WFIRST AFTA Telescope Temperature Impacts

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SDT Telecon

September 26, 2014

Background

- Previous baseline telescope temperature (05/2013 report) was 270 K.
  - This was based on preliminary assessments 2 years ago.
- We have been asked to study the science impact of operations within the currently qualified range of temperatures for the fore optics
  - This means 277 K + 5 K (margin) = 282 K
- There is a sensitivity impact from increased thermal emission (3.2x in F184) from the primary and secondary mirrors at higher temperature.
- Previous assessment (01/2014) showed the greatest impact on the high latitude survey, less on supernovae and microlensing.
  - The coronagraph is a visible instrument and is not sensitive at wavelengths where the thermal emission is relevant.

Current Assumptions for Wide Field Channel

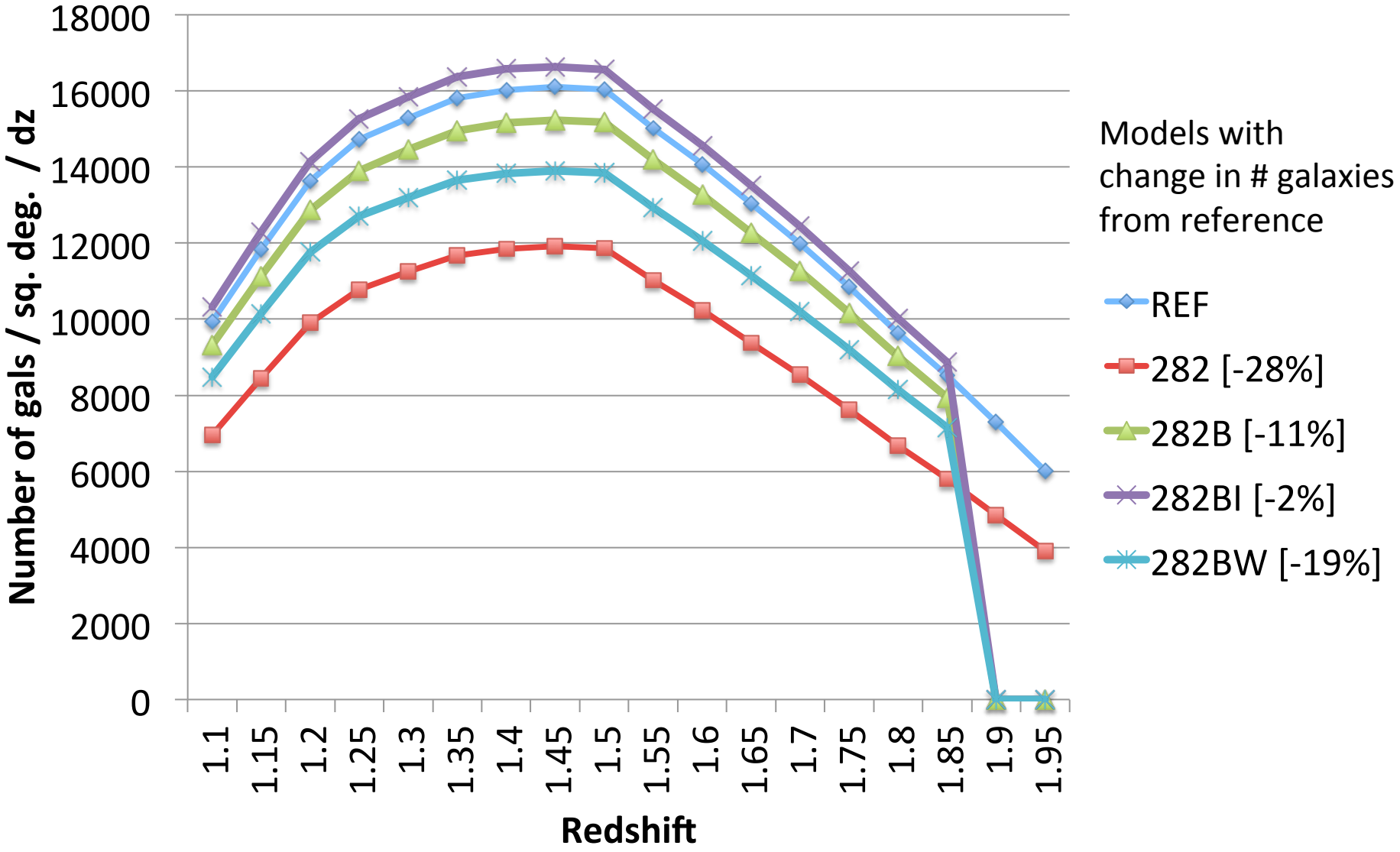
- 2.5% emissivity per surface for PM and SM
  - Current throughput model has 1.7% loss at 2 μm; the difference is allowances of various sorts.
- +2 K margin added to telescope temperature to account for miscellaneous effects (non uniform temperature, non-step function red cutoff).
- Out-of-band rejection 10^{-4} (requires attention for 2.5 μm cutoff detectors)
- Spider and central obstruction at PM/SM temperature if not blocked by exit pupil mask.
- Read noise 20 e per CDS, 5 e floor.

- *More details available in the write-up.*
- *This was for the wide field channel – the IFU / SN program impact is being reviewed.*

HLS - Spectroscopy

- Assessment based on 2013 SDT report HαLF model.
- "Reference" case is at 270 K, 1.35—1.95 μm bandpass ($1.06<z_{H\alpha}<1.97$), 200 nm rms wave front error.
- Also ran cases at 282 K:
  - "282" → Just changed telescope temperature
  - "282B" → Reduce bandpass, $z_{H\alpha}$ max = 1.88.
  - "282BI" and "282BW" → explored changes to the wavefront error (150 or 240 nm rms) [useful to compare the telescope temperature to the impact of other parameters.]

HLS Spectroscopy Impacts (Hα)



HLS - Imaging

- Largest impact expected in reddest filter (F184).
- Under reference conditions (3 min HLS exposure, 1.3x zodi at pole):
  - Expect 48 e/pix of zodi
  - Thermal emission is 213 e/pix at 282 K (67 e/pix @ 270 K)
  - Read noise variance is 100 e^2/pix.
  - Thermal emission contribution rises from 33% of total noise budget in an RSS sense (270 K) to 61% (282 K).
  - Corresponds to 0.30 mag loss of depth.
- Impact is smaller in the bluer filters.
- Cycle 5 will implement an exit pupil mask in H-band.

HLS – Imaging Depths

	Depth (270 K) Mag AB 5σ pt src	Depth (282 K) Mag AB 5σ pt src	PSF ½ light radius arcsec
Y	26.70	26.67	0.118
J	26.84	26.81	0.125
H	26.71	26.63	0.134
F184	26.13	25.83	0.143

Imaging Depths for longer exposures

Lim. mag.	F184		H		J	
	270 K	282 K	270 K	282 K	270 K	282 K
26.4	1243	2118	678	734	745	745
26.5	1412	2514	734	819	813	813
26.6	1610	2966	819	875	881	915
26.7	1864	3531	904	988	983	983
26.8	2147	4209	1017	1101	1050	1084
26.9	2514	5028	1130	1214	1186	1220
27.0	2938	6017	1271	1356	1288	1356
27.1	3474	7203	1412	1553	1457	1491
27.2	4096	8644	1610	1779	1627	1695
27.3	4859	10367	1864	2034	1830	1898
27.4	5763	12430	2147	2344	2067	2169
27.5	6893	14916	2486	2712	2373	2508
27.6	8220	17910	2909	3192	2745	2915
27.7	9831	21526	3418	3757	3186	3390
27.8	11780	25848	4039	4407	3695	3966
27.9	14096	31046	4774	5226	4339	4644
28.0	16921	37318	5678	6215	5085	5491

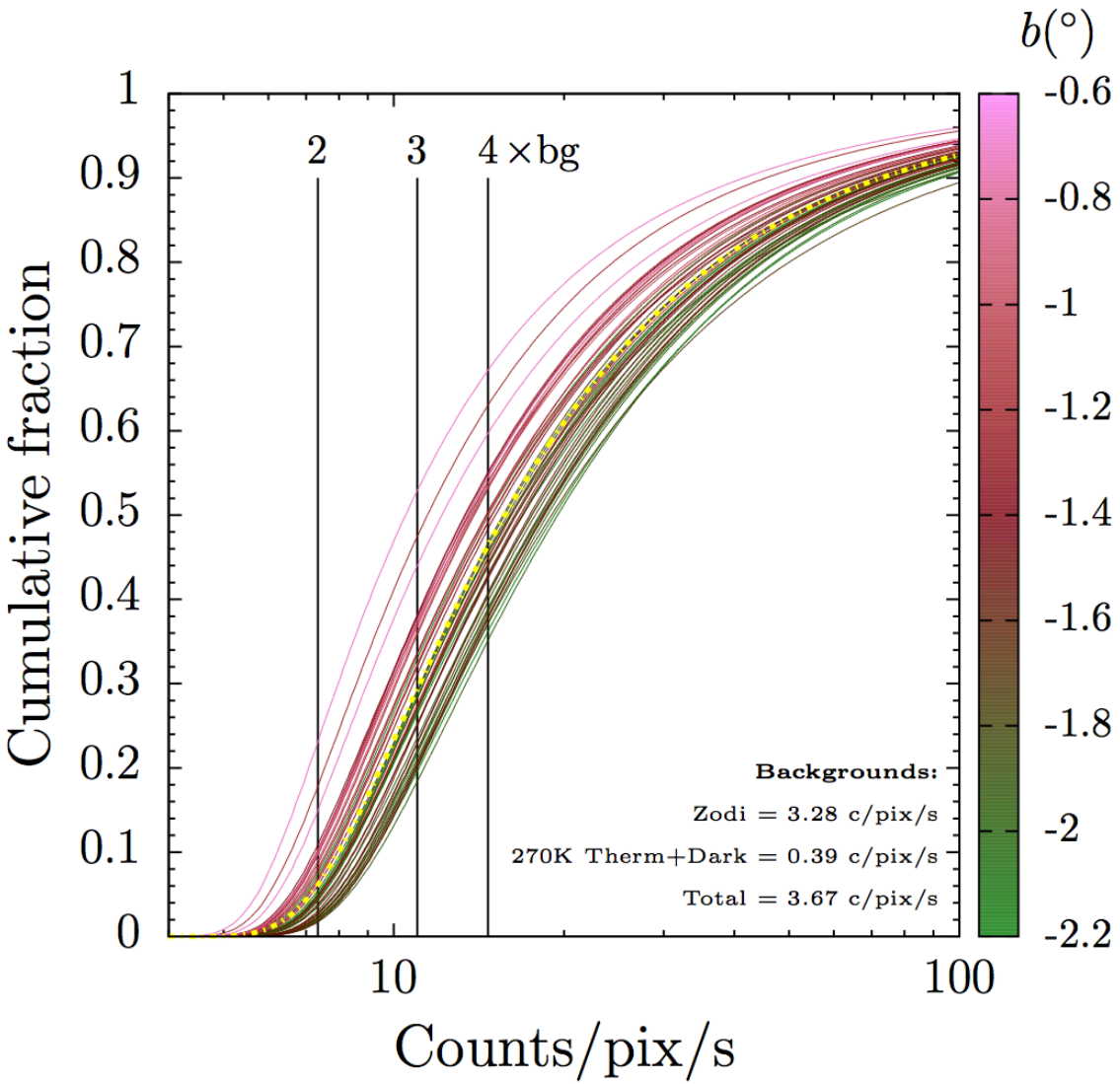
Total live time in seconds for HLS dithering strategy to reach 5σ pt src depth (AB mag).

Exposure time penalty at AB 28 is 2.2x (F184) or 1.1x (H).

Alternatively the long exposure in F184 is 0.43 mag shallower.

Microlensing

(Analysis by Matthew Penny)



- Median zodi is 3.3 e/p/s – dominant over thermal emission even at 282 K since we look in the ecliptic plane.
- The brightness of the stars in the bulge exceeds zodi in the vast majority of pixels.
- Increased RMS noise due to 282 K operation is estimated at 2.6% in median pixel (5.0% in 10th percentile faint pixel)