Simulated Peak Pixel Rates for 150 Brightest I-Band Stars for a Notional Astrometric Telescope

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ABSTRACT

The minimum, median, and maximum count rates for the single brightest pixel on a Notational Astrometric Telescope FPA for each of the 151 brightest stars are calculated, along with the corresponding integration times required to prevent saturation. For further requirement analysis, the count rates of the 151 brightest stars are increased by 25% and used to calculate new counts rates and necessary integration times. With an integration time of 20ms, 122 of the 152 brightest stars will saturate, while with an integration time of 1 ms, only 4 of the 152 brightest will saturate.

1. Introduction

The magnitude of stars a Notational Astrometric Telescope will be able to observe without saturation depends on the integration time of the Focal Plane Assembly (FPA). The 151 brightest stars and their integrated count rates, documented by Bartlett in TM 08-18, are particularly important because these stars are the ones that may cause saturation. In this technical memorandum, the proportion of the integrated count rate that falls on the brightest pixel is calculated for each spectral type. These proportions are then multiplied by the count rates of the 151 brightest stars to determine the projected count rates for the brightest pixels.

2. General Methodology

Normalized polychromatic PSFs, are generated by co-adding monochromatic PSFs using weights calculated by Dugan in TM 08-20. One of the polychromatic PSFs is shown in Figure 1.

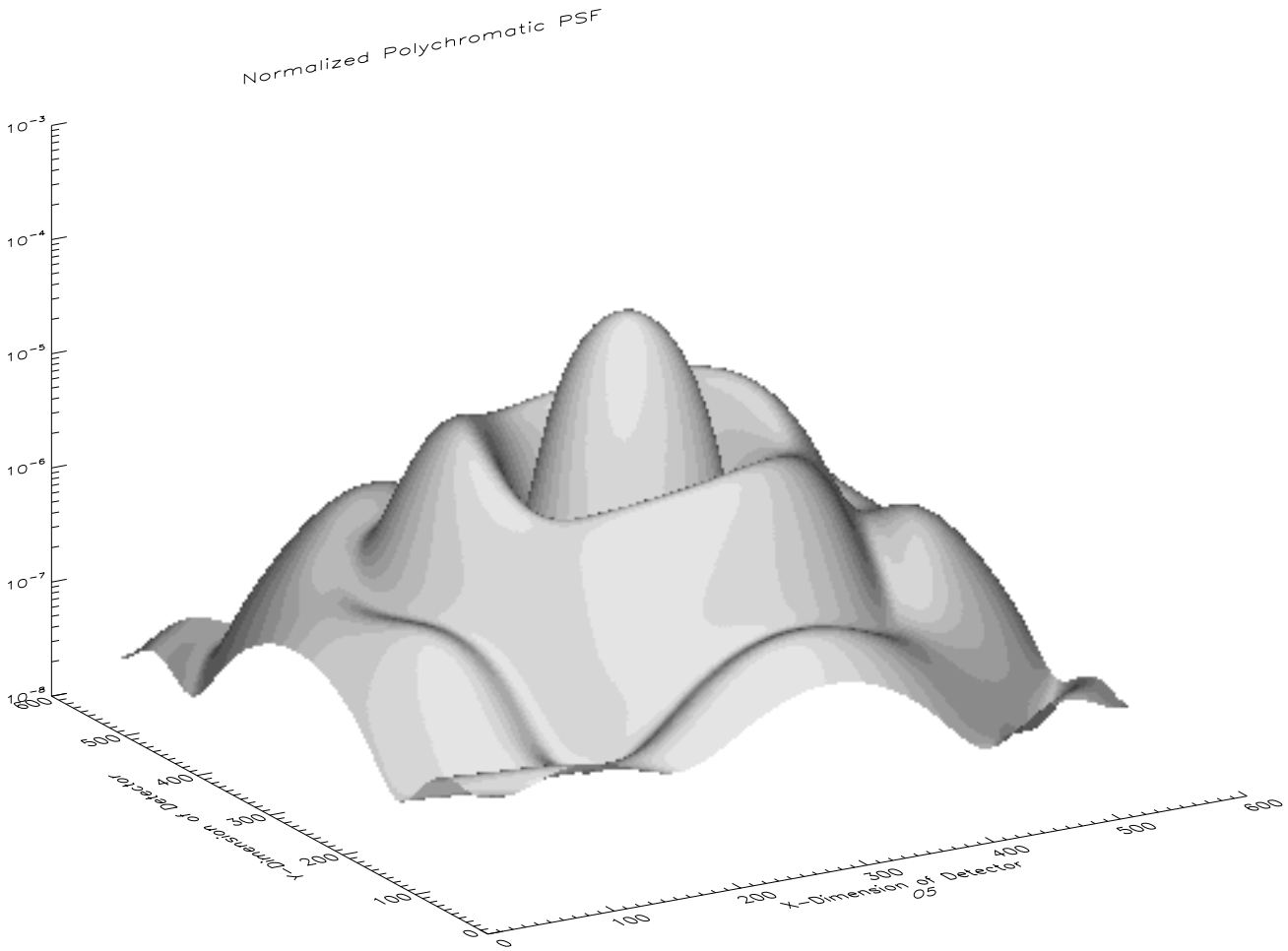


Figure 1: Polychromatic PSF for an O5
Note: Plot is logarithmic.

Monochromatic PSFs from SSG are 512×512 pixel matrices binned at 0.2 μm per pixel, and as a result, so are the polychromatic PSFs calculated in TM 08-20. The PSF relevant for a Notational Astrometric Telescope is 8×8 pixels binned at 10 μm per pixel. Thus, a new, smaller PSF region is extracted from the original matrix, and then re-binned by a factor of 50 to match the required 10 μm per pixel. The proportion between the highest PSF pixel value from the smaller PSF region and the sum of all PSF pixel values over the entire detector is calculated. Because all the polychromatic PSFs are normalized, that proportion is simply the PSF value of the brightest pixel.

The initial position of the extracted smaller PSF region within the original polychromatic PSF is varied over the spanning set of 12,769 sub pixel phase positions at 0.2 μm resolution. The smaller PSF region is rebinned from 400×400 at 0.2 μm to 8×8 at 10 μm afterward. This process is diagrammed in Figure 2.

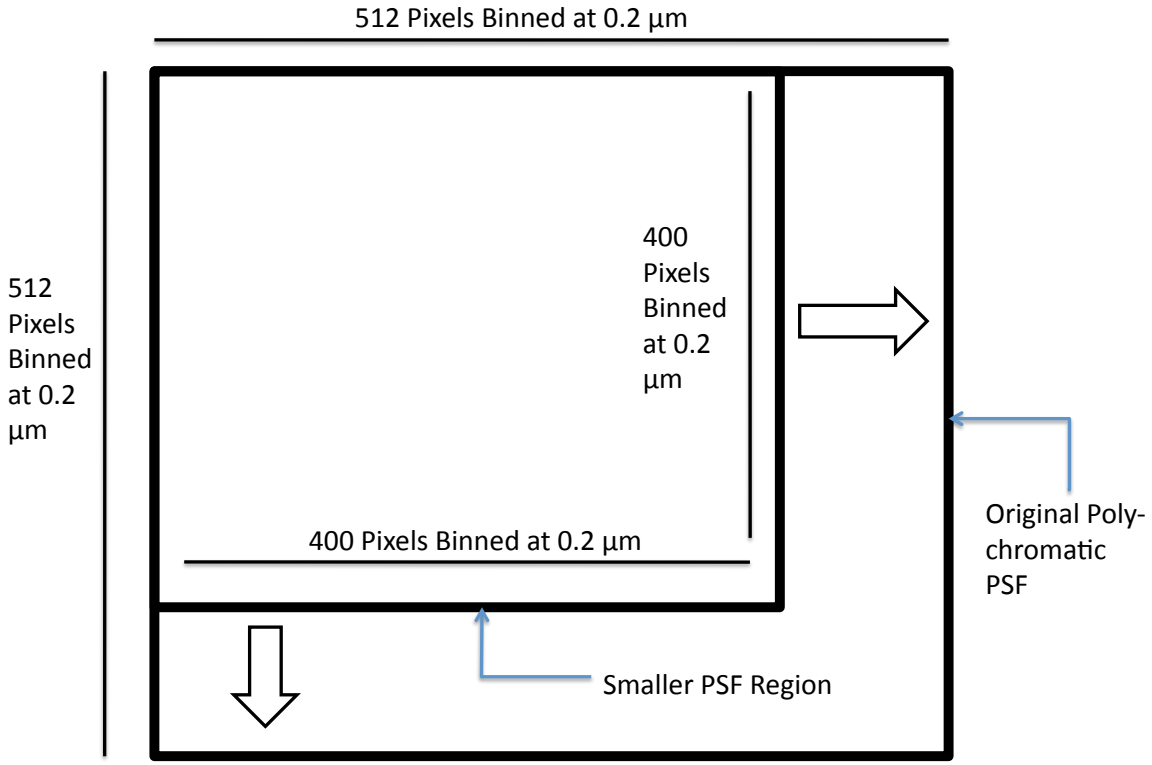
The biggest proportion from each iteration is retained, giving 12,769 values for the maximum proportions, or brightest PSF pixel values. A histograms of all the brightest PSF pixel values from each iteration for all spectral types is created for each spectral type along with an exceedence plot, which shows the fraction of all values for the brightest pixel in each iteration greater than a threshhold pixel value. The histogram for one of the spectral types, O5, is shown in Figure 3, while the exceedence plot for all the spectral types is shown in Figure 4.

Of the 12,769 values for the brightest PSF pixel for each spectral type, the minimum, median, and maximum values are recorded in Table 1.

Table 1: Limits on Brightest PSF Pixel Value

Spectral Type	Minimum	Median	Maximum
O5	0.1239	0.1821	0.2260
O9	0.1239	0.1820	0.2258
B5	0.1231	0.1777	0.2206
A5	0.1234	0.1791	0.2228
F5	0.1228	0.1774	0.2186
G5	0.1227	0.1767	0.2174
K4	0.1222	0.1755	0.2157
M1	0.1214	0.1729	0.2117
M5	0.1202	0.1691	0.2060
M6	0.1198	0.1674	0.2033

Note: Table values are all PSF value for brightest PSF pixel.



Note: The size of the smaller PSF region leaves 112 pixels binned at 0.2μm to the right and to the bottom. To analyze all possible smaller PSF regions, $(112 + 1)^2$= 12,769 iterations are required. After extraction, the smaller PSF region was rebinned from 400×400 at 0.2μm to 8×8 at 10μm.

Figure 2: Diagram of PSF Sampling

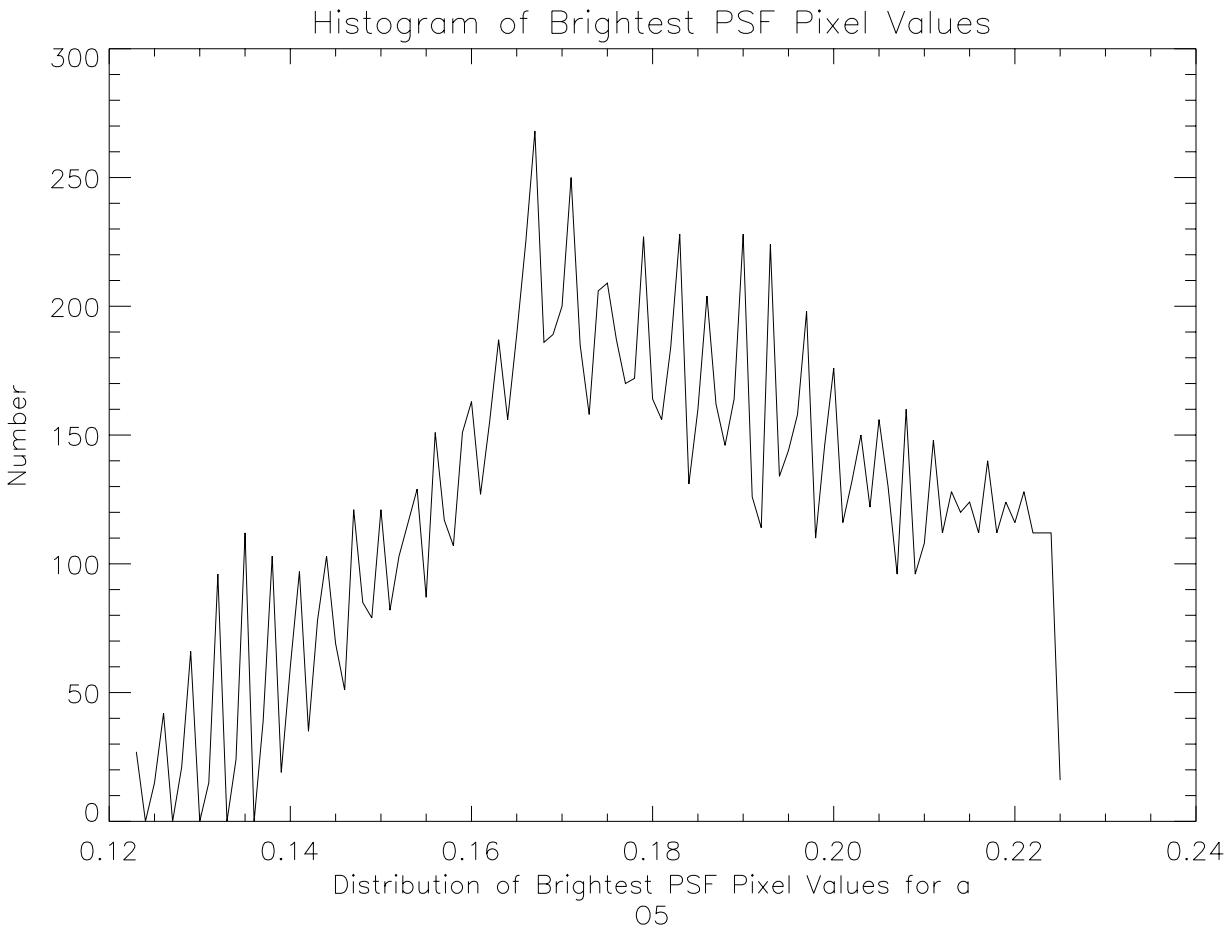


Figure 3: Histogram of Highest Pixel Ratios for an O5

Note: all the polychromatic PSFs are normalized so that each PSF pixel value is equal to the fraction of total light falling on the detector that will land in that particular pixel.

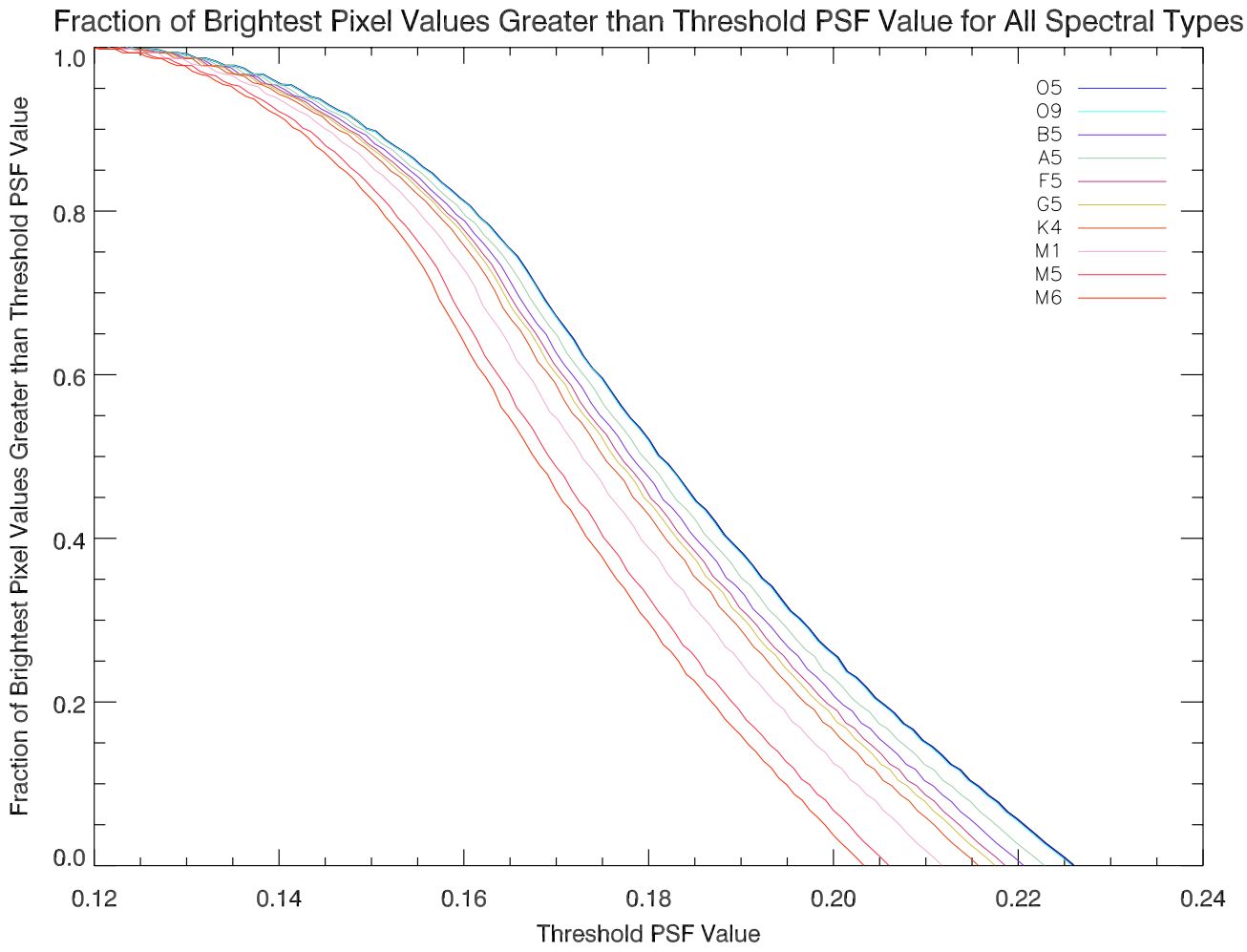


Figure 4: Exceedence Plot for All Spectral Types

3. Application to Brightest Stars

Each of the 151 brightest stars is matched with its spectral type and three corresponding limits, minimum, median, and maximum, on brightest PSF pixel value, recorded in Table 1. As stated in Section 2, the brightest PSF pixel values are equal to the proportion of total light that falls on the brightest pixel. Thus, every star's count rate is multiplied its spectral type's three limiting PSF pixel values to calculate the minimum, median, and maximum count rates for the brightest pixel. Those count rates are recorded in Table 2.

For purposes of this analysis, we assume a notional detector full well capacity of 10^5 electrons. To determine the number of read-outs per second required to prevent saturation of the detector from the given pixel count rates, each of the pixel count rates is divided by 10^5. The integration times for each star's count rates in milliseconds are calculated by inverting the required number of read-outs per millisecond. Those values are listed in Table 3. To set absolute parameters for the shortest necessary integration times, all the integration times are re-calculated for count rates that had been increased by 25%. Those values are listed in Table 4.

Table 5 provides a summary of 4 integration times, the brightest I_c band magnitude that can be observed using that integration time without saturation, and the number of the 151 brightest stars that saturate during that integration time.

4. Conclusions

As expected, because the polychromatic PSFs for earlier spectral types are sharper, earlier spectral types are more likely to saturate the brightest pixel on the detector than a later spectral type of the same magnitude. An O5 type star can have up to 22.6% of the total light landing on the detector falling on the brightest pixel while an M6 can have only 20.3% falling on the same pixel.

The number of the brightest stars that can cause saturation drops significantly after the detector's integration time drops to 5 ms or shorter, as shown in Table 5. With an integration time of 10 ms, 51 of the brightest stars saturate the detector, whereas with integration times of 5 and 1 ms, only 15 and 4 of the brightest stars can saturate the detector, respectively.

Table 2: Brightest Pixel Count Rates of Brightest Stars

Stars Listed by I-band Brightness	Hipparcos Number	Common Name	Minimum Pixel Count Rate	Median Pixel Count Rate	Maximum Pixel Count Rate
1	27989	Betelgeuse	110	156	191
2	80763	Antares	107	152	186
3	32349	Sirius	73.6	107	133
4	69673	Arcturus	63.5	91.2	112
5	30438	Canopus	43.4	62.6	77.2
6	21421	Aldebaran	41.4	59.8	73.7
7	61084	γ Cru	39.8	56.0	68.2
8	24608	Capella	39.1	55.7	68.2
9	71683	α Cen A	37.7	54.3	66.8
10	112122	β Gru	31.6	44.5	54.2
11	37279	Procyon	21.5	31.1	38.3
12	91262	Vega	19.2	27.9	34.7
13	113881	Scheat	17.4	24.8	30.3
14	24436	Rigel	17.3	25.0	31.0
15	37826	Pollux	16.6	23.8	29.2
16	5447	Mirach	14.5	20.6	25.2
17	82273	α TrA	12.9	18.5	22.8
18	71681	α Cen B	12.8	18.4	22.6
19	97649	Altair	12.7	18.4	22.9
20	44816	λ Vel	12.0	17.2	21.2
21	14354	ρ Per	11.7	16.7	20.4
22	14135	Menkar	11.6	16.5	20.2
23	30343	μ Gem	11.6	16.5	20.2
24	46390	Alphard	11.4	16.3	20.0
25	72607	Kochab	11.2	16.1	19.9
26	29655	η Gem	11.2	15.9	19.5
27	7588	Achernar	11.2	16.2	20.1
28	107259	Erakis	10.7	15.2	18.6
29	41037	ϵ Car	10.4	14.7	18.3
30	87833	Etamin	10.4	14.9	18.3
31	9640	Almach	10.1	14.6	18.2
32	10826	Mira	9.60	13.4	16.3
33	54061	Dubhe	9.66	14.0	17.2
34	50583	Algieba	9.10	13.0	16.1
35	89642	η Sgr	8.87	12.6	15.5
36	68702	Agena	9.00	13.0	16.1
37	9884	Hamal	8.77	12.6	15.5
38	21479	HD 29712	8.5	11.9	14.5
39	79593	δ Oph	8.5	12.1	14.8
40	92862	13 Lyr	8.16	11.5	14.0
41	107315	Enif	8.15	11.7	14.4
42	34922	HD 56096	8.01	11.3	13.7
43	113368	Fomalhaut	7.86	11.4	14.2
44	73714	σ Lib	7.58	10.7	13.0
45	60718	α Cru	7.69	11.1	13.8
46	3419	β Cet	7.57	10.9	13.4
47	68933	5 Cen	7.50	10.8	13.2
48	35264	π Pup	7.43	10.7	13.1
49	102098	Deneb	7.30	10.6	13.2
50	3179	Schedar	7.09	10.2	12.5
51	63090	δ Vir	6.73	9.46	11.5
52	15863	Mirfak	6.81	9.84	12.1
53	34444	Wezen	6.81	9.84	12.1
54	82396	ϵ Sco	6.59	9.46	11.6
55	18543	Zaurak	6.55	9.32	11.4
56	67457	2 Cen	6.48	9.12	11.1
57	80704	30 Her	6.28	8.78	10.7
58	65474	Spica	6.40	9.24	11.5
59	23015	ι Aur	6.35	9.12	11.2

Note: Count Rates in Electrons Per 10^{-6} Seconds

Table 2 Continued: Brightest Pixel Count Rates of Brightest Stars

Stars Listed by I-band Brightness	Hipparcos Number	Common Name	Minimum Pixel Count Rate	Median Pixel Count Rate	Maximum Pixel Count Rate
60	59929	ϵ Mus	6.19	8.71	10.6
61	11767	Polaris	6.15	8.89	10.9
62	97278	Tarazed	6.07	8.71	10.7
63	15474	16 Eri	5.97	8.39	10.2
64	2081	α Phe	6.01	8.63	10.6
65	50801	μ UMa	5.97	8.50	10.4
66	17678	γ Hyi	5.81	8.27	10.1
67	48036	HD 84748	5.73	8.01	9.73
68	85258	β Ara	5.74	8.24	10.1
69	89931	δ Sgr	5.58	8.02	9.86
70	86228	HD 159532	5.56	8.03	9.90
71	72105	Izar	5.48	7.96	9.90
72	49669	Regulus	5.18	7.47	9.28
73	102488	ϵ Cyg	5.05	7.25	8.91
74	45860	α Lyn	4.97	7.07	8.66
75	110130	α Tuc	4.95	7.11	8.74
76	62434	Mimosa	4.90	7.07	8.78
77	83081	ζ Ara	4.86	6.98	8.58
78	36850	Castor	4.87	7.06	8.79
79	77070	Unukalhai	4.77	6.86	8.43
80	46701	HD 82668	4.64	6.67	8.20
81	100453	Sadr	4.62	6.68	8.23
82	68815	HD 122250	4.47	6.25	7.59
83	92791	12 Lyr	4.36	6.14	7.48
84	111043	HD 213080	4.32	6.08	7.41
85	45238	β Car	4.36	6.32	7.87
86	84345	Rasalgethi	4.24	5.97	7.27
87	86742	Cebalrai	4.27	6.14	7.55
88	112961	λ Aqr	4.25	6.05	7.41
89	33856	σ CMa	4.24	6.08	7.48
90	6867	γ Phe	4.20	6.03	7.41
91	23685	ϵ Lep	4.16	5.97	7.34
92	65835	HD 117287	4.08	5.70	6.92
93	33579	Adara	4.15	5.99	7.44
94	98608	HD 189124	4.04	5.64	6.85
95	36377	σ Pup	4.08	5.86	7.21
96	25428	Elnath	4.00	5.77	7.17
97	61359	β Crv	3.88	5.59	6.87
98	52727	μ Vel	3.84	5.53	6.81
99	90496	λ Sgr	3.83	5.50	6.76
100	73199	HD 132813	3.77	5.30	6.45
101	109268	Alnair	3.86	5.57	6.91
102	90185	Kaus Australis	3.86	5.57	6.91
103	25945	119 Tau	3.80	5.42	6.63
104	28404	π Aur	3.77	5.37	6.57
105	59316	Minkar	3.79	5.45	6.69
106	62956	Alioth	3.79	5.51	6.85
107	32768	τ Pup	3.76	5.40	6.63
108	37819	HD 63032	3.76	5.40	6.63
109	17884	HD 23475	3.70	5.27	6.45
110	109492	ζ Cep	3.72	5.35	6.57
111	80816	β Her	3.64	5.24	6.44
112	32246	ϵ Gem	3.66	5.31	6.60
113	26311	Alnilam A	3.62	5.22	6.48
114	28360	Menkalinan	3.62	5.26	6.54
115	84380	π Her	3.59	5.15	6.33
116	25336	Bellatrix	3.58	5.17	6.42
117	85670	β Dra	3.57	5.14	6.33
118	98337	γ Sge	3.56	5.11	6.28
119	85927	Shaula	3.58	5.17	6.42

Note: Count Rates in Electrons Per 10^{-6} Seconds

Table 2 Continued: Brightest Pixel Count Rates of Brightest Stars

Stars Listed by I-band Brightness	Hipparcos Number	Common Name	Minimum Pixel Count Rate	Median Pixel Count Rate	Maximum Pixel Count Rate
120	42913	δ Vel	3.53	5.12	6.36
121	746	Caph	3.51	5.07	6.24
122	110256	ϵ Oct	3.42	4.78	5.81
123	31681	Alhena	3.49	5.07	6.31
124	52943	ν Hya	3.46	4.97	6.11
125	39953	γ Vel	3.51	5.15	6.40
126	80331	η Dra	3.47	5.00	6.15
127	8837	ψ Phe	3.37	4.74	5.78
128	54539	ψ UMa	3.40	4.88	5.99
129	86032	Rasalhague	3.43	4.98	6.19
130	26727	Alnitak	3.41	5.01	6.22
131	98688	62 Sgr	3.28	4.61	5.62
132	45556	ι Car	3.37	4.89	6.08
133	67301	Alcaid	3.36	4.85	6.02
134	50371	HD 89388	3.30	4.74	5.83
135	25606	Nihal	3.29	4.73	5.82
136	75177	HD 136422	3.18	4.57	5.62
137	24169	HD 33664	3.09	4.32	5.25
138	88635	γ Sgr	3.15	4.53	5.57
139	95947	Albereo	3.13	4.49	5.52
140	45058	HD 78712	3.06	4.28	5.20
141	80047	HD 145366	3.05	4.29	5.22
142	63608	Vindemiatrix	3.08	4.44	5.46
143	27628	β Col	3.07	4.41	5.42
144	154	30 Psc	3.05	4.34	5.32
145	56211	λ Dra	3.02	4.30	5.27
146	67927	η Boo	3.05	4.40	5.41
147	109074	Sadalmelik	3.05	4.40	5.41
148	100751	Peacock	3.03	4.38	5.44
149	57632	Denebola	3.04	4.42	5.49
150	87261	HD 161892	3.01	4.33	5.32
151	3092	δ And	3.01	4.33	5.32

Note: Count Rates in Electrons Per 10^{-6} Seconds

Table 3: Integration Times of Count Rates of Brightest Stars

Stars Listed by I-band Brightness	Hipparcos Number	Common Name	Maximum Required Integration Time (ms)	Median Required Integration Time (ms)	Minimum Required Integration Time (ms)
1	27989	Betelgeuse	...	...	...
2	80763	Antares	...	...	...
3	32349	Sirius	1	...	...
4	69673	Arcturus	1	1	...
5	30438	Canopus	2	1	1
6	21421	Aldebaran	2	1	1
7	61084	γ Cru	2	1	1
8	24608	Capella	2	1	1
9	71683	α Cen A	2	1	1
10	112122	β Gru	3	2	1
11	37279	Procyon	4	3	2
12	91262	Vega	5	3	2
13	113881	Scheat	5	4	3
14	24436	Rigel	5	4	3
15	37826	Pollux	6	4	3
16	5447	Mirach	6	4	3
17	82273	α TrA	7	5	4
18	71681	α Cen B	7	5	4
19	97649	Altair	7	5	4
20	44816	λ Vel	8	5	4
21	14354	ρ Per	8	6	4
22	14135	Menkar	8	6	4
23	30343	μ Gem	8	6	4
24	46390	Alphard	8	6	4
25	72607	Kochab	8	6	5
26	29655	η Gem	8	6	5
27	7588	Achernar	8	6	4
28	107259	Erakis	9	6	5
29	41037	ϵ Car	9	6	5
30	87833	Etamin	9	6	5
31	9640	Almach	9	6	5
32	10826	Mira	10	7	6
33	54061	Dubhe	10	7	5
34	50583	Algieba	10	7	6
35	89642	η Sgr	11	7	6
36	68702	Agena	11	7	6
37	9884	Hamal	11	7	6
38	21479	HD 29712	11	8	6
39	79593	δ Oph	11	8	6
40	92862	13 Lyr	12	8	7
41	107315	Enif	12	8	6
42	34922	HD 56096	12	8	7
43	113368	Fomalhaut	12	8	7
44	73714	σ Lib	13	9	7
45	60718	α Cru	13	9	7
46	3419	β Cet	13	9	7
47	68933	5 Cen	13	9	7
48	35264	π Pup	13	9	7
49	102098	Deneb	13	9	7
50	3179	Schedar	14	9	7
51	63090	δ Vir	14	10	8
52	15863	Mirfak	14	10	8
53	34444	Wezen	14	10	8
54	82396	ϵ Sco	15	10	8
55	18543	Zaurak	15	10	8
56	67457	2 Cen	15	10	9
57	80704	30 Her	15	11	9
58	65474	Spica	15	10	8
59	23015	ι Aur	15	10	8

Table 3 Continued: Integration Times of Count Rates of Brightest Stars

Stars Listed by I-band Brightness	Hipparcos Number	Common Name	Maximum Required Integration Time (ms)	Median Required Integration Time (ms)	Minimum Required Integration Time (ms)
60	59929	ϵ Mus	16	11	9
61	11767	Polaris	16	11	9
62	97278	Tarazed	16	11	9
63	15474	16 Eri	16	11	9
64	2081	α Phe	16	11	9
65	50801	μ UMa	16	11	9
66	17678	γ Hyi	17	12	9
67	48036	HD 84748	17	12	10
68	85258	β Ara	17	12	9
69	89931	δ Sgr	17	12	10
70	86228	HD 159532	17	12	10
71	72105	Izar	18	12	10
72	49669	Regulus	19	13	10
73	102488	ϵ Cyg	19	13	11
74	45860	α Lyn	20	14	11
75	110130	α Tuc	20	14	11
76	62434	Mimosa	20	14	11
77	83081	ζ Ara	20	14	11
78	36850	Castor	20	14	11
79	77070	Unukalhai	20	14	11
80	46701	HD 82668	21	14	12
81	100453	Sadr	21	14	12
82	68815	HD 122250	22	16	13
83	92791	12 Lyr	22	16	13
84	111043	HD 213080	23	16	13
85	45238	β Car	22	15	12
86	84345	Rasalgethi	23	16	13
87	86742	Cebalrai	23	16	13
88	112961	λ Aqr	23	16	13
89	33856	σ CMa	23	16	13
90	6867	γ Phe	23	16	13
91	23685	ϵ Lep	24	16	13
92	65835	HD 117287	24	17	14
93	33579	Adara	24	16	13
94	98608	HD 189124	24	17	14
95	36377	σ Pup	24	17	13
96	25428	Elnath	25	17	13
97	61359	β Crv	25	17	14
98	52727	μ Vel	26	18	14
99	90496	λ Sgr	26	18	14
100	73199	HD 132813	26	18	15
101	109268	Alnair	25	17	14
102	90185	Kaus Australis	25	17	14
103	25945	119 Tau	26	18	15
104	28404	π Aur	26	18	15
105	59316	Minkar	26	18	14
106	62956	Alioth	26	18	14
107	32768	τ Pup	26	18	15
108	37819	HD 63032	26	18	15
109	17884	HD 23475	27	18	15
110	109492	ζ Cep	26	18	15
111	80816	β Her	27	19	15
112	32246	ϵ Gem	27	18	15
113	26311	Alnilam A	27	19	15
114	28360	Menkalinan	27	19	15
115	84380	π Her	27	19	15
116	25336	Bellatrix	27	19	15
117	85670	β Dra	28	19	15
118	98337	γ Sge	28	19	15
119	85927	Shaula	27	19	15

Table 3 Continued: Integration Times of Count Rates of Brightest Stars

Stars Listed by I-band Brightness	Hipparcos Number	Common Name	Maximum Required Integration Time (ms)	Median Required Integration Time (ms)	Minimum Required Integration Time (ms)
120	42913	δ Vel	28	19	15
121	746	Caph	28	19	16
122	110256	ϵ Oct	29	20	17
123	31681	Alhena	28	19	15
124	52943	ν Hya	28	20	16
125	39953	γ Vel	28	19	15
126	80331	η Dra	28	19	16
127	8837	ψ Phe	29	21	17
128	54539	ψ UMa	29	20	16
129	86032	Rasalhague	29	20	16
130	26727	Alnitak	29	19	16
131	98688	62 Sgr	30	21	17
132	45556	ι Car	29	20	16
133	67301	Alcaid	29	20	16
134	50371	HD 89388	30	21	17
135	25606	Nihal	30	21	17
136	75177	HD 136422	31	21	17
137	24169	HD 33664	32	23	19
138	88635	γ Sgr	31	22	17
139	95947	Albereo	32	22	18
140	45058	HD 78712	32	23	19
141	80047	HD 145366	32	23	19
142	63608	Vindemiatrix	32	22	18
143	27628	β Col	32	22	18
144	154	30 Psc	32	23	18
145	56211	λ Dra	33	23	18
146	67927	η Boo	32	22	18
147	109074	Sadalmelik	32	22	18
148	100751	Peacock	32	22	18
149	57632	Denebola	32	22	18
150	87261	HD 161892	33	23	18
151	3092	δ And	33	23	18

Table 4: Integration Times of Increased Count Rates of Brightest Stars

Stars Listed by I-band Brightness	Hipparcos Number	Common Name	Maximum Required Integration Time (ms)	Median Required Integration Time (ms)	Minimum Required Integration Time (ms)
1	27989	Betelgeuse	...	...	...
2	80763	Antares	...	...	...
3	32349	Sirius	1	...	...
4	69673	Arcturus	1	...	...
5	30438	Canopus	1	1	1
6	21421	Aldebaran	1	1	1
7	61084	γ Cru	2	1	1
8	24608	Capella	2	1	1
9	71683	α Cen A	2	1	1
10	112122	β Gru	2	1	1
11	37279	Procyon	3	2	2
12	91262	Vega	4	2	2
13	113881	Scheat	4	3	2
14	24436	Rigel	4	3	2
15	37826	Pollux	4	3	2
16	5447	Mirach	5	3	3
17	82273	α TrA	6	4	3
18	71681	α Cen B	6	4	3
19	97649	Altair	6	4	3
20	44816	λ Vel	6	4	3
21	14354	ρ Per	6	4	3
22	14135	Menkar	6	4	3
23	30343	μ Gem	6	4	3
24	46390	Alphard	7	4	3
25	72607	Kochab	7	4	4
26	29655	η Gem	7	5	4
27	7588	Achernar	7	4	3
28	107259	Erakis	7	5	4
29	41037	ϵ Car	7	5	4
30	87833	Etamin	7	5	4
31	9640	Almach	7	5	4
32	10826	Mira	8	5	4
33	54061	Dubhe	8	5	4
34	50583	Algieba	8	6	4
35	89642	η Sgr	9	6	5
36	68702	Agena	8	6	4
37	9884	Hamal	9	6	5
38	21479	HD 29712	9	6	5
39	79593	δ Oph	9	6	5
40	92862	13 Lyr	9	6	5
41	107315	Enif	9	6	5
42	34922	HD 56096	9	7	5
43	113368	Fomalhaut	10	7	5
44	73714	σ Lib	10	7	6
45	60718	α Cru	10	7	5
46	3419	β Cet	10	7	5
47	68933	5 Cen	10	7	6
48	35264	π Pup	10	7	6
49	102098	Deneb	10	7	6
50	3179	Schedar	11	7	6
51	63090	δ Vir	11	8	6
52	15863	Mirfak	11	8	6
53	34444	Wezen	11	8	6
54	82396	ϵ Sco	12	8	6
55	18543	Zaurak	12	8	7
56	67457	2 Cen	12	8	7
57	80704	30 Her	12	9	7
58	65474	Spica	12	8	6
59	23015	ι Aur	12	8	7

Table 4 Continued: Integration Times of Increased Count Rates of Brightest Stars

Stars Listed by I-band Brightness	Hipparcos Number	Common Name	Maximum Required Integration Time (ms)	Median Required Integration Time (ms)	Minimum Required Integration Time (ms)
60	59929	ϵ Mus	12	9	7
61	11767	Polaris	13	9	7
62	97278	Tarazed	13	9	7
63	15474	16 Eri	13	9	7
64	2081	α Phe	13	9	7
65	50801	μ UMa	13	9	7
66	17678	γ Hyi	13	9	7
67	48036	HD 84748	13	9	8
68	85258	β Ara	13	9	7
69	89931	δ Sgr	14	9	8
70	86228	HD 159532	14	9	8
71	72105	Izar	14	10	8
72	49669	Regulus	15	10	8
73	102488	ϵ Cyg	15	11	8
74	45860	α Lyn	16	11	9
75	110130	α Tuc	16	11	9
76	62434	Mimosa	16	11	9
77	83081	ζ Ara	16	11	9
78	36850	Castor	16	11	9
79	77070	Unukalhai	16	11	9
80	46701	HD 82668	17	11	9
81	100453	Sadr	17	11	9
82	68815	HD 122250	17	12	10
83	92791	12 Lyr	18	13	10
84	111043	HD 213080	18	13	10
85	45238	β Car	18	12	10
86	84345	Rasalgethi	18	13	11
87	86742	Cebalrai	18	13	10
88	112961	λ Aqr	18	13	10
89	33856	σ CMa	18	13	10
90	6867	γ Phe	19	13	10
91	23685	ϵ Lep	19	13	10
92	65835	HD 117287	19	14	11
93	33579	Adara	19	13	10
94	98608	HD 189124	19	14	11
95	36377	σ Pup	19	13	11
96	25428	Elnath	19	13	11
97	61359	β Crv	20	14	11
98	52727	μ Vel	20	14	11
99	90496	λ Sgr	20	14	11
100	73199	HD 132813	21	15	12
101	109268	Alnair	20	14	11
102	90185	Kaus Australis	20	14	11
103	25945	119 Tau	21	14	12
104	28404	π Aur	21	14	12
105	59316	Minkar	21	14	11
106	62956	Alioth	21	14	11
107	32768	τ Pup	21	14	12
108	37819	HD 63032	21	14	12
109	17884	HD 23475	21	15	12
110	109492	ζ Cep	21	14	12
111	80816	β Her	22	15	12
112	32246	ϵ Gem	21	15	12
113	26311	Alnilam A	22	15	12
114	28360	Menkalinan	22	15	12
115	84380	π Her	22	15	12
116	25336	Bellatrix	22	15	12
117	85670	β Dra	22	15	12
118	98337	γ Sge	22	15	12
119	85927	Shaula	22	15	12

Table 4 Continued: Integration Times of Increase Count Rates of Brightest Stars

Stars Listed by I-band Brightness	Hipparcos Number	Common Name	Maximum Required Integration Time (ms)	Median Required Integration Time (ms)	Minimum Required Integration Time (ms)
120	42913	δ Vel	22	15	12
121	746	Caph	22	15	12
122	110256	ϵ Oct	23	16	13
123	31681	Alhena	22	15	12
124	52943	ν Hya	23	16	13
125	39953	γ Vel	22	15	12
126	80331	η Dra	23	15	13
127	8837	ψ Phe	23	16	13
128	54539	ψ UMa	23	16	13
129	86032	Rasalhague	23	16	12
130	26727	Alnitak	23	15	12
131	98688	62 Sgr	24	17	14
132	45556	ι Car	23	16	13
133	67301	Alcaid	23	16	13
134	50371	HD 89388	24	16	13
135	25606	Nihal	24	16	13
136	75177	HD 136422	25	17	14
137	24169	HD 33664	25	18	15
138	88635	γ Sgr	25	17	14
139	95947	Albereo	25	17	14
140	45058	HD 78712	26	18	15
141	80047	HD 145366	26	18	15
142	63608	Vindemiatrix	25	18	14
143	27628	β Col	26	18	14
144	154	30 Psc	26	18	15
145	56211	λ Dra	26	18	15
146	67927	η Boo	26	18	14
147	109074	Sadalmelik	26	18	14
148	100751	Peacock	26	18	14
149	57632	Denebola	26	18	14
150	87261	HD 161892	26	18	15
151	3092	δ And	26	18	15

Table 5: Summary of Integration Times

Integration Time (ms)	Brightest Observable I_c Mag	Number of 151 Brightest Stars that Saturate
20	1.89	122
10	1.15	51
5	0.46	15
1	-1.27	4

Table 5 presents the brightest observable I_c band magnitude that can be observed without saturation and the number of the 151 brightest stars that saturate as a function of the integration time, according to Bartlett (2008).

5. Summary

Normalized polychromatic PSFs specific to spectral types are sampled over the fully spanning set of 12,769 cases and re-binned, then used to calculate the PSF value of the brightest pixel for each case. For each spectral type, the minimum, median, and maximum values for the brightest PSF pixel value are multiplied by the count rates of the 151 brightest stars to calculate the minimum, median, and maximum count rates of the brightest pixel. These count rates and count rates increased by 25% are used to calculate integration times necessary to prevent saturation. These integration times will assist in selecting the most economical dynamic range for the H4RG detector.

6. References

Bartlett, J., "150 Brightest Stars," 2008, TM 08-18 (Washington DC USNO)
Dugan, Z., "Astrometric Passband Polychromatic Weighting for Monochromatic Point Spread Functions," 2008, 08-20 (Washington DC USNO)