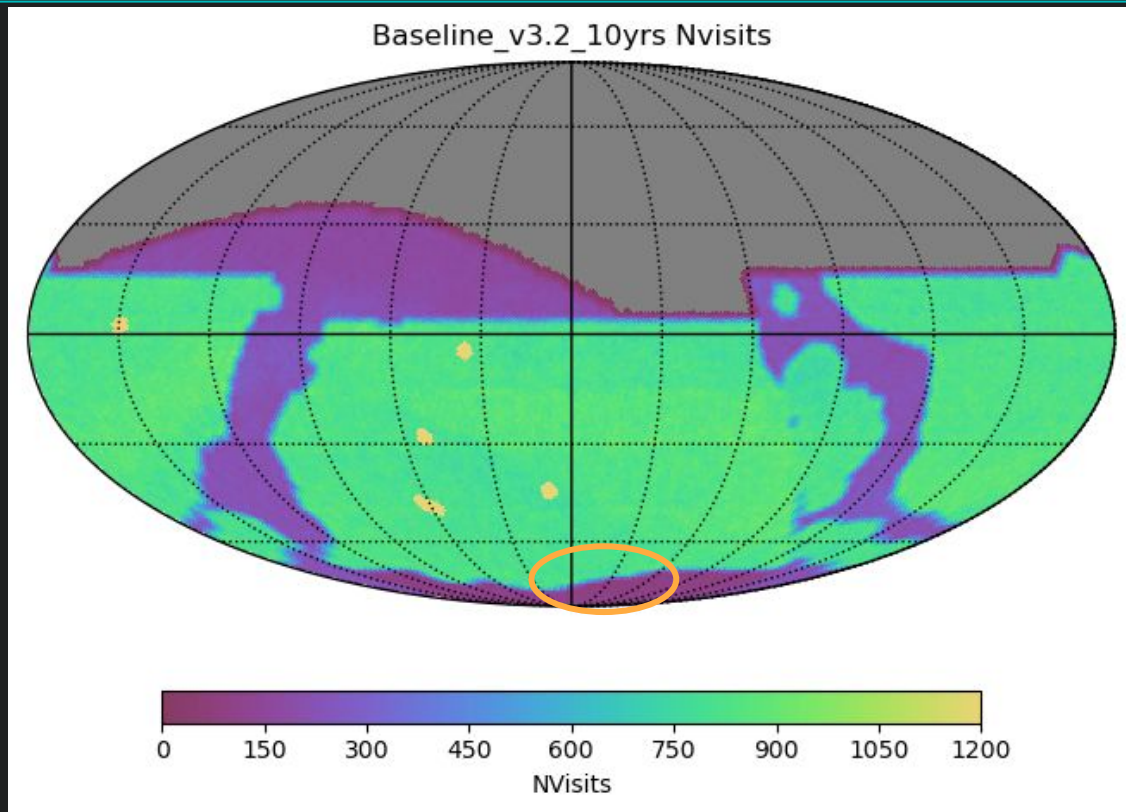
V3.2 Update footprint with Euclid swath



V3.2 Update footprint with Euclid swath



V3.2 Update footprint with Euclid swath



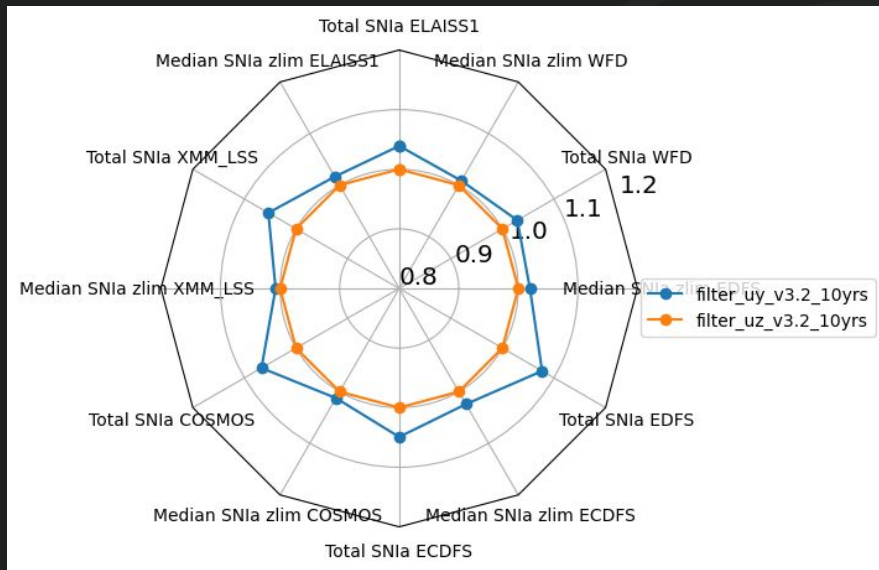
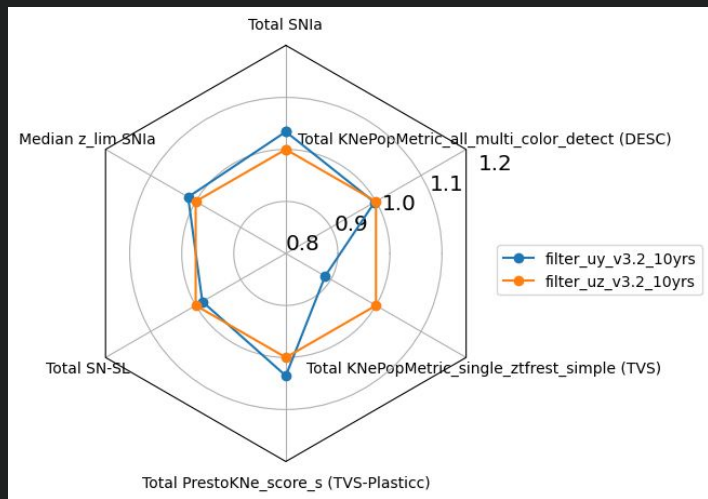
V3.2 Swap u with y filter ($u-y$) instead of z

DDF coverage depends on when/what filter is available -

DDF science depends more on cadence in z than cadence in y

No (clear) major changes in other science metrics (remember uncertainties too!)

Keeps z band filter safer

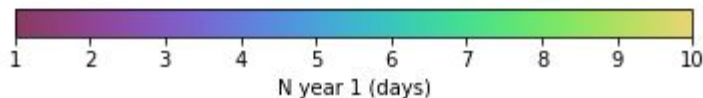
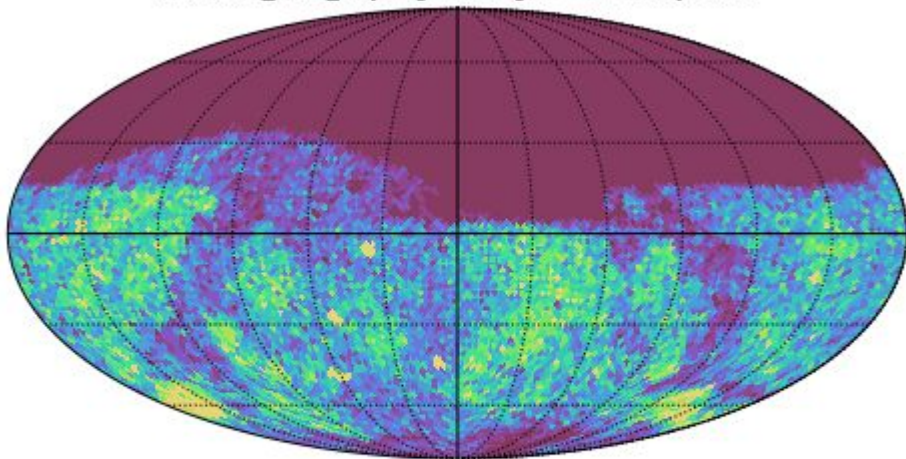


V3.2 Improve uniformity of first year coverage

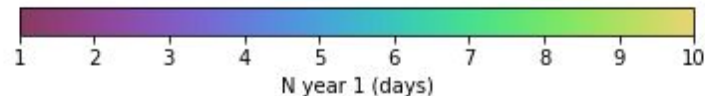
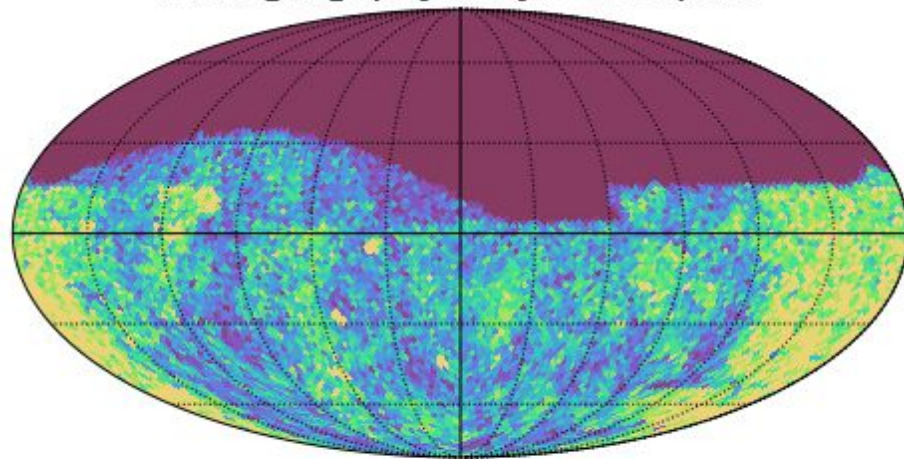
First year coverage in blue filters corrected
(in v3.0, fewer visits in *u* and *g* band left some parts of the sky poorly observed)

NOTE: Y1 strategy subject to
change - see [Early Science
session \(L. Guy\)](#)

baseline_v3.0_10yrs g and night < 365: N year 1

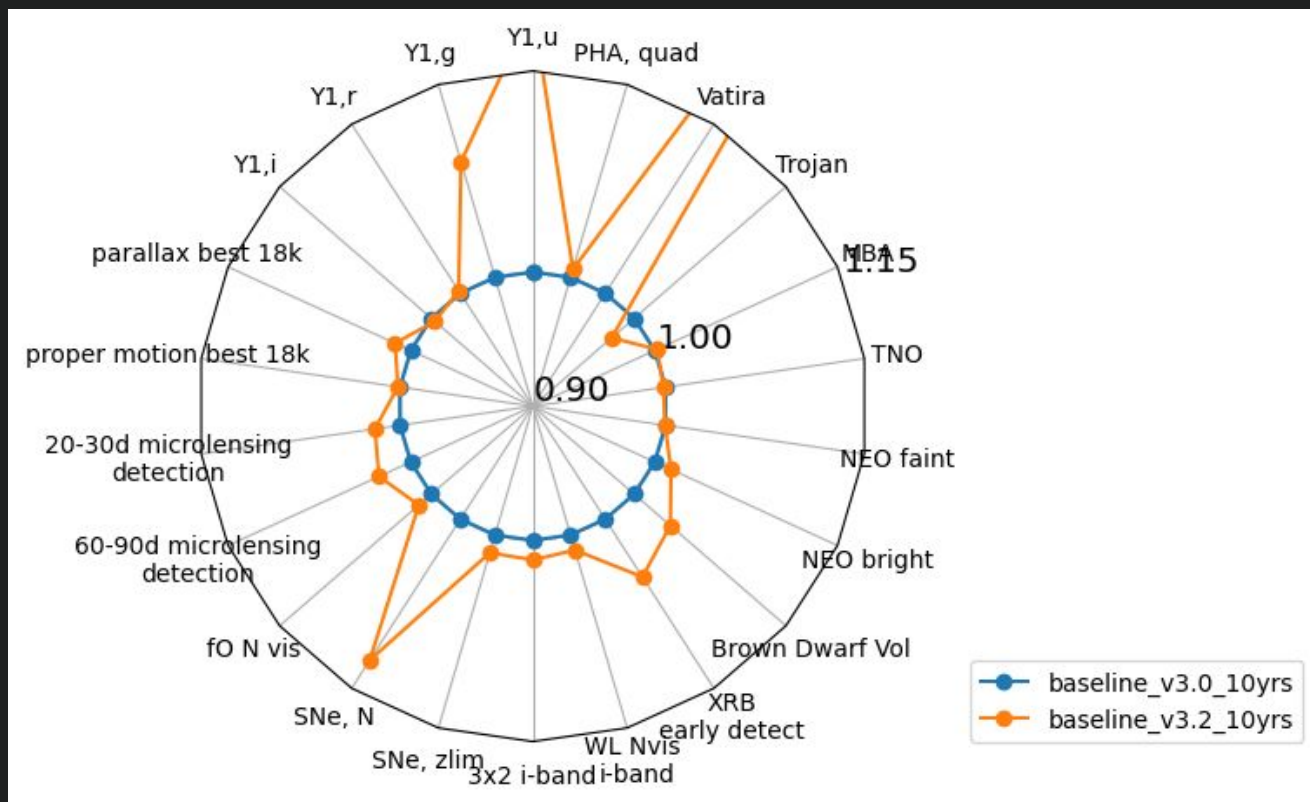


baseline_v3.2_10yrs g and night < 365: N year 1



Changes v3.0 -> v3.2

- SNe Ia improve from leaving z loaded full time
- Vatira and XRB improved by better twilight strategy
- Slight dip in Trojan recovery (probably due to start date change)



SCOC Progress and Plans - Federica Bianco

- Introduction to the SCOC and SST
- V3.2 Baseline Survey Strategy
 - Evolution in the baseline from v2.0
 - Specific updates in v3.2
- Current SCOC activities (remaining questions)
 - Filter loading/swaps with lunar cycle
 - Galactic Plane and Magellanic Clouds coverage
 - DDF strategy
 - Survey Uniformity
 - ToO Options
 - Early Science
 - Responding to Commissioning (snaps, throughputs and filter balance)
- Future SCOC plans
 - The SCOC during Operations

SCOC Pending Recommendations

PSTN-055 identified the following topics were identified where decisions remain to be finalized:

- Availability of filters on the filter wheel (swapping uz , uy , or uzy with moon phases)

SCOC Pending Recommendations

PSTN-055 identified the following topics were identified where decisions remain to be finalized:

- ~~Availability of filters on the filter wheel (swapping *uz*, *uy*, or *uzy* with moon phases)~~
- Filter balance in response to on-sky throughput
- 2x15 vs 1x30 second snaps per exposure

Require commissioning / on-sky data to be finalized

SCOC Pending Recommendations

PSTN-055 identified the following topics were identified where decisions remain to be finalized:

- ~~Availability of filters on the filter wheel (swapping *uz*, *uy*, or *uzy* with moon phases)~~
- Filter balance in response to on-sky throughput
- 2x15 vs 1x30 second snaps per exposure
- Uniformity of coadds within a rolling cadence
- Galactic Plane/Bulge footprint and filter balance optimization
- Intranight cadence in the Deep Drilling Fields (and Euclid synergy)
- Target of Opportunity strategy
- Early Science

PSTN-055 identified the following topics were identified where decisions remain to be finalized:

The SCOC offered the opportunity to share updates that impact directly the decisions that remain to be made - **thank you to all respondents!**

14 respondents: AGN SC (1); DESC (3); GAL SC (1); SMWLV (5); SLSC (2); SSSC (1); TVS (5)

Observing strategy desiderata

This form is designed for community members to identify and update key desiderata and concerns within their white papers and cadence notes that may be impacted by future recommendations of the SCOC on survey parameters yet to be finalized. The format of this form is as follows:

In the first section we will ask you to identify your contributions to the optimization of the LSST survey cadence. This allows us to understand the context of the following answers

Subsequent sections are associated with the subset of the topics for future deliberation identified by the SCOC (in <https://pstn-055.lsst.io/> Section 4) that depend on community input. For each topic you will be able to restate the desiderata and concerns expressed in your white papers and cadence notes; we also ask that you identify the white paper/cadence note where these were shared with the SCOC in the first place. In each of these sections a short synopsis of the framework for further deliberation is included, as reported in Section 4 of PSTN-055. We recommend that survey responders review the associated subsection of PSTN-055 in full before filling in a section to have a complete understanding of the remaining flexibility in the survey strategy choices and the context for the SCOC deliberations.

Form input will be viewed only by members of the [Rubin Survey Cadence Optimization Committee \(SCOC\)](#).

The form will remain open until June 7th 11:59PM Pacific Time

Topic	Responses
DDF intranight cadence	3
MW strategy	6
Uniformity of coadds	2
Early Science	6
Availability of filters	3
ToO strategy	4
2x15 vs 1x30 exposure	6
Filter rebalancing	7



SCOC Pending Recommendations

Remaining survey strategy questions: SCOC TASK FORCES (*agile but inclusive!*)

- **Uniformity of survey coadds** (chair: Rachel Mandelbaum)

To provide input to SCOC discussions and quantitative assessments on the scientific impact of the baseline rolling cadence on the uniformity of the annual data release coadds, and explore cadence improvements within the Phase 2 recommendation for 2 sky areas + 0.9 rolling strength.

- **Milky Way Strategy** (chairs: Jay Strader, Rachel Street)

To provide input to SCOC discussions and quantitative assessments on the scientific impact of Milky Way, Magellanic Cloud, South Celestial Pole observing strategy choices that remain to be finalized including footprint and rolling on footprint and filter balance.

- **Deep Drilling Fields Strategy** (chair: Saurabh Jha)

To provide input to SCOC discussions and quantitative assessments on the scientific impact of intranight cadence in choices on the Deep Drilling Fields (DDFs) including filter sequences, and distribution of observations within the 10 years (within the constraints of PSTN-055)

Recommendations to SCOC planned by end of 2023 (MW and Uniformity) + 2024 Q1 (DDF)

SCOC Pending Recommendations

Remaining survey strategy questions: SCOC TASK FORCES

- **Uniformity of survey coadds (chair: Rachel Mandelbaum)**
- **Milky Way Strategy (chairs: Jay Strader, Rachel Street)**

[Observing strategy and photometric calibration](#) session on Monday

#day1-mon-1400-obs-strat-phot-cal

Peter Yoachim (chair)

Eli Rykoff

Loredana Prisinzano



SCOC Pending Recommendations

Remaining survey strategy questions: Target of Opportunity

- A recommendation on the overall time to allocate to ToOs was included in PSTN-055

The SCOC recommends a Target of Opportunity (ToO) program be enabled to respond to Gravitational Waves and Multi-Messenger Astronomy triggers with a fraction of $\leq 3\%$ of dedicated survey time, with the possibility of extending it to additional types of targets in the future; a path toward a process to formulate recommendations for target selection and observing strategy details is outlined (subsection 2.8).

- Remaining decision includes:
 - To what triggers will we respond
 - What observing strategy will be implemented on each trigger

The SCOC is working toward the organization of a community workshop to deliver this decision via a white paper co-written at the workshop by community members, Rubin Obs members, and the SCOC.

To make the workshop inclusive, the SCOC is seeking support and funding - Berkeley will kindly host us!

Likely early 2024 - hybrid format (limited in person capacity) - stay tuned! - contacts: SCOC + Igor Andreoni

Commissioning, science validation and verification, and the first year of operations will tell us a lot about Rubin's capabilities and operations

Questions addressed in time period:

- Updates in the throughputs will happen as mirror coating decisions happen (triple Ag), as measurements come in from the labs, and as we get on-sky
 - evaluate the distribution of visits between filters (filter balance)
- 2x15s visits or 1x30s visits (snaps or no snaps)
- Priorities during commissioning and early science to enable 10-year success
 - e.g., should templates be maximized over area or over multiple filters?

SCOC recognizes and values previously gathered feedback; will solicit more

The SCOC in Operations (work in progress)

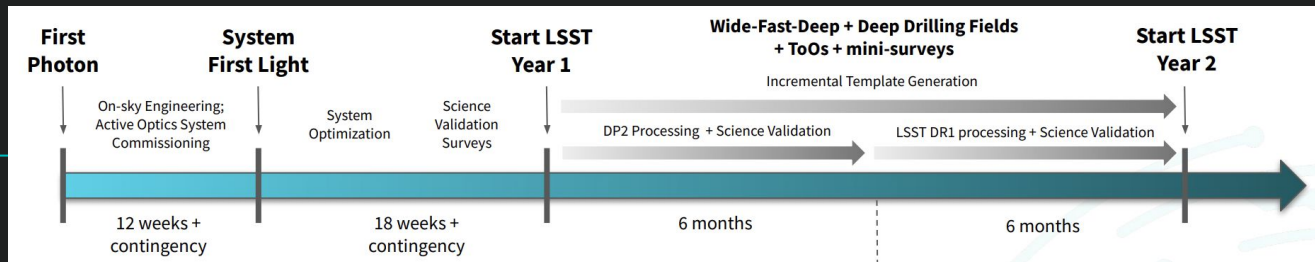
Expected concerns for the SCOC during operations:

- Modifications to ToO strategy
- Responding to new scientific priorities - *e.g.* adding options to include new science or microsurveys
- Respond to unexpected events in operations

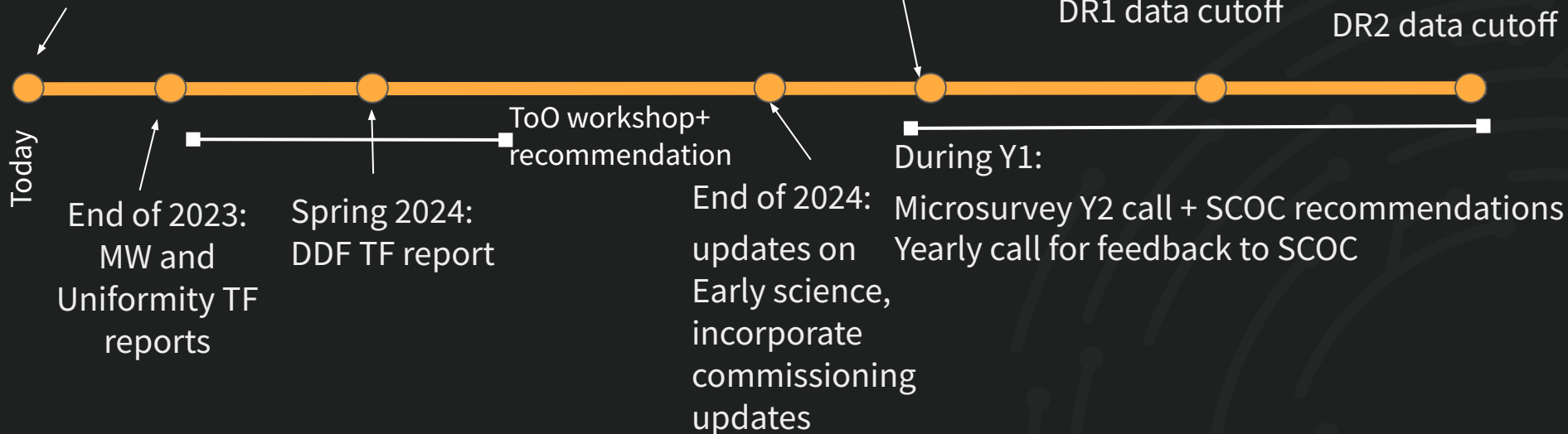
How will the SCOC recognize them and address them?

- Continuing roles of liaisons into the SCs
- Annual call for feedback
- Open community portal to share feedback on an ongoing basis - annual action
- Release of quarterly and annual reports of survey progress

Timeline



Current status:
v3.2 baseline



Questions from slido (not previously addressed)

There were questions about timelines and priorities which were hopefully addressed in previous slides. Additional Slido questions include:

Can the SCOC commit to finalizing the remaining cadence decisions that do not require on-sky LSSTCam data by December 2023? If not, can you explain why?

No, and there is no compelling reason to. The questions that remain to be answered require input from the community and we are working with the community. Rushing the decisions that are not needed by 2023 by the Observatory would put unnecessary pressure on the community.

Questions from slido (not previously addressed)

There were questions about timelines and priorities which were hopefully addressed in previous slides. Additional Slido questions include:

The low Solar-elongation Solar System twilight survey likely needs some optimization. Is this something the SCOC will look at in 2025?

Obviously we would like to make the survey as useful as possible, including the near-sun twilight survey, and presumably the optimization for this microsurvey is within a fairly limited 'box'.

The SCOC will be taking feedback yearly after operations start, so the timeline for when and how to adjust the microsurvey is worth considering - the SST would anticipate at least some adjustments to this microsurvey during commissioning as we learn more about twilight sky brightness, telescope efficiency at the very ends of the night, and the state of satellite constellations.

Questions from slido (not previously addressed)

There were questions about timelines and priorities which were hopefully addressed in previous slides. Additional Slido questions include:

Are there notebooks that plot the various key metrics the SCOC is using to evaluate the cadence comparing v2.2, v3.0, and v3.2 baselines?

YES!

They are a bit scattered in location at the moment (reflecting a limited set of changes from v3.0 to v3.2) but see for example -

https://github.com/lsst-sims/sims_featureScheduler_runs3.2/blob/main/maf/quick_look.ipynb

Questions from slido (not previously addressed)

There were questions about timelines and priorities which were hopefully addressed in previous slides. Additional Slido questions include:

The current SCOC started in Jan 2023. With a now-mid 2025 expected start date, is the plan to have a new SCOC take over in Jan 2025 during commissioning?

The SCOC membership is generally renewed on a 2-year appointment basis. We expect some SCOC members to stay on for 2 terms and some to rotate off. At a minimum we expect 5 members of the SCOC who are already on their second term to rotate off but transfer of knowledge and continuity are ensured by the other members.

Questions and Discussion

Please ask questions into the microphone whenever possible (or remind speakers to repeat question)

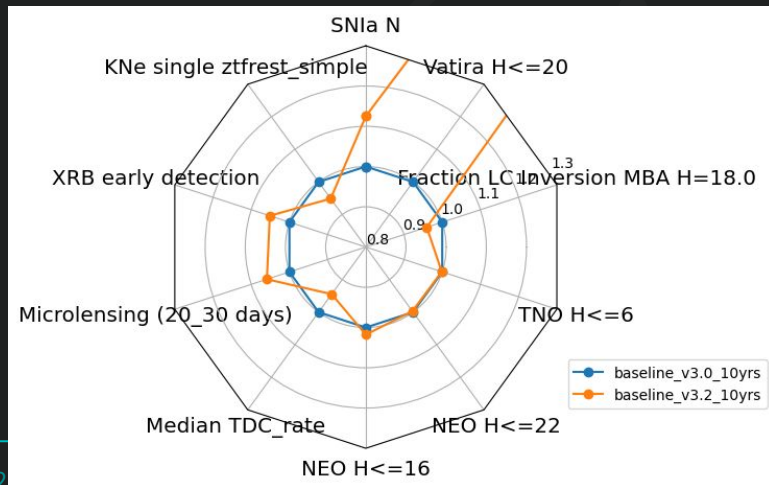
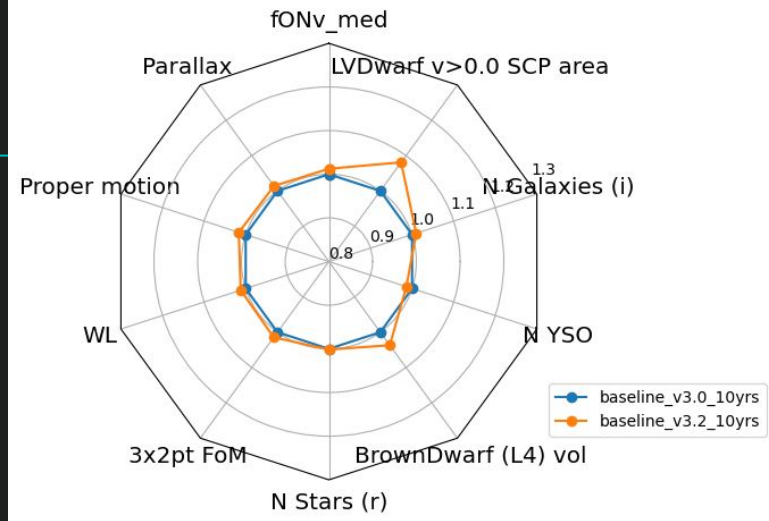
Please ask questions on the slack channel (rather than bluejeans) -
rubin2023pcw #day3-wed-1400-survey-strategy



Backup Slides

Changes v3.0-> v3.2

- SNe Ia improve from leaving z loaded full time
- Vatira and XRB improved by better twilight strategy
- Slight dip in Trojan recovery (probably due to start date change)



Current strategy is conservative on microsurvey commitment, recognizing that efficiency of telescope operations is still uncertain.

Pending survey progress in first year, the SCOC anticipate making a call for microsurvey proposals ~6 mo after survey start to select Y2/3 microsurveys

We may only be able to select a few and only select what is to start in Y2

The SCOC is planning to hold annual calls for feedback throughout operations and may issue more specific calls for micro/nano surveys