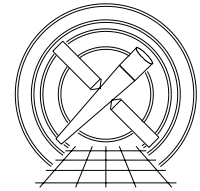




MIT Kavli Institute



Chandra X-Ray Center

MEMORANDUM

October 27, 2009

To: Jonathan McDowell, SDS Group Leader
From: Glenn E. Allen, SDS
Subject: Bias repair
Revision: 2.0
URL: http://space.mit.edu/CXC/docs/docs.html#bias_rep
File: `/nfs/cxc/h2/gea/sds/docs/memos/bias_repair_2.0.tex`

1 Introduction

Biases can be adversely affected for a number of reasons, including the interaction of charged particles in the detector, the transmission of optical light through the optical-blocking filter (e.g. Fig. 1), and the loss of part or all of the bias telemetry. In order to produce the most accurate ACIS event data possible, biases may have to be repaired or replaced. If a problem affects an entire CCD, then replacement of the bias for the CCD is necessary. This spec describes how to replace a bias for one observation with a modified version of a bias from another observation.

2 Replacement

The following steps should be performed in sequence to replace bias file B for an observation (e.g. a bias file for OBS_ID 11799, Fig. 1) with bias file B' from another observation (e.g. a bias file for OBS_ID 9345, Fig. 2).

1. Identify¹ and copy a suitable bias file B' . The bias file B' is suitable if the following conditions are satisfied.
 - a. The bias file B' is for the same CCD as the bias file B .
 - b. The parameter-block keywords

BEP_MODE' = BEP_MODE, (1)

DEALOAD' = DEALOAD, (2)

DTYCYCLE' = DTYCYCLE, (3)

EXP_SKIP' = EXP_SKIP, (4)

EXPTIMEA' = EXPTIMEA, (5)

EXPTIMEB' = EXPTIMEB, (6)

FEPLOAD' = FEPLOAD, (7)

¹Peter Ford's Perl script `/nfs/acis/h4/tools/bin/sun4/search4bias.pl` can be used to identify a suitable replacement file.

$$\text{FEP_MODE}' = \text{FEP_MODE}, \quad (8)$$

$$\text{NOBADCOL}' = \text{NOBADCOL}, \quad (9)$$

$$\text{NOBADPIX}' = \text{NOBADPIX}, \quad (10)$$

$$\text{OCLKPAIR}' = \text{OCLKPAIR}, \quad (11)$$

$$\text{ORC_MODE}' = \text{ORC_MODE}, \quad (12)$$

$$\text{ROWCNT}' = \text{ROWCNT}, \quad (13)$$

$$\text{STARTROW}' = \text{STARTROW}, \text{ and} \quad (14)$$

$$\text{SUM_2X2}' = \text{SUM_2X2}. \quad (15)$$

The keywords on the left-hand sides of equations 1–15 are from the parameter-block file (ac-isf*pbk0.fits) for the same observation as the replacement bias file B' . The keywords on the right-hand sides of the equations are from the parameter-block file for the same observation as the bias file B being replaced.

c. The tabulated parameter-block data

$$\text{BIASALG}' = \text{BIASALG}, \quad (16)$$

$$\text{BIASARG0}' = \text{BIASARG0}, \quad (17)$$

$$\text{BIASARG1}' = \text{BIASARG1}, \quad (18)$$

$$\text{BIASARG2}' = \text{BIASARG2}, \quad (19)$$

$$\text{BIASARG3}' = \text{BIASARG3}, \quad (20)$$

$$\text{BIASARG4}' = \text{BIASARG4}, \text{ and} \quad (21)$$

$$\text{VIDRESP}' = \text{VIDRESP} \quad (22)$$

for the CCD associated with B and B' . Again, the left- and right-hand sides of equations 16–22 are from the parameter-block files associated with B' and B , respectively.

d. The time difference between B' and B

$$\Delta t \equiv |t' - t| \leq \tau. \quad (23)$$

While small τ are best, in some cases the difference may have to be relatively large.²

e. The focal-plane temperature difference between B' and B

$$\Delta T \equiv |T' - T| \leq \Upsilon. \quad (24)$$

Again, small Υ are best.³

2. For the first node of the bias B' (i.e. columns 1–256), modify the values of every pixel in the node so that

$$B' \rightarrow B' - \text{INITOCLA}' + \text{INITOCLA}, \quad (25)$$

where $\text{INITOCLA}'$ and INITOCLA are keywords in the headers of the bias files B' and B , respectively.

3. Modify the value of initial-overclock keyword $\text{INITOCLA}'$ in B' so that

$$\text{INITOCLA}' = \text{INITOCLA}. \quad (26)$$

²The time difference can be specified with the “-d” option of search4bias.pl. If this option is not used, then search4bias.pl sets $\tau = 5$ days.

³The temperature difference can be specified with the “-t” option of search4bias.pl. If this option is not used, then search4bias.pl sets $\Upsilon = 1$ °C. If the “-T” option is used, then search4bias.pl compares the temperatures during the event data collection instead of the temperatures during the bias data collection.

4. Repeat steps 2 and 3 for the other three nodes, using INITOCLB, INITOCLC, and INITOCLD, instead of INITOCLA, for columns 257–512, 513–768, and 769–1024, respectively.
5. Add appropriate history keywords to the header of the modified bias file B' . For example:


```
HISTORY  YYYY-MM-DD:HH:MM:SS
HISTORY  The name and version number of the code used to produce the file
HISTORY
HISTORY  This bias file was created by replacing the file
HISTORY  acisf????????N???.?_bias0.fits with a modified version of the file
HISTORY  acisf????????N???.?_bias0.fits. The original file is contaminated with a
HISTORY  light leak.
```
6. Process the ACIS event data using the modified version of the bias file B' .
7. Examine the pulse-height information of the event data after it has been processed with the replacement bias (see Fig. 3). If `DATAMODE = FAINT`, then prepare a histogram of the pulse heights of the 4 corner pixels for every event on the first node. If `DATAMODE = VFAINT`, then prepare a histogram using the pulse heights of the outer 16 pixels instead of the 4 corner pixels. The peak of the distribution should be at a pulse height of 0 adu. If it is not, then add or subtract the difference between the location of the peak and 0 adu to every pixel on the node for the bias file B' .⁴ Repeat this process for the other nodes.
8. Repeat steps 6–7 until the condition specified in step 7 is satisfied.

3 Caveats

1. If the bias being adjusted suffers from a light leak, then some events near the event threshold will have been lost and cannot be recovered.
2. The algorithm described in this spec may not be appropriate for continuous-clocking mode observations.

⁴The value of the keyword `INITOCLA'` should not be changed in the same way. Only the data in the bias file B' is modified in step 7.

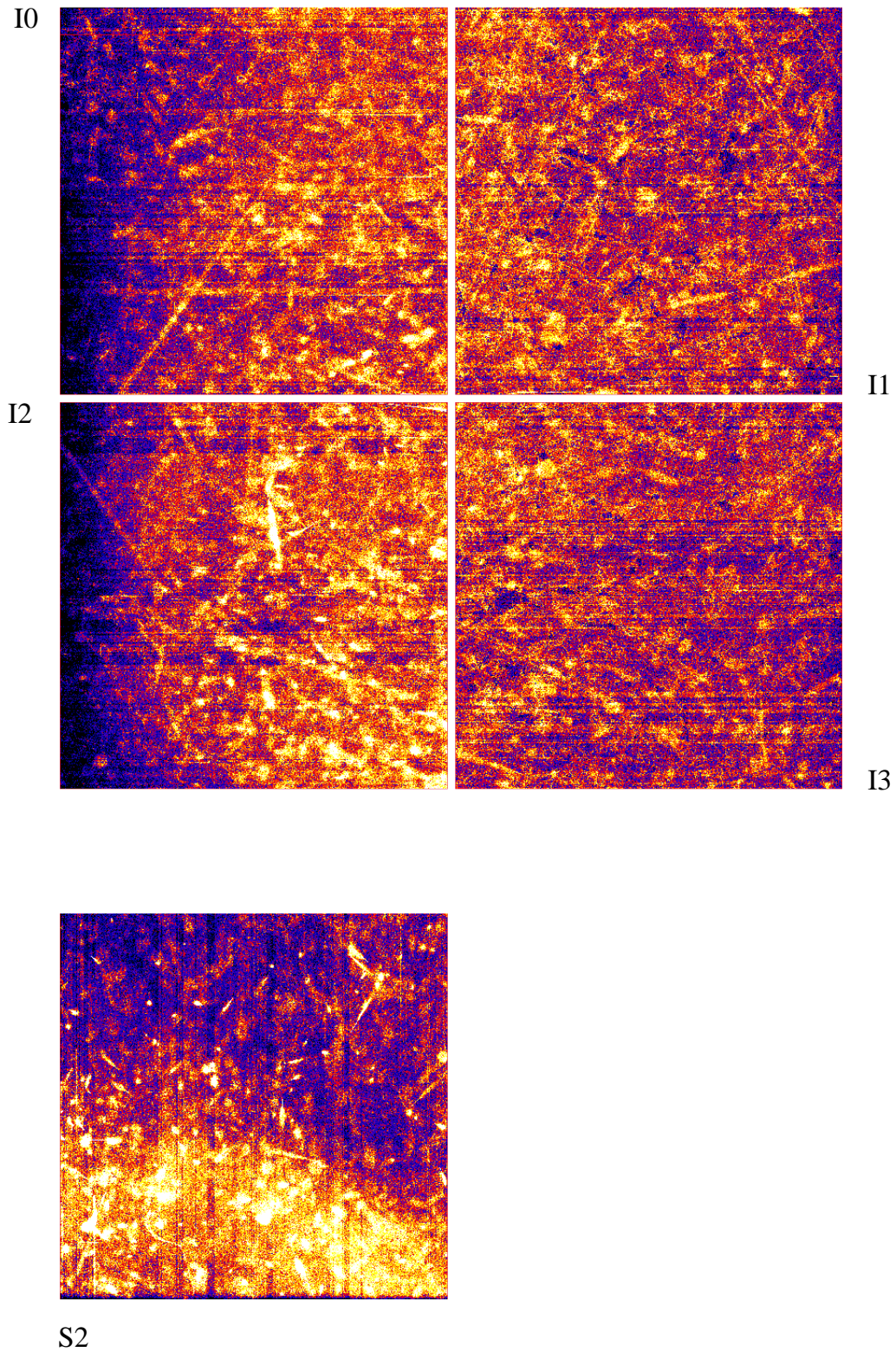


Figure 1: An image of the bias residuals for the five CCDs used for OBS_ID 11799. The median of each column has been subtracted from the bias values for the column. Excess charge from an optical light leak is evident, particularly on ACIS-S2, -I2, and -I0. The labels for each CCD are located near $(CHIPX, CHIPY) = (1, 1)$.

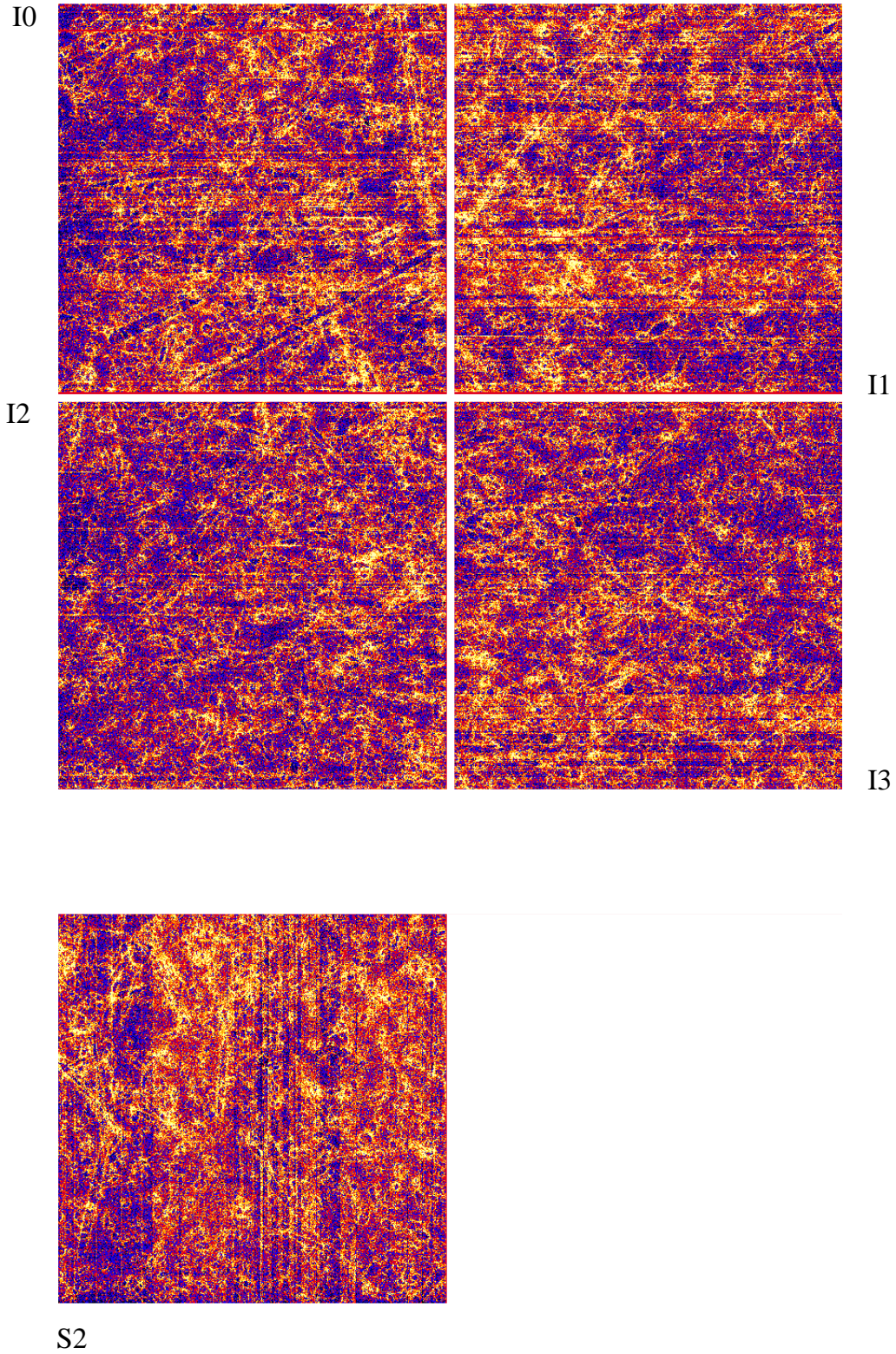


Figure 2: An image of the bias residuals for the five CCDs used for OBS_ID 11799 after the bias files were replaced with modified versions of the bias files for OBS_ID 9345. The median of each column has been subtracted from the bias values for the column. The labels for each CCD are located near $(\text{CHIPX}, \text{CHIPY}) = (1, 1)$.

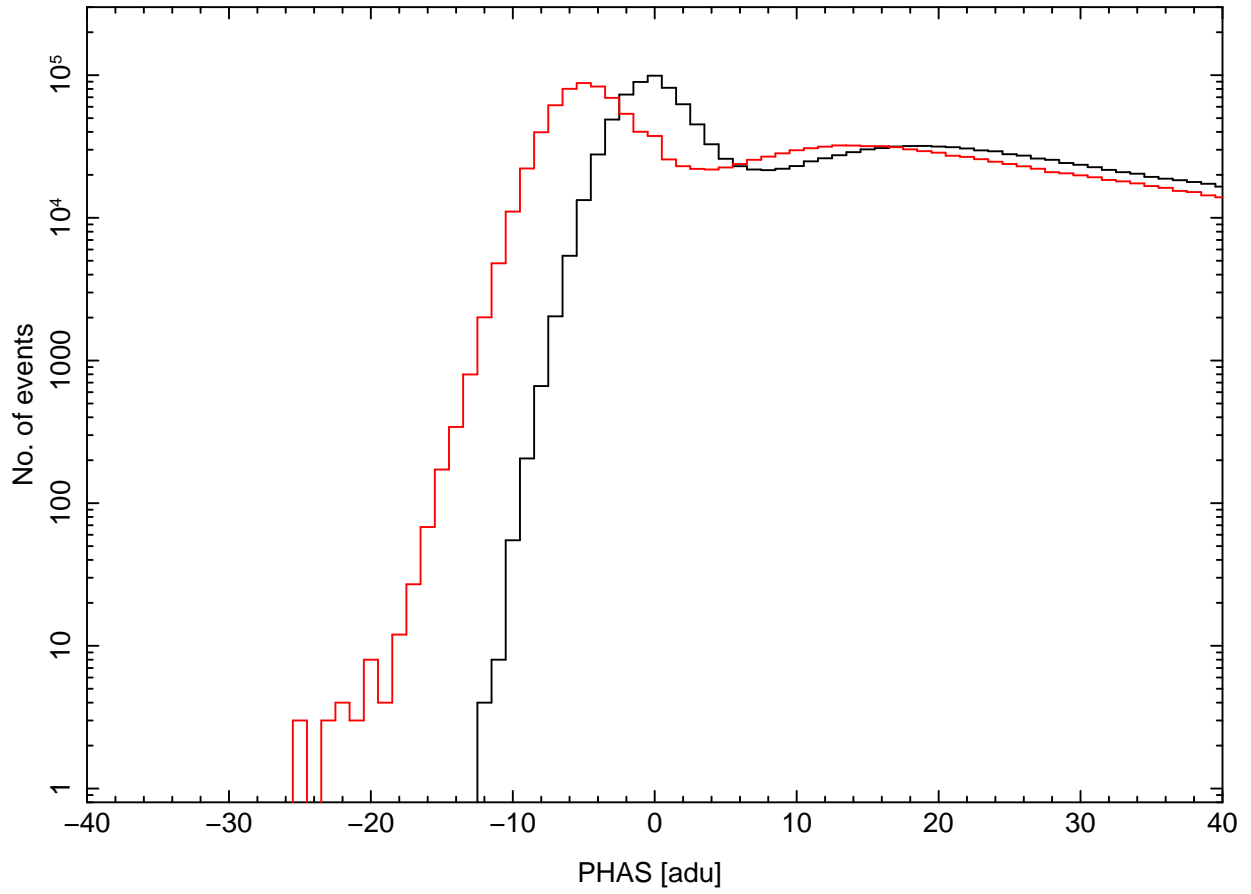


Figure 3: Histograms of the pulse heights of the outer 16 pixels of the $5 \text{ pixel} \times 5 \text{ pixel}$ event islands for OBS_ID 11799. Only events on the first node of ACIS-I2 are included. The red histogram is the distribution obtained using the data processed with the biases contaminated by a light leak. The peak of the distribution is at -5 adu , instead of zero. The black histogram is the distribution obtained after the data were reprocessed using modified versions of the biases for OBS_ID 9345. The peak of the distribution is at 0 adu , as desired.