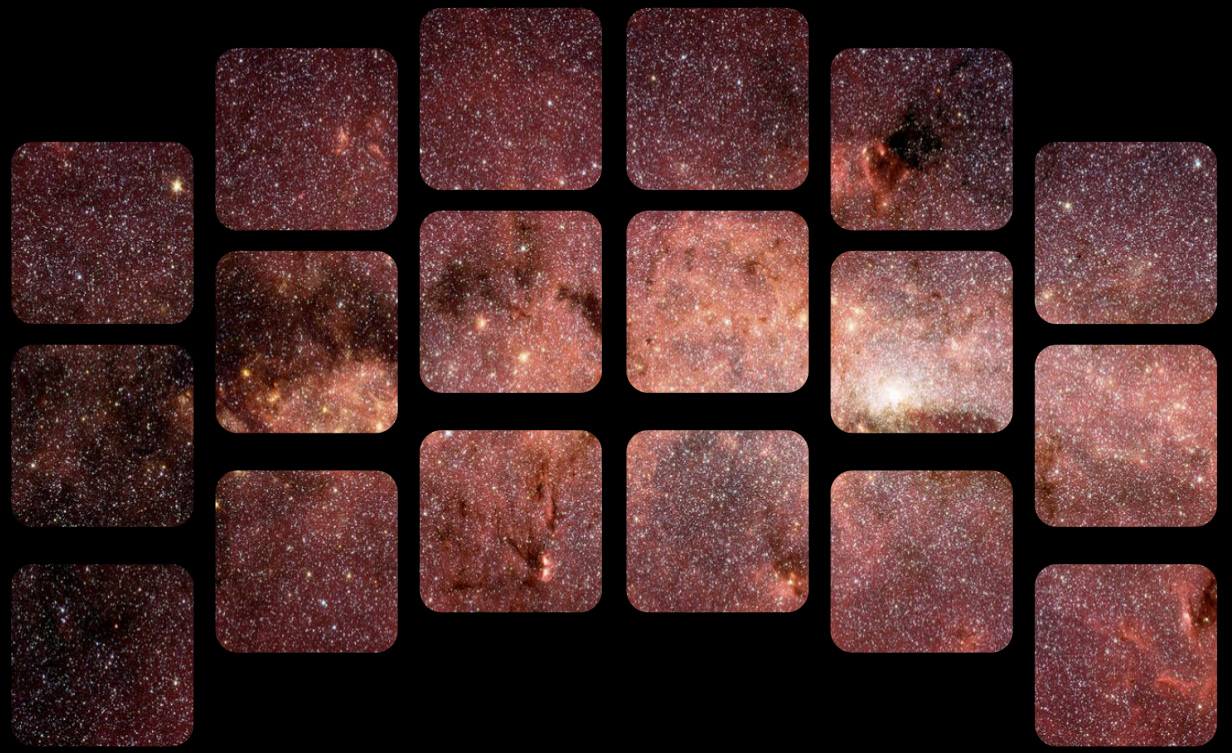
Science Requirements vs observing time trades



Core Community Surveys – Observing time trades

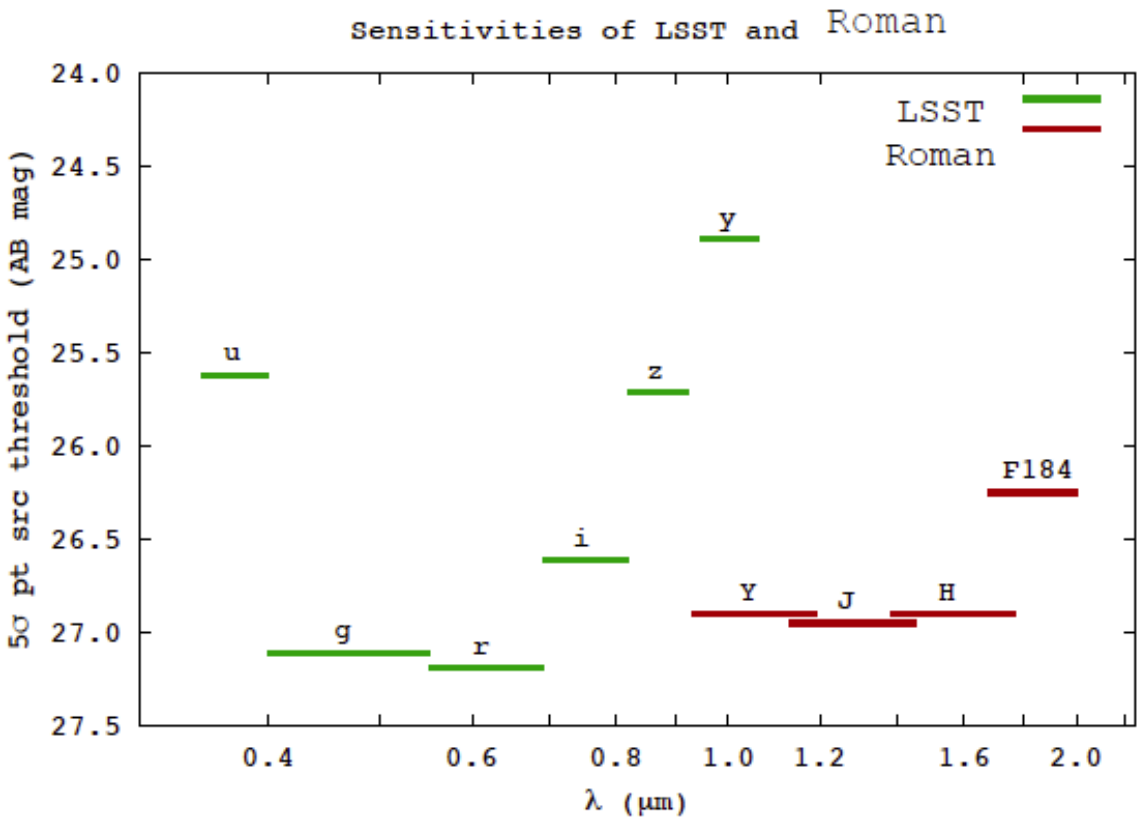
- **Relationship between science requirements and observation time for each survey is complex because there are multiple ways to adjust observation time for each survey**

- **In what follows, we'll list the survey parameters that affect observing time, and describe the impact of changing them**

High Latitude Wide Area Survey - Imaging

- **Reduction in Survey Area**
  - Reduces statistical power of survey
  - Reduces sensitivity to largest angular scales
  - Reduces margin in budget that could be available to devote to other terms

- **Reduction in Survey Depth**
  - Reduces statistical power of survey by reducing the number of galaxies
    - Loss is preferentially at higher redshifts
  - Reduced sensitivity on small angular scales
  - Reduced precision of PSF characterization affects entire sample
  - Several planned internal calibrations may be degraded

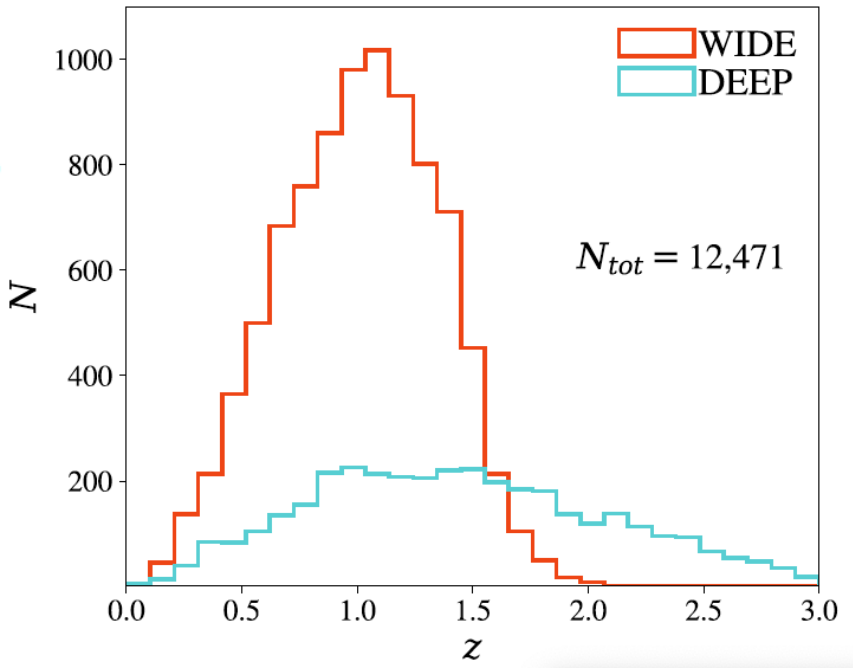


High Latitude Wide Area Survey - Imaging

- **Reduce number of dithers**
  - Reduced sampling PSF (Roman pixels are undersampled at 0.11 arcsec)
    - Because chip gaps cause parts of survey to have fewer exposures than the rest, these areas are already at the minimum number of samples
  - Increases effects of chip gaps on survey depth
    - Already have significant variation in cumulative exposure time over survey area
- **Reduce number of filters**
  - Would impact ability to determine photo-z over significant redshift ranges
  - Reduces ability to detect subtle wavelength-dependent PSF errors
  - Would reduce ability to use cross-power spectrum tests of shear bias
    - Shear maps in 3 filters provides internal consistency checks and test for multiplicative bias

High Latitude Time Domain Survey

- **Reduce Survey Area**
  - Number of transients
  - Loss is greater than linear as smaller tiling pattern is less efficient: lose increasing fractions of light curve as tiling pattern rotates on the sky
- **Increased Cadence**
  - Ability to characterize SNIa
  - Coarse sampling of light curve reduces accuracy of light curve fits at low redshift end of sample
- **Reduced Imaging Exposure time**
  - Number of transients as a function of redshift
  - Ability to characterize transients
  - Reduces accuracy of SNIa luminosity distance determination
- **Reduced Prism Exposure times**
  - Redshifts, classification, standardization, systematics and evolution control
- **Reduced Number of filters**
  - Broad wavelength range to measure colors and build templates
  - Greatly reduced SNIa redshift coverage in each tier



Galactic Bulge Time Domain

- **Reducing time allocation to this program does not affect:**
  - Survey Area
  - Cadence
  - Imaging Exposure time
  - Number of filters
  - Because the survey revisits the same fields over and over at a particular cadence
  - Conversely: don't save time by changing any of the above
- **Reducing duration of seasons:**
  - Reduces number of planets,
  - more than linearly because light curves are interrupted, especially for gaps in the middle of a season
- **Reducing Number of Seasons**
  - Reduces number of planets

Trade Space for High Latitude Survey

- **Current HLWA survey will enable galaxy shape measurements in multiple colors and two roll angle**
  - Provides exquisite control of systematics
- **To reach the weak lensing FoM requirement in minimum time, could survey part of the Rubin footprint with a single wide-band filter (Euclid-like)**
  - Good statistical constraining power for weak lensing
  - BUT
    - Won't provide internal checks on shear systematics for the region with a single NIR filter
    - No color information in near IR, degraded photo-z at z>1
    - **Meets the letter, but not the spirit of objective 1 (wide field IR survey to AB 26.5 mag)**
      - **Greatly impacts astrophysics science return**

ROMAN
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Backup

Survey Capability Requirements Summary

Weak Lensing
(HLIS 2.0.x)

1: FoM_{WL}>327400
2: N_{eff}>27/arcmin^2
3: Additive shear error <2.7 10^{-4}
4: Multiplicative shear bias <3.2 10^{-4}
5: deep field

Galaxy Redshift
(HLSS 2.0.x)

1: FoM_{BAO}>7533
2: FoM_{RSD}>4047
3: Slitless spectra
4: Completeness > 0.6
5: redshift accuracy, outlier fraction

Supernova Cosmology
(SN 2.0.x)

1: FoM_{SN}>325
2: μ(z), 0.2≤ z ≤ 1.7 σμ ≤ 0.02 per Δz=0.1
3: >100 SNIa per Δz=0.1
4: σ_z /(1 + z) bias

Exoplanet Microlensing
(EML 2.0.x)

1: Mass function for $1M_{Earth}$< m <$30M_{jupiter}$ to <15%
2: Mass function for $0.1M_{Earth}$< m <$0.3M_{Earth}$ to <25%
3: masses, distances to 40% host stars
4: free-floating planet frequency
5: estimate η_{Earth}

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Key Wide Field Science Performance Requirements

Representative values shown; full details in SRD.		Expansion, Structure, NIR Survey		Expansion	Exoplanet
		Weak Lensing	Galaxy Redshift Survey	Supernovae	Microlensing
Surveys & Data	Area/Survey Speed	0.20 deg^2/hr (1,700 deg^2)	0.34 deg^2/hr (1,700 deg^2)	14, 5 deg^2 >100 SNe/Δz=0.1	586 deg^2-day Over 6+ seasons
	Redshift	0≤z≤3	1.1 < z < 1.9 (2.9 w/OIII)	0.2≤z≤1.7	
	Sensitivity	S/N≥18 @ 24.4/24.3/23.7 (AB J/H/F184) r_{eff}=0.18"	S/N≥6.5 for 1.0x10^{-16} erg/cm^2/s	S/N≥13 (brightest filters at peak)	S/N>100 for H_{AB}=21.4 star
	Cadence			~ 5 days	15 min
	Data Vol.	≥3 reads/exp	≥3 reads/exp	≥3 reads/exp	≥3 reads/exp
PSF	Quality	EE50 ≤ 0.12" (J) EE50 ≤ 0.17" (IFC)	EE50≤0.21"@1.5 μm	EE50 ≤ 0.12" (J) EE50 ≤ 0.14" (IFC)	EE50 ≤ 0.15" (wide)
	Stability	1 nm RMS ΔWFE in 180s			
	Knowledge	2nd moment ≤7.2x10^{-4} Ellipticity ≤5.7x10^{-4}		0.2%	
Flux Calibration Relative Over	Time	0.5% /observing program	<2% rel spect-photometry	<0.5% / 2 wk	<0.1%/season
	Wavelength	<2% abs/0.5% photo zeropt	<2% rel over bandpass	<2% abs/ 0.5% photo zeropt	<3% abs <1.4% photo zeropt
	Dynamic Range			<0.3% 15<AB<26	<0.1% over 2 mag
	Area	<10 mmag	<2% rel over survey area		
Color	Filters	4 NIR bands for photo-z, 3 reddest for shapes	Overlap with HLIS for 3 filter imaging	6 filters 0.5-2.0μm	Wide filter, & 1 short, 1 longward of 1μm
	Dispersion		10-12 Å/pix	70 < R < 150	