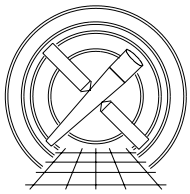

MIT Kavli Institute **Chandra X-Ray Center**

MEMORANDUM
April 4, 2007

To:	Jonathan McDowell, SDS Group Leader
From:	Glenn E. Allen, SDS
Subject:	acis_build_mask
Revision:	4.0[1]
URL:	http://space.mit.edu/CXC/docs/docs.html#msk
File:	/nfs/cxc/h2/gea/sds/docs/memos/memo_acis_build_mask_4.0.tex

1 acis_build_mask

1.1 Description

A Level 1 ACIS mask file for an observation contains information about the valid ranges of CHIPX, CHIPY and PHA for each CCD used for the observation. If a user specifies one or more spatial and/or spectral window for their observation, then this information is included in the mask file. Unlike the pixels and columns identified as bad in a bad-pixel file, no events should be detected in the regions identified as invalid in a mask file. However, there may be events with pulse heights that are slightly outside the valid PHA range because the pulse heights are typically recomputed on the ground.

1.2 Input

1. A Level 0 parameter block file (acis*pbk0.fits)
2. A Level 0 window-block file (acis*win0.fits)
3. A Level 1 event data file (acis*evt1.fits)

1.3 Output

A Level 1 mask file (acis*msk1.fits) that contains one extension for each active CCD. Each extension includes a binary table with one or more rows and the following columns.

1. SHAPE
2. COMPONENT
3. CHIPX (a two element vector)

[1]This revision has been substantially restructured with respect to the previous revision. The only significant changes are marked with changebars. Yet, no change to the tool acis_build_mask is necessary. The tool already includes the features marked with changebars. The changes marked with changebars were made to align the spec with the tool.

4. CHIPY (a two element vector)
5. SAMP_CYC
6. PHAMIN
7. PHAMAX

The columns WINDOW and OVERLAP, which are in older mask files, have been dropped. Since WINDOW = COMPONENT − 1, the column WINDOW is redundant. The column OVERLAP was dropped because it is not used by any CIAO tool.

1.4 Parameters

1. pbkfile,s,a,“”,,,“Name of input parameter-block file”
2. pbkext,s,h,“PBK”,,,“Name of extension in parameter-block file”
3. winfile,s,a,“”,,,“Name of input window-block file”
4. winext,s,h,“WIN”,,,“Name of extension in window-block file”
5. evtfile,s,h,“none”,,,“Name of input event file”
6. outfile,s,a,“”,,,“Name of output file”
7. kernel,s,h,“default”,fits—iraf—default,,“Output format type”
8. clobber,b,h,“no”,,,“Overwrite output file if it exists?”
9. verbose,i,h,0,0,5,“Amount of messages produced (0=none, 5=a lot)”
10. mode,s,h,“ql”,,,

1.5 Processing

One FITS extension is produced for every “active” CCD. A CCD is defined to be active if the CCD is included in the “PBK” extension of the parameter-block file. Each extension has one or more rows. One row is used to mark an entire CCD as invalid. Additional rows are used, if necessary, to mark portions of the CCD as valid. This method insures that every CCD has at least one row in the mask file and that the outer edge of a CCD is marked as invalid.

1. Verify that the specified extensions of the input files exist. If clobber = “no,” then verify that the output file does not exist.
2. Read the values of the keywords STARTROW, ROWCNT, and WIND_ID in the header of the input parameter-block file. If STARTROW < 0 or STARTROW + ROWCNT > 1023, then do not create the output file and exit with an error message that the keywords are invalid. If the keywords are valid, then copy the value of the keyword WIND_ID to a keyword of the same name in the header of the output file.
3. Read the contents of the window-block file.
4. Determine the contents of the columns SHAPE, COMPONENT, CHIPX, CHIPY, SAMP_CYC, PHAMIN and PHAMAX in the output file as follows.
   a. **SHAPE:**
   The SHAPE is either a “rectangle” or “!rectangle,” as appropriate.

Table 1. CHIPX and CHIPY values for SAMP_CYC ≥ 1

DATAMODE	CHIPX[0]	CHIPX[1]	CHIPY[0]	CHIPY[1]
Default values[a]				
CC33_FAINT[b]	$\begin{pmatrix} 2 \\ 2 \end{pmatrix}$	$\begin{pmatrix} 1023 \\ 1023 \end{pmatrix}$	$\begin{pmatrix} 2 \\ 514 \end{pmatrix}$	$\begin{pmatrix} 511 \\ 1023 \end{pmatrix}$
CC33_GRADED[b]	$\begin{pmatrix} 2 \\ 2 \end{pmatrix}$	$\begin{pmatrix} 1023 \\ 1023 \end{pmatrix}$	$\begin{pmatrix} 2 \\ 514 \end{pmatrix}$	$\begin{pmatrix} 511 \\ 1023 \end{pmatrix}$
FAINT	2	1023	2	1023
FAINT_BIAS	2	1023	2	1023
GRADED	2	1023	2	1023
VFAINT	2	1023	3	1022
General formulae[a]				
CC33_FAINT[b]	$\begin{pmatrix} x_0{+}1 \\ x_0{+}1 \end{pmatrix}$	$\begin{pmatrix} x_1{+}1 \\ x_1{+}1 \end{pmatrix}$	$\begin{pmatrix} 2 \\ 514 \end{pmatrix}$	$\begin{pmatrix} 511 \\ 1023 \end{pmatrix}$
CC33_GRADED[b]	$\begin{pmatrix} x_0{+}1 \\ x_0{+}1 \end{pmatrix}$	$\begin{pmatrix} x_1{+}1 \\ x_1{+}1 \end{pmatrix}$	$\begin{pmatrix} 2 \\ 514 \end{pmatrix}$	$\begin{pmatrix} 511 \\ 1023 \end{pmatrix}$
FAINT	$x_0 + 1$	$x_1 + 1$	$y_0 + 2$	y_1
FAINT_BIAS	$x_0 + 1$	$x_1 + 1$	$y_0 + 2$	y_1
GRADED	$x_0 + 1$	$x_1 + 1$	$y_0 + 2$	y_1
VFAINT	$x_0 + 1$	$x_1 + 1$	$y_0 + 3$	$y_1 - 1$

[a] The valid region is the region defined by CHIPX[0] $\leq$ CHIPX $\leq$ CHIPX[1] and CHIPY[0] $\leq$ CHIPY $\leq$ CHIPY[1].
[b] Two rows are written for each CCD. One for the top half of a CCD and one for the bottom half of the CCD.
x_0 = LL_CCDX
x_1 = LL_CCDX + CCDCOL
y_0 = max(LL_CCDY, STARTROW)
y_1 = min(LL_CCDY + CCDROW, STARTROW + ROWCNT)

b. **COMPONENT:**
Each rectangular component of the mask for an observation is numbered sequentially from one. The index number for a component is listed in the column named COMPONENT.

c. **CHIPX and CHIPY:**

i. SAMP_CYC ≥ 1*:*
If the SAMP_CYC ≥ 1 for a region, then the region is valid and Table 1 is used to determine the values of the boundaries for the region. Typically, the valid region for a CCD is the entire CCD. In this case, the top half of Table 1 is used to determine the values of CHIPX[0], CHIPX[1], CHIPY[0] and CHIPY[1]. However, if only a subset of a CCD is used, as has been the case for some observations of the Crab, for example, then the formulae in the bottom half of Table 1 are used to determine the boundaries.
If SAMP_CYC ≥ 1 and CHIPX[0] = 1 or CHIPX[1] = 1024, then change the CHIPX boundary to be consistent with the default value listed in Table 1. If SAMP_CYC ≥ 1 and CHIPY[0] = 1 (or 2 for VFAINT) or CHIPY[1] = 1024 (or 1023 for VFAINT), then change the CHIPY boundary to be consistent with the default value listed in Table 1. If SAMP_CYC ≥ 1 and CHIPX[0] < 1, CHIPX[1] > 1024, CHIPY[0] < 1 or CHIPY[1] > 1024, then do not create the output file and exit with an error message.

ii. SAMP_CYC = 0*:*
If the SAMP_CYC = 0 for a region, then the region is invalid and Table 2 is used to determine the values of the boundaries for the region. If a CCD is "active", but the entire CCD has a window with a sample cycle of zero, then the top half of Table 2 is used to determine the values of CHIPX[0], CHIPX[1], CHIPY[0], and CHIPY[1]. If only a subset of a CCD has a window with a SAMP_CYC = 0, as has been the case for some grating observations where

Table 2. CHIPX and CHIPY values for SAMP_CYC = 0

DATAMODE	CHIPX[0]	CHIPX[1]	CHIPY[0]	CHIPY[1]
Default values[a]				
CC33_FAINT	1	1024	1	1024
CC33_GRADED	1	1024	1	1024
FAINT	1	1024	1	1024
FAINT_BIAS	1	1024	1	1024
GRADED	1	1024	1	1024
VFAINT	1	1024	1	1024
General formulae[a]				
CC33_FAINT[b]	$\begin{pmatrix} x_0+1 \\ x_0+1 \end{pmatrix}$	$\begin{pmatrix} x_1+1 \\ x_1+1 \end{pmatrix}$	$\begin{pmatrix} 2 \\ 514 \end{pmatrix}$	$\begin{pmatrix} 511 \\ 1023 \end{pmatrix}$
CC33_GRADED[b]	$\begin{pmatrix} x_0+1 \\ x_0+1 \end{pmatrix}$	$\begin{pmatrix} x_1+1 \\ x_1+1 \end{pmatrix}$	$\begin{pmatrix} 2 \\ 514 \end{pmatrix}$	$\begin{pmatrix} 511 \\ 1023 \end{pmatrix}$
FAINT	x_0+1	x_1+1	y_0+1	y_1+1
FAINT_BIAS	x_0+1	x_1+1	y_0+1	y_1+1
GRADED	x_0+1	x_1+1	y_0+1	y_1+1
VFAINT	x_0+1	x_1+1	y_0+1	y_1+1

[a] The invalid region is the region defined by CHIPX[0] $\leq$ CHIPX $\leq$ CHIPX[1] and CHIPY[0] $\leq$ CHIPY $\leq$ CHIPY[1].
[b] Two rows are written for each CCD. One for the top half of a CCD and one for the bottom half of the CCD.
x_0 = LL_CCDX
x_1 = LL_CCDX + CCDCOL
y_0 = max(LL_CCDY, STARTROW)
y_1 = min(LL_CCDY + CCDROW, STARTROW + ROWCNT)

the zeroth-order events are excluded, then the formulae in the bottom half of Table 2 are used to determine the boundaries.
If SAMP_CYC = 0 and CHIPX[0] $<$ 1, CHIPX[1] $>$ 1024, CHIPY[0] $<$ 1 or CHIPY[1] $>$ 1024, then do not create the output file and exit with an error message.

d. **SAMP_CYC:**
The value of SAMP_CYC for each component is copied from the Level 0 window file with the following exception. If SAMP_CYC = 1, $\text{PHAMIN}_{\text{win}} = 0$ and $\text{PHARANGE}_{\text{win}} = 0$, then SAMP_CYC = 0 in the output file. (PHAMIN and PHAMAX are computed as described below in any case.)

e. **PHAMIN:**
The value of PHAMIN for a window (for all DATAMODEs) is given by the larger of

$$\text{PHAMIN}_{\text{pbk}} + 1, \tag{1}$$

$$\min\left(\text{EVT\_THR}[0], \text{EVT\_THR}[1], \text{EVT\_THR}[2], \text{EVT\_THR}[3]\right) + 1, \text{ and} \tag{2}$$

$$\text{PHAMIN}_{\text{win}} + 0, \tag{3}$$

where $\text{PHAMIN}_{\text{pbk}}$ is the value of the keyword PHAMIN in the header of the parameter block file, EVT_THR[i] is the value of the event threshold for node i of the appropriate CCD in the first extension of the parameter block file and $\text{PHAMIN}_{\text{win}}$ is the value of PHAMIN for the window in the first extension of the window-block file.

f. **PHAMAX:**
The value of PHAMAX for a window (for all DATAMODEs) is given by the smaller of

$$\text{PHAMIN}_{\text{pbk}} + \text{PHARANGE}_{\text{pbk}} - 1, \tag{4}$$

$$\text{PHAMIN}_{\text{win}} + \text{PHARANGE}_{\text{win}} - 1, \text{ and} \tag{5}$$

$$32767, \tag{6}$$

where $\mathrm{PHARANGE_{pbk}}$ is the value of the keyword PHARANGE in the header of the parameter block file and $\mathrm{PHARANGE_{win}}$ is the value of PHARANGE for the window in the first extension of the window-block file.

If $\mathrm{PHAMIN_{win}} = 0$ and $\mathrm{PHARANGE_{win}} = 0$, then set $\mathrm{PHAMIN} = \mathrm{PHAMIN_{pbk}} + 1$ and PHAMAX = 32767. If PHAMAX $\leq$ PHAMIN, then do not create the output file and exit with an error message.

5. Write the data to the specified output file.

6. **FIRSTROW and LASTROW:**
Add the keywords FIRSTROW and LASTROW to the header of the output file for each CCD. FIRSTROW is the smallest value of CHIPY[0] for any masked region on the CCD (as long as the region has SAMP_CYC > 0). LASTROW is largest value of CHIPY[1] for any masked region on the CCD (as long as the region has SAMP_CYC > 0). If FIRSTROW < 1, LASTROW > 1024 or LASTROW $<$ FIRSTROW, then do not create the output file and exit with an error message. If a CCD has no active region, then do not write the keywords FIRSTROW and LASTROW to the output file for the CCD.

7. **PHAMIN and PHARANGE:**
Add the keywords PHAMIN and PHARANGE to the header of the output file for each CCD. PHAMIN is the smallest value of PHAMIN for any masked region on the CCD (as long as the region has SAMP_CYC > 0). PHARANGE is largest value of PHAMAX for any masked region on the CCD (as long as the region has SAMP_CYC > 0) less the value of the keyword PHAMIN. If PHARANGE < 1, then do not create the output file and exit with an error message. If a CCD has no active region, then do not write the keywords PHAMIN and PHARANGE to the output file for the CCD.

A Notes about Window-Block Files

Window-block files specify an ordered set of filters that are used to exclude selected events from telemetry. The selection criteria can include the location, pulse height or exposure number of an event. For timed-exposure mode observations, the fate of event i on CCD_ID $= c_i$ at the coordinates CCDX $= x_i$ and CCDY $= y_i$ is determined by the first row r in the window-block file for the observation such that

$$\mathrm{CCD\_ID}_r = c_i, \tag{7}$$

$$\mathrm{LL\_CCDX}_r \leq x_i \leq \mathrm{LL\_CCDX}_r + \mathrm{CCDCOL}_r, \text{ and} \tag{8}$$

$$\mathrm{LL\_CCDY}_r + n \leq y_i \leq \mathrm{LL\_CCDY}_r + \mathrm{CCDROW}_r - n, \tag{9}$$

where $\mathrm{CCD\_ID}_r$, $\mathrm{LL\_CCDX}_r$, $\mathrm{LL\_CCDY}_r$, CCDCOL_r and CCDROW_r are the values of CCD_ID, LL_CCDX, LL_CCDY, CCDCOL and CCDROW, respectively, for row r of the window-block file and $n = 0$, 1 or 2 (see Tables 1 or 2). Event i is telemetered if all of the following conditions are true:

$$\mathrm{SAMP\_CYC}_r > 0, \tag{10}$$

$$\mathrm{EXPNO}_i \text{ is an integer multiple of } \mathrm{SAMP\_CYC}_r, \text{ and} \tag{11}$$

$$\mathrm{PHAMIN}_r \leq \mathrm{PHA}_i \leq \mathrm{PHAMIN}_r + \mathrm{PHARANGE}_r, \tag{12}$$

where $\mathrm{SAMP\_CYC}_r$, PHAMIN_r and $\mathrm{PHARANGE}_r$ are the values of SAMP_CYC, PHAMIN, and PHARANGE, respectively, for row r of the window-block file and EXPNO_i is the value of EXPNO for event i. If more than one row satisfies equations 7–9, then the values of SAMP_CYC, PHAMIN and PHARANGE from only the first of these rows are used. If no rows satisfy these conditions or there is no window-block file for the observation, then all the events that satisfy the standard pulse-height range are telemetered. PHAMIN and PHARANGE are computed as described above. If the observation is performed in continuous-clocking mode, then only conditions 7 and 8 are used.

The following examples illustrate some of the ways in which window-block files are used. The contents in the examples are the contents of the HDU named "WIN" of a window-block file (i.e. a *win0.fits file).

1. If an entire CCD is used and no pulse-height filtering is performed for the CCD, then the window-block file does not contain an entry for the CCD. If these conditions are satisfied for all of the CCDs used for an observation, then no window-block file is created for the observation.

2. If an entire CCD is "active," but disabled, the window-block file contains a single entry for the CCD which specifies that the CCD is disabled. For example, the window-block file for OBS_ID 62724 includes

CCD_ID	LL_CCDX	CCDCOL	SAMP_CYC	PHAMIN	PHARANGE
8	0	1023	0	0	24570
9	0	1023	0	0	24570

3. If only a portion of a CCD is used (as is the case, for example, for some of the observations of the Crab), then the window-block file contains two entries for the CCD. One entry specifies that the entire CCD is disabled. The second entry specifies the portion of the CCD that is used. For example, the window-block file for OBS_ID 770 includes

CCD_ID	LL_CCDX	LL_CCDY	CCDCOL	CCDROW	SAMP_CYC	PHAMIN	PHARANGE
7	185	10	139	139	1	23	2270
7	0	0	1023	1023	0	0	65535

4. If only a portion of a CCD is disabled (e.g. to block out the zeroth order events from a bright source observed with the gratings), then the window block file contains a single entry for the CCD. For example, the window block file for OBS_ID 1939 includes

CCD_ID	LL_CCDX	LL_CCDY	CCDCOL	CCDROW	SAMP_CYC	PHAMIN	PHARANGE
7	180	99	149	199	0	0	0

   This entry specifies the portion of the CCD that is not used. Although there is no other entry for CCD_ID = 7 in the file, the rest of the CCD is implicitly enabled (see item 1).

5. If an entire CCD is used, but a portion of it has a sample cycle of $n > 1$ instead of one (e.g. to reduce the number of zeroth-order events telemetered for a grating observation of a bright source), then the window-block file contains a single entry for the CCD. This case is similar to case 4. For example, the window-block file for OBS_ID 4568 includes

CCD_ID	LL_CCDX	CCDCOL	SAMP_CYC	PHAMIN	PHARANGE
7	161	99	20	25	3750

   This entry specifies the portion of the CCD that has a sample cycle of twenty. The rest of the CCD is implicitly enabled with a sample cycle of one.