**Figure of Merit Computations for the Roman HLS Reference Surveys for the SRD**

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Version 3

***Abstract.*** – This document describes the determination of the Reference Survey figures of merit for the Roman SRD. It covers the High-Latitude Imaging Survey (HLIS) and the High-Latitude Spectroscopic Survey (HLSS). The summary provides both high-level results and discussion of a general nature, while the remaining sections include the many technical details and choices that would be needed to reproduce the calculations from HLS SIT software. The performance of the 1.5 m WFIRST concept (using the JDEMΩ “hardware template” as selected by the Decadal Survey) is also assessed using the same performance metrics. Finally, we have included the performance of the Phase C Design Reference Mission.

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# Summary

The Nancy Grace Roman Space Telescope (previously WFIRST) SRD specifies three figures of merit for the cosmology performance of the HLS. For the HLSS, there is a “baryon acoustic oscillations figure of merit” FoMBAO for the measurement of cosmic geometry, defined as

where *FD* is an overall scaling factor on the angular diameter distance and *FH* is an overall scaling factor on the Hubble rate, aggregated over redshifts 1 < *z* < 3. There is also a “redshift space distortion figure of merit” FoMRSD for the measurement of the growth of structure,

where *FG* is an overall scaling factor on the linear amplitude of structure, aggregated over redshifts 1 < *z* < 3 and over scales *k* < *k*max = 0.20*h* Mpc−1 comoving. For the HLIS, there is a “weak lensing figure of merit” for measurements of the growth of structure

where *FG* is an overall scaling factor on the linear amplitude of structure σ8(*z*), aggregated over *all* redshifts (weak lensing is a projected measurement and as such all weak lensing power spectra have some contribution from low redshift) and over scales *l* < 3000. These figures of merit are included *without* astrophysical systematics, so that we can write requirements on WFIRST that do not depend on as-yet-unknown astrophysical properties of galaxies. Forecasts of these figures of merit for WFIRST *do* include observational systematic errors, unless denoted as statistical by “FoMstat” or otherwise indicated. Note that the Reference Survey, as defined in the SRD, has a figure of merit FoMref that is computed with only statistical errors so that observational systematics can be counted as part of the FoM degradation.

The SRD Reference Surveys, as defined in the SRD, refer to a survey area of 2000 deg2. The reference HLSS has a wavelength range of 1.00—1.93 μm, and a point source sensitivity of 1.0×10−16 erg cm−2 s−1 at λ = 1.8 μm, and is calculated with an astrophysical model for the population of Hα emitting galaxies (ETC Model 992). The reference HLIS achieves an effective source number density of *n*eff = 30 galaxies arcmin−2. These specifications do not completely define the survey performance, and as noted in this document assorted ancillary assumptions were required to calculate FoMref.

The required levels of performance are tied to those directed by the 2010 Decadal Survey (New Worlds New Horizons; NWNH). Different choices of numbers can be found in Decadal Survey documents; for this comparison, we take the “NWNH” survey to be based on the JDEMΩ hardware design [N. Gehrels *et al.*, “The Joint Dark Energy Mission (JDEM)/Omega,” arXiv:1008.4936 (2010)], which was specified as a template by NWNH. We use the ETC configuration files for JDEMΩ, with updates only to fix three known problems (the configuration file had the wrong telescope temperature, was written before we had settled on how to incorporate stray light into the ETC, and the throughput loss due to the pupil mask had not been incorporated). JDEMΩ used a 1.5 m on-axis telescope, and had 36 H2RG detector arrays (24 for imaging and 12 for spectroscopy). The JDEMΩ design had two survey modes, a “deep” mode (for weak lensing and redshift surveys in parallel, at 3300 deg2 yr−1) and a “wide” mode (redshift survey only, with some photometry acquired in parallel but not sufficient for weak lensing, at 6900 deg2 yr−1). The performance in NWNH depends on the assumptions made about time allocations. NWNH was deliberately not prescriptive, but the EOS Panel Report [NRC, *Panel Reports – New Worlds, New Horizons in Astronomy and Astrophysics* (2010); Chapter 6] specifies an example (p. 275) that would give 2.13 years for dark energy studies. Assuming a 2:2:1 breakdown between deep, wide, and supernova modes as in the original JDEMΩ submission, this gives 2812 deg2 of deep coverage and 5879 deg2 of wide coverage. We define these as our definitions of “NWNH – Deep” and “NWNH – Wide,” respectively.

Subsequently, NASA joined the ESA-led Euclid mission, which includes a wide spectroscopic survey. The WFIRST Science Definition Team then dropped the separate spectroscopic channels in JDEMΩ and the associated aft optics (which were also present in the 2011 Interim Design Reference Mission), and in 2012 and later versions of the WFIRST reports the wide spectroscopic survey was not included. This revised plan, in which WFIRST would focus on the deeper/narrower spectroscopic survey while relying on Euclid for the wide component, was presented to two NRC panels [NRC, *Evaluation of the Implementation of WFIRST/AFTA in the Context of New Worlds, New Horizons in Astronomy and Astrophysics* (2014: F. Harrison *et al.*); and NRC, *New Worlds, New Horizons: A Midterm Assessment* (2016: J. Hewitt *et al.*)]. While neither NRC report contains detailed guidance on this issue, the Harrison report did note these changes and noted in their Finding 1-2 that “For each of the cosmological probes described in NWNH, WFIRST/AFTA exceeds the goals set out in NWNH. These are the goals that led to the specifications of the WFIRST/IDRM (with 2.0 μm cut-off).”

Results from the FoM computations are shown in Table 1. Following the decision to use Euclid as the wide survey, we consider the deep NWNH survey in our baseline computation of FoMNWNH (although we show both “wide” and “total” figures of merit in the table for comparison). We emphasize that the decision to do or not do a wide survey with WFIRST (in its 2.4 m incarnation) has not yet been made, only that this is not part of the Reference Survey. The performance ratios FoMref/FoMNWNH,stat are 1.53 (BAO); 1.13 (RSD); and 1.78 (WL). Note that all of the FoMs are proportional to survey area if the intrinsic properties of the data (depth, bandpass, resolution, etc.) are held fixed.

Note that this table is **not** a comparison of the current WFIRST design to JDEMΩ. The current WFIRST design has more statistical power than the Reference Survey. Also some of the detailed differences described herein make the comparison not “fair” – some of the improvements that we have taken credit for in our forecasts for WFIRST have not been updated in our historical look at NWNH. The logic for this is two-fold: first, the purpose of our estimates of NWNH performance is to understand the mission that was selected by NWNH, *not* how well we could have optimized the mission (including detector performance and analysis capabilities) within the JDEMΩ-like architecture; and second, the current WFIRST study is much more mature than the 2009 submission to NWNH and incorporates some performance reductions that we are not counting against FoMNWNH in this document.

Finally, in the bottom rows of Table 1, we show the performance of the Design Reference Mission in Phase C and its ratio to the SRD Reference Survey. The SRD contains requirements (HLSS 2.0.1 for BAO; HLSS 2.0.2 for RSD; and HLIS 2.0.1 for WL) requiring a minimum FoM ratio (i.e., FoM/FoMref). These requirements are noted in the table.

Table 1: The figures of merit for the SRD Reference Survey and our interpretations of the performance from NWNH. The bottom rows show the performance of the Design Reference Mission in Phase C. Note that there is a different FoM for each technique; the numbers are not comparable to each other.

|  |  |  |  |
| --- | --- | --- | --- |
|  | High-Latitude Spectroscopic Survey (HLSS) | | High-Latitude Imaging Survey (HLIS) |
|  | Baryon Acostic Oscillations (BAO) | Redshift Space Distortions (RSD) | Weak Lensing (WL) |
| SRD Reference Survey Figure of Merit,  FoMref (stat only) | 1.13×104 | 6.07×103 | 5.73×105 |
| NWNH Figure of Merit,  FoMNWNH,stat | *Deep* 7.39×103  *Wide* 5.17×103  *Total* 1.26×104 | *Deep* 5.35×103  *Wide* 5.30×103  *Total* 1.06×104 | 3.21×105 |
| Ratio using “deep” NWNH survey,  FoMref/FoMNWNH,stat | 1.53 | 1.13 | 1.78 |
| Phase C Figure of Merit, FoMPhC | 1.13×104 | 5.75×103 | 5.06×105 |
| Ratio of Phase C Figure of Merit to SRD Reference Survey Figure of Merit | 1.00  (req’t: ≥0.67) | 0.95  (req’t: ≥0.67) | 0.88  (req’t: ≥0.57) |

# The High-Latitude Spectroscopic Survey (HLSS)

This section describes the computation of the HLS spectroscopic survey yields for the Reference Survey, and the corresponding BAO and RSD figures of merit.

## Reference Survey Definition

The Reference Survey is defined by the following parameters:

*Observational assumptions:*

* Wavelength range 1.00—1.93 µm.
* Point source sensitivity 1.0×10−16 erg cm−2 s−1 at 1.8 μm.
* The completeness for galaxies with lines brighter than the sensitivity threshold is 60%.
* Survey solid angle 2000 deg2.

*Astrophysical assumptions:*

* Luminosity function & size distribution: we use the average of the 3 Euclid models [L. Pozzetti *et al.*, “Modelling the number density of Hα emitters for future spectroscopic near-IR space missions,” *Astron. Astrophys.* **590**:A3 (2016)] and the log-normal size distribution implemented in the WFIRST Exposure Time Calculator. (This is model 992 in ETC v16.)
* Bias of Hα emitting galaxies: *b*(*z*) = 1.0 + 0.5*z*.

Note that the FoM requirement in the WFIRST SRD is to be computed under this standard set of astrophysical assumptions (whether or not they are a perfect representation of Nature).

A few ancillary pieces of information are required to convert the Reference Survey specification above into predicted survey yields and cosmological performance. Specifically, we need to specify how the sensitivity degrades for extended sources, and the shape of the sensitivity curve as a function of wavelength. We address this using the following procedure:

* We take the SRR grism design, generate an ETC configuration file restricted to the 1.00—1.93 μm wavelength range, and generate a curve of point source sensitivity versus wavelength.
* We then find the re-scaling factor from this predicted sensitivity to the specified flux limit (1.0×10−16 erg cm−2 s−1 at 1.8 μm).
* By imposing this re-scaling factor on the ETC (as an input, via the S/N threshold), we compute the predicted galaxy yields for the Reference Survey.

The configuration file (“SRR/grism.dat”) used was as follows, based on the Phase A data file (“WFIRST-WFI-Transmission\_170907.xlsm”) posted on the WFIRST website.[[2]](#footnote-2) This includes thermal emission, a 10% stray light contribution, an exit pupil mask, a 150 nm RMS wavefront error, and two diffractive surfaces. Note that there are two throughput columns, one for background and one for signal.

# Tel temp 267 K (front end) + 216 K (back end)

# Wavefront residuals: <set to 150 nm rms across the board>

# blaze angle kept at 1.5 deg

!SLITLESS

!THERMAL 269. 0.024 1 1 218. 0.066 0.015

!WAVEFRONT 1.650 0.150 0 0

Big Telescope - On Axis - Grism

2.37 0.32 0.1129 42

0.9500 0.3650 0.1222

0.9756 0.3644 0.1449

1.0012 0.3879 0.1780

1.0268 0.4125 0.2134

1.0524 0.4050 0.2314

1.0780 0.4220 0.2617

1.1037 0.4372 0.2897

1.1293 0.4377 0.3061

1.1549 0.4342 0.3164

1.1805 0.4372 0.3282

1.2061 0.4344 0.3306

1.2317 0.4376 0.3370

1.2573 0.4365 0.3392

1.2829 0.4375 0.3410

1.3085 0.4328 0.3366

1.3341 0.4294 0.3315

1.3598 0.4300 0.3283

1.3854 0.4266 0.3209

1.4110 0.4229 0.3124

1.4366 0.4248 0.3072

1.4622 0.4255 0.3004

1.4878 0.4220 0.2903

1.5134 0.4282 0.2864

1.5390 0.4291 0.2784

1.5646 0.4420 0.2779

1.5902 0.4470 0.2719

1.6159 0.4490 0.2638

1.6415 0.4541 0.2575

1.6671 0.4618 0.2524

1.6927 0.4623 0.2434

1.7183 0.4759 0.2411

1.7439 0.4739 0.2309

1.7695 0.4834 0.2263

1.7951 0.4812 0.2165

1.8207 0.4773 0.2061

1.8463 0.4774 0.1979

1.8720 0.4825 0.1919

1.8976 0.4679 0.1785

1.9232 0.4708 0.1722

1.9488 0.4582 0.1607

1.9744 0.4498 0.1512

2.0000 0.4303 0.1387

The line flux sensitivity mode of the ETC is enabled with the compiler flags:

gcc exptimecalc.c -lm -Wall -O3 -o pzcaletc.exe -DPZCAL\_MODE -DIN\_DLON

The sensitivity is then computed as follows; remember that the purpose of this computation is to find the re-scaling factor from the predicted to the Reference Survey sensitivity:

$ ./pzcaletc.exe

Exposure time calculator v16

Mode: PZCAL

Options: -DIN\_DLON

Enter telescope configuration [0=generic, 1=from file]: 1

Input file name: SRR/grism.dat

Using configuration: Big Telescope - On Axis - Grism

Enter detector type [e.g. 0=H2RG]: 2

Enter pointing jitter (arcsec rms per axis): .07

Enter minimum wavelength (microns): 1.00

Enter maximum wavelength (microns): 1.93

Enter completeness: .6

Enter linear spectral dispersion d theta/d lambda (arcsec/um): 102

Enter single exposure time (s): 297.01

Enter read noise floor (effective e- rms per pixel): 5

Enter dark current (e-/pix/sec): .015

Enter ecliptic latitude (degrees): 70.4

Enter ecliptic longitude relative to the Sun (degrees): 0

Enter Galactic reddening, E(B-V) (magnitudes): 0

Enter number of exposures: 6

Enter significance cut (number of sigmas): 5

The resulting point source sensitivity is obtained by interpolating the output:

…

Limiting fluxes in W/m2 vs wavelength and galaxy size

lambda| 0.0" | …

um | | …

…

1.7971 9.85209E-20 …

1.8304 1.03229E-19 …

…

Linear interpolation gives a sensitivity of 9.893×10−17 erg cm−2 s−1. (Note: the ETC is in SI units, with the conversion that 1 W m−2 = 1000 erg cm−2 s−1.) This means that – relative to the configuration file – the sensitivity must be scaled up by a factor of 10−16/(9.893×10−17) = 1.011 (i.e. a S/N=5 detection for the Reference Survey is S/N=5×1.011=5.054 for the configuration file).

*Comment.* – The use of S/N=5 in this calculation is arbitrary, as it cancels out of the final survey yields (it is actually the flux limit that we specify).

## Reference Survey Yields

The survey yields are now obtained via ETC v16 with the following settings:

gcc exptimecalc.c -lm -Wall -O3 -o baoetc-ref.exe -DBAO\_MODE -DIN\_DLON\

-DUSE\_NII -DUSE\_SNRE

gcc exptimecalc.c -lm -Wall -O3 -o baoetc-ref-o3.exe -DBAO\_MODE -DIN\_DLON\

-DOIII\_GAL -DUSE\_SNRE

Note here that the [N ii] enhancement is turned on (-DUSE\_NII), and that the calculation of galaxies above the flux limit does not include Eddington bias (i.e., -DUSE\_SNRE is on). The latter choice is made since the S/N re-scaling procedure conflicts with the way the Eddington bias correction is implemented.

The predicted Hα + [N ii] HLSS yields are then:[[3]](#footnote-3)

$ ./baoetc-ref.exe

Exposure time calculator v16

Mode: BAO

Options: -DIN\_DLON -DUSE\_SNRE -DUSE\_NII

Enter telescope configuration [0=generic, 1=from file]: 1

Input file name: SRR/grism.dat

Using configuration: Big Telescope - On Axis - Grism

Enter detector type [e.g. 0=H2RG]: 2

Enter pointing jitter (arcsec rms per axis): .07

Enter minimum wavelength (microns): 1.00

Enter maximum wavelength (microns): 1.93

Enter completeness: .6

Enter linear spectral dispersion d theta/d lambda (arcsec/um): 102

Enter single exposure time (s): 297.01

Enter read noise floor (effective e- rms per pixel): 5

Enter dark current (e-/pix/sec): .015

Enter ecliptic latitude (degrees): 70.4

Enter ecliptic longitude relative to the Sun (degrees): 0

Enter Galactic reddening, E(B-V) (magnitudes): .035

Enter number of exposures: 6

Enter significance cut (number of sigmas): 5.054

Enter galaxy population model [SDT2013 report = 42]: 992

Using luminosity function model: H alpha 3-model ave.

z |lambda| EE50 | dV/dz/dA | Flim@0.30"| n targets | dN/dz/dA |…

| um |arcsec| Mpc3/deg2 | W/m2 | Mpc^-3 | deg^-2 |…

0.550 1.0176 0.1908 4.01340E+06 3.67024E-19 6.59531E-04 2.64697E+03 …

0.600 1.0504 0.1908 4.53608E+06 3.10251E-19 7.50742E-04 3.40542E+03 …

0.650 1.0832 0.1908 5.05407E+06 2.58866E-19 8.80149E-04 4.44833E+03 …

0.700 1.1160 0.1907 5.56334E+06 2.25848E-19 9.68071E-04 5.38570E+03 …

0.750 1.1489 0.1906 6.06057E+06 2.08081E-19 9.88008E-04 5.98790E+03 …

0.800 1.1817 0.1905 6.54313E+06 1.93597E-19 1.00118E-03 6.55083E+03 …

0.850 1.2145 0.1907 7.00894E+06 1.86053E-19 9.72650E-04 6.81725E+03 …

0.900 1.2474 0.1913 7.45644E+06 1.78361E-19 9.53611E-04 7.11054E+03 …

0.950 1.2802 0.1920 7.88451E+06 1.72763E-19 9.24644E-04 7.29036E+03 …

1.000 1.3130 0.1927 8.29240E+06 1.71246E-19 8.68235E-04 7.19975E+03 …

1.050 1.3458 0.1934 8.67969E+06 1.70192E-19 8.13862E-04 7.06407E+03 …

1.100 1.3787 0.1941 9.04621E+06 1.70105E-19 7.57377E-04 6.85139E+03 …

1.150 1.4115 0.1949 9.39200E+06 1.72037E-19 6.91797E-04 6.49736E+03 …

1.200 1.4443 0.1956 9.71731E+06 1.72352E-19 6.42572E-04 6.24408E+03 …

1.250 1.4771 0.1964 1.00225E+07 1.74913E-19 5.83659E-04 5.84972E+03 …

1.300 1.5100 0.1972 1.03081E+07 1.75948E-19 5.38622E-04 5.55215E+03 …

1.350 1.5428 0.1981 1.05746E+07 1.77848E-19 4.84427E-04 5.12260E+03 …

1.400 1.5756 0.1989 1.08226E+07 1.76371E-19 4.52207E-04 4.89407E+03 …

1.450 1.6084 0.1998 1.10529E+07 1.79062E-19 4.03610E-04 4.46108E+03 …

1.500 1.6413 0.2007 1.12662E+07 1.81687E-19 3.60393E-04 4.06027E+03 …

1.550 1.6741 0.2016 1.14632E+07 1.83913E-19 3.23118E-04 3.70397E+03 …

1.600 1.7069 0.2025 1.16446E+07 1.86578E-19 2.88064E-04 3.35440E+03 …

1.650 1.7397 0.2034 1.18112E+07 1.90971E-19 2.51450E-04 2.96993E+03 …

1.700 1.7726 0.2044 1.19637E+07 1.94022E-19 2.22631E-04 2.66349E+03 …

1.750 1.8054 0.2053 1.21027E+07 2.02408E-19 1.84741E-04 2.23588E+03 …

1.800 1.8382 0.2063 1.22291E+07 2.10971E-19 1.52570E-04 1.86580E+03 …

1.850 1.8710 0.2073 1.23435E+07 2.16761E-19 1.29829E-04 1.60254E+03 …

1.900 1.9039 0.2082 1.24465E+07 2.31783E-19 9.86528E-05 1.22789E+03 …

Summary statistics:

Sky background flux: 8.46147E-01 e-/pix/s

Thermal background flux: 9.85977E-02 e-/pix/s

telescope: 8.34285E-02 e-/pix/s

upstream: 1.69167E-04 e-/pix/s

downstream: 1.50000E-02 e-/pix/s

Noise variance per unit solid angle in one exposure:

sky only: 1.97165E+04 e-^2/arcsec^2

total: 3.05467E+04 e-^2/arcsec^2

Available galaxy density: 6.65319E+03 gal/deg^2

Similarly, for the [O iii] emitters:

$ ./baoetc-ref-o3.exe

Exposure time calculator v16

Mode: BAO

Options: -DIN\_DLON -DUSE\_SNRE -DOIII\_GAL

Enter telescope configuration [0=generic, 1=from file]: 1

Input file name: SRR/grism.dat

Using configuration: Big Telescope - On Axis - Grism

Enter detector type [e.g. 0=H2RG]: 2

Enter pointing jitter (arcsec rms per axis): .07

Enter minimum wavelength (microns): 1.00

Enter maximum wavelength (microns): 1.93

Enter completeness: .6

Enter linear spectral dispersion d theta/d lambda (arcsec/um): 102

Enter single exposure time (s): 297.01

Enter read noise floor (effective e- rms per pixel): 5

Enter dark current (e-/pix/sec): .015

Enter ecliptic latitude (degrees): 70.4

Enter ecliptic longitude relative to the Sun (degrees): 0

Enter Galactic reddening, E(B-V) (magnitudes): .035

Enter number of exposures: 6

Enter significance cut (number of sigmas): 5.054

Enter galaxy population model [SDT2013 report = 42]: 1992

Using luminosity function model: [O III] 3-model ave.

z |lambda| EE50 | dV/dz/dA | Flim@0.30"| n targets | dN/dz/dA |…

| um |arcsec| Mpc3/deg2 | W/m2 | Mpc^-3 | deg^-2 |…

1.000 1.0018 0.1908 8.29240E+06 4.18255E-19 3.09230E-05 2.56426E+02 …

1.050 1.0268 0.1908 8.67969E+06 3.41935E-19 4.30238E-05 3.73433E+02 …

1.100 1.0519 0.1908 9.04621E+06 3.08411E-19 4.70190E-05 4.25344E+02 …

1.150 1.0769 0.1908 9.39200E+06 2.67308E-19 5.70330E-05 5.35654E+02 …

1.200 1.1020 0.1908 9.71731E+06 2.36456E-19 6.62937E-05 6.44196E+02 …

1.250 1.1270 0.1907 1.00225E+07 2.18527E-19 7.03329E-05 7.04912E+02 …

1.300 1.1521 0.1906 1.03081E+07 2.06671E-19 7.15249E-05 7.37283E+02 …

1.350 1.1771 0.1905 1.05746E+07 1.95326E-19 7.34808E-05 7.77026E+02 …

1.400 1.2022 0.1905 1.08226E+07 1.89290E-19 7.19944E-05 7.79169E+02 …

1.450 1.2272 0.1909 1.10529E+07 1.82479E-19 7.23487E-05 7.99665E+02 …

1.500 1.2523 0.1914 1.12662E+07 1.77477E-19 7.20962E-05 8.12252E+02 …

1.550 1.2773 0.1919 1.14632E+07 1.73235E-19 7.17271E-05 8.22223E+02 …

1.600 1.3023 0.1924 1.16446E+07 1.71569E-19 6.94903E-05 8.09188E+02 …

1.650 1.3274 0.1930 1.18112E+07 1.70960E-19 6.67587E-05 7.88500E+02 …

1.700 1.3524 0.1935 1.19637E+07 1.69837E-19 6.49005E-05 7.76447E+02 …

1.750 1.3775 0.1941 1.21027E+07 1.70061E-19 6.22548E-05 7.53454E+02 …

1.800 1.4025 0.1947 1.22291E+07 1.71460E-19 5.90244E-05 7.21817E+02 …

1.850 1.4276 0.1952 1.23435E+07 1.72036E-19 5.68209E-05 7.01369E+02 …

1.900 1.4526 0.1958 1.24465E+07 1.72689E-19 5.48579E-05 6.82790E+02 …

1.950 1.4777 0.1964 1.25388E+07 1.74979E-19 5.19791E-05 6.51757E+02 …

2.000 1.5027 0.1971 1.26210E+07 1.76049E-19 5.02634E-05 6.34374E+02 …

2.050 1.5277 0.1977 1.26936E+07 1.77162E-19 4.87446E-05 6.18746E+02 …

2.100 1.5528 0.1983 1.27573E+07 1.76925E-19 4.83198E-05 6.16430E+02 …

2.150 1.5778 0.1990 1.28125E+07 1.76480E-19 4.81933E-05 6.17477E+02 …

2.200 1.6029 0.1996 1.28598E+07 1.78451E-19 4.66292E-05 5.99640E+02 …

2.250 1.6279 0.2003 1.28995E+07 1.80729E-19 4.14126E-05 5.34204E+02 …

2.300 1.6530 0.2010 1.29323E+07 1.82185E-19 3.62430E-05 4.68705E+02 …

2.350 1.6780 0.2017 1.29585E+07 1.84547E-19 3.08365E-05 3.99594E+02 …

2.400 1.7031 0.2024 1.29785E+07 1.86688E-19 2.63222E-05 3.41622E+02 …

2.450 1.7281 0.2031 1.29927E+07 1.88366E-19 2.26251E-05 2.93961E+02 …

2.500 1.7531 0.2038 1.30015E+07 1.92420E-19 1.88051E-05 2.44493E+02 …

2.550 1.7782 0.2045 1.30051E+07 1.95350E-19 1.58898E-05 2.06650E+02 …

2.600 1.8032 0.2053 1.30041E+07 2.01795E-19 1.27720E-05 1.66087E+02 …

2.650 1.8283 0.2060 1.29985E+07 2.08673E-19 1.02123E-05 1.32745E+02 …

2.700 1.8533 0.2067 1.29889E+07 2.13976E-19 8.35929E-06 1.08578E+02 …

2.750 1.8784 0.2075 1.29753E+07 2.20101E-19 6.77120E-06 8.78582E+01 …

2.800 1.9034 0.2082 1.29581E+07 2.31690E-19 5.09182E-06 6.59801E+01 …

2.850 1.9285 0.2090 1.29375E+07 2.38820E-19 4.08108E-06 5.27987E+01 …

Summary statistics:

Sky background flux: 8.46147E-01 e-/pix/s

Thermal background flux: 9.85977E-02 e-/pix/s

telescope: 8.34285E-02 e-/pix/s

upstream: 1.69167E-04 e-/pix/s

downstream: 1.50000E-02 e-/pix/s

Noise variance per unit solid angle in one exposure:

sky only: 1.97165E+04 e-^2/arcsec^2

total: 3.05467E+04 e-^2/arcsec^2

Available galaxy density: 9.80495E+02 gal/deg^2

We take this density of galaxies, and the 2000 deg2 area, as the input to the BAO and RSD figure of merit calculations for the Reference survey.

The total number of galaxies with spectroscopic measurements in the Reference Survey is 1.33×107 (Hα+[N ii], of which 8.02×106 are at *z* > 1) and 1.96×106 ([O iii]). We construct an input file for the galaxy clustering tools (“BAOREV/ref\_bao”) as follows, using the Hα+[N ii] number counts out to *z* = 1.94, and [O iii] beyond that. Note that some [O iii] lines will be detected at *z* < 1.94; depending on the line ratios there is a good chance that Hα+[N ii] will also be detected. To be conservative, therefore, we do not count these [O iii] emitters as unique objects.[[4]](#footnote-4) Also, since the BAO and RSD figures of merit are defined for the 1 < *z* < 3 range, we begin the Hα redshift distribution at *z* = 1. Note that even with [O iii] emitters, the Reference Survey does not quite reach *z* = 3.

38 0.04848 0.001

1.000 0.025 1.500 8.68E-04 0.500

1.050 0.050 1.525 8.14E-04 0.500

1.100 0.050 1.550 7.57E-04 0.500

1.150 0.050 1.575 6.92E-04 0.500

1.200 0.050 1.600 6.43E-04 0.500

1.250 0.050 1.625 5.84E-04 0.500

1.300 0.050 1.650 5.39E-04 0.500

1.350 0.050 1.675 4.84E-04 0.500

1.400 0.050 1.700 4.52E-04 0.500

1.450 0.050 1.725 4.04E-04 0.500

1.500 0.050 1.750 3.60E-04 0.500

1.550 0.050 1.775 3.23E-04 0.500

1.600 0.050 1.800 2.88E-04 0.500

1.650 0.050 1.825 2.51E-04 0.500

1.700 0.050 1.850 2.23E-04 0.500

1.750 0.050 1.875 1.85E-04 0.500

1.800 0.050 1.900 1.53E-04 0.500

1.850 0.050 1.925 1.30E-04 0.500

1.900 0.065 1.950 9.87E-05 0.500

1.950 0.035 1.975 5.20E-05 0.500

2.000 0.050 2.000 5.03E-05 0.500

2.050 0.050 2.025 4.87E-05 0.500

2.100 0.050 2.050 4.83E-05 0.500

2.150 0.050 2.075 4.82E-05 0.500

2.200 0.050 2.100 4.66E-05 0.500

2.250 0.050 2.125 4.14E-05 0.500

2.300 0.050 2.150 3.62E-05 0.500

2.350 0.050 2.175 3.08E-05 0.500

2.400 0.050 2.200 2.63E-05 0.500

2.450 0.050 2.225 2.26E-05 0.500

2.500 0.050 2.250 1.88E-05 0.500

2.550 0.050 2.275 1.59E-05 0.500

2.600 0.050 2.300 1.28E-05 0.500

2.650 0.050 2.325 1.02E-05 0.500

2.700 0.050 2.350 8.36E-06 0.500

2.750 0.050 2.375 6.77E-06 0.500

2.800 0.050 2.400 5.09E-06 0.500

2.850 0.028 2.425 4.08E-06 0.500

Here the first line is the number of *z*-bins; the fractional sky coverage (0.04848 = 2000/41253); and the redshift uncertainty per galaxy, σ(*z*)/(1+*z*). Subsequent lines have the format: (i) redshift *z*; (ii) bin width Δ*z* (usually 0.050); (iii) bias *b*(*z*); (iv) galaxy number density *n* in Mpc−3 (no *h*); and (v) reconstruction floor (in the limit of large number density, the non-linear BAO peak smearing is assumed to be reduced by this factor in amplitude). Several bins have had their width adjusted to ensure the same boundaries that are in the configuration file and FoM definition: we set *z*min = 1; there is an Hα – [O iii] survey boundary at *z* = 1.940; and there is an [O iii] *z*max = 2.853.

## The BAO Figure of Merit

The baryon-acoustic oscillation performance is computed using the standard SE07 methd [H. Seo & D. Eisenstein, “Improved forecasts for the baryon acoustic oscillations and cosmological distance scale,” *Astrophys. J.* **665**:14 (2007)], as implemented by the FoMSWG codes (and later by ADEPT, the JDEM SCG, and several WFIRST working groups). The one aspect of the computation that does not exactly follow SE07 is the reconstruction. Reconstruction is implemented by multiplying the smearing parameters Σ|| and Σ by some factor *f*recons. The input file BAOREV/ref\_bao specifies a minimum reconstruction *f*recons,min = 0.5 (the standard assumption based on how well reconstruction works in low shot noise simulations). However, at finite shot noise there is a correlation coefficient between the reconstructed displacement field and the true displacement field, even in linear theory. The correlation coefficient for displacements at two positions separated by *s* (here the BAO peak scale) is

Here *P*(*k*) is the power spectrum, and *nP*(*k*) is the ratio of clustering signal to shot noise, and *W*(*ks*) is the angular-averaged window function for converting the displacement power spectrum into the power spectrum for relative displacements between two points separated by *s* along the separation vector. There is no *k*2 in the integral from Fourier-space volume since the conversion from matter to displacement power spectrum introduces a factor of 1/*k*2. The window function is

Under perfect circumstances, we would then have post-reconstruction smearing

We instead implement *f*recons,min as a floor:

which has the desired feature of approaching *f*recons,min when the shot noise is negligible and approaching *f*recons,ideal when the floor *f*recons,min is set to zero. The values of *f*recons realized in the Reference Survey forecast range from 0.58—0.97 (with the larger values occurring at high redshift where the number density is lowest and the shot noise is most significant).

The resulting forecast is that σ(*FD*) = 0.00696; σ(*FH*) = 0.01276; and FoMref = 1.13×104.

## The RSD Figure of Merit

We construct the RSD forecasts using a Fisher matrix approach. The galaxy power spectrum is modeled as

where μ is the cosine of the angle between the wave vector and the line of sight. The parameter space contains an overall normalization (*FG*; actually implemented in the code as ln *FG*), a galaxy biasing parameter (actually implemented as β=*f*/*b*); and a finger of God length parameter Σ2. The actual code is an implementation of the multi-tracer technique [a clone of P. McDonald & U. Seljak, *J. Cosmo. Astropart. Phys.* 09(10)007 (2009)], but with the multi-tracer functionality turned off. The Gaussian covariance matrix was used.

For WFIRST, the fiducial value of the finger of God length Σ is determined by the redshift smearing: it is Σ = *c*σ*z*/*H*(*z*), where *c* is the speed of light, *H*(*z*) is the Hubble rate at that redshift, and σ*z*=0.001(1+*z*). We use *k*max = 0.2*h* Mpc−1. Note that unlike some published forecasts, we marginalize over Σ2 as it contains potential astrophysical uncertainties from the deeply non-linear regime in addition to observational uncertainties.

The resulting forecast for the Reference Survey, aggregated over redshift bins, is FoMRSD,ref = 6.07×103.

# The High-Latitude Imaging Survey (HLIS)

This section describes the computation of the HLS imaging survey yields for the Reference Survey, and the corresponding WL figure of merit.

## Reference Survey Definition

The reference HLIS is defined in the SRD as:

* A survey solid angle of 2000 deg2.
* An effective source density *n*eff = 30 galaxies arcmin−2.

Note that the effective source density is defined in the usual way for weak lensing as

where *A* is the survey area, the sum is over galaxies *i*, σint is the intrinsic shape noise per component of the galaxies (0.25 in shear units), and σmeas,*i* is the measurement error on the shape per component for galaxy *i*.

Again, this specification tells us the total number of galaxies, but does not specify the redshift distribution of the Reference Survey. To do this, we generate a configuration file based on the SRR throughput spreadsheets: The configuration file (“SRR/imBlue.dat”) used was as follows, based on the Phase A data file (“WFIRST-WFI-Transmission\_170907.xlsm”) posted on the WFIRST website.[[5]](#footnote-5) This includes thermal emission, a 10% stray light contribution, no exit pupil mask, and a 94 nm RMS wavefront error. Note that there are two throughput columns, one for background and one for signal (these differ due to stray light, and due to the fact that diffraction spikes are counted in background but not in signal).

!IMAGING

!THERMAL 269. 0.095 1 1 218. 0.066 0.015

Big Telescope - On Axis - Imaging

2.370 0.320 0.11 42

0.4500 0.5681 0.4900

0.4927 0.5865 0.5059

0.5354 0.7295 0.6292

0.5780 0.7311 0.6306

0.6207 0.7299 0.6296

0.6634 0.7721 0.6659

0.7061 0.7687 0.6630

0.7488 0.7644 0.6593

0.7915 0.7602 0.6557

0.8341 0.7211 0.6219

0.8768 0.7159 0.6174

0.9195 0.7266 0.6267

0.9622 0.7277 0.6276

1.0049 0.7269 0.6270

1.0476 0.7264 0.6266

1.0902 0.7142 0.6160

1.1329 0.7110 0.6132

1.1756 0.7023 0.6057

1.2183 0.6989 0.6028

1.2610 0.6946 0.5991

1.3037 0.6954 0.5998

1.3463 0.6979 0.6019

1.3890 0.7001 0.6039

1.4317 0.7032 0.6065

1.4744 0.7130 0.6150

1.5171 0.7171 0.6185

1.5598 0.7322 0.6315

1.6024 0.7360 0.6348

1.6451 0.7373 0.6359

1.6878 0.7428 0.6407

1.7305 0.7574 0.6533

1.7732 0.7729 0.6666

1.8159 0.7711 0.6651

1.8585 0.7829 0.6752

1.9012 0.7874 0.6791

1.9439 0.7899 0.6813

1.9866 0.8007 0.6906

2.0293 0.7905 0.6818

2.0720 0.8058 0.6950

2.1146 0.7978 0.6881

2.1573 0.7866 0.6784

2.2000 0.7959 0.6865

The weighted redshift probability distribution:

is taken from the ETC outputs. The redshift range considered is 0 < *z* < 4.

The compilation flags for the ETC are:

gcc exptimecalc.c -lm -Wall -O3 -o wletc.exe -DWL\_MODE -DWL\_CUT\_DEFAULT\

-DOUT\_WL\_CAT -DIN\_DLON

We use the source galaxy catalog based on the CANDELS GOODS-S field (“data/2K.dat,” available on the WFIRST science team wiki page). This is based on the actual CANDELS GOODS-S catalog [Y. Guo *et al.*, “CANDELS multi-wavelength catalogs: Source detection and photometry in the GOODS-South Field,” *Astrophys. J. Supp.* **207**:24 (2013)] with the photometric redshifts [L. Hsu *et al.*, “CANDELS/GOODS-S, CDFS, ECDFS: Photometric Redshifts For Normal and for X-Ray-Detected Galaxies,” *Astrophys. J.* **796**:60 (2014)]. The ETC v16 output is:

$ ./wletc.exe

Exposure time calculator v16

Mode: WL

Options: -DIN\_DLON -DOUT\_WL\_CAT

Enter telescope configuration [0=generic, 1=from file]: 1

Input file name: SRR/imBlue.dat

Warning: PM/SM emissivity 9.50000E-02 is unusual.

Warning: PM/SM emissivity 9.50000E-02 is unusual.

Using configuration: Big Telescope - On Axis - Imaging

Enter rms wavefront error (microns): .094

Enter detector type [e.g. 0=H2RG]: 2

Enter pointing jitter (arcsec rms per axis): .0144

Enter minimum wavelength (microns): 1.380

Enter maximum wavelength (microns): 1.774

Enter filter throughput: 0.95

Enter single exposure time (s): 140.26

Enter read noise floor (effective e- rms per pixel): 5

Enter dark current (e-/pix/sec): .015

Enter ecliptic latitude (degrees): 70.4

Enter ecliptic longitude relative to the Sun (degrees): 0

Enter Galactic reddening, E(B-V) (magnitudes): 0.035

Enter number of exposures: 5

Enter minimum resolution factor: .4

Enter maximum ellipticity error: .2

Enter input galaxy catalog file: data/2K.dat

Enter output galaxy catalog file: /dev/null

General properties:

PSF EE50: 1.32049E-01 arcsec

PSF effective area: 1.65375E-01 arcsec^2

PSF encircled energy: 0.372861, 0.754654, 0.907390 (at 0.1", 0.25",

0.5")

Spatial frequency cutoff: 9.15876E-01 cycles/pix

Sampling case: Weakly undersampled

Min usable galaxy r\_eff: 1.07817E-01 arcsec

Sky background flux: 4.82826E-01 e-/pix/s

Thermal background flux: 6.70077E-02 e-/pix/s

telescope: 5.19920E-02 e-/pix/s

upstream: 1.57037E-05 e-/pix/s

downstream: 1.50000E-02 e-/pix/s

Noise variance per unit solid angle in one exposure:

sky only: 5.59679E+03 e-^2/arcsec^2

total: 1.38208E+04 e-^2/arcsec^2

Source counts per exposure:

at AB mag 20: 4.46952E+04 e-

at AB mag 21: 1.77935E+04 e-

at AB mag 22: 7.08371E+03 e-

at AB mag 23: 2.82007E+03 e-

at AB mag 24: 1.12269E+03 e-

at AB mag 25: 4.46952E+02 e-

5 sigma pt src threshold: 26.553 mag AB

5 sigma ext src threshold: 25.444 mag AB [r\_eff=0.3"]

| r\_eff |Om\_eff |penalty|resolution|lim mag |S/N at |

| | |factor | factor |(shapes)|shape |

|arcsec |arcsec2| | | AB |lim mag|

0.11220 0.3794 5.8831 0.41928 24.38775 24.255

0.12589 0.4239 5.1312 0.47615 24.40189 22.652

0.14125 0.4776 4.5212 0.53364 24.40576 21.263

0.15849 0.5429 4.0235 0.59026 24.39954 20.059

0.17783 0.6223 3.6157 0.64458 24.38346 19.015

0.19953 0.7192 3.2799 0.69541 24.35784 18.110

0.22387 0.8376 3.0022 0.74189 24.28170 18.000

0.25119 0.9829 2.7717 0.78348 24.19489 18.000

0.28184 1.1614 2.5795 0.82000 24.10429 18.000

0.31623 1.3813 2.4186 0.85152 24.01016 18.000

0.35481 1.6527 2.2835 0.87834 23.91276 18.000

0.39811 1.9885 2.1696 0.90089 23.81236 18.000

0.44668 2.4046 2.0733 0.91963 23.70922 18.000

0.50119 2.9210 1.9917 0.93509 23.60360 18.000

0.56234 3.5631 1.9224 0.94774 23.49573 18.000

0.63096 4.3624 1.8634 0.95804 23.38585 18.000

0.70795 5.3588 1.8131 0.96638 23.27418 18.000

0.79433 6.6021 1.7702 0.97311 23.16091 18.000

0.89125 8.1551 1.7335 0.97852 23.04623 18.000

1.00000 10.0966 1.7021 0.98286 22.93030 18.000

| z | dN/dz/dA |dNeff/dz/dA|

| | deg^-2 | deg^-2 |

0.100 6.63981E+04 6.45774E+04

0.300 3.88136E+04 3.71024E+04

0.500 5.67557E+04 5.39094E+04

0.700 1.08507E+05 1.03571E+05

0.900 5.10191E+04 4.84427E+04

1.100 6.89613E+04 6.55970E+04

1.300 5.82204E+04 5.51771E+04

1.500 4.72354E+04 4.38948E+04

1.700 2.73404E+04 2.56597E+04

1.900 3.16123E+04 2.91277E+04

2.100 2.28243E+04 2.09934E+04

2.300 1.70877E+04 1.56766E+04

2.500 1.51349E+04 1.38599E+04

2.700 1.30599E+04 1.18184E+04

2.900 3.90577E+03 3.48252E+03

3.100 5.00427E+03 4.48698E+03

3.300 1.70877E+03 1.48787E+03

3.500 2.56316E+03 2.29862E+03

3.700 8.54387E+02 7.42524E+02

3.900 1.22055E+02 1.11519E+02

Weak lensing n: 1.27426E+05 gal/deg^2

= 3.53960E+01 gal/arcmin^2

Weak lensing n\_eff: 1.20403E+05 gal/deg^2

= 3.34454E+01 gal/arcmin^2

The resulting effective source density *n*eff is 33.45 galaxies arcmin−2, so these source densities must be scaled down by a factor of 30/33.45 = 0.897 to define the Reference Survey.

## Reference Survey Yields

The re-scaled redshift distribution from the ETC (normalized to 30 galaxies arcmin−2) is given in Table 2. The area for the Reference Survey is 2000 deg2.

Table 2: The redshift distribution for the Reference Survey used for weak lensing forecasts. The distribution *dn*eff/*dz* is given in galaxies arcmin−2 (Δ*z*)−1.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| *z* range | *dn*eff/*dz* |  | *z* range | *dn*eff/*dz* |  | *z* range | *dn*eff/*dz* |
| 0.00—0.20 | 16.090 |  | 1.40—1.60 | 10.937 |  | 2.80—3.00 | 0.868 |
| 0.20—0.40 | 9.245 |  | 1.60—1.80 | 6.393 |  | 3.00—3.20 | 1.118 |
| 0.40—0.60 | 13.432 |  | 1.80—2.00 | 7.258 |  | 3.20—3.40 | 0.371 |
| 0.60—0.80 | 25.806 |  | 2.00—2.20 | 5.231 |  | 3.40—3.60 | 0.573 |
| 0.80—1.00 | 12.070 |  | 2.20—2.40 | 3.906 |  | 3.60—3.80 | 0.185 |
| 1.00—1.20 | 16.344 |  | 2.40—2.60 | 3.453 |  | 3.80—4.00 | 0.028 |
| 1.20—1.40 | 13.748 |  | 2.60—2.80 | 2.945 |  |  |  |

The effective number of shapes *N*eff = *n*eff × *A* in the Reference Survey is 2.16×108. (The total number of shapes, without noise down-weighting, is 2.28×108.) Of these, the number at redshifts greater than one is *N*eff(*z*>1) = 1.06×108 or *N*(*z*>1) = 1.13×108.

## The WL Figure of Merit

The weak lensing figure of merit, defined in the SRD, is the aggregate precision on *F*WL, which is a multiplying factor on the overall linear amplitude of structure. That is, *F*WL re-scales the amplitude of matter fluctuations in the fiducial cosmology:

σ8(*z*) = *F*WL × σ8,fid(*z*);

*F*WL=1 corresponds to the fiducial cosmology. Then FoMWL is the inverse-variance of *F*WL with all other parameters held fixed.

The WL figure of merit is computed with the Gaussian error bars (including shape noise). Non-Gaussian terms (massive halo shot noise and super-sample covariance) are not included for this purpose, since there is an ongoing effort to develop mitigation schemes and we do not want the SRD to pre-judge how well these will perform. Finally, astrophysical systematic errors (baryonic effects and intrinsic alignments) are turned off for the computation of FoMWL, since the SRD is supposed to set requirements only on WFIRST and not on the Universe.

The tool used for FoMWL is that from the JDEM Figure of Merit Science Working Group (FoMSWG).[[6]](#footnote-6) This is described in the FoMSWG report [A. Albrecht *et al.*, “Findings of the Joint Dark Energy Mission Figure of Merit Science Working Group,” arXiv:0901.0721 (2009)] and its details will not be repeated here.

The weak lensing input data file (“lensing/refsurvey\_wl”) is:

20 12 12.68 0.475 0.04848

0.10 1.643E-09 1.00E-05 1.00E-05

0.30 2.860E-09 1.00E-05 1.00E-05

0.50 1.969E-09 1.00E-05 1.00E-05

0.70 1.025E-09 1.00E-05 1.00E-05

0.90 2.191E-09 1.00E-05 1.00E-05

1.10 1.618E-09 1.00E-05 1.00E-05

1.30 1.923E-09 1.00E-05 1.00E-05

1.50 2.418E-09 1.00E-05 1.00E-05

1.70 4.136E-09 1.00E-05 1.00E-05

1.90 3.643E-09 1.00E-05 1.00E-05

2.10 5.055E-09 1.00E-05 1.00E-05

2.30 6.770E-09 1.00E-05 1.00E-05

2.50 7.657E-09 1.00E-05 1.00E-05

2.70 8.980E-09 1.00E-05 1.00E-05

2.90 3.047E-08 1.00E-05 1.00E-05

3.10 2.365E-08 1.00E-05 1.00E-05

3.30 7.133E-08 1.00E-05 1.00E-05

3.50 4.617E-08 1.00E-05 1.00E-05

3.70 1.429E-07 1.00E-05 1.00E-05

3.90 9.516E-07 1.00E-05 1.00E-05

The format of this file is that the first line consists of the number of redshift bins; the number of multipole bins (*l*-bins); *l*min; Δ ln *l*; and the fractional sky coverage *f*sky. Each subsequent line has a central redshift, a white noise level (σint2/*n*eff; note this is in sr); a 1σ photo-*z* systematic error; and a 1σ shear calibration error. Note that the last two columns have been artificially set to small values, since the Reference Survey performance is defined without these systematic errors.

Our definition of FoMWL is such that it is the 7,7 entry of the Fisher matrix in FoMSWG format (\*.swg). It is thus easily readable from FoMSWG tools.

For the Reference Survey, we find σ(*F*WL) = 1.32×10−3 and hence the inverse variance is

FoMWL,ref = 5.73×105.

# Performance of the 1.5 m WFIRST Concept

In this section, we assess the performance of the surveys identified in the 2010 Decadal Survey, New Worlds New Horizons (NWNH). The performance is based on the JDEMΩ hardware template, and with the time allocations (areas) stated in the summary.

To assess JDEMΩ performance for both imaging and spectroscopy, we retrieved the May 2011 configuration files used by the Science Definition Team (these were the last snapshot of JDEMΩ before we ended consideration of the 1.5 m on-axis designs). We constructed updated configuration files fixing three omissions/errors: (i) the telescope temperature has been corrected to the JDEMΩ submission value (243 K); (ii) the 10% stray light allowance was incorporated; and (iii) the pupil mask (mission from the historical throughput table, but included in the NWNH submission) has been placed back in. Aside from these three corrections, the performance assessments herein correspond to our estimates of NWNH, but evaluated with present-day tools (e.g. the updated galaxy luminosity function). Pupil mask data was obtained from the last JDEMΩ spreadsheet delivered to the SDT (Throughput table JDEM Omega 110506.xlsx).

## Baryon Acoustic Oscillations and Redshift Space Distortions

For the NWNH spectroscopic survey, we use the following configuration file (“data/JDEM\_Omega\_mask\_SpC\_th\_update.dat”). This file is based on the last snapshot of JDEMΩ configuration file used by the SDT (May 2011), with the change of telescope temperature (now 243 K), the stray light (second column), and the pupil mask (area loss = 11.98% by area of the 1.5 m aperture).

# JDEM Omega, with pupil mask

# based on 'Throughput table JDEM Omega 110506'

!THERMAL 243. 0.02 1 1 210. 0.0776 0.03

JDEM\_Omega\_with\_pupil\_mask

1.5 0.5 0.37 30

1.1000 0.3809 0.2962

1.1310 0.3834 0.2982

1.1621 0.4217 0.3280

1.1931 0.4638 0.3608

1.2241 0.4954 0.3853

1.2552 0.5290 0.4115

1.2862 0.5371 0.4178

1.3172 0.5450 0.4239

1.3483 0.5533 0.4304

1.3793 0.5614 0.4367

1.4103 0.5561 0.4326

1.4414 0.5538 0.4308

1.4724 0.5502 0.4279

1.5034 0.5459 0.4246

1.5345 0.5419 0.4215

1.5655 0.5379 0.4184

1.5966 0.5493 0.4273

1.6276 0.5611 0.4364

1.6586 0.5727 0.4454

1.6897 0.5848 0.4548

1.7207 0.5971 0.4644

1.7517 0.6094 0.4740

1.7828 0.6084 0.4732

1.8138 0.6057 0.4711

1.8448 0.6038 0.4696

1.8759 0.6029 0.4689

1.9069 0.5795 0.4507

1.9379 0.5583 0.4343

1.9690 0.5395 0.4196

2.0000 0.5421 0.4217

A spectral dispersion of 142 arcsec μm−1 was used (*D*θ = 220 arcsec at the center of the bandpass), although for the JDEMΩ prism configuration this is not truly constant. We also use only the Hα emission line. We also set the S/N threshold at 6.5, consistent with the statement in the JDEMΩ submission. The resulting redshift survey yields at 24 × 150 s depth (i.e. “deep”) according to ETC v16 are as follows:

$ gcc exptimecalc.c -lm -Wall -O3 -o baoetc-ref-ha.exe -DBAO\_MODE\

-DIN\_DLON -DUSE\_SNRE

$ ./baoetc-ref-ha.exe

Exposure time calculator v16

Mode: BAO

Options: -DIN\_DLON -DUSE\_SNRE

Enter telescope configuration [0=generic, 1=from file]: 1

Input file name: data/JDEM\_Omega\_mask\_SpC\_th\_update.dat

Using configuration: JDEM\_Omega\_with\_pupil\_mask

Enter rms wavefront error (microns): .213

Enter detector type [e.g. 0=H2RG]: 0

Enter pointing jitter (arcsec rms per axis): .04

Enter minimum wavelength (microns): 1.10

Enter maximum wavelength (microns): 2.00

Enter completeness: .6

Enter linear spectral dispersion d theta/d lambda (arcsec/um): 142

Enter single exposure time (s): 150

Enter read noise floor (effective e- rms per pixel): 5

Enter dark current (e-/pix/sec): .05

Enter ecliptic latitude (degrees): 70.4

Enter ecliptic longitude relative to the Sun (degrees): 0

Enter Galactic reddening, E(B-V) (magnitudes): .035

Enter number of exposures: 24

Enter significance cut (number of sigmas): 6.5

Enter galaxy population model [SDT2013 report = 42]: 992

Using luminosity function model: H alpha 3-model ave.

z |lambda| EE50 | dV/dz/dA | Flim@0.30"| n targets | dN/dz/dA |…

| um |arcsec| Mpc3/deg2 | W/m2 | Mpc^-3 | deg^-2 |…

0.700 1.1160 0.3916 5.56334E+06 4.75224E-19 1.44912E-04 8.06195E+02 …

0.750 1.1489 0.3942 6.06057E+06 4.36481E-19 1.49226E-04 9.04395E+02 …

0.800 1.1817 0.3968 6.54313E+06 3.84918E-19 1.72262E-04 1.12713E+03 …

0.850 1.2145 0.3995 7.00894E+06 3.46908E-19 1.90299E-04 1.33379E+03 …

0.900 1.2474 0.4011 7.45644E+06 3.15891E-19 2.06801E-04 1.54200E+03 …

0.950 1.2802 0.4025 7.88451E+06 2.99858E-19 2.05697E-04 1.62182E+03 …

1.000 1.3130 0.4038 8.29240E+06 2.88543E-19 1.99694E-04 1.65594E+03 …

1.050 1.3458 0.4052 8.67969E+06 2.77698E-19 1.95042E-04 1.69290E+03 …

1.100 1.3787 0.4064 9.04621E+06 2.67561E-19 1.91083E-04 1.72857E+03 …

1.150 1.4115 0.4077 9.39200E+06 2.64392E-19 1.77090E-04 1.66323E+03 …

1.200 1.4443 0.4089 9.71731E+06 2.60189E-19 1.66324E-04 1.61623E+03 …

1.250 1.4771 0.4102 1.00225E+07 2.56870E-19 1.55478E-04 1.55827E+03 …

1.300 1.5100 0.4114 1.03081E+07 2.53927E-19 1.45239E-04 1.49713E+03 …

1.350 1.5428 0.4127 1.05746E+07 2.51047E-19 1.33906E-04 1.41599E+03 …

1.400 1.5756 0.4139 1.08226E+07 2.46034E-19 1.26639E-04 1.37057E+03 …

1.450 1.6084 0.4152 1.10529E+07 2.36266E-19 1.26615E-04 1.39947E+03 …

1.500 1.6413 0.4165 1.12662E+07 2.27035E-19 1.26692E-04 1.42734E+03 …

1.550 1.6741 0.4179 1.14632E+07 2.18299E-19 1.26832E-04 1.45390E+03 …

1.600 1.7069 0.4194 1.16446E+07 2.09947E-19 1.27114E-04 1.48019E+03 …

1.650 1.7397 0.4220 1.18112E+07 2.02253E-19 1.26944E-04 1.49936E+03 …

1.700 1.7726 0.4248 1.19637E+07 1.97890E-19 1.21984E-04 1.45938E+03 …

1.750 1.8054 0.4276 1.21027E+07 1.95744E-19 1.14041E-04 1.38020E+03 …

1.800 1.8382 0.4304 1.22291E+07 1.93678E-19 1.06528E-04 1.30275E+03 …

1.850 1.8710 0.4333 1.23435E+07 1.91362E-19 9.98601E-05 1.23262E+03 …

1.900 1.9039 0.4363 1.24465E+07 1.95663E-19 8.52558E-05 1.06114E+03 …

1.950 1.9367 0.4393 1.25388E+07 2.00868E-19 7.16091E-05 8.97894E+02 …

2.000 1.9695 0.4424 1.26210E+07 2.05516E-19 6.03835E-05 7.62100E+02 …

Summary statistics:

Sky background flux: 3.31422E+00 e-/pix/s

Thermal background flux: 6.80294E-02 e-/pix/s

telescope: 3.71739E-02 e-/pix/s

upstream: 8.55508E-04 e-/pix/s

downstream: 3.00000E-02 e-/pix/s

Noise variance per unit solid angle in one exposure:

sky only: 3.63136E+03 e-^2/arcsec^2

total: 4.86469E+03 e-^2/arcsec^2

Available galaxy density: 1.84408E+03 gal/deg^2

The galaxy density is 1844 galaxies deg−2, of which 1436 galaxies deg−2 are at *z*>1.

The redshift survey input file (“BAOREV/nwnh\_bao\_deep”) based on these densities, and restricted to 1 < *z* < 3 (as relevant for the calculation of FoMBAO and FoMRSD; but note that with Hα we stop at *z* = 2.046) is:

21 0.06816 0.001

1.000 0.025 1.500 2.00E-04 0.500

1.050 0.050 1.525 1.95E-04 0.500

1.100 0.050 1.550 1.91E-04 0.500

1.150 0.050 1.575 1.77E-04 0.500

1.200 0.050 1.600 1.66E-04 0.500

1.250 0.050 1.625 1.55E-04 0.500

1.300 0.050 1.650 1.45E-04 0.500

1.350 0.050 1.675 1.34E-04 0.500

1.400 0.050 1.700 1.27E-04 0.500

1.450 0.050 1.725 1.27E-04 0.500

1.500 0.050 1.750 1.27E-04 0.500

1.550 0.050 1.775 1.27E-04 0.500

1.600 0.050 1.800 1.27E-04 0.500

1.650 0.050 1.825 1.27E-04 0.500

1.700 0.050 1.850 1.22E-04 0.500

1.750 0.050 1.875 1.14E-04 0.500

1.800 0.050 1.900 1.07E-04 0.500

1.850 0.050 1.925 9.99E-05 0.500

1.900 0.050 1.950 8.53E-05 0.500

1.950 0.050 1.975 7.16E-05 0.500

2.000 0.071 2.000 6.04E-05 0.500

For this survey, we find σ(*FD*) = 0.00883 and σ(*FH*) = 0.01531, so FoMBAO,stat = 7.39×103 for the NWNH deep survey. We further find FoMRSD,stat = 5.35×103.

A similar computation can be done for the wide survey, using 12 instead of 24 exposures. This leads to the following input file (“BAOREV/nwnh\_bao\_wide”):

21 0.14251 0.001

1.000 0.025 1.500 8.07E-05 0.500

1.050 0.050 1.525 7.84E-05 0.500

1.100 0.050 1.550 7.64E-05 0.500

1.150 0.050 1.575 6.95E-05 0.500

1.200 0.050 1.600 6.43E-05 0.500

1.250 0.050 1.625 5.92E-05 0.500

1.300 0.050 1.650 5.44E-05 0.500

1.350 0.050 1.675 4.95E-05 0.500

1.400 0.050 1.700 4.64E-05 0.500

1.450 0.050 1.725 4.66E-05 0.500

1.500 0.050 1.750 4.68E-05 0.500

1.550 0.050 1.775 4.71E-05 0.500

1.600 0.050 1.800 4.74E-05 0.500

1.650 0.050 1.825 4.75E-05 0.500

1.700 0.050 1.850 4.54E-05 0.500

1.750 0.050 1.875 4.19E-05 0.500

1.800 0.050 1.900 3.86E-05 0.500

1.850 0.050 1.925 3.57E-05 0.500

1.900 0.050 1.950 2.94E-05 0.500

1.950 0.050 1.975 2.38E-05 0.500

2.000 0.071 2.000 1.93E-05 0.500

For this survey, we find σ(*FD*) = 0.01096 and σ(*FH*) = 0.01766, so FoMBAO,stat = 5.17×103 for the NWNH wide survey. We further find FoMRSD,stat = 5.30×103.

The combination (inverse variance sum) of the deep and wide surveys gives σ(*FD*) = 0.00688 and σ(*FH*) = 0.01157, so FoMBAO,NWNH,tot,stat = 1.26×104. The RSD figures of merit add for independent surveys, so FoMRSD,NWHN,tot,stat = 1.06×104.

## Weak Lensing

For the NWNH imaging survey, we use the following configuration file (“data/JDEM\_Omega\_mask\_ImC\_th\_update.dat”). Like the spectroscopy configuration file, it is based on the last snapshot of JDEMΩ configuration file used by the SDT (May 2011), with the same three changes. First, the telescope temperature has been corrected to the JDEMΩ submission value (243 K). Second, the 10% stray light allowance has been incorporated (its omission was an oversight in the 2011 version of the file). Finally, the pupil mask was inserted (area loss = 9.96% by area of the 1.5 m aperture).

# JDEM Omega, with pupil mask

# based on 'Throughput table JDEM Omega 110506'

!THERMAL 243. 0.02 1 1 210. 0.0588 5e-3

JDEM\_Omega\_with\_pupil\_mask

1.5 0.5 0.18 30

0.4000 0.4308 0.3430

0.4552 0.5139 0.4092

0.5103 0.5493 0.4374

0.5655 0.5748 0.4577

0.6207 0.5908 0.4704

0.6759 0.6052 0.4819

0.7310 0.6089 0.4849

0.7862 0.6122 0.4875

0.8414 0.6139 0.4888

0.8966 0.6165 0.4909

0.9517 0.6154 0.4900

1.0069 0.6160 0.4905

1.0621 0.6180 0.4921

1.1172 0.6211 0.4946

1.1724 0.6252 0.4978

1.2276 0.6296 0.5014

1.2828 0.6406 0.5101

1.3379 0.6515 0.5187

1.3931 0.6626 0.5276

1.4483 0.6738 0.5365

1.5034 0.6849 0.5453

1.5586 0.6961 0.5543

1.6138 0.7019 0.5589

1.6690 0.7074 0.5633

1.7241 0.7129 0.5676

1.7793 0.7180 0.5717

1.8345 0.7125 0.5673

1.8897 0.7082 0.5639

1.9950 0.7120 0.5670

2.0000 0.7021 0.5590

The resulting WL performance from ETC v16 (a modern tool) is as follows. We assumed 3 logarithmically spaced bands from 1—2 μm, and used the middle one for this estimate. Note that the total number of exposures (12, for a total live time of 12 × 150 s = 1800 s for each galaxy) is combined across all 3 filters to improve S/N.

$ ./wletc.exe

Exposure time calculator v16

Mode: WL

Options: -DIN\_DLON -DOUT\_WL\_CAT

Enter telescope configuration [0=generic, 1=from file]: 1

Input file name: data/JDEM\_Omega\_mask\_ImC\_th\_update.dat

Using configuration: JDEM\_Omega\_with\_pupil\_mask

Enter rms wavefront error (microns): .071

Enter detector type [e.g. 0=H2RG]: 0

Enter pointing jitter (arcsec rms per axis): .04

Enter minimum wavelength (microns): 1.260

Enter maximum wavelength (microns): 1.587

Enter filter throughput: .95

Enter single exposure time (s): 150

Enter read noise floor (effective e- rms per pixel): 5

Enter dark current (e-/pix/sec): .05

Enter ecliptic latitude (degrees): 70.4

Enter ecliptic longitude relative to the Sun (degrees): 0

Enter Galactic reddening, E(B-V) (magnitudes): .035

Enter number of exposures: 12

Enter minimum resolution factor: .4

Enter maximum ellipticity error: .2

Enter input galaxy catalog file: data/2K.dat

Enter output galaxy catalog file: /dev/null

General properties:

PSF EE50: 2.48063E-01 arcsec

PSF effective area: 5.00370E-01 arcsec^2

PSF encircled energy: 0.174040, 0.503204, 0.821222 (at 0.1", 0.25",

0.5")

Spatial frequency cutoff: 1.03889E+00 cycles/pix

Sampling case: Strongly undersampled

Min usable galaxy r\_eff: 2.02543E-01 arcsec

Sky background flux: 3.77845E-01 e-/pix/s

Thermal background flux: 5.00695E-03 e-/pix/s

telescope: 6.91431E-06 e-/pix/s

upstream: 3.55359E-08 e-/pix/s

downstream: 5.00000E-03 e-/pix/s

Noise variance per unit solid angle in one exposure:

sky only: 1.74928E+03 e-^2/arcsec^2

total: 3.83323E+03 e-^2/arcsec^2

Source counts per exposure:

at AB mag 20: 1.23847E+04 e-

at AB mag 21: 4.93045E+03 e-

at AB mag 22: 1.96285E+03 e-

at AB mag 23: 7.81424E+02 e-

at AB mag 24: 3.11091E+02 e-

at AB mag 25: 1.23847E+02 e-

5 sigma pt src threshold: 25.730 mag AB

5 sigma ext src threshold: 25.030 mag AB [r\_eff=0.3"]

| r\_eff |Om\_eff |penalty|resolution|lim mag |S/N at |

| | |factor | factor |(shapes)|shape |

|arcsec |arcsec2| | | AB |lim mag|

0.22387 1.3169 5.1621 0.44888 23.56128 22.720

0.25119 1.4847 4.5227 0.50626 23.56794 21.267

0.28184 1.6890 4.0034 0.56348 23.56415 20.009

0.31623 1.9384 3.5813 0.61906 23.54988 18.924

0.35481 2.2434 3.2375 0.67169 23.52493 18.000

0.39811 2.6172 2.9564 0.72033 23.44125 18.000

0.44668 3.0765 2.7259 0.76429 23.35348 18.000

0.50119 3.6418 2.5359 0.80323 23.26191 18.000

0.56234 4.3390 2.3787 0.83711 23.16681 18.000

0.63096 5.2005 2.2479 0.86612 23.06850 18.000

0.70795 6.2668 2.1386 0.89065 22.96725 18.000

0.79433 7.5887 2.0469 0.91114 22.86335 18.000

0.89125 9.2299 1.9697 0.92810 22.75706 18.000

1.00000 11.2705 1.9044 0.94203 22.64863 18.000

| z | dN/dz/dA |dNeff/dz/dA|

| | deg^-2 | deg^-2 |

0.100 4.52825E+04 4.39890E+04

0.300 2.45331E+04 2.34827E+04

0.500 3.06359E+04 2.90875E+04

0.700 6.11497E+04 5.83778E+04

0.900 2.44111E+04 2.30007E+04

1.100 3.44196E+04 3.27557E+04

1.300 2.83168E+04 2.63857E+04

1.500 1.78201E+04 1.62811E+04

1.700 9.52031E+03 8.71894E+03

1.900 9.76443E+03 8.84935E+03

2.100 6.59099E+03 5.89599E+03

2.300 4.14988E+03 3.65127E+03

2.500 3.78371E+03 3.40708E+03

2.700 1.83083E+03 1.58913E+03

2.900 3.66166E+02 3.15153E+02

3.100 6.10277E+02 5.00991E+02

3.300 1.22055E+02 1.07165E+02

3.500 2.44111E+02 2.17217E+02

3.700 0.00000E+00 0.00000E+00

3.900 0.00000E+00 0.00000E+00

Weak lensing n: 6.07103E+04 gal/deg^2

= 1.68640E+01 gal/arcmin^2

Weak lensing n\_eff: 5.73225E+04 gal/deg^2

= 1.59229E+01 gal/arcmin^2

Note that the *n*eff = 15.9 galaxies arcmin−2, less than the 30 galaxies arcmin−2 originally expected by the JDEMΩ study. Part of this difference is the improved fidelity of the tools, which include more sources of miscellaneous background, and part of it is the lower number of galaxies in the NIR (recall that the JDEMΩ study was performed prior to any HST/WFC3 data).

The weak lensing input data file (“lensing/decadal\_wl”) based on these galaxy densities is:

18 12 12.68 0.475 0.06816

0.10 2.164E-09 1.00E-05 1.00E-05

0.30 4.054E-09 1.00E-05 1.00E-05

0.50 3.273E-09 1.00E-05 1.00E-05

0.70 1.631E-09 1.00E-05 1.00E-05

0.90 4.139E-09 1.00E-05 1.00E-05

1.10 2.906E-09 1.00E-05 1.00E-05

1.30 3.608E-09 1.00E-05 1.00E-05

1.50 5.847E-09 1.00E-05 1.00E-05

1.70 1.092E-08 1.00E-05 1.00E-05

1.90 1.076E-08 1.00E-05 1.00E-05

2.10 1.615E-08 1.00E-05 1.00E-05

2.30 2.607E-08 1.00E-05 1.00E-05

2.50 2.794E-08 1.00E-05 1.00E-05

2.70 5.990E-08 1.00E-05 1.00E-05

2.90 3.021E-07 1.00E-05 1.00E-05

3.10 1.900E-07 1.00E-05 1.00E-05

3.30 8.883E-07 1.00E-05 1.00E-05

3.50 4.382E-07 1.00E-05 1.00E-05

For this survey, we find σ(*F*WL) = 1.76×10−3 (statistical error only!) and hence the inverse variance is

FoMWL,NWNH,stat = 3.21×105.

# Phase C Design Reference Mission

In this section, we assess the performance of the Design Reference Mission in Phase C. We used the updated Exposure Time Calculator (v17), and built new configuration files based on the transmission table (“Roman\_effarea\_20201130.xlsx”). Since these tables include filter transmission, the separate “Filter Transmission” input in the ETC was set to 1.

The survey area for both HLIS and HLSS is set to 1700 deg2, in accordance with the Design Reference Mission.

## Baryon Acoustic Oscillations and Redshift Space Distortions

The configuration file for the grism mode (“PhaseC/grism.dat”) is as follows:

!SLITLESS

!THERMAL 267. 0.02 1 1 220. 0.06 0.035

!WAVEFRONT 1.000 0.108 0 0.036

Big Telescope - On Axis - Grism

2.37 0.31 0.11 187

.995 0.693190344 0.281040711

1.005 0.693190344 0.281040711

1.01 0.692816307 0.288891131

1.015 0.692467206 0.29667685

1.02 0.692143041 0.304419434

1.025 0.691843811 0.312118884

1.03 0.691594453 0.319732066

1.035 0.690995994 0.327108009

1.04 0.690871315 0.334613356

1.045 0.690746636 0.342032434

1.05 0.690696764 0.349365243

1.055 0.6907217 0.356633352

1.06 0.690796507 0.363836759

1.065 0.690921186 0.370953897

1.07 0.691095737 0.377963201

1.075 0.691295223 0.384886236

1.08 0.691519646 0.391679868

1.085 0.692118105 0.398581336

1.09 0.692292655 0.405094596

1.095 0.692492142 0.411500021

1.1 0.693015794 0.41794858

1.105 0.692666692 0.423750127

1.11 0.692666692 0.42957324

1.115 0.692990858 0.435482622

1.12 0.693290088 0.441241034

1.125 0.69321528 0.446611239

1.13 0.693589317 0.452110846

1.135 0.693763868 0.457330081

1.14 0.693963354 0.462398347

1.145 0.694038162 0.467250941

1.15 0.694511942 0.472211371

1.155 0.694711428 0.476848295

1.16 0.694960786 0.481355816

1.165 0.695609117 0.485971173

1.17 0.695958218 0.490241456

1.175 0.696681357 0.494619575

1.18 0.697429431 0.498868291

1.185 0.697803468 0.502685665

1.19 0.698601413 0.506697143

1.195 0.699424295 0.510536085

1.2 0.699798332 0.513943685

1.205 0.700272112 0.517243449

1.21 0.701169801 0.520737317

1.215 0.702092425 0.524080216

1.22 0.702591141 0.526970205

1.225 0.703389087 0.529946463

1.23 0.704236904 0.532814886

1.235 0.704810428 0.535359802

1.24 0.705309144 0.537689048

1.245 0.705932539 0.539975159

1.25 0.706007346 0.541722093

1.255 0.70628164 0.543469027

1.26 0.706356447 0.544935589

1.265 0.706206833 0.546078644

1.27 0.70598241 0.54707073

1.275 0.705907603 0.548019682

1.28 0.70580786 0.548839232

1.285 0.70533408 0.549249006

1.29 0.705309144 0.549896019

1.295 0.705159529 0.550305793

1.3 0.705084722 0.550650867

1.305 0.705383951 0.551211611

1.31 0.705359015 0.551384148

1.315 0.705782924 0.551793922

1.32 0.706256704 0.552138996

1.325 0.706381383 0.552138996

1.33 0.707004778 0.552376234

1.335 0.707653109 0.552570338

1.34 0.707927403 0.552376234

1.345 0.70860067 0.552376234

1.35 0.709373679 0.552376234

1.355 0.70984746 0.552052727

1.36 0.710745149 0.551944892

1.365 0.711318672 0.55151355

1.37 0.712241297 0.551276312

1.375 0.713213793 0.55099594

1.38 0.713737445 0.550284226

1.385 0.714784748 0.549874452

1.39 0.715408143 0.549098037

1.395 0.71578218 0.548041249

1.4 0.716031538 0.546811925

1.405 0.715856988 0.545194394

1.41 0.715582694 0.54344746

1.415 0.715383208 0.541678959

1.42 0.715557758 0.540126128

1.425 0.716156217 0.53885367

1.43 0.716405575 0.537257706

1.435 0.71685442 0.535726443

1.44 0.716879356 0.533850106

1.445 0.71655519 0.531650263

1.45 0.716729741 0.529773927

1.455 0.717028971 0.527940724

1.46 0.717253393 0.525999686

1.465 0.717403008 0.523950813

1.47 0.717552622 0.521880373

1.475 0.717951595 0.519939335

1.48 0.717951595 0.517674791

1.485 0.718350568 0.515647485

1.49 0.718450311 0.51338294

1.495 0.718924091 0.511334067

1.5 0.719073706 0.509026389

1.505 0.719173449 0.506632442

1.51 0.719722037 0.504562002

1.515 0.720096074 0.502297458

1.52 0.720495047 0.500054481

1.525 0.721143378 0.497919339

1.53 0.721342864 0.495482258

1.535 0.721991195 0.493303982

1.54 0.722639526 0.491104139

1.545 0.723113306 0.488753327

1.55 0.723612022 0.486402514

1.555 0.723986059 0.483943867

1.56 0.724360096 0.481485219

1.565 0.724584518 0.478875601

1.57 0.725158042 0.476503222

1.575 0.725432336 0.473915171

1.58 0.725731565 0.471327121

1.585 0.726255217 0.468868473

1.59 0.726878612 0.466452959

1.595 0.727676558 0.464145281

1.6 0.72867399 0.461945438

1.605 0.729646486 0.459702461

1.61 0.730718725 0.457524185

1.615 0.731666286 0.455238074

1.62 0.732688654 0.452995097

1.625 0.734085059 0.45096779

1.63 0.735506399 0.448940484

1.635 0.736528767 0.446654373

1.64 0.737501263 0.444346695

1.645 0.738398952 0.441974315

1.65 0.739221834 0.439537234

1.655 0.740244202 0.437207989

1.66 0.740717982 0.434576804

1.665 0.741565799 0.432139723

1.67 0.742338809 0.429659508

1.675 0.74268791 0.426942055

1.68 0.743012076 0.424203035

1.685 0.743660406 0.421658119

1.69 0.743959636 0.418897532

1.695 0.744184058 0.416115378

1.7 0.744882261 0.413592029

1.705 0.745580463 0.411068679

1.71 0.746278666 0.40854533

1.715 0.746827253 0.405935713

1.72 0.74767507 0.403520199

1.725 0.748123915 0.400867447

1.73 0.748522888 0.398193128

1.735 0.749021604 0.395583511

1.74 0.749445512 0.392930759

1.745 0.750168651 0.390105471

1.75 0.750915565 0.387452719

1.755 0.75064881 0.384390193

1.76 0.750595459 0.381500203

1.765 0.749981922 0.378351408

1.77 0.749235008 0.375181047

1.775 0.748488094 0.372010685

1.78 0.747714504 0.36886189

1.785 0.747367722 0.365950333

1.79 0.746674159 0.362844673

1.795 0.746113973 0.359846848

1.8 0.745340384 0.356762754

1.805 0.744860224 0.35382963

1.81 0.744993602 0.351198446

1.815 0.744620145 0.348373157

1.82 0.745073628 0.345914509

1.825 0.74542041 0.343434294

1.83 0.745847218 0.340975646

1.835 0.746274026 0.338560133

1.84 0.74672751 0.336166186

1.845 0.747180994 0.333772239

1.85 0.747607802 0.331378293

1.855 0.747981259 0.328962779

1.86 0.748381392 0.326590399

1.865 0.749154981 0.324390556

1.87 0.749501763 0.32199661

1.875 0.750195326 0.3197752

1.88 0.750488757 0.31740282

1.885 0.750702161 0.315008874

1.89 0.750488757 0.31244239

1.895 0.750568783 0.310005309

1.9 0.750568783 0.307568229

1.905 0.750382055 0.305066446

1.91 0.750462081 0.302715634

1.915 0.750061949 0.300170718

1.92 0.749528438 0.297625801

1.925 0.749154981 0.291263511

1.955 0.749154981 0.291263511

We compile ETC v17 as follows:

gcc exptimecalc.c -lm -Wall -O3 -o baoetc-ref.exe -DBAO\_MODE -DIN\_DLON\

-DUSE\_NII -DUSE\_SNRE

gcc exptimecalc.c -lm -Wall -O3 -o baoetc-ref-o3.exe -DBAO\_MODE -DIN\_DLON\

-DOIII\_GAL -DUSE\_SNRE

We use the median sky brightness from a tiling simulation for the grism observations (1.4× Ecliptic pole). The predicted Hα + [N ii] HLSS yields are then:

$ ./baoetc-ref.exe

Exposure time calculator v17

Mode: BAO

Options: -DIN\_DLON -DUSE\_SNRE -DUSE\_NII

Enter telescope configuration [0=generic, 1=from file]: 1

Input file name: PhaseC/grism.dat

Using configuration: Big Telescope - On Axis - Grism

Enter detector type [e.g. 0=H2RG]: 2

Enter pointing jitter (arcsec rms per axis): .07

Enter minimum wavelength (microns): 1.00

Enter maximum wavelength (microns): 1.93

Enter completeness: .6

Enter linear spectral dispersion d theta/d lambda (arcsec/um): 102

Enter single exposure time (s): 297.01

Enter read noise floor (effective e- rms per pixel): 5

Enter dark current (e-/pix/sec): .015

Enter ecliptic latitude (degrees): 72.66

Enter ecliptic longitude relative to the Sun (degrees): 0

Enter Galactic reddening, E(B-V) (magnitudes): .035

Enter number of exposures: 6

Enter significance cut (number of sigmas): 6.5

Enter galaxy population model [SDT2013 report = 42]: 992

Using luminosity function model: H alpha 3-model ave.

z |lambda| EE50 | dV/dz/dA | Flim@0.30"| n targets | dN/dz/dA |…

| um |arcsec| Mpc3/deg2 | W/m2 | Mpc^-3 | deg^-2 |…

0.550 1.0176 0.1640 4.01340E+06 3.62765E-19 6.61916E-04 2.65653E+03 …

0.600 1.0504 0.1653 4.53608E+06 3.02413E-19 7.73525E-04 3.50877E+03 …

0.650 1.0832 0.1666 5.05407E+06 2.59511E-19 8.69338E-04 4.39370E+03 …

0.700 1.1160 0.1679 5.56334E+06 2.28913E-19 9.42904E-04 5.24569E+03 …

0.750 1.1489 0.1692 6.06057E+06 2.06546E-19 9.95118E-04 6.03099E+03 …

0.800 1.1817 0.1705 6.54313E+06 1.89537E-19 1.03076E-03 6.74440E+03 …

0.850 1.2145 0.1719 7.00894E+06 1.76500E-19 1.05089E-03 7.36566E+03 …

0.900 1.2474 0.1732 7.45644E+06 1.66828E-19 1.05362E-03 7.85622E+03 …

0.950 1.2802 0.1746 7.88451E+06 1.60549E-19 1.03334E-03 8.14739E+03 …

1.000 1.3130 0.1759 8.29240E+06 1.56130E-19 1.00165E-03 8.30610E+03 …

1.050 1.3458 0.1773 8.67969E+06 1.52503E-19 9.67662E-04 8.39900E+03 …

1.100 1.3787 0.1787 9.04621E+06 1.49774E-19 9.29658E-04 8.40988E+03 …

1.150 1.4115 0.1801 9.39200E+06 1.48716E-19 8.79955E-04 8.26454E+03 …

1.200 1.4443 0.1815 9.71731E+06 1.48729E-19 8.24667E-04 8.01354E+03 …

1.250 1.4771 0.1829 1.00225E+07 1.49468E-19 7.67399E-04 7.69125E+03 …

1.300 1.5100 0.1843 1.03081E+07 1.50808E-19 7.09625E-04 7.31486E+03 …

1.350 1.5428 0.1858 1.05746E+07 1.52480E-19 6.42772E-04 6.79702E+03 …

1.400 1.5756 0.1872 1.08226E+07 1.54847E-19 5.77771E-04 6.25299E+03 …

1.450 1.6084 0.1886 1.10529E+07 1.57232E-19 5.19212E-04 5.73882E+03 …

1.500 1.6413 0.1901 1.12662E+07 1.59567E-19 4.66757E-04 5.25859E+03 …

1.550 1.6741 0.1915 1.14632E+07 1.62880E-19 4.14514E-04 4.75166E+03 …

1.600 1.7069 0.1930 1.16446E+07 1.66988E-19 3.64260E-04 4.24167E+03 …

1.650 1.7397 0.1945 1.18112E+07 1.71442E-19 3.18349E-04 3.76008E+03 …

1.700 1.7726 0.1959 1.19637E+07 1.77584E-19 2.72098E-04 3.25528E+03 …

1.750 1.8054 0.1974 1.21027E+07 1.84733E-19 2.29236E-04 2.77439E+03 …

1.800 1.8382 0.1989 1.22291E+07 1.90946E-19 1.94902E-04 2.38349E+03 …

1.850 1.8710 0.2004 1.23435E+07 1.97226E-19 1.65139E-04 2.03839E+03 …

1.900 1.9039 0.2018 1.24465E+07 2.04528E-19 1.37743E-04 1.71442E+03 …

Summary statistics:

Sky background flux: 1.23951E+00 e-/pix/s

Thermal background flux: 1.19401E-01 e-/pix/s

telescope: 8.40874E-02 e-/pix/s

upstream: 3.13397E-04 e-/pix/s

downstream: 3.50000E-02 e-/pix/s

Noise variance per unit solid angle in one exposure:

sky only: 3.04255E+04 e-^2/arcsec^2

total: 4.43807E+04 e-^2/arcsec^2

Available galaxy density: 7.86577E+03 gal/deg^2

The [O III] yields are:

$ ./baoetc-ref-o3.exe

Exposure time calculator v17

Mode: BAO

Options: -DIN\_DLON -DUSE\_SNRE -DOIII\_GAL

Enter telescope configuration [0=generic, 1=from file]: 1

Input file name: PhaseC/grism.dat

Using configuration: Big Telescope - On Axis - Grism

Enter detector type [e.g. 0=H2RG]: 2

Enter pointing jitter (arcsec rms per axis): .07

Enter minimum wavelength (microns): 1.00

Enter maximum wavelength (microns): 1.93

Enter completeness: .6

Enter linear spectral dispersion d theta/d lambda (arcsec/um): 102

Enter single exposure time (s): 297.01

Enter read noise floor (effective e- rms per pixel): 5

Enter dark current (e-/pix/sec): .015

Enter ecliptic latitude (degrees): 72.66

Enter ecliptic longitude relative to the Sun (degrees): 0

Enter Galactic reddening, E(B-V) (magnitudes): .035

Enter number of exposures: 6

Enter significance cut (number of sigmas): 6.5

Enter galaxy population model [SDT2013 report = 42]: 1992

Using luminosity function model: [O III] 3-model ave.

z |lambda| EE50 | dV/dz/dA | Flim@0.30"| n targets | dN/dz/dA |…

| um |arcsec| Mpc3/deg2 | W/m2 | Mpc^-3 | deg^-2 |…

1.000 1.0018 0.1634 8.29240E+06 3.93932E-19 3.76488E-05 3.12199E+02 …

1.050 1.0268 0.1644 8.67969E+06 3.43354E-19 4.41965E-05 3.83612E+02 …

1.100 1.0519 0.1653 9.04621E+06 3.00150E-19 5.19288E-05 4.69759E+02 …

1.150 1.0769 0.1663 9.39200E+06 2.66738E-19 5.91335E-05 5.55382E+02 …

1.200 1.1020 0.1673 9.71731E+06 2.40710E-19 6.55369E-05 6.36842E+02 …

1.250 1.1270 0.1683 1.00225E+07 2.20694E-19 7.06803E-05 7.08393E+02 …

1.300 1.1521 0.1693 1.03081E+07 2.04696E-19 7.49290E-05 7.72373E+02 …

1.350 1.1771 0.1703 1.05746E+07 1.91654E-19 7.84469E-05 8.29541E+02 …

1.400 1.2022 0.1713 1.08226E+07 1.81064E-19 8.11704E-05 8.78476E+02 …

1.450 1.2272 0.1724 1.10529E+07 1.72378E-19 8.37351E-05 9.25520E+02 …

1.500 1.2523 0.1734 1.12662E+07 1.65709E-19 8.55095E-05 9.63369E+02 …

1.550 1.2773 0.1744 1.14632E+07 1.61011E-19 8.58699E-05 9.84345E+02 …

1.600 1.3023 0.1755 1.16446E+07 1.57486E-19 8.55077E-05 9.95705E+02 …

1.650 1.3274 0.1765 1.18112E+07 1.54435E-19 8.51379E-05 1.00558E+03 …

1.700 1.3524 0.1776 1.19637E+07 1.51880E-19 8.46714E-05 1.01298E+03 …

1.750 1.3775 0.1786 1.21027E+07 1.49842E-19 8.40324E-05 1.01702E+03 …

1.800 1.4025 0.1797 1.22291E+07 1.48717E-19 8.26948E-05 1.01129E+03 …

1.850 1.4276 0.1808 1.23435E+07 1.48570E-19 8.05582E-05 9.94371E+02 …

1.900 1.4526 0.1819 1.24465E+07 1.48859E-19 7.82711E-05 9.74203E+02 …

1.950 1.4777 0.1829 1.25388E+07 1.49490E-19 7.59324E-05 9.52104E+02 …

2.000 1.5027 0.1840 1.26210E+07 1.50503E-19 7.34945E-05 9.27575E+02 …

2.050 1.5277 0.1851 1.26936E+07 1.51683E-19 7.11853E-05 9.03601E+02 …

2.100 1.5528 0.1862 1.27573E+07 1.53118E-19 6.88997E-05 8.78974E+02 …

2.150 1.5778 0.1873 1.28125E+07 1.55036E-19 6.64100E-05 8.50878E+02 …

2.200 1.6029 0.1884 1.28598E+07 1.56863E-19 6.42824E-05 8.26656E+02 …

2.250 1.6279 0.1895 1.28995E+07 1.58530E-19 5.75434E-05 7.42284E+02 …

2.300 1.6530 0.1906 1.29323E+07 1.60626E-19 4.99741E-05 6.46280E+02 …

2.350 1.6780 0.1917 1.29585E+07 1.63378E-19 4.24092E-05 5.49559E+02 …

2.400 1.7031 0.1928 1.29785E+07 1.66520E-19 3.57684E-05 4.64219E+02 …

2.450 1.7281 0.1940 1.29927E+07 1.69767E-19 3.01135E-05 3.91255E+02 …

2.500 1.7531 0.1951 1.30015E+07 1.73674E-19 2.50982E-05 3.26313E+02 …

2.550 1.7782 0.1962 1.30051E+07 1.78817E-19 2.05300E-05 2.66996E+02 …

2.600 1.8032 0.1973 1.30041E+07 1.84275E-19 1.67184E-05 2.17408E+02 …

2.650 1.8283 0.1984 1.29985E+07 1.89119E-19 1.37486E-05 1.78712E+02 …

2.700 1.8533 0.1996 1.29889E+07 1.93825E-19 1.13376E-05 1.47262E+02 …

2.750 1.8784 0.2007 1.29753E+07 1.98668E-19 9.33825E-06 1.21166E+02 …

2.800 1.9034 0.2018 1.29581E+07 2.04422E-19 7.59581E-06 9.84270E+01 …

2.850 1.9285 0.2030 1.29375E+07 2.12369E-19 5.98993E-06 7.74945E+01 …

Summary statistics:

Sky background flux: 1.23951E+00 e-/pix/s

Thermal background flux: 1.19401E-01 e-/pix/s

telescope: 8.40874E-02 e-/pix/s

upstream: 3.13397E-04 e-/pix/s

downstream: 3.50000E-02 e-/pix/s

Noise variance per unit solid angle in one exposure:

sky only: 3.04255E+04 e-^2/arcsec^2

total: 4.43807E+04 e-^2/arcsec^2

Available galaxy density: 1.24152E+03 gal/deg^2

Again, we construct an input file for the galaxy clustering tools (“BAOREV/ref\_bao\_PhaseC”), using the Hα+[N ii] number counts out to *z* = 1.94, and [O iii] beyond that. Since the BAO and RSD figures of merit are defined for the 1 < *z* < 3 range, we begin the Hα redshift distribution at *z* = 1. Note that even with [O iii] emitters, we do not quite reach *z* = 3. The galaxy clustering input file is:

38 0.04121 0.001

1.000 0.025 1.500 1.00E-03 0.500

1.050 0.050 1.525 9.68E-04 0.500

1.100 0.050 1.550 9.30E-04 0.500

1.150 0.050 1.575 8.80E-04 0.500

1.200 0.050 1.600 8.25E-04 0.500

1.250 0.050 1.625 7.67E-04 0.500

1.300 0.050 1.650 7.10E-04 0.500

1.350 0.050 1.675 6.43E-04 0.500

1.400 0.050 1.700 5.78E-04 0.500

1.450 0.050 1.725 5.19E-04 0.500

1.500 0.050 1.750 4.67E-04 0.500

1.550 0.050 1.775 4.15E-04 0.500

1.600 0.050 1.800 3.64E-04 0.500

1.650 0.050 1.825 3.18E-04 0.500

1.700 0.050 1.850 2.72E-04 0.500

1.750 0.050 1.875 2.29E-04 0.500

1.800 0.050 1.900 1.95E-04 0.500

1.850 0.050 1.925 1.65E-04 0.500

1.900 0.065 1.950 1.38E-04 0.500

1.950 0.035 1.975 7.59E-05 0.500

2.000 0.050 2.000 7.35E-05 0.500

2.050 0.050 2.025 7.12E-05 0.500

2.100 0.050 2.050 6.89E-05 0.500

2.150 0.050 2.075 6.64E-05 0.500

2.200 0.050 2.100 6.43E-05 0.500

2.250 0.050 2.125 5.75E-05 0.500

2.300 0.050 2.150 5.00E-05 0.500

2.350 0.050 2.175 4.24E-05 0.500

2.400 0.050 2.200 3.58E-05 0.500

2.450 0.050 2.225 3.01E-05 0.500

2.500 0.050 2.250 2.51E-05 0.500

2.550 0.050 2.275 2.05E-05 0.500

2.600 0.050 2.300 1.67E-05 0.500

2.650 0.050 2.325 1.37E-05 0.500

2.700 0.050 2.350 1.13E-05 0.500

2.750 0.050 2.375 9.34E-06 0.500

2.800 0.050 2.400 7.60E-06 0.500

* 1. 0.028 2.425 5.99E-06 0.500

The BAO Fisher matrix code gives σ(*FD*) = 0.00692 and σ(*FH*) = 0.01275, so FoMBAO = 1.13×104. The RSD Fisher matrix code gives FoMRSD = 5.75×103.

## Weak Lensing

The configuration file for the imaging mode (“PhaseC/imBlue.dat”) is as follows. (This is designed to reproduce the effective areas for the modes without the full pupil mask.)

!IMAGING

!THERMAL 267. 0.06 1 1 220. 0.06 0.035

Big Telescope - On Axis - Imaging

2.370 0.310 0.11 282

0.495 0.366256787 0.306323858

0.5 0.365318869 0.305539418

0.505 0.366146443 0.306231571

0.51 0.36926364 0.30883868

0.515 0.3743946 0.313130029

0.52 0.381428981 0.31901333

0.525 0.390173683 0.32632708

0.53 0.400159746 0.33467906

0.535 0.411525099 0.344184628

0.54 0.423883542 0.35452078

0.545 0.436710943 0.365249152

0.55 0.450365918 0.376669677

0.555 0.464545024 0.388528566

0.56 0.479882734 0.401356468

0.565 0.495882503 0.414738094

0.57 0.51229606 0.428465795

0.575 0.528764788 0.44223964

0.58 0.544847314 0.455690481

0.585 0.56021261 0.468541455

0.59 0.574502059 0.480492631

0.595 0.587274288 0.491174859

0.6 0.598198269 0.500311279

0.605 0.606363668 0.507140523

0.61 0.613425635 0.513046895

0.615 0.618997969 0.517707392

0.62 0.623632385 0.521583449

0.625 0.62774267 0.525021142

0.63 0.632377086 0.528897199

0.635 0.636183928 0.532081103

0.64 0.639135609 0.534549782

0.645 0.641287303 0.53634938

0.65 0.642501078 0.537364538

0.655 0.64274935 0.537572184

0.66 0.641728675 0.536718529

0.665 0.640708001 0.535864873

0.67 0.639163195 0.534572854

0.675 0.637894248 0.533511553

0.68 0.638225278 0.533788414

0.685 0.638611479 0.534111419

0.69 0.639080438 0.534503639

0.695 0.639301124 0.534688213

0.7 0.639135609 0.534549782

0.705 0.637811491 0.533442338

0.71 0.636128756 0.53203496

0.715 0.634446022 0.530627582

0.72 0.633094317 0.529497065

0.725 0.632459844 0.528966415

0.73 0.632046057 0.528620338

0.735 0.63063918 0.527443678

0.785 0.681948785 0.570357166

0.79 0.683769448 0.571879902

0.795 0.684321165 0.572341338

0.8 0.685231496 0.573102706

0.805 0.688210764 0.575594457

0.81 0.691714161 0.578524571

0.815 0.69541066 0.581616188

0.82 0.69916233 0.584753949

0.825 0.702996757 0.587960924

0.83 0.705341551 0.589922025

0.835 0.707244972 0.591513977

0.84 0.709534594 0.593428933

0.845 0.711962145 0.595459249

0.85 0.7153552 0.598297076

0.855 0.720072373 0.602242348

0.86 0.725065405 0.606418338

0.865 0.730775667 0.611194194

0.87 0.735851456 0.615439399

0.875 0.741313446 0.620007609

0.88 0.746665093 0.624483532

0.885 0.751878811 0.628844096

0.89 0.756816671 0.632973943

0.895 0.760954542 0.636434708

0.9 0.764513111 0.639410966

0.905 0.768099267 0.642410296

0.91 0.771216463 0.645017405

0.915 0.773864701 0.647232295

0.92 0.775906051 0.648939606

0.925 0.776871554 0.649747118

0.93 0.777312927 0.650116266

0.935 0.777478442 0.650254697

0.94 0.776347424 0.649308754

0.945 0.77400263 0.647347654

0.95 0.767961338 0.642294937

0.955 0.770526818 0.644440611

0.96 0.773092298 0.646586286

0.965 0.772926783 0.646447855

0.97 0.772568168 0.646147922

0.975 0.771575079 0.645317338

0.98 0.770968191 0.64480976

0.985 0.769975102 0.643979176

0.99 0.768871669 0.643056305

0.995 0.768264782 0.642548726

1 0.767326864 0.641764286

1.005 0.766857905 0.641372066

1.01 0.766444118 0.64102599

1.015 0.766057917 0.640702985

1.02 0.765699301 0.640403052

1.025 0.765368272 0.640126191

1.03 0.765092413 0.639895473

1.035 0.764430354 0.639341751

1.04 0.764292425 0.639226392

1.045 0.764154496 0.639111033

1.05 0.764099324 0.639064889

1.055 0.76412691 0.639087961

1.06 0.764209668 0.639157177

1.065 0.764347597 0.639272535

1.07 0.764540697 0.639434038

1.075 0.764761384 0.639618612

1.08 0.765009656 0.639826258

1.085 0.765671715 0.64037998

1.09 0.765864816 0.640541483

1.095 0.766085503 0.640726057

1.1 0.766664805 0.641210564

1.105 0.766278603 0.640887559

1.11 0.766278603 0.640887559

1.115 0.766637219 0.641187492

1.12 0.766968248 0.641464353

1.125 0.766885491 0.641395138

1.13 0.767299278 0.641741214

1.135 0.767492379 0.641902717

1.14 0.767713065 0.642087291

1.145 0.767795823 0.642156506

1.15 0.768319953 0.64259487

1.155 0.76854064 0.642779444

1.16 0.768816498 0.643010162

1.165 0.769533729 0.643610028

1.17 0.76991993 0.643933032

1.175 0.770719919 0.644602114

1.18 0.771547493 0.645294267

1.185 0.77196128 0.645640343

1.19 0.772844026 0.64637864

1.195 0.773754358 0.647140008

1.2 0.774168145 0.647486085

1.205 0.774692275 0.647924448

1.21 0.775685364 0.648755032

1.215 0.776706039 0.649608687

1.22 0.777257755 0.650070123

1.225 0.778140501 0.650808419

1.23 0.779078419 0.651592859

1.235 0.779712892 0.65212351

1.24 0.780264608 0.652584945

1.245 0.780954254 0.653161739

1.25 0.781037011 0.653230955

1.255 0.781340455 0.653484744

1.26 0.781423212 0.653553959

1.265 0.781257698 0.653415529

1.27 0.781009425 0.653207883

1.275 0.780926668 0.653138668

1.28 0.780816325 0.653046381

1.285 0.780292194 0.652608017

1.29 0.780264608 0.652584945

1.295 0.780099094 0.652446515

1.3 0.780016336 0.652377299

1.305 0.780347366 0.652654161

1.31 0.78031978 0.652631089

1.315 0.780788739 0.653023309

1.32 0.781312869 0.653461672

1.325 0.781450798 0.653577031

1.33 0.782140443 0.654153825

1.335 0.782857674 0.654753691

1.34 0.783161118 0.655007481

1.345 0.783905935 0.655630419

1.35 0.784761095 0.656345643

1.355 0.785285226 0.656784007

1.36 0.786278315 0.657614591

1.365 0.786912788 0.658145241

1.37 0.787933463 0.658998897

1.375 0.78900931 0.659898696

1.38 0.789588612 0.660383203

1.385 0.790747216 0.661352217

1.39 0.791436861 0.661929011

1.395 0.791850648 0.662275088

1.4 0.792126506 0.662505805

1.405 0.791933406 0.662344303

1.41 0.791629962 0.662090513

1.415 0.791409275 0.661905939

1.42 0.791602376 0.662067442

1.425 0.792264435 0.662621164

1.43 0.792540293 0.662851882

1.435 0.793036838 0.663267174

1.44 0.793064424 0.663290245

1.445 0.792705808 0.662990312

1.45 0.792898909 0.663151815

1.455 0.793229939 0.663428676

1.46 0.793478211 0.663636322

1.465 0.793643726 0.663774753

1.47 0.793809241 0.663913183

1.475 0.794250614 0.664282331

1.48 0.794250614 0.664282331

1.485 0.794691987 0.66465148

1.49 0.79480233 0.664743767

1.495 0.79532646 0.66518213

1.5 0.795491975 0.665320561

1.505 0.795602318 0.665412848

1.51 0.796209206 0.665920427

1.515 0.796622993 0.666266503

1.52 0.797064366 0.666635652

1.525 0.797781597 0.667235518

1.53 0.798002284 0.667420092

1.535 0.798719515 0.668019958

1.54 0.799436746 0.668619824

1.545 0.799960876 0.669058187

1.55 0.800512592 0.669519623

1.555 0.800926379 0.669865699

1.56 0.801340167 0.670211776

1.565 0.801588439 0.670419422

1.57 0.802222912 0.670950072

1.575 0.802526356 0.671203862

1.58 0.802857386 0.671480723

1.585 0.803436688 0.67196523

1.59 0.804126333 0.672542024

1.595 0.805009079 0.673280321

1.6 0.806112512 0.674203191

1.605 0.807188358 0.67510299

1.61 0.808374548 0.676095076

1.615 0.809422809 0.676971804

1.62 0.810553827 0.677917746

1.625 0.812098632 0.679209765

1.63 0.813671023 0.680524856

1.635 0.814802041 0.681470798

1.64 0.815877888 0.682370597

1.645 0.816870977 0.683201181

1.65 0.817781309 0.683962549

1.655 0.818912327 0.684908492

1.66 0.819436457 0.685346855

1.665 0.820374375 0.686131295

1.67 0.821229535 0.68684652

1.675 0.821615736 0.687169525

1.68 0.821974352 0.687469458

1.685 0.822691583 0.688069324

1.69 0.823022612 0.688346185

1.695 0.823270885 0.688553831

1.7 0.824043287 0.68919984

1.705 0.82481569 0.68984585

1.71 0.825588093 0.690491859

1.715 0.82619498 0.690999438

1.72 0.827132898 0.691783878

1.725 0.827629443 0.69219917

1.73 0.828070815 0.692568318

1.735 0.828622532 0.693029754

1.74 0.82909149 0.693421974

1.745 0.829891479 0.694091055

1.75 0.83071777 0.694782135

1.755 0.830422666 0.694535321

1.76 0.830363645 0.694485958

1.765 0.829684906 0.693918285

1.77 0.828858615 0.693227205

1.775 0.828032324 0.692536125

1.78 0.827176522 0.691820364

1.785 0.826792887 0.691499505

1.79 0.826025616 0.690857788

1.795 0.825405898 0.690339478

1.8 0.824550096 0.689623717

1.805 0.824018909 0.689179451

1.81 0.824166461 0.689302858

1.815 0.823753316 0.688957319

1.82 0.824254992 0.689376903

1.825 0.824638628 0.689697761

1.83 0.825110794 0.690092664

1.835 0.82558296 0.690487567

1.84 0.826084637 0.690907151

1.845 0.826586314 0.691326735

1.85 0.82705848 0.691721638

1.855 0.827471626 0.692067178

1.86 0.827914282 0.6924374

1.865 0.828770084 0.693153161

1.87 0.829153719 0.693474019

1.875 0.829920989 0.694115736

1.88 0.830245604 0.694387232

1.885 0.830481687 0.694584684

1.89 0.830245604 0.694387232

1.895 0.830334135 0.694461276

1.9 0.830334135 0.694461276

1.905 0.830127562 0.694288506

1.91 0.830216093 0.694362551

1.915 0.829773437 0.693992329

1.92 0.829183229 0.693498701

1.925 0.828770084 0.693153161

1.93 0.827619178 0.692190585

1.935 0.826350231 0.691129284

1.94 0.824136951 0.689278177

2.08 0.830127562 0.694288506

We present here the galaxy yields from the H filter observations only (the deepest filter, but by using only one we are being conservative). The sky brightness is set to the median from the tiling plan of 1.49× the mean zodiacal brightness at the Ecliptic poles.

$ ./wletc.exe

Exposure time calculator v17

Mode: WL

Options: -DIN\_DLON -DOUT\_WL\_CAT -DOUT\_EXTRA\_PSF\_PROPERTIES

Enter telescope configuration [0=generic, 1=from file]: 1

Input file name: PhaseC/imBlue.dat

Using configuration: Big Telescope - On Axis - Imaging

Enter rms wavefront error (microns): .094

Enter detector type [e.g. 0=H2RG]: 2

Enter pointing jitter (arcsec rms per axis): .0144

Enter minimum wavelength (microns): 1.380

Enter maximum wavelength (microns): 1.774

Enter filter throughput: 1

Enter single exposure time (s): 140.26

Enter read noise floor (effective e- rms per pixel): 5

Enter dark current (e-/pix/sec): .015

Enter ecliptic latitude (degrees): 70.61

Enter ecliptic longitude relative to the Sun (degrees): 0

Enter Galactic reddening, E(B-V) (magnitudes): .035

Enter number of exposures: 5

Enter minimum resolution factor: .4

Enter maximum ellipticity error: .2

Enter input galaxy catalog file: data/2K.dat

Enter output galaxy catalog file: /dev/null

General properties:

PSF EE50: 1.30386E-01 arcsec

PSF effective area: 1.62342E-01 arcsec^2

PSF encircled energy: 0.377004, 0.758077, 0.908704 (at 0.1", 0.25", 0.5")

PSF centroid error coeff: 1.13754E-01 arcsec

PSF peak surface brightness: 2.20838E-01 /pix

Spatial frequency cutoff: 9.15876E-01 cycles/pix

Sampling case: Weakly undersampled

Min usable galaxy r\_eff: 1.06459E-01 arcsec

Sky background flux: 5.63415E-01 e-/pix/s

Thermal background flux: 6.49261E-02 e-/pix/s

telescope: 2.99036E-02 e-/pix/s

upstream: 2.24922E-05 e-/pix/s

downstream: 3.50000E-02 e-/pix/s

Noise variance per unit solid angle in one exposure:

sky only: 6.53095E+03 e-^2/arcsec^2

total: 1.49138E+04 e-^2/arcsec^2

Source counts per exposure:

at AB mag 20: 5.08526E+04 e-

at AB mag 21: 2.02448E+04 e-

at AB mag 22: 8.05959E+03 e-

at AB mag 23: 3.20858E+03 e-

at AB mag 24: 1.27736E+03 e-

at AB mag 25: 5.08526E+02 e-

5 sigma pt src threshold: 26.662 mag AB

5 sigma ext src threshold: 25.546 mag AB [r\_eff=0.3"]

| r\_eff |Om\_eff |penalty|resolution|lim mag |S/N at |

| | |factor | factor |(shapes)|shape |

|arcsec |arcsec2| | | AB |lim mag|

0.11220 0.3753 5.8007 0.42546 24.50025 24.085

0.12589 0.4195 5.0639 0.48247 24.51343 22.503

0.14125 0.4732 4.4667 0.53995 24.51626 21.134

0.15849 0.5383 3.9797 0.59637 24.50897 19.949

0.17783 0.6175 3.5804 0.65036 24.49183 18.922

0.19953 0.7141 3.2515 0.70076 24.46521 18.032

0.22387 0.8323 2.9794 0.74671 24.38399 18.000

0.25119 0.9772 2.7532 0.78775 24.29684 18.000

0.28184 1.1554 2.5644 0.82371 24.20593 18.000

0.31623 1.3748 2.4062 0.85470 24.11152 18.000

0.35481 1.6458 2.2732 0.88103 24.01386 18.000

0.39811 1.9810 2.1611 0.90313 23.91323 18.000

0.44668 2.3964 2.0661 0.92149 23.80988 18.000

0.50119 2.9122 1.9856 0.93661 23.70406 18.000

0.56234 3.5534 1.9172 0.94898 23.59602 18.000

0.63096 4.3518 1.8590 0.95905 23.48599 18.000

0.70795 5.3471 1.8093 0.96719 23.37418 18.000

0.79433 6.5892 1.7669 0.97376 23.26078 18.000

0.89125 8.1409 1.7306 0.97905 23.14599 18.000

1.00000 10.0809 1.6996 0.98328 23.02995 18.000

| z | dN/dz/dA |dNeff/dz/dA|

| | deg^-2 | deg^-2 |

0.100 6.81069E+04 6.63471E+04

0.300 4.12547E+04 3.94196E+04

0.500 6.04174E+04 5.74256E+04

0.700 1.14854E+05 1.09639E+05

0.900 5.54131E+04 5.25787E+04

1.100 7.34773E+04 6.99078E+04

1.300 6.26144E+04 5.93492E+04

1.500 5.19956E+04 4.84087E+04

1.700 2.90492E+04 2.73441E+04

1.900 3.42975E+04 3.17716E+04

2.100 2.62419E+04 2.41283E+04

2.300 1.96509E+04 1.80555E+04

2.500 1.70877E+04 1.56757E+04

2.700 1.44025E+04 1.31370E+04

2.900 4.51605E+03 4.04070E+03

3.100 6.10277E+03 5.47789E+03

3.300 2.44111E+03 2.13983E+03

3.500 3.17344E+03 2.85239E+03

3.700 1.22055E+03 1.06287E+03

3.900 1.22055E+02 1.13313E+02

Weak lensing n: 1.37288E+05 gal/deg^2

= 3.81355E+01 gal/arcmin^2

Weak lensing n\_eff: 1.29775E+05 gal/deg^2

= 3.60486E+01 gal/arcmin^2

The weak lensing input data file (“lensing/wl\_phaseC”) based on these galaxy densities is:

20 12 12.68 0.475 0.04121

0.10 1.435E-09 2.20E-03 3.20E-04

0.30 2.415E-09 2.60E-03 3.20E-04

0.50 1.658E-09 3.00E-03 3.20E-04

0.70 8.682E-10 3.40E-03 3.20E-04

0.90 1.810E-09 3.80E-03 3.20E-04

1.10 1.362E-09 4.20E-03 3.20E-04

1.30 1.604E-09 4.60E-03 3.20E-04

1.50 1.966E-09 5.00E-03 3.20E-04

1.70 3.481E-09 5.40E-03 3.20E-04

1.90 2.996E-09 5.80E-03 3.20E-04

2.10 3.945E-09 6.20E-03 3.20E-04

2.30 5.272E-09 6.60E-03 3.20E-04

2.50 6.073E-09 7.00E-03 3.20E-04

2.70 7.246E-09 7.40E-03 3.20E-04

2.90 2.356E-08 7.80E-03 3.20E-04

3.10 1.738E-08 8.20E-03 3.20E-04

3.30 4.449E-08 8.60E-03 3.20E-04

3.50 3.337E-08 9.00E-03 3.20E-04

3.70 8.956E-08 9.40E-03 3.20E-04

3.90 8.401E-07 9.80E-03 3.20E-04

Here we have used the same conversion from effective number density to shear error (sint=0.25). The third and fourth columns represent the photo-z error 0.002(1+*z*) (from HLIS 2.1.10) and shear calibration error 3.2×10­–4 (from HLIS 2.0.4) respectively. The area of 1700 deg2 is reported as a fraction of the sky, *f*sky = 0.04121.

For this survey, again using the FoMSWG tools, we find σ(*F*WL) = 1.41×10–3 and hence the inverse variance is

FoMPh = 5.06×105.

1. Point of contact; e-mail: hirata.10@osu.edu [↑](#footnote-ref-1)
2. URL: https://wfirst.gsfc.nasa.gov/science/WFIRST\_Reference\_Information.html [↑](#footnote-ref-2)
3. Some output columns that are not needed for this calculation are suppressed to save space. [↑](#footnote-ref-3)
4. Even though the Hα and [O iii] samples overlap, [O iii] could still improve the number of sources with measured spectroscopic redshifts because one could combine the detection S/N of both lines. We treat any benefit from this as added margin against the SRD requirements. [↑](#footnote-ref-4)
5. URL: https://wfirst.gsfc.nasa.gov/science/WFIRST\_Reference\_Information.html [↑](#footnote-ref-5)
6. Specifically, we use the function get\_wl\_fisher\_matrix with flags 0x18. [↑](#footnote-ref-6)