ACIS Memo #162

Massachusetts Institute of Technology

Center for Space Research
Cambridge, MA 02139
Room 37-558

To: ACIS Team
From: Fred Baganoff (fkb@space.mit.edu)
Subject: ACIS On-orbit Background Rates and Spectra from Chandra OAC Phase 1
Date: 1 September 1999

This memo presents the results of an analysis of the particle-induced background rates and spectra in the ACIS CCDs using data obtained during Chandra OAC Phase 1. The data are from OBSIDs 62704–62710, and span one-half the Chandra orbit from near apogee to well into the radiation belts. The ACIS door was open and the aft HRMA cover was closed, so no X-rays were directly incident on the focal plane during these measurements. The ACIS focal plane temperature was −90 C.

Figures 1–3 show the ACIS background spectra in a front-illuminated (S2) and a back-illuminated (S3) CCD in the passband 0.3–10 keV. Spectra are shown for three scientifically interesting combinations of ASCA grades: G02346 (top), G0234 (middle), and G0 (bottom). The bin size is 16 eV.

The background spectrum in the frontside device is roughly flat from 2–10 keV, rising smoothly toward lower energies with a power-law index of ~ 2.2. The spectrum of the backside device has a broad minimum from 0.5–7 keV. The spectrum rises by a factor of 6 from 7 keV to 10 keV, and forms a broad peak around 13–15 keV. Below 0.5 keV, the backside spectrum rises sharply: more than a factor of 10 over a span of only 0.2 keV.

Five fluorescence lines are prominent in the frontside spectrum: Al K_α [1.486 keV], Si K_α [1.740 keV], Au $M_{\alpha,\beta}$ [2.1 keV], Ni K_α [7.469 keV], and Au L_α [9.67 keV]. These same lines are visible in the backside spectrum, although they appear to be weaker, with the exception of the Si K_α line.

The mean background event rate in the 0.3–10 keV passband is listed for each detector type and grade combination on the corresponding plot in Figures 1–3, and tabulated for reference in Table 1. The fourth column of Table 1 shows the relative strength of the background rates in the backside and frontside devices. It can be seen that the background rate in the standard ASCA grades (G02346) is 2.4 times higher in the backside device in this passband.

The higher background rate in the backside device occurs mainly in the regions of the spectrum below 0.5 keV and above 7 keV. Therefore, we have computed the background rates in several potentially useful energy ranges, and included the results in Table 1. The background rate in the backside device in grades G02346 becomes almost three times higher than the frontside rate if the low-energy cutoff is extended down to 0.1 keV. On the otherhand, the backside rate is only 63% higher than the frontside rate in the 0.5–7 keV passband.

Table 2 presents a comparison of the measured and predicted on-orbit background event rates for the two detector types in the 0.1–10 keV passband, using an ASCA G02346 grade filter. The measured background rate in the frontside device is only 57% of the predicted rate, while the measured and predicted rates in the backside device are nearly identical.

The fraction of all events in each ACIS flight grade are shown in Figure 4 (all energies) and Figure 5 (0.3–10 keV passband). The most significant flight grades have been labelled in each plot. Twelve flight grades contain the majority of the background events in the frontside device: 24, 66, 107, 126, 127, 214, 219, 223, 248, 251, 254, and 255. These same flight grades comprise less than half of the events in the backside device (see Table 3).

To study the variation in background rate with orbital position and time, we have plotted the background rates in each detector vs. time in Figure 6 and altitude in Figure 7. The plotted rates are averages over 60-s bins. The background rates are steady to within 23% (RMS) in S2 and 15% (RMS) in S3 for nearly the entire measurement, until Chandra enters the radiation belts at around 50,720 ks since Jan. 1, 1998. This corresponds to an altitude of about 43,000–44,000 km. The increase in the background rates is rapid below this altitude: a factor of 10 increase in the rates for a 5000 km decrease in altitude. Thus, it appears that useful ACIS observations can be performed down to an altitude of about 45,000 km. Lowering the ACIS power-down altitude from the current 60,000 km to 45,000 km will yield an extra ~ 1.5 hr per orbit of observing time on each side of the radiation belts passage. This would increase Chandra/ACIS's observing efficiency by about 4.7%.

ASCA Grades	S2 (ct/cm^2/s/keV)	S3 (ct/cm^2/s/keV)	S3/S2
0.1–10 keV			
G02346	0.00855	0.02521	2.95
G0234	0.00716	0.01738	2.43
G0	0.00350	0.00724	2.07
0.3–10 keV			
G02346	0.00777	0.01864	2.40
G0234	0.00635	0.01065	1.68
G0	0.00286	0.00340	1.19
0.5–10 keV			
G02346	0.00732	0.01725	2.36
G0234	0.00592	0.00917	1.55
G0	0.00281	0.00216	0.77
0.3–7 keV			
G02346	0.00712	0.01274	1.79
G0234	0.00621	0.00878	1.41
G0	0.00289	0.00384	1.33
0.5–7 keV			
G02346	0.00645	0.01054	1.63
G0234	0.00558	0.00657	1.18
G0	0.00283	0.00204	0.72

Table 1: Mean On-orbit Background Rates in ACIS Devices S2 and S3

	S2 (ct/cm^2/s/keV)	S3 (ct/cm^2/s/keV)	S3/S2
0.1–10 keV G02346			
Measured	0.0086	0.025	2.9
Predicted	0.015	0.026	1.7
Ratio	0.57	0.96	

Table 2: Comparison of Measured and Predicted On-orbit Background Rates in ACIS Devices S2 and S3

Passband	S2	S3
All Energies	0.927	0.280
0.3–10 keV	0.977	0.489

† ACIS flight grades 24, 66, 107, 126, 127, 214, 219, 223, 248, 251, 254, and 255.

Table 3: Fraction of Background Events in Twelve ACIS Flight Grades† in ACIS Devices S2 and S3

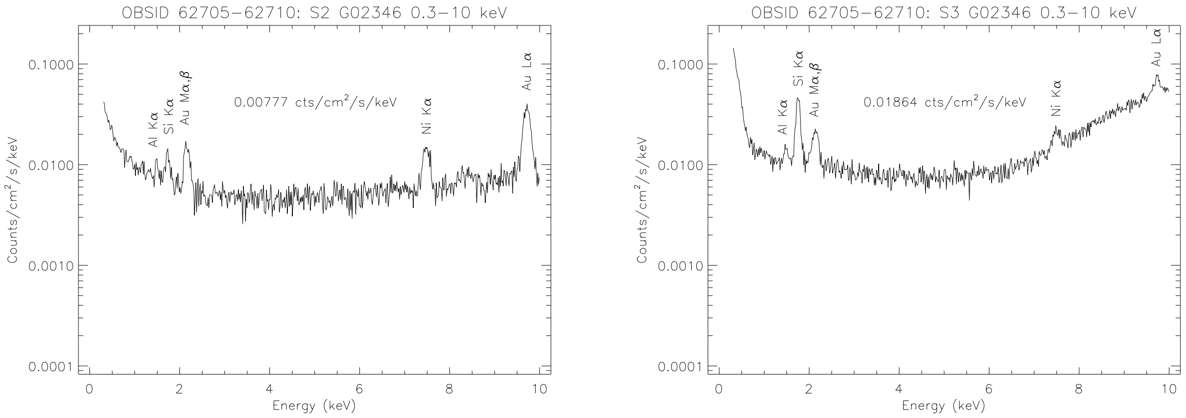

Figure 1: ACIS background spectra in ASCA grades 02346 from 0.3–10 keV in S2 (left) and S3 (right).

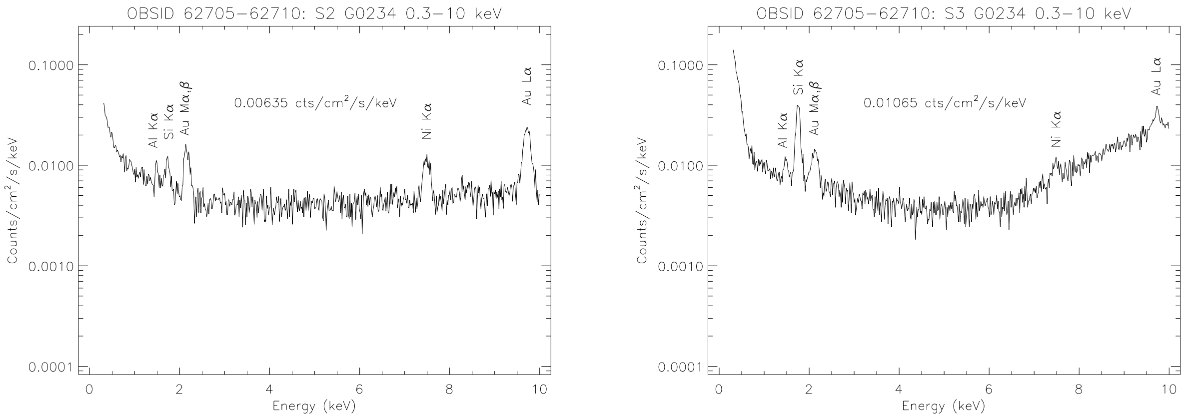

Figure 2: ACIS background spectra in ASCA grades 0234 from 0.3–10 keV in S2 (left) and S3 (right).

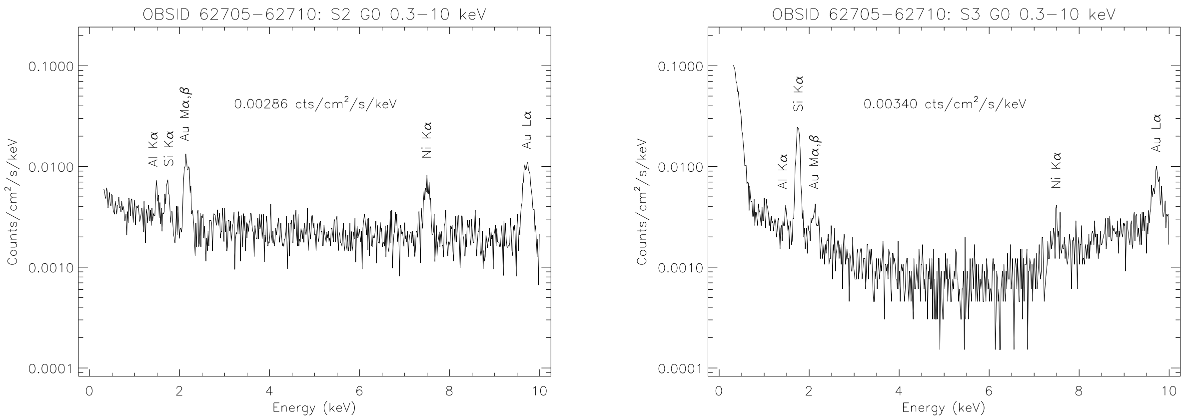

Figure 3: ACIS background spectra in ASCA grade 0 from 0.3–10 keV in S2 (left) and S3 (right).

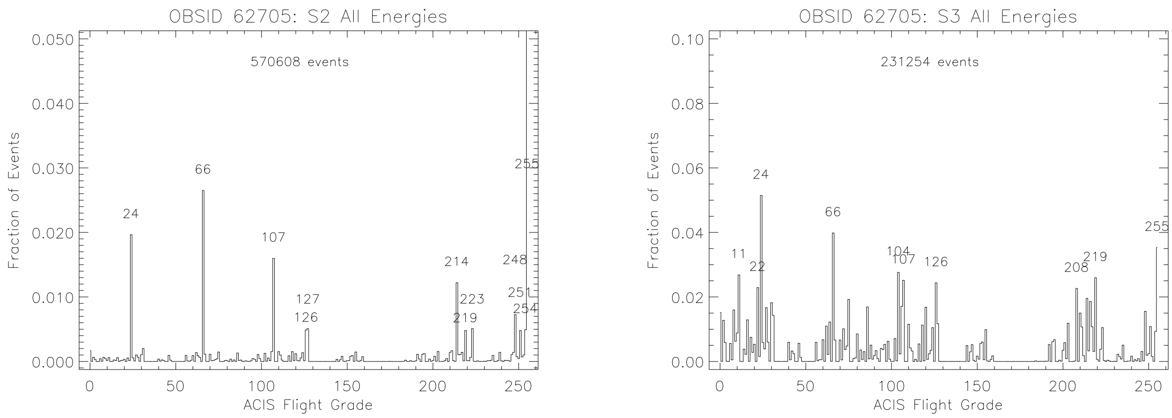

Figure 4: Fraction of ACIS background events vs. ACIS flight grade for all energies in S2 (left) and S3 (right). Flight grades containing at least 0.2% (2%) of all events in S2 (S3) are marked.

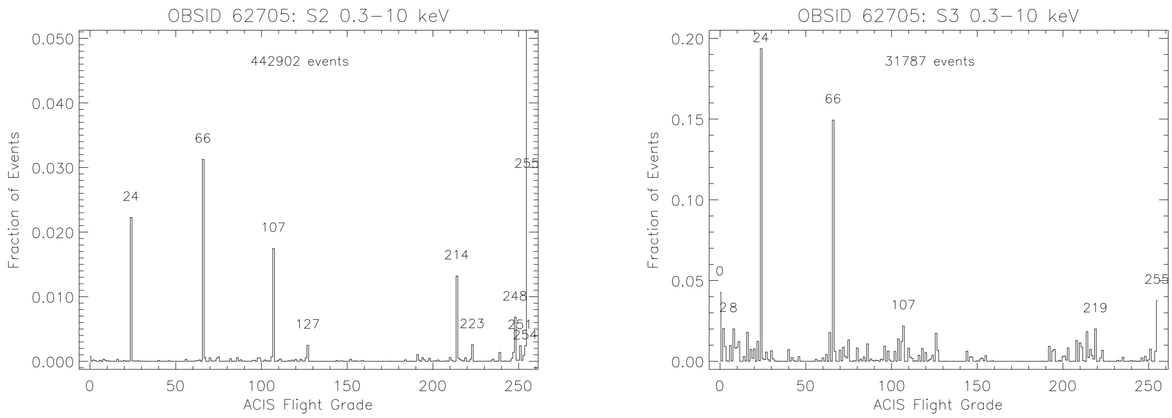

Figure 5: Fraction of ACIS background events vs. ACIS flight grade from 0.3–10 keV in S2 (left) and S3 (right). Flight grades containing at least 0.2% (S2) or 2% (S3) of all events are marked.

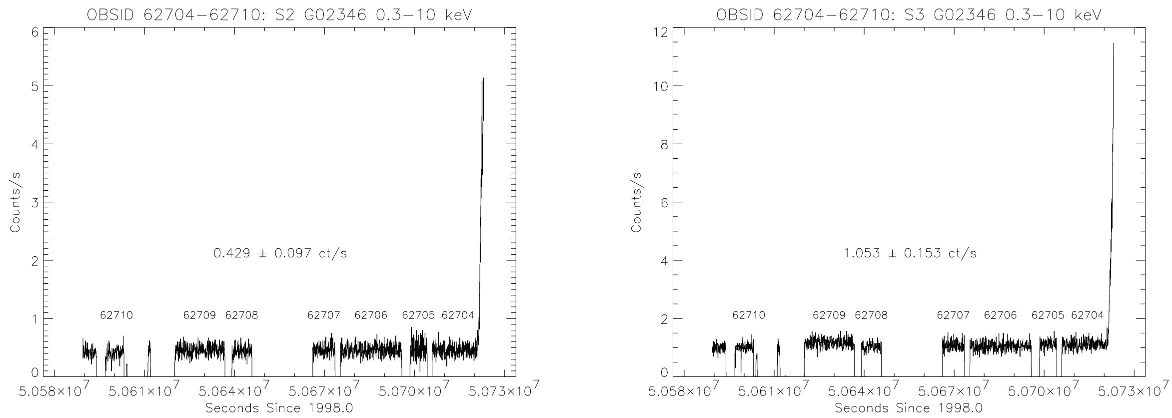

Figure 6: ACIS background event rates vs. time in ASCA grades 02346 from 0.3–10 keV in S2 (left) and S3 (right). Plotted count rates are the average over 60-second bins.

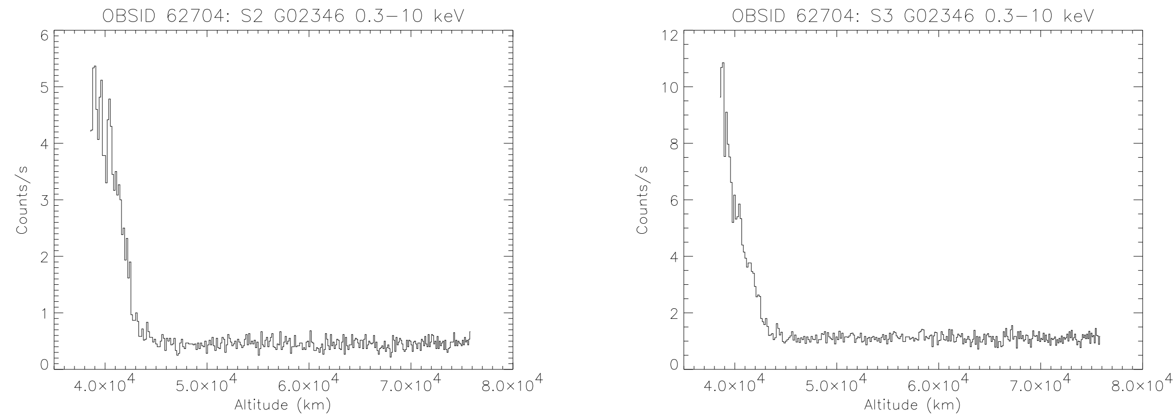

Figure 7: ACIS background event rates vs. altitude in ASCA grades 02346 from 0.3–10 keV in S2 (left) and S3 (right). Plotted count rates are the average over 60-second bins.