HLS Faster Survey Option

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v3

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Introduction

- There is a strong desire from the dark energy community to increase survey area while preserving the redundant observing strategy of WFIRST and not eating other programs.
- We are also in a highly cost-constrained environment, and primary mission duration is one parameter.
  - e.g. the SDT coronagraph option adds 6th year to the mission; but not clear if funding for the 6th year will actually materialize.
- This set of charts looks at some options to increase the speed of the HLS.
  - These are **not** recommendations, the new baseline, etc.
  - They **are** part of the trade space we should be considering.
- Aim is to discuss at the January 2014 SDT and decide whether to put the "fast" option in the interim report.

Changes to assumptions since SDT report

- Revised Colbert et al. HαLF (arXiv: 1305.1399v2), down by typically ~20% in the range relevant to WFIRST.
  - For the forecasts I am now using a joint fit to Sobral et al. (2012) and Colbert et al. (2013). Enhancement to S/N from partially blended [NII] is calculated self-consistently; still require S/N=7.
  - The agreement between these datasets is now good at the level we need: e.g. in $1.1<z<1.9$ and $F>10^{-16}$ erg/cm^2/s, the predicted counts differ by only 7%.
  - Formal χ^2 for the joint fit is still not acceptable, still under investigation.
- Incorporated new grism image quality.
  - Also included chromatic losses with a diffractive corrector.
- Changed assumed extinction to E(B−V)=0.035.
  - Minor effect, but 90% of the HLS is better than this value.

Faster HLS Option

- The improved grism quality speeds up the grism survey.
  - Option presented here is 4—6 exposures, with a median of 5 (vs. 6 in SDT report).
  - Overall galaxy counts are affected by the HαLF; this affects all options.
- The imaging survey already has significant read noise, and we cannot significantly reduce the sampling. If one wants to go substantially faster, we would have to go down to 3 NIR bands.
  - This is similar to what we had on the 2011 IDRM.
  - Examples of bands: Y (0.92—1.23 μm), J (1.16—1.56), H (1.48—1.98).
  - The plan presented here has YJH depths are 0.1 mag shallower than the SDT baseline. The wider bands partially alleviate the read noise penalty associated with shorter exposures.

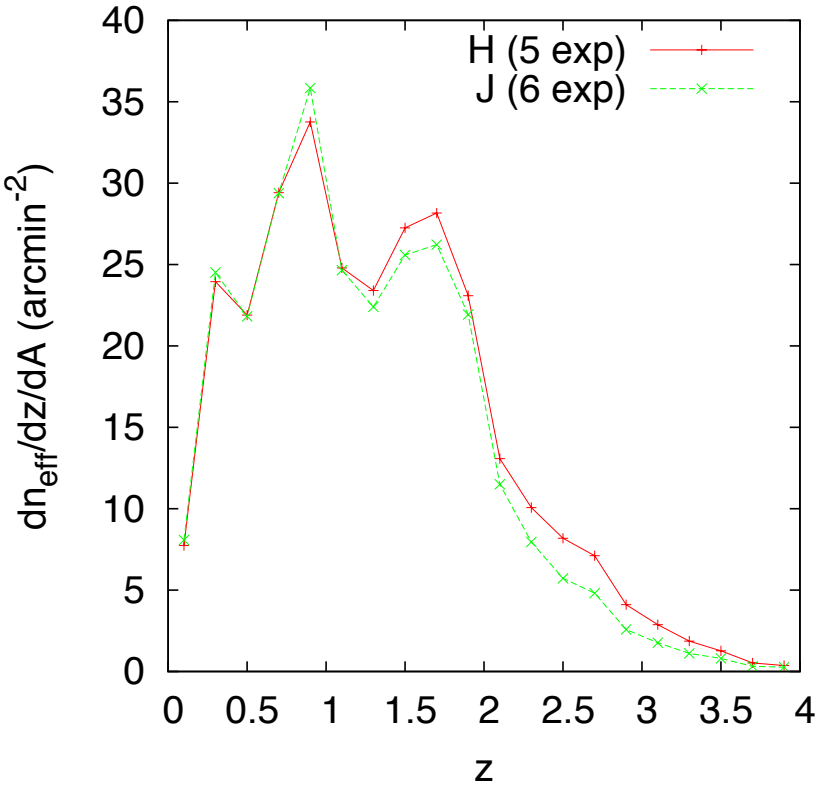
Survey time requirement table

Band	Exposure Time	Time requirement
Y	5 x 147 s	142 days/1000 deg^2 [all 3 imaging bands]
J	6 x 147 s	
H	5 x 158 s	
Spectro	(4—6) x 339 s	83 days/1000 deg^2
Total		225 days/1000 deg^2

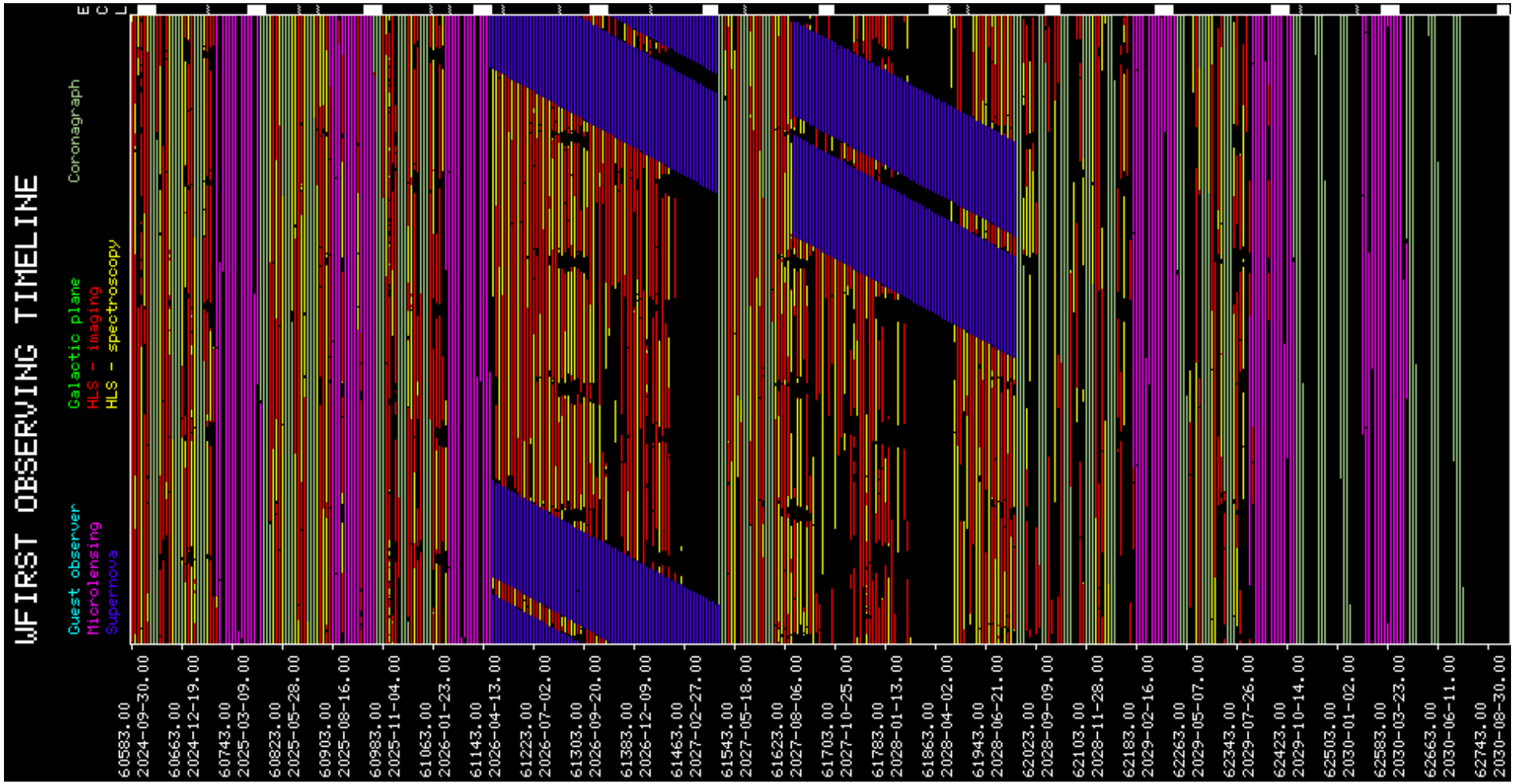
- Example here is 1.85 years out of a 6(=5+1) year mission with 3020 deg^2.
- Backup charts show 1.56 year survey of 2530 deg^2.
- 2013 SDT report strategy was 336 days/1000 deg^2; the “fast” mode is 1.5x faster.

Weak lensing summary

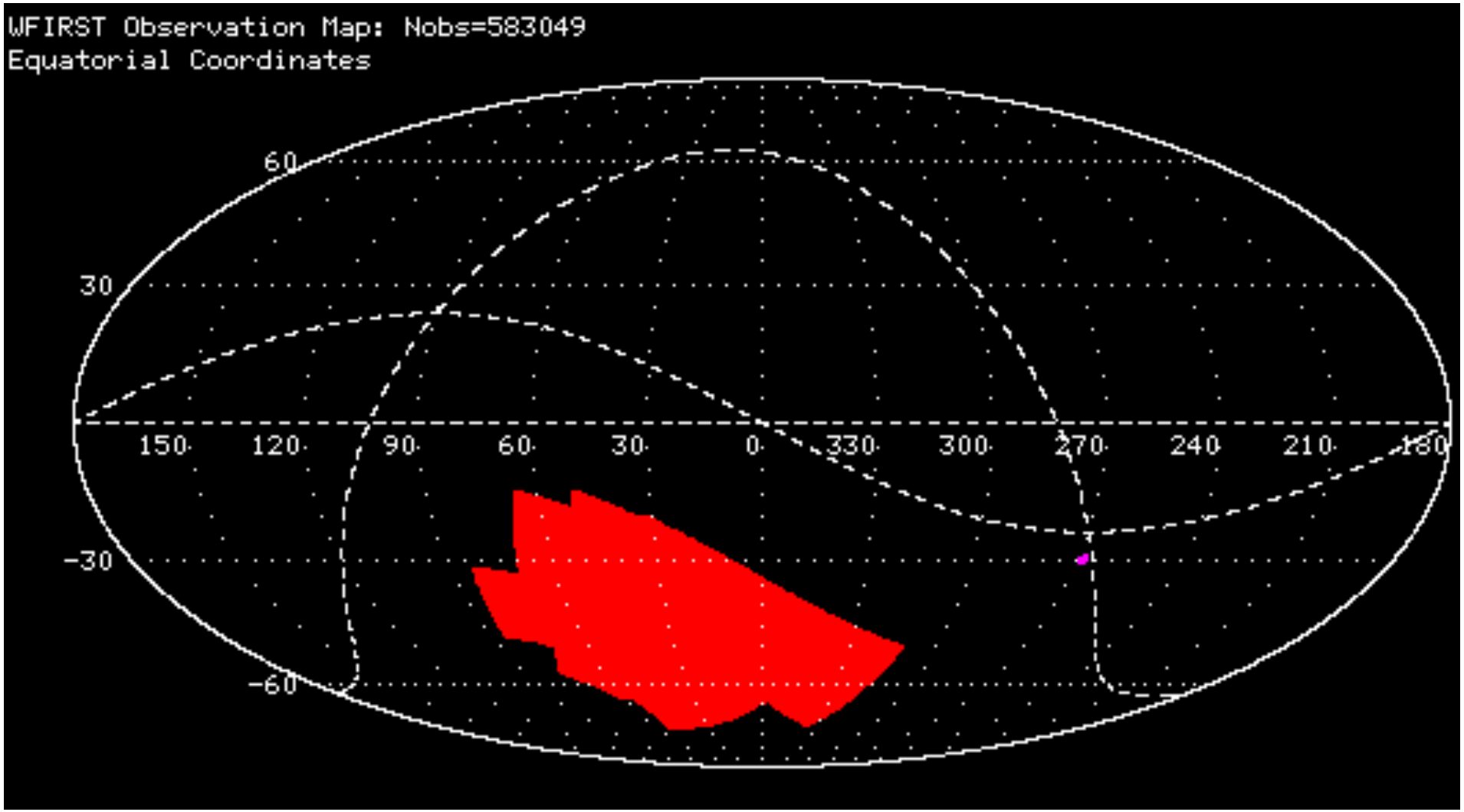
- Fast 3 filter survey option supports 54 gal/am^2 in J, 62 gal/am^2 in H.
  - Same assumptions as in SDT report: Res>0.4, S/N>18, σ_e<0.2, at least 3 clean exposures.
  - Total (stacked J+H) is ~74/am^2.
  - May differ from cuts used by other groups.
  - Same outcome as well.
- Analysis of color terms is ongoing.
  - We are partway through this analysis; there is no significant change due to the different filters. Having a 2nd filter is much more important than how we perturb its location/width, in accordance with previous studies.

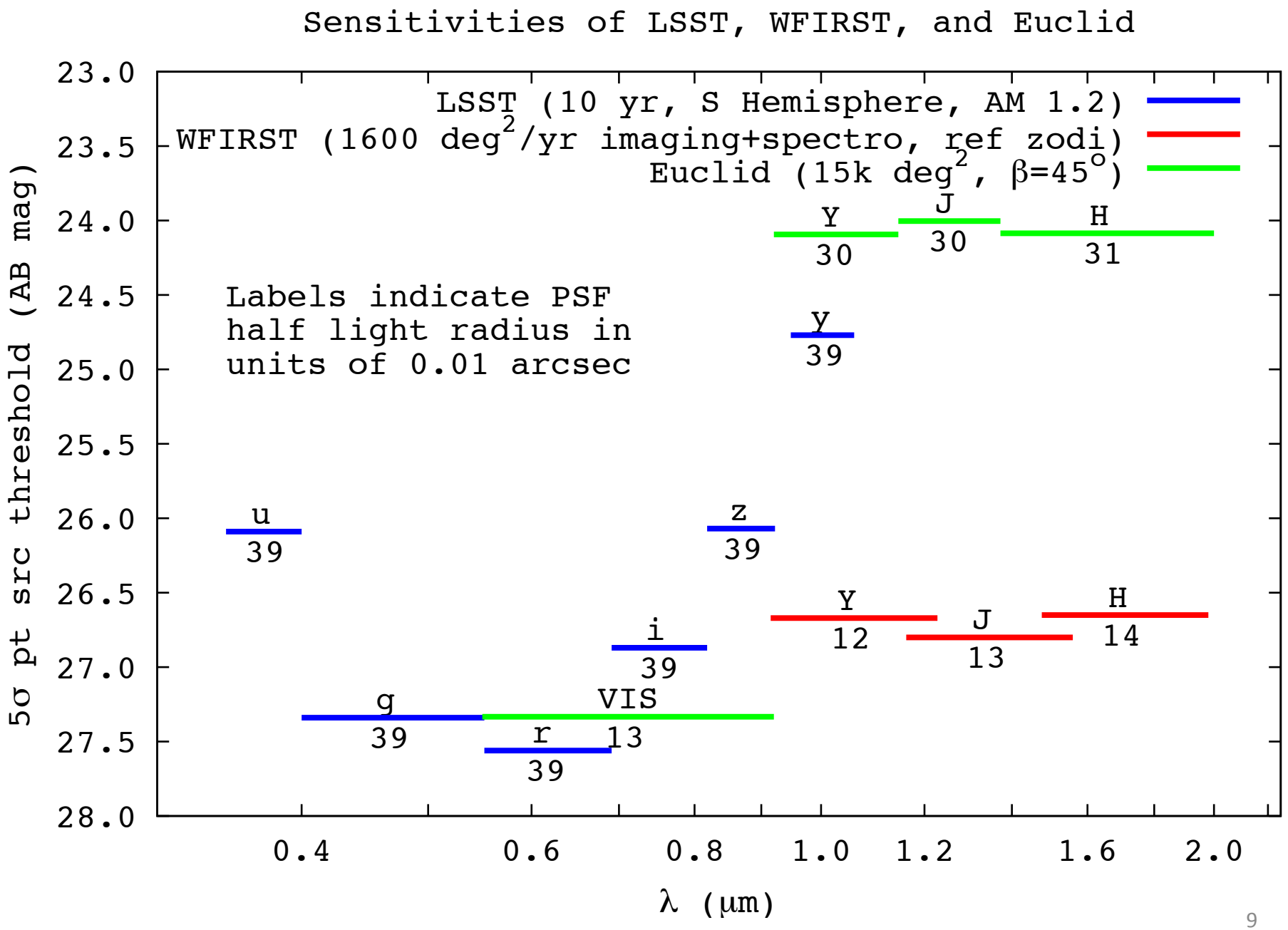


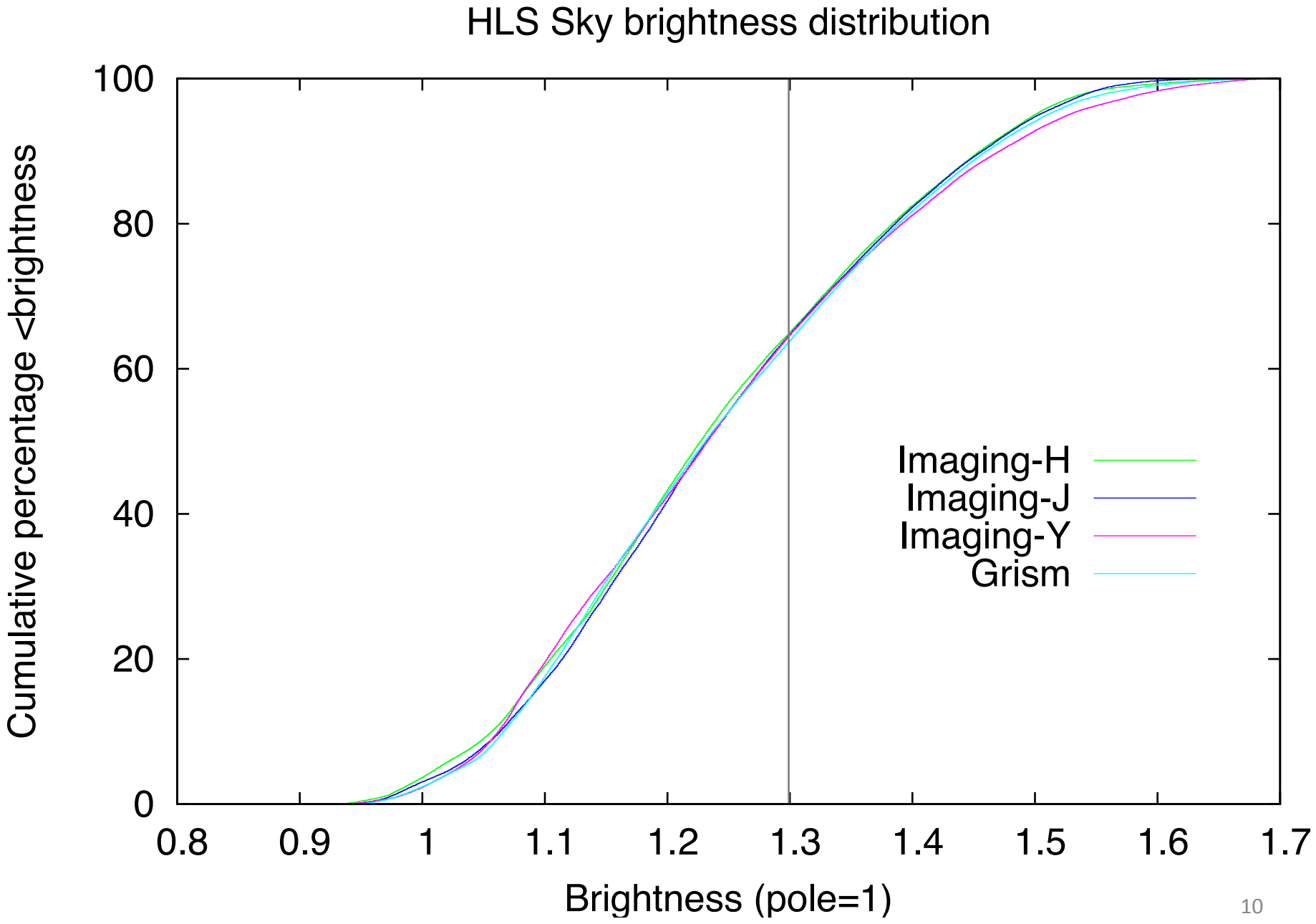
Example Observing Sequence

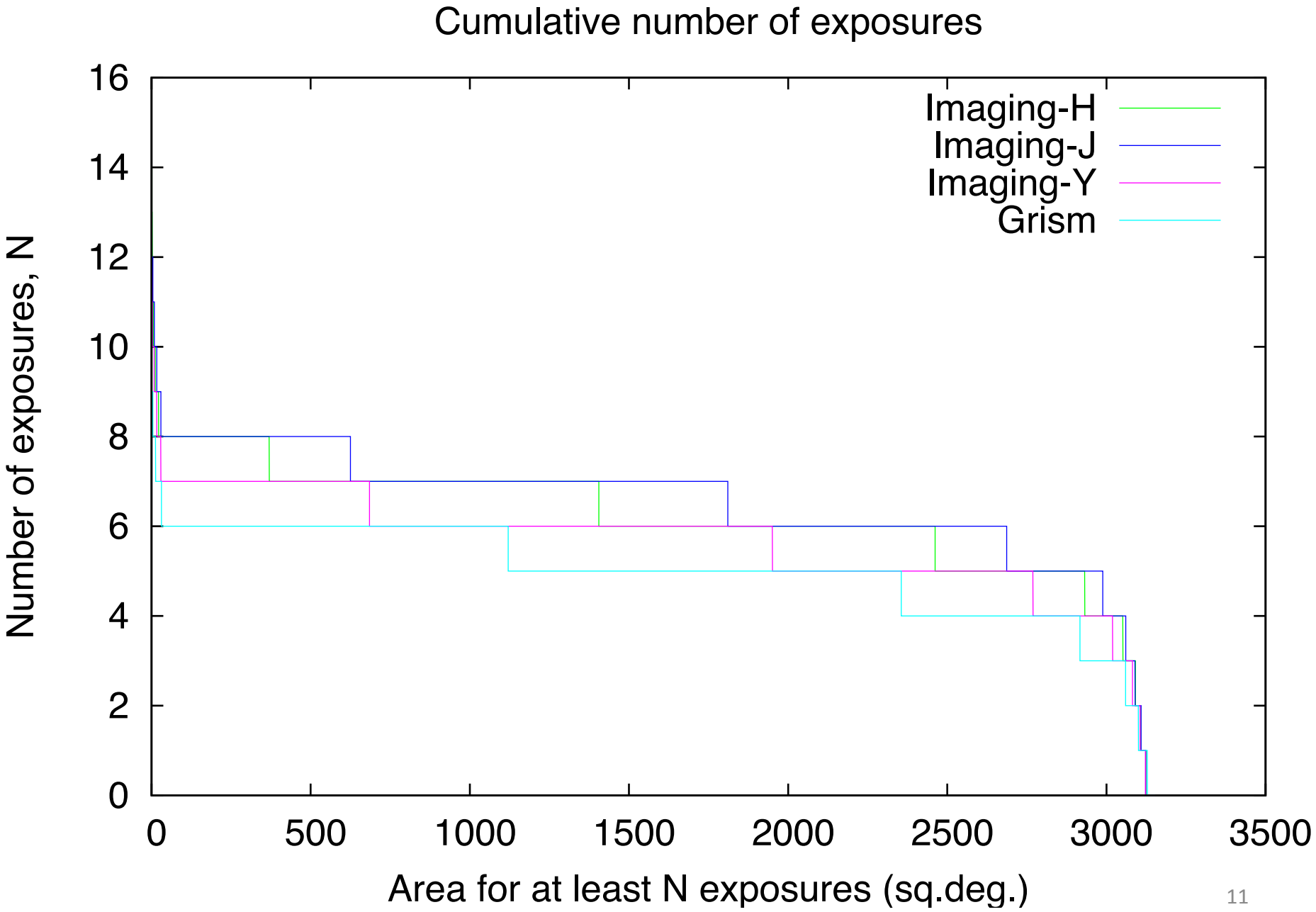


Sky Coverage

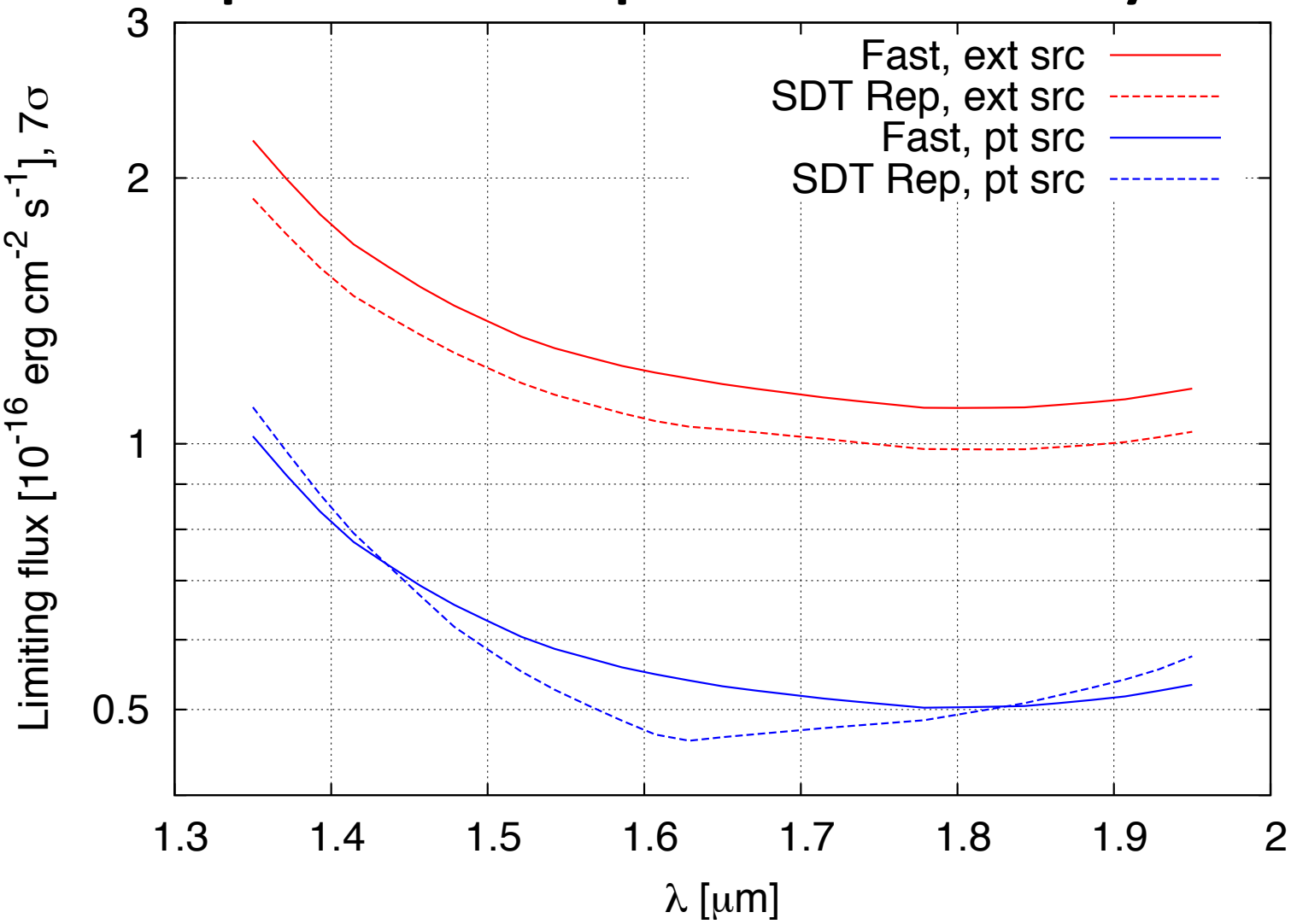



Sensitivities of LSST, WFIRST, and Euclid
LSST (10 yr, S Hemisphere, AM 1.2)
WFIRST (1600 deg^2/yr imaging+spectro, ref zodi)
Euclid (15k deg^2, β=45°)
Labels indicate PSF
half light radius in
units of 0.01 arcsec
u 39
g 39
r 39
i 39
z 39
y 39
VIS 13
Y 30
J 30
H 31
Y 12
J 13
H 14
5σ pt src threshold (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


HLS Sky brightness distribution
Cumulative percentage <brightness
100
80
60
40
20
0
0.8
0.9
1
1.1
1.2
1.3
1.4
1.5
1.6
1.7
Brightness (pole=1)
Imaging-H
Imaging-J
Imaging-Y
Grism


Cumulative number of exposures
Number of exposures, N
Area for at least N exposures (sq.deg.)
Imaging-H
Imaging-J
Imaging-Y
Grism
0
2
4
6
8
10
12
14
16
0
500
1000
1500
2000
2500
3000
3500

Spectroscopic Sensitivity



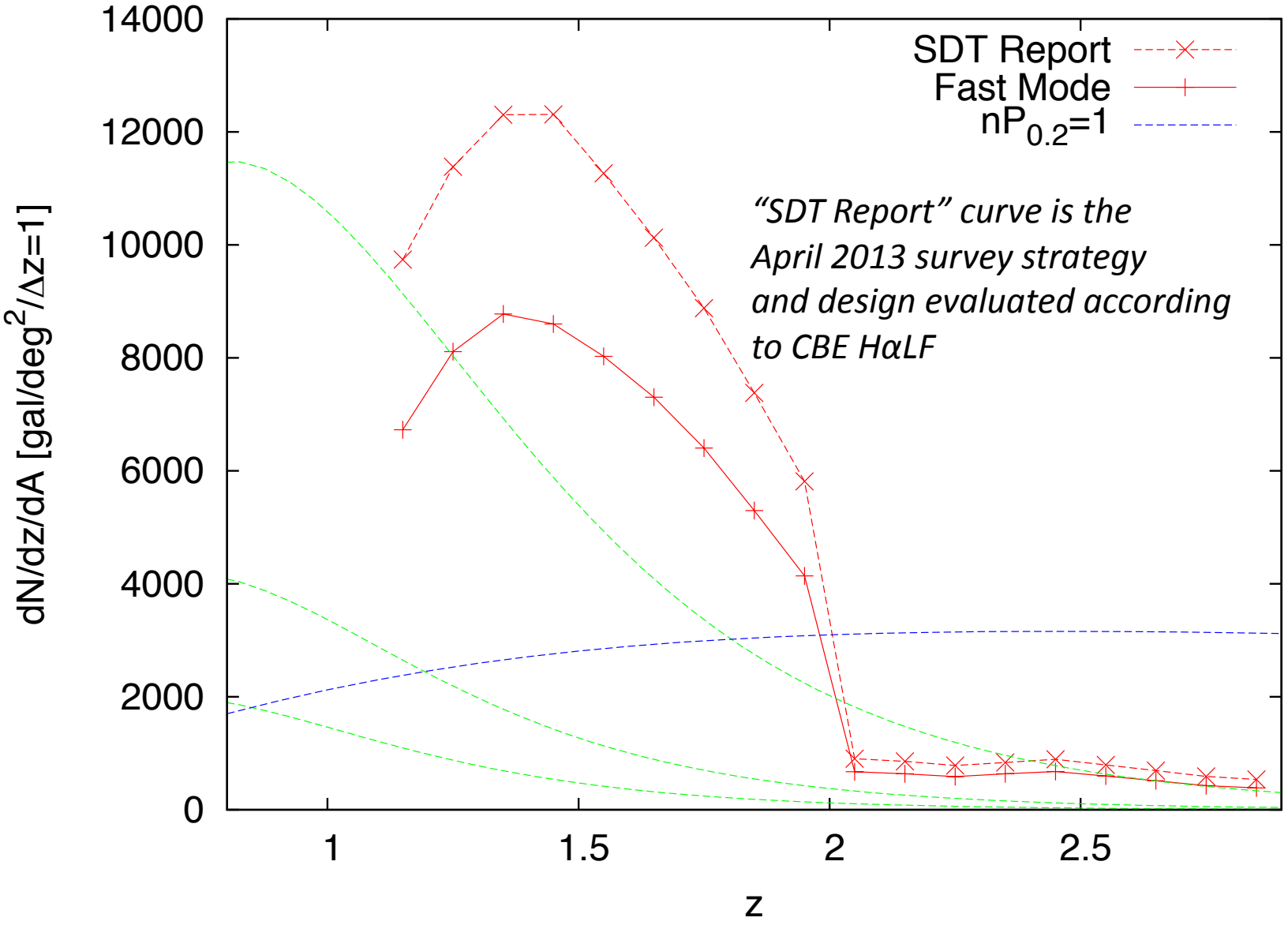
"Extended source" = exponential disc, 0.3 arcsec half light radius

GALAXY REDSHIFT SURVEY PERFORMANCE

Hα to z=1.97, then [OIII]

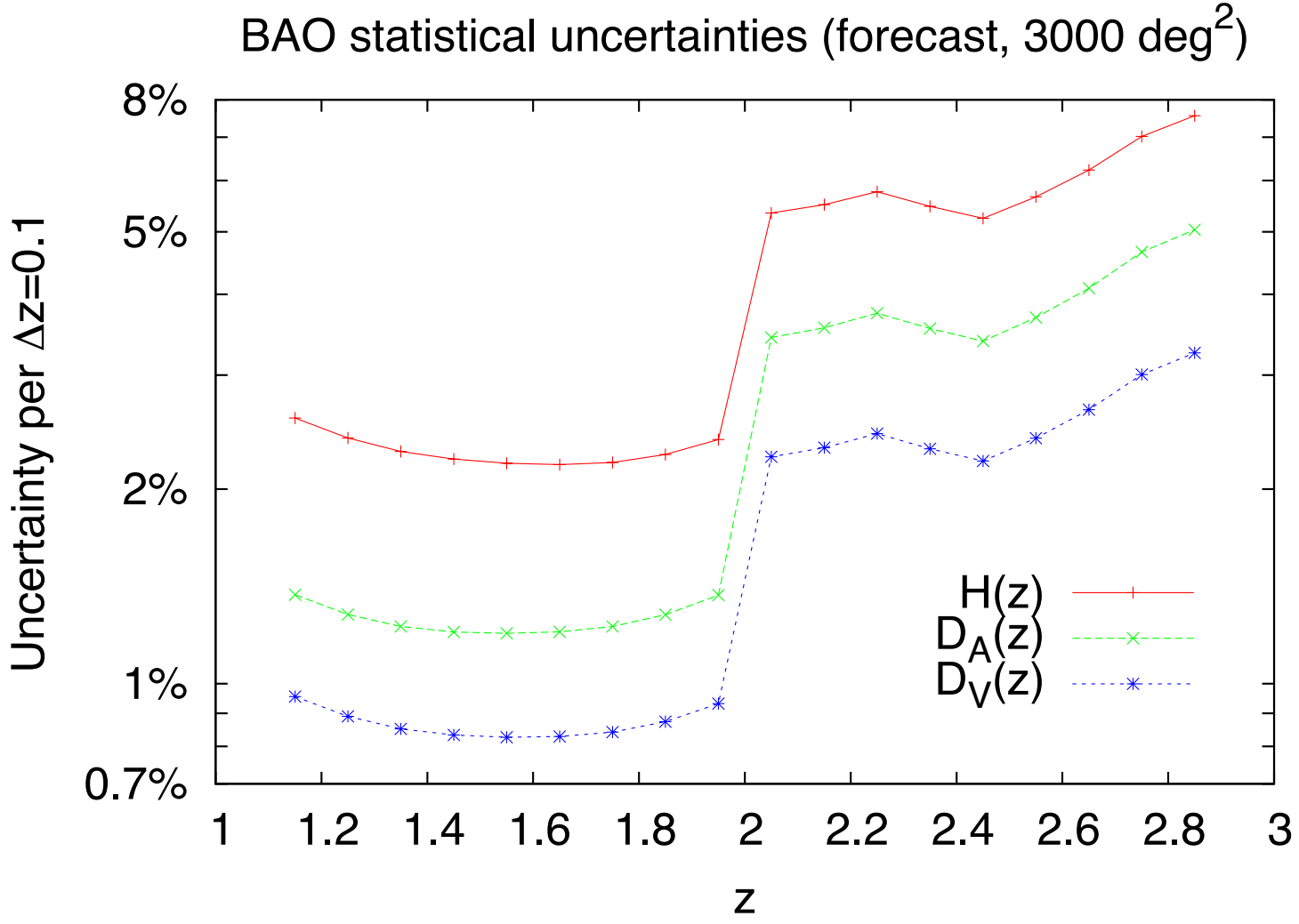
Green lines show 70% completeness at $F_{H\alpha}$ = 1, 2, 3×10^{-16} erg/cm^2/s

Total for fast survey is 7000 gal/deg^2, 21M total in the 1.85 yr (imaging+spectro) HLS



BAO Constraints

Aggregate statistical uncertainty on the overall distance scale is 0.27% (1σ).

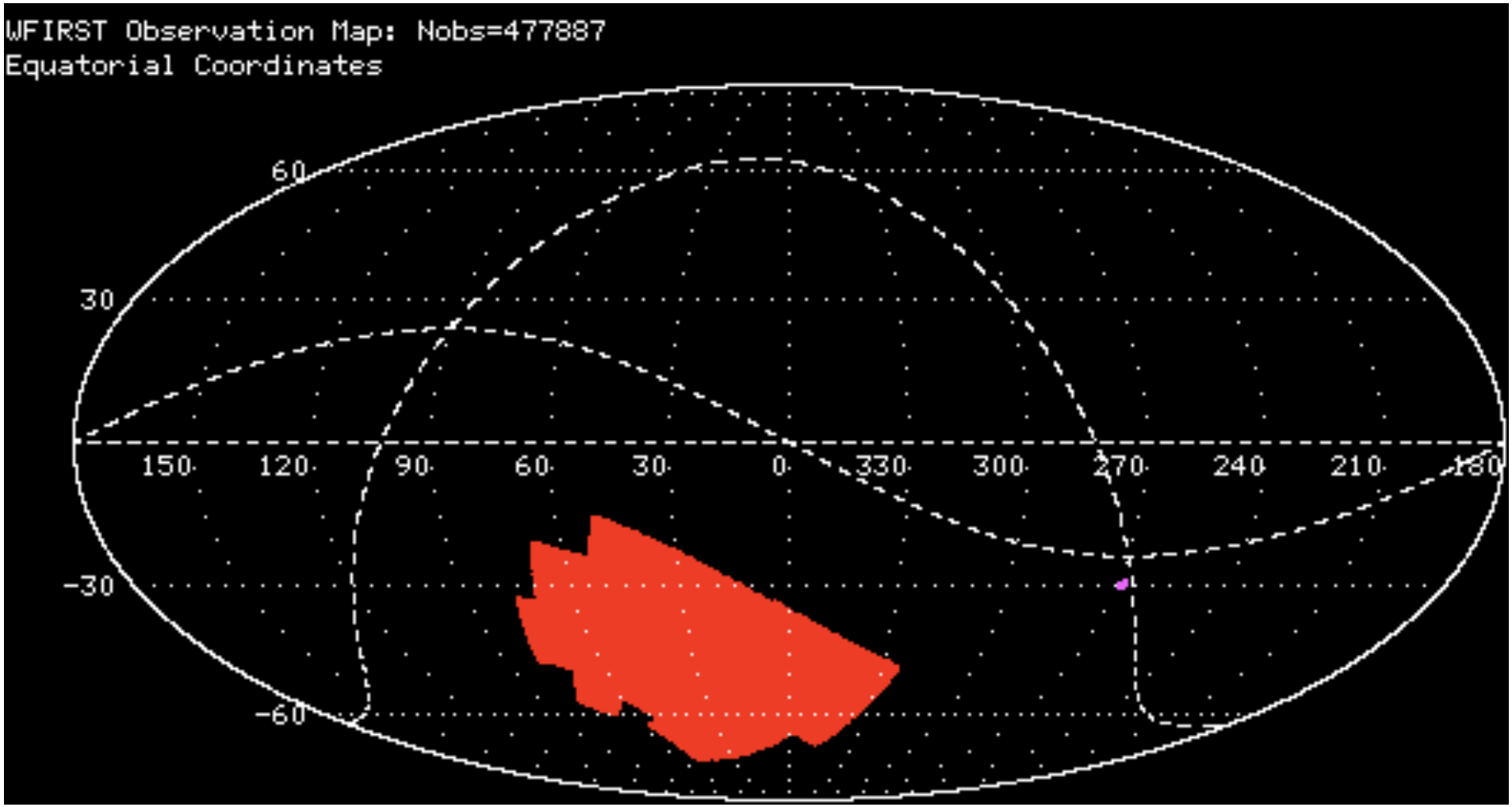


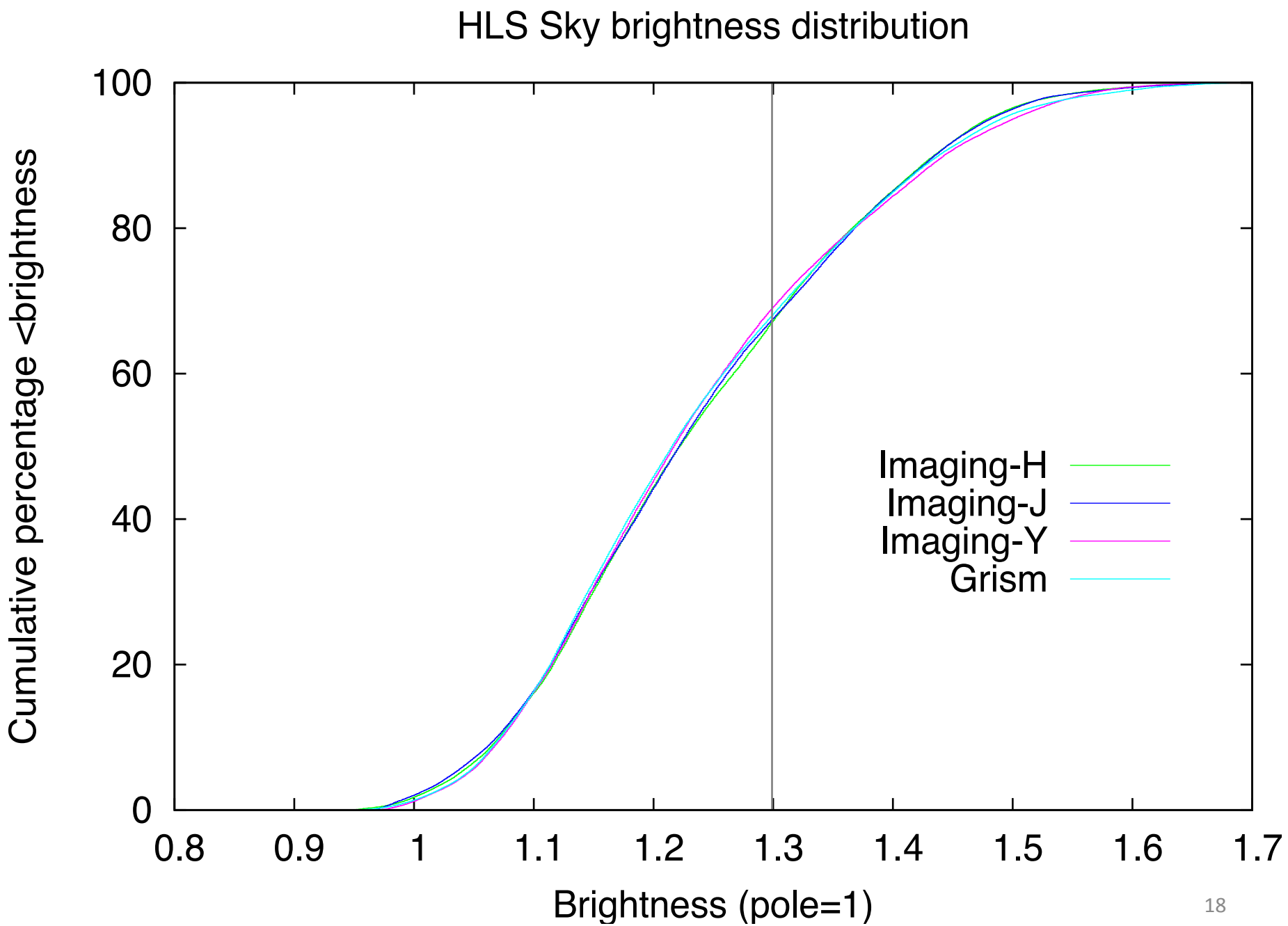
Summary

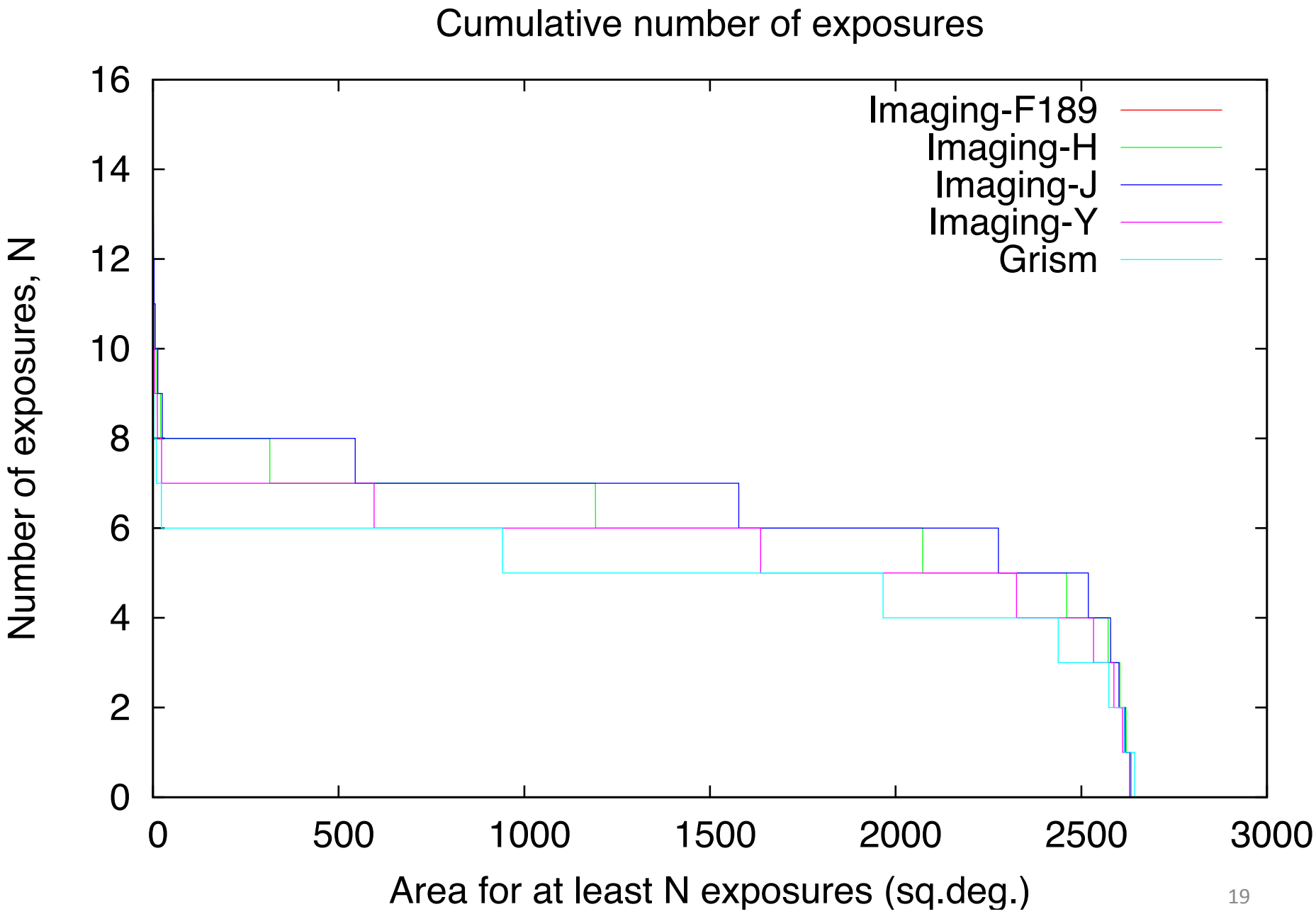
- HLS options exist that are faster than presented in the SDT.
- The trade is not obvious and depends on several factors:
  - The DE community has voiced a strong desire for more area. To what extent are we willing to make marginal sacrifices to accomplish this?
  - What is the added value of 4 vs 3 NIR filters in the primary HLS imaging survey?
  - Implications of filter widths/placements for other science programs.
  - Complementarity with LSST and Euclid.

Backup Charts on “short” version (1.56 yr HLS, designed to fit in 5 year mission)

Sky Coverage in 1.56 yr




HLS Sky brightness distribution
Cumulative percentage <brightness
100
80
60
40
20
0
0.8
0.9
1
1.1
1.2
1.3
1.4
1.5
1.6
1.7
Brightness (pole=1)
Imaging-H
Imaging-J
Imaging-Y
Grism


Cumulative number of exposures
Imaging-F189
Imaging-H
Imaging-J
Imaging-Y
Grism
Number of exposures, N
Area for at least N exposures (sq.deg.)
0
2
4
6
8
10
12
14
16
0
500
1000
1500
2000
2500
3000