The WFIRST High Latitude Survey

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Outline

- Recap of HLS parameters
- Examples of currently open trades & issues

High Latitude Survey Overview

Summary

- ✓ 2 year survey during 6-year baseline mission
- ✓ 4 filters: Y, J, H, F184 spanning 0.92—2 μm
- ✓ + grism, 1.35—1.89 μm bandpass (R=660)
- ✓ 2213 deg^2 footprint, subset of LSST footprint
  - Joint wavelength coverage is u band through 2 μm
  - Photo-z for weak lensing & redshift survey
- ✓ 5—7 observations per filter; 2 roll angles (imaging) or 4 (grism)
- ✓ This is a snapshot of where we are now, in Pre-Phase A these are not final decisions!

Significant Changes since 2013

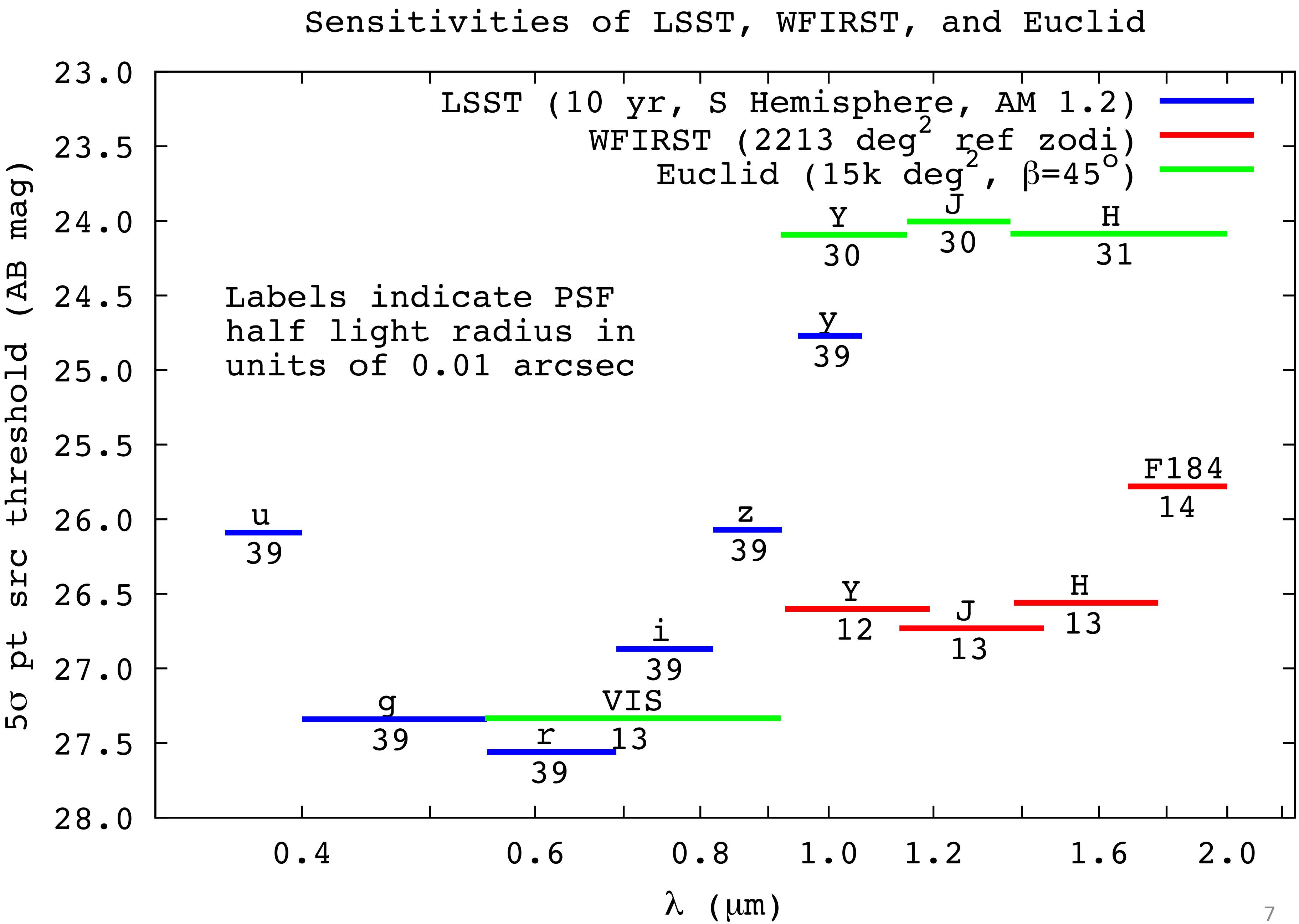
- Telescope temperature increased to 282 K – cost 0.3 mag of depth in the reddest filter and 11% fewer galaxies in the grism survey, <0.1 mag elsewhere.
  - Temperature studies are ongoing and this is not final.
- Examined surveys at lower ecliptic latitude to benefit observations from ground based telescopes in both hemispheres.
  - This is the version shown in this talk.
- Revisions underway to universe models (mock catalogs, luminosity functions).
- Improvements in the treatment of observing overheads.

Major design considerations

1. Robustness: emphasize cross checks and multiple observations (imaging filters for WL; multiple roll angles for spectra; dither positions)

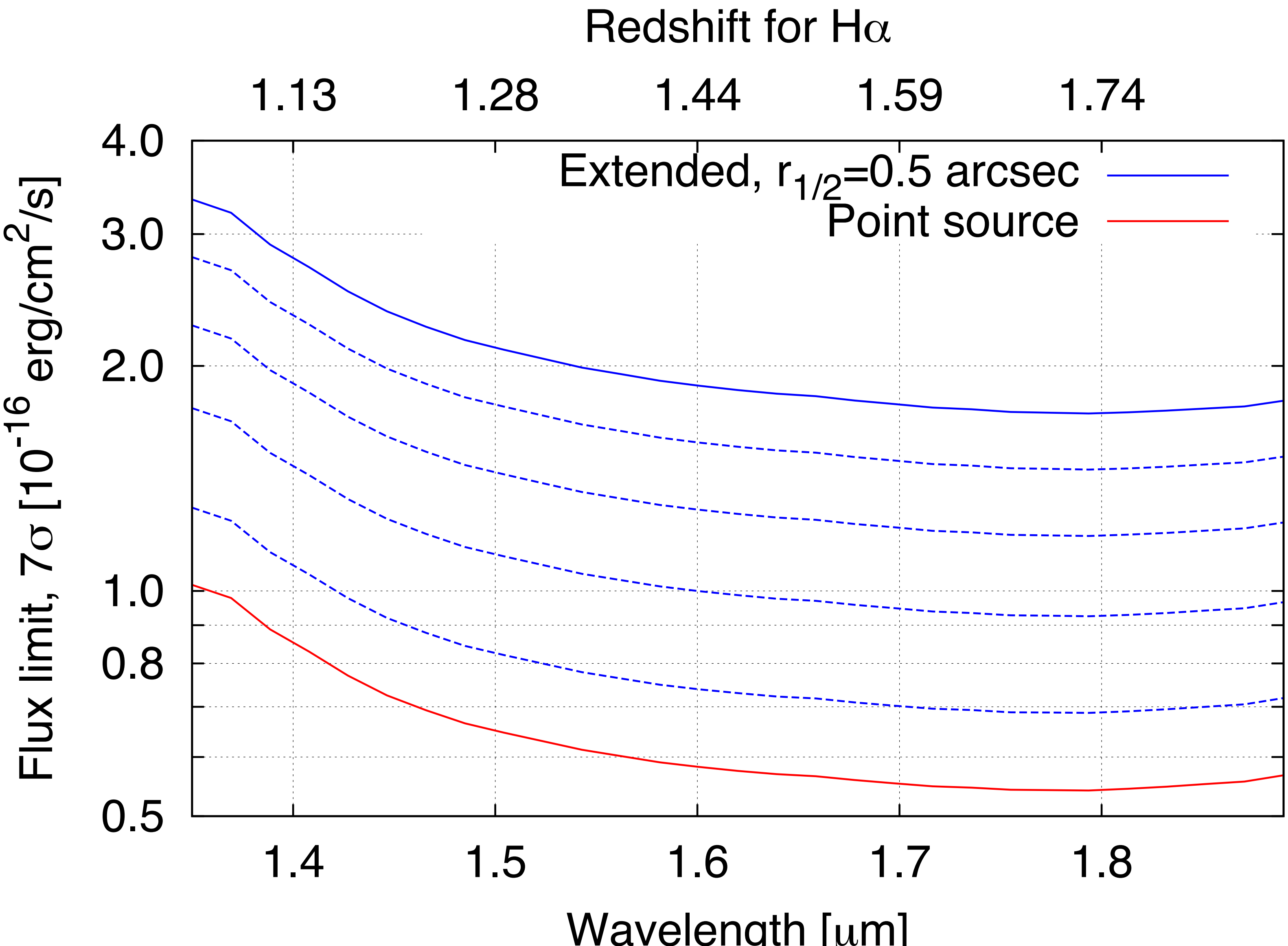
2. Survey area: more area is usually better, for the example plan we went as fast as possible without hitting the overhead/read noise curve. Not set at d(FoM)/d(speed)=0. Final optimizations to be done once we know the telescope temperature, detector properties, etc.

3. Previous versions (up to 2011) had deep + wide split. Now wide is to be covered by Euclid+DESI; WFIRST is specialized to "deep" (still thousands of deg^2, but not required to be half the sky).



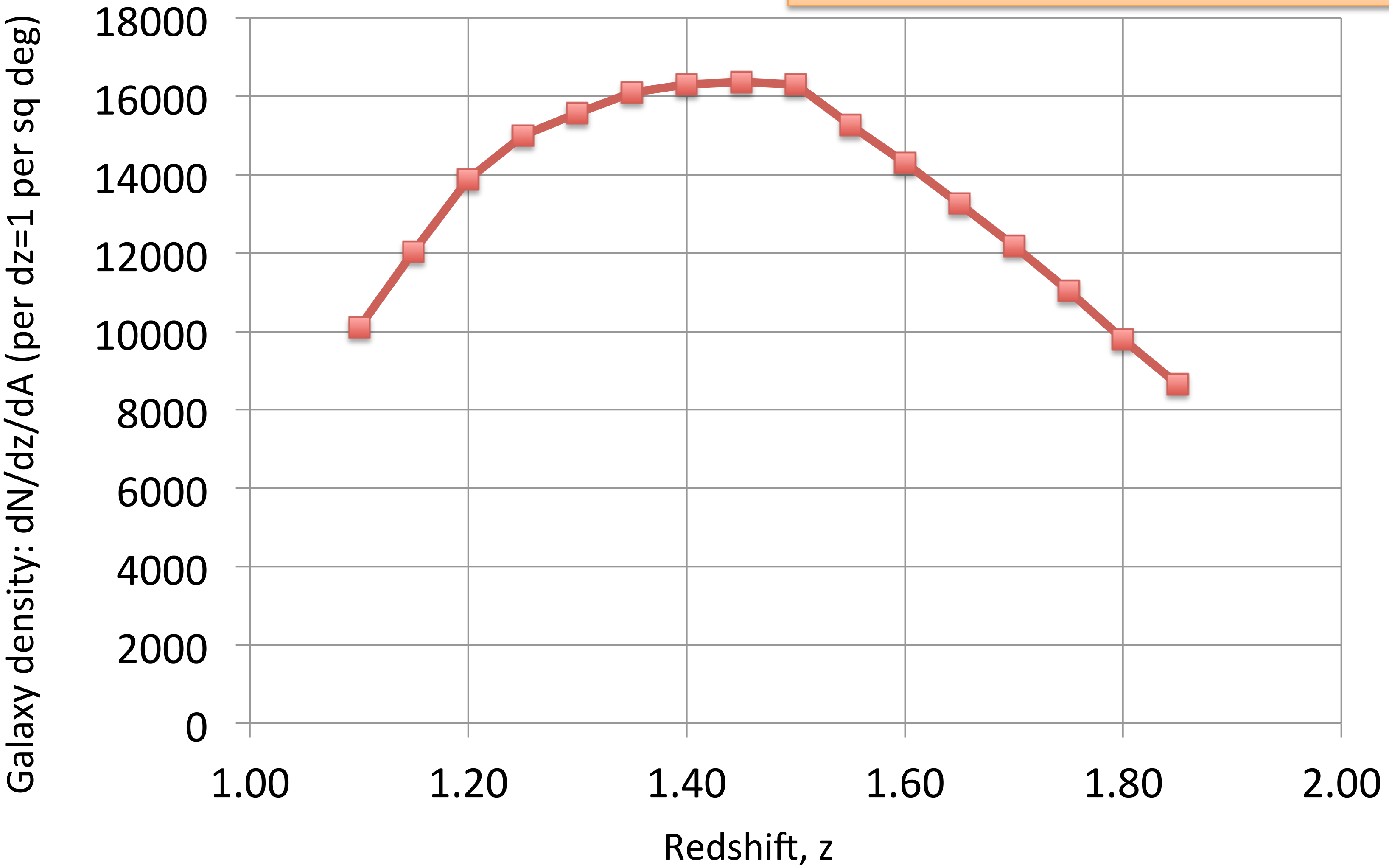
Sensitivities of LSST, WFIRST, and Euclid
LSST (10 yr, S Hemisphere, AM 1.2)
WFIRST (2213 deg^2 ref zodi)
Euclid (15k deg^2, β=45°)
Labels indicate PSF half light radius in units of 0.01 arcsec
5σ pt src threshold (AB mag)
λ (μm)
23.0
23.5
24.0
24.5
25.0
25.5
26.0
26.5
27.0
27.5
28.0
0.4
0.6
0.8
1.0
1.2
1.6
2.0
u 39
g 39
r 39
i 39
z 39
y 39
VIS 13
Y 30
J 30
H 31
Y 12
J 13
H 13
F184 14

Grism Sensitivity



Redshift Survey Density

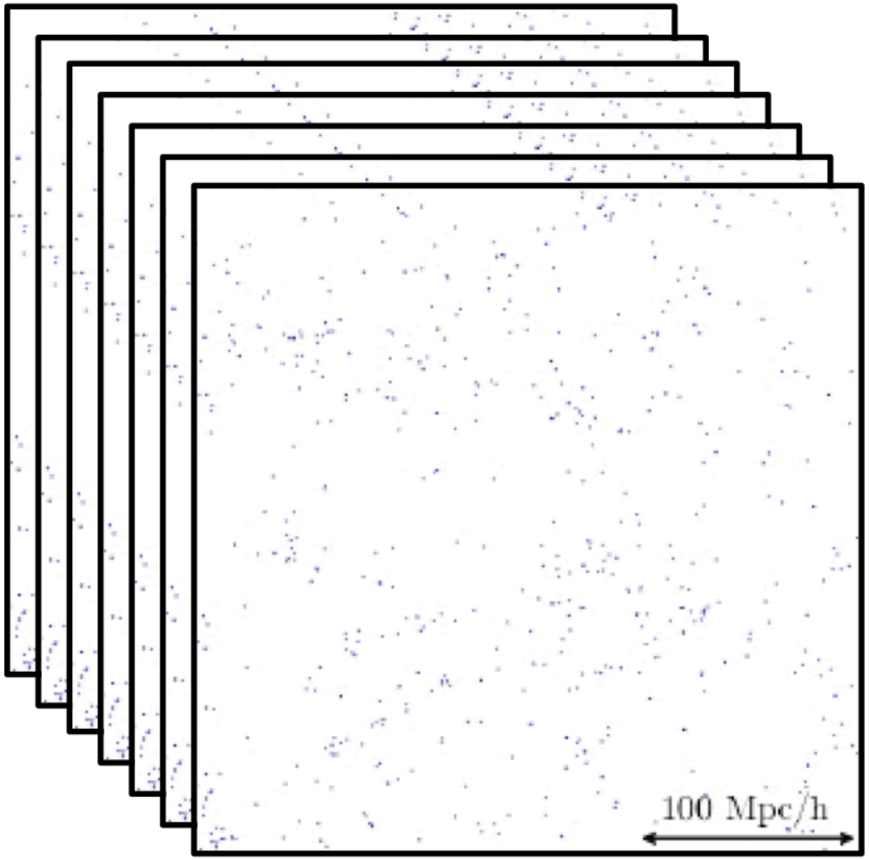
25 M galaxies in 2213 sq deg



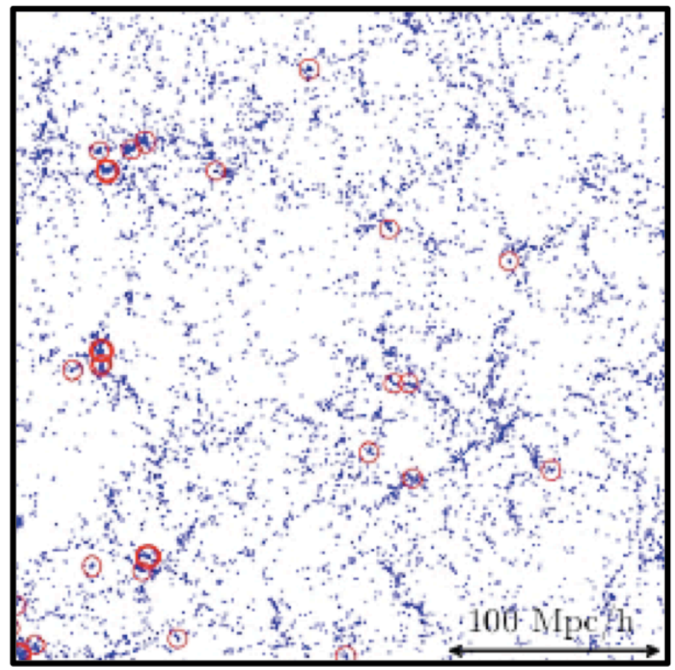
Redshift Survey Comparison

[2014 SDT Report]

Large scale structure simulation showing 0.1% of the total WFIRST-AFTA Galaxy Redshift Survey Volume



Euclid
15,000 deg² @ 1700 gal/deg²



WFIRST
2,400 deg² @ 12,600 gal/deg²

Large scale structure simulations from 2013 SDT Report – courtesy of Ying Zu

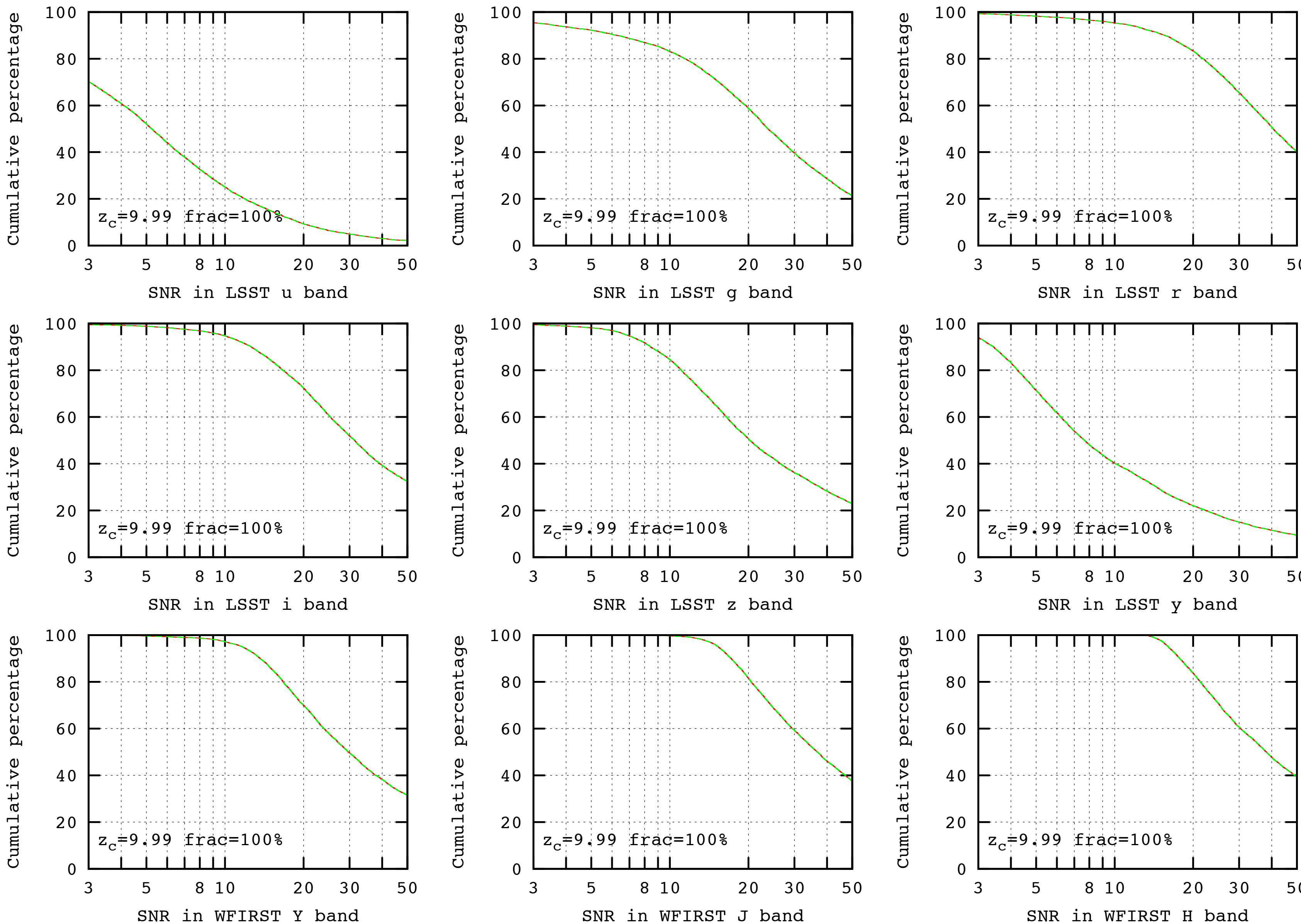
Thin and thick red circles mark clusters with masses exceeding 5 x 10^{13} M_{sun} *and* 10^{14} M_{Sun}*, respectively*

WL Galaxy Yields – AFTA Report Filters

Two numbers are given in each cell, n and n_{eff}. Both are in galaxies/arcmin^2.
Filter choices shown are J (1.13—1.45 μm), H (1.38—1.77 μm), and F184 (1.68—2.00 μm).
3 minute exposures (32 samples up the ramp), 5x or 6x as appropriate
With CANDELS data – Galametz et al, Guo et al.

	COSMOS Mock Catalog (08/2011)	CANDELS UDS	CANDELS GOODS-S
WFIRST J 6 exp	59 / 55	38 / 36	39 / 36
WFIRST H 5 exp	65 / 61	40 / 38	40 / 38
WFIRST F184 5 exp	47 / 44	29 / 27	29 / 28
WFIRST J+H 11 exp	79 / 75	50 / 47	50 / 47

Forecast Detection SNR of WL Galaxies in LSST+WFIRST



Trades & Considerations

Thermal Analyses for WL in GEO Orbit

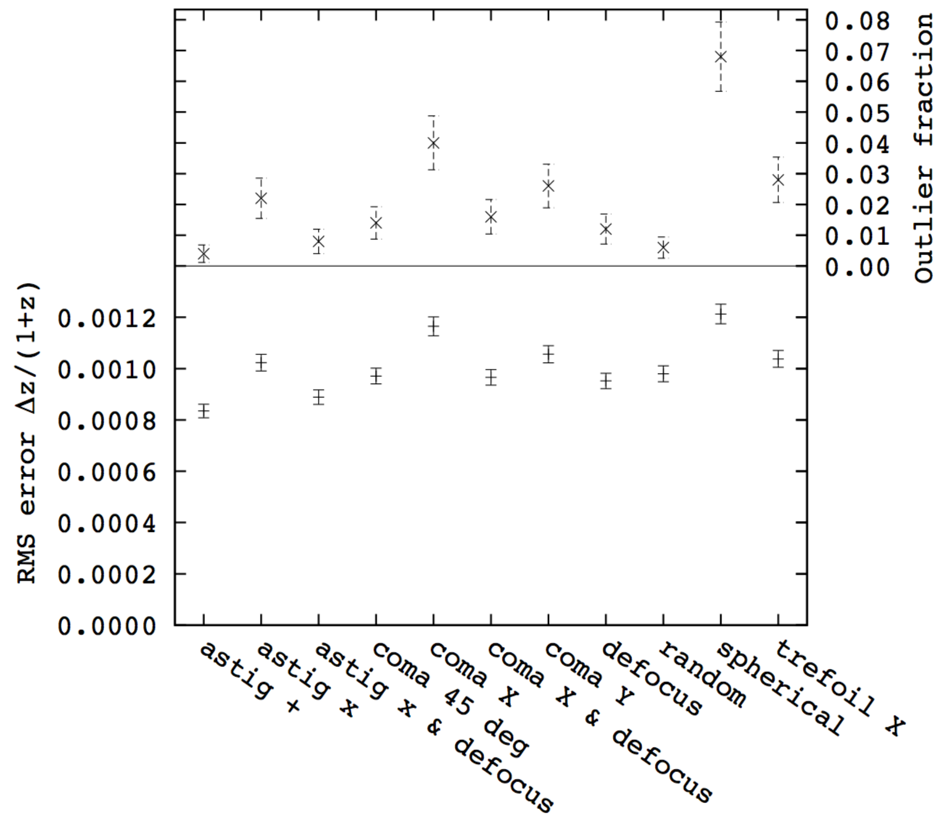
[WFIRST Project Integrated Modeling Team – from 2014 Report]

STOP Predictions/Margins for Fixed Attitude and Worst-Slew Cases

- Stabilities of WFI Imager PSF ellipticity and WFE have significant margins even for a STOP WFI Worst-Case Slew:
  - **x9 margin** on WFE drift (rqt ≤ 0.707 nm drift/184s at WFI Focus)
    - x25 better than HST WFE variations, which can be ±30 nm over an orbit
  - **x108 margin** on PSF ellipticity (total rqt ≤ 4.7 e-4/184s at WFI Focus)
- PM/SM Position/Shape Stabilities for STOP Fixed-Attitude case were viewed positively by the Coronagraph Team:
  - **Zernike instabilities were dominated by easily corrected focus errors** at a fraction of a nanometer to a few picometers over 12 hours
  - **Rigid body motions were sub-micron** over 24 hours
- **MUF (Model Uncertainty Factor) of x3 is applied to all results, prior to any margin assessment.**

Grism Survey Issues

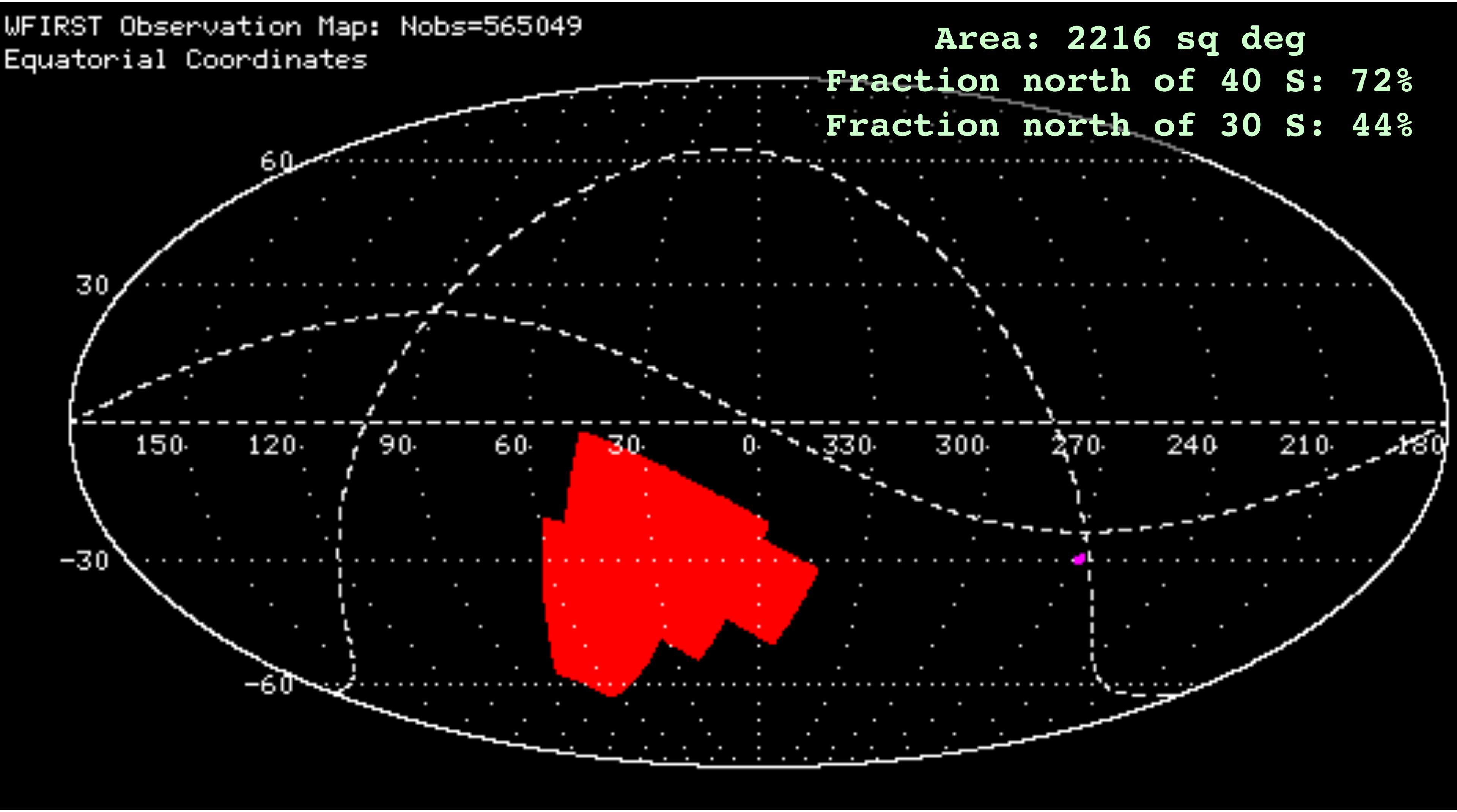
- We have all the usual issues (e.g. overlapping spectra, single line emitters)
- Image quality, spectral dispersion, and background are variable across x, y, and (if applicable) λ
- This impacts selection in the GRS, e.g. with [N II]+Hα blending. Will need to understand this very well!



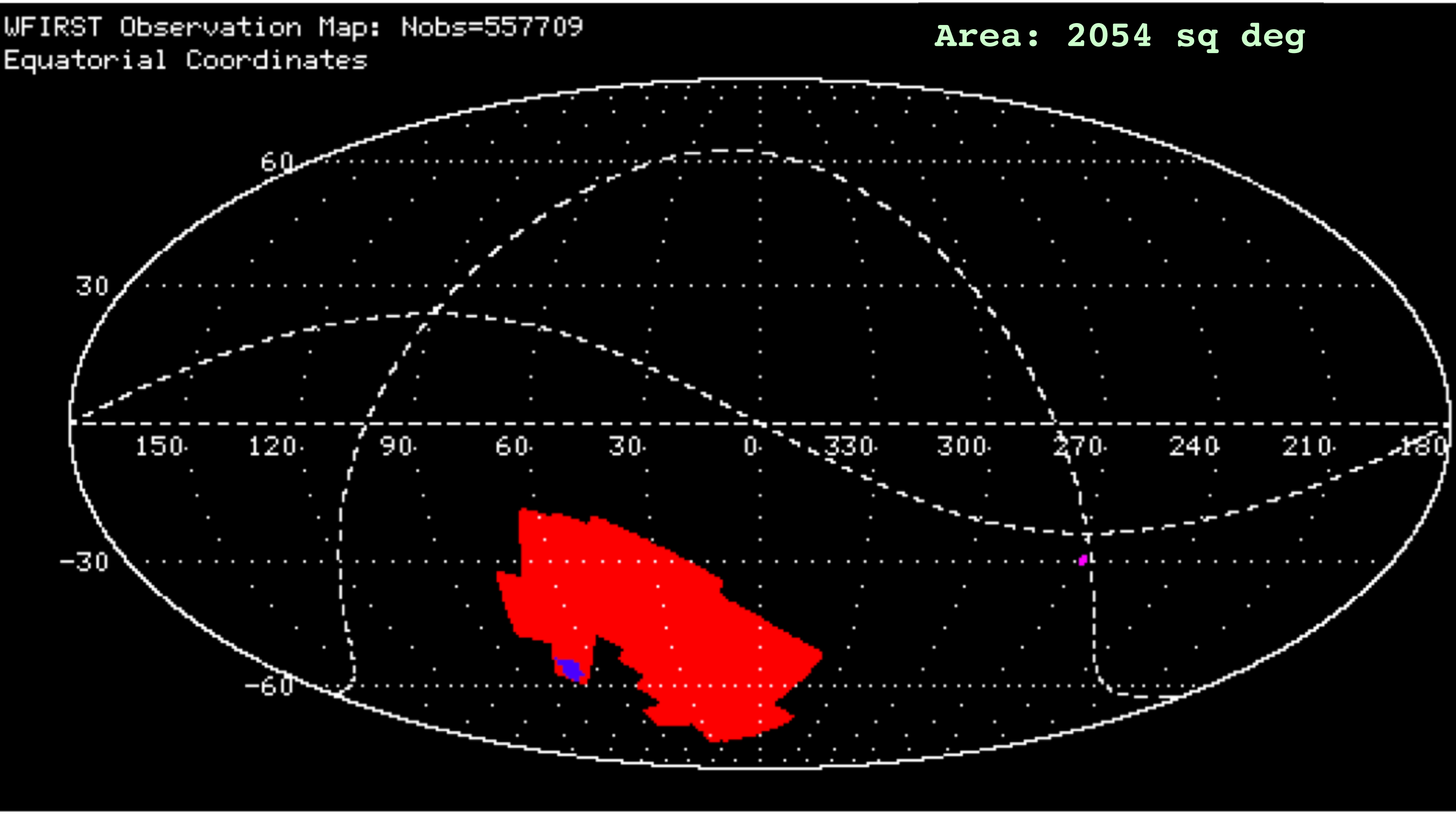
Toy simulation, **not** full-instrument, for emission lines at 5σ, at 213 nm rms wavefront error. Tools such as this were used to set **preliminary** dispersion requirements – much more work is needed here!

Example Footprint

[Equatorial Coordinates]



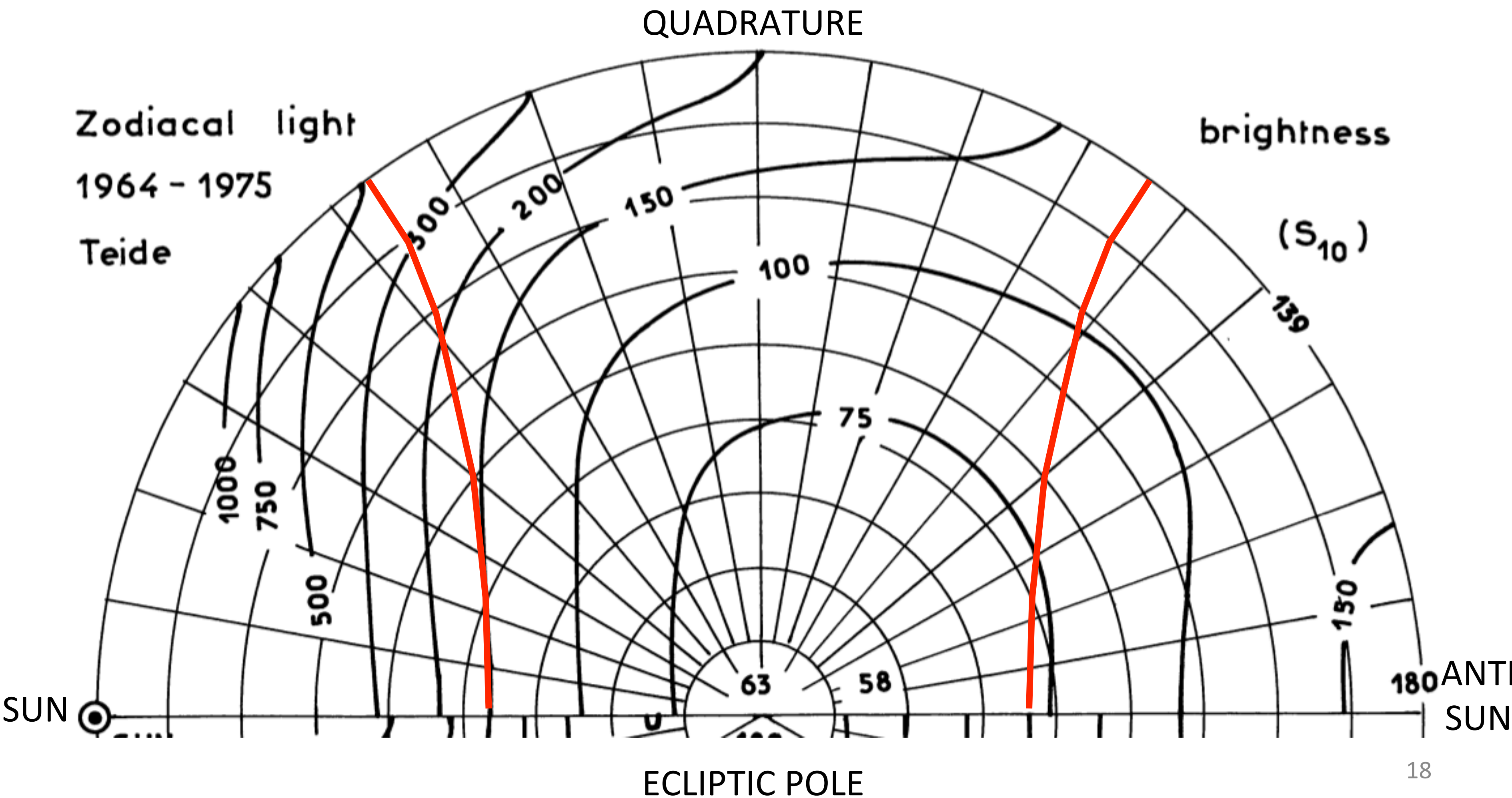
Compare to 2013 Version



(Average) zodiacal brightness

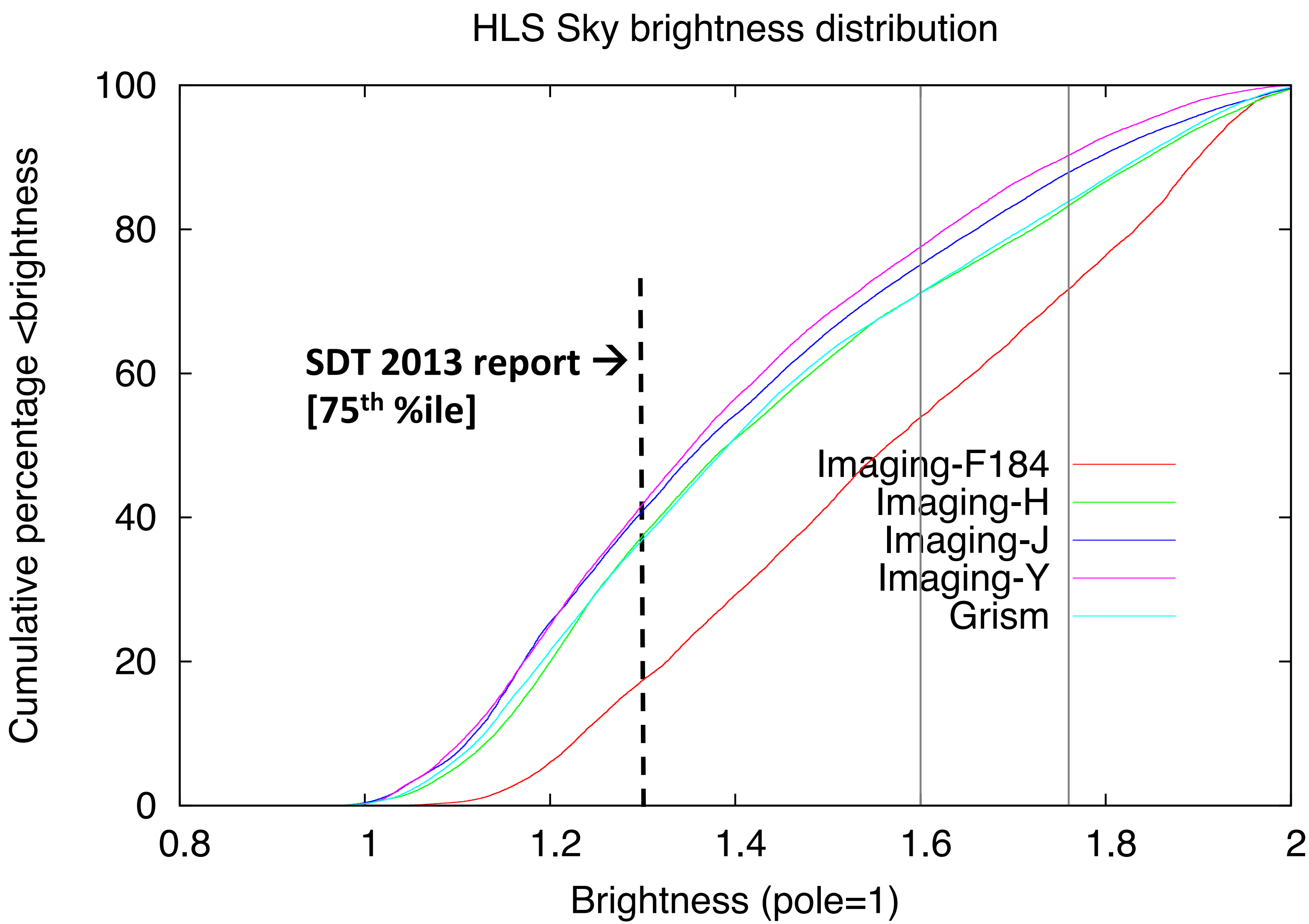
[Dumont & Sánchez 1976]

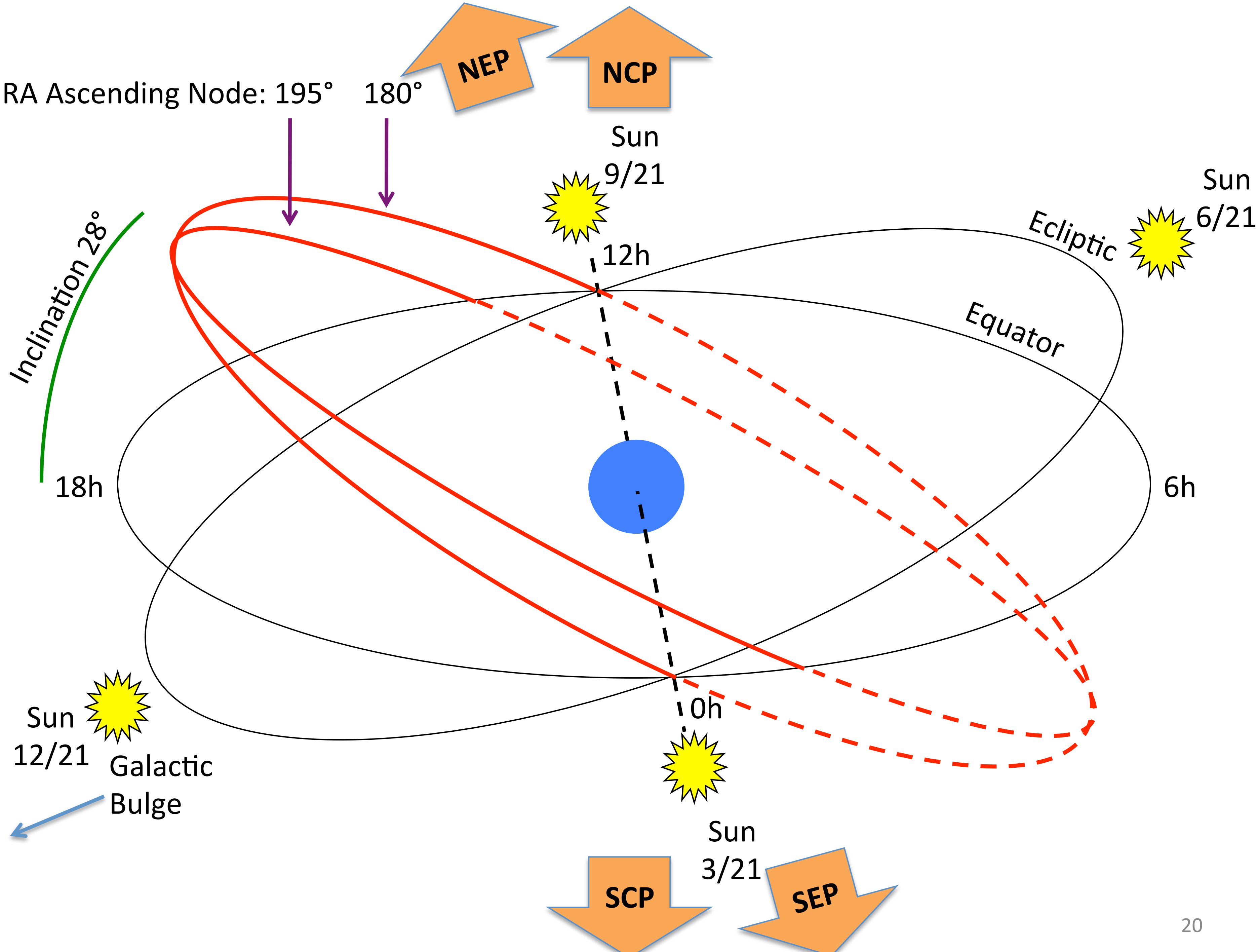
Red lines indicate WFIRST observing limits.



Sky brightness

[F184 filter is farthest from zodi limited so was scheduled at lower Sun angle]

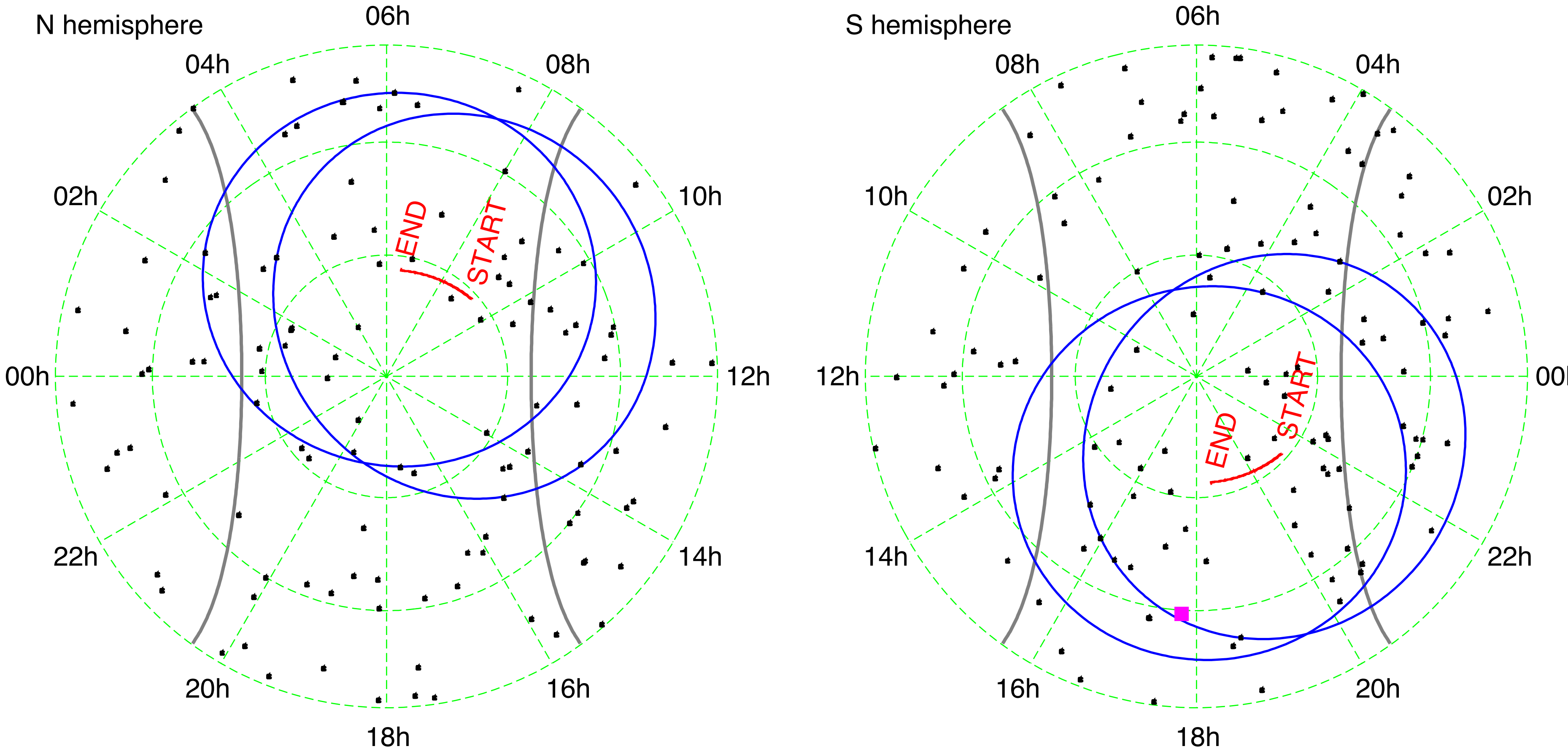



RA Ascending Node: 195°
180°
NEP
NCP
Sun
9/21
Sun
6/21
Ecliptic
Equator
12h
Inclination 28°
18h
6h
0h
Sun
12/21
Galactic
Bulge
Sun
3/21
SCP
SEP

Combined Cutout Charts

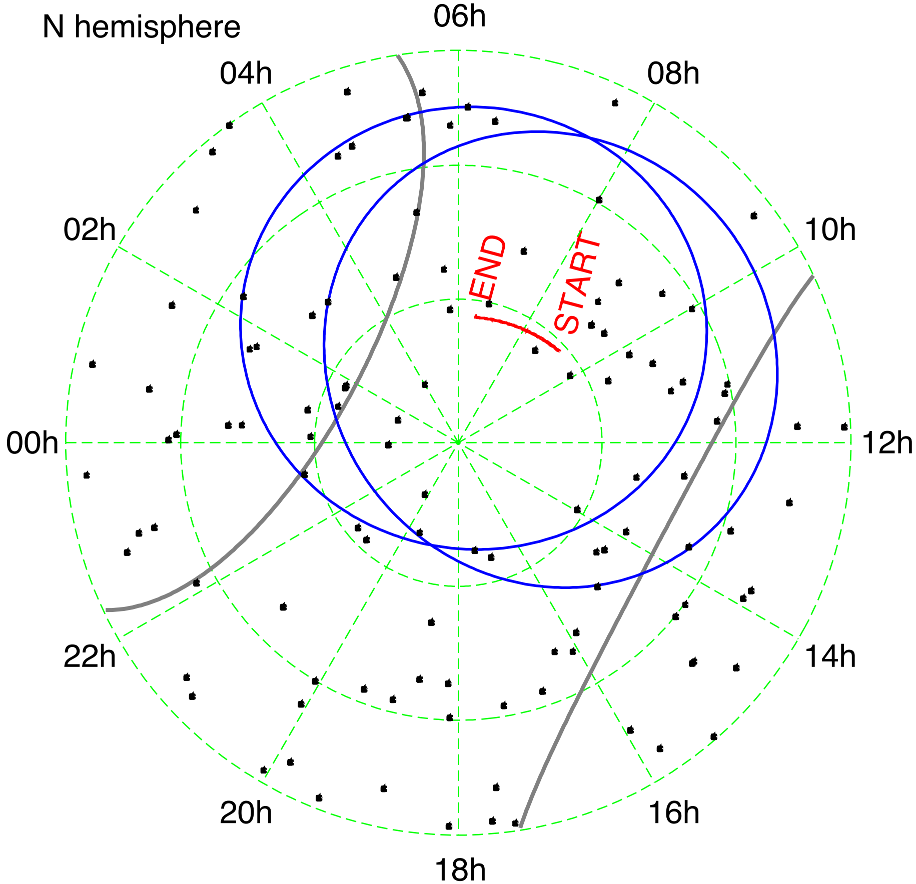
- The following 7 charts show the combined Earth + Sun viewing constraints at 1 month intervals.
- The Sun viewing constraint is periodic every 6 months since the pitch limit is symmetric under positive pitch (away from Sun, up to +36°) and negative pitch (toward Sun, down to −36°). Thus the last chart is the same as the first.
- In each hemisphere, the region **between** the gray curves is allowed by the Sun.
- The region **within** the blue circles is viewable 24 hours per day. Regions allowed by the Sun cutout but outside the blue circles are visible for part of the day.
- Moon avoidance is in the scheduler but not shown on these charts.

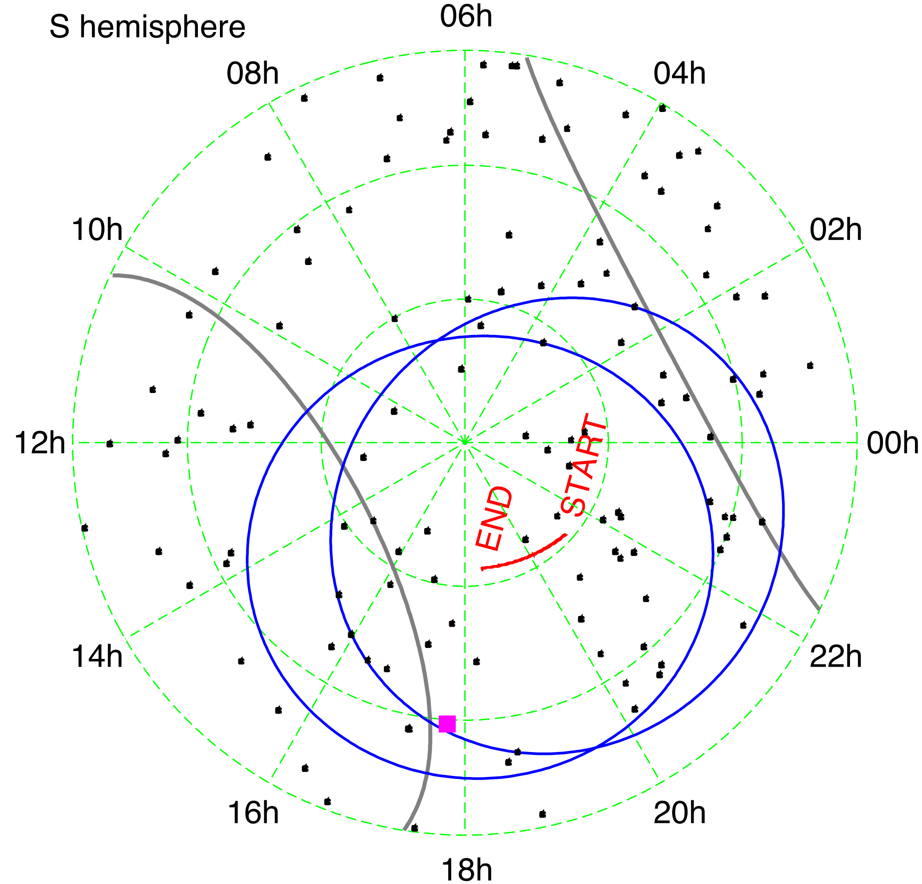
Viewing Zones
March 21 OR September 21



Viewing Zones

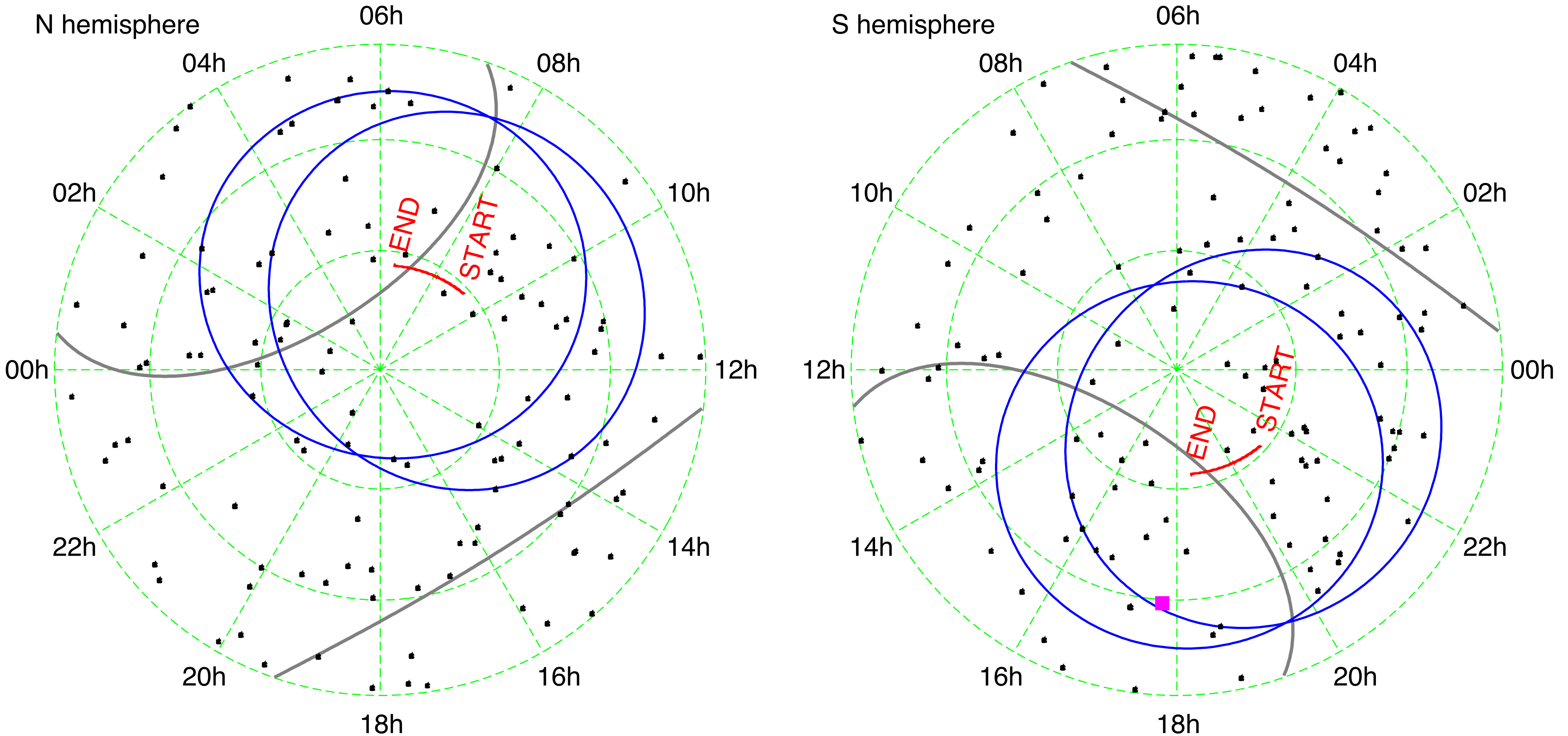
April 21 OR October 21



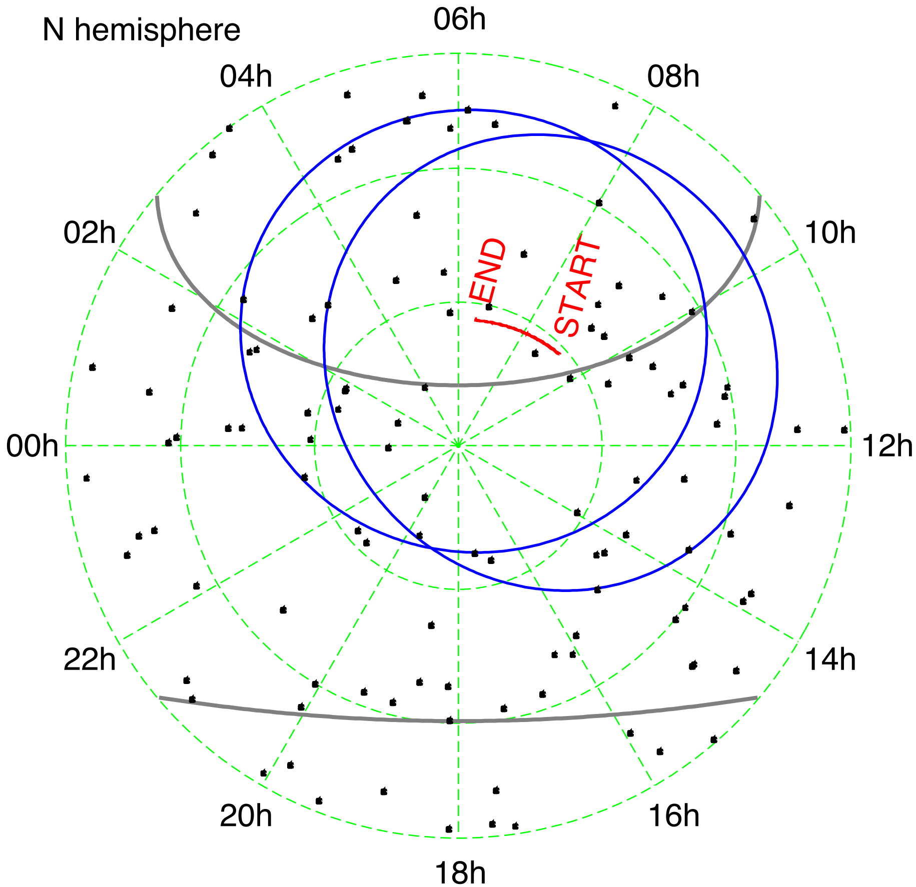


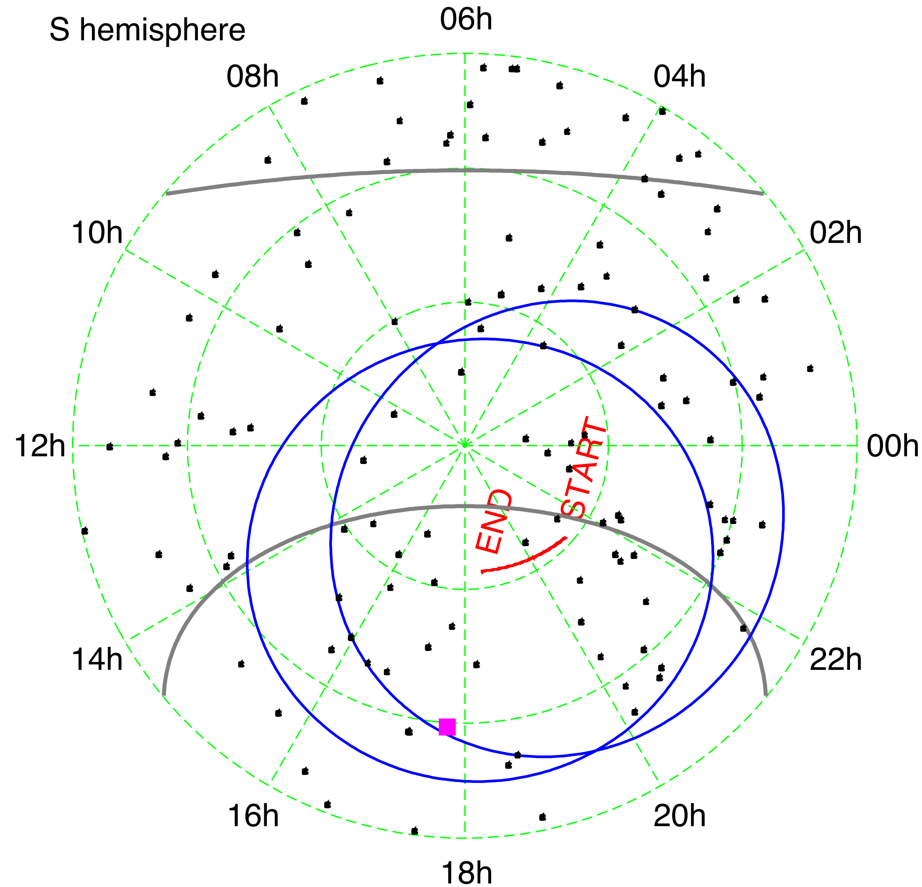
Viewing Zones

May 21 OR November 21



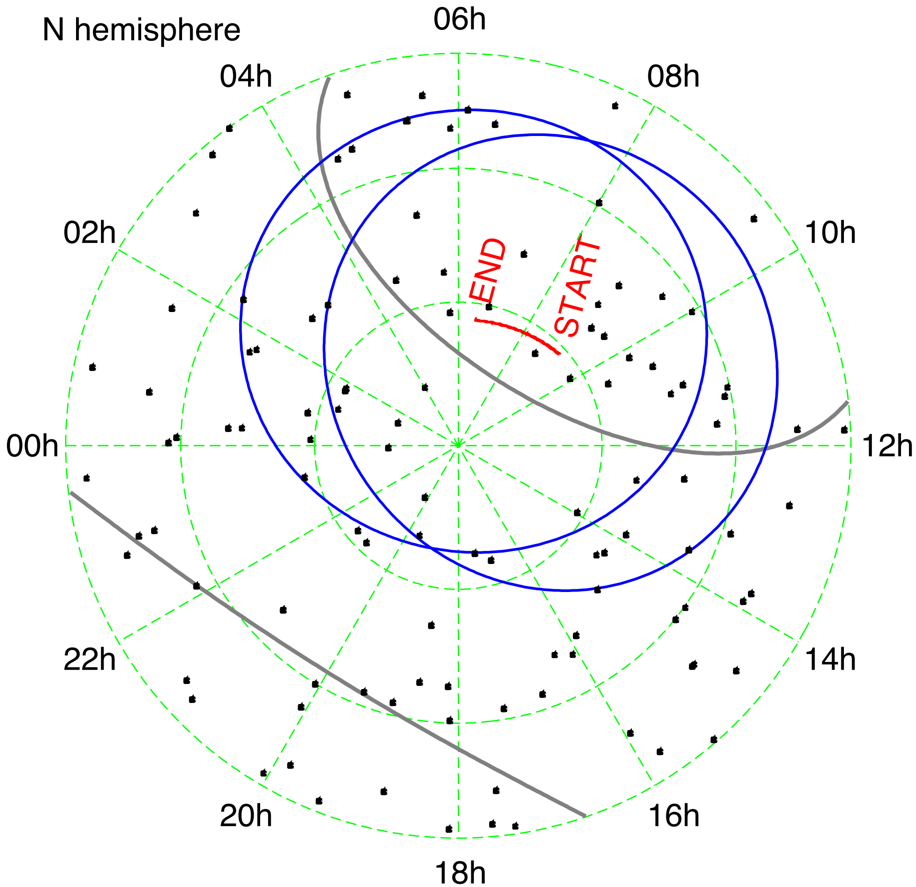
Viewing Zones
June 21 OR December 21

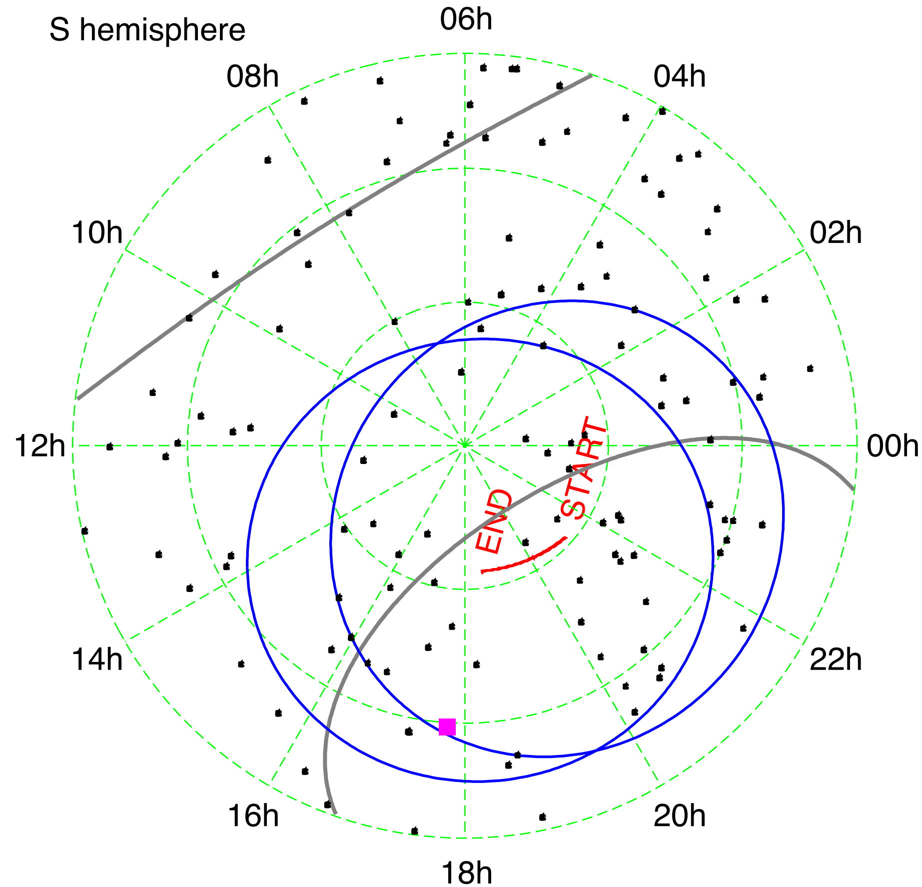




Viewing Zones

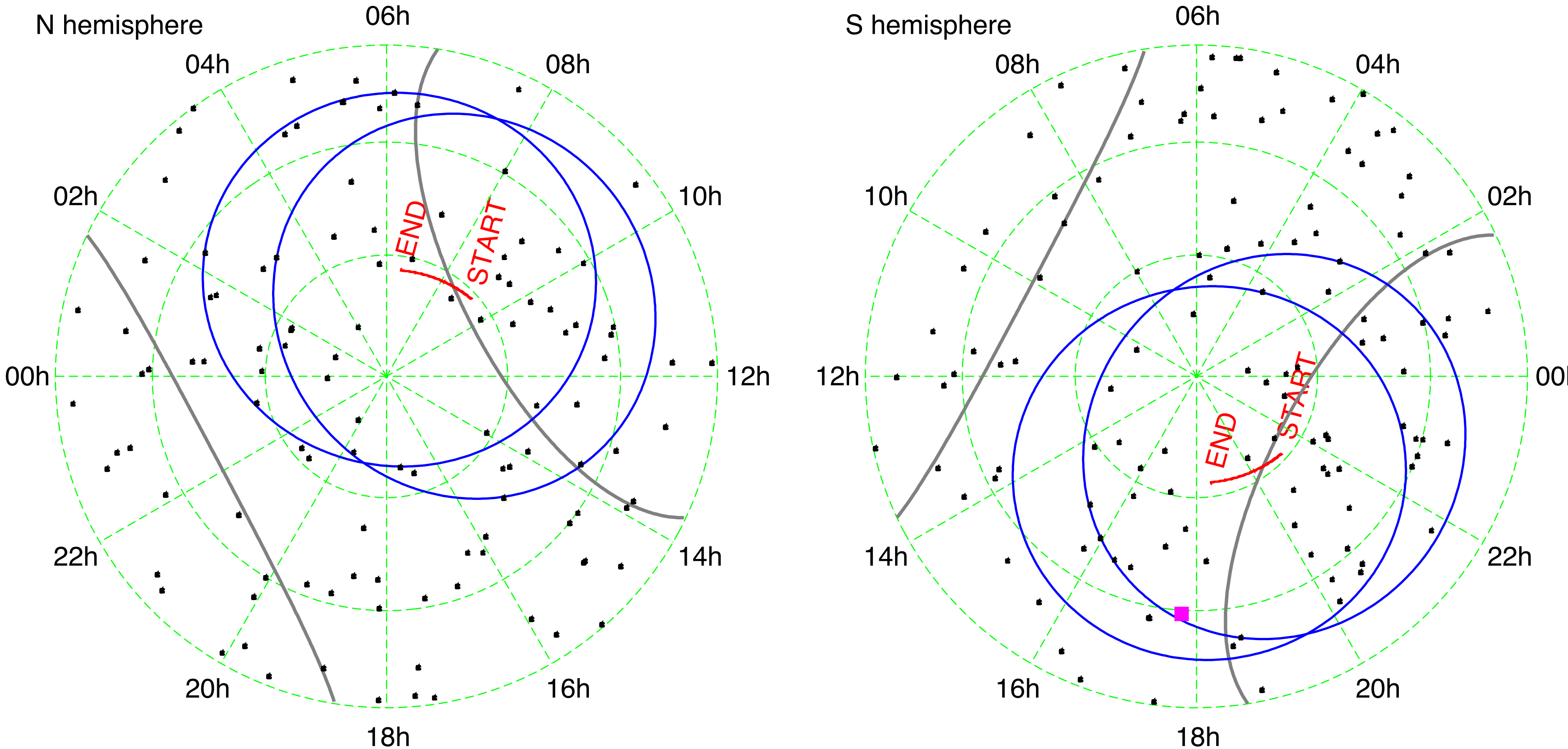
July 21 OR January 21



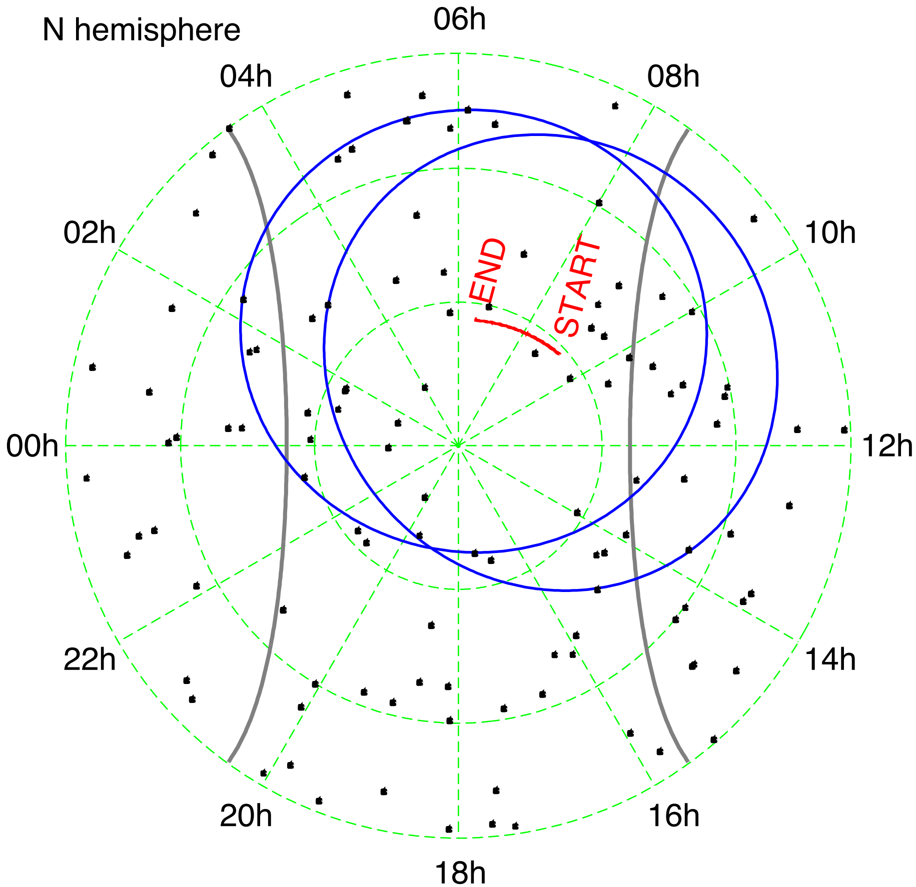


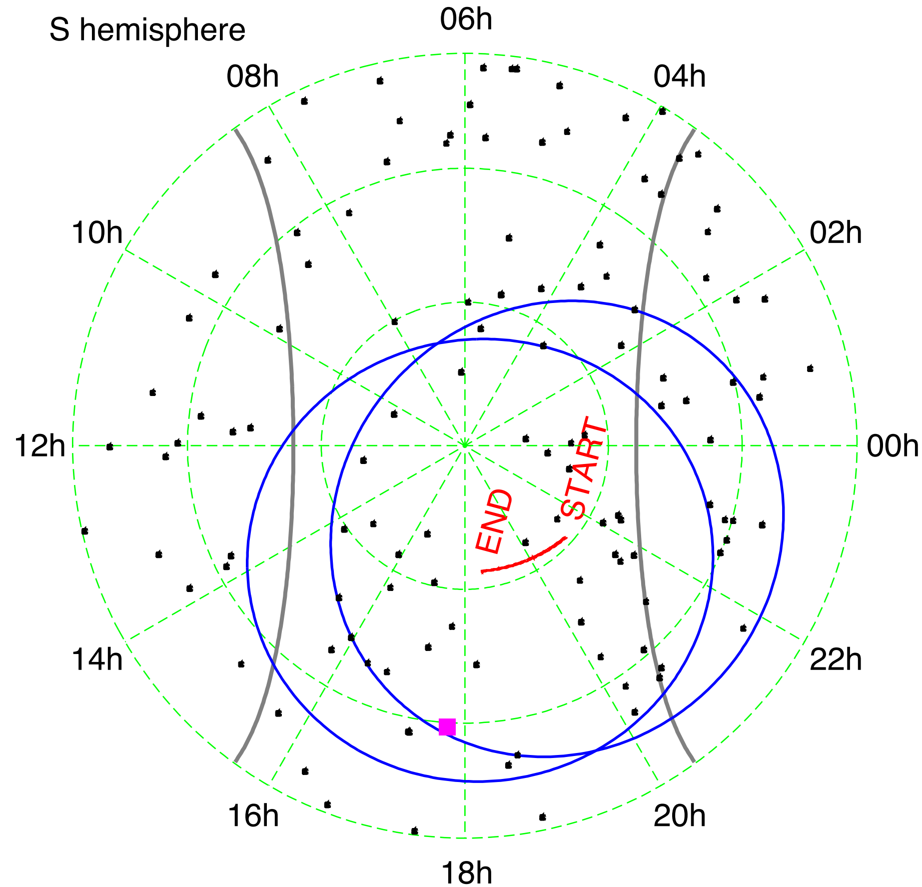
Viewing Zones

August 21 OR February 21

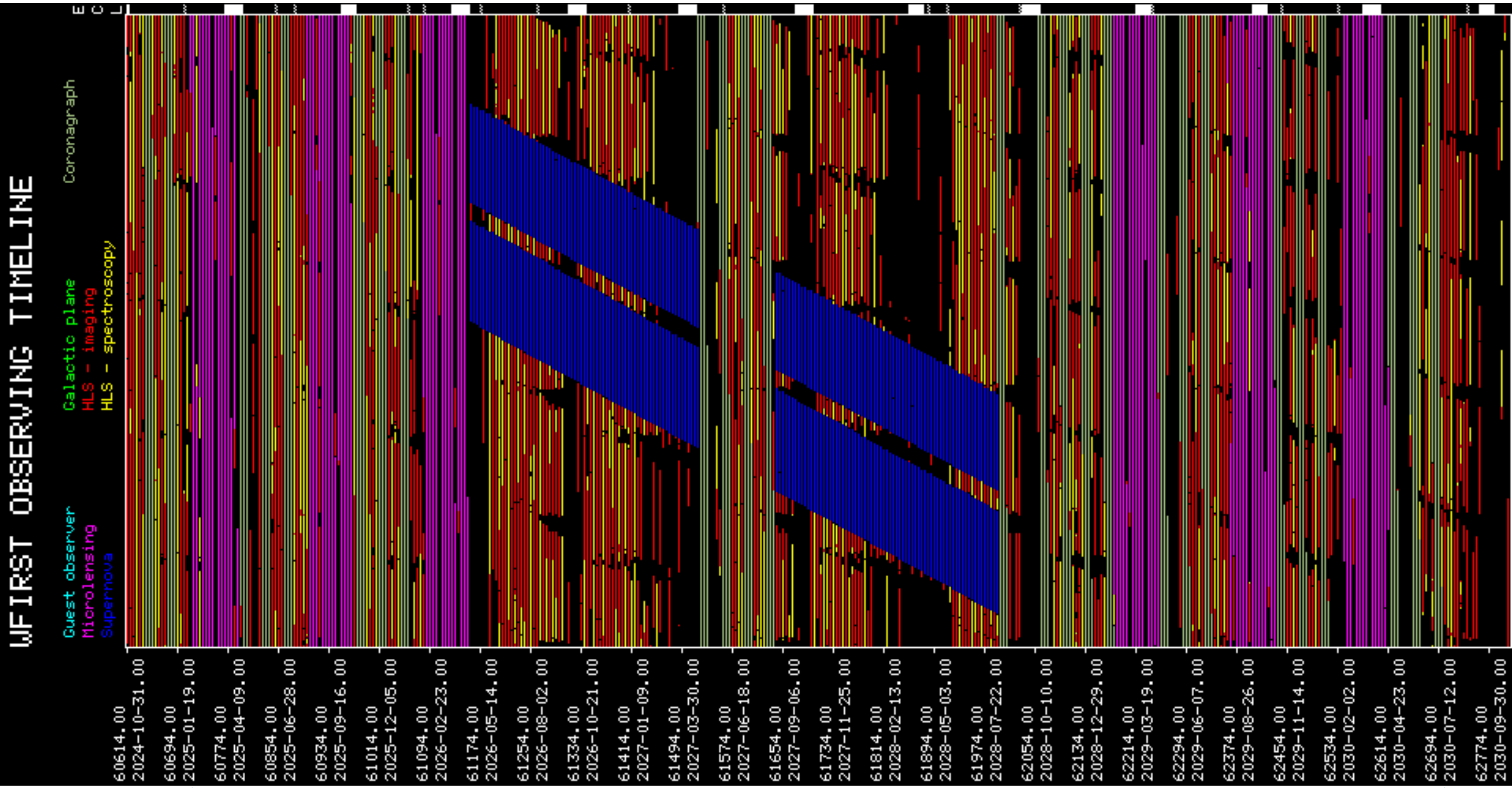


Viewing Zones
September 21 OR March 21





Example Observing Timeline



6 YEARS

Summary

- The WFIRST HLS is a powerful complement to LSST (optical) and Euclid (wide-shallow).

- We've emphasized multiple high-resolution filters, highly redundant shape measurements, and a high density for the redshift survey.

- The footprint and observing strategy will be refined as we move forward – currently have an existence proof and will maintain this at each step. This is closely linked with the rest of the mission design.