WFIRST Operations Concept

Chris Hirata

AFTA-WFIRST SDT #1

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Outline

1. Basic constraints & issues for DRM1/2
2. Timelines for DRM1/2 report
3. Suggestions for the AFTA study

WFIRST Programs

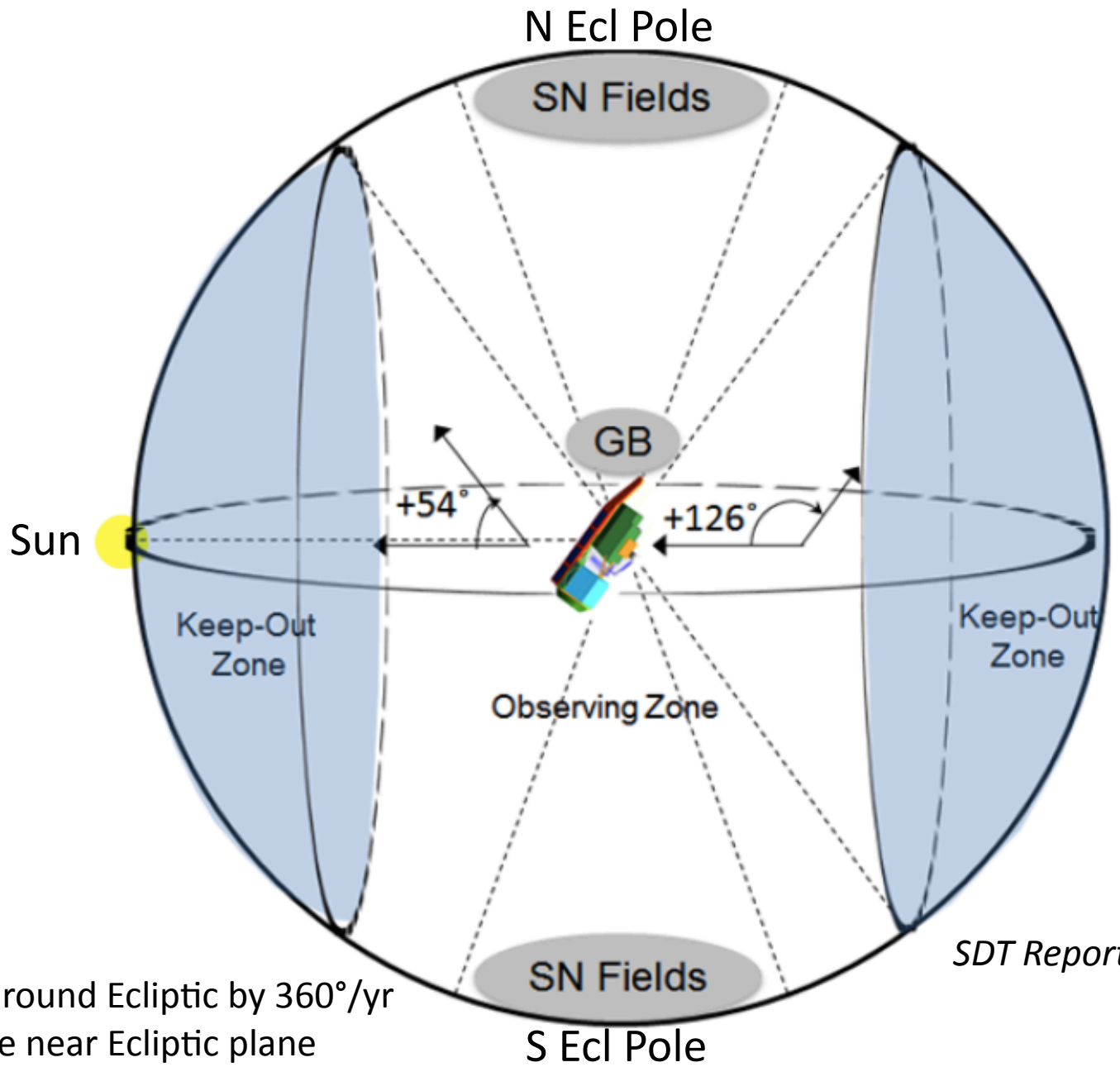
- Requirement was to plan 5 programs –
  - ① High Galactic latitude survey (HLS)
    - Both imaging & spectroscopy included
  - ② Supernova (SN) survey – near an Ecliptic pole
  - ③ Microlensing (μL) – in Galactic bulge
  - ④ Galactic Plane survey (GPS) – at $b \sim 0°$, $l = 0—360°$
  - ⑤ Guest observer (GO) – target fields, revisits/cadence TBD
- For AFTA, we will also consider:
  - ⑥ Coronagraph (not in DRM1/2)
- The constraints for these programs are more than just adding up mission time.
  - We need an "existence proof" plan (to be refined later).
  - **Treat all programs as equal priority for this exercise**, but the observing plan first schedules the observations whose constraints are "hard."

Health Warning

Again … the purpose of this exercise was to (i) provide an existence proof and (ii) understand what kinds of constraints would arise in scheduling the actual mission. This is **not** a “recommended program.”

DRM1/2: Field of regard = 54—126° from Sun

AFTA: ???

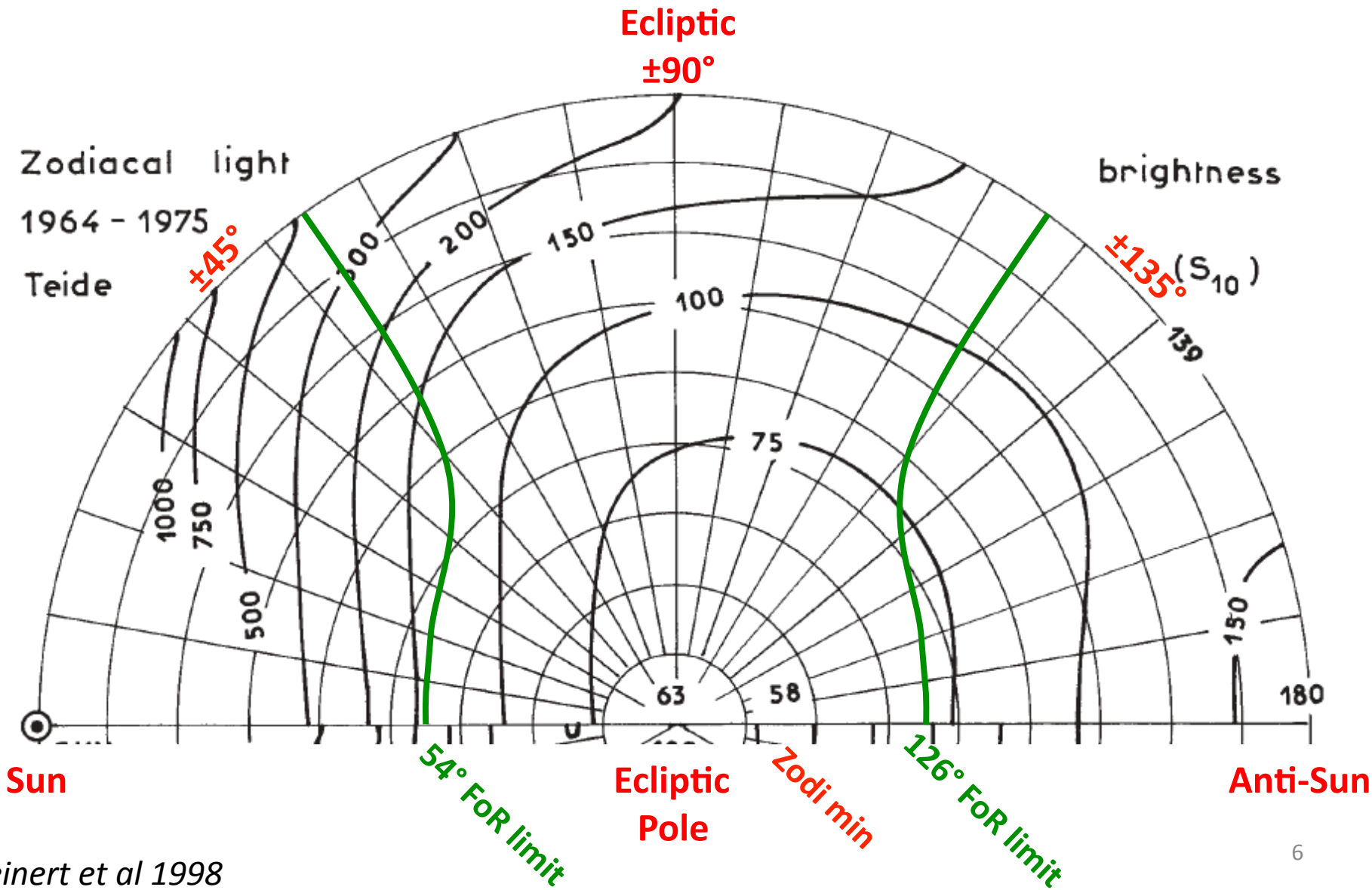


SDT Report, Figure 41

- FoR rotates around Ecliptic by 360°/yr
- Galactic bulge near Ecliptic plane

Zodiacal Light Background

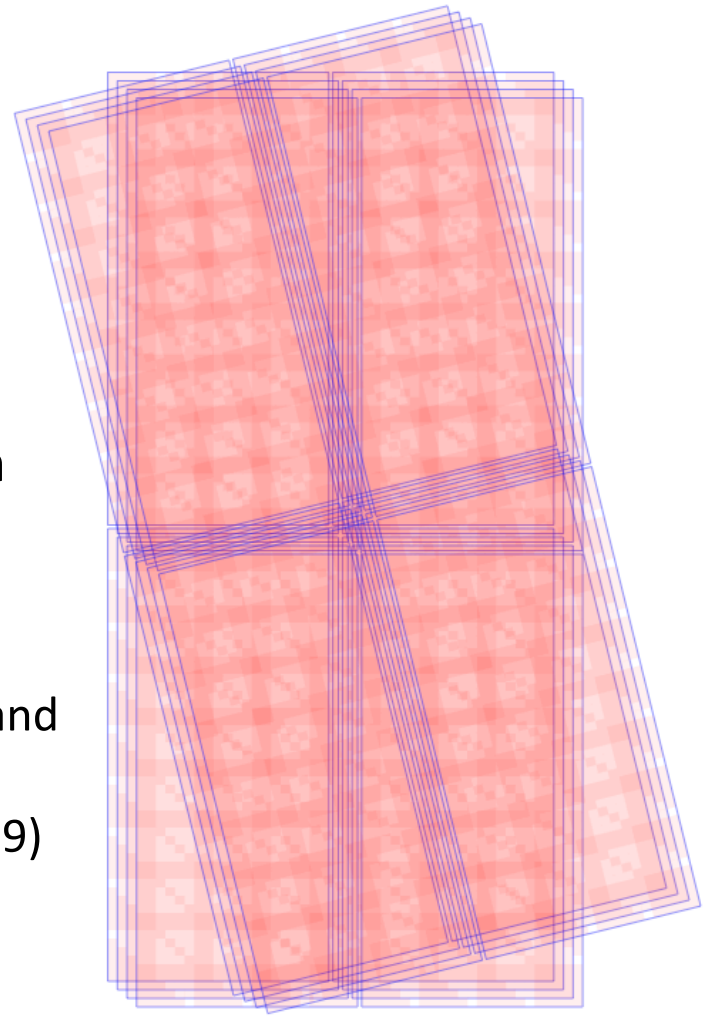
[in ecliptic polar azimuthal equidistant projection]



Leinert et al 1998

HLS Considerations – Imaging

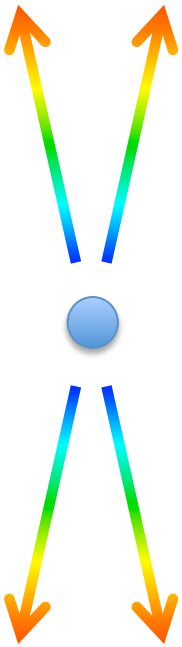
- We will need multiple revisits per field in each filter.
  - Sampling.
  - Cover chip gaps.
  - Recover from defects and CR hits.
  - Ubercalibration.
- To do this with reasonable overheads, solution has been 2 rolled passes.
  - Each roll consists of a sequence of fast diagonal steps by 1+ε chip gaps.
  - Second roll position required for ubercalibration and suppression of Moiré degeneracies.
  - Modern algorithms/computing extend Lauer (1999) image combination algorithms to this case.
  - Two visits separated in time (>1 month, usually much more) to allow ubercal to solve out secular drift.



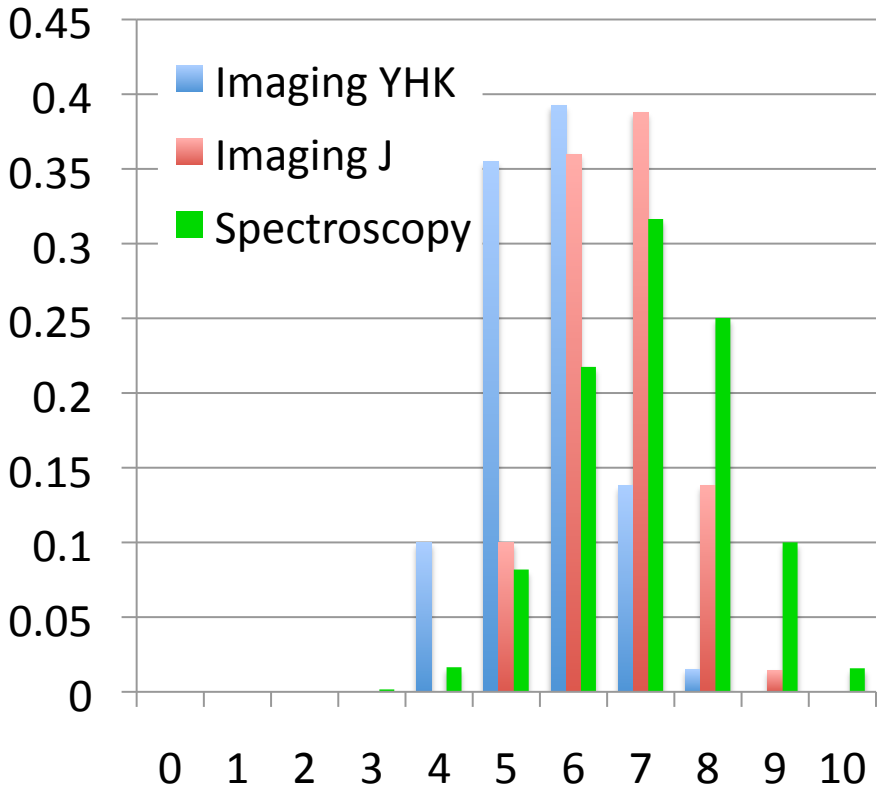
DRM1 strategy
(DRM2, AFTA similar)

HLS Considerations – Spectroscopy

- Generally similar issues to imaging
- New feature is the need for opposing dispersion directions to break degeneracy between λ and emission line centroid.
- WFIRST DRM1/2 strategy is to get 4 roll angles (2 north, 2 south) and ≥6 dither positions over 90% of the surveyed area.
  - *cf.* Euclid: nominally 2 positions, only 1 over 25% of the area. Large dispersion D_θ = 500 arcsec mitigates centroid issue.
- Two implementations possible:
  - Use 2 prisms (DRM1/2)
  - Revisit ½ yr later with S/C rolled 180°. Not chosen:
    - Additional operational constraints
    - Achieving opposite dispersion forces increase in background by up to ~10% since you can't tilt all the way back to ε = 126° at both roll angles!



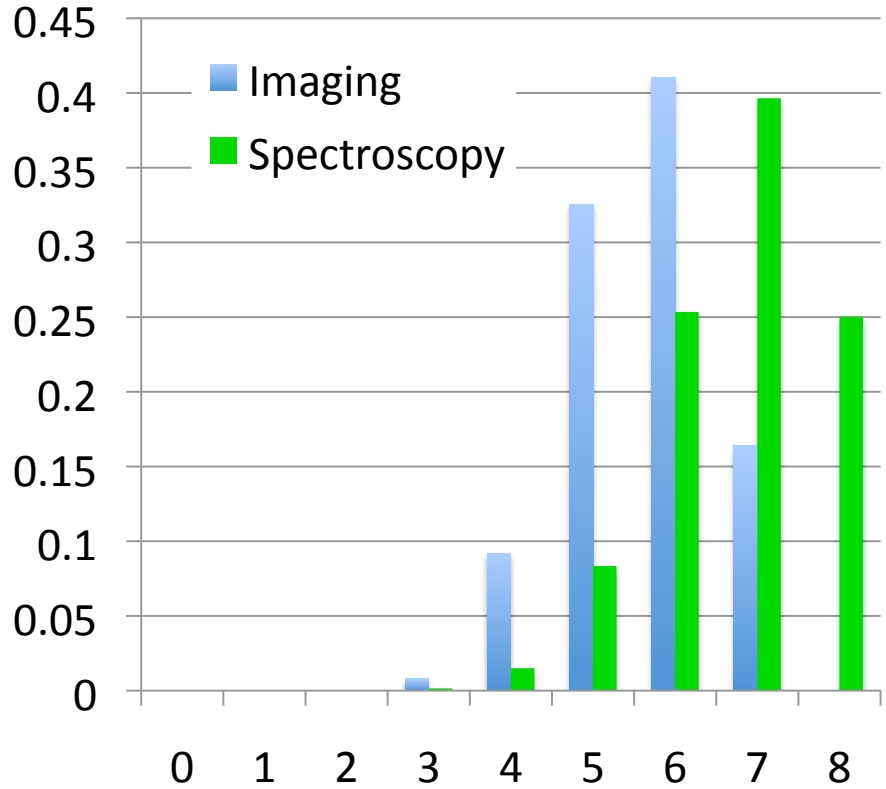
HLS Exposure Count Histogram



DRM 1

Steps per pass:

4, 4	Imaging (YHK)
5, 4	Imaging (J)
3, 2, 3, 2	Spectroscopy



DRM 2

Steps per pass:

4, 3	Imaging (each filter)
2, 2, 2, 2	Spectroscopy

Changes due mainly to smaller gaps (only 2 rows of detectors)

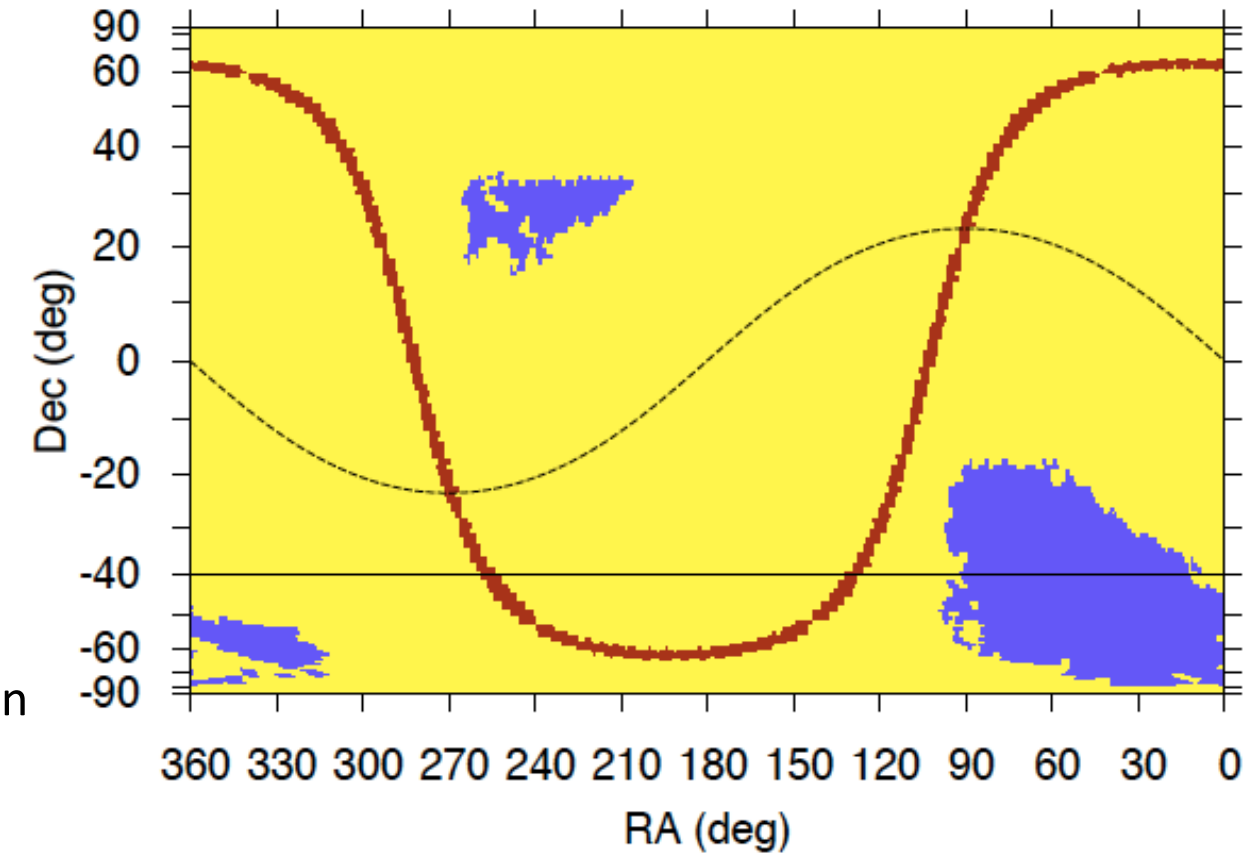
HLS further considerations

We absolutely need:

- Avoidance of Galactic plane
- Avoidance of Ecliptic (high sky brightness)

We would like:

- Observe at lowest zodi brightness available
- Fit within LSST footprint
- Accessible from Northern Hemisphere sites (e.g. Hawaii)



DRM1 – Example Survey, begin May 21
HLS Footprint (Purple)
Galactic Plane (Red)
Ecliptic (dashed)

Can't do it all – one example shown here. Others possible (e.g. can make survey more accessible from both N and S Hemispheres, at expense of greater background).

Supernovae

- Monitor SN field with ~5 day cadence (light curves)
- Implies fields near the Ecliptic Poles for year-round availability
  - In current design, $|\beta|>54°$; in practice $>75°$ to keep zodiacal light low.
  - SEP fields would have to be offset to $\beta\sim-82°$ to avoid LMC, Galactic dust
- Duration of survey
  - Longer is better to suppress edge-effect losses
  - Prism approach (DRM1/2 baseline) requires 2 year duration to obtain reference spectra
    - Year 1 provides the reference for Year 2 and vice versa
  - IFU would change the constraints:
    - No roll angle constraint – reference spectra at any time of year.
    - Reference spectrum must come after the SN fades away.

Microlensing Program

- Observe the Galactic bulge – ecliptic λ=269°, β=−5°.
  - Actual observing plan is several fields spaced around the bulge with ~15 min cadence.
- Accessible for 72 day periods ("seasons") twice per year, centered around $L_\odot$ = 0, 180° (±36°).
- μL constraints:
  - Multiple seasons (6 for DRM1, 4 for DRM2)
  - Coverage over entire season to track stellar lightcurve
  - Interrupts reduce efficiency (planetary lightcurve edge effects).
  - As large a baseline as possible to measure lens-source relative proper motion.
- Potential conflicts:
  - ✗ In a 3 year mission, interrupts are required to make compatible with SN
  - ✗ Uses most of the available observing time when λ ~ 90, 270° accessible

Galactic Plane Survey

- Covers the Galactic Plane at ~2× the HLS rate (TBR)
  - Entire range of $0<l<360°$
  - Due to confusion:
    - No slitless spectroscopy planned
    - Imaging times are shorter, no restriction on zodi background
- This program makes extensive use of the full FoR
  - Regions near l = 0, 180° observable only during μL seasons
    - Filled in during "skipped" seasons
  - To accommodate HLS & GO constraints, some regions get pushed to Sun angles close to the 54° limit.

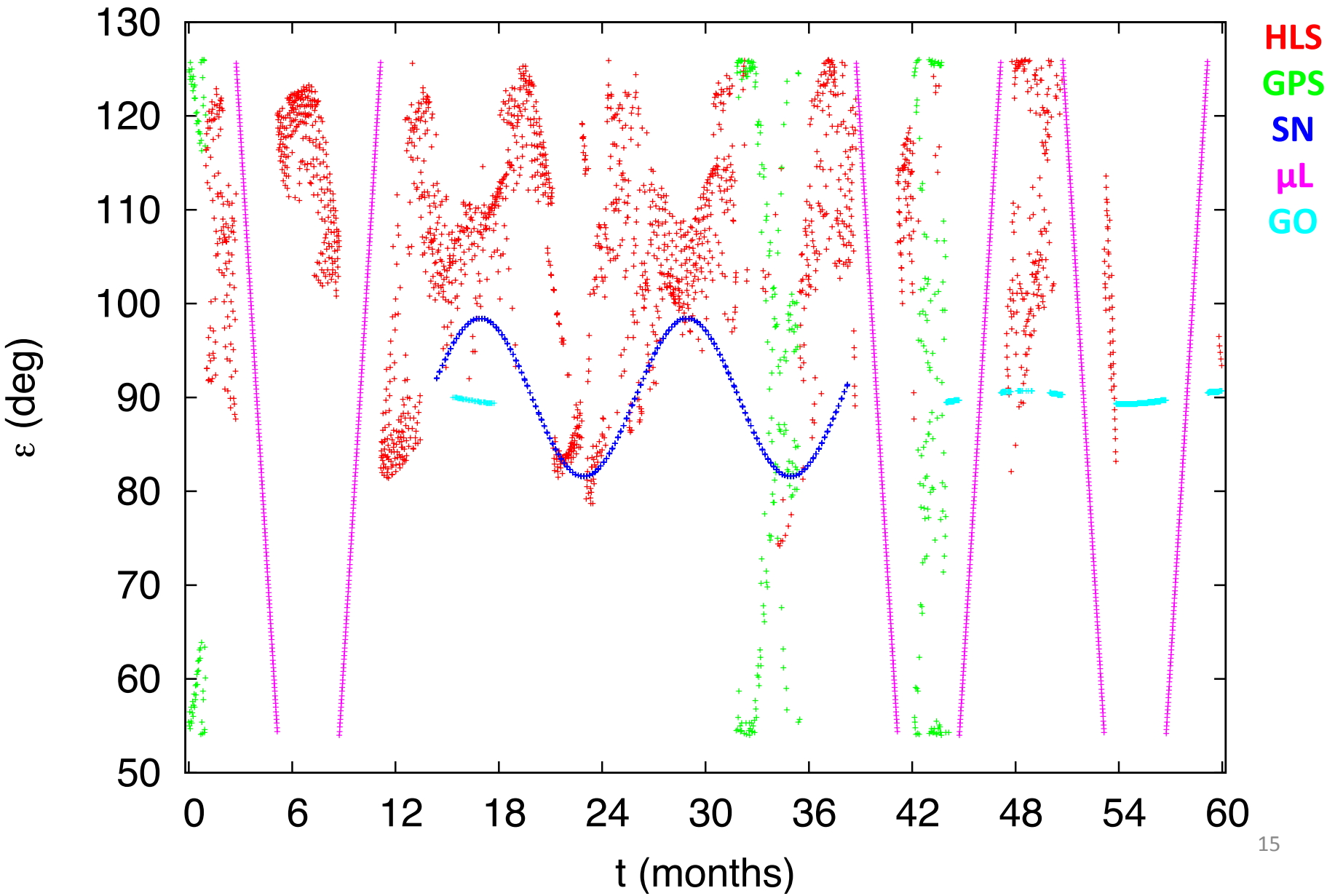
GO Program

- Well obviously I can't schedule this one – the whole point is that we will rely on the ingenuity of the community to fill this one in!

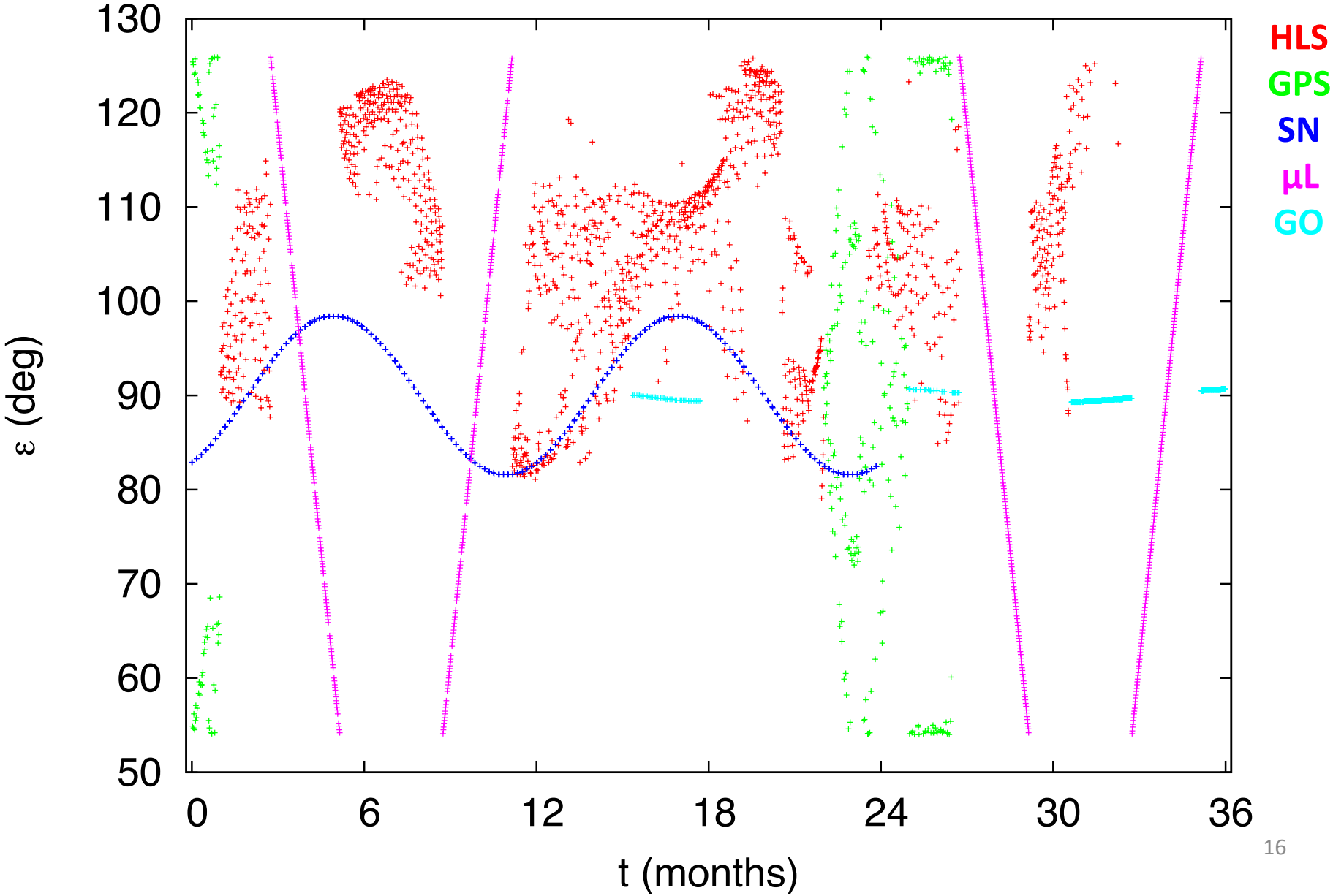
- Notional constraints are:
  - At least 10% of the science time must be devoted to GO programs.
    - TAC will have at least some (maybe full?) ability to revisit this, but the notional plan needs to accommodate both the large programs and have some unallocated time.
  - Every object in the sky has to be accessible during the notional GO time.
    - Seems like common sense.
    - Community science is about flexibility as well as raw capabilities.

- As a practical implementation, we would re-optimize the entire program (or remainder thereof) after each TAC Cycle, rather than setting the GO observing periods in advance.

DRM1 5-year Plan



DRM2 3-year Plan



Scheduling Procedure

- Time domain programs (SN, μL) were scheduled first.
- Reserved observations next.
- Tried to schedule HLS next.
  - HLS footprint was determined dynamically by the scheduler – footprint varies with launch date!
  - Multiple passes were required; lowest zodi scheduled first.
- Galactic plane next.
  - Some longitudes could not be scheduled because the HLS had already used the viewing opportunities. Had to go back and "reserve" these periods for the Galactic Plane survey.
- GO program.
  - Again if the previous programs are greedy, the GO program is unable to view some regions and time has to be reserved.
  - Not ideal solution: in a 3-year mission (DRM2), some targets are only available if you get in your proposal early (can't observe in Year 3).

Some General Lessons

- Scheduling the mix of programs in WFIRST will be hard.
  - Time domain surveys.
  - Background requirements for HLS.
  - Field of regard constraints.

- Particular issue will be integrating a GO program into these constraints.
  - Enthusiasm has been expressed for increasing this to many tens of percents.
  - Flexibility of both the observatory and the "key projects" is critical, especially if time-critical programs are to be enabled.