MIT Kavli Institute **Chandra X-Ray Center**

MEMORANDUM
November 14, 2013

To:	Jonathan McDowell, SDS Group Leader
From:	Glenn E. Allen, SDS
Subject:	Bias-parity error spec
Revision:	1.3
URL:	http://space.mit.edu/CXC/docs/docs.html#berr
File:	/nfs/inconceivable/d0/SDS/SPECS/BERR/bias_parity_error_spec_1.3.tex

1 Bias-parity errors

1.1 Description

Some observations are adversely affected by bias-parity errors. To explore the properties of these errors, 16,304 bias-parity error files were obtained from the archive for the interval from the beginning of the mission through July 8, 2010. Figure 1 shows histograms of the total number and the "valid" number (see sec. 1.5) of errors for each file. The results for the valid errors are also listed in Table 1. The results below the horizontal line in the middle of the table are the results for the twelve files that contain errors associated with the "FEP0 problem." The number of errors, if any, per frame of data is typically very small (Fig. 2 and Table 2). The only bias-parity error files that have more than 10 errors per frame are the twelve files associated with the FEP0 problem. As shown in Figure 3, the number of bias-parity errors varies with time. There is a correlation between the number of errors and the number of pixels on which the errors occur (Fig. 4). Of the 16,304 files, there are only seven where the number of valid errors is not equal to the number of pixels affected by the errors. Six of these seven files are ones associated with FEP0 problem for which the number of errors is comparable to or greater than 262,144, the maximum number of pixels that can be affected by the problem. The seventh file is for `OBS_ID` 7649, where all but one of the 7,439 errors are reported for the pixel $(\texttt{CCD\_ID}, \texttt{CHIPX}, \texttt{CHIPY}) = (8, 786, 356)$.[1]

The distribution of the valid errors in chip coordinates is shown in Figure 5. Inspection of this figure suggests that there is a periodic pattern every 32 pixels in `CHIPX`.[2] Figures 6 and 7 confirm the existence of a periodic pattern. As shown in Figure 8, there is a similar, but much less pronounced, 32-pixel periodicity in the `CHIPX` values of the errors associated with the FEP0 problem. A much more prominent feature of the FEP0 errors is that they only occur in columns with odd values of `CHIPX` (Fig. 9) and in rows with values of $\texttt{CHIPY} \geq 513$ (Fig. 8).

The remainder of this spec describes how the tool `acis_build_badpix` handles bias-parity error files.

1.2 Input

1. One or more Level 0 bias-parity error file (acis*berr0.fits)

[1]These errors are valid and are not associated with the FEP0 problem.
[2]The FEP reads the bias-parity error data in 32-bit words.

2. A Level 0 parameter-block file (acis*pbk0.fits)

1.3 Output

1. A bad-pixel file that includes, among other things, a list of the pixels with valid bias-parity errors (acis*bpix1.fits).

1.4 Parameters

1. `berrfile,f,a,"",,,"Name(s) of input bias-parity error file(s)"`
2. `berrext,s,h,"BERR",,,"Name of bias-parity error extension"`
3. `pbkfile,f,a,"",,,"Name of input parameter-block file"`
4. `maxerr,i,h,10,1,100`[3]`,"Maximum number of valid bias-parity errors per frame"`
5. `outfile,f,a"",,,"Name of output bad-pixel file"`

1.5 Processing

Perform the following tests before processing begins.

- Verify that each `berrfile` exists and has an an extension where the value of `EXTNAME` is identical to the value specified by `berrext`. If one or both of these conditions is not true, then exit with an error message.
- Verify that the `pbkfile` exists. If it does not, then exit with an error message.
- Verify that `maxerr` is in the specified range.
- If `clobber = no`, then verify that the `outfile` does not exist. If it does, then exit with an error message.

Perform the following steps, in sequence, for each bias-parity error file. Note that each file corresponds to a single CCD for an observation.

1. Ignore invalid bias-parity errors. Invalid errors are those for which `DATAMODE = VFAINT` and for which the coordinates[4]
   - $(\mathtt{CCDX}, \mathtt{CCDY}) = (0, \mathtt{ROWCNT})$ or
   - $(\mathtt{CCDX}, \mathtt{CCDY}) = (1, \mathtt{ROWCNT})$ or
   - $(\mathtt{CCDX}, \mathtt{CCDY}) = (1022, 0)$ or
   - $(\mathtt{CCDX}, \mathtt{CCDY}) = (1023, 0)$.

   Here `DATAMODE` is a keyword in the `berrfile`, `CCDX` and `CCDY` are elements of columns with the same names in the `berrfile` and `ROWCNT` is a keyword in the `pbkfile`.
2. If a `berrfile` includes one or more valid bias-parity errors, then set the `FEP_ID` equal to the value of the keyword of the same name in the `berrfile` and use the information in the binary table of the `pbkfile` to find the corresponding `CCD_ID`.
3. A FEP is identified as having suffered from the FEP0 problem if
   - the `FEP_ID` = 0,

[3] A maximum value of 100 is large enough to be well above the maximum number of valid errors per frame for files that are not associated with the FEP0 problem (Fig. 2 and Table 2) and small enough to be well below the number of errors per frame in the first frame associated with the FEP0 problem for the twelve FEP0 `OBS_ID`s in Table 1.

[4] As defined here, all errors associated with the FEP0 problem, except for those at $(\mathtt{CCDX}, \mathtt{CCDY}) = (0, \mathtt{ROWCNT})$, are valid.

- the errors have $\texttt{CCDY} \geq 0$ (if the $\texttt{DATAMODE} = \texttt{CC33\_FAINT}$ or CC33_GRADED) or have $\texttt{CCDY} \geq 512$ (if the DATAMODE is anything else), and
- the total number of valid errors per frame, in the appropriate CCDY range, is greater than maxerr for any frame.

4. If a berrfile includes one or more valid bias-parity errors that are not associated with the FEP0 problem, then the extension of the outfile that is associated with CCD_ID includes one or more entries such that

   - SHAPE is computed as usual,
   - COMPONENT is computed as usual,
   - $\texttt{CHIPX} = \texttt{CCDX} + 1$,
   - $\texttt{CHIPY} = \texttt{CCDY} + \texttt{STARTROW} + 1$ (if DATAMODE = FAINT, FAINT_BIAS, GRADED, or VFAINT), or $1 \leq \texttt{CHIPY} \leq 1024$ (if DATAMODE = CC33_FAINT or CC33_GRADED),
   - $\texttt{TIME} = \texttt{TIME}_{\rm berr}$,
   - TIME_STOP = TSTOP, and
   - STATUS has bit 2 (of 0-31) set to one.

   Here, CCDX and CCDY are the coordinates of the bias-parity error, $\texttt{TIME}_{\rm berr}$ is the TIME associated with the error, and STARTROW and TSTOP are keywords in the pbkfile.

5. If a berrfile contains valid bias-parity errors associated with the FEP0 problem, then the extension of the outfile that is associated with CCD_ID includes an entry such that[5]

   - SHAPE is determined as usual,
   - COMPONENT is computed as usual,
   - $1 \leq \texttt{CHIPX} \leq 1024$,
   - $513 \leq \texttt{CHIPY} \leq 1024$ (if DATAMODE = FAINT, FAINT_BIAS, GRADED, or VFAINT), or $1 \leq \texttt{CHIPY} \leq 1024$ (if DATAMODE = CC33_FAINT or CC33_GRADED),
   - $\texttt{TIME} = \texttt{TIME}_{\rm berr}$,
   - TIME_STOP = TSTOP, and
   - STATUS has bit 13 (of 0-31) set to one.

   Here, $\texttt{TIME}_{\rm berr}$ is the TIME associated with the first frame in which there are more than maxerr valid bias-parity errors and TSTOP is a keyword in the pbkfile.

1.6 Caveats

1. The values of TIME in the bias-parity error files appear to be the TIMEs of the mid points of the frames. Therefore, perhaps the values of TIME in the output file should be $\texttt{TIME}_{\rm stat} - \texttt{TIMEPIXR}_{\rm stat} \times \texttt{TIMEDEL}_{\rm stat}$ instead of $\texttt{TIME}_{\rm berr}$, where $\texttt{TIME}_{\rm stat}$ is the time associated with the relevant EXPNO.

[5] An examination of the twelve bias-parity error files that include errors associated with the FEP0 problem (i.e. ones for the OBS_IDs that are below the line in Table 1), reveals that the only errors reported are errors associated with the FEP0 problem. There is no evidence that there are other valid errors in the files.

Table 1. Histogram of the number of valid bias-parity errors

No. valid errors	No. files	OBS_ID(s)
0	14079	...
1	2055	...
2	124	...
3	23	...
4	6	2977, 5771, 9581, 10052, 10806, 11011
5	1	4195
6	2	9893, 11058
7	1	9924
7439	1	7649
127003 [3550]	1	62340
136481 [625]	1	62338
139559 [139522]	1	965
139756 [139744]	1	510
149668 [149668]	1	62502
186595 [186383]	1	62333
200635 [4827]	1	62327
238050 [146756]	1	62353
265784 [118226]	1	18
336595 [79091]	1	62363
1043209 [139813]	1	1383
3286241 [101649]	1	333
Total	16304	...

The numbers inside the square brackets in the first column are the number of errors in the first frame that has an error. These values are well above the maximum allowed value for `maxerr`.

Table 2. Histogram of the number of valid bias-parity errors per frame

No. valid errors per frame	No. frames	OBS_ID(s)
1	9613	...
2	90	...
3	13	...
4	1	5771
5	1	4195
6	2	9893, 11058
7	1	9924
Total	9721	...

The very large number of frames with no valid errors is omitted. The data in the files that are associated with the FEP0 problem are also omitted. Therefore, the values for the number of frames are the differences between the red and green histograms in Figure 2.

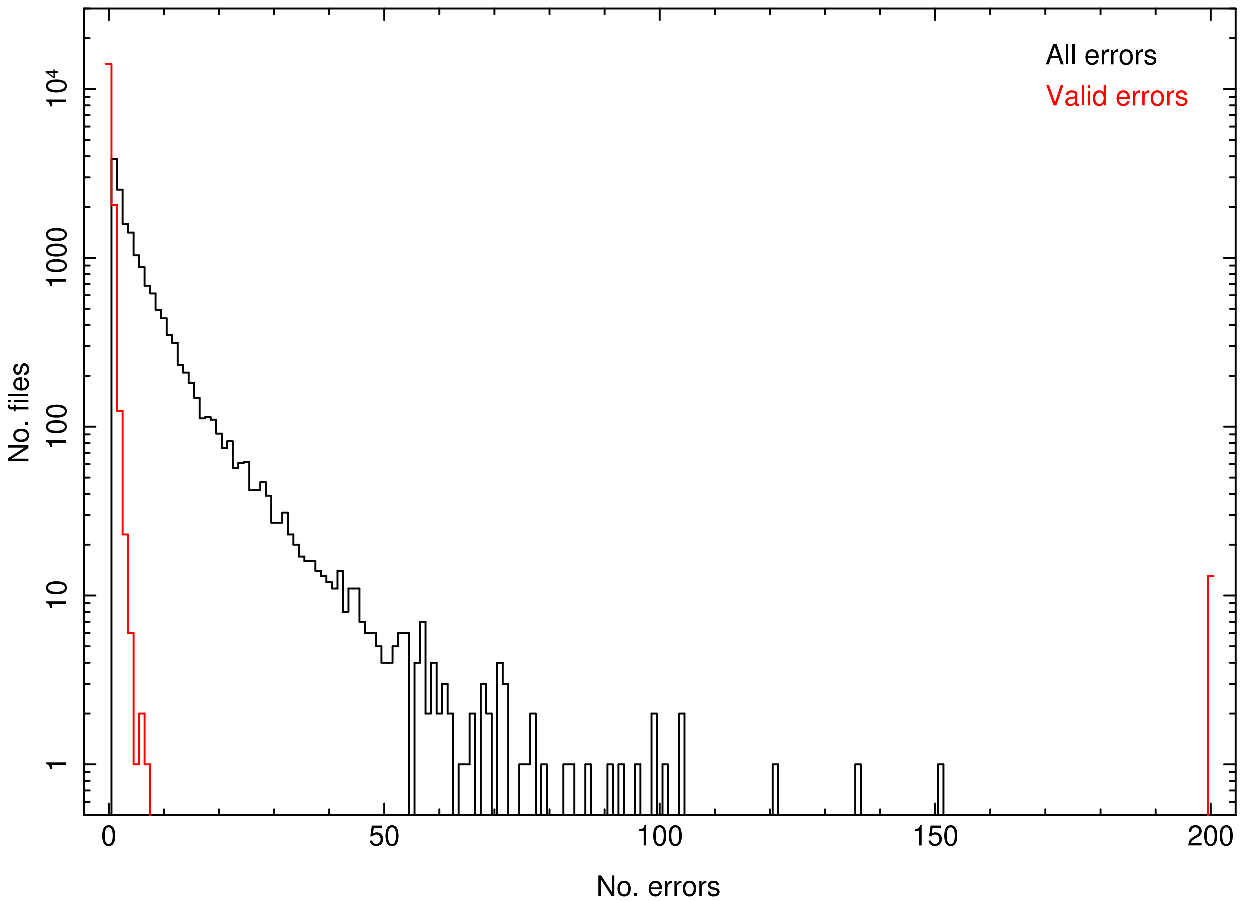

Figure 1: Histograms of the number of bias-parity errors in the bias-parity error files. The black histogram includes all telemetered bias-parity errors. The red histogram includes only the valid errors (see sec. 1.5). The bin at the right-hand side of the plot indicates the number of files that have at least 200 errors.

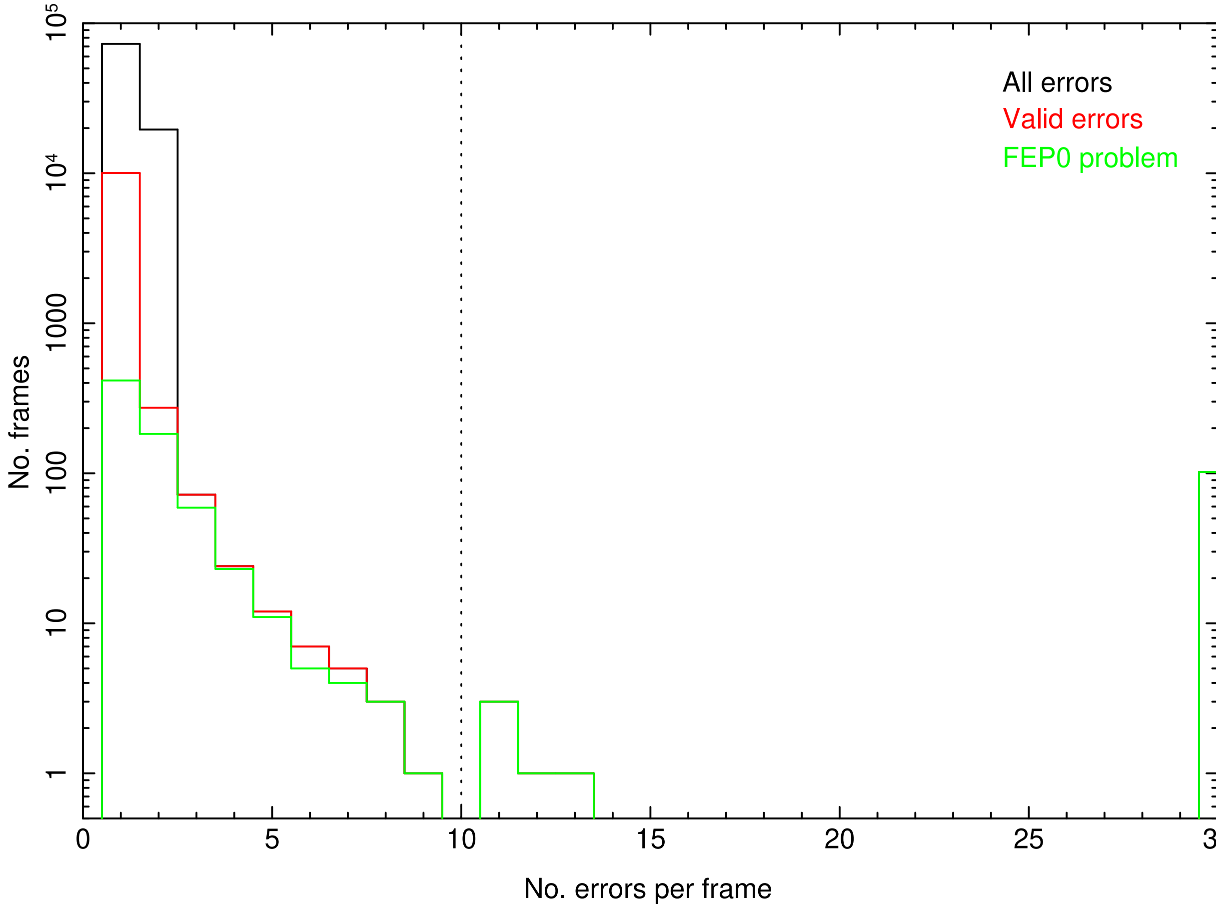

Figure 2: Histograms of the number of bias-parity errors per frame of data. The black histogram includes all telemetered bias-parity errors. The red histogram includes only the valid errors (see sec. 1.5). The green histogram includes only the valid errors that are associated with the FEP0 problem. The bin at the right-hand side of the plot indicates the number for frames that have at least 30 errors. All twelve of the files associated with the FEP0 problem have at least one frame with 30 or more errors (Table 1). The dotted, vertical line is the default value for `maxerr`.

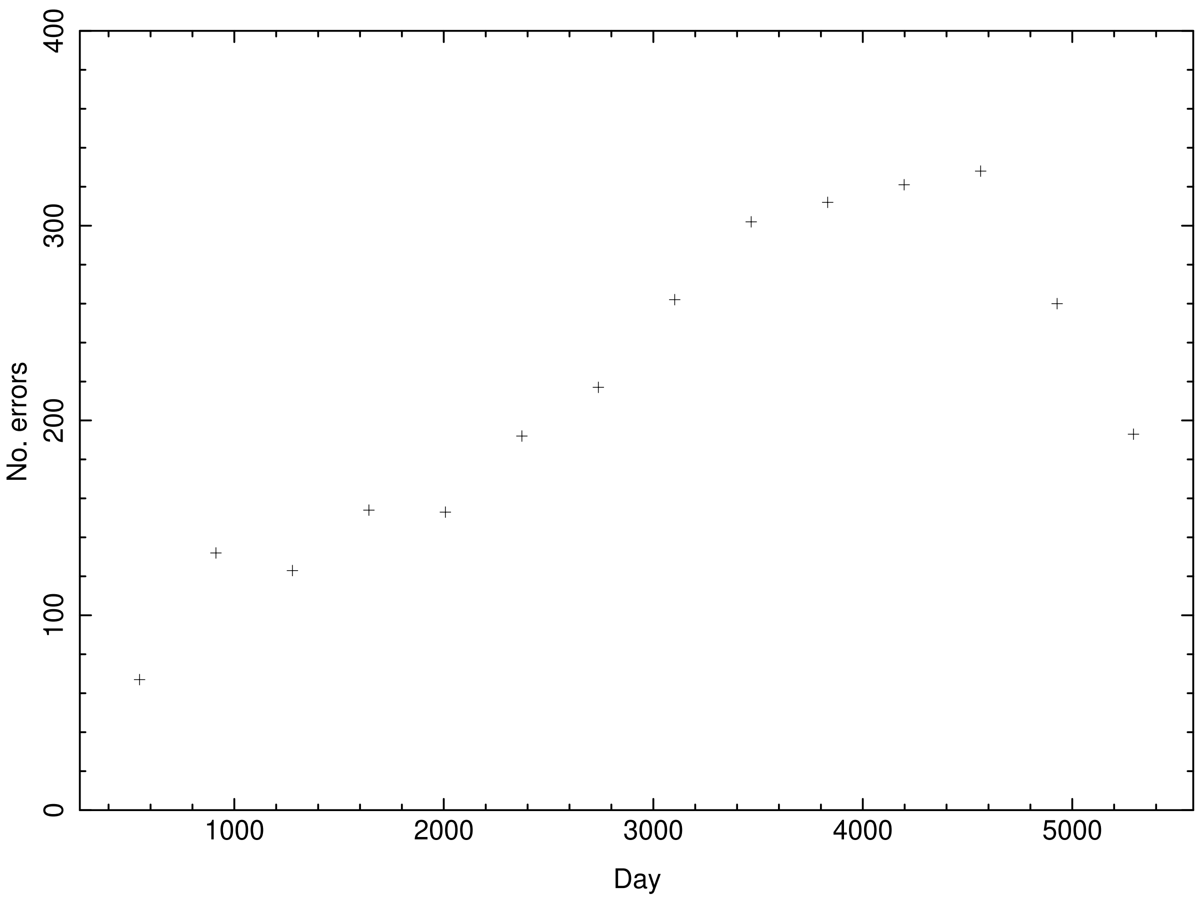

Figure 3: The number of valid bias-parity errors as a function of time. Each data point is the sum over a 365-day interval. The day is the mission elapsed time (i.e. is relative to 1998-01-01T00:00:00). The data associated with the FEP0 problem and with `OBS_ID` 7649 are excluded. As noted by Peter Ford, there is a correlation between the number of bias-parity errors and the number of threshold crossings.

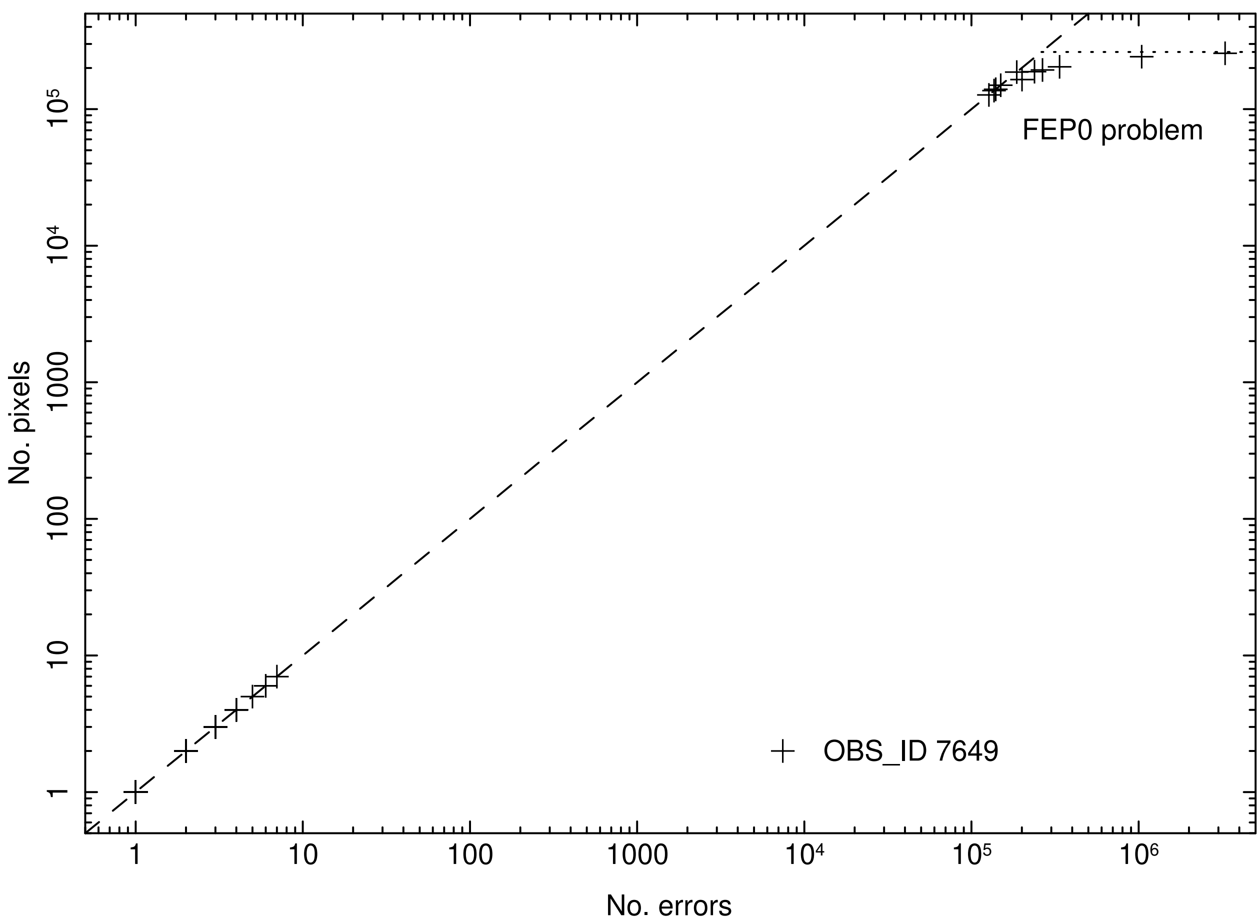

Figure 4: The number of pixels on which valid bias-parity errors occur v. the number of valid errors. The dashed line is the line along which the number of pixels equals the number of errors. It is not possible for a data point to lie above this line (i.e. to have more pixels with bias-parity errors than errors). The cluster of points near the upper, right-hand corner are those associated with the FEP0 problem. The dotted, horizontal line at 262,144 represents the maximum number of pixels that can be affected by the FEP0 problem. The point near the middle of the lower edge is for `OBS_ID` 7649. A bias-parity error file for this observation had 7,439 errors, all but one of which occurred at the location ($\texttt{CCD\_ID}, \texttt{CHIPX}, \texttt{CHIPY}) = (8, 786, 356)$.

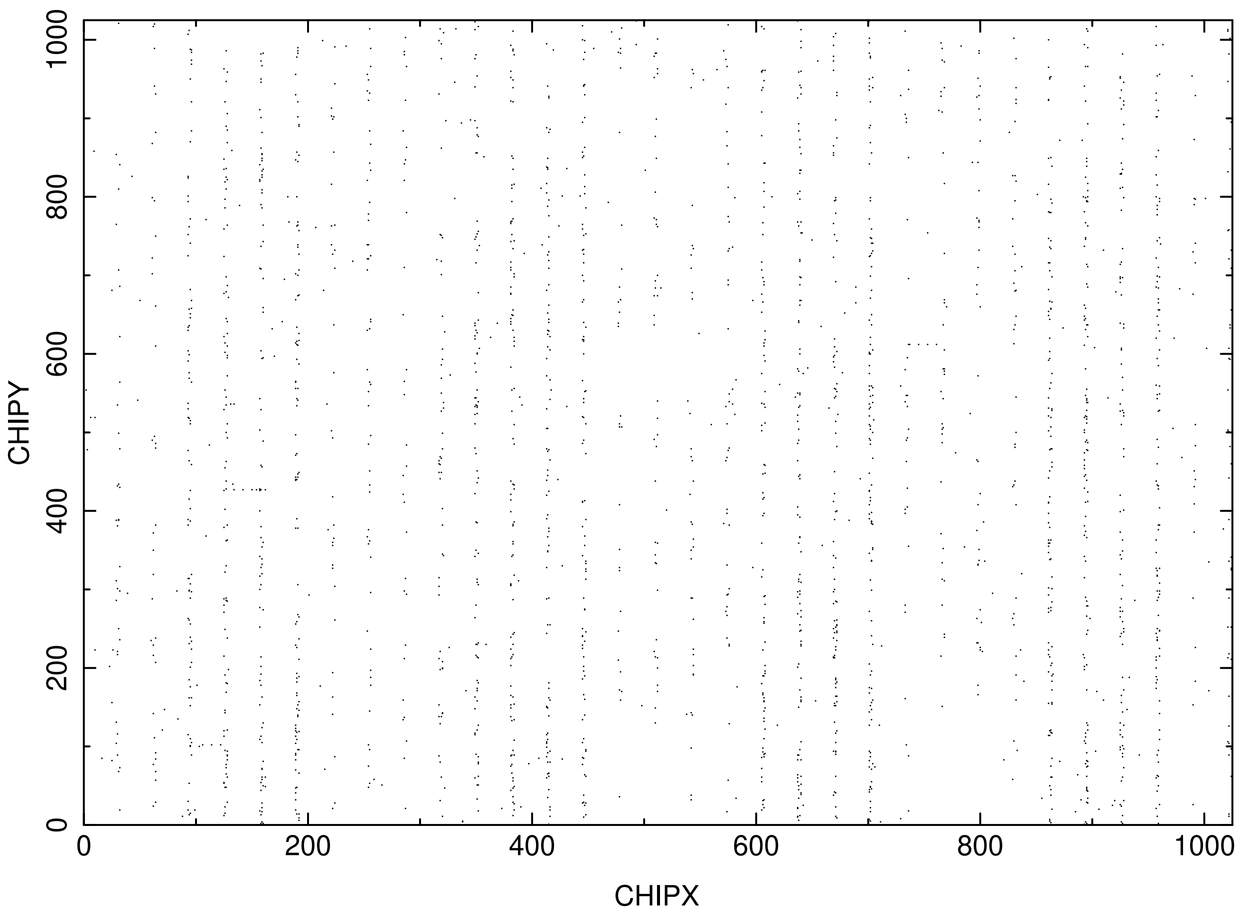

Figure 5: A plot of the chip coordinates at which valid bias-parity errors occur. Note that all CCDs are included. The data in the files that are associated with the FEP0 problem are excluded. A periodic pattern in `CHIPX` is evident.

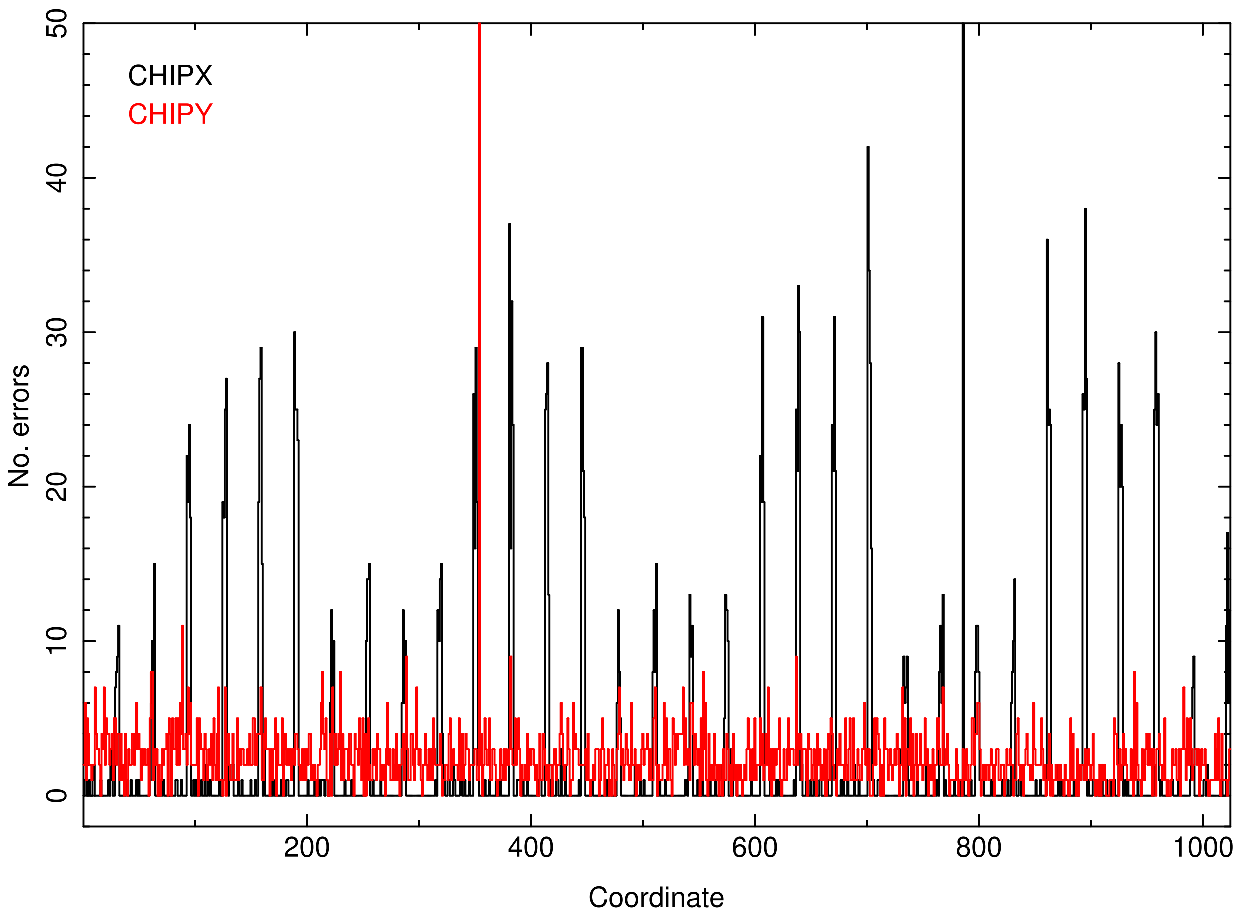

Figure 6: Histograms of the number of valid bias-parity errors as a function of `CHIPX` (black) and `CHIPY` (red). Note that all CCDs are included. The data in the files that are associated with the FEP0 problem are excluded. The spikes at `CHIPX` $= 786$ and `CHIPY` $= 356$ are associated with the 7,438 errors at this location for `OBS_ID` 7649. A periodic pattern in `CHIPX` is evident.

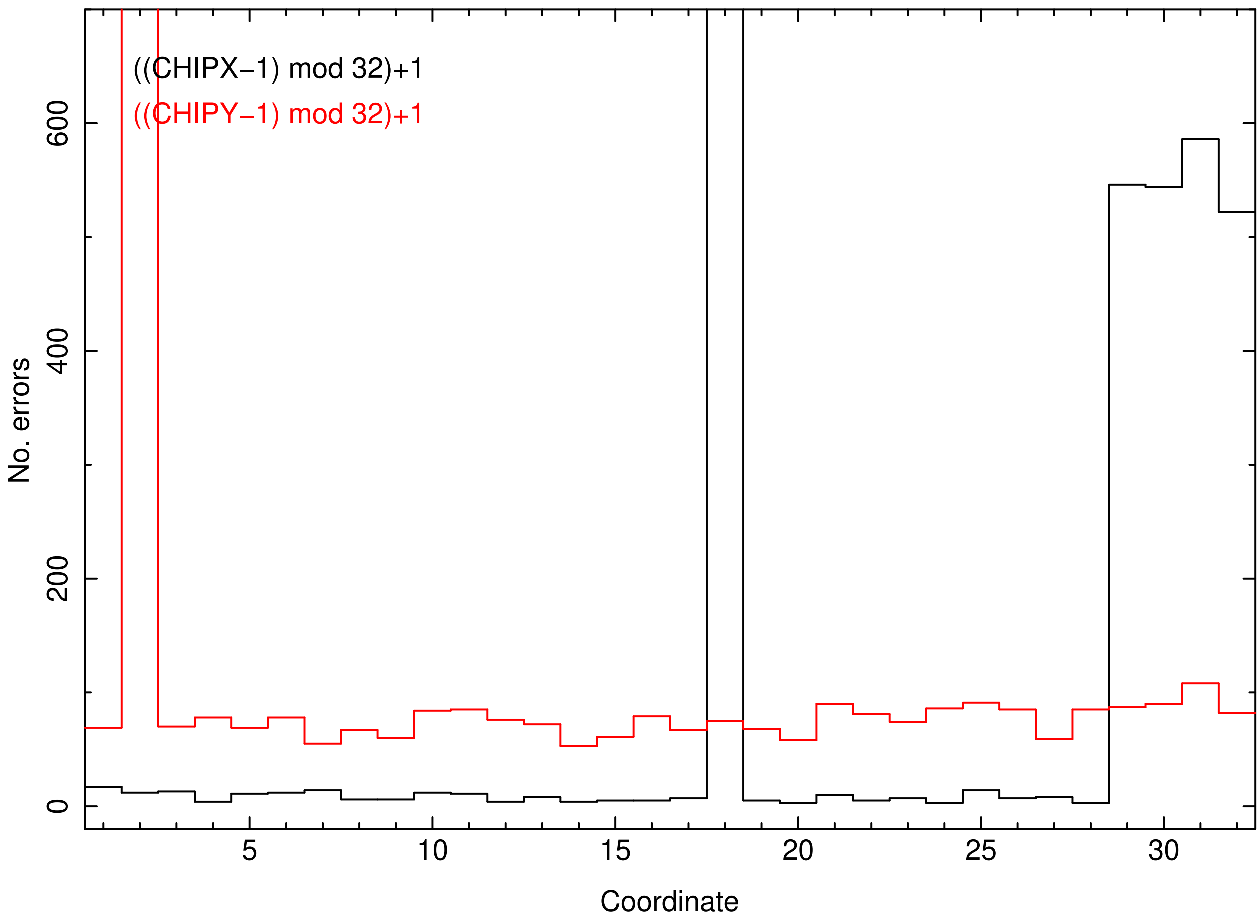

Figure 7: Histograms of the number of valid bias-parity errors as a function of CHIPX (black) and CHIPY (red). The coordinates are modulo 32. Note that all CCDs are included. The data in the files that are associated with the FEP0 problem are excluded. The spikes at coordinates of 18 and 2 are associated with the 7,438 errors at CHIPX = 786 and CHIPY = 356 for OBS_ID 7649. Errors occur almost exclusively on one of the last four columns in each set of 32 columns.

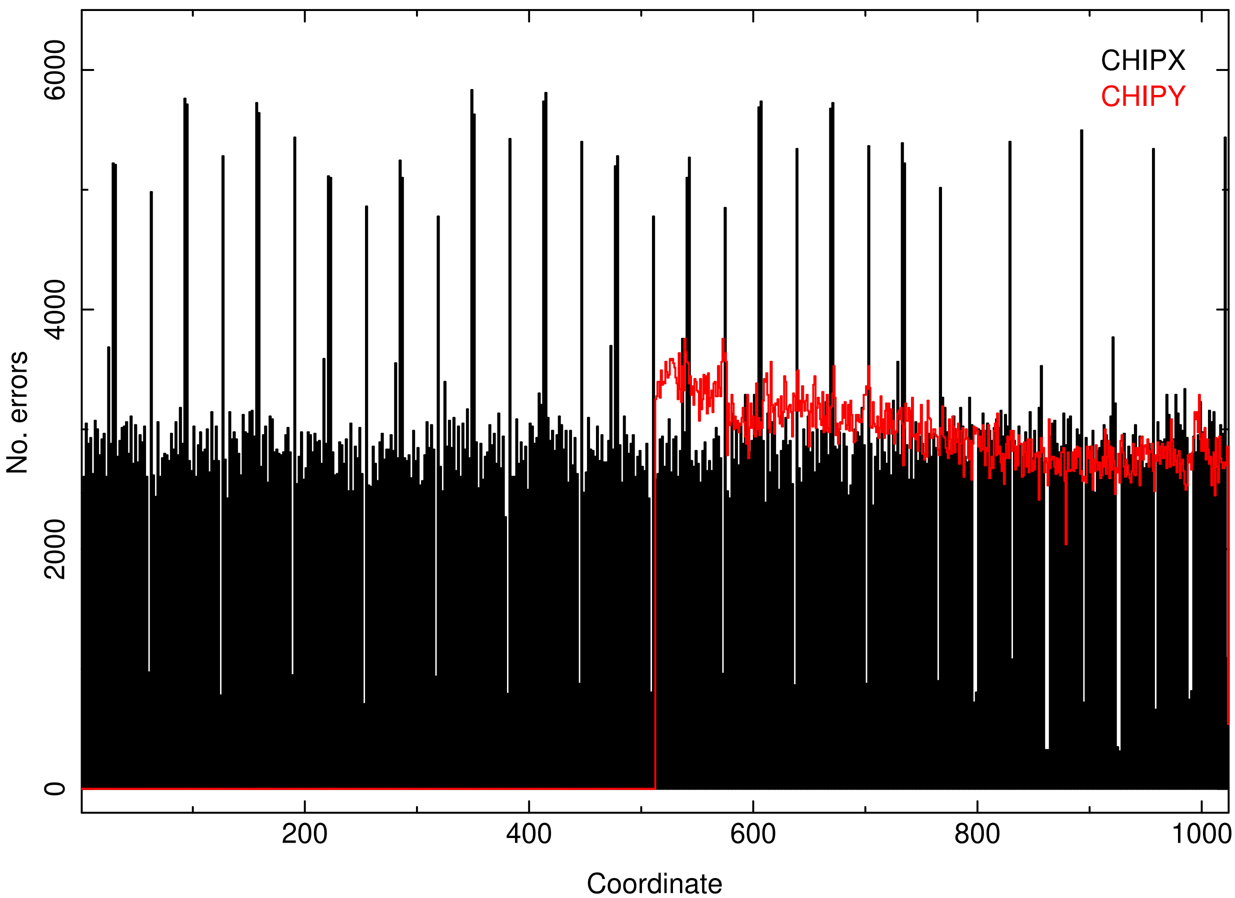

Figure 8: Histograms of the number of bias-parity errors as a function of `CHIPX` (black) and `CHIPY` (red) for the errors associated with the FEP0 problem. Note that all CCDs are included. A periodic pattern in `CHIPX` is evident. No errors are reported for pixels that have `CHIPY` < 513.

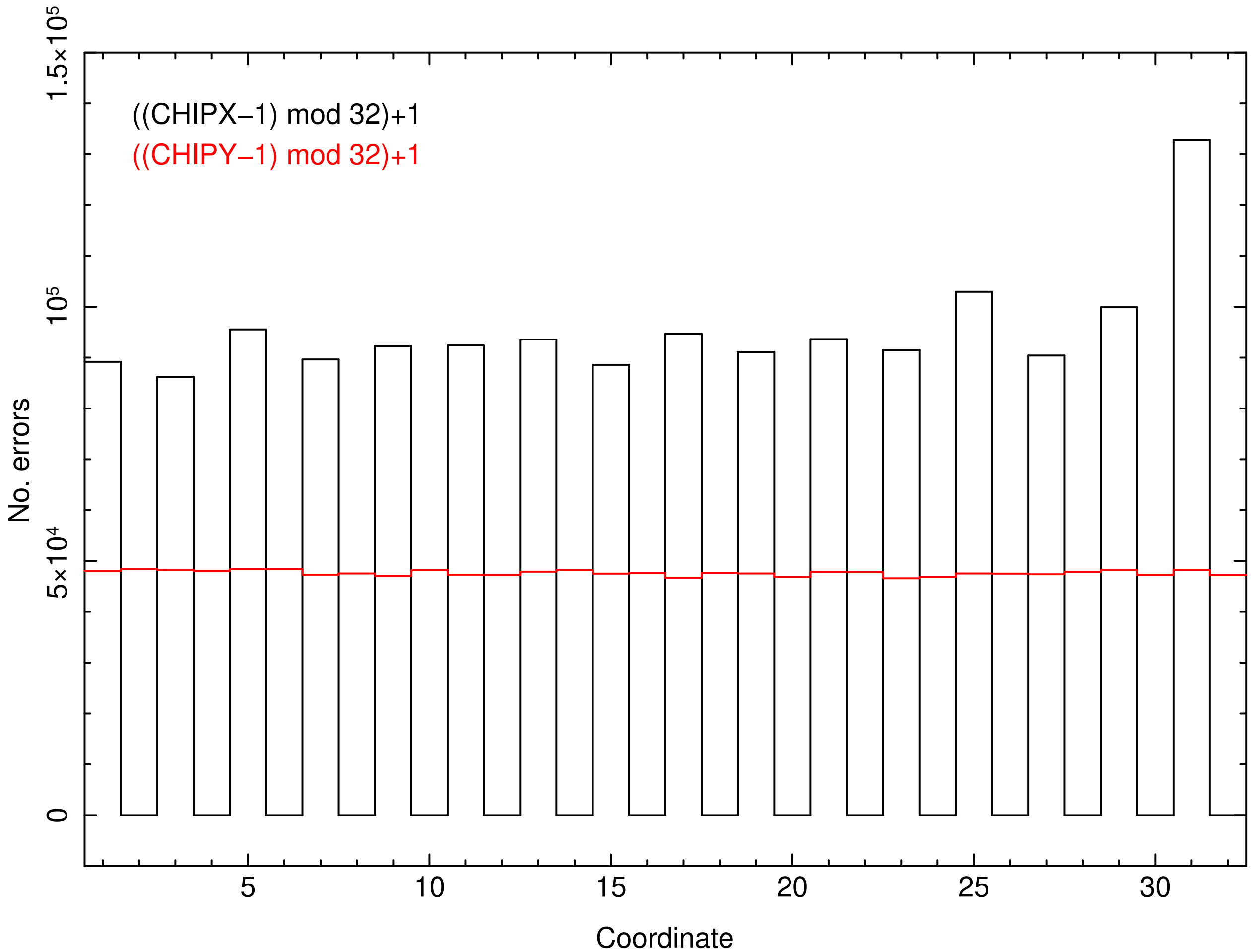

Figure 9: Histograms of the number of bias-parity errors as a function of `CHIPX` (black) and `CHIPY` (red) for the errors associated with the FEP0 problem. The coordinates are modulo 32. Note that all CCDs are included. No errors are reported for pixels that have even values of `CHIPX`.