High Latitude Survey in the Roman DRM

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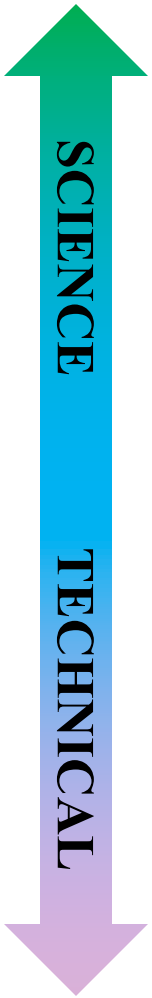
Overview

1. Considerations in Survey Design
2. HLIS design & basic features
   (including historical context, where relevant)
3. The HLSS
4. A few thoughts on alternative strategies

Important:
* The Reference Survey **is** something we could execute that meets the science requirements.
* The Reference Survey **is not** necessarily the survey that we will execute or our continuously updated thinking on the scientifically optimal way to use Roman.

High Latitude Survey Considerations

- Survey constraining power
  - depth, resolution, wavelength coverage
  - area (or area per unit time)
- Survey cross checks
  - weak lensing shear vs. wavelength, survey conditions
  - redshift survey with multiple lines
- Survey data quality
  - dithers (for defects, sampling, internal calibration),
  - rolls (for spectral decontamination), tiling
- Observatory characteristics
  - pixel scale, field layout
  - viewing constraints vs. time
  - backgrounds (natural, warm telescope, …)



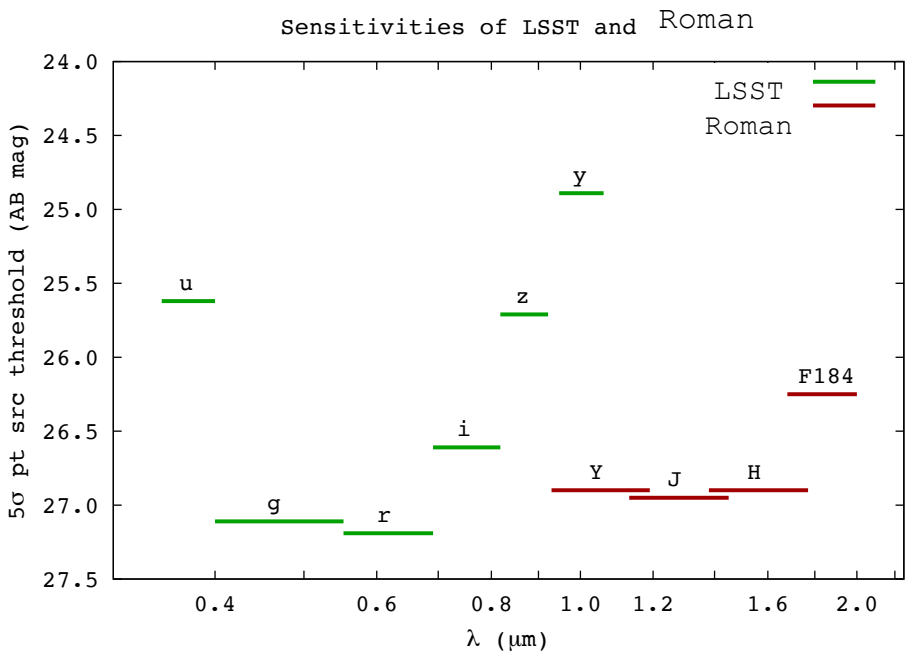
High Latitude Imaging Survey

- Main driver was weak lensing. Basic needs are a wide area survey with:
  1. Angular resolution (+ well understood PSF) for shapes Constrained by 2.4 m aperture
  2. Depth (may trade with area)
  3. Near IR photometric coverage (from space) + need visible data from ground for photo-z's (Rubin/LSST or HSC)
  4. Internal cross checks (see previous slide)

  A choice [Astro2010 guidance] was to do the shapes in NIR, and optimize the pixel size for J & H bands.
- Additional data:
  - ❖ Deep fields used to understand noise effects in shallower survey.
  - ❖ Spectroscopic data to calibrate photo-z's.

HLIS Reference Survey Design

- Choose bands from Y band (LSST coverage) to 2 μm (beyond which background would increase dramatically).
  - Reference Survey did not plan to use the visible filters for the wide survey as LSST is providing the necessary depth.
  - This pre-dates the K_s filter.
- Shape measurement with J & H (primary) + F184.
  - Y band is most challenging for shapes due to sampling & wavefront. We intend to do shapes in Y on a best-effort basis, requirements are set for J & longer λ.
  - F184 is 0.7 mag shallower than H.
- Depth vs. area trade depends on how you tile the sky.



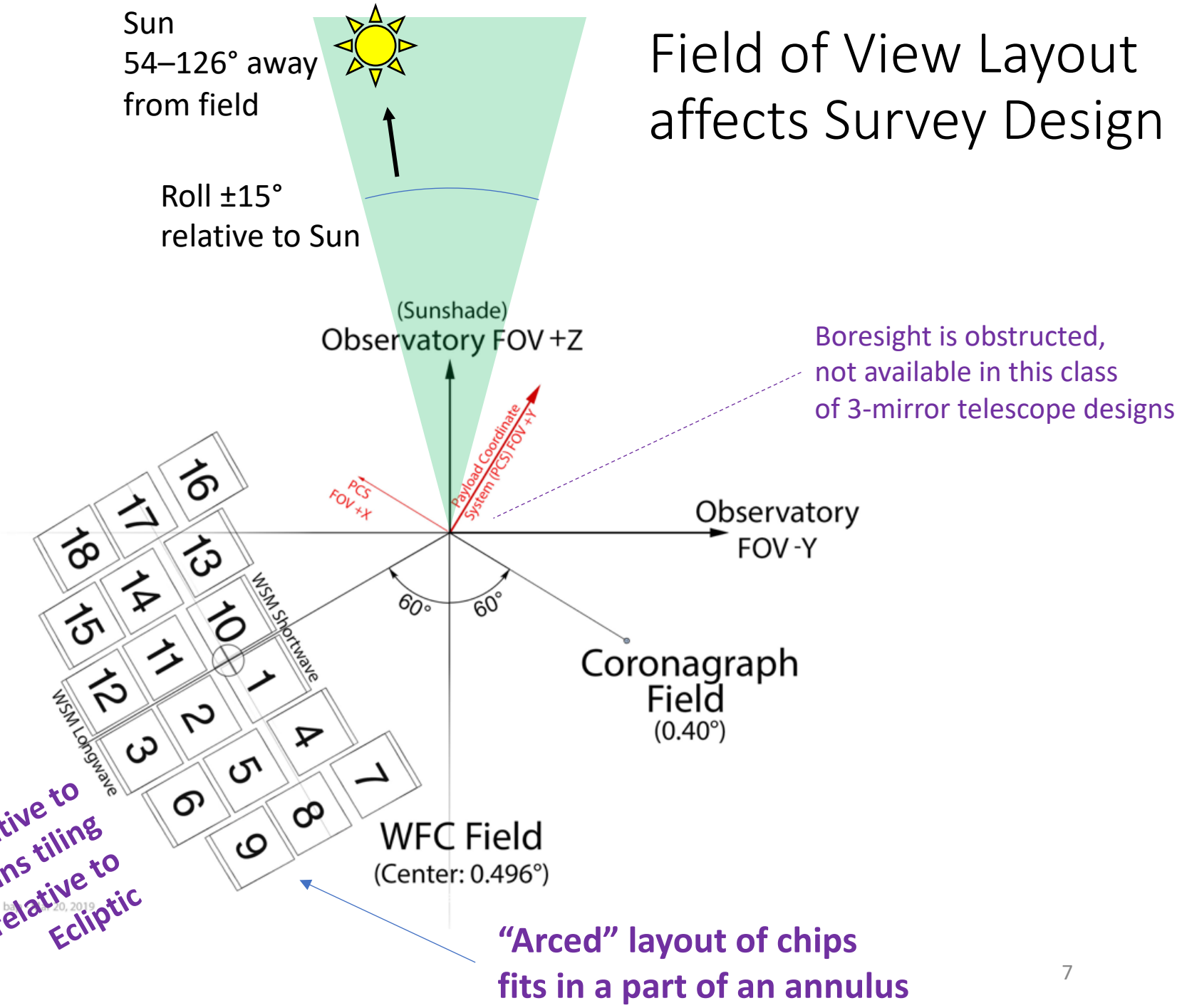
Reference survey:
Shapes n_{eff} = 50 galaxies/arcmin^2
(35 in H-band only)

HLIS Dithering & Tiling Considerations

- Weak lensing will typically be done with several dither positions.
  - Sampling – Roman pixels are undersampled @ 0.11 arcsec; this is λ/D at 1.26 μm and would be λ/2D (full sampling) at 2.52 μm if we went out that far.
    (initial pixel scale study based on Rowe et al. 2011 simulations; see Troxel et al. 2020 for "modern" GALSIM simulations)
  - Some samples lost to cosmic rays or cosmetics
  - Need to cover chip gaps

- Internal calibration requires repeat observations.
  - Want to do multiple passes to tie survey calibration together, e.g., SDSS and Pan-STARRS; Reference Survey is very conservative and does a repeat of the whole footprint (2 passes).

Field of View Layout affects Survey Design



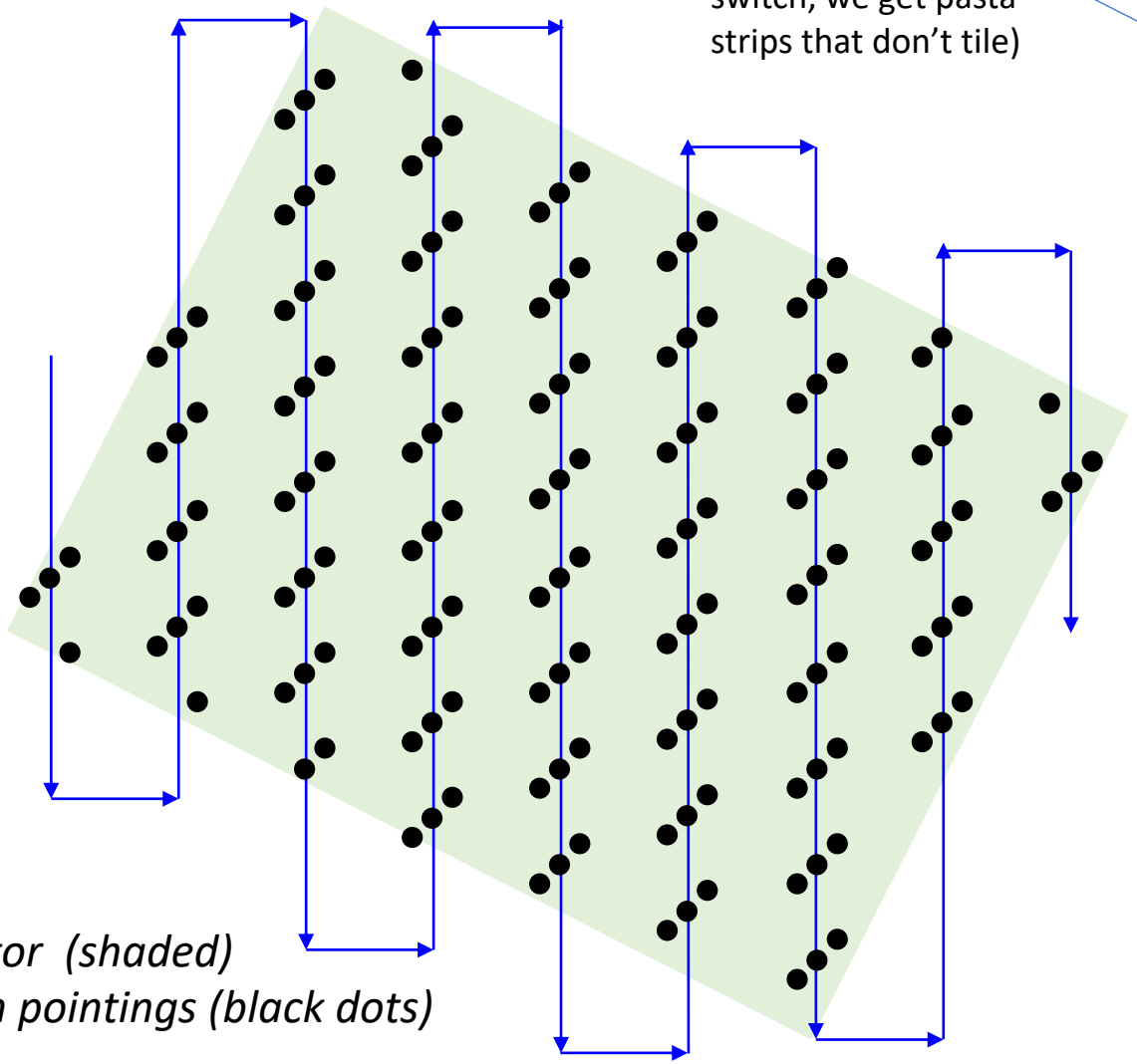
… there is a natural way to a pass over a sector of the sky …

This order is important (if we switch, we get pasta strips that don't tile)

"Outer for loop" = steps in x

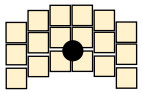
"Medium for loop" = steps in y

"Inner for loop" = small diagonal dithers over gaps

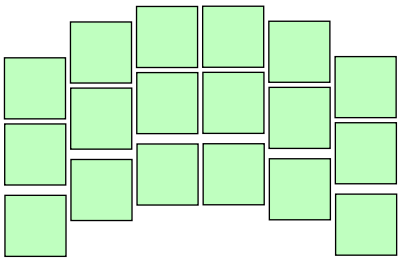


Sector (shaded) with pointings (black dots)

Wide Field Instrument Field Orientation



Example Tiling



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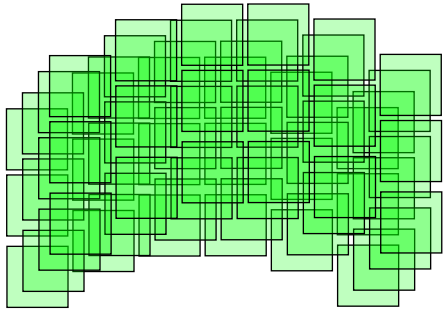
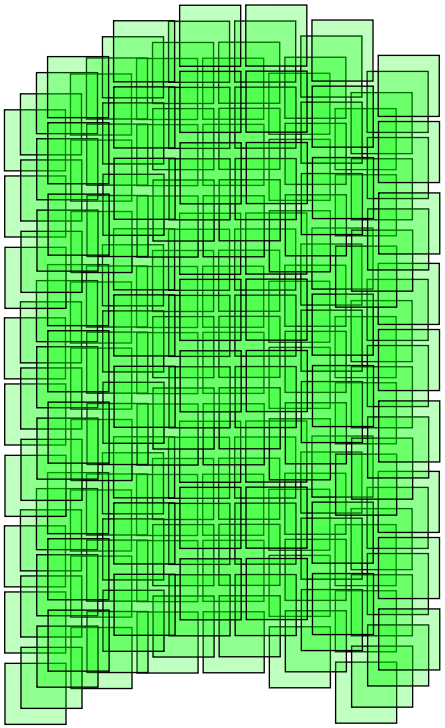
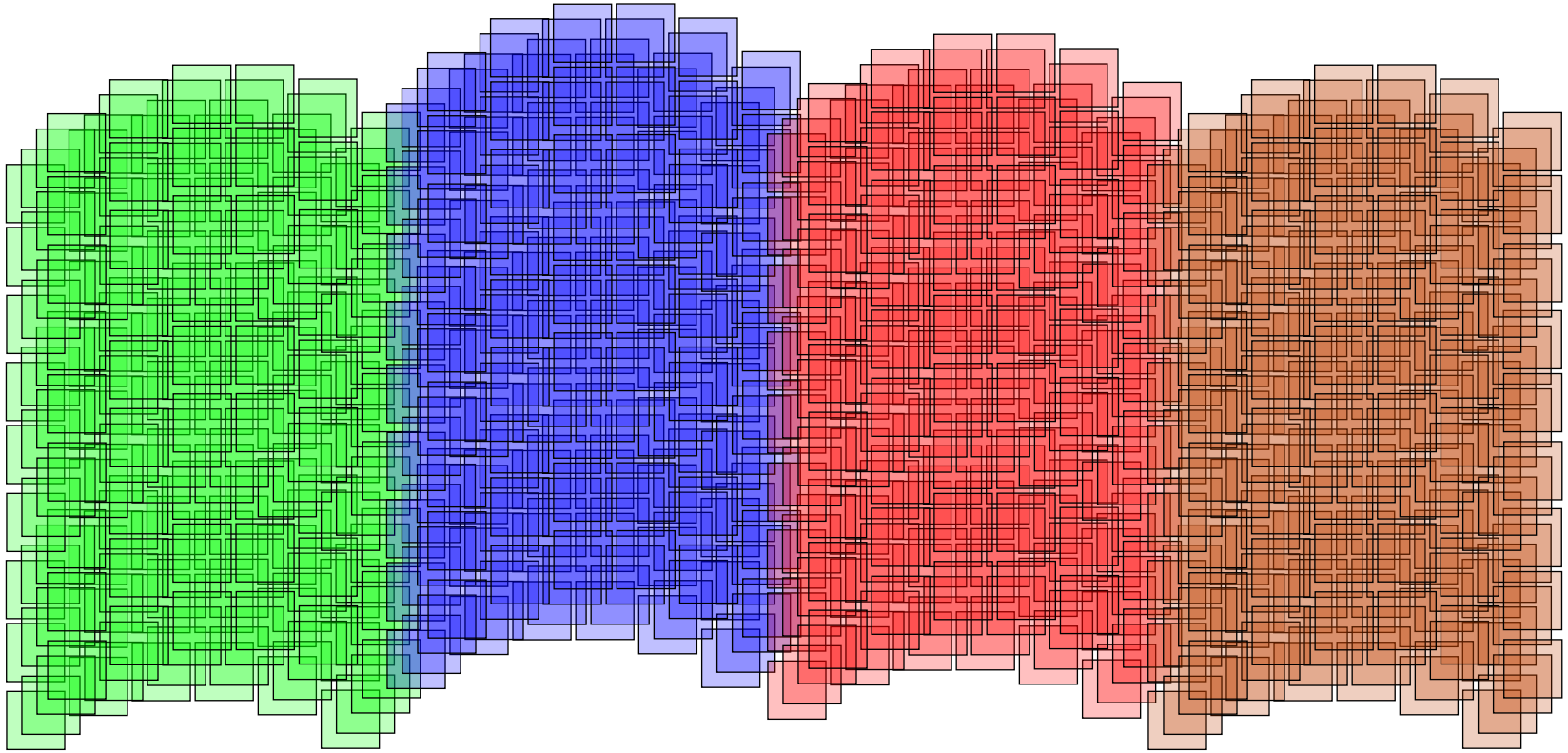


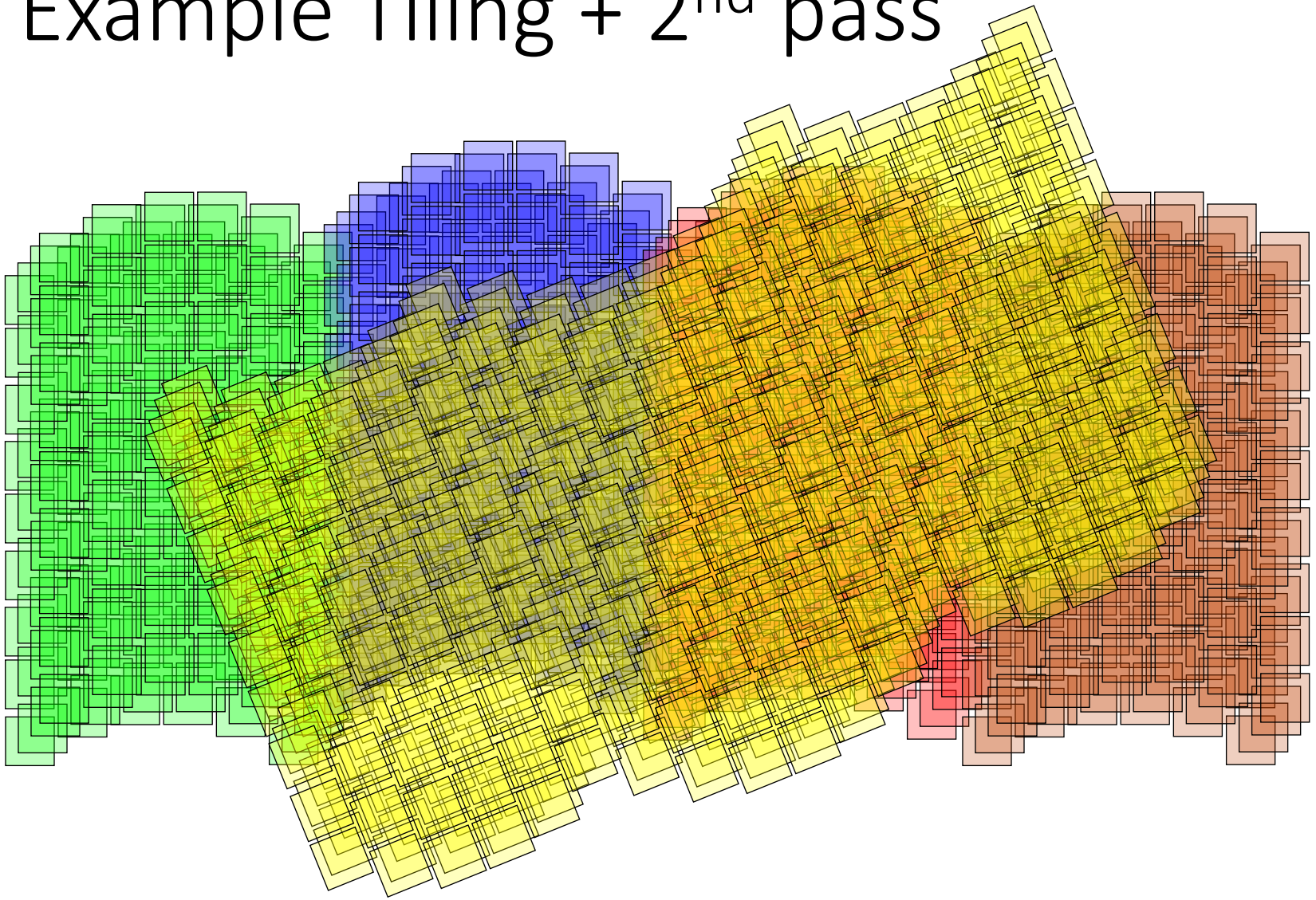
Example Tiling



Example Tiling



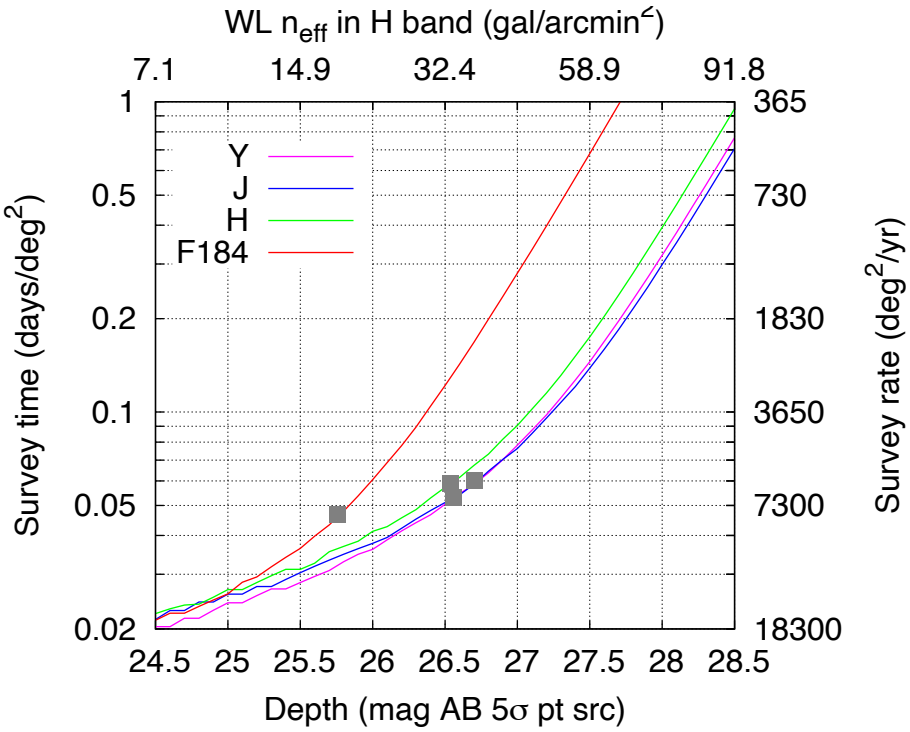
Example Tiling + 2nd pass



2nd pass (yellow) must be done at a different time of year if rotated by a large angle

Depth vs. area

- We have kept all the HLS imaging exposure times the same, currently 140 s.
  - All the same for ease of calibration, although we could revisit this.
  - Typically 5—7 dither positions per filter.
  - Have made minor adjustments the exposure time; was 174 s at SDT2015.
- Can do 2000 deg^2 + 10% of time for deep fields in 16 months.



2015 SDT report
(note some minor tweaks since then)

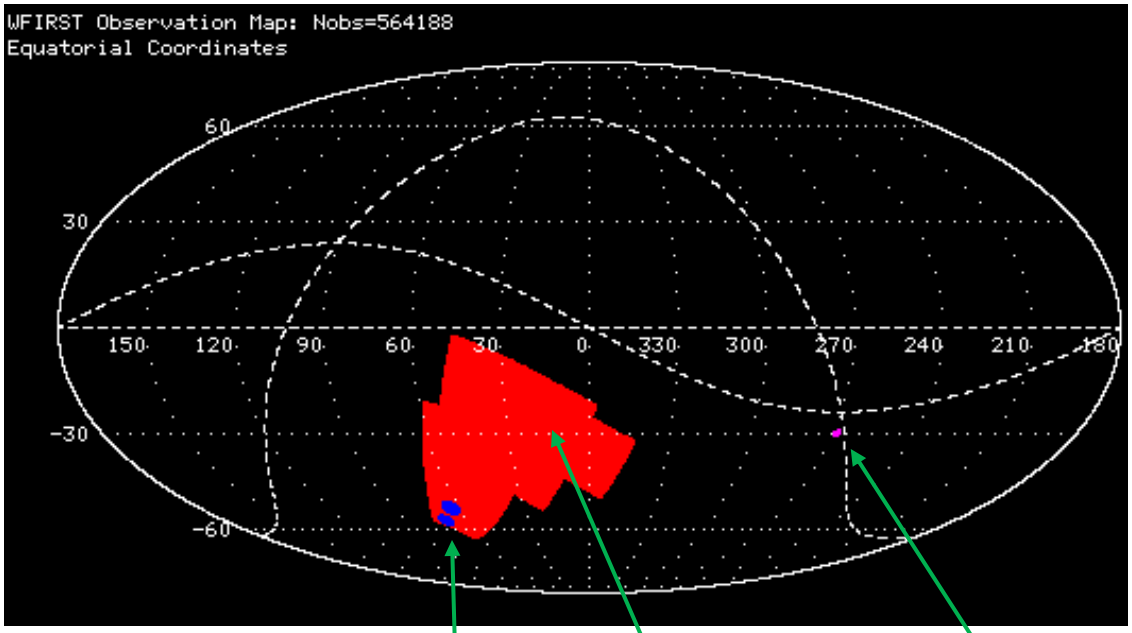
Where?

Want to avoid Ecliptic (highest Zodi background), and Galactic plane (dust, stars).

SDT report placed a contiguous HLS footprint in the south to overlap Rubin/LSST.

A part of the survey sticks up near the Equator and would overlap with Northern Hemisphere telescopes (Subaru @ 20 °N).

Alternatives could include a northern cap (with HSC observations).



2015 SDT report footprint

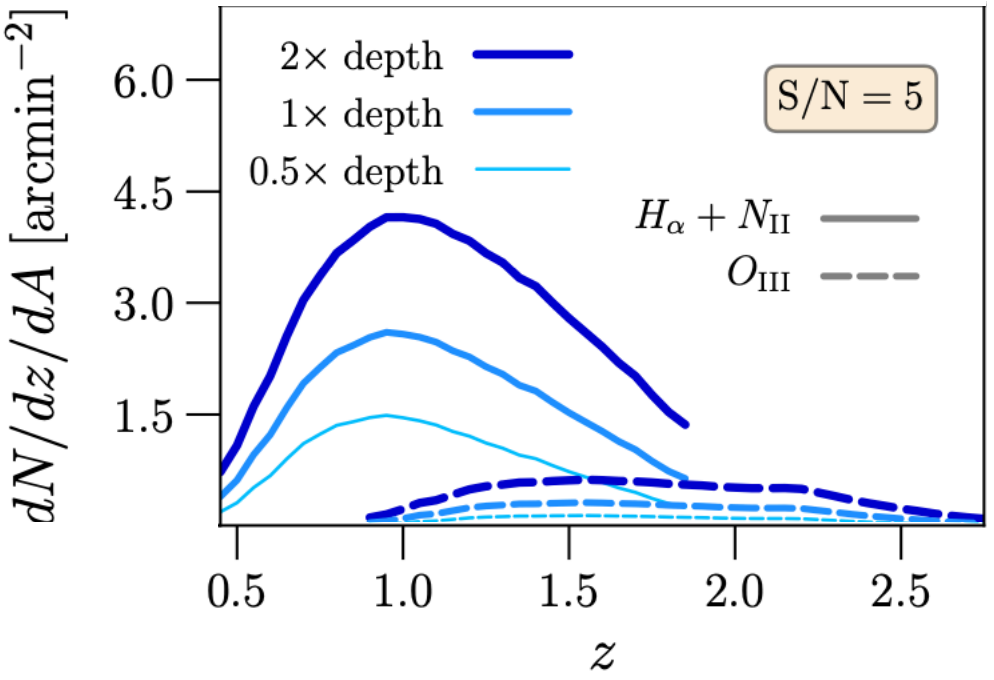
The HLSS

Slitless spectroscopy. Many aspects of the survey plan are similar to the imaging survey, but:

- Multiple rolls for spectral de-contamination; baseline = 4.
- Dispersion directions not the same: with Roman, this means we need to roll the telescope (only 1 grism) and thus observe ~n+ ½ years later.
- Wavelength range trade:
  - The SITs extended the wavelength range to 1.00—1.93 μm (vs. 1.35—1.89 in SDT).
  - Driven by reduced line confusion (for cosmology) + general astrophysics science drivers for the blue end.
  - There was some consideration of 2 grism bands (confusion, 1st order efficiency advantages) but not prioritized by the filters WG.
- Sampling not a driver (not trying to do <0.1% shape measurement from the spectra!) so fewer dithers per roll (baseline = 2).
- Sensitivity at given area & time is a major driver; we extended the exposure time to 297 s to reduce overhead losses.

HLSS performance

- 7 months of HLSS in Reference Survey.
- Sensitivity of 7×10^{-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)

Proposal for Wide Survey

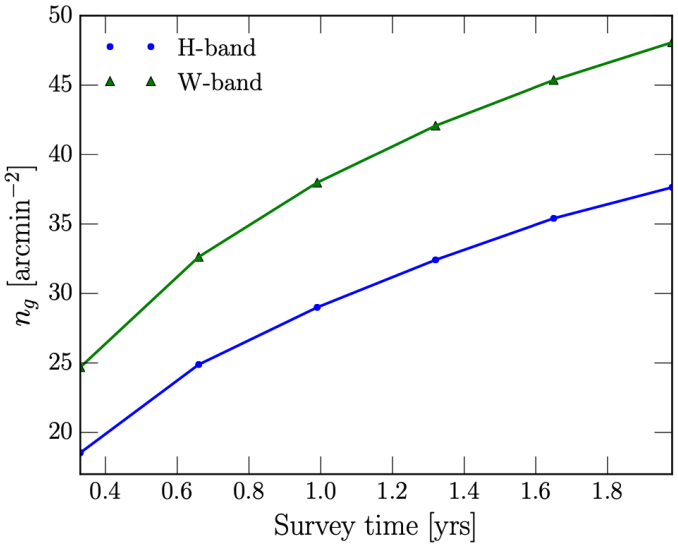
Suggestion to cover the LSST footprint in wide (microlensing) filter (Eifler, Simet, Krause et al. 2020)

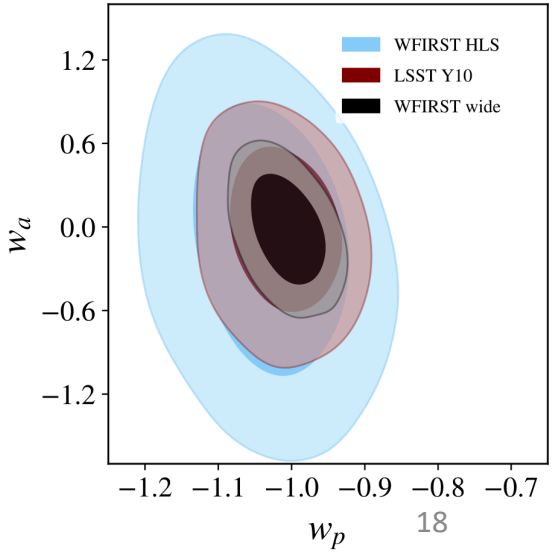
- 18,000 deg^2 in 1.5 years
- By far the greatest statistical constraining power of any conceivable survey …
- but won't by itself provide the internal checks that we need, or as good of photo-z information at z>1

My view is that this is most likely in a "wedding cake" strategy where the HLS provides the detailed understanding of systematics and is used to calibrate the Wide layer.

- One choice is to do this in an extended mission …
- or could shrink the HLIS to ~1200 deg^2 and do the highest priority ~6000 deg^2 of LSST in the primary mission

If there is interest, we could discuss this option at a future meeting.





Questions?