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Chandra X-Ray Center

MEMORANDUM
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To:	Martin Elvis, SDS Group Leader
From:	Glenn E. Allen, SDS
Subject:	acis_build_mask
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1 acis_build_mask

1.1 Description

A Level 1 ACIS mask file (acis*msk1.fits) for an observation contains information about the valid ranges of CHIPX, CHIPY, and PHA for the observation. If a user specifies a spatial or spectral window to be used for their observation, this information is recorded in the mask file. Level 1 ACIS bad pixel files (acis*bpix1.fits) also contain information about which pixels or columns are valid. One difference between a mask and a bad pixel or column is that no events should be reported outside the valid region of a CCD as specified in the mask file. However, events may be reported for the pixels and columns described in a bad pixel file. The contents of a bad pixel file should include only regions of a CCD that are within the boundaries specified in the mask file. That is, the contents of a mask file and the associated bad pixel file should be mutually exclusive. (This condition is not true if SAMP_CYC = 0.) For example, the edges of a CCD should be excluded using a mask file (instead of a bad pixel file) because the onboard event detection algorithm does not report events whose coordinates are at CHIPX = 1 or 1024 or CHIPY = 1 or 1024. The node boundaries at CHIPX = 256, 257, 512, 513, 768, and 769 are included in a bad pixel file (instead of a mask file) because it is possible to have events along these columns. The columns are considered bad because most of the events in these columns are associated with cosmic rays.

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 that contains one extension for each active CCD. Each extension will have one or more rows with the following columns.

1. SHAPE
2. COMPONENT
3. CHIPX (a two element vector)
4. CHIPY (a two element vector)
5. SAMP_CYC
6. PHAMIN
7. PHAMAX

Since the columns WINDOW and OVERLAP, which are in older mask files, are not necessary, they are not included here.

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=most)”
10. mode,s,h,“ql”,,,

1.5 Processing

One FITS extension is produced for every “active” CCD and each extension has one or more rows. A CCD is defined to be active if the CCD is included in the “PBK” extension of the parameter block file. One row in each extension indicates that the entire CCD is disabled (see Table 2). Additional rows are included as necessary.

1. Verify that the specified extensions of the input files exist. If clobber = “no,” 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.
3. Add the keywords FIRSTROW and LASTROW to the header of the output file, where

   $$\mathrm{FIRSTROW} = \mathrm{STARTROW} + 1 \quad (1)$$
   $$\mathrm{LASTROW} = \mathrm{STARTROW} + \mathrm{ROWCNT} + 1 \quad (2)$$

   However, if FIRSTROW $<$ 1 or LASTROW $>$ 1024, then do not create the output file and exit with an error message that the keywords are invalid.

   Copy the value of the keyword WIND_ID to a keyword of the same name in the header of the output file.

4. Read the contents of the window block file.
5. Determine the contents of the columns SHAPE, COMPONENT, CHIPX, CHIPY, SAMP_CYC, PHAMIN, and PHAMAX in the output file as follows.
    a. The SHAPE is either a "rectangle" or "!rectangle," as appropriate.
    b. 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. If SAMP_CYC ≥ 1, the permitted values of CHIPX and CHIPY are specified to be CHIPX[0] $\leq$ CHIPX $\leq$ CHIPX[1] and CHIPY[0] $\leq$ CHIPY $\leq$ CHIPY[1]. In most cases, an entire CCD is active, SAMP_CYC = 1, and the CHIPX and CHIPY boundaries have the default values listed in Table 1.

Table 1. Default values for SAMP_CYC ≥ 1

READMODE	DATAMODE	CHIPX[0]	CHIPX[1]	CHIPY[0]	CHIPY[1]
TIMED	FAINT	2	1023	2	1023
TIMED	FAINT_BIAS	2	1023	2	1023
TIMED	GRADED	2	1023	2	1023
TIMED	VFAINT	2	1023	3	1022
CONTINUOUS	CC33_FAINT	2	1023	2	511
		2	1023	514	1023
CONTINUOUS	CC33_GRADED	2	1023	2	511
		2	1023	514	1023

There are cases where a CCD is active, but the entire CCD has a mask with a sample cycle of zero. In this case, the values of CHIPX[0], CHIPX[1], CHIPY[0], and CHIPY[1] have the default values specified in Table 2.

Table 2. Default values for SAMP_CYC = 0

READMODE	DATAMODE	CHIPX[0]	CHIPX[1]	CHIPY[0]	CHIPY[1]
TIMED	FAINT	1	1024	1	1024
TIMED	FAINT_BIAS	1	1024	1	1024
TIMED	GRADED	1	1024	1	1024
TIMED	VFAINT	1	1024	1	1024
CONTINUOUS	CC33_FAINT	1	1024	1	1024
CONTINUOUS	CC33_GRADED	1	1024	1	1024

More complex rectangular masks can be used, for example, to exclude the zeroth order events for observations that use the gratings or to include events from only a small region around a bright source such as the Crab. If SAMP_CYC ≥ 1, then CHIPX[0], CHIPX[1], CHIPY[0], and CHIPY[1] are computed using the expressions in Table 3.

Table 3. SAMP_CYC ≥ 1

READMODE	DATAMODE	CHIPX[0]	CHIPX[1]	CHIPY[0]	CHIPY[1]
TIMED	FAINT	LL_CCDX + 1	LL_CCDX + CCDCOL + 1	LL_CCDY + 2	LL_CCDY + CCDROW
TIMED	FAINT_BIAS	LL_CCDX + 1	LL_CCDX + CCDCOL + 1	LL_CCDY + 2	LL_CCDY + CCDROW
TIMED	GRADED	LL_CCDX + 1	LL_CCDX + CCDCOL + 1	LL_CCDY + 2	LL_CCDY + CCDROW
TIMED	VFAINT	LL_CCDX + 1	LL_CCDX + CCDCOL + 1	LL_CCDY + 3	LL_CCDY + CCDROW − 1
CONTINUOUS	CC33_FAINT	LL_CCDX + 1	LL_CCDX + CCDCOL + 1	2	511
		LL_CCDX + 1	LL_CCDX + CCDCOL + 1	514	1023
CONTINUOUS	CC33_GRADED	LL_CCDX + 1	LL_CCDX + CCDCOL + 1	2	511
		LL_CCDX + 1	LL_CCDX + CCDCOL + 1	514	1023

For example, consider obsid 770, an observation of the Crab nebula. The only active CCD is ACIS-S3 and events are excluded from all but a rectangular region defined in the Level 0 window file by LL_CCDX = 185, LL_CCDY = 10, CCDCOL = 139, and CCDROW = 139. The appropriate CHIPX and CHIPY boundaries reported in the corresponding mask file for the observation are CHIPX[0] = 186, CHIPX[1] = 325, CHIPY[0] = 12, and CHIPY[1] = 149. Events can only be reported for CHIPX values as low as 186 and as high 325 and for CHIPY values as low as 12 and as high as 149.

If SAMP_CYC ≥ 1 and CHIPX[0] = 1, CHIPX[1] = 1024, CHIPY[0] = 1 or CHIPY[1] = 1024, then change the value to be consistent with Table 1. If 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.

If SAMP_CYC = 0, then no events can be reported for the region specified by CHIPX[0] $\leq$ CHIPX $\leq$ CHIPX[1] and CHIPY[0] $\leq$ CHIPY $\leq$ CHIPY[1] (and the edges of a CCD), where these coordinates are computed using the expressions in Table 4.

Table 4. SAMP_CYC = 0

READMODE	DATAMODE	CHIPX[0]	CHIPX[1]	CHIPY[0]	CHIPY[1]
TIMED	FAINT	LL_CCDX + 1	LL_CCDX + CCDCOL + 1	LL_CCDY + 1	LL_CCDY + CCDROW + 1
TIMED	FAINT_BIAS	LL_CCDX + 1	LL_CCDX + CCDCOL + 1	LL_CCDY + 1	LL_CCDY + CCDROW + 1
TIMED	GRADED	LL_CCDX + 1	LL_CCDX + CCDCOL + 1	LL_CCDY + 1	LL_CCDY + CCDROW + 1
TIMED	VFAINT	LL_CCDX + 1	LL_CCDX + CCDCOL + 1	LL_CCDY + 1	LL_CCDY + CCDROW + 1
CONTINUOUS	CC33_FAINT	LL_CCDX + 1	LL_CCDX + CCDCOL + 1	2	511
		LL_CCDX + 1	LL_CCDX + CCDCOL + 1	514	1023
CONTINUOUS	CC33_GRADED	LL_CCDX + 1	LL_CCDX + CCDCOL + 1	2	511
		LL_CCDX + 1	LL_CCDX + CCDCOL + 1	514	1023

For example, obsid 1939 is a grating observation of 4U 1636−53. All six of the ACIS-S CCDs are active, but the events in a rectangular region around the zeroth order source position are excluded. This region is defined in the Level 0 window file by LL_CCDX = 180, LL_CCDY = 99, CCDCOL = 149, and CCDROW = 199. The appropriate CHIPX and CHIPY boundaries reported in the corresponding mask file for the observation are CHIPX[0] = 181, CHIPX[1] = 330, CHIPY[0] = 100, and CHIPY[1] = 299. Events that land in this region will be excluded from the telemetry for CHIPX values as low as 181 and as high 330 and for CHIPY values as low as 100 and as high as 299.

If 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.

If LL_CCDY < STARTROW or LL_CCDY + CCDROW > STARTROW + ROWCNT, then do not create the output file and exit with an error message.

d. The value of SAMP_CYC for each component is copied from the Level 0 window file.

e. The value of PHAMIN for a window (for all observing modes) is given by the larger of

$$\mathrm{PHAMIN_{pbk}} + 1, \tag{3}$$

$$\min\left(\mathrm{EVT\_THR[0]}, \mathrm{EVT\_THR[1]}, \mathrm{EVT\_THR[2]}, \mathrm{EVT\_THR[3]}\right) + 1, \text{ and} \tag{4}$$

$$\mathrm{PHAMIN_{win}} + 0, \tag{5}$$

where $\mathrm{PHAMIN_{pbk}}$ 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 $\mathrm{PHAMIN_{win}}$ is the value of PHAMIN for the window in the first extension of the window block file.

f. The value of PHAMAX for a window (for all observing modes) is given by the smaller of

$$\mathrm{PHAMIN_{pbk}} + \mathrm{PHARANGE_{pbk}} - 1, \tag{6}$$

$$\mathrm{PHAMIN_{win}} + \mathrm{PHARANGE_{win}} - 1, \text{ and} \tag{7}$$

$$32767, \tag{8}$$

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.

For example, if $\mathrm{PHAMIN_{pbk}} = 20$ and $\mathrm{PHARANGE_{pbk}} = 3750$, then $\mathrm{PHAMAX_{pbk}} = 3769$.

If $\mathrm{PHAMIN}_{\mathrm{win}} = 0$ and $\mathrm{PHARANGE}_{\mathrm{win}} = 0$, then ignore these values and use only the value from the parameter block file and the value 32767. If PHAMAX $\leq$ PHAMIN, then do not create the output file and exit with an error message.

6. Write the output header and data to the specified output file.