1.7 Quantum Efficiencies of ACIS Flight Detectors Relative to Reference Detectors

1.7.1 Measurement Method, Analysis Techniques, and Data Products

1.7.1.1 Calibration Strategy

The quantum detection efficiency of each ACIS flight CCD was calibrated relative to one or more reference CCDs at the CCD Laboratory in MIT's Center for Space Research. The reference CCDs used as calibration transfer standards for the flight CCDs are of the same design and are essentially identical to the flight CCDs except for small manufacturing variations. The reference CCDs were previously calibrated using the facilities of the Physikalisch-Technishe Bundesanstalt (PTB) laboratory at the Berlin Electron Storage ring BESSY[8], as well as via comparison to a Si(Li) solid state detector at energies above 3 keV. The calibrations performed at PTB-BESSY are described in Section 1.6.1.

The strategy adopted to measure the relative quantum detection efficiency of flight CCDs vs. reference CCDs consisted of alternately moving one flight CCD and one reference CCD into a stable quasi-monochromatic X-ray beam at each of several energies, spanning the spectral range of 0.3–10 keV. Two special vacuum chambers were built for this purpose, containing mounts for two CCDs attached to X-Y translation stages, X-ray sources, and alignment systems employing LEDs and pinholes[7]. The pinholes illuminated the CCDs with small spots, coaxial with the X-ray sources, whose centroids were determined to the nearest pixel in order to alternately position each CCD at the same X-Y location for the calibration measurements.

Both radioactive (^{55}Fe) and fluorescent X-ray sources were used to illuminate the CCDs, providing a range of discrete emission lines to cover the energy band. Two fluorescent sources were used, one with a tritium source whose beta particles excite low-Z targets (for C, O, and F lines), and one employing a Mo-anode commercial X-ray tube to excite higher-Z targets (Al, Si, P, K, Cl, Ti, V, Fe, Co, Ni, Cu, Zn, and Ge targets were available). These sources have been described in detail elsewhere[7]. The carbon source was only used with back-illuminated (BI) CCDs, as front-illuminated (FI) CCDs have very poor efficiency at 277 eV. The sources used for relative QE calibration and the energies of their K_α lines are shown below:

Element	(C)	O	F	Si	P	Ti	Mn	Cu
Energy (keV)	.277	.525	.677	1.74	2.02	4.51	5.89	8.04

To analyze the relative quantum efficiency (QE) data, a Gaussian fit to the main X-ray line was made to the cumulative spectra (for each CCD quadrant); then all counts within 3 sigma of that peak were counted towards the detected flux rate in that line. Both the flight and reference CCDs (containing 1024×1024 pixels) were divided into 1024 "superpixels" (32×32 pixel square regions). The calibration measurements collected approximately 10000 counts per superpixel for 1% accuracy (in counting statistics) at the superpixel level. This goal required collecting over ten million counts in each CCD for each energy of interest, a process requiring typically 10 days, with two shifts of data operators per day, per flight CCD candidate. [Counting re-flexed CCDs, almost 40 devices have undergone this process since Jan. 1996.] Smaller sets of data were also taken at the energies not used for quantum efficiency analysis in order to fully characterize the spectral response (gain and FWHM vs. energy).

The alignment process ensured that each reference CCD superpixel viewed the same X-ray flux as the corresponding flight CCD superpixel, even for non-uniform source radiation patterns (C, O, and F were most sharply peaked on axis—the higher energies were relatively flat). It is estimated that the flight and reference CCDs were positioned at the same location in the X-Y (translation stage) plane to within two pixels. The raw relative QE (uncorrected for pileup) for each superpixel pair was taken to be the ratio of the flight CCD count rate (counts/sec/superpixel) to the reference CCD count rate.

This yielded 1024 values of the QE ratio, with typically a Gaussian distribution. By fitting a Gaussian to this histogram of ratios, we obtained a fitted centroid, representing the nominal QE ratio for the two CCDs, and a width (sigma) which represents the spatial variations. A simple average of the 1024 ratios was also calculated, along with the standard deviation. The standard deviation is quite sensitive to outlying values that can originate from bad pixels, hot columns, or edge effects (particularly shadows along one edge attributed to the framestore covers attached to each CCD).

Images and histograms of the spatial uniformity of the superpixel ratios at each energy are presented in Figures 1.77–1.86 in section 1.7.2.

1.7.1.2 Pileup Corrections To Relative Quantum Efficiency Values

The average count rate for each CCD is used to estimate pileup correction factors, which are then used to obtain corrected nominal values of the QE ratio and the sigma value. The pileup correction is typically very close to unity when both the flight and reference CCD have the same exposure time. Larger corrections were found in several cases where the reference CCD used older (and slower) electronics than the flight CCD and therefore recorded higher counts/frame and pileup values. Also, data comparing FI CCDs to BI CCDs can be affected by slight differences in pileup behavior exhibited by the two types of detector.

The pileup model and parameters are explained in Section 1.4; flux scaling studies were used to fit typical FI and BI pileup model parameters at energies above 1.5 keV. These studies consisted of recording data from fluorescent targets at different current values on the commercial X-ray tube (at constant voltage); analysis of total charge collected indicates that the X-ray flux is linear with respect to this current. For energies below 1.5 keV (O and F data), parameters measured with the Al source were employed. A more refined treatment for these energies is planned later. Note, however, that empirically fit pileup parameters were typically independent of energy below 3 keV. For a given flux level, pileup is greatest for high energy photons because their charge clouds typically spread to more pixels, especially if the X-ray is energetic enough to penetrate below the depletion layer of the CCD before initiating a photoelectric interaction.

Pileup effects may be expressed for one measurement in terms of a correction factor (f), defined as the ratio of counting rate (corrected) to counting rate (raw). Typical correction factors (f) and errors in the correction are shown in Table 1.37 for the relative QE calibration of flight CCD I1 (w193c2) vs. reference CCD w103c4. This is an example in which the reference CCD used the older electronics and was limited to a 7.15 second exposure time, whereas the flight CCD using engineering versions of the flight electronics was capable of running with 3.28 second exposures if the flux was high enough to warrant it.

Pileup correction factors applied to the MIT CSR measurements of relative quantum efficiency are presented below in Section 1.7.2.

Energy	I1 f	I1 exp	Ref f	Ref exp	f ratio	+/-
.525	1.061	7 sec	1.071	7 sec	0.991	0.013
.677	1.031	7 sec	1.041	7 sec	0.990	0.001
1.74	1.046	3 sec	1.109	7 sec	0.943	0.016
2.02	1.022	3 sec	1.051	7 sec	0.972	0.009
4.51	1.027	3 sec	1.059	7 sec	0.969	0.006
5.89	1.065	3 sec	1.146	7 sec	0.930	0.014
8.04	1.068	3 sec	1.144	7 sec	0.934	0.012

Table 1.37: Pileup correction factors f for the relative quantum efficiency calibration of ACIS detector I1 (w193c2) versus reference detector w103c4. The correction factors are defined by f =(Corrected count rate)/(Raw count rate). The corrected relative QE is the raw relative QE multiplied by the f ratio of the two CCDs.

1.7.1.3 Relative Quantum Efficiency Error Sources

Several factors contribute to the uncertainty in the relative QE measurements. Photon statistics contribute $\sim 1.4\%$ for the 1024 individual superpixel quantum efficiency ratios, but only $\sim 0.04\%$ to the full CCD nominal value (assuming spatially uniform QE), where the nominal value is taken to be the centroid of the Gaussian fit to the histogram of 1024 values.

Reproducibility of relative QE measurements made after moving the CCDs out of and then back into the chamber is typically within 1%, but is observed to be as poor as 3% at Cu (8.04 keV), possibly due to relatively high uncertainty in the pileup factor for the reference CCD caused by a high count rate at high energy.

It should also be noted that the pileup correction parameters are generally similar from one FI CCD to another, but they do seem to be slightly different for one older reference CCD (w103c4) used to calibrate some flight CCDs. Because older electronics were used for this CCD, the depletion depth is thought to be smaller, which would exert some influence on the pileup rate. This difference has not yet been incorporated into the correction codes.

A further test of the accuracy of the relative quantum efficiency measurements is described in Section 1.7.3.

1.7.1.4 Data Products and Valid Data Summary

The data used for relative quantum efficiency measurements are listed in Tables 1.38 through 1.50.

The column labeled "Directory" is the location of the dataset from /ohno/di/database on the local CSR network.

In the column labeled "Rejected Frames" the letter "b" following the number indicates that the majority of the rejected frames were rejected due to pixels above the event threshold in the overclock region. The letter "n" following the number indicates that the majority of the rejected frames were rejected due to standard deviation of the overclocks exceeding the noise threshold.

The column labeled "Counts per Frame" contains the total number of G02346 events under the main peak for the data set.

Each data set included has been checked by visual inspection of the data products and for consistency with other data sets.

Chip	Target/Energy eV	Directory	Accepted Frames	Rejected Frames	Frame Time (seconds)	Counts per Frame
w203c4r/I0	o/525	w203c4r/beavis/o/31dec96/2351	322	3b	7.149	2847.2
w203c4r/I0	o/525	w203c4r/beavis/o/31dec96/2203	647	3b	7.148	2844.4
w203c4r/I0	o/525	w203c4r/beavis/o/31dec96/1654	647	3b	7.148	2869.2
w203c4r/I0	o/525	w203c4r/beavis/o/31dec96/1509	644	6b	7.148	2869.6
w203c4r/I0	o/525	w203c4r/beavis/o/31dec96/1207	646	4b	7.148	2893.2
w203c4r/I0	o/525	w203c4r/beavis/o/31dec96/1040	647	3b	7.148	2902
w190c3/REF	o/525	w190c3/beavis/o/31dec96/2033	647	3b	7.148	2947.6
w190c3/REF	o/525	w190c3/beavis/o/31dec96/1908	645	5b	7.148	2949.2
w190c3/REF	o/525	w190c3/beavis/o/31dec96/1337	629	16b	7.149	2968.4
w190c3/REF	o/525	w190c3/beavis/o/31dec96/0904	648	2b	7.148	2996.4
w190c3/REF	o/525	w190c3/beavis/o/01jan97/2115	648	2b	7.148	2996.4
w203c4r/I0	f/677	w203c4r/beavis/f/01jan97/1647	647	3b	7.148	3888.4
w203c4r/I0	f/677	w203c4r/beavis/f/01jan97/1520	646	4b	7.148	3893.2
w203c4r/I0	f/677	w203c4r/beavis/f/01jan97/1213	645	5b	7.148	3898.8
w203c4r/I0	f/677	w203c4r/beavis/f/01jan97/1045	645	5b	7.148	3896.4
w190c3/REF	f/677	w190c3/beavis/f/01jan97/1950	649	1b	7.148	3911.6
w190c3/REF	f/677	w190c3/beavis/f/01jan97/1825	647	3b	7.148	3907.2
w190c3/REF	f/677	w190c3/beavis/f/01jan97/1342	645	5b	7.148	3912
w190c3/REF	f/677	w190c3/beavis/f/01jan97/0917	648	2b	7.148	3913.6
w203c4r/I0	si/1740	w203c4r/beavis/si/02jan97/1440	640	5b	3.276	5382.4
w203c4r/I0	si/1740	w203c4r/beavis/si/02jan97/1338	647	3b	3.277	5386
w203c4r/I0	si/1740	w203c4r/beavis/si/02jan97/1159	649	1b	3.277	5390.8
w190c3/REF	si/1740	w190c3/beavis/si/02jan97/1527	645	5b	3.277	5389.6
w190c3/REF	si/1740	w190c3/beavis/si/02jan97/1246	647	3b	3.277	5385.6
w190c3/REF	si/1740	w190c3/beavis/si/02jan97/1108	641	8b	3.277	5390.8
w203c4r/I0	p/2015	w203c4r/beavis/p/02jan97/2116	247	2b	3.277	4594
w203c4r/I0	p/2015	w203c4r/beavis/p/02jan97/2033	649	1b	3.277	4596
w203c4r/I0	p/2015	w203c4r/beavis/p/02jan97/1853	645	4b	3.277	4587.6
w203c4r/I0	p/2015	w203c4r/beavis/p/02jan97/1714	648	1b	3.277	4610.4
w190c3/REF	p/2015	w190c3/beavis/p/02jan97/2139	223	2b	3.277	4637.2
w190c3/REF	p/2015	w190c3/beavis/p/02jan97/1947	646	3b	3.277	4643.2
w190c3/REF	p/2015	w190c3/beavis/p/02jan97/1806	648	2b	3.277	4635.6
w190c3/REF	p/2015	w190c3/beavis/p/02jan97/1625	647	1b	3.277	4662.8
w203c4r/I0	ti/4508	w203c4r/beavis/ti/03jan97/2035	324	1b	3.277	4900
w203c4r/I0	ti/4508	w203c4r/beavis/ti/03jan97/1956	646	2b	3.277	4897.2
w203c4r/I0	ti/4508	w203c4r/beavis/ti/03jan97/1827	645	5b	3.277	4896.8
w203c4r/I0	ti/4508	w203c4r/beavis/ti/03jan97/1746	648	1b	3.277	4892
w190c3/REF	ti/4508	w190c3/beavis/ti/03jan97/2140	323	1b	3.277	4905.2
w190c3/REF	ti/4508	w190c3/beavis/ti/03jan97/2100	647	3b	3.277	4906.8
w190c3/REF	ti/4508	w190c3/beavis/ti/03jan97/1914	645	5b	3.277	4902.4
w190c3/REF	ti/4508	w190c3/beavis/ti/03jan97/1646	647	2b	3.277	4895.6
w203c4r/I0	fe55/5894	w203c4r/beavis/fe55/03jan97/1549	320	5b	3.277	3517.2
w203c4r/I0	fe55/5894	w203c4r/beavis/fe55/03jan97/1508	642	7b	3.277	3520
w203c4r/I0	fe55/5894	w203c4r/beavis/fe55/03jan97/1337	650	0n	3.277	3518
w203c4r/I0	fe55/5894	w203c4r/beavis/fe55/03jan97/1151	639	4b	3.277	3523.6
w203c4r/I0	fe55/5894	w203c4r/beavis/fe55/03jan97/1011	645	4b	3.277	3527.2
w190c3/REF	fe55/5894	w190c3/beavis/fe55/03jan97/1619	322	3b	3.277	3582.8
w190c3/REF	fe55/5894	w190c3/beavis/fe55/03jan97/1425	640	9b	3.277	3584.4
w190c3/REF	fe55/5894	w190c3/beavis/fe55/03jan97/1238	648	2b	3.277	3584.4
w190c3/REF	fe55/5894	w190c3/beavis/fe55/03jan97/1059	646	3b	3.277	3582.4
w190c3/REF	fe55/5894	w190c3/beavis/fe55/03jan97/0921	647	3b	3.277	3584.8
w203c4r/I0	cu/8040	w203c4r/beavis/cu/04jan97/1939	325	0n	3.277	2850
w203c4r/I0	cu/8040	w203c4r/beavis/cu/04jan97/1815	647	2b	3.277	2848
w203c4r/I0	cu/8040	w203c4r/beavis/cu/04jan97/1650	645	5b	3.277	2829.2
w203c4r/I0	cu/8040	w203c4r/beavis/cu/04jan97/1541	643	4b	3.277	2846
w203c4r/I0	cu/8040	w203c4r/beavis/cu/04jan97/1419	648	2b	3.277	2836.8
w203c4r/I0	cu/8040	w203c4r/beavis/cu/04jan97/1241	553	3b	3.285	2827.6
w190c3/REF	cu/8040	w190c3/beavis/cu/04jan97/2119	324	1n	3.277	2998
w190c3/REF	cu/8040	w190c3/beavis/cu/04jan97/2003	650	0n	3.277	2995.6
w190c3/REF	cu/8040	w190c3/beavis/cu/04jan97/1733	650	0n	3.277	2984
w190c3/REF	cu/8040	w190c3/beavis/cu/04jan97/1457	645	5b	3.277	3008.4
w190c3/REF	cu/8040	w190c3/beavis/cu/04jan97/1325	648	2b	3.277	2999.6
w190c3/REF	cu/8040	w190c3/beavis/cu/04jan97/1158	641	7b	3.277	2986.4

Table 1.38: w203c4r/I0 CSR Quantum Efficiency Data Sets

Chip	Target/Energy eV	Directory	Accepted Frames	Rejected Frames	Frame Time (seconds)	Counts per Frame
w193c2/I1	o/525	w193c2/butthead/o/23nov96/2100	645	5b	7.148	3278.8
w193c2/I1	o/525	w193c2/butthead/o/23nov96/1934	648	2n	7.148	3295.2
w193c2/I1	o/525	w193c2/butthead/o/23nov96/1426	645	5b	7.15	3289.2
w193c2/I1	o/525	w193c2/butthead/o/23nov96/1009	649	1b	7.15	3283.2
w103c4/REF	o/525	w103c4/butthead/o/23nov96/2239	295	4b	7.224	3748.4
w103c4/REF	o/525	w103c4/butthead/o/23nov96/1800	587	8b	7.225	3712.8
w103c4/REF	o/525	w103c4/butthead/o/23nov96/1633	551	37b	7.225	3706.4
w103c4/REF	o/525	w103c4/butthead/o/23nov96/1137	566	32b	7.224	3719.6
w103c4/REF	o/525	w103c4/butthead/o/23nov96/0842	573	24b	7.225	3724.8
w193c2/I1	f/677	w193c2/butthead/f/24nov96/2049	644	3n	7.15	1755.6
w193c2/I1	f/677	w193c2/butthead/f/24nov96/1703	647	3b	7.15	1754.4
w193c2/I1	f/677	w193c2/butthead/f/24nov96/1324	613	4n	7.15	1760.4
w193c2/I1	f/677	w193c2/butthead/f/24nov96/1108	581	7n	7.148	1756.4
w103c4/REF	f/677	w103c4/butthead/f/24nov96/2225	589	8b	7.224	2281.6
w103c4/REF	f/677	w103c4/butthead/f/24nov96/1842	595	14b	7.225	2279.2
w103c4/REF	f/677	w103c4/butthead/f/24nov96/1528	586	14b	7.224	2282.4
w103c4/REF	f/677	w103c4/butthead/f/24nov96/0954	575	11b	7.225	2284.4
w193c2/I1	f/677	w193c2/butthead/f/25nov96/1605	699	1b	7.15	1747.2
w193c2/I1	f/677	w193c2/butthead/f/25nov96/1433	692	8b	7.15	1749.6
w193c2/I1	f/677	w193c2/butthead/f/25nov96/1147	597	2b	7.15	1754
w193c2/I1	f/677	w193c2/butthead/f/25nov96/1019	598	2b	7.15	1753.2
w103c4/REF	f/677	w103c4/butthead/f/25nov96/1738	580	12b	7.225	2281.6
w103c4/REF	f/677	w103c4/butthead/f/25nov96/1311	489	14n	7.225	2281.2
w103c4/REF	f/677	w103c4/butthead/f/25nov96/0859	582	10b	7.224	2276.4
w193c2/I1	si/1740	w193c2/butthead/si/29nov96/1830	661	4n	3.277	2500.8
w193c2/I1	si/1740	w193c2/butthead/si/29nov96/1744	678	1b	3.277	2499.6
w193c2/I1	si/1740	w193c2/butthead/si/29nov96/1358	642	6b	3.277	2504.8
w193c2/I1	si/1740	w193c2/butthead/si/29nov96/1315	647	3b	3.277	2505.6
w193c2/I1	si/1740	w193c2/butthead/si/29nov96/1233	647	2b	3.277	2503.2
w193c2/I1	si/1740	w193c2/butthead/si/29nov96/1013	649	0n	3.277	2503.2
w103c4/REF	si/1740	w103c4/butthead/si/29nov96/1616	547	27n	7.226	5382.4
w103c4/REF	si/1740	w103c4/butthead/si/29nov96/1449	13	17n	7.224	5427.6
w103c4/REF	si/1740	w103c4/butthead/si/29nov96/1101	581	14b	7.224	5388.4
w193c2/I1	p/2015	w193c2/butthead/p/27nov96/2248	647	1b	3.277	1701.2
w193c2/I1	p/2015	w193c2/butthead/p/27nov96/2149	645	4b	3.277	1704
w193c2/I1	p/2015	w193c2/butthead/p/27nov96/2110	588	2n	3.277	1703.6
w193c2/I1	p/2015	w193c2/butthead/p/27nov96/1907	642	3n	3.277	1718.8
w193c2/I1	p/2015	w193c2/butthead/p/27nov96/1825	646	2n	3.277	1721.6
w193c2/I1	p/2015	w193c2/butthead/p/27nov96/1541	617	5n	3.277	1719.2
w193c2/I1	p/2015	w193c2/butthead/p/27nov96/1502	647	3b	3.277	1717.2
w193c2/I1	p/2015	w193c2/butthead/p/27nov96/1233	648	2b	3.277	1720.8
w193c2/I1	p/2015	w193c2/butthead/p/27nov96/1142	596	3b	3.277	1718.8
w103c4/REF	p/2015	w103c4/butthead/p/27nov96/2313	293	NA	7.227	3776
w103c4/REF	p/2015	w103c4/butthead/p/27nov96/1950	584	15b	7.224	3779.2
w103c4/REF	p/2015	w103c4/butthead/p/27nov96/1654	589	8b	7.225	3802
w103c4/REF	p/2015	w103c4/butthead/p/27nov96/1318	579	13b	7.225	3796.8
w103c4/REF	p/2015	w103c4/butthead/p/27nov96/1006	583	11b	7.225	3800
w193c2/I1	ti/4508	w193c2/butthead/ti/01dec96/2018	313	2n	3.277	2184.4
w193c2/I1	ti/4508	w193c2/butthead/ti/01dec96/1939	547	2n	3.277	2183.6
w193c2/I1	ti/4508	w193c2/butthead/ti/01dec96/1745	610	1n	3.277	2182.4
w193c2/I1	ti/4508	w193c2/butthead/ti/01dec96/1514	649	0n	3.277	2186
w193c2/I1	ti/4508	w193c2/butthead/ti/01dec96/1431	644	6b	3.277	2189.2
w193c2/I1	ti/4508	w193c2/butthead/ti/01dec96/1348	620	4n	3.277	2179.6
w193c2/I1	ti/4508	w193c2/butthead/ti/01dec96/1137	618	3n	3.277	2178.8
w193c2/I1	ti/4508	w193c2/butthead/ti/01dec96/1054	625	5n	3.277	2184.8
w103c4/REF	ti/4508	w103c4/butthead/ti/01dec96/2042	214	9b	7.225	4634
w103c4/REF	ti/4508	w103c4/butthead/ti/01dec96/1826	533	12b	7.225	4634.8
w103c4/REF	ti/4508	w103c4/butthead/ti/01dec96/1622	533	12b	7.225	4640
w103c4/REF	ti/4508	w103c4/butthead/ti/01dec96/0943	125	19n	7.225	4620
w193c2/I1	fe55/5894	w193c2/butthead/fe55/30nov96/1713	416	2n	3.277	3362.4
w193c2/I1	fe55/5894	w193c2/butthead/fe55/30nov96/1520	640	6b	3.277	3362
w193c2/I1	fe55/5894	w193c2/butthead/fe55/30nov96/1435	639	2b	3.28	3360
w193c2/I1	fe55/5894	w193c2/butthead/fe55/30nov96/1124	647	3b	3.277	3363.6
w103c4/REF	fe55/5894	w103c4/butthead/fe55/30nov96/1749	541	38b	7.225	6646.8
w103c4/REF	fe55/5894	w103c4/butthead/fe55/30nov96/1321	362	184b	7.225	6631.6
w103c4/REF	fe55/5894	w103c4/butthead/fe55/30nov96/0905	554	15b	7.225	6638.8
w193c2/I1	cu/8040	w193c2/butthead/cu/02dec96/1746	645	4b	3.277	1313.2
w193c2/I1	cu/8040	w193c2/butthead/cu/02dec96/1702	650	0n	3.277	1311.2
w193c2/I1	cu/8040	w193c2/butthead/cu/02dec96/1426	646	2b	3.277	1334.4
w193c2/I1	cu/8040	w193c2/butthead/cu/02dec96/1224	647	3b	3.277	1293.6
w193c2/I1	cu/8040	w193c2/butthead/cu/02dec96/1136	644	5b	3.277	1294.8
w193c2/I1	cu/8040	w193c2/butthead/cu/02dec96/1035	638	2b	3.279	1310.8
w103c4/REF	cu/8040	w103c4/butthead/cu/02dec96/2201	571	12b	7.225	2427.2
w103c4/REF	cu/8040	w103c4/butthead/cu/02dec96/1525	482	102b	7.225	2448
w103c4/REF	cu/8040	w103c4/butthead/cu/02dec96/1312	492	77b	7.224	2478
w103c4/REF	cu/8040	w103c4/butthead/cu/02dec96/0856	558	10b	7.225	2501.2

Table 1.39: w193c2/I1 CSR Quantum Efficiency Data Sets

Chip	Target/Energy eV	Directory	Accepted Frames	Rejected Frames	Frame Time (seconds)	Counts per Frame
w158c4r/I2	o/525	w158c4r/butthead/o/26oct96/1826	595	5b	7.148	3732
w158c4r/I2	o/525	w158c4r/butthead/o/26oct96/0158	299	1b	7.15	3720.4
w103c4/REF	o/525	w103c4/butthead/o/26oct96/1706	588	9b	7.225	4059.2
w103c4/REF	o/525	w103c4/butthead/o/26oct96/0114	298	2b	7.224	4060.8
w158c4r/I2	o/525	w158c4r/butthead/o/31oct96/2018	137	0n	7.149	3620.4
w158c4r/I2	o/525	w158c4r/butthead/o/31oct96/1849	663	7b	7.15	3543.2
w158c4r/I2	o/525	w158c4r/butthead/o/31oct96/1724	667	3b	7.15	3511.2
w158c4r/I2	o/525	w158c4r/butthead/o/31oct96/1417	664	6b	7.15	3599.6
w158c4r/I2	o/525	w158c4r/butthead/o/31oct96/1256	593	7b	7.15	3538.4
w103c4/REF	o/525	w103c4/butthead/o/31oct96/2222	194	6b	7.225	3951.6
w103c4/REF	o/525	w103c4/butthead/o/31oct96/2050	588	12b	7.224	3928.8
w103c4/REF	o/525	w103c4/butthead/o/31oct96/1554	571	29b	7.225	3820.4
w103c4/REF	o/525	w103c4/butthead/o/31oct96/1123	588	12b	7.224	3876.4
w103c4/REF	o/525	w103c4/butthead/o/31oct96/0951	590	10b	7.224	3956.8
w158c4r/I2	f/677	w158c4r/butthead/f/01nov96/1853	643	7b	7.15	1830.8
w158c4r/I2	f/677	w158c4r/butthead/f/01nov96/1730	642	8b	7.15	1832.8
w158c4r/I2	f/677	w158c4r/butthead/f/01nov96/1232	695	5b	7.15	1830.8
w158c4r/I2	f/677	w158c4r/butthead/f/01nov96/1038	342	2b	7.149	1831.6
w103c4/REF	f/677	w103c4/butthead/f/01nov96/2030	590	8b	7.224	2268.4
w103c4/REF	f/677	w103c4/butthead/f/01nov96/1609	587	10b	7.224	2270.4
w103c4/REF	f/677	w103c4/butthead/f/01nov96/1444	584	11b	7.225	2272
w103c4/REF	f/677	w103c4/butthead/f/01nov96/0901	588	11b	7.225	2276.4
w158c4r/I2	f/677	w158c4r/butthead/f/06nov96/1935	647	3b	7.148	1817.2
w158c4r/I2	f/677	w158c4r/butthead/f/06nov96/1631	648	2b	7.15	1818
w158c4r/I2	f/677	w158c4r/butthead/f/06nov96/1453	648	2b	7.15	1818.8
w103c4/REF	f/677	w103c4/butthead/f/06nov96/2130	588	7b	7.227	2257.2
w103c4/REF	f/677	w103c4/butthead/f/06nov96/1807	582	16b	7.226	2263.2
w103c4/REF	f/677	w103c4/butthead/f/06nov96/1311	550	NA	7.225	2247.6
w158c4r/I2	si/1740	w158c4r/butthead/si/29oct96/2059	425	3b	3.277	1701.2
w158c4r/I2	si/1740	w158c4r/butthead/si/29oct96/2018	641	9b	3.277	1700
w158c4r/I2	si/1740	w158c4r/butthead/si/29oct96/1920	653	0n	3.278	1698.4
w158c4r/I2	si/1740	w158c4r/butthead/si/29oct96/1840	647	3b	3.277	1699.2
w158c4r/I2	si/1740	w158c4r/butthead/si/29oct96/1213	647	3b	3.277	1698
w158c4r/I2	si/1740	w158c4r/butthead/si/29oct96/1123	648	2b	3.277	1692.8
w103c4/REF	si/1740	w103c4/butthead/si/29oct96/2133	559	13b	7.224	3688.8
w103c4/REF	si/1740	w103c4/butthead/si/29oct96/1722	540	17b	7.225	3686.8
w103c4/REF	si/1740	w103c4/butthead/si/29oct96/0943	560	33b	7.225	3678.8
w158c4r/I2	si/1740	w158c4r/butthead/si/05nov96/1535	643	3b	3.277	1686.4
w158c4r/I2	si/1740	w158c4r/butthead/si/05nov96/1449	642	8b	3.277	1690.4
w158c4r/I2	si/1740	w158c4r/butthead/si/05nov96/1201	640	4b	3.274	1688.4
w103c4/REF	si/1740	w103c4/butthead/si/05nov96/1625	563	7b	7.225	3668.8
w103c4/REF	si/1740	w103c4/butthead/si/05nov96/1323	536	11b	7.225	3671.6
w103c4/REF	si/1740	w103c4/butthead/si/05nov96/1017	534	15b	7.225	3666
w158c4r/I2	p/2015	w158c4r/butthead/p/30oct96/2029	646	3b	3.279	1733.2
w158c4r/I2	p/2015	w158c4r/butthead/p/30oct96/1940	644	4b	3.277	1735.2
w158c4r/I2	p/2015	w158c4r/butthead/p/30oct96/1602	646	4b	3.277	1732
w158c4r/I2	p/2015	w158c4r/butthead/p/30oct96/1459	649	1b	3.277	1730.8
w158c4r/I2	p/2015	w158c4r/butthead/p/30oct96/1252	645	4b	3.277	1732
w158c4r/I2	p/2015	w158c4r/butthead/p/30oct96/1155	642	8b	3.278	1730.4
w158c4r/I2	p/2015	w158c4r/butthead/p/30oct96/1105	644	6b	3.277	1730.8
w103c4/REF	p/2015	w103c4/butthead/p/30oct96/1825	434	111b	7.225	3776
w103c4/REF	p/2015	w103c4/butthead/p/30oct96/1338	499	43b	7.225	3773.2
w103c4/REF	p/2015	w103c4/butthead/p/30oct96/0930	529	20b	7.225	3771.2
w158c4r/I2	p/2015	w158c4r/butthead/p/05nov96/2112	633	2b	3.277	1699.6
w158c4r/I2	p/2015	w158c4r/butthead/p/05nov96/2030	646	4b	3.277	1695.2
w158c4r/I2	p/2015	w158c4r/butthead/p/05nov96/1950	646	2b	3.278	1698
w158c4r/I2	p/2015	w158c4r/butthead/p/05nov96/1909	641	8b	3.277	1700.4
w103c4/REF	p/2015	w103c4/butthead/p/05nov96/2219	560	13b	7.224	3703.2
w103c4/REF	p/2015	w103c4/butthead/p/05nov96/2159	100	NA	7.225	3698.4
w103c4/REF	p/2015	w103c4/butthead/p/05nov96/1746	561	12b	7.225	3702.4
w158c4r/I2	ti/4508	w158c4r/butthead/ti/04nov96/2011	643	1b	3.28	2226
w158c4r/I2	ti/4508	w158c4r/butthead/ti/04nov96/1915	648	2b	3.277	2222.8
w158c4r/I2	ti/4508	w158c4r/butthead/ti/04nov96/1834	647	2b	3.277	2222
w158c4r/I2	ti/4508	w158c4r/butthead/ti/04nov96/1559	647	3b	3.277	2225.2
w158c4r/I2	ti/4508	w158c4r/butthead/ti/04nov96/1455	649	NA	3.277	2222
w158c4r/I2	ti/4508	w158c4r/butthead/ti/04nov96/1238	648	1b	3.277	2224.4
w158c4r/I2	ti/4508	w158c4r/butthead/ti/04nov96/1146	647	3b	3.277	2225.6
w103c4/REF	ti/4508	w103c4/butthead/ti/04nov96/2145	565	7b	7.225	4705.2
w103c4/REF	ti/4508	w103c4/butthead/ti/04nov96/1657	569	6b	7.225	4699.6
w103c4/REF	ti/4508	w103c4/butthead/ti/04nov96/1324	558	17b	7.225	4707.2
w103c4/REF	ti/4508	w103c4/butthead/ti/04nov96/1016	584	12b	7.225	4701.2
w158c4r/I2	fe55/5894	w158c4r/butthead/fe55/27oct96/2044	631	7b	3.28	3438.8
w158c4r/I2	fe55/5894	w158c4r/butthead/fe55/27oct96/2003	643	4b	3.277	3437.6
w158c4r/I2	fe55/5894	w158c4r/butthead/fe55/27oct96/1655	648	2b	3.277	3441.2
w158c4r/I2	fe55/5894	w158c4r/butthead/fe55/27oct96/1414	648	2b	3.277	3442.8
w103c4/REF	fe55/5894	w103c4/butthead/fe55/27oct96/2128	506	50b	7.225	6798
w103c4/REF	fe55/5894	w103c4/butthead/fe55/27oct96/1753	550	10b	7.224	6801.6
w103c4/REF	fe55/5894	w103c4/butthead/fe55/27oct96/1238	555	15b	7.225	6801.2

Table 1.40: w158c4r/I2 CSR Quantum Efficiency Data Sets - continued on next page

Chip	Target/Energy eV	Directory	Accepted Frames	Rejected Frames	Frame Time (seconds)	Counts per Frame
w158c4r/I2	cu/8040	w158c4r/butthead/cu/02nov96/2018	649	1b	3.277	1300.4
w158c4r/I2	cu/8040	w158c4r/butthead/cu/02nov96/1920	642	6b	3.277	1303.6
w158c4r/I2	cu/8040	w158c4r/butthead/cu/02nov96/1817	644	6b	3.277	1300.4
w158c4r/I2	cu/8040	w158c4r/butthead/cu/02nov96/1720	648	2b	3.277	1300.8
w158c4r/I2	cu/8040	w158c4r/butthead/cu/02nov96/1436	595	5b	3.277	1301.6
w158c4r/I2	cu/8040	w158c4r/butthead/cu/02nov96/1355	596	3b	3.277	1304.8
w103c4/REF	cu/8040	w103c4/butthead/cu/02nov96/2104	558	9b	7.225	2442.4
w103c4/REF	cu/8040	w103c4/butthead/cu/02nov96/1552	558	12b	7.225	2444.4
w103c4/REF	cu/8040	w103c4/butthead/cu/02nov96/1056	548	17b	7.225	2448.8

Table 1.41: w158c4r/I2 CSR Quantum Efficiency Data Sets - continued from previous page

Chip	Target/Energy eV	Directory	Accepted Frames	Rejected Frames	Frame Time (seconds)	Counts per Frame
w215c2r/I3	o/525	w215c2r/beavis/o/07jan97/2013	149	1b	7.148	2756.4
w215c2r/I3	o/525	w215c2r/beavis/o/07jan97/1848	647	3b	7.148	2764
w215c2r/I3	o/525	w215c2r/beavis/o/07jan97/1724	648	2b	7.148	2768.4
w215c2r/I3	o/525	w215c2r/beavis/o/07jan97/1417	646	4b	7.148	2771.6
w215c2r/I3	o/525	w215c2r/beavis/o/07jan97/1118	649	1b	7.148	2781.2
w190c3/REF	o/525	w190c3/beavis/o/07jan97/2210	247	3b	7.148	2752.4
w190c3/REF	o/525	w190c3/beavis/o/07jan97/2045	645	3n	7.148	2754
w190c3/REF	o/525	w190c3/beavis/o/07jan97/1551	606	37b	7.148	2762
w190c3/REF	o/525	w190c3/beavis/o/07jan97/1247	610	22n	7.148	2765.6
w190c3/REF	o/525	w190c3/beavis/o/07jan97/0949	641	5n	7.148	2775.2
w215c2r/I3	o/525	w215c2r/beavis/o/08jan97/1216	246	4b	7.148	2758.8
w215c2r/I3	o/525	w215c2r/beavis/o/08jan97/1050	645	5b	7.148	2753.6
w190c3/REF	o/525	w190c3/beavis/o/08jan97/1307	250	0n	7.148	2748.8
w190c3/REF	o/525	w190c3/beavis/o/08jan97/0854	648	2b	7.148	2756.4
w215c2r/I3	f/677	w215c2r/beavis/f/08jan97/1948	648	2b	7.148	3954.4
w215c2r/I3	f/677	w215c2r/beavis/f/08jan97/1647	647	3b	7.148	3957.2
w215c2r/I3	f/677	w215c2r/beavis/f/08jan97/1522	648	2b	7.148	3962.4
w190c3/REF	f/677	w190c3/beavis/f/08jan97/2115	648	2b	7.148	3884.4
w190c3/REF	f/677	w190c3/beavis/f/08jan97/1816	649	1b	7.148	3885.2
w190c3/REF	f/677	w190c3/beavis/f/08jan97/1345	647	3b	7.148	3891.6
w215c2r/I3	f/677	w215c2r/beavis/f/09jan97/0944	648	2b	7.149	3959.6
w190c3/REF	f/677	w190c3/beavis/f/09jan97/1112	396	4b	7.148	3884.4
w190c3/REF	f/677	w190c3/beavis/f/09jan97/0856	297	3b	7.148	3883.2
w215c2r/I3	si/1740	w215c2r/beavis/si/10jan97/1301	645	3b	3.277	5251.6
w215c2r/I3	si/1740	w215c2r/beavis/si/10jan97/1120	646	4b	3.277	5254
w215c2r/I3	si/1740	w215c2r/beavis/si/10jan97/1036	646	1b	3.277	5253.2
w190c3/REF	si/1740	w190c3/beavis/si/10jan97/1358	645	5b	3.277	5243.2
w190c3/REF	si/1740	w190c3/beavis/si/10jan97/1202	646	4b	3.277	5250.4
w190c3/REF	si/1740	w190c3/beavis/si/10jan97/0938	650	0n	3.277	5246.8
w215c2r/I3	p/2015	w215c2r/beavis/p/10jan97/1957	521	3b	3.277	4482.4
w215c2r/I3	p/2015	w215c2r/beavis/p/10jan97/1918	646	3b	3.277	4484
w215c2r/I3	p/2015	w215c2r/beavis/p/10jan97/1721	644	3b	3.277	4486
w215c2r/I3	p/2015	w215c2r/beavis/p/10jan97/1555	646	2b	3.277	4488
w190c3/REF	p/2015	w190c3/beavis/p/10jan97/2044	522	0n	3.277	4513.2
w190c3/REF	p/2015	w190c3/beavis/p/10jan97/1828	646	4b	3.277	4508.8
w190c3/REF	p/2015	w190c3/beavis/p/10jan97/1638	645	4b	3.277	4503.2
w190c3/REF	p/2015	w190c3/beavis/p/10jan97/1453	642	6b	3.277	4518.4
w215c2r/I3	ti/4508	w215c2r/beavis/ti/11jan97/1339	648	1b	3.277	5136.4
w190c3/REF	ti/4508	w190c3/beavis/ti/11jan97/1456	647	2b	3.277	5140
w190c3/REF	ti/4508	w190c3/beavis/ti/11jan97/1203	646	2b	3.277	5138.4
w190c3/REF	ti/4508	w190c3/beavis/ti/11jan97/1024	522	102b	3.277	5129.2
w215c2r/I3	fe55/5894	w215c2r/beavis/fe55/11jan97/2146	199	1b	3.277	3529.2
w215c2r/I3	fe55/5894	w215c2r/beavis/fe55/11jan97/2106	647	2b	3.277	3518
w215c2r/I3	fe55/5894	w215c2r/beavis/fe55/11jan97/2025	644	5b	3.277	3516.4
w190c3/REF	fe55/5894	w190c3/beavis/fe55/11jan97/2204	391	48b	3.277	3572
w190c3/REF	fe55/5894	w190c3/beavis/fe55/11jan97/1930	622	6n	3.277	3578.8
w215c2r/I3	cu/8040	w215c2r/beavis/cu/09jan97/2047	373	2b	3.277	2808.4
w215c2r/I3	cu/8040	w215c2r/beavis/cu/09jan97/1958	640	9b	3.277	2800.8
w215c2r/I3	cu/8040	w215c2r/beavis/cu/09jan97/1826	648	1b	3.277	2780
w215c2r/I3	cu/8040	w215c2r/beavis/cu/09jan97/1659	646	4b	3.277	2795.2
w215c2r/I3	cu/8040	w215c2r/beavis/cu/09jan97/1525	645	4b	3.277	2800
w215c2r/I3	cu/8040	w215c2r/beavis/cu/09jan97/1349	648	2b	3.277	2801.2
w190c3/REF	cu/8040	w190c3/beavis/cu/09jan97/2129	150	0n	3.277	2967.2
w190c3/REF	cu/8040	w190c3/beavis/cu/09jan97/1911	647	3b	3.277	2967.2
w190c3/REF	cu/8040	w190c3/beavis/cu/09jan97/1743	648	2b	3.277	2940
w190c3/REF	cu/8040	w190c3/beavis/cu/09jan97/1614	647	3b	3.277	2964
w190c3/REF	cu/8040	w190c3/beavis/cu/09jan97/1434	645	5b	3.277	2970.4
w190c3/REF	cu/8040	w190c3/beavis/cu/09jan97/1306	649	1b	3.277	2975.2

Table 1.42: w215c2r/I3 CSR Quantum Efficiency Data Sets

The data products in each directory are summarized in Table 1.51. See MIT ACIS memo PS-71 dated 4 May 1995, by J. Woo (which can be found at http://acis.mit.edu/ttools/acis-analysis.html) for a detailed description of the file formats.

Chip	Target/Energy eV	Directory	Accepted Frames	Rejected Frames	Frame Time (seconds)	Counts per Frame
w168c4r/S0	o/525	w168c4r/beavis/o/15dec96/1108	598	2b	7.15	3596
w168c4r/S0	o/525	w168c4r/beavis/o/15dec96/1540	647	3b	7.149	3588.8
w190c3/REF	o/525	w190c3/beavis/o/15dec96/0915	596	4b	7.149	3410.8
w190c3/REF	o/525	w190c3/beavis/o/15dec96/1409	644	6b	7.149	3409.6
w190c3/REF	o/525	w190c3/beavis/o/15dec96/2136	647	3b	7.149	3394.8
w168c4r/S0	o/525	w168c4r/beavis/o/16dec96/1609	593	1b	7.149	3610.4
w168c4r/S0	o/525	w168c4r/beavis/o/16dec96/1942	649	1b	7.15	3601.2
w168c4r/S0	o/525	w168c4r/beavis/o/16dec96/2113	325	NA	7.15	3603.2
w190c3/REF	o/525	w190c3/beavis/o/16dec96/0930	548	2b	7.149	3394.4
w190c3/REF	o/525	w190c3/beavis/o/16dec96/1217	549	1b	7.149	3390.8
w190c3/REF	o/525	w190c3/beavis/o/16dec96/1344	648	2b	7.149	3388.4
w190c3/REF	o/525	w190c3/beavis/o/16dec96/1803	649	1b	7.149	3393.2
w190c3/REF	o/525	w190c3/beavis/o/16dec96/2200	323	2b	7.149	3380.4
w168c4r/S0	f/677	w168c4r/beavis/f/17dec96/1135	648	2b	7.15	3886.4
w168c4r/S0	f/677	w168c4r/beavis/f/17dec96/1300	600	0n	7.15	3882
w168c4r/S0	f/677	w168c4r/beavis/f/17dec96/1608	647	3b	7.15	3884.4
w168c4r/S0	f/677	w168c4r/beavis/f/17dec96/1757	648	2b	7.149	3875.6
w168c4r/S0	f/677	w168c4r/beavis/f/17dec96/1926	199	1b	7.15	3875.2
w190c3/REF	f/677	w190c3/beavis/f/17dec96/1007	645	5b	7.148	3583.6
w190c3/REF	f/677	w190c3/beavis/f/17dec96/1429	648	2b	7.149	3575.6
w190c3/REF	f/677	w190c3/beavis/f/17dec96/2002	648	2b	7.149	3579.6
w190c3/REF	f/677	w190c3/beavis/f/17dec96/2126	648	2b	7.148	3578.4
w190c3/REF	f/677	w190c3/beavis/f/17dec96/2250	200	0n	7.148	3582.8
w168c4r/S0	si/1740	w168c4r/beavis/si/18dec96/1100	647	3b	3.277	5247.2
w168c4r/S0	si/1740	w168c4r/beavis/si/18dec96/1227	645	2b	3.277	5247.6
w168c4r/S0	si/1740	w168c4r/beavis/si/18dec96/1306	647	3b	3.277	5243.2
w190c3/REF	si/1740	w190c3/beavis/si/18dec96/1013	648	2b	3.277	5218.8
w190c3/REF	si/1740	w190c3/beavis/si/18dec96/1144	649	1b	3.277	5218.4
w190c3/REF	si/1740	w190c3/beavis/si/18dec96/1350	647	1b	3.277	5222
w168c4r/S0	p/2015	w168c4r/beavis/p/18dec96/1722	645	5b	3.277	4562.8
w168c4r/S0	p/2015	w168c4r/beavis/p/18dec96/1854	644	6b	3.277	4558
w168c4r/S0	p/2015	w168c4r/beavis/p/18dec96/1939	645	5b	3.277	4560.4
w168c4r/S0	p/2015	w168c4r/beavis/p/18dec96/2022	638	6b	3.277	4553.2
w190c3/REF	p/2015	w190c3/beavis/p/18dec96/1459	646	4b	3.277	4494.4
w190c3/REF	p/2015	w190c3/beavis/p/18dec96/1617	646	3b	3.277	4494.4
w190c3/REF	p/2015	w190c3/beavis/p/18dec96/1809	646	3b	3.277	4494.4
w190c3/REF	p/2015	w190c3/beavis/p/18dec96/2106	646	3b	3.277	4494.4
w168c4r/S0	ti/4508	w168c4r/beavis/ti/19dec96/1802	646	2b	3.277	5186.4
w168c4r/S0	ti/4508	w168c4r/beavis/ti/19dec96/1947	646	3b	3.277	5182.4
w168c4r/S0	ti/4508	w168c4r/beavis/ti/19dec96/2034	648	2b	3.277	5184
w190c3/REF	ti/4508	w190c3/beavis/ti/19dec96/1713	647	3b	3.277	5186.8
w190c3/REF	ti/4508	w190c3/beavis/ti/19dec96/1850	649	1b	3.277	5193.6
w190c3/REF	ti/4508	w190c3/beavis/ti/19dec96/2157	648	2b	3.277	5195.6
w168c4r/S0	fe55/5894	w168c4r/beavis/fe55/19dec96/0952	640	3b	3.277	3592.8
w168c4r/S0	fe55/5894	w168c4r/beavis/fe55/19dec96/1307	647	3b	3.277	3593.6
w168c4r/S0	fe55/5894	w168c4r/beavis/fe55/19dec96/1349	645	4b	3.277	3592
w168c4r/S0	fe55/5894	w168c4r/beavis/fe55/19dec96/1502	647	3b	3.277	3595.2
w168c4r/S0	fe55/5894	w168c4r/beavis/fe55/19dec96/1546	224	1b	3.277	3589.6
w190c3/REF	fe55/5894	w190c3/beavis/fe55/19dec96/0907	641	4b	3.277	3686.8
w190c3/REF	fe55/5894	w190c3/beavis/fe55/19dec96/1036	644	5b	3.277	3682.8
w190c3/REF	fe55/5894	w190c3/beavis/fe55/19dec96/1221	643	7b	3.277	3684.8
w190c3/REF	fe55/5894	w190c3/beavis/fe55/19dec96/1435	302	3b	3.277	3681.6
w190c3/REF	fe55/5894	w190c3/beavis/fe55/19dec96/1635	491	8b	3.277	3686.4
w168c4r/S0	cu/8040	w168c4r/beavis/cu/20dec96/1138	645	4b	3.277	2806
w168c4r/S0	cu/8040	w168c4r/beavis/cu/20dec96/1318	646	2b	3.277	2804.8
w168c4r/S0	cu/8040	w168c4r/beavis/cu/20dec96/1448	641	4b	3.277	2808
w168c4r/S0	cu/8040	w168c4r/beavis/cu/20dec96/1715	631	4b	3.277	2766
w168c4r/S0	cu/8040	w168c4r/beavis/cu/20dec96/1839	647	3b	3.277	2776
w168c4r/S0	cu/8040	w168c4r/beavis/cu/20dec96/1920	324	1b	3.277	2772.4
w190c3/REF	cu/8040	w190c3/beavis/cu/20dec96/1025	649	1b	3.277	2995.6
w190c3/REF	cu/8040	w190c3/beavis/cu/20dec96/1230	645	4b	3.277	3006.4
w190c3/REF	cu/8040	w190c3/beavis/cu/20dec96/1403	647	3b	3.277	3013.6
w190c3/REF	cu/8040	w190c3/beavis/cu/20dec96/1634	649	1b	3.277	2970.4
w190c3/REF	cu/8040	w190c3/beavis/cu/20dec96/1756	650	0n	3.277	2976.8
w190c3/REF	cu/8040	w190c3/beavis/cu/20dec96/1948	99	1b	3.277	2986.4

Table 1.43: w168c4r/S0 CSR Quantum Efficiency Data Sets

Chip	Target/Energy eV	Directory	Accepted Frames	Rejected Frames	Frame Time (seconds)	Counts per Frame
w140c4r/S1	c/277	w140c4r/butthead/c/08mar97/1445	712	3b	3.277	2356
w140c4r/S1	c/277	w140c4r/butthead/c/08mar97/1239	717	3b	3.277	2370.4
w140c4r/S1	c/277	w140c4r/butthead/c/08mar97/1132	706	13b	3.277	2380
w140c4r/S1	c/277	w140c4r/butthead/c/08mar97/1039	712	8b	3.277	2378.4
w140c4r/S1	c/277	w140c4r/butthead/c/08mar97/0624	695	5b	3.277	2426.8
w140c4r/S1	c/277	w140c4r/butthead/c/08mar97/0412	692	6b	3.277	2476.4
w134c4r/S3	c/277	w134c4r/butthead/c/08mar97/1544	524	196b	3.277	2348.4
w134c4r/S3	c/277	w134c4r/butthead/c/08mar97/1341	719	1b	3.277	2356
w134c4r/S3	c/277	w134c4r/butthead/c/08mar97/0921	715	5b	3.277	2390
w134c4r/S3	c/277	w134c4r/butthead/c/08mar97/0835	706	13b	3.277	2400.8
w134c4r/S3	c/277	w134c4r/butthead/c/08mar97/0539	687	3b	3.277	2452.4
w134c4r/S3	c/277	w134c4r/butthead/c/08mar97/0304	687	13b	3.277	2315.6
w140c4r/S1	o/525	w140c4r/butthead/o/07mar97/2337	696	4b	3.277	4804.8
w140c4r/S1	o/525	w140c4r/butthead/o/07mar97/2202	699	1b	3.277	4800.8
w134c4r/S3	o/525	w134c4r/butthead/o/07mar97/2250	616	83b	3.277	4634.8
w134c4r/S3	o/525	w134c4r/butthead/o/07mar97/2108	622	370b	3.277	4656.4
w140c4r/S1	o/525	w140c4r/butthead/o/08mar97/0216	688	2b	3.277	4826.8
w140c4r/S1	o/525	w140c4r/butthead/o/08mar97/0126	699	1b	3.277	4839.2
w134c4r/S3	o/525	w134c4r/butthead/o/08mar97/0240	349	1b	3.277	4676.8
w134c4r/S3	o/525	w134c4r/butthead/o/08mar97/0020	639	60b	3.277	4668.8
w140c4r/S1	f/677	w140c4r/butthead/f/23jan97/2114	647	1b	3.277	2550
w140c4r/S1	f/677	w140c4r/butthead/f/23jan97/2035	649	1b	3.277	2542.8
w140c4r/S1	f/677	w140c4r/butthead/f/23jan97/1830	650	0n	3.277	2552.4
w140c4r/S1	f/677	w140c4r/butthead/f/23jan97/1745	649	1b	3.277	2554
w140c4r/S1	f/677	w140c4r/butthead/f/23jan97/1525	649	1b	3.277	2506
w140c4r/S1	f/677	w140c4r/butthead/f/23jan97/1432	646	2b	3.277	2548
w103c4/REF	f/677	w103c4/butthead/f/23jan97/2202	248	105b	7.226	2220.8
w103c4/REF	f/677	w103c4/butthead/f/23jan97/1913	568	27b	7.227	2220.4
w103c4/REF	f/677	w103c4/butthead/f/23jan97/1612	566	77b	7.227	2220.8
w103c4/REF	f/677	w103c4/butthead/f/23jan97/1302	532	131b	7.226	2222
w140c4r/S1	si/1740	w140c4r/butthead/si/20jan97/1839	325	0n	3.277	2645.2
w140c4r/S1	si/1740	w140c4r/butthead/si/20jan97/1754	649	1b	3.277	2644.8
w140c4r/S1	si/1740	w140c4r/butthead/si/20jan97/1706	619	31b	3.277	2626.4
w140c4r/S1	si/1740	w140c4r/butthead/si/20jan97/1436	614	36b	3.277	2655.6
w140c4r/S1	si/1740	w140c4r/butthead/si/20jan97/1354	650	0n	3.277	2651.6
w140c4r/S1	si/1740	w140c4r/butthead/si/20jan97/1213	650	0n	3.277	2640
w140c4r/S1	si/1740	w140c4r/butthead/si/20jan97/1054	650	0n	3.277	2655.2
w103c4/REF	si/1740	w103c4/butthead/si/20jan97/1909	554	266b	7.227	5355.6
w103c4/REF	si/1740	w103c4/butthead/si/20jan97/1524	557	335b	7.227	5354.8
w103c4/REF	si/1740	w103c4/butthead/si/20jan97/1218	552	371b	7.227	5366
w103c4/REF	si/1740	w103c4/butthead/si/20jan97/0936	538	438b	7.226	5354.8
w140c4r/S1	p/2015	w140c4r/butthead/p/21jan97/2341	648	1b	3.277	2486
w140c4r/S1	p/2015	w140c4r/butthead/p/21jan97/2259	647	1b	3.277	2501.2
w140c4r/S1	p/2015	w140c4r/butthead/p/21jan97/2055	643	3b	3.277	2495.6
w140c4r/S1	p/2015	w140c4r/butthead/p/21jan97/2013	648	1b	3.277	2506
w140c4r/S1	p/2015	w140c4r/butthead/p/21jan97/1932	649	1b	3.277	2510
w140c4r/S1	p/2015	w140c4r/butthead/p/21jan97/1427	648	1b	3.277	2470.4
w140c4r/S1	p/2015	w140c4r/butthead/p/21jan97/1347	646	2b	3.277	2487.2
w140c4r/S1	p/2015	w140c4r/butthead/p/21jan97/1138	649	1b	3.277	2487.2
w140c4r/S1	p/2015	w140c4r/butthead/p/21jan97/1059	648	0n	3.277	2486
w140c4r/S1	p/2015	w140c4r/butthead/p/21jan97/0023	324	0n	3.277	2500
w103c4/REF	p/2015	w103c4/butthead/p/21jan97/2140	357	293b	7.227	3753.6
w103c4/REF	p/2015	w103c4/butthead/p/21jan97/1814	571	244b	7.227	3757.2
w103c4/REF	p/2015	w103c4/butthead/p/21jan97/1222	563	153b	7.226	3713.2
w103c4/REF	p/2015	w103c4/butthead/p/21jan97/0900	562	54b	7.227	3718.4
w103c4/REF	p/2015	w103c4/butthead/p/21jan97/0047	35	163b	7.226	3733.6
w140c4r/S1	ti/4508	w140c4r/butthead/ti/25jan97/2107	649	1b	3.277	2070
w140c4r/S1	ti/4508	w140c4r/butthead/ti/25jan97/2026	648	1b	3.277	2061.2
w140c4r/S1	ti/4508	w140c4r/butthead/ti/25jan97/1802	644	4b	3.277	2064.8
w140c4r/S1	ti/4508	w140c4r/butthead/ti/25jan97/1716	643	5b	3.277	2048.8
w140c4r/S1	ti/4508	w140c4r/butthead/ti/25jan97/1427	648	2b	3.277	2041.2
w140c4r/S1	ti/4508	w140c4r/butthead/ti/25jan97/1345	647	3b	3.277	2036.4
w103c4/REF	ti/4508	w103c4/butthead/ti/25jan97/2154	247	6b	7.227	4697.6
w103c4/REF	ti/4508	w103c4/butthead/ti/25jan97/1847	521	202b	7.226	4694.8
w103c4/REF	ti/4508	w103c4/butthead/ti/25jan97/1514	220	365b	7.227	4693.6
w103c4/REF	ti/4508	w103c4/butthead/ti/25jan97/1226	559	15b	7.226	4697.6
w140c4r/S1	fe55/5894	w140c4r/butthead/fe55/24jan97/1951	323	2b	3.277	2481.2
w140c4r/S1	fe55/5894	w140c4r/butthead/fe55/24jan97/1820	645	5b	3.277	2474.4
w140c4r/S1	fe55/5894	w140c4r/butthead/fe55/24jan97/1738	647	1b	3.277	2475.6
w140c4r/S1	fe55/5894	w140c4r/butthead/fe55/24jan97/1547	649	1b	3.277	2481.6
w140c4r/S1	fe55/5894	w140c4r/butthead/fe55/24jan97/1505	646	2b	3.277	2474.8
w140c4r/S1	fe55/5894	w140c4r/butthead/fe55/24jan97/1218	648	2b	3.277	2470.4
w103c4/REF	fe55/5894	w103c4/butthead/fe55/24jan97/2023	125	NA	7.227	6416.8
w103c4/REF	fe55/5894	w103c4/butthead/fe55/24jan97/1630	432	262b	7.227	6406
w103c4/REF	fe55/5894	w103c4/butthead/fe55/24jan97/1343	524	66b	7.227	6412.4
w103c4/REF	fe55/5894	w103c4/butthead/fe55/24jan97/1058	562	159b	7.226	6418.4

Table 1.44: w140c4r/S1 CSR Quantum Efficiency Data Sets - continued on next page

Chip	Target/Energy eV	Directory	Accepted Frames	Rejected Frames	Frame Time (seconds)	Counts per Frame
w140c4r/S1	cu/8040	w140c4r/butthead/cu/26jan97/2054	647	2b	3.277	837.6
w140c4r/S1	cu/8040	w140c4r/butthead/cu/26jan97/2018	649	1b	3.277	835.6
w140c4r/S1	cu/8040	w140c4r/butthead/cu/26jan97/1933	645	3b	3.277	838.8
w140c4r/S1	cu/8040	w140c4r/butthead/cu/26jan97/1645	649	1b	3.277	839.6
w140c4r/S1	cu/8040	w140c4r/butthead/cu/26jan97/1605	647	2b	3.277	833.2
w140c4r/S1	cu/8040	w140c4r/butthead/cu/26jan97/1510	646	2b	3.277	832.8
w140c4r/S1	cu/8040	w140c4r/butthead/cu/26jan97/1304	645	5b	3.277	837.6
w140c4r/S1	cu/8040	w140c4r/butthead/cu/26jan97/1219	646	3b	3.277	840
w140c4r/S1	cu/8040	w140c4r/butthead/cu/26jan97/1047	648	0n	3.277	838.8
w103c4/REF	cu/8040	w103c4/butthead/cu/26jan97/2137	557	19b	7.226	2464.8
w103c4/REF	cu/8040	w103c4/butthead/cu/26jan97/1805	476	314b	7.226	2469.2
w103c4/REF	cu/8040	w103c4/butthead/cu/26jan97/1305	463	152b	7.227	2468.8
w103c4/REF	cu/8040	w103c4/butthead/cu/26jan97/0922	562	15b	7.227	2478
w140c4r/S1	cu/8040	w140c4r/butthead/cu/27jan97/2009	649	1b	3.277	836.8
w140c4r/S1	cu/8040	w140c4r/butthead/cu/27jan97/1928	649	0n	3.277	829.6
w140c4r/S1	cu/8040	w140c4r/butthead/cu/27jan97/1848	650	0n	3.277	838
w140c4r/S1	cu/8040	w140c4r/butthead/cu/27jan97/1559	646	3b	3.277	830.8
w140c4r/S1	cu/8040	w140c4r/butthead/cu/27jan97/1519	650	0n	3.277	839.2
w140c4r/S1	cu/8040	w140c4r/butthead/cu/27jan97/1438	646	3b	3.277	842
w140c4r/S1	cu/8040	w140c4r/butthead/cu/27jan97/1211	649	1b	3.277	828.8
w140c4r/S1	cu/8040	w140c4r/butthead/cu/27jan97/1128	648	4b	3.277	831.2
w140c4r/S1	cu/8040	w140c4r/butthead/cu/27jan97/1046	648	1b	3.277	834.4
w103c4/REF	cu/8040	w103c4/butthead/cu/27jan97/2104	561	11b	7.227	2490.8
w103c4/REF	cu/8040	w103c4/butthead/cu/27jan97/1654	544	29b	7.227	2493.2
w103c4/REF	cu/8040	w103c4/butthead/cu/27jan97/1300	566	8b	7.227	2494
w103c4/REF	cu/8040	w103c4/butthead/cu/27jan97/0910	330	68b	7.227	2523.2

Table 1.45: w140c4r/S1 CSR Quantum Efficiency Data Sets - continued from previous page

Chip	Target/Energy eV	Directory	Accepted Frames	Rejected Frames	Frame Time (seconds)	Counts per Frame
w182c4r/S2	o/525	w182c4r/butthead/o/18dec96/2221	198	2b	7.148	2303.2
w182c4r/S2	o/525	w182c4r/butthead/o/18dec96/1930	649	1b	7.148	2327.6
w182c4r/S2	o/525	w182c4r/butthead/o/18dec96/1805	647	3b	7.148	2333.2
w182c4r/S2	o/525	w182c4r/butthead/o/18dec96/1244	646	4b	7.148	2399.6
w182c4r/S2	o/525	w182c4r/butthead/o/18dec96/1111	598	2b	7.148	2422
w103c4/REF	o/525	w103c4/butthead/o/18dec96/2225	280	14b	7.227	2316
w103c4/REF	o/525	w103c4/butthead/o/18dec96/2100	577	17b	7.227	2321.2
w103c4/REF	o/525	w103c4/butthead/o/18dec96/1553	576	16b	7.227	2358.8
w103c4/REF	o/525	w103c4/butthead/o/18dec96/1432	561	26b	7.227	2378.4
w103c4/REF	o/525	w103c4/butthead/o/18dec96/0933	512	81b	7.227	2431.2
w182c4r/S2	o/525	w182c4r/butthead/o/19dec96/1527	640	10b	7.148	2258.8
w182c4r/S2	o/525	w182c4r/butthead/o/19dec96/1408	599	1b	7.148	2246
w182c4r/S2	o/525	w182c4r/butthead/o/19dec96/1249	593	7b	7.148	2236
w103c4/REF	o/525	w103c4/butthead/o/19dec96/1709	581	17b	7.227	2232
w103c4/REF	o/525	w103c4/butthead/o/19dec96/1109	577	17b	7.227	2274.8
w103c4/REF	o/525	w103c4/butthead/o/19dec96/0911	587	9b	7.227	2306.8
w182c4r/S2	f/677	w182c4r/butthead/f/19dec96/2131	324	1n	7.148	2155.6
w182c4r/S2	f/677	w182c4r/butthead/f/19dec96/1953	648	2b	7.148	2155.2
w103c4/REF	f/677	w103c4/butthead/f/19dec96/2217	349	10b	7.227	2253.2
w103c4/REF	f/677	w103c4/butthead/f/19dec96/1835	567	22b	7.227	2250.4
w182c4r/S2	f/677	w182c4r/butthead/f/20dec96/1958	698	2b	7.148	2162
w182c4r/S2	f/677	w182c4r/butthead/f/20dec96/1827	697	3b	7.148	2159.6
w182c4r/S2	f/677	w182c4r/butthead/f/20dec96/1531	696	4b	7.148	2154
w182c4r/S2	f/677	w182c4r/butthead/f/20dec96/1137	560	7n	7.148	2168.4
w103c4/REF	f/677	w103c4/butthead/f/20dec96/2131	575	20b	7.226	2259.6
w103c4/REF	f/677	w103c4/butthead/f/20dec96/1704	576	19b	7.227	2260.8
w103c4/REF	f/677	w103c4/butthead/f/20dec96/1401	549	47b	7.227	2261.6
w103c4/REF	f/677	w103c4/butthead/f/20dec96/1015	578	21b	7.226	2264.4
w182c4r/S2	si/1740	w182c4r/butthead/si/21dec96/1829	362	6n	3.277	2516.4
w182c4r/S2	si/1740	w182c4r/butthead/si/21dec96/1747	627	6n	3.277	2521.2
w182c4r/S2	si/1740	w182c4r/butthead/si/21dec96/1659	633	6n	3.277	2523.2
w182c4r/S2	si/1740	w182c4r/butthead/si/21dec96/1442	628	8n	3.277	2523.6
w182c4r/S2	si/1740	w182c4r/butthead/si/21dec96/1403	622	5n	3.277	2518.8
w182c4r/S2	si/1740	w182c4r/butthead/si/21dec96/1152	633	6n	3.277	2520.8
w182c4r/S2	si/1740	w182c4r/butthead/si/21dec96/1109	596	5n	3.277	2517.6
w103c4/REF	si/1740	w103c4/butthead/si/21dec96/1903	196	4b	7.226	5330.8
w103c4/REF	si/1740	w103c4/butthead/si/21dec96/1534	583	13b	7.227	5326
w103c4/REF	si/1740	w103c4/butthead/si/21dec96/1236	584	12b	7.227	5328.4
w103c4/REF	si/1740	w103c4/butthead/si/21dec96/0925	577	19b	7.227	5321.2
w182c4r/S2	p/2015	w182c4r/butthead/p/22dec96/2013	637	7b	3.277	1776
w182c4r/S2	p/2015	w182c4r/butthead/p/22dec96/1933	647	3b	3.277	1777.6
w182c4r/S2	p/2015	w182c4r/butthead/p/22dec96/1705	643	3b	3.277	1773.2
w182c4r/S2	p/2015	w182c4r/butthead/p/22dec96/1626	643	6b	3.277	1772.4
w182c4r/S2	p/2015	w182c4r/butthead/p/22dec96/1420	642	3b	3.277	1772.8
w182c4r/S2	p/2015	w182c4r/butthead/p/22dec96/1341	645	5b	3.277	1768.8
w182c4r/S2	p/2015	w182c4r/butthead/p/22dec96/1054	581	4n	3.277	1776.4
w103c4/REF	p/2015	w103c4/butthead/p/22dec96/2100	556	15b	7.226	3754
w103c4/REF	p/2015	w103c4/butthead/p/22dec96/1755	562	15b	7.227	3754.8
w103c4/REF	p/2015	w103c4/butthead/p/22dec96/1506	550	20b	7.226	3753.6
w103c4/REF	p/2015	w103c4/butthead/p/22dec96/0915	570	19b	7.226	3748.4
w182c4r/S2	ti/4508	w182c4r/butthead/ti/31dec96/2045	646	4b	3.277	2174.4
w182c4r/S2	ti/4508	w182c4r/butthead/ti/31dec96/1842	646	2b	3.277	2170.4
w182c4r/S2	ti/4508	w182c4r/butthead/ti/31dec96/1757	646	4b	3.277	2170.4
w182c4r/S2	ti/4508	w182c4r/butthead/ti/31dec96/1455	623	6b	3.277	2170.4
w182c4r/S2	ti/4508	w182c4r/butthead/ti/31dec96/1214	642	7b	3.277	2168
w182c4r/S2	ti/4508	w182c4r/butthead/ti/31dec96/1131	649	1b	3.277	2170
w103c4/REF	ti/4508	w103c4/butthead/ti/31dec96/2132	167	32b	7.226	4566
w103c4/REF	ti/4508	w103c4/butthead/ti/31dec96/1939	240	9b	7.227	4582.8
w103c4/REF	ti/4508	w103c4/butthead/ti/31dec96/1617	548	24b	7.226	4570.4
w103c4/REF	ti/4508	w103c4/butthead/ti/31dec96/1316	443	125b	7.227	4575.6
w103c4/REF	ti/4508	w103c4/butthead/ti/31dec96/1017	552	22b	7.227	4574.8
w182c4r/S2	fe55/5894	w182c4r/butthead/fe55/30dec96/2132	647	3b	3.277	3386.8
w182c4r/S2	fe55/5894	w182c4r/butthead/fe55/30dec96/1544	587	5n	3.277	3369.2
w182c4r/S2	fe55/5894	w182c4r/butthead/fe55/30dec96/1501	606	6n	3.277	3385.2
w182c4r/S2	fe55/5894	w182c4r/butthead/fe55/30dec96/1256	584	7n	3.277	3385.6
w182c4r/S2	fe55/5894	w182c4r/butthead/fe55/30dec96/1212	562	8n	3.277	3376
w103c4/REF	fe55/5894	w103c4/butthead/fe55/30dec96/2314	99	1b	7.227	6499.2
w103c4/REF	fe55/5894	w103c4/butthead/fe55/30dec96/1714	293	7b	7.227	6512
w103c4/REF	fe55/5894	w103c4/butthead/fe55/30dec96/1341	561	13b	7.226	6515.6
w103c4/REF	fe55/5894	w103c4/butthead/fe55/30dec96/1052	546	23b	7.227	6517.6

Table 1.46: w182c4r/S2 CSR Quantum Efficiency Data Sets - continued on next page

Chip	Target/Energy eV	Directory	Accepted Frames	Rejected Frames	Frame Time (seconds)	Counts per Frame
w182c4r/S2	cu/8040	w182c4r/butthead/cu/02jan97/2212	644	6b	3.277	1360.4
w103c4/REF	cu/8040	w103c4/butthead/cu/02jan97/2256	231	20b	7.227	2372.4
w103c4/REF	cu/8040	w103c4/butthead/cu/02jan97/2103	284	13b	7.227	2363.6
w182c4r/S2	cu/8040	w182c4r/butthead/cu/03jan97/2353	521	4b	3.277	1423.2
w182c4r/S2	cu/8040	w182c4r/butthead/cu/03jan97/2318	520	5b	3.277	1422.4
w182c4r/S2	cu/8040	w182c4r/butthead/cu/03jan97/2112	636	9b	3.277	1416.8
w182c4r/S2	cu/8040	w182c4r/butthead/cu/03jan97/2031	637	6b	3.277	1417.6
w182c4r/S2	cu/8040	w182c4r/butthead/cu/03jan97/1945	643	7b	3.277	1418.8
w182c4r/S2	cu/8040	w182c4r/butthead/cu/03jan97/1737	646	4b	3.277	1420.8
w182c4r/S2	cu/8040	w182c4r/butthead/cu/03jan97/1640	645	5b	3.277	1421.2
w182c4r/S2	cu/8040	w182c4r/butthead/cu/03jan97/1430	645	4b	3.277	1419.6
w182c4r/S2	cu/8040	w182c4r/butthead/cu/03jan97/1349	644	6b	3.277	1421.2
w103c4/REF	cu/8040	w103c4/butthead/cu/03jan97/2158	560	11b	7.227	2440.4
w103c4/REF	cu/8040	w103c4/butthead/cu/03jan97/1821	61	512b	7.227	2452.8
w103c4/REF	cu/8040	w103c4/butthead/cu/03jan97/1521	501	68b	7.226	2455.6
w103c4/REF	cu/8040	w103c4/butthead/cu/03jan97/1132	476	91b	7.225	2452.8
w103c4/REF	cu/8040	w103c4/butthead/cu/03jan97/0034	376	188b	7.227	2430.8
w182c4r/S2	cu/8040	w182c4r/butthead/cu/04jan97/1411	449	1b	3.277	1419.2
w182c4r/S2	cu/8040	w182c4r/butthead/cu/04jan97/1157	648	2b	3.277	1416.8
w103c4/REF	cu/8040	w103c4/butthead/cu/04jan97/1603	423	150b	7.226	2437.2
w103c4/REF	cu/8040	w103c4/butthead/cu/04jan97/1448	480	94b	7.227	2442
w103c4/REF	cu/8040	w103c4/butthead/cu/04jan97/1249	337	NA	7.227	2436.4
w103c4/REF	cu/8040	w103c4/butthead/cu/04jan97/1036	518	51b	7.227	2456.8

Table 1.47: w182c4r/S2 CSR Quantum Efficiency Data Sets - continued from previous page

Chip	Target/Energy eV	Directory	Accepted Frames	Rejected Frames	Frame Time (seconds)	Counts per Frame
w134c4r/S3	c/277	w134c4r/butthead/c/08mar97/0304	687	13b	3.277	2315.6
w134c4r/S3	c/277	w134c4r/butthead/c/08mar97/0539	687	3b	3.277	2452.4
w134c4r/S3	c/277	w134c4r/butthead/c/08mar97/0835	706	13b	3.277	2400.8
w134c4r/S3	c/277	w134c4r/butthead/c/08mar97/0921	715	5b	3.277	2390
w134c4r/S3	c/277	w134c4r/butthead/c/08mar97/1341	719	1b	3.277	2356
w134c4r/S3	c/277	w134c4r/butthead/c/08mar97/1544	524	196b	3.277	2348.4
w140c4r/S1	c/277	w140c4r/butthead/c/08mar97/0412	692	6b	3.277	2476.4
w140c4r/S1	c/277	w140c4r/butthead/c/08mar97/0624	695	5b	3.277	2426.8
w140c4r/S1	c/277	w140c4r/butthead/c/08mar97/1039	712	8b	3.277	2378.4
w140c4r/S1	c/277	w140c4r/butthead/c/08mar97/1132	706	13b	3.277	2380
w140c4r/S1	c/277	w140c4r/butthead/c/08mar97/1239	717	3b	3.277	2370.4
w140c4r/S1	c/277	w140c4r/butthead/c/08mar97/1445	712	3b	3.277	2356
w134c4r/S3	o/525	w134c4r/butthead/o/02feb97/1525	648	2b	3.277	4164.8
w134c4r/S3	o/525	w134c4r/butthead/o/02feb97/1753	650	0n	3.277	4151.6
w134c4r/S3	o/525	w134c4r/butthead/o/02feb97/2030	648	1b	3.277	4164
w134c4r/S3	o/525	w134c4r/butthead/o/02feb97/2249	300	0n	3.277	4130
w203c2/REF	o/525	w203c2/butthead/o/02feb97/1314	628	22b	7.148	2666.4
w203c2/REF	o/525	w203c2/butthead/o/02feb97/1614	645	5b	7.148	2672.4
w203c2/REF	o/525	w203c2/butthead/o/02feb97/1857	625	5b	7.148	2583.6
w203c2/REF	o/525	w203c2/butthead/o/02feb97/2118	623	7b	7.148	2615.2
w203c2/REF	o/525	w203c2/butthead/o/02feb97/2317	623	7b	7.148	2635.2
w134c4r/S3	f/677	w134c4r/butthead/f/03feb97/1438	643	5b	3.277	2504.4
w134c4r/S3	f/677	w134c4r/butthead/f/03feb97/1702	647	0n	3.277	2510
w134c4r/S3	f/677	w134c4r/butthead/f/03feb97/1917	649	1b	3.277	2506
w134c4r/S3	f/677	w134c4r/butthead/f/03feb97/2127	649	1b	3.277	2505.6
w134c4r/S3	f/677	w134c4r/butthead/f/03feb97/2332	649	1b	3.277	2501.2
w203c2/REF	f/677	w203c2/butthead/f/03feb97/1015	646	4b	7.148	1405.6
w203c2/REF	f/677	w203c2/butthead/f/03feb97/1315	645	5b	7.148	1398.4
w203c2/REF	f/677	w203c2/butthead/f/03feb97/1532	645	5b	7.148	1393.6
w203c2/REF	f/677	w203c2/butthead/f/03feb97/1746	646	4b	7.148	1394.4
w203c2/REF	f/677	w203c2/butthead/f/03feb97/2000	647	3b	7.148	1390.8
w203c2/REF	f/677	w203c2/butthead/f/03feb97/2210	646	4b	7.148	1388.4
w203c2/REF	f/677	w203c2/butthead/f/04feb97/0019	644	4b	7.148	1388.4
w203c2/REF	f/677	w203c2/butthead/f/04feb97/0148	649	4b	7.148	1388.4
w203c2/REF	f/677	w203c2/butthead/f/04feb97/0312	647	4b	7.148	1388.4
w134c4r/S3	si/1740	w134c4r/butthead/si/04feb97/0957	648	1b	3.277	5545.6
w134c4r/S3	si/1740	w134c4r/butthead/si/04feb97/1122	649	1b	3.277	5550
w134c4r/S3	si/1740	w134c4r/butthead/si/04feb97/1205	455	1b	3.277	5540
w203c2/REF	si/1740	w203c2/butthead/si/04feb97/0904	615	5b	3.277	4993.6
w203c2/REF	si/1740	w203c2/butthead/si/04feb97/1039	646	2b	3.277	4991.2
w203c2/REF	si/1740	w203c2/butthead/si/04feb97/1239	646	2b	3.277	4992.8
w134c4r/S3	p/2015	w134c4r/butthead/p/04feb97/1427	648	2b	3.277	4560.4
w134c4r/S3	p/2015	w134c4r/butthead/p/04feb97/1738	649	1b	3.277	4560.4
w134c4r/S3	p/2015	w134c4r/butthead/p/04feb97/1833	473	2b	3.277	4564.4
w203c2/REF	p/2015	w203c2/butthead/p/04feb97/1341	646	4b	3.277	3036.4
w203c2/REF	p/2015	w203c2/butthead/p/04feb97/1511	644	6b	3.277	3037.6
w203c2/REF	p/2015	w203c2/butthead/p/04feb97/1732	640	6b	3.277	3030.8
w203c2/REF	p/2015	w203c2/butthead/p/04feb97/1907	680	5b	3.277	3036
w134c4r/S3	ti/4508	w134c4r/butthead/ti/05feb97/0931	646	2b	3.277	4559.2
w134c4r/S3	ti/4508	w134c4r/butthead/ti/05feb97/1027	648	0n	3.277	4594
w203c2/REF	ti/4508	w203c2/butthead/ti/05feb97/0843	357	292b	3.277	4626
w203c2/REF	ti/4508	w203c2/butthead/ti/05feb97/1117	647	2b	3.277	4627.6
w134c4r/S3	fe55/5894	w134c4r/butthead/fe55/04feb97/2047	648	1b	3.277	2832
w134c4r/S3	fe55/5894	w134c4r/butthead/fe55/04feb97/2212	646	1b	3.277	2812
w134c4r/S3	fe55/5894	w134c4r/butthead/fe55/04feb97/2310	646	3b	3.277	2825.2
w134c4r/S3	fe55/5894	w134c4r/butthead/fe55/04feb97/2350	648	0n	3.277	2839.2
w203c2/REF	fe55/5894	w203c2/butthead/fe55/04feb97/2001	640	6b	3.277	3215.6
w203c2/REF	fe55/5894	w203c2/butthead/fe55/04feb97/2130	645	5b	3.277	3212
w203c2/REF	fe55/5894	w203c2/butthead/fe55/05feb97/0116	648	2b	3.277	3214.8
w203c2/REF	fe55/5894	w203c2/butthead/fe55/05feb97/0156	649	0n	3.277	3214.4
w134c4r/S3	cu/8040	w134c4r/butthead/cu/05feb97/2139	646	3b	3.277	2409.2
w134c4r/S3	cu/8040	w134c4r/butthead/cu/05feb97/2221	649	0n	3.277	2392
w203c2/REF	cu/8040	w203c2/butthead/cu/05feb97/2043	643	nun		
w203c2/REF	cu/8040	w203c2/butthead/cu/05feb97/2333	647	nun		
w134c4r/S3	cu/8040	w134c4r/butthead/cu/06feb97/0024	375	0n	3.277	2415.6
w203c2/REF	cu/8040	w203c2/butthead/cu/06feb97/0109	100	0n	3.277	2886.8

Table 1.48: w134c4r/S3 CSR Quantum Efficiency Data Sets

Chip	Target/Energy eV	Directory	Accepted Frames	Rejected Frames	Frame Time (seconds)	Counts per Frame
w457c4/S4	o/525	w457c4/beavis/o/29nov96/2108	692	3b	7.15	3561.6
w457c4/S4	o/525	w457c4/beavis/o/29nov96/1936	690	5b	7.149	3563.2
w457c4/S4	o/525	w457c4/beavis/o/29nov96/1556	698	2b	7.149	3555.2
w457c4/S4	o/525	w457c4/beavis/o/29nov96/1157	598	2b	7.149	3574
w190c3/REF	o/525	w190c3/beavis/o/29nov96/2245	692	3b	7.149	3481.6
w190c3/REF	o/525	w190c3/beavis/o/29nov96/1757	692	3b	7.149	3485.6
w190c3/REF	o/525	w190c3/beavis/o/29nov96/1407	596	4b	7.149	3475.6
w190c3/REF	o/525	w190c3/beavis/o/29nov96/1023	422	2b	7.149	3490.8
w457c4/S4	o/525	w457c4/beavis/o/30nov96/1231	352	5b	7.15	3548
w457c4/S4	o/525	w457c4/beavis/o/30nov96/1037	647	3b	7.149	3550.4
w190c3/REF	o/525	w190c3/beavis/o/30nov96/1401	447	3b	7.149	3483.6
w190c3/REF	o/525	w190c3/beavis/o/30nov96/0857	697	3b	7.149	3488.8
w457c4/S4	f/677	w457c4/beavis/f/30nov96/2112	646	4b	7.149	3903.2
w457c4/S4	f/677	w457c4/beavis/f/30nov96/1822	647	3b	7.149	3896
w457c4/S4	f/677	w457c4/beavis/f/30nov96/1659	648	2b	7.15	3870.8
w190c3/REF	f/677	w190c3/beavis/f/30nov96/2239	648	2b	7.149	3644.8
w190c3/REF	f/677	w190c3/beavis/f/30nov96/1947	648	2b	7.149	3643.2
w190c3/REF	f/677	w190c3/beavis/f/30nov96/1523	647	3b	7.149	3631.2
w457c4/S4	si/1740	w457c4/beavis/si/03dec96/1304	648	2b	3.277	5518.8
w457c4/S4	si/1740	w457c4/beavis/si/03dec96/1216	646	4b	3.277	5520
w457c4/S4	si/1740	w457c4/beavis/si/03dec96/1029	648	2b	3.277	5512.4
w190c3/REF	si/1740	w190c3/beavis/si/03dec96/1359	648	1n	3.277	5468.4
w190c3/REF	si/1740	w190c3/beavis/si/03dec96/1117	647	2b	3.277	5456.8
w190c3/REF	si/1740	w190c3/beavis/si/03dec96/0933	645	4b	3.277	5452.4
w457c4/S4	p/2015	w457c4/beavis/p/03dec96/2120	123	NA	3.277	4600.8
w457c4/S4	p/2015	w457c4/beavis/p/03dec96/1923	643	4b	3.277	4602.8
w457c4/S4	p/2015	w457c4/beavis/p/03dec96/1727	651	2b	3.277	4601.6
w190c3/REF	p/2015	w190c3/beavis/p/03dec96/2217	405	1b	3.277	4555.6
w190c3/REF	p/2015	w190c3/beavis/p/03dec96/2027	633	5b	3.277	4558
w190c3/REF	p/2015	w190c3/beavis/p/03dec96/1825	634	NA	3.278	4554.4
w190c3/REF	p/2015	w190c3/beavis/p/03dec96/1646	644	1b	3.277	4370.4
w457c4/S4	ti/4508	w457c4/beavis/ti/04dec96/2019	648	2b	3.277	5091.6
w457c4/S4	ti/4508	w457c4/beavis/ti/04dec96/1937	642	5b	3.277	5088.4
w457c4/S4	ti/4508	w457c4/beavis/ti/04dec96/1855	646	4b	3.277	5091.6
w190c3/REF	ti/4508	w190c3/beavis/ti/04dec96/2306	64	1b	3.277	5052.8
w190c3/REF	ti/4508	w190c3/beavis/ti/04dec96/2144	435	1b	3.277	5068
w190c3/REF	ti/4508	w190c3/beavis/ti/04dec96/2101	645	5b	3.277	5069.2
w190c3/REF	ti/4508	w190c3/beavis/ti/04dec96/1804	648	2b	3.277	5061.6
w457c4/S4	fe55/5894	w457c4/beavis/fe55/04dec96/1700	150	0n	3.277	3741.2
w457c4/S4	fe55/5894	w457c4/beavis/fe55/04dec96/1440	648	2b	3.277	3744
w457c4/S4	fe55/5894	w457c4/beavis/fe55/04dec96/1344	646	4b	3.277	3744.8
w457c4/S4	fe55/5894	w457c4/beavis/fe55/04dec96/1206	645	4b	3.277	3747.2
w457c4/S4	fe55/5894	w457c4/beavis/fe55/04dec96/1014	648	5b	3.277	3742.4
w190c3/REF	fe55/5894	w190c3/beavis/fe55/04dec96/1737	150	0n	3.277	3731.6
w190c3/REF	fe55/5894	w190c3/beavis/fe55/04dec96/1533	647	3b	3.277	3729.6
w190c3/REF	fe55/5894	w190c3/beavis/fe55/04dec96/1254	645	5b	3.277	3730
w190c3/REF	fe55/5894	w190c3/beavis/fe55/04dec96/1113	641	5b	3.277	3732.4
w190c3/REF	fe55/5894	w190c3/beavis/fe55/04dec96/0925	645	4b	3.277	3734.4
w457c4/S4	cu/8040	w457c4/beavis/cu/05dec96/2017	519	1b	3.277	3209.2
w457c4/S4	cu/8040	w457c4/beavis/cu/05dec96/1646	650	0n	3.277	3198.4
w457c4/S4	cu/8040	w457c4/beavis/cu/05dec96/1549	645	4b	3.277	3201.2
w457c4/S4	cu/8040	w457c4/beavis/cu/05dec96/1343	644	6b	3.277	3202
w457c4/S4	cu/8040	w457c4/beavis/cu/05dec96/1208	645	3b	3.277	3202.4
w190c3/REF	cu/8040	w190c3/beavis/cu/05dec96/2056	514	5b	3.277	3179.2
w190c3/REF	cu/8040	w190c3/beavis/cu/05dec96/1834	644	4b	3.277	3158.4
w190c3/REF	cu/8040	w190c3/beavis/cu/05dec96/1430	646	3b	3.277	3194
w190c3/REF	cu/8040	w190c3/beavis/cu/05dec96/1252	646	6b	3.277	3193.2
w190c3/REF	cu/8040	w190c3/beavis/cu/05dec96/1017	644	3b	3.277	3203.6

Table 1.49: w457c4/S4 CSR Quantum Efficiency Data Sets

Chip	Target/Energy eV	Directory	Accepted Frames	Rejected Frames	Frame Time (seconds)	Counts per Frame
w201c3r/S5	o/525	w201c3r/beavis/o/07dec96/1854	650	NA	7.15	3467.6
w201c3r/S5	o/525	w201c3r/beavis/o/07dec96/1705	650	NA	7.149	3471.2
w201c3r/S5	o/525	w201c3r/beavis/o/07dec96/1513	344	5b	7.15	3475.6
w190c3/REF	o/525	w190c3/beavis/o/07dec96/2026	645	5b	7.149	3416.4
w190c3/REF	o/525	w190c3/beavis/o/07dec96/1532	649	1b	7.149	3366
w190c3/REF	o/525	w190c3/beavis/o/07dec96/1238	646	4b	7.149	3471.6
w201c3r/S5	o/525	w201c3r/beavis/o/08dec96/1525	648	2b	7.15	3445.6
w201c3r/S5	o/525	w201c3r/beavis/o/08dec96/1324	647	3b	7.15	3444.8
w190c3/REF	o/525	w190c3/beavis/o/08dec96/1806	648	2b	7.149	3430.4
w190c3/REF	o/525	w190c3/beavis/o/08dec96/1150	648	2b	7.149	3434.4
w201c3r/S5	f/677	w201c3r/beavis/f/08dec96/2235	399	1b	7.15	3728.8
w190c3/REF	f/677	w190c3/beavis/f/08dec96/2344	198	2b	7.15	3629.6
w190c3/REF	f/677	w190c3/beavis/f/08dec96/2049	84	0n	7.149	3622.4
w201c3r/S5	f/677	w201c3r/beavis/f/09dec96/2219	574	1b	7.15	3714
w201c3r/S5	f/677	w201c3r/beavis/f/09dec96/1806	362	0n	7.15	3716.8
w201c3r/S5	f/677	w201c3r/beavis/f/09dec96/1609	574	1b	7.149	3717.2
w201c3r/S5	f/677	w201c3r/beavis/f/09dec96/1054	649	1b	7.149	3723.6
w190c3/REF	f/677	w190c3/beavis/f/09dec96/1923	562	4b	7.149	3612.4
w190c3/REF	f/677	w190c3/beavis/f/09dec96/1415	572	3b	7.149	3628.8
w190c3/REF	f/677	w190c3/beavis/f/09dec96/1238	572	3b	7.149	3622
w201c3r/S5	si/1740	w201c3r/beavis/si/10dec96/1321	573	2b	3.277	5557.6
w201c3r/S5	si/1740	w201c3r/beavis/si/10dec96/1238	647	3b	3.277	5546.8
w201c3r/S5	si/1740	w201c3r/beavis/si/10dec96/1055	647	NA	3.277	5550
w190c3/REF	si/1740	w190c3/beavis/si/10dec96/1402	575	NA	3.277	5544.8
w190c3/REF	si/1740	w190c3/beavis/si/10dec96/1147	646	2b	3.277	5543.6
w190c3/REF	si/1740	w190c3/beavis/si/10dec96/0921	650	5b	3.277	5536.8
w201c3r/S5	p/2015	w201c3r/beavis/p/10dec96/2123	299	1b	3.277	4542
w201c3r/S5	p/2015	w201c3r/beavis/p/10dec96/2033	642	1n	3.279	4546.4
w201c3r/S5	p/2015	w201c3r/beavis/p/10dec96/1810	644	4b	3.277	4544.4
w201c3r/S5	p/2015	w201c3r/beavis/p/10dec96/1558	648	1b	3.277	4551.2
w190c3/REF	p/2015	w190c3/beavis/p/10dec96/2156	349	1b	3.277	4563.2
w190c3/REF	p/2015	w190c3/beavis/p/10dec96/1858	644	3b	3.277	4566.4
w190c3/REF	p/2015	w190c3/beavis/p/10dec96/1720	650	NA	3.277	4571.6
w190c3/REF	p/2015	w190c3/beavis/p/10dec96/1502	643	4b	3.277	4570.8
w201c3r/S5	ti/4508	w201c3r/beavis/ti/12dec96/1555	147	3b	3.277	5066.8
w201c3r/S5	ti/4508	w201c3r/beavis/ti/12dec96/1456	646	4b	3.277	5068.4
w201c3r/S5	ti/4508	w201c3r/beavis/ti/12dec96/1327	668	7b	3.277	5068.4
w201c3r/S5	ti/4508	w201c3r/beavis/ti/12dec96/1141	637	11b	3.277	5071.2
w190c3/REF	ti/4508	w190c3/beavis/ti/12dec96/1613	399	1b	3.277	5064
w190c3/REF	ti/4508	w190c3/beavis/ti/12dec96/1235	645	3b	3.277	5022.8
w190c3/REF	ti/4508	w190c3/beavis/ti/12dec96/1002	649	1b	3.277	5082.4
w201c3r/S5	fe55/5894	w201c3r/beavis/fe55/11dec96/1730	546	4b	3.277	3714.8
w201c3r/S5	fe55/5894	w201c3r/beavis/fe55/11dec96/1645	639	7b	3.277	3723.2
w201c3r/S5	fe55/5894	w201c3r/beavis/fe55/11dec96/1426	646	4b	3.277	3712
w201c3r/S5	fe55/5894	w201c3r/beavis/fe55/11dec96/1235	646	4b	3.277	3718.4
w201c3r/S5	fe55/5894	w201c3r/beavis/fe55/11dec96/1056	255	2b	3.277	3717.6
w190c3/REF	fe55/5894	w190c3/beavis/fe55/11dec96/1331	460	4b	3.277	3715.6
w190c3/REF	fe55/5894	w190c3/beavis/fe55/11dec96/1141	646	4b	3.277	3711.2
w190c3/REF	fe55/5894	w190c3/beavis/fe55/11dec96/1008	647	1b	3.277	3714.4
w201c3r/S5	cu/8040	w201c3r/beavis/cu/12dec96/2101	643	1b	3.28	2989.6
w201c3r/S5	cu/8040	w201c3r/beavis/cu/12dec96/1923	645	3b	3.277	3002.4
w201c3r/S5	cu/8040	w201c3r/beavis/cu/12dec96/1754	646	1b	3.277	2996.8
w190c3/REF	cu/8040	w190c3/beavis/cu/12dec96/2007	644	6b	3.277	2960.8
w190c3/REF	cu/8040	w190c3/beavis/cu/12dec96/1838	649	NA	3.277	2983.2
w190c3/REF	cu/8040	w190c3/beavis/cu/12dec96/1644	645	4b	3.277	2984.8
w201c3r/S5	cu/8040	w201c3r/beavis/cu/13dec96/2019	400	0n	3.277	3057.2
w201c3r/S5	cu/8040	w201c3r/beavis/cu/13dec96/1940	649	1b	3.277	3052.8
w190c3/REF	cu/8040	w190c3/beavis/cu/13dec96/2054	399	1b	3.277	3028
w190c3/REF	cu/8040	w190c3/beavis/cu/13dec96/1857	643	4b	3.277	3041.6

Table 1.50: w201c3r/S5 CSR Quantum Efficiency Data Sets

Data File	Description
*_rt.evlist	ACIS RV format eventlist
*_rt_bias_avg.fits	mean bias frame
*_bias.000?.fits	sample bias frames
*_frame.000?.fits	sample data frames
*.mca.summary	ascii file summarizing the dataset
*.mca.data	IDL save file including average overclock level, average overclock noise, total number of events, peak location, peak width, and number of events under the peak as a function of frame number.
*.mca.spec	IDL save file including number of events as a function of energy, quadrant, and grade, and an image of the g02346 events under the peak in 32x32 pixel bins.
products/*g0234_img.fits	number density map of detected events in g0234.
products/*g0.qdp	for each quadrant, the pulse height histogram of g0 events.
products/*g0234.qdp	for each quadrant, the pulse height histogram of g0234 events.
products/*g0234_lightcv.qdp	for each quadrant, g0234 count rate as a function of frame number.
prodcuts/*pcf.qdp	for each quadrant, pulse height histograms of each grade.
products/*neighborhist*.qdp	for each quadrant, histograms of corner, top, bottom, left, and right pixel distributions of detected events.

Table 1.51: CSR Database Products

1.7.1.5 IDL Data Products

Each data set in the CSR subassembly calibration database has several files created by and for IDL procedures.

These include the .evlist, .mca.data, .mca.summary, and .mca.spec files.

The .evlist file is an RV format event list. See http://acis.mit.edu/ttools/acis-analysis.html for a description of the file format.

The .mca.data file is an IDL file created by the "save" command. The variables saved in this file are biasl, noise, evlog, peaknum, width, peakloc, bad_data, and good_data. biasl is an array that contains the frame number and the average overclock value for each of the four quadrants for each frame. noise is an array that contains the frame number, the standard deviation of the overclocks for each of the four quadrants, the total number of overclock pixels above the event threshold, the difference between pixels at the top of the image area and those at the bottom of the image area, and the difference between pixels in the image area and pixels in the overclocks for each frame. evlog is an array that contains the number of pixels above threshold, the total number of events, the number of g0234 events in all energies, and the number of g0 events in all energies for each frame. peaknum is an array that contains the total number of counts under the gaussian fit to the main peak of the cumulative g02346 spectrum for each quadrant for each frame. width is an array that contains the width of the gaussian fit to the main peak of the cumulative g02346 spectrum for each quadrant for each frame. peakloc is an array that contains the location in ADU of the gaussian fit to the main peak of the cumulative g02346 spectrum for each quadrant for each frame. bad_data is an array containing the frame number of all unacceptable frames (these frames are not included in the event list). good_data is an array containing the frame number of all acceptable frames.

The .mca.summary file is an ascii file that summarizes the data set. Included in the summary file are the thresholds used, the integration time (msec per frame), the total number of requested frames, the total number of acceptable frames, the total number of frames with unacceptable noise, the total number of frames with overclock pixels over the event threshold, the average overclock level, the average overclock standard deviation, the location (in ADU) of the fitted g02346 peak, the sigma (in ADU) of the fitted g02346 peak, the FWHM (in eV) of the fitted g02346 peak, the total number of counts in the fitted g02346 peak, the number of counts per frame in the fitted g02346 peak, a summary of the total number of events (all energies) in each grade, the branching ratios for each grade, and the counts per frame (all energies) for each grade for each quadrant.

The .mca.spec file is an IDL file created by the "save" command. The variables saved in this file are spectrum, uniplot, and badcol. spectrum is an array that contains the number of events per channel for each quadrant for each grade. uniplot is a 32 x 32 array of the uniformity of the g02346 events under the peak. Each value is the total number of g02346 events under the peak for a 32 x 32 pixel region (in chip coordinates). badcol is an array that contains the total number of events in the g02346 peak per column (in chip coordinates).

1.7.2 Relative Quantum Efficiency Measured at MIT CSR

Here we present results of relative quantum efficiency (QE) measurements made at MIT CSR. In section 1.7.2.1 we discuss spatially-averaged relative quantum efficiency measurements and their internal consistency. In section 1.7.2.2 we discuss spatial variations in relative quantum efficiency.

1.7.2.1 Spatially-averaged Relative Quantum Efficiency Measurements

The results of the relative quantum efficiency measurements described above in Section 1.7.1 are presented in Table 1.52. The mean relative efficiencies given in the table are the centroids obtained from Gaussian fits to histograms of the superpixel ratios in each measurement. These values have been corrected for pileup and are our best estimates for the spatially averaged relative efficiency between the corresponding flight and reference detectors. Listed in parentheses are measurements of the spatial variation (RMS) in efficiency across each chip, obtained by computing the standard deviation of the superpixel ratios. (Note that the RMS variations in efficiency are heavily influenced the framestore cover shielding at the edge of each device. An alternative measure of spatial variation, which is more representative of the majority of the area of each device, is presented and discussed in Figures 1.77–1.86 in section 1.7.2.2.) The name of the reference device used during each measurement is listed in the table, along with the focal plane position of each flight device. Note the QE ratio listed for w140c4r at 525 eV is referenced to w134c4r, a backside chip. No measurement relative to w103c4 was made at this energy because of time constraints. Also, the QE ratio for w134c4r relative to w203c2 at 677 eV was derived from the corresponding ratio for w140c4r relative to w134c4r. This was necessary because reference device w203c2 was misaligned during calibration of w134c4r at this energy.

The correction factors used to correct the count rates at CSR for pileup are presented in Table 1.53. The values listed in parenthesis are the pileup correction factors applied to the count rates from the reference devices.

In Table 1.54 we have used the values given in Table 1.52 to compute QE ratios referenced to w190c3 for each flight device. The results are plotted in Figure 1.76. Most of the relative efficiency points in the upper panel of the figure lie within 5% of unity, and all but two of the points lie within 10%, indicating that at each energy the absolute efficiencies of the eight frontside devices are nearly identical. In the lower panel we see the backside devices are about three times more efficient than the frontside devices at low energies ($<$ 1 keV), but are less efficient than the frontside devices at high energies ($>$ 3–4 keV).

We have computed the mean relative efficiency and the maximum absolute deviation from the mean for each CCD type as a function of energy (see Table 1.55). The largest absolute deviations from the mean ($\sim$10–20%) in the frontside devices are at 525 eV, 677 eV, and 8 keV. The deviations at 525 eV and 677 eV are due to the high relative efficiency of w182c4r at these energies, which in turn is caused by that detector's relatively thin oxide layer. The reason for the large deviations at 8 keV is still unknown.

From the RMS variations listed in Table 1.54 it can be seen that spatial variations in efficiency across the frontside devices are low (~3–6%). About two-thirds of the RMS variation is the result of shadowing by the framestore covers. Thus, we find the detection efficiencies of the frontside devices are highly uniform within each chip and between the chips.

The spatial variations in efficiency across the backside devices are generally larger (~5–8%) than in the frontside devices, but the maximum absolute deviations from the mean of the backside devices are of comparable amplitude to those of the frontside devices. Hence the spatially averaged quantum efficiencies of the two backside devices are in reasonably good agreement with each other.

1.7.2.1.1 Uncertainties in the Cross-calibration of Reference Detectors at 8 keV. The cross-calibration of the two reference detectors w190c3 and w103c4 requires special discussion. The first cross-calibration measurements were made in 1996 April, before we understood how rapidly pileup probability rises with increasing energy. As a result, the fluences used were fairly high (~ 2000 and ~ 3600 counts per CCD per frametime for w103c4 and w190c3, respectively) and the pileup corrections were large (12% and 23%, respectively). For this reason, the measurements at 8 keV were repeated in 1997 October at fluences about a factor of two lower. The (pileup-corrected) estimates of relative QE (w190c3:w103c4) at 8 keV obtained from these two measurements are substantially different: 1.210 for the earlier, higher-flux measurement, and 1.110 for the later one. Relative QE measurements at 5.9 keV made at these two epochs agree to within 2%.

A third estimate of the relative efficiency of these two devices is available because one flight detector, I0 (w203c4r), was calibrated against both reference detectors (at relatively low flux). Assuming that the flight detector is stable, we infer a relative QE (w190c3:w103c4) of 1.174 (see Table 1.56).

The cause of this discrepancy is unknown. It is possible, and perhaps plausible, that the pileup corrections are systematically in error for reference detector w103c4 at high energies. This detector has always been operated with an older (non-ACIS) set of analog electronics, which provides lower depletion depth and longer minimum integration times than the ACIS electronics. These differences tend to increase the severity of pileup, particularly at high energies. In spite of these differences, we have used a single pileup model for both detectors.

In the end, we have adopted the unweighted average of the three estimates ($(1.110 + 1.210 + 1.174)/3 = 1.164$) as the relative QE of w190c3:w103c4 at 8 keV. While this number affects our comparison of CSR and XRCF efficiencies, it has no effect on our absolute quantum efficiency model. With our current model, the high energy efficiency is determined entirely by branching ratios at 5.9 keV (see Section 1.6.2).

1.7.2.1.2 Internal Consistency of Relative Quantum Efficiency Measurements made at MIT CSR. As noted above, the flight detector I0 (w203c4r) was calibrated with respect to both w190c3 and w103c4. Since we also cross-calibrated w190c3 and w103c4 with respect to one another, it is possible to check the consistency of these measurements. This comparison is shown in Table 1.56. Excluding the point at 8 keV (which was used in the reference detector cross-calibration), the mean difference is 0.0037 ± 0.0035, consistent with zero, where we have taken the standard deviation of the mean as the error. The RMS about the mean is 0.0085. Assuming each of the 3 relative QE measurement sets has the same error, and that the error is independent of energy, then, to a good approximation, the error in any single measurement is $\sigma_{rqe} = 0.0085/\sqrt{3} = 0.0049$.

This level of error, while probably acceptable for ACIS calibration purposes, is one order of magnitude larger than the limiting uncertainty imposed by photon counting statistics. A number of factors may contribute to this excess error. The two reference detectors used are known to have slightly different pileup characteristics, but the same pileup model was used in the analysis of both data sets. One reference detector (w103c4) was operated with an older (pre-ACIS) generation of electronics that is somewhat noisier than the ACIS electronics; the slight differences in response function may contribute some error. Finally, relative misalignment between flight and reference CCDs can influence low energy ratios (C, O, F) due to the non-uniformity of these sources. (Some misalignment on order 50 pixels seems evident in a few cases, despite the apparent precision achieved with the alignment system.) This is less important for higher energies, which make use of a commercial X-ray tube and have a flatter illumination pattern at the CCD location (primarily due to a larger source-detector separation).

Systematic errors in the modelling of the relative calibration measurements are discussed in detail in Section 1.8.

Flight Device	Position	Mean (RMS) Relative Efficiency vs. Energy (keV)							Reference Device
		0.525	0.677	1.740	2.015	4.509	5.894	8.040	
		O	F	Si	P	Ti	Fe55	Cu	
w203c4r	I0	0.972 (0.040)	0.992 (0.041)	0.996 (0.046)	0.982 (0.046)	0.994 (0.046)	0.977 (0.045)	0.933 (0.043)	w190c3
w193c2	I1	0.885 (0.045)	0.768 (0.040)	0.980 (0.052)	0.951 (0.049)	1.005 (0.054)	1.034 (0.055)	1.097 (0.060)	w103c4
w158c4r	I2	0.914 (0.040)	0.804 (0.037)	0.986 (0.047)	0.968 (0.045)	1.007 (0.047)	1.029 (0.048)	1.096 (0.055)	w103c4
w215c2r	I3	0.999 (0.041)	1.015 (0.040)	0.997 (0.051)	0.989 (0.050)	0.996 (0.052)	0.980 (0.053)	0.929 (0.046)	w190c3
w168c4r	S0	1.064 (0.042)	1.089 (0.044)	1.004 (0.050)	1.014 (0.050)	0.997 (0.050)	0.972 (0.048)	0.916 (0.047)	w190c3
w182c4r	S2	1.009 (0.042)	0.962 (0.042)	1.003 (0.053)	1.002 (0.052)	1.014 (0.053)	1.067 (0.055)	1.210 (0.064)	w103c4
w457c4	S4	1.020 (0.030)	1.070 (0.043)	1.005 (0.031)	1.020 (0.032)	1.000 (0.031)	0.999 (0.031)	1.000 (0.031)	w190c3
w201c3r	S5	1.004 (0.032)	1.025 (0.034)	1.001 (0.038)	0.991 (0.037)	1.000 (0.039)	1.000 (0.039)	1.005 (0.040)	w190c3
w140c4r	S1	1.030 (0.037)	1.078 (0.038)						w134c4r
			2.507 (0.114)	1.035 (0.050)	1.442 (0.082)	0.934 (0.080)	0.763 (0.054)	0.631 (0.041)	w103c4
w134c4r	S3	3.457 (0.113)	2.955 (0.184)	1.108 (0.061)	1.570 (0.087)	1.014 (0.061)	0.882 (0.054)	0.743 (0.051)	w203c2
w190c3	Ref.	0.890 (0.020)	0.767 (0.017)	0.986 (0.018)	0.949 (0.014)	1.010 (0.014)	1.058 (0.016)	1.164 (0.051)	w103c4
w203c2	Ref.	0.872 (0.016)	0.787 (0.016)	0.979 (0.015)	0.950 (0.015)	1.004 (0.015)	1.009 (0.016)	1.041 (0.021)	w103c4

Table 1.52: Spatially Averaged Relative Detection Efficiency at CSR

Flight Device	Position	Flight (Reference) Pileup Correction vs. Energy (keV)							Reference Device
		0.525	0.677	1.740	2.015	4.509	5.894	8.040	
		O	F	Si	P	Ti	Fe55	Cu	
w203c4r	I0	1.053 (1.055)	1.074 (1.075)	1.075 (1.076)	1.097 (1.100)	1.063 (1.064)	1.068 (1.070)	1.169 (1.185)	w190c3
w193c2	I1	1.061 (1.071)	1.031 (1.041)	1.033 (1.076)	1.033 (1.079)	1.026 (1.060)	1.064 (1.146)	1.067 (1.142)	w103c4
w158c4r	I2	1.068 (1.076)	1.032 (1.041)	1.022 (1.050)	1.033 (1.078)	1.027 (1.061)	1.066 (1.151)	1.066 (1.141)	w103c4
w215c2r	I3	1.051 (1.051)	1.075 (1.075)	1.073 (1.074)	1.095 (1.097)	1.066 (1.067)	1.068 (1.070)	1.166 (1.182)	w190c3
w168c4r	S0	1.068 (1.064)	1.074 (1.068)	1.073 (1.074)	1.097 (1.096)	1.067 (1.068)	1.070 (1.073)	1.166 (1.184)	w190c3
w182c4r	S2	1.042 (1.042)	1.039 (1.041)	1.033 (1.075)	1.034 (1.078)	1.026 (1.059)	1.065 (1.143)	1.073 (1.140)	w103c4
w457c4	S4	1.067 (1.066)	1.074 (1.069)	1.078 (1.078)	1.098 (1.096)	1.066 (1.066)	1.073 (1.074)	1.200 (1.201)	w190c3
w201c3r	S5	1.065 (1.065)	1.070 (1.069)	1.078 (1.079)	1.096 (1.098)	1.065 (1.066)	1.072 (1.073)	1.184 (1.184)	w190c3
w140c4r	S1	1.073 (1.072)	1.037 (1.034)						w134c4r
			1.037 (1.040)	1.030 (1.076)	1.048 (1.078)	1.032 (1.061)	1.049 (1.140)	1.018 (1.144)	w103c4
w134c4r	S3	1.063 (1.049)	1.033 (1.031)	1.068 (1.070)	1.096 (1.062)	1.077 (1.060)	1.057 (1.062)	1.057 (1.176)	w203c2
w190c3	Ref.	1.062 (1.070)	1.070 (1.093)	1.067 (1.069)	1.091 (1.097)	1.052 (1.119)	1.078 (1.172)	1.087 (1.166)	w103c4
w203c2	Ref.	1.035 (1.041)	1.031 (1.040)	1.034 (1.078)	1.032 (1.076)	1.026 (1.059)	1.056 (1.127)	1.070 (1.158)	w103c4

Table 1.53: Pileup Correction Factors Applied to Count Rates from CSR

Flight Device	Position	Mean (RMS) Relative Efficiency vs. Energy (keV)						
		0.525	0.677	1.740	2.015	4.509	5.894	8.040
		O	F	Si	P	Ti	Fe55	Cu
w203c4r	I0	0.972 (0.040)	0.992 (0.041)	0.996 (0.046)	0.982 (0.046)	0.994 (0.046)	0.977 (0.045)	0.933 (0.043)
w193c2	I1	0.994 (0.053)	1.002 (0.054)	0.994 (0.056)	1.002 (0.053)	0.996 (0.055)	0.977 (0.054)	0.942 (0.076)
w158c4r	I2	1.027 (0.048)	1.049 (0.050)	1.000 (0.050)	1.020 (0.050)	0.997 (0.049)	0.972 (0.049)	0.941 (0.073)
w215c2r	I3	0.999 (0.041)	1.015 (0.040)	0.997 (0.051)	0.989 (0.050)	0.996 (0.052)	0.980 (0.053)	0.929 (0.046)
w168c4r	S0	1.064 (0.042)	1.089 (0.044)	1.004 (0.050)	1.014 (0.050)	0.997 (0.050)	0.972 (0.048)	0.916 (0.047)
w182c4r	S2	1.133 (0.052)	1.255 (0.058)	1.017 (0.057)	1.056 (0.056)	1.005 (0.055)	1.008 (0.055)	1.039 (0.083)
w457c4	S4	1.020 (0.030)	1.070 (0.043)	1.005 (0.031)	1.020 (0.032)	1.000 (0.031)	0.999 (0.031)	1.000 (0.031)
w201c3r	S5	1.004 (0.032)	1.025 (0.034)	1.001 (0.038)	0.991 (0.037)	1.000 (0.039)	1.000 (0.039)	1.005 (0.040)
w140c4r	S1	3.487 (0.190)	3.269 (0.154)	1.050 (0.054)	1.519 (0.088)	0.925 (0.080)	0.721 (0.053)	0.542 (0.047)
w134c4r	S3	3.386 (0.139)	3.032 (0.203)	1.100 (0.065)	1.572 (0.093)	1.008 (0.064)	0.841 (0.055)	0.664 (0.062)

Table 1.54: Spatially Averaged Relative Detection Efficiency at CSR—Referenced to w190c3

Device Type	Mean (Max. Abs. Dev.) Relative Efficiency vs. Energy (keV)						
	0.525	0.677	1.740	2.015	4.509	5.894	8.040
	O	F	Si	P	Ti	Fe55	Cu
FI	1.027 (0.106)	1.062 (0.193)	1.002 (0.015)	1.009 (0.046)	0.998 (0.006)	0.986 (0.022)	0.963 (0.076)
BI	3.436 (0.050)	3.151 (0.119)	1.075 (0.025)	1.546 (0.027)	0.967 (0.041)	0.781 (0.060)	0.603 (0.061)

Table 1.55: Mean Relative Detection Efficiencies for FI and BI CCDs at CSR—Referenced to w190c3

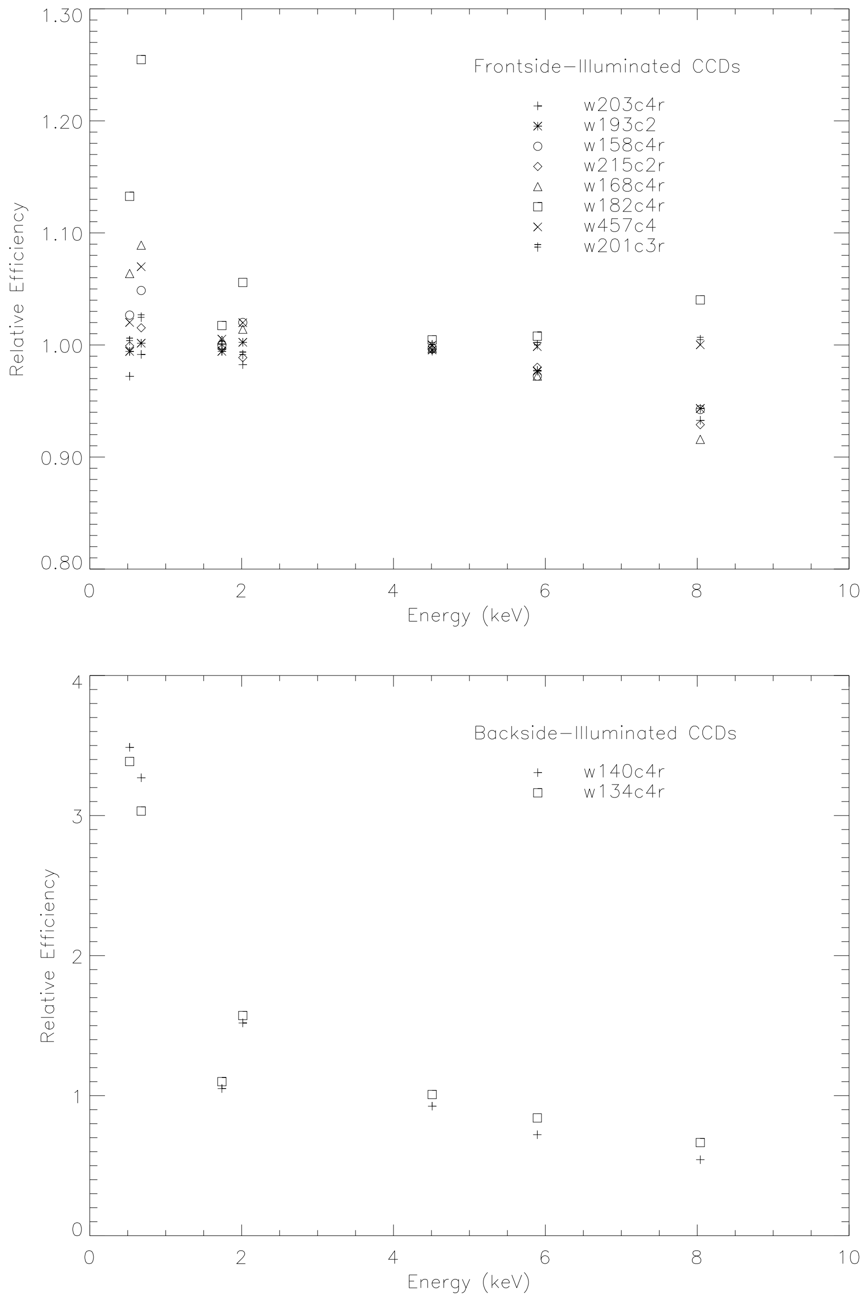


Figure 1.76: Relative detection efficiencies of front-illuminated (upper panel) and back-illuminated (lower panel) ACIS flight CCDs as a function of energy—referenced to w190c3.

Flight Device	Position	Mean Relative Efficiency vs. Energy (keV)							Reference Device
		0.525	0.677	1.740	2.015	4.509	5.894	8.040	
		O	F	Si	P	Ti	Fe55	Cu	
w203c4r	I0	0.972	0.992	0.996	0.982	0.994	0.977	0.933	w190c3 (meas.)
w190c3	Ref.	0.890	0.767	0.986	0.949	1.010	1.058	1.164†	w103c4 (meas.)
w203c4r	I0	0.866	0.760	0.982	0.932	1.004	1.034	1.086†	w103c4 (calc.)
w203c4r	I0	0.848	0.756	0.977	0.940	1.005	1.030	1.095	w103c4 (meas.)
Difference	line 3 – line 4	0.018	0.004	0.005	−0.008	−0.001	0.004	−0.009†	

†Cross-calibration of w190c3 vs. w103c4 uses w203c4r data; see text
Mean Difference, excluding 8 keV point : 0.0037
RMS Difference, excluding 8 keV point : 0.0085

Table 1.56: Reproducibility of Relative Quantum Efficiency Measurment of Detector I0

1.7.2.2 Spatial Variations in Quantum Efficiency

As discussed in section 1.7.1 above, we have measured quantum efficiency (relative to a reference detector) of each ACIS flight device as a function of position. For purposes of presentation, we have binned the relative quantum efficiency into 32-by-32-pixel "superpixels"; we expect that in typical AXAF observations the celestial image will be dithered over an area of about this size ($\sim$ 15 arcsec) on the ACIS focal plane.

Maps showing the spatial uniformity of the relative quantum efficiency at each measurment energy are presented in Figures 1.77–1.86. Alongside each map is a histogram of the superpixel relative efficiencies. The efficiencies shown in these figures have not been corrected for pileup. The reference CCD count rates used to generate each superpixel relative efficiency have been corrected for cosmetic defects, including the effects of shadowing by the framestore covers used during subassembly calibration at MIT. The flight CCD count rates have not been corrected for cosmetic defects, but have been corrected for shadowing by the subassembly calibration framestore cover. In addition, each uniformity map has been adjusted to reproduce the effect of shadowing by the flight framestore cover. This procedure is intended to produce spatial uniformity maps which replicate the quantum efficiency patterns that will be present in data obtained with the flight CCDs on orbit. The number of rows in each device shadowed by the subassembly and flight framestore covers are listed in Table 1.57.

Histogram legends in Figures 1.77–1.86 indicate the centroid and standard deviation of a Gaussian fit to each histogram. The fitted standard deviation of the histogram provides a good measure of the residual spatial variation in relative quantum efficiency, excluding the effects of the flight framestore shield.

Spatial variations in relative QE are comparable to expected statistical fluctuations for the FI CCDs, except the ratios which are affected by bad or hot columns or pixels and border effects (especially the shadows of frame store covers). These superpixel ratios are generally outliers in the QE ratio histograms, and only weakly affect the Gaussian fit. These effects may be seen in Figures 1.77–1.86. Columns darker than their surrounding regions correspond to either bad columns in the flight CCD or hot columns in the reference CCD, while lighter columns typically correspond to bad columns in the reference CCD. The dark row at the bottom of each relative uniformity map is due to shadowing by the flight framestore cover.

Larger spatial variations are observed in the BI CCDs, and are believed to be caused in part by relatively high charge transfer inefficiency (CTI), exceeding 25% at higher energies. Some provision will need to be developed to characterize this spatial nonuniformity in the two backside flight CCDs (S1 and S3). These variations affect the quality of the Gaussian fit to the histogram of QE ratios.

Flight Device	Position	Framestore Cover	
		Subassembly	Flight
w203c4r	I0	4	7
w193c2	I1	6	8
w158c4r	I2	7	7
w215c2r	I3	6	7
w168c4r	S0	6	6
w182c4r	S2	7	6
w457c4	S4	1	5
w201c3r	S5	4	5
w140c4r	S1	6	6
w134c4r	S3	8	5
w190c3	Ref.	10	
w203c2	Ref.	9	
w103c4	Ref.	7	

Table 1.57: Number of CCD Rows Shadowed by the Framestore Covers

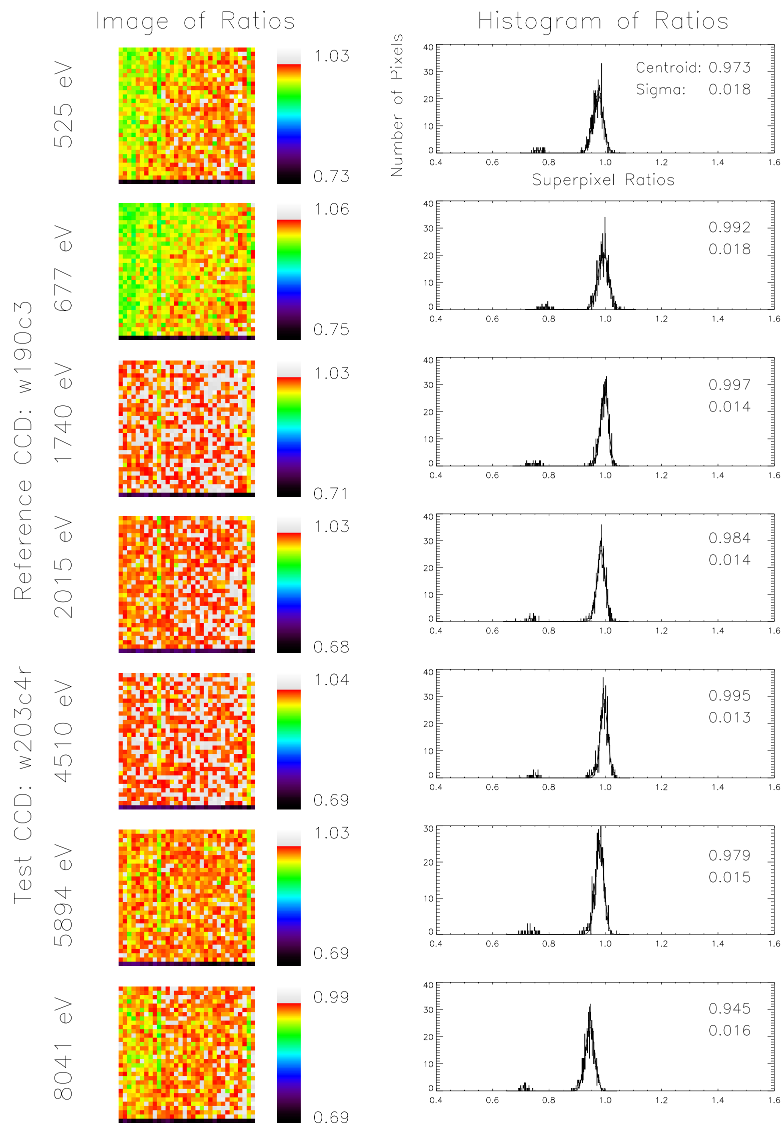


Figure 1.77: Uniformity maps and histograms showing the spatial uniformity of the quantum efficiency of ACIS flight device I0 (w203c4r) relative to reference device w190c3 at seven energies. Each pixel value is the ratio of the raw count rate (i.e. uncorrected for pileup) in a 32×32 pixel subarray of the flight device to the count rate in the corresponding subarray of the reference device.

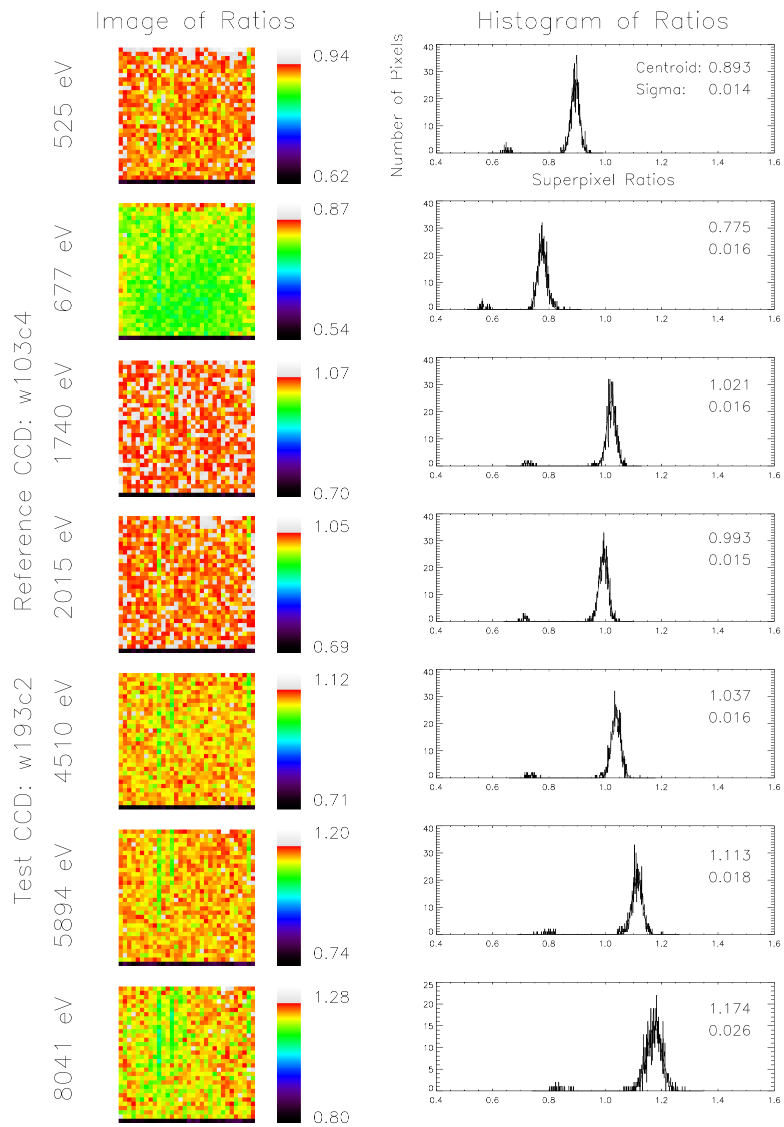


Figure 1.78: Uniformity maps and histograms showing the spatial uniformity of the quantum efficiency of ACIS flight device I1 (w193c2) relative to reference device w103c4 at seven energies. Each pixel value is the ratio of the raw count rate (i.e. uncorrected for pileup) in a 32×32 pixel subarray of the flight device to the count rate in the corresponding subarray of the reference device.

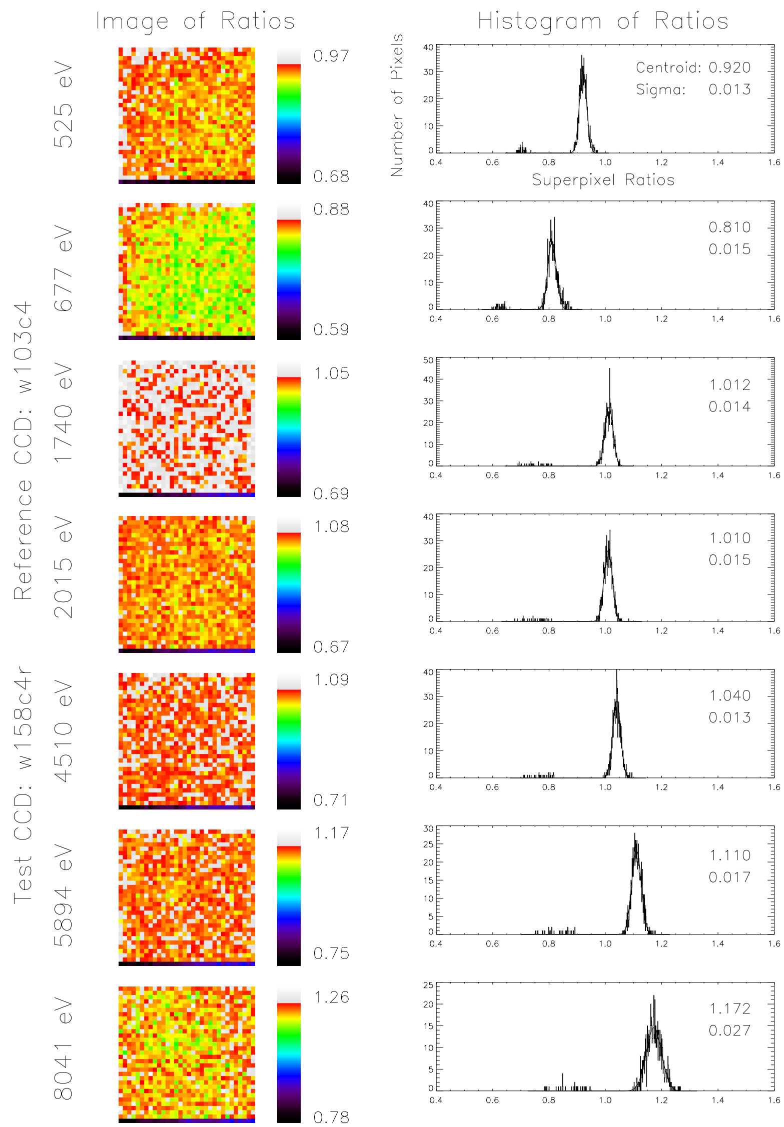


Figure 1.79: Uniformity maps and histograms showing the spatial uniformity of the quantum efficiency of ACIS flight device I2 (w158c4r) relative to reference device w103c4 at seven energies. Each pixel value is the ratio of the raw count rate (i.e. uncorrected for pileup) in a 32×32 pixel subarray of the flight device to the count rate in the corresponding subarray of the reference device.

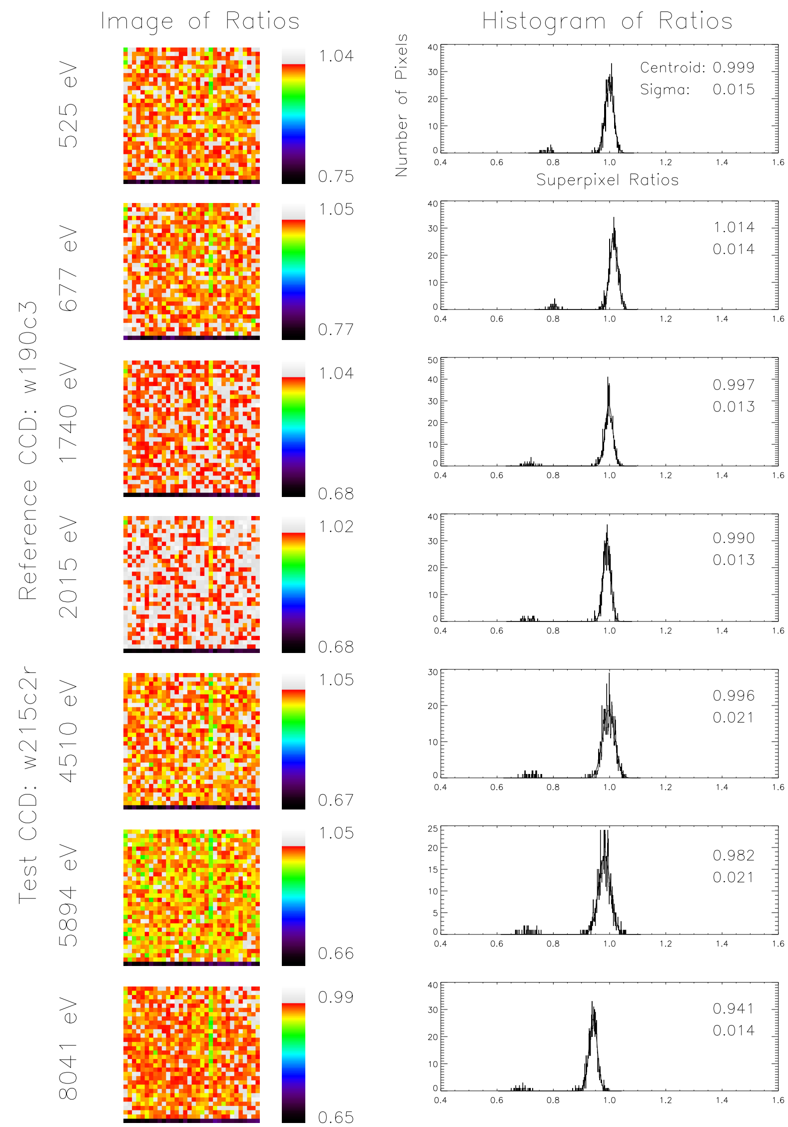


Figure 1.80: Uniformity maps and histograms showing the spatial uniformity of the quantum efficiency of ACIS flight device I3 (w215c2r) relative to reference device w190c3 at seven energies. Each pixel value is the ratio of the raw count rate (i.e. uncorrected for pileup) in a 32×32 pixel subarray of the flight device to the count rate in the corresponding subarray of the reference device.

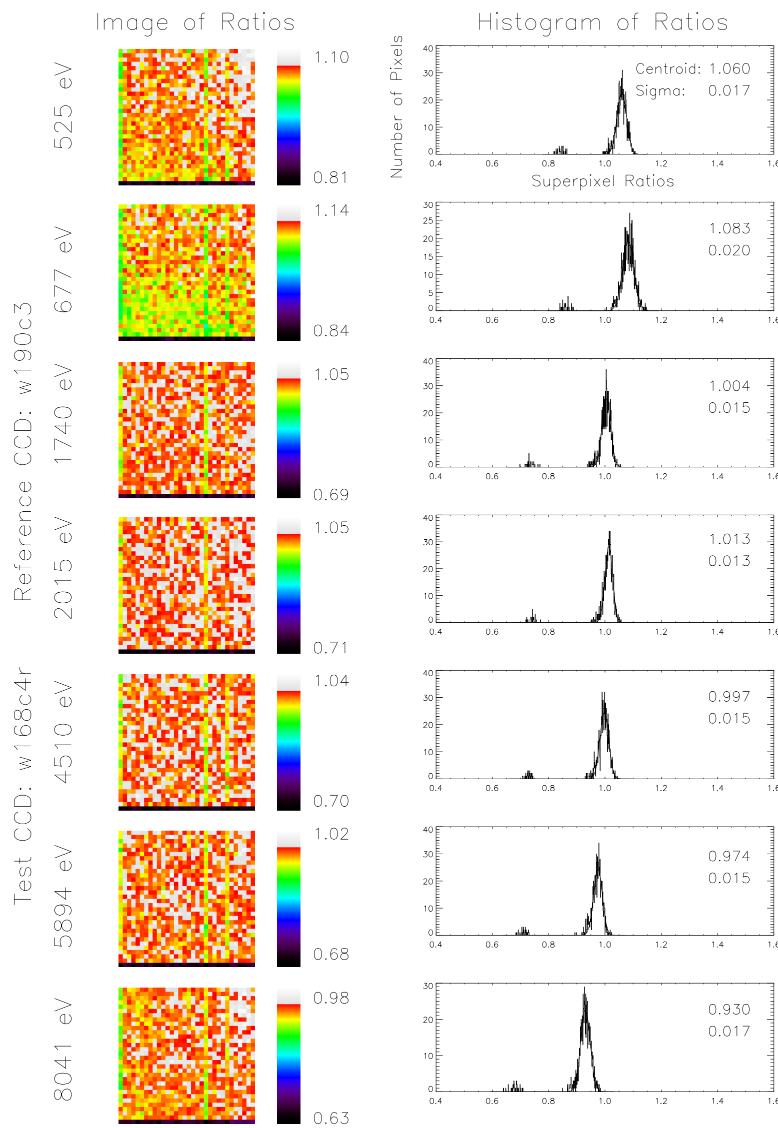


Figure 1.81: Uniformity maps and histograms showing the spatial uniformity of the quantum efficiency of ACIS flight device S0 (w168c4r) relative to reference device w190c3 at seven energies. Each pixel value is the ratio of the raw count rate (i.e. uncorrected for pileup) in a 32×32 pixel subarray of the flight device to the count rate in the corresponding subarray of the reference device.

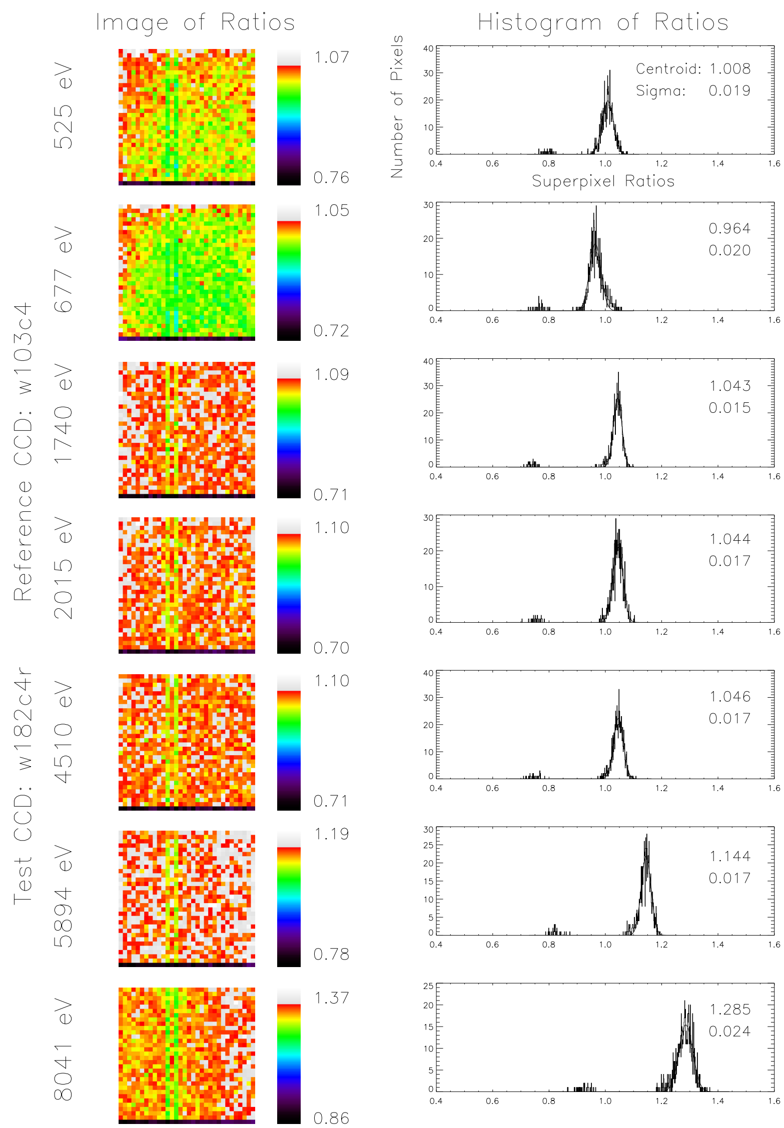


Figure 1.82: Uniformity maps and histograms showing the spatial uniformity of the quantum efficiency of ACIS flight device S2 (w182c4r) relative to reference device w103c4 at seven energies. Each pixel value is the ratio of the raw count rate (i.e. uncorrected for pileup) in a 32×32 pixel subarray of the flight device to the count rate in the corresponding subarray of the reference device.

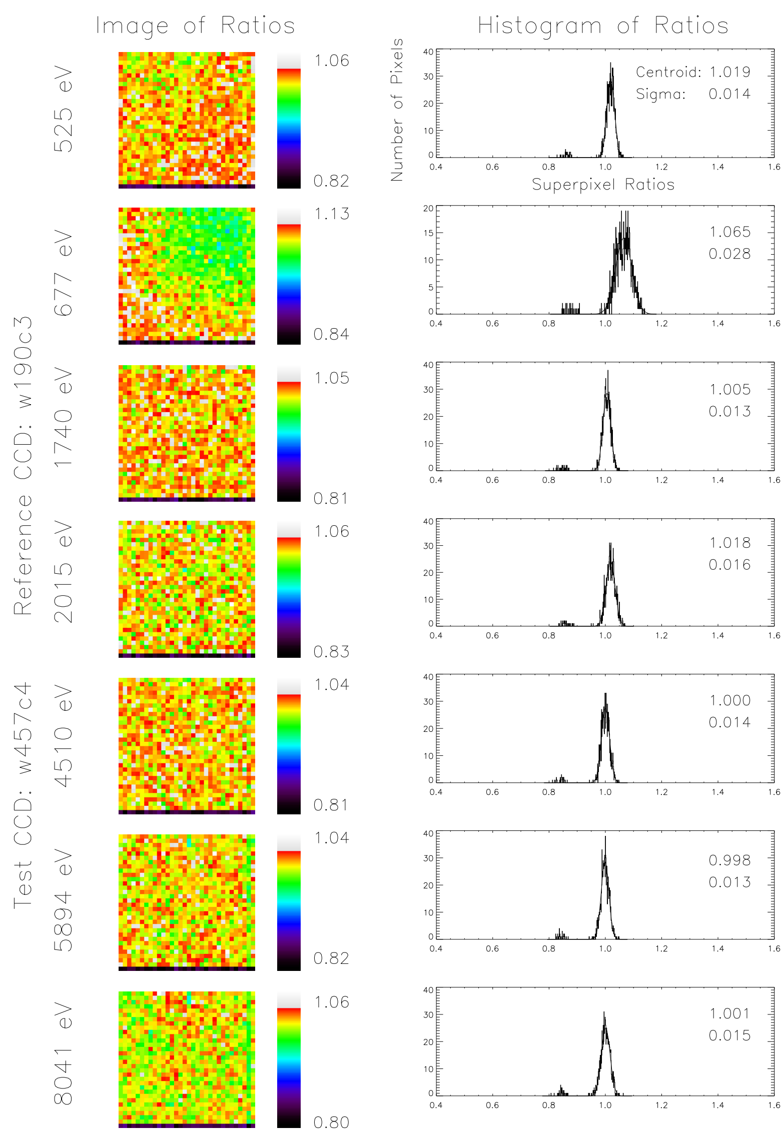


Figure 1.83: Uniformity maps and histograms showing the spatial uniformity of the quantum efficiency of ACIS flight device S4 (w457c4) relative to reference device w190c3 at seven energies. Each pixel value is the ratio of the raw count rate (i.e. uncorrected for pileup) in a 32×32 pixel subarray of the flight device to the count rate in the corresponding subarray of the reference device.

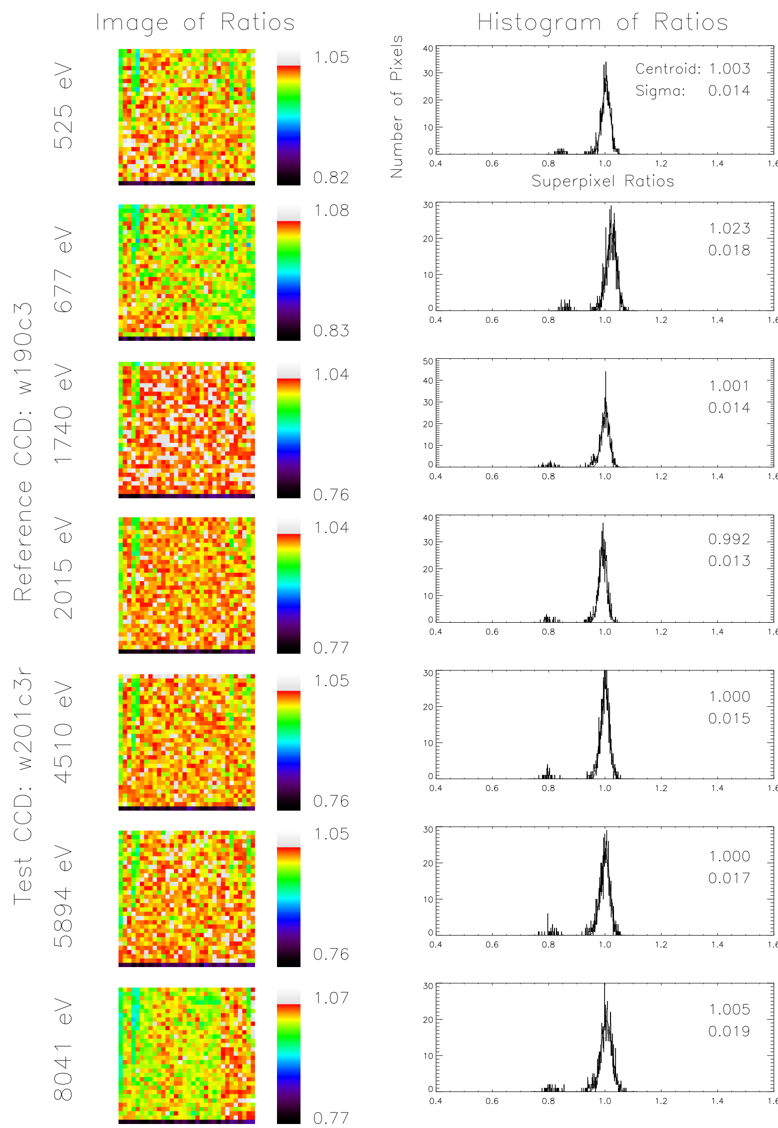


Figure 1.84: Uniformity maps and histograms showing the spatial uniformity of the quantum efficiency of ACIS flight device S5 (w201c3r) relative to reference device w190c3 at seven energies. Each pixel value is the ratio of the raw count rate (i.e. uncorrected for pileup) in a 32×32 pixel subarray of the flight device to the count rate in the corresponding subarray of the reference device.

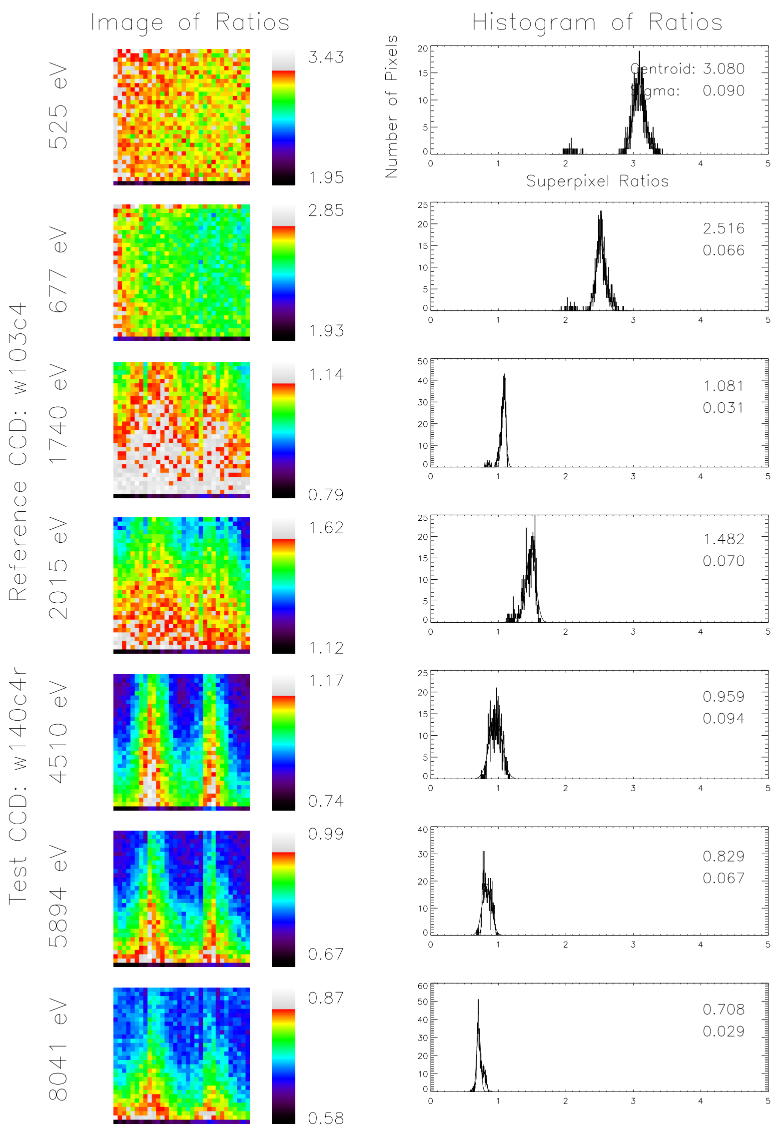


Figure 1.85: Uniformity maps and histograms showing the spatial uniformity of the quantum efficiency of ACIS flight device S1 (w140c4r) relative to reference device w103c4 at seven energies. Each pixel value is the ratio of the raw count rate (i.e. uncorrected for pileup) in a 32×32 pixel subarray of the flight device to the count rate in the corresponding subarray of the reference device.

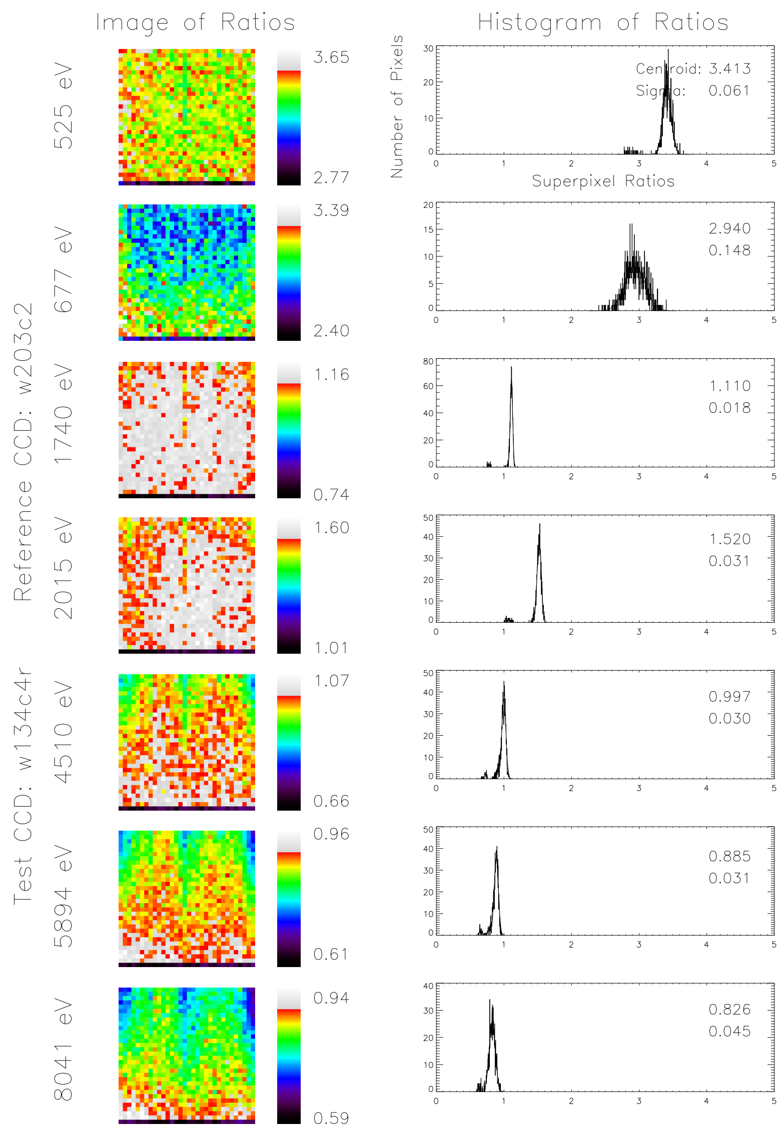


Figure 1.86: Uniformity maps and histograms showing the spatial uniformity of the quantum efficiency of ACIS flight device S3 (w134c4r) relative to reference device w203c2 at seven energies. Each pixel value is the ratio of the raw count rate (i.e. uncorrected for pileup) in a 32×32 pixel subarray of the flight device to the count rate in the corresponding subarray of the reference device.

1.7.3 Comparison Between MIT and XRCF (Phase I) Measurements of Relative Quantum Efficiency

To compare measurements of relative quantum efficiency made at MIT's Center for Space Research (CSR) and Marshall Spaceflight Center's X-ray Calibration Facility (XRCF), we have used the data in Table 1.54 to compute relative QE ratios referenced to device S2. The results are presented in Table 1.58. Similarly, we have compiled relative QE ratios referenced to S2 from telemetry data taken at XRCF (see Table 1.59). The telemetry data was taken using windows near the top and bottom of each device to avoid saturating the telemetry stream. The pileup correction factors applied to the XRCF count rates are presented in Table 1.60.

Flight Device	Position	Mean (RMS) Relative Efficiency vs. Energy (keV)						
		0.525	0.677	1.740	2.015	4.509	5.894	8.040
		O	F	Si	P	Ti	Fe55	Cu
w203c4r	I0	0.858 (0.055)	0.790 (0.049)	0.979 (0.071)	0.930 (0.066)	0.990 (0.072)	0.970 (0.074)	0.898 (0.090)
w193c2	I1	0.878 (0.058)	0.798 (0.053)	0.977 (0.073)	0.949 (0.069)	0.991 (0.075)	0.969 (0.077)	0.907 (0.087)
w158c4r	I2	0.906 (0.055)	0.836 (0.051)	0.983 (0.070)	0.966 (0.067)	0.993 (0.071)	0.965 (0.073)	0.906 (0.084)
w215c2r	I3	0.882 (0.056)	0.809 (0.049)	0.980 (0.074)	0.936 (0.069)	0.991 (0.076)	0.972 (0.079)	0.894 (0.092)
w168c4r	S0	0.939 (0.058)	0.868 (0.053)	0.987 (0.074)	0.960 (0.070)	0.992 (0.074)	0.965 (0.076)	0.881 (0.091)
w182c4r	S2	1.000 (0.000)	1.000 (0.000)	1.000 (0.000)	1.000 (0.000)	1.000 (0.000)	1.000 (0.000)	1.000 (0.000)
w457c4	S4	0.901 (0.051)	0.853 (0.052)	0.988 (0.063)	0.966 (0.060)	0.995 (0.064)	0.991 (0.068)	0.963 (0.091)
w201c3r	S5	0.886 (0.051)	0.817 (0.047)	0.984 (0.067)	0.939 (0.061)	0.996 (0.068)	0.992 (0.072)	0.967 (0.095)
w140c4r	S1	3.078 (0.207)	2.606 (0.159)	1.033 (0.074)	1.439 (0.110)	0.921 (0.093)	0.715 (0.066)	0.522 (0.053)
w134c4r	S3	2.989 (0.170)	2.417 (0.187)	1.082 (0.084)	1.489 (0.116)	1.004 (0.082)	0.835 (0.072)	0.640 (0.068)

Table 1.58: Spatially Averaged Relative Detection Efficiency at CSR—Referenced to S2

1.7.3.1 Repeatability and Estimated Errors in Relative Quantum Efficiency Measurements of Front-Illuminated Detectors

In Table 1.61 we have computed the fractional difference (1−XRCF/CSR) between the relative QE measurements made at each site. The relative QE ratios at XRCF for the frontside devices are in excellent agreement with the ratios obtained at CSR. Indeed, averaged over seven FI chips and the lowest three energies, the mean difference in relative quantum efficiency is $0.27\% \pm 0.24\%$, where the error is the standard deviation about the mean, and the RMS deviation about the mean is 1.1%. If we assume that the CSR and XRCF relative QE measurements in this energy range each have the same random error, and account properly for the normalization of the CSR measurements by the efficiency of S2 required to make this comparison, we infer that the error on a single relative QE measurement is (very nearly) $\sigma_{rqe} = 0.011/\sqrt{3} = 0.006$. This estimate is only slightly larger than the value obtained from internal consistency of the MIT CSR measurements alone ($\sigma_{rqe} = 0.0049$; see section 1.7.2) For purposes of QE model fitting, to be discussed in Section 1.8, we will adopt the larger value as the uncertainty in the relative QE measurement.

The data at 8 keV require special comment for two reasons. First, the bias obtained from ACIS telemetry for S4 for the 8 keV measurement (ACIS XRCF Science Run 93, TRW ID's I-IAS-SG-1.032 and I-IAS-EA-2.043 through I-IAS-EA-2.048) is peculiar, showing excess charge of order 5 electrons/pixel. The spectral resolution in S4 is severely compromised (FWHM $\sim$ 200 eV) by the bias error, and this in turn affects the measured quantum efficiency. As a result, a replacement (telemetry) bias was used (taken from ACIS Science Run 89) to compute the relative efficiency listed in Table 1.59. Even with the replacement bias, the spectral resolution was not quite as good as measured at MIT. For this reason, we regard this measurement as suspect, and have quoted statistics in Table 1.61 with this point excluded. The cause of the bias error is not understood. The high-speed tap data obtained for S4 during (a subset of) ACIS XRCF Science Run 93 show no obvious anomalies.

Second, as noted above, the cross-calibration of the two reference detectors w190c3 and w103c4 at MIT is rather uncertain at 8 keV. We require this cross-calibration to compute the response of S2 relative to reference detector w190c3, since S2 was only measured with respect to reference detector w103c4. Formally, the RMS uncertainty of this cross-calibration (derived from the reproducibility of three measurement sets) is about 0.03 (1-sigma). This uncertainty is expected to dominate other errors in the QE, relative to S2, of the five devices (I0, I3, S0, S4 and S5) for which w190c3 is the primary reference standard.

Nevertheless, excluding the S4 point, we find a mean relative quantum efficiency difference of -0.013 ± 0.008, where the error is the standard deviation of the mean, and the RMS deviation of measurements about the mean is 0.019. Thus, whatever the source of the uncertainty in the CSR measurements of the w190c3 vs. w103c4 cross-calibration, the value we have adopted for this cross-calibration is just consistent, at 90% confidence, (i.e., within 1.3%) with the XRCF relative quantum efficiency data.

A related comparison between the best-fit quantum efficiency models and the XRCF data is presented in Section 1.8.

1.7.3.2 Repeatability and Estimated Errors in Relative Quantum Efficiency Measurements of Back-Illuminated Detectors

The agreement between XRCF and CSR is not as good for the backside devices. At 525 eV, both S1 and S3 appear to have been 10–12% more efficient relative to S2 in the XRCF data compared to the CSR data. Discrepancies at the 5% level are also apparent at several other energies. Here we discuss possible origins for these discrepancies.

We have investigated the effects of windowing and spatial variation in the charge transfer inefficiency of the backside devices by averaging the relative efficiency uniformity maps at 525 eV over all columns and plotting the average relative efficiency versus row number. This analysis indicates that the peak-to-peak variation in the relative efficiency of the backside devices, averaged over regions of 1024 columns by 24 rows (similar to the windows used at XRCF), is only $\sim$2–3%. This is too small to account for the differences between the CSR and XRCF relative efficiencies at 525 eV, although this level of variation would constitute a significant fraction of the discrepancies measured at the higher energies.

The spectral redistribution functions of the front- and back-illuminated detectors are significantly different. Moreover, the X-ray sources used at both MIT and XRCF emitted significant and differing continuum fluxes in addition to the intended line flux. In principle, therefore, proper analysis of BI-to-FI relative QE measurements must account for response function differences. Our analysis to date has ignored these response function differences, and so is subject to several systematic errors as a result. In an effort to bound these errors, we have begun to examine the line-to-continuum ratios the various sources. We find, for example, that the continuum level of the XRCF source was stronger relative to the emission line at 525 eV than was the case in the CSR source (see Figures 1.87 and 1.88).

We estimate that neglect of the continuum biases the BI-to-FI QE ratio at 525 eV, measured at XRCF, by as much as 15% above the true value. In the CSR measurements, the lower continuum produces a substantially lower bias (about 5%). We also note that one would expect this error to be most serious at the lowest energies, where the BI and FI response functions differ in width by as much as a factor of two; at higher energies, the response function widths differ by 30% or less. Figures 1.89 and 1.90 show that differences in the line-to-continuum ratios at XRCF and CSR were negligible at higher energies.

We conclude that our heretofore inadequate treatment of the redistribution functions and source spectra may well account for the XRCF-to-CSR discrepancies in BI-to-FI relative quantum efficiency measurements. A corollary conclusion is that the CSR measurements of these quantities may be in error by $\sim 5\%$ at low energies.

We have some confidence that suitable modelling of the BI redistribution function and the source spectra will provide us with more accurate estimates of the BI response. The excellent repeatability of the FI results demonstrates that our fundamental measurement procedures are sound. Moreover, each BI measurement was accompanied by a simultaneous or nearly simultaneous measurement of the same source with an FI device. These FI data, and our sound FI models, will provide independent constraints on the source spectra used to characterize the BI detectors. These constraints, in turn, should improve our understanding of the BI-to-FI relative quantum efficiency data.

Flight Device	Position	Mean Relative Efficiency vs. Energy (keV)								
		0.277	0.525	0.705	1.487	1.740	2.166	4.509	6.399	8.040
		C	O	Fe L	Al	Si	Nb L	Ti	Fe K	Cu
w203c4r	I0		0.842	0.810	0.962	0.982	0.942	0.981	0.948	0.903
w193c2	I1		0.868	0.805	0.965	0.979	0.954	0.985	0.946	0.910
w158c4r	I2		0.909	0.849	0.979	0.996	0.969	0.988	0.951	0.894
w215c2r	I3		0.865	0.807	0.976	0.994	0.961	0.989		0.907
w168c4r	S0	0.687	0.912	0.873	0.979	0.986	0.964	1.002	0.953	0.904
w182c4r	S2	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000
w457c4	S4	0.625	0.897	0.910	0.975	0.991	0.965	1.005	0.980	1.049*
w201c3r	S5	0.625	0.876	0.828	0.966	0.983	0.966	0.999	0.972	1.008
w140c4r	S1	36.619	3.460	3.022	1.071	1.034	1.287	0.847	0.617	0.527
w134c4r	S3	35.679	3.280	3.033	1.115	1.092	1.342	0.949	0.755	0.671

* The XRCF bias for this data point is peculiar.

Table 1.59: Spatially Averaged Relative Detection Efficiency from XRCF Telemetry—Referenced to S2

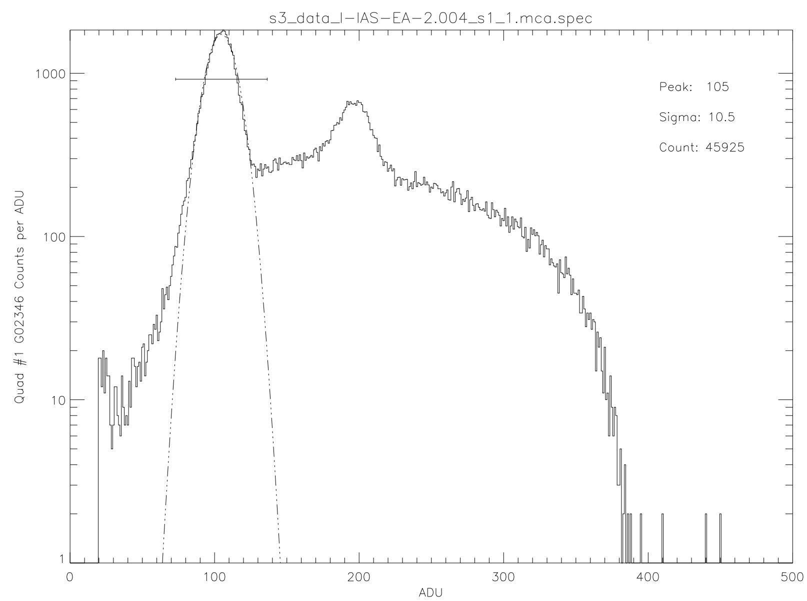
Flight Device	Position	Pileup Correction vs. Energy (keV)								
		0.277	0.525	0.705	1.487	1.740	2.166	4.509	6.399	8.040
		C	O	Fe L	Al	Si	Nb L	Ti	Fe K	Cu
w203c4r	I0		1.001	1.007	1.049	1.007	1.020	1.017	1.021	1.119
w193c2	I1		1.001	1.007	1.049	1.007	1.020	1.017	1.021	1.117
w158c4r	I2		1.001	1.007	1.050	1.008	1.021	1.009	1.015	1.116
w215c2r	I3		1.001	1.007	1.050	1.008	1.021	1.017		1.116
w168c4r	S0	1.000	1.001	1.002	1.050	1.008	1.021	1.018	1.028	1.139
w182c4r	S2	1.000	1.001	1.007	1.051	1.008	1.022	1.013	1.020	1.140
w457c4	S4	1.000	1.001	1.003	1.050	1.008	1.021	1.011	1.029	1.164
w201c3r	S5	1.000	1.001	1.002	1.049	1.008	1.021	1.018	1.029	1.157
w140c4r	S1	1.001	1.004	1.007	1.044	1.007	1.029	1.019	1.016	1.036
w134c4r	S3	1.001	1.003	1.009	1.046	1.008	1.030	1.016	1.018	1.042

Table 1.60: Pileup Correction Factors Applied to Count Rates from XRCF Telemetry

Flight Device	Position	Frac. Rel. Eff. Diff. vs. Energy (keV)			
		0.525	1.740	4.509	8.040
		O	Si	Ti	Cu
w203c4r	I0	0.019	−0.003	0.009	−0.006
w193c2	I1	0.011	−0.002	0.006	−0.004
w158c4r	I2	−0.003	−0.013	0.005	0.013
w215c2r	I3	0.019	−0.015	0.002	−0.014
w168c4r	S0	0.029	0.001	−0.010	−0.026
w182c4r	S2	0.000	0.000	0.000	0.000
w457c4	S4	0.004	−0.003	−0.010	*
w201c3r	S5	0.012	0.001	−0.003	−0.042
FI Mean		0.013	−0.005	−0.000	−0.013
FI Std Dev.		0.011	0.006	0.008	0.019
w140c4r	S1	−0.124	−0.001	0.080	−0.010
w134c4r	S3	−0.097	−0.010	0.055	−0.050
BI Mean		−0.111	−0.006	0.068	−0.030
BI Std Dev.		0.019	0.006	0.018	0.028

* This data point was excluded because the XRCF bias for this point was peculiar.

Table 1.61: Fractional Difference (1−XRCF/CSR) between Relative Detection Efficiencies at CSR and XRCF—Referenced to S2



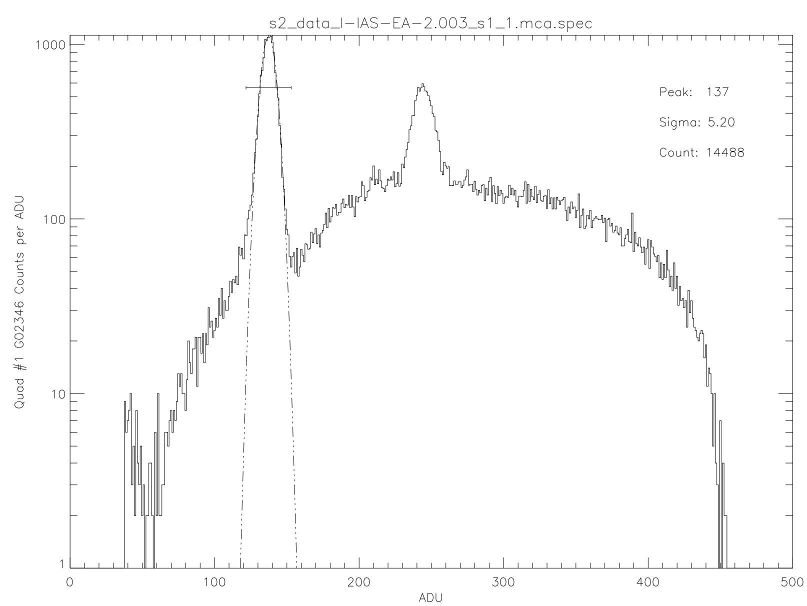


Figure 1.87: O-K spectra for S3 (upper panel) and S2 (lower panel) from XRCF Phase I. The bar in each plot marks the range of channels within 3 sigma of the peak.

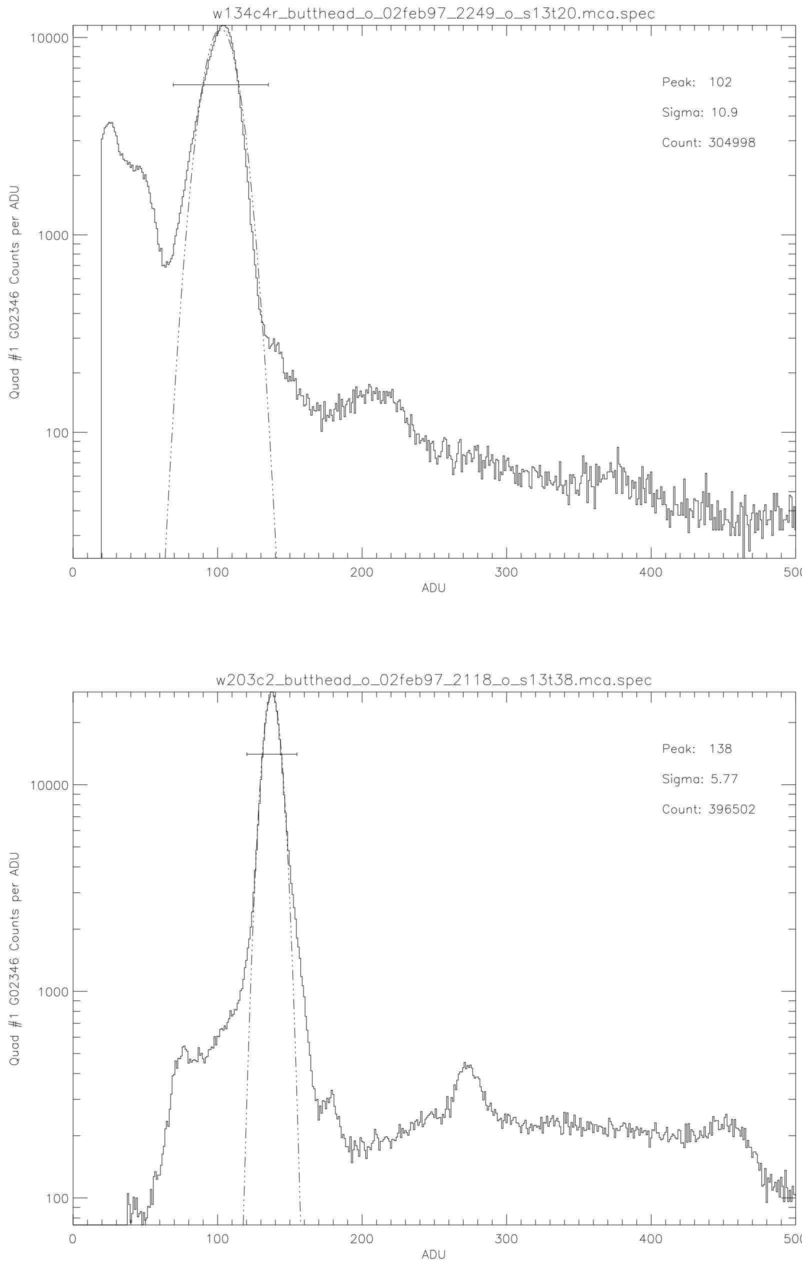


Figure 1.88: O-K spectra for S3 (upper panel) and w203c2 (lower panel) from CSR Subassembly Calibration. The bar in each plot marks the range of channels within 3 sigma of the peak.

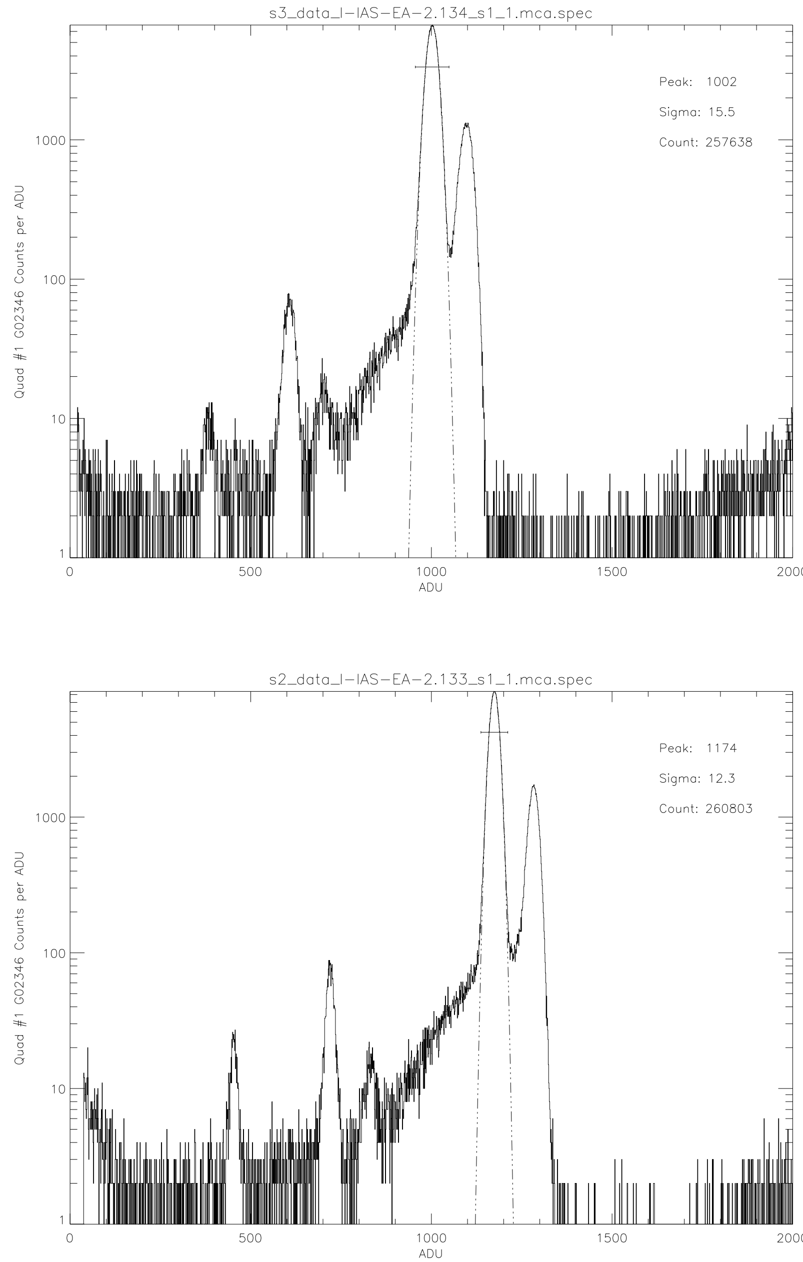


Figure 1.89: Ti-K spectra for S3 (upper panel) and S2 (lower panel) from XRCF Phase I. The bar in each plot marks the range of channels within 3 sigma of the peak.

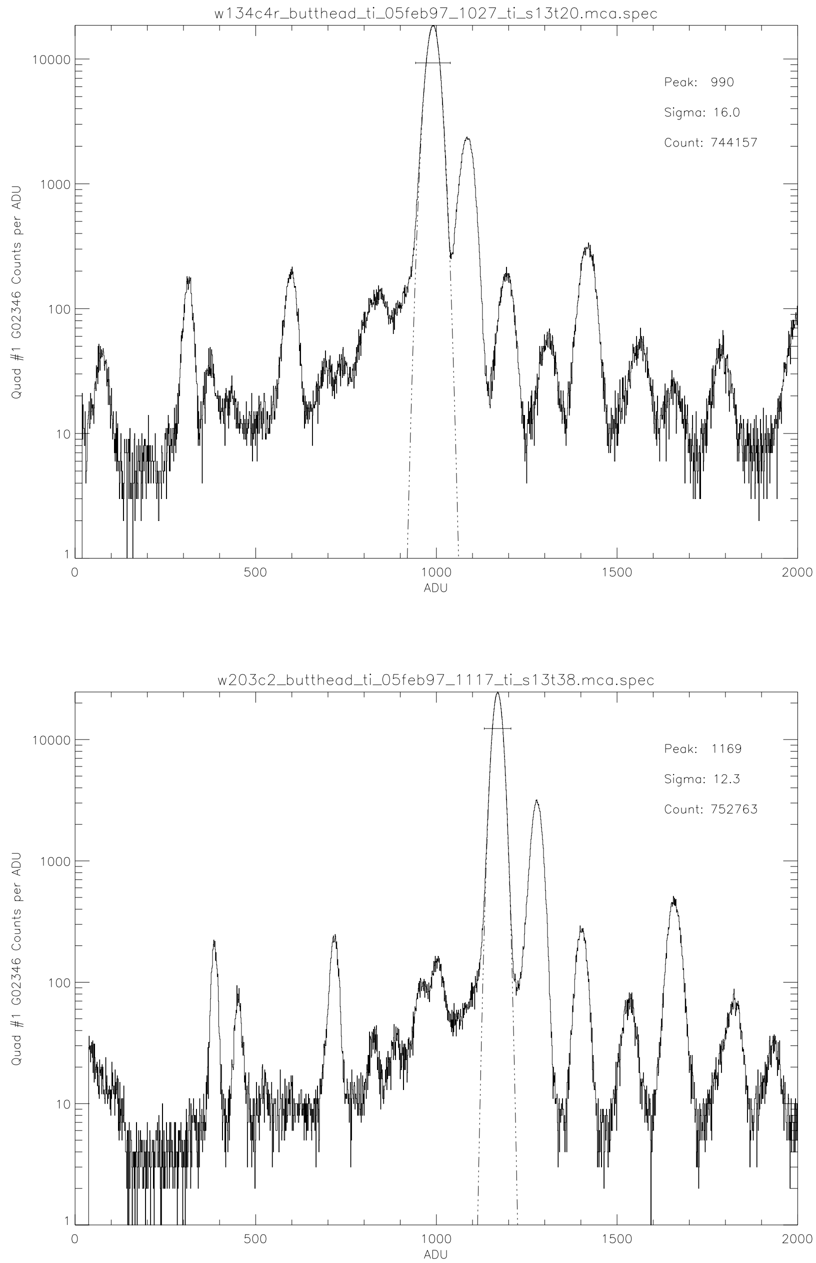


Figure 1.90: Ti-K spectra for S3 (upper panel) and w203c2 (lower panel) from CSR Subassembly Calibration. The bar in each plot marks the range of channels within 3 sigma of the peak.