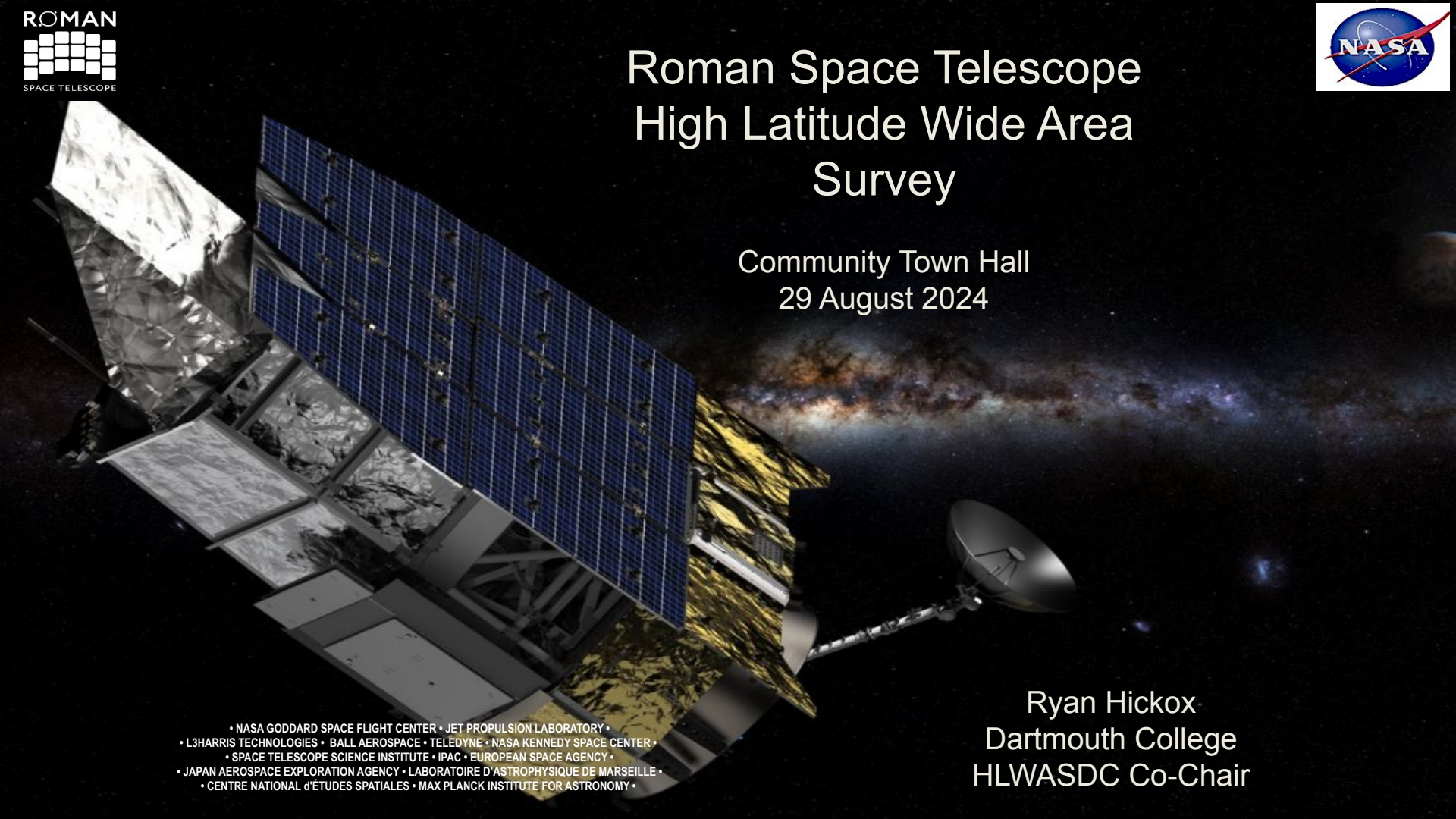
Roman Space Telescope High Latitude Wide Area Survey

Community Town Hall
29 August 2024



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Ryan Hickox
Dartmouth College
HLWASDC Co-Chair

Outline

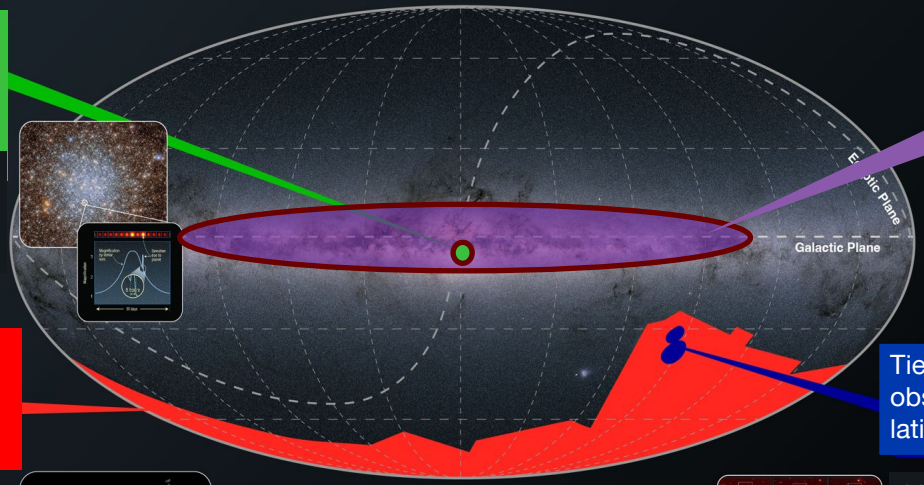
1. Introduction to the Core Community Surveys
2. The High Latitude Wide Area Survey and nominal Design Reference Mission survey
3. Definition Committee and process so far (overview of white paper and science pitch input)
4. Nominal survey plan (Wide, Deep, and Medium Tiers)
5. Trade spaces and considerations
6. Outstanding technical questions
7. Opportunities for input

Core Community Surveys (CCS)

Example implementation of Core Community Surveys (CCS)

~< 15 min cadence observations over few deg^2 towards Galactic bulge

Galactic Bulge Time Domain Survey



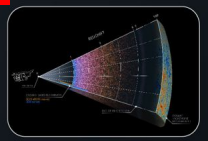
Galactic Plane Survey (Early Definition)

~1000 deg^2 in three bands (~JHK)

Wide area (thousands of deg2) survey including multiband imaging and slitless spectroscopy

Tiered, multiband time domain observations of ~10s of deg^2 at high latitudes with slitless spectroscopy

High Latitude Wide Area Survey



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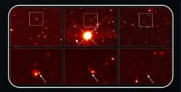
Core Surveys



High Latitude Time Domain Survey

Roman Space Telescope's larger view and fast survey speeds will unveil the evolving universe in ways that have never been possible before.

Top Level Goal for Defining the Core Community Surveys

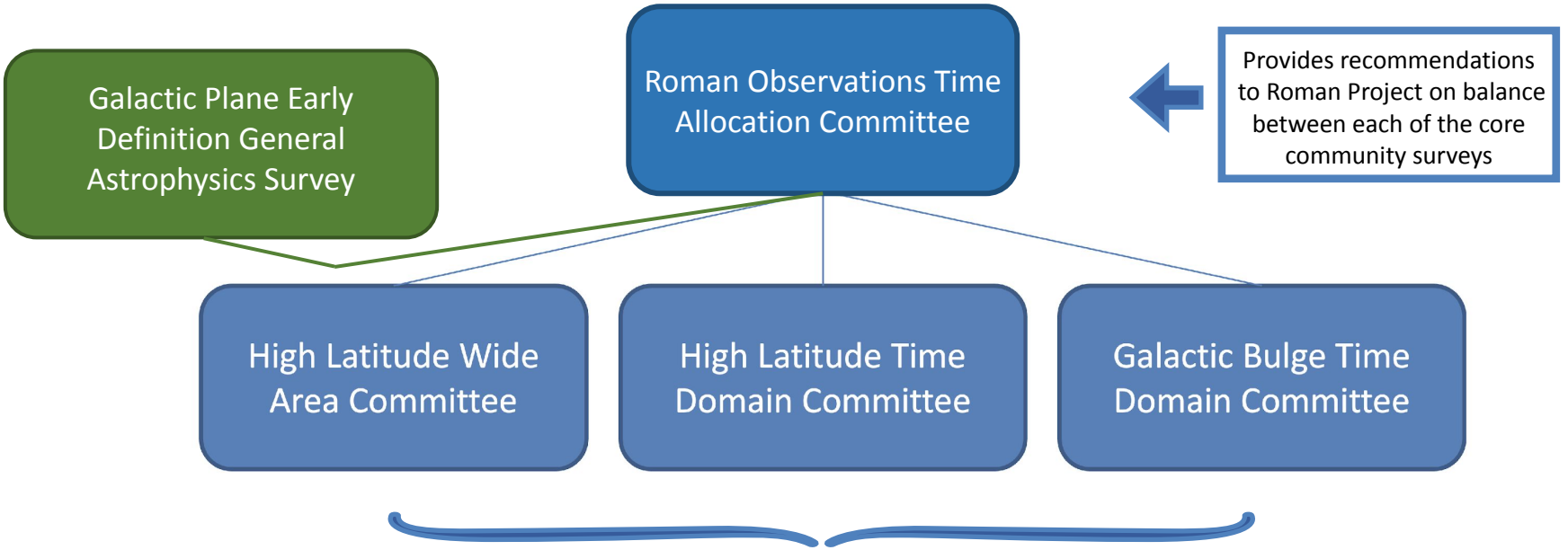
Maximize the overall science return of Roman's wide field infrared surveys

While meeting Mission requirements focused on cosmology and exoplanets

The existing survey strategies served their primary function in showing the mission can meet its requirements.

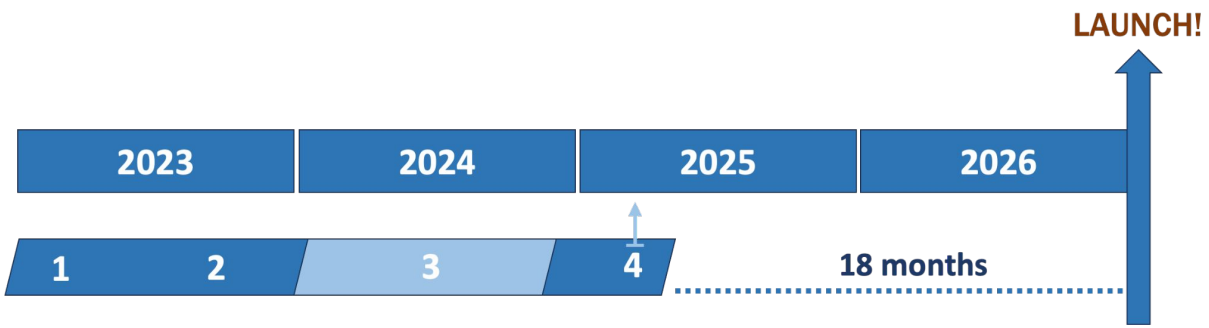
The actual surveys to be implemented will be defined by the science community.

Strategy for Defining the Core Community Surveys



Evaluate initial community input; solicit additional, more targeted community input through a variety of channels; evaluate survey options against science metrics; produce recommendations for survey implementations with options for enhancements/descopes

Community-Led Definition of Core Community Surveys



(1) Initial Request for Community Input

(2) Formation of CCS Definition Committees

(3) Committee-driven investigations, deliberations, and gathering of additional community input, including community discussions

(4) Final report detailing CCS observations due to Project

Summary of Science Pitch Submissions

Submitted Science Pitches

Submitted White Papers

High Latitude Wide Area Survey

•Imaging

–Main driver of requirements is weak lensing for cosmology. Basic needs are a wide area survey with:

•Angular resolution (+ well understood PSF) for shapes constrained by 2.4 m aperture

•Depth / area

•Near IR photometric coverage (from space)

–Internal calibration requires repeat observations

•Deep fields used to understand sensitivity limits and systematic effects in shallower survey.

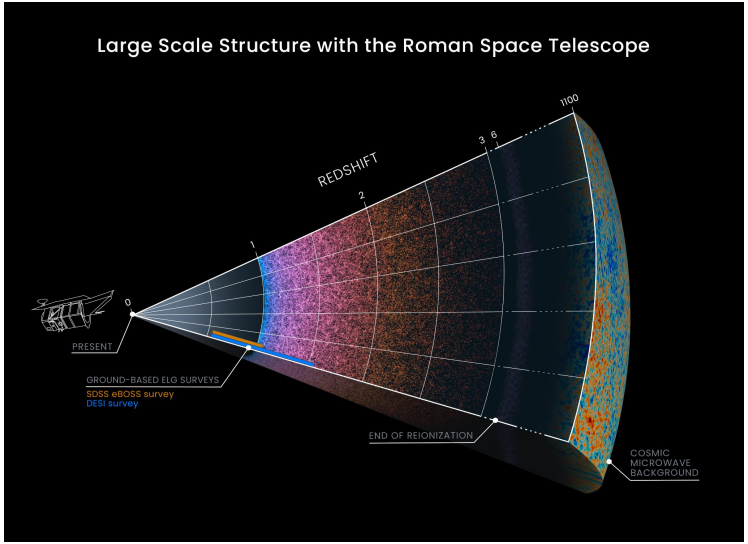
•Spectroscopic data to calibrate photo-z's

•Spectroscopy

–Slitless spectroscopy driven by Galaxy redshift survey for baryon acoustic oscillations (BAOs) and redshift space distortions (RSDs)

•Multiple rolls for spectral de-contamination; baseline = 4.

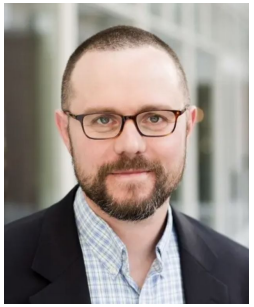
•Sensitivity at given area & time is a major driver



Observing time allocation:
520 days (over/underguide 540/480 days)

This survey also addresses the mission objective for a Wide Field infrared Survey with Imaging and spectroscopy to >26.5 AB mag

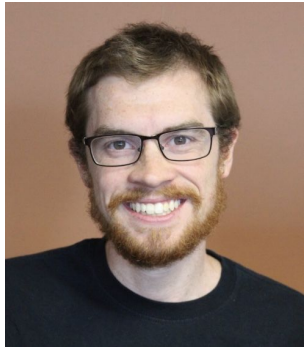
HLWAS Definition Committee Members



Ryan Hickox
(Dartmouth, Co-chair)

Risa Wechsler
(Stanford, Co-chair)

Micaela Bagley
(UT Austin)



Keith Bechtol
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Michael Blanton
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Chris Hirata
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Elisabeth Krause
(Arizona)

Nikhil Padmanabhan
(Yale, GRS PIT)

Ismael Tereno
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Anja von der Linden
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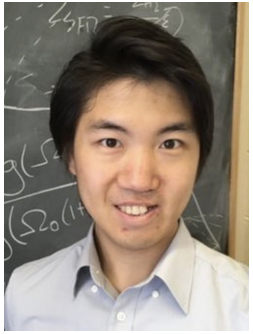
David Weinberg
(Ohio State)



Aaron Yung
(STScI)

HLWAS Definition Committee: Where we stand

- **Feb 2024:** Kick-off meeting
- **Mar 2024:** Design & organize review process for white papers & science pitches
- **Apr-Jun 2024:** Reviews, rankings & discussion of science ideas
- **Jul-Aug 2024:** Explore trade spaces and outstanding technical questions
- **Jul-Aug 2024:** Report to community for feedback and iteration.
  - Jul 9-12: Roman Science Conference, Pasadena, CA
  - **Aug 29/Sep 5: Virtual Town Halls (we are here!)**
- **Sep-Oct 2024:** Refine trades with technical input and develop implementation plans
- **Nov 2024:** Report due to Roman project

Reference HLWAS Design

•~2000 sq deg area to measure ~>10^8 galaxy shapes and ~>10^7 galaxy spectroscopic redshifts

–Imaging

• Two passes in 4 NIR bands: Y (F106), J (F129), H (F158) , H/K (F184) spanning the range from 0.93-2.00 μm to magnitudes 25.8-26.7 AB (band-dependent) and reaching the diffraction limit in F129 and redder bands

• 4 dithers on each pass (to enable shape measurements and diagnose systematics)

• 140 s for each exposure

–Spectroscopy

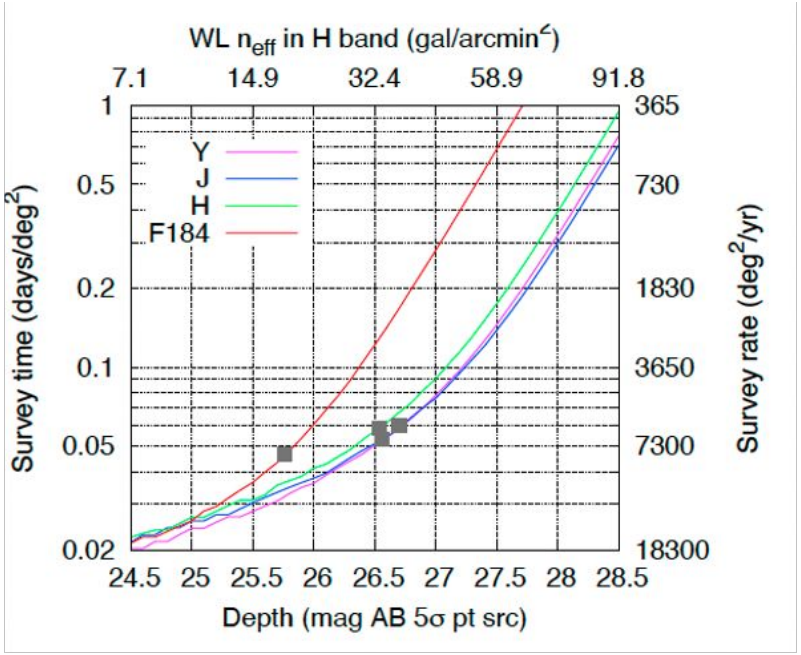
• Four passes

• Two dithers per pass

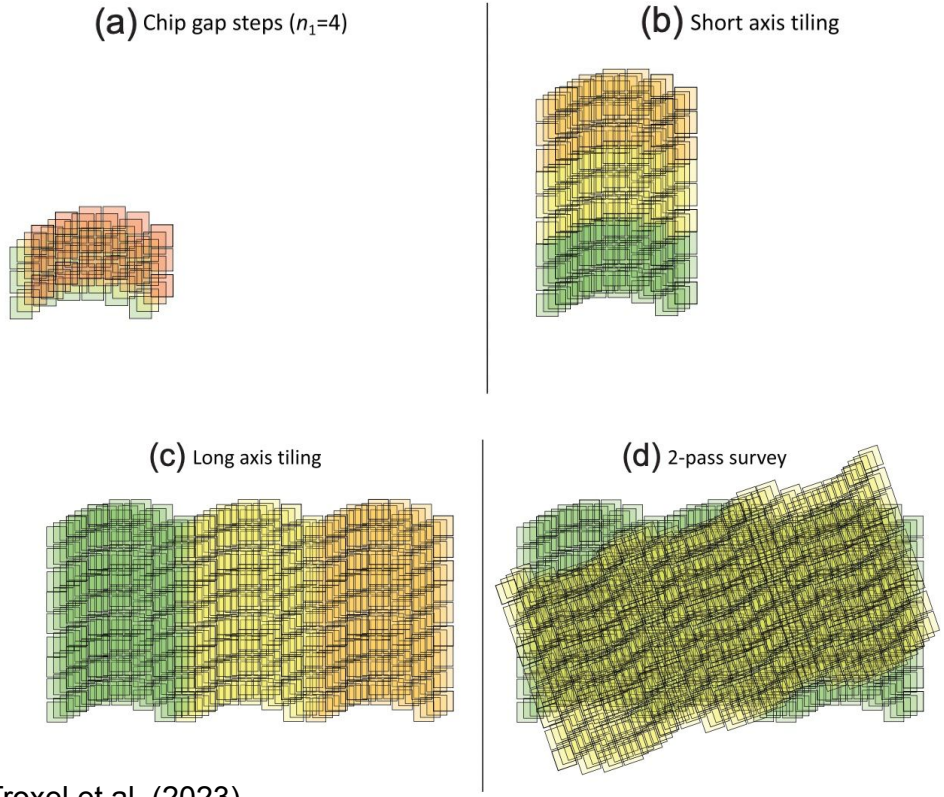
• 298 s per exposure

• 20 sq deg deep field

• 10% of time allocated to imaging+spectroscopic survey.



Reference HLWAS Design: Imaging



Troxel et al. (2023)

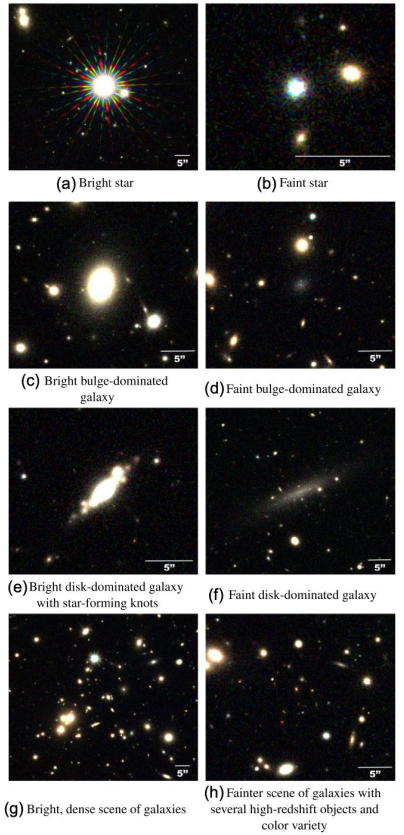


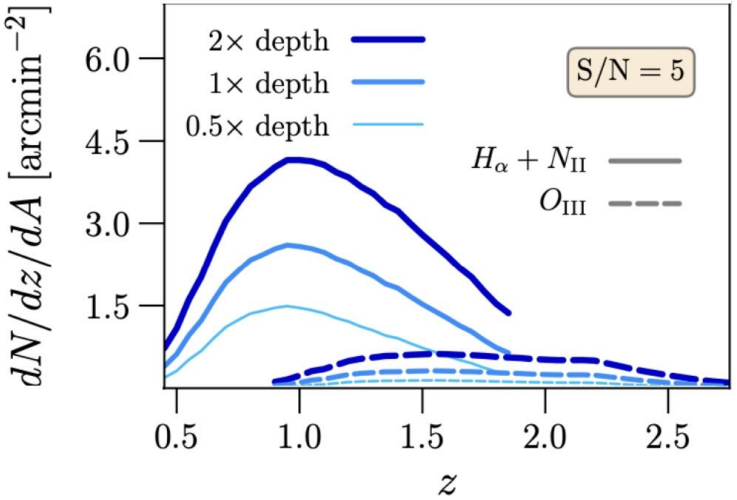
Figure 1. Some example Y106/J129/H158-colour cutouts of star, bulge- and disc-dominated galaxies, and larger scenes from the simulated 5-yr Roman HLIS coadd images.

Reference HLWAS Design: Spectroscopy

• Sensitivity of **7x10^{-17} erg/cm^2/s** for a point source in the center of the band (can be a few times higher for extended sources like galaxies).

• **14M** Hα redshifts & **3.6M** [O III] redshifts in the Reference Survey (3M redshifts per month)

• Eifler et al. (2020) explores depth vs. area trade and implications for cosmological constraints.

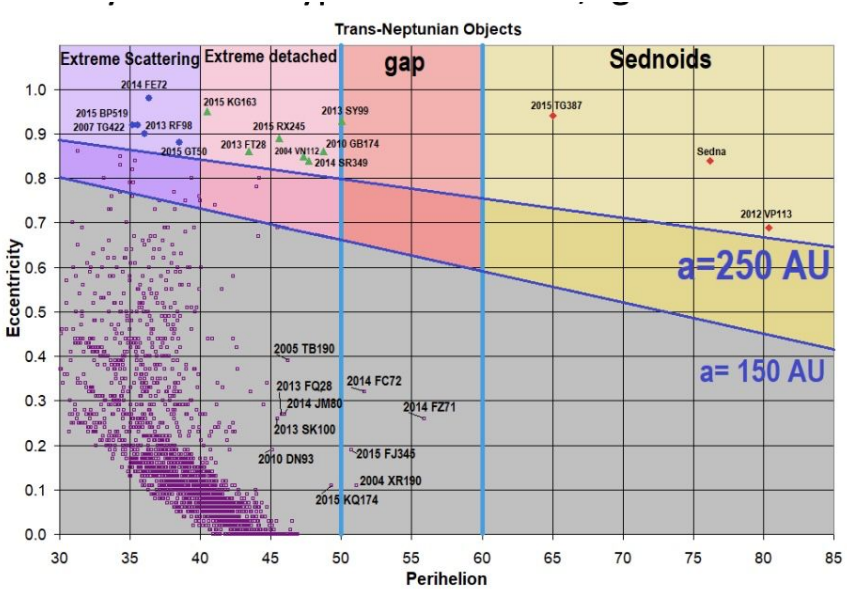


Eifler et al. (2020)

HLWAS Survey Science Examples

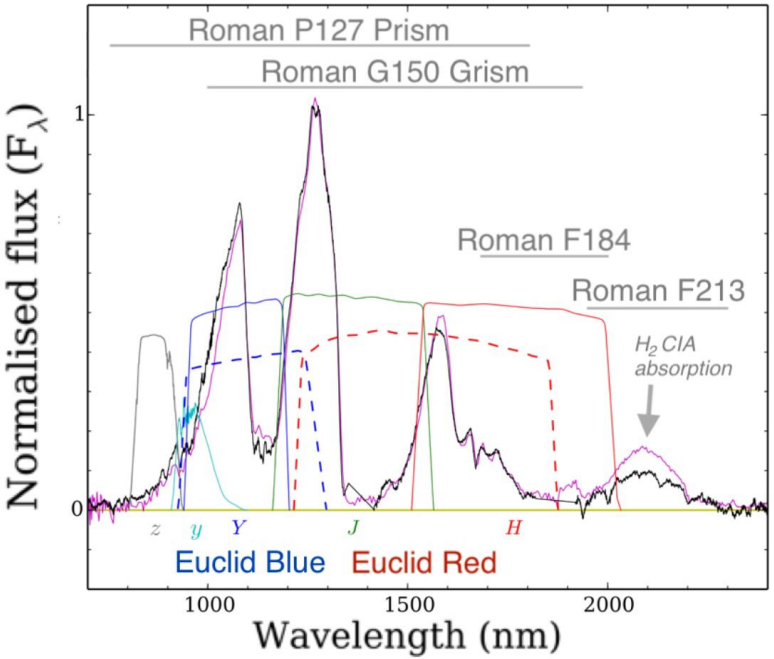
HLWAS White Paper Examples

Solar System objects



Holler+ white paper

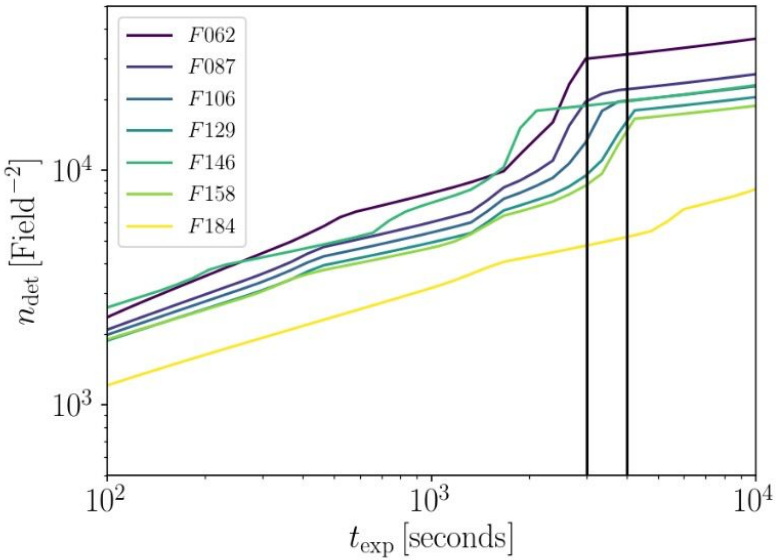
Ultracool dwarfs



Meisner+ white paper

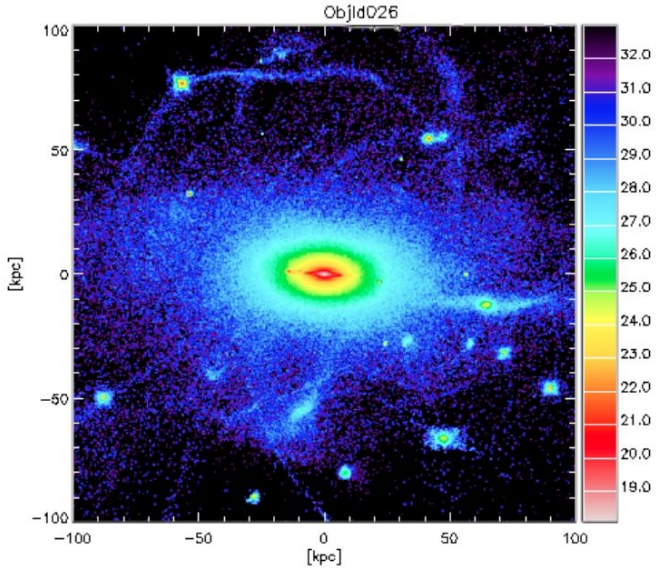
HLWAS White Paper Examples

Resolved stellar populations



Williams+ white paper

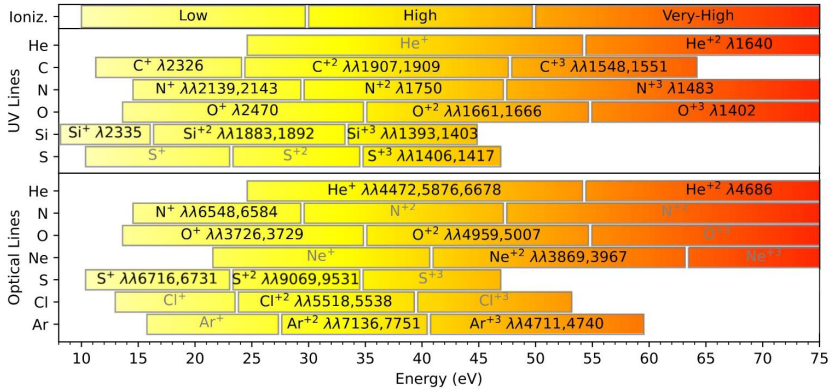
Low surface brightness structures



Montes+ white paper

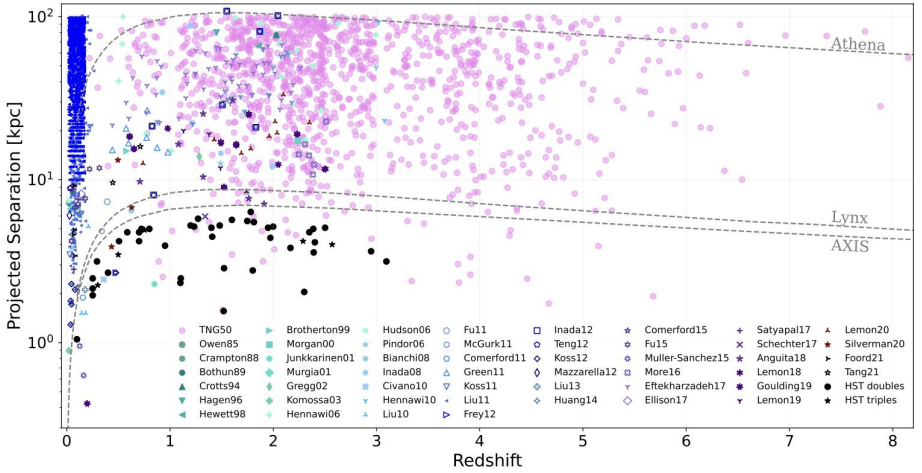
HLWAS White Paper Examples

Galaxy emission-line diagnostics



Danekhar+ white paper

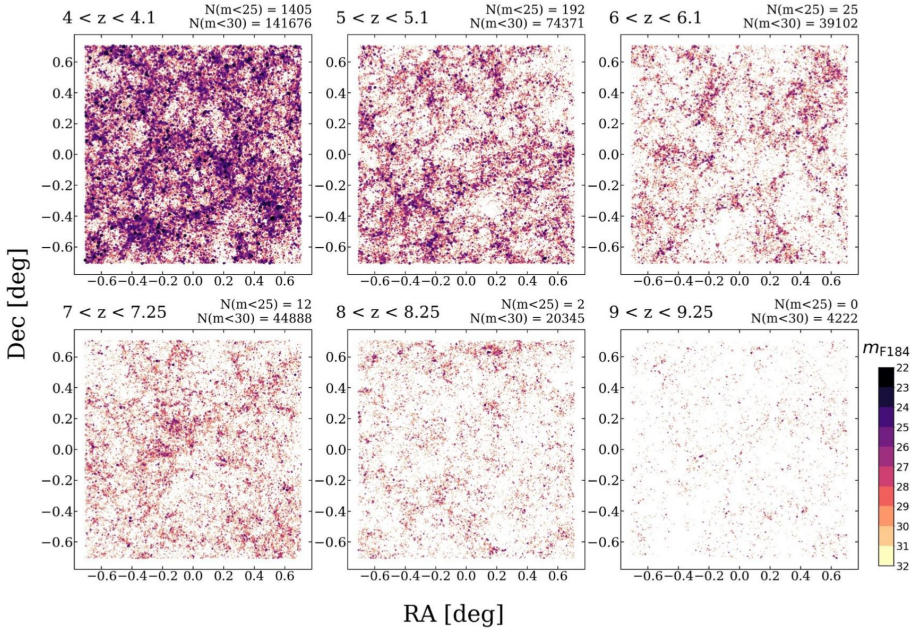
AGN and SMBH evolution



Shen+ white paper

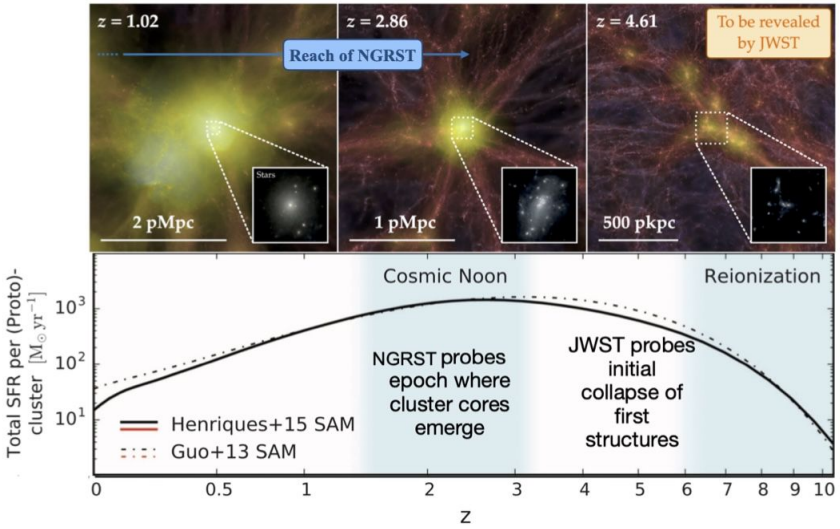
HLWAS White Paper Examples

High-redshift galaxies



Yung+ white paper

Galaxy evolution in clusters



Rudnick+ white paper

Ideas for point designs in response to WP and SP input

1. Many WPs and SPs present science cases emphasizing the value of **relatively wide deep fields**, largely for galaxy evolution and early Universe science. We are therefore exploring **deep fields larger than the 20 deg^2** in the DRM.

2. A number of WPs and SPs demonstrate the science potential of an **extremely wide, shallow survey** in a single band. This is useful for many general astrophysics applications, and also maximizes the number of galaxies for cosmological weak lensing measurements (at the cost of systematic uncertainty due to the lack of color information). We are therefore exploring a design with an additional **single-band Wide Tier**.

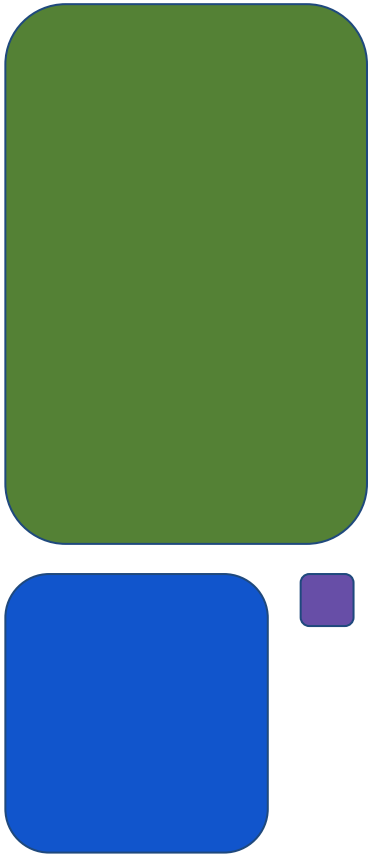
Current “nominal” survey plan

Three tiers: **Wide**, **Medium**, **and Deep**

Medium (~1-2x10^3 deg^2) and **Deep (~50 deg^2)** tiers broadly correspond to the DRM in terms of bands (including grism spectroscopy) and depth with some adjustments in area. **Deep** tier essential for calibration of **Medium** and **Wide** tiers.

Wide (~4x10^3 deg^2) tier provides additional area in a single band for both cosmology and general astrophysics. Advocated for in a substantial number of white papers/science pitches/community inputs.

Trade spaces being considered in depth/area/bands, field location, and observing strategy (tiling/cadence/etc.)



Trade spaces: Medium/Deep Depth/Area/Bands

Medium Tier: Depth *broadly* set to maximize the number of galaxies for shear measurements. Medium tier can be uniform, or include a smaller area with more filters than a wider area (i.e. “4-tier”)

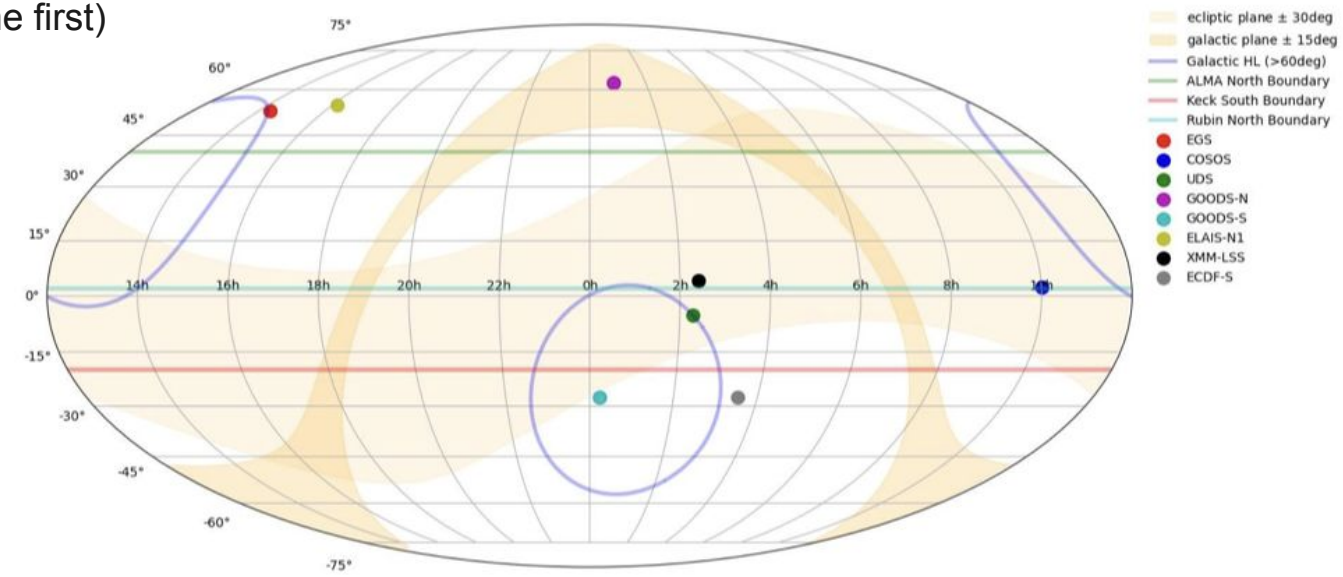
Deep Tier: Could go deeper (particularly for high-redshift science cases) or wider (for larger galaxy numbers and to mitigate cosmic variance)

Additional filters (e.g., Ks-band) in part of the area

Trade spaces: Medium/Deep Field Choice

Considerations:

1. Complementarity with Wide Tier and High Latitude Time Domain Survey
2. Overlap with the field of regard of ground-based instruments
3. Overlap with wide-area surveys (Euclid, LSST, Subaru, LS, etc.)
4. Solar system science considerations (field in Ecliptic Plane?)
6. Timing (which fields get done first)
7. How many deep fields?
8. Zodiacal foregrounds



Trade spaces: Wide Tier

Overall strategy

- Sufficient **sampling** to enable WL shape measurements. Focus on H (F158) band.
- Within this constraint, balance depth vs. area to **maximize number of detected galaxies**, perhaps with a slight bias towards larger area.
- All **southern/equatorial sky** for overlap with LSST and CMB surveys. (Detailed **field choice** still TBD, partly depending on other tier choices.)
- Single pass, multiple **dithers**, exposure time similar to or shorter than **Medium** tier.
- **Scheduling** may be preferable to schedule *after* some or all of the **Medium**/**Deep** tiers so that lessons from those can inform **Wide** tier strategy.

Roads (currently) not taken

- W-band instead of H-band (limited by systematics in shape measurements)
- Ks-band instead of H-band (limited by sensitivity)
- Full LSST footprint or full sky (undersampled images limit ability to do Roman weak lensing)

Note - the overall scale of the Wide tier is limited by total exposure time and cosmology requirements

Outstanding technical questions

We are actively working with the Roman project and the Project Infrastructure Teams to address **technical questions** such as:

- What are the minimum area and depth for the Deep observations to support calibration of the wider tiers?
- In the context of weak lensing shear estimation, is a single pass (multiple dithers at a single roll angle) in a single band sufficient to accurately model the PSF and measure galaxy shapes?
- Is it possible to do a successful spectroscopic program with only 2 bands of imaging (J and H)?
- What are the technical considerations for contiguous fields vs. splitting tiers (edge effects, cosmic variance, etc.)
- What is the impact of including CMB cross-correlation on cosmological measurements?

Opportunities for further input / feedback

Questionnaire:

https://forms.gle/4UogRf4KS2RkADHY7

Via email to the committee co-chairs: ryan.c.hickox@dartmouth.edu, rwechsler@stanford.edu

Key point: Many science cases presented in WPs and SPs could not be included in the CCS due to time constraints but would make **compelling GA surveys**

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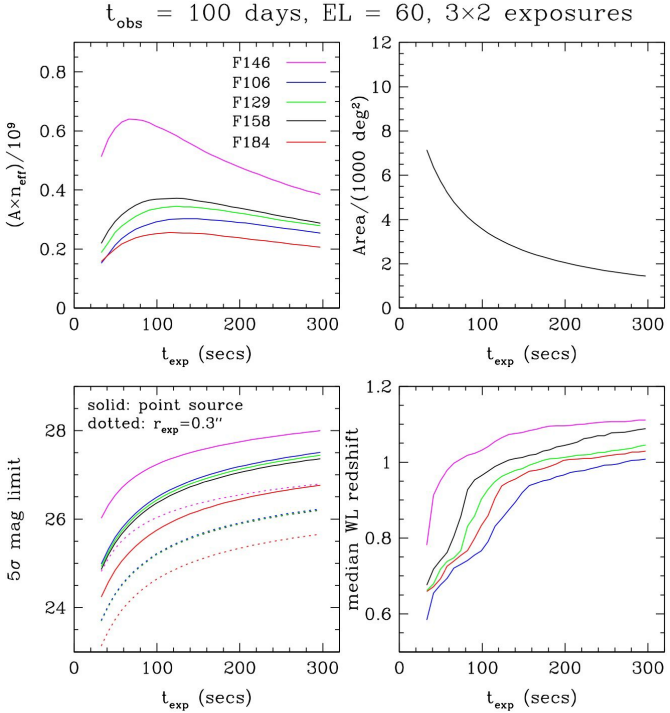
Additional slides

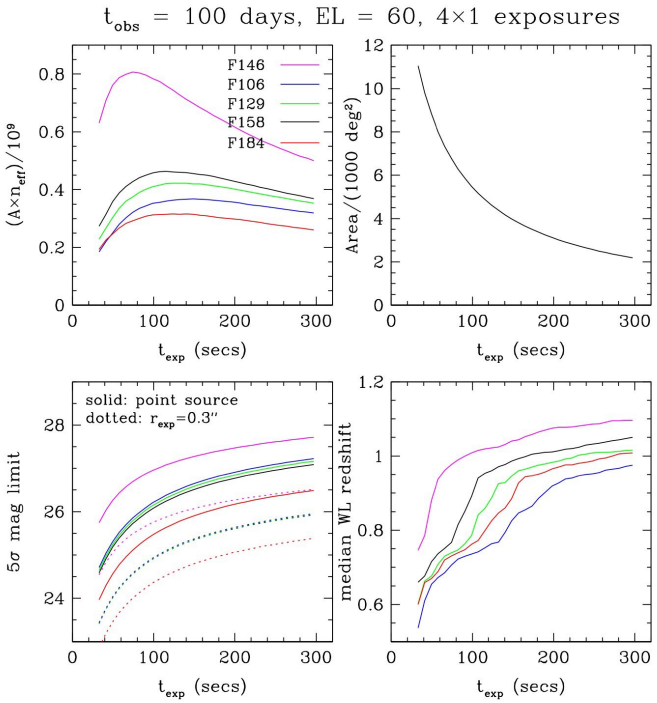
One representation of the “nominal” survey plan

Tier	Spectroscopy	Imaging	Field Area + Placement	Scheduling
Wide (~30%)	none	H 8 x 140 sec exposures (matches DRM)	~4000 deg^2 overlap w/ LSST + Euclid, high Galactic latitude	delayed start to allow optimization w/ combination of Roman + LSST + Euclid data
Medium (~50%)	4 x 300 sec exposures (matches DRM)	Y, J, H, F184 8 x 140 sec exposures (matches DRM)	~1000 deg^2 two contiguous patches (north + south) overlapping w/ HSC, LSST, CMB surveys, and/or nearby galaxy group, high Galactic latitude	early + late passes in Y for astrometry with long time baseline
Deep (~20%)	8 x 750 sec exposures (matches DRM)	Y, J, H, F184, F213 32 x 140 sec exposures (matches DRM)	~80 deg^2 two contiguous patches (north + south), high Galactic latitude	first half of exposures early for calibration; second half of exposures optimized for time domain

Yields v. exposure time

Preliminary





X dithers per pass x Y passes (vs. time per single exposure)

Normalized to 100 days observing time, includes overheads

Includes overheads as part of the trade space

Zodiacal light at ±60 degrees ecliptic latitude