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

MEMORANDUM
August 24, 2015

To:	Jonathan McDowell, SDS Group Leader
From:	Glenn E. Allen, SDS
Subject:	`acis_process_events` spec
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1 acis_process_events

This spec, which is incomplete, describes some of processing steps for continuous-clocking mode data.

1.1 Description

1.2 Input

1.3 Output

1.4 Parameters

1.5 Processing

1.5.1 Error checking

The following steps are performed once prior to the processing of the data for each input ACIS event.

1. `obsfile`:
   (a) Validation:
      i. Existence:
      If

$$\texttt{obsfile} \neq \text{none and} \tag{1}$$
$$\texttt{obsfile} \neq \text{NONE} \tag{2}$$

      and the `obsfile` does not exist, then `obsfile` is changed to "none" and `acis_process_events` produces a warning message.

ii. Permission:
If

$$\texttt{obsfile} \neq \text{none and} \tag{3}$$
$$\texttt{obsfile} \neq \text{NONE} \tag{4}$$

and the file permissions do not allow the `obsfile` to be read, then `obsfile` is changed to "none" and `acis_process_events` produces a warning message.

iii. `OBS_MODE`:
If

$$\texttt{obsfile} \neq \text{none and} \tag{5}$$
$$\texttt{obsfile} \neq \text{NONE,} \tag{6}$$

then

A. If the `obsfile` does not include the keyword `obs_mode`, then `OBS_MODE` is set to "none".

B. If the `obsfile` includes the keyword `obs_mode` and

$$\texttt{obs\_mode} = \text{pointing or} \tag{7}$$
$$\texttt{obs\_mode} = \text{POINTING or} \tag{8}$$
$$\texttt{obs\_mode} = \text{secondary or} \tag{9}$$
$$\texttt{obs\_mode} = \text{SECONDARY,} \tag{10}$$

then `OBS_MODE` is set to the value of `obs_mode`. Hereafter this keyword is referred to as `OBS_MODE`.

C. If the `obsfile` includes the keyword `obs_mode` and

$$\texttt{obs\_mode} \neq \text{pointing and} \tag{11}$$
$$\texttt{obs\_mode} \neq \text{POINTING and} \tag{12}$$
$$\texttt{obs\_mode} \neq \text{secondary and} \tag{13}$$
$$\texttt{obs\_mode} \neq \text{SECONDARY,} \tag{14}$$

then `OBS_MODE` is set to "none".

2. `acaofffile`:

(a) Validation:
If

$$\texttt{OBS\_MODE} = \text{pointing or} \tag{15}$$
$$\texttt{OBS\_MODE} = \text{POINTING,} \tag{16}$$

then

i. Setting:
If

$$\texttt{acaofffile} = \text{none or} \tag{17}$$
$$\texttt{acaofffile} = \text{NONE,} \tag{18}$$

then `acis_process_events` produces a warning message.

ii. Existence:
If

$$\texttt{acaofffile} \neq \text{none and} \tag{19}$$
$$\texttt{acaofffile} \neq \text{NONE} \tag{20}$$

and the `acaofffile` does not exist, then `acis_process_events` produces a warning and `acaofffile` is set to "none."

iii. Permission:
If the `acaofffile` exists and the file permissions do not allow it to be read, then `acis_process_events` produces a warning message and `acaofffile` is set to "none."

iv. `CONTENT`:
If the `acaofffile` does not have an HDU h_{acaoff} with the keyword

$$\texttt{CONTENT} = \text{ASPSOL}, \tag{21}$$

then `acis_process_events` produces a warning message and `acaofffile` is set to "none."

v. Keyword:
If HDU h_{acaoff} of the `acaofffile` does not include the keyword `TSTART`, then `acis_process_events` produces a warning message and `acaofffile` is set to "none."

vi. Columns:
If HDU h_{acaoff} of the `acaofffile` does not include the columns `TIME`, `RA`, `DEC`, and `ROLL` then `acis_process_events` produces a warning message and `acaofffile` is set to "none." Hereafter, these columns are referred to as $\texttt{TIME}_{\mathrm{acaoff}}$, $\texttt{RA}_{\mathrm{acaoff}}$, $\texttt{DEC}_{\mathrm{acaoff}}$, and $\texttt{ROLL}_{\mathrm{acaoff}}$.

vii. Sequential:
If more than one valid `acaofffile` is specified and the the values `TSTART` are not in increasing order, then `acis_process_events` produces a warning message and `acaofffile` is set to "none."

3. `alignmentfile`:

(a) Validation:
If

$$\texttt{OBS\_MODE} = \text{pointing or} \tag{22}$$
$$\texttt{OBS\_MODE} = \text{POINTING}, \tag{23}$$

then

i. Setting:
If

$$\texttt{alignmentfile} = \text{none or} \tag{24}$$
$$\texttt{alignmentfile} = \text{NONE}, \tag{25}$$

then `acis_process_events` produces a warning message.

ii. Existence:
If

$$\texttt{alignmentfile} \neq \text{none and} \tag{26}$$
$$\texttt{alignmentfile} \neq \text{NONE} \tag{27}$$

and the `alignmentfile` does not exist, then `acis_process_events` produces a warning message and `alignmentfile` is set to "none.".

iii. Permission:
If the `alignmentfile` exists and the file permissions do not allow it to be read, then `acis_process_events` produces a warning message and `alignmentfile` is set to "none.".

iv. `CONTENT`:
If the `alignmentfile` does not have an HDU $h_{\text{alignment}}$ with the keyword

$$\texttt{CONTENT} = \text{ASPSOL}, \tag{28}$$

then `acis_process_events` produces a warning message and `alignmentfile` is set to "none.".

v. Keyword:
If HDU $h_{\text{alignment}}$ of the `alignmentfile` does not include the keyword `TSTART`, then `acis_process_events` produces a warning message and `alignmentfile` is set to "none.".

vi. Columns:
If HDU $h_{\text{alignment}}$ of the `alignmentfile` does not include the columns `DY`, `DZ`, and `DTHETA` then `acis_process_events` produces a warning message and `alignmentfile` is set to "none.".

vii. Sequential:
If more than one valid `alignmentfile` is specified and the values `TSTART` are not in increasing order, then `acis_process_events` produces a warning message and `alignmentfile` is set to "none.".

4. `infile`:

(a) Existence:
If the `infile` does not exist, then `acis_process_events` exits with an error message.

(b) Permission:
If the `infile` exists and the file permissions do not allow it to be read, then `acis_process_events` exits with an error message.

(c) Validation:

i. `OBS_MODE`:
If `OBS_MODE` = none, then

A. The `OBS_MODE` is read from the HDU h_{in} keyword of the same name. Hereafter this keyword is referred to as `OBS_MODE`.

B. If the HDU h_{in} does not include the keyword `OBS_MODE`, then `OBS_MODE` is set to "none" and `acis_process_events` produces a warning message.

C. If the HDU h_{in} includes the keyword `OBS_MODE` and

$$\texttt{obs\_mode} \neq \text{pointing and} \tag{29}$$
$$\texttt{obs\_mode} \neq \text{POINTING and} \tag{30}$$
$$\texttt{obs\_mode} \neq \text{secondary and} \tag{31}$$
$$\texttt{obs\_mode} \neq \text{SECONDARY}, \tag{32}$$

then `OBS_MODE` is set to "none" and `acis_process_events` produces a warning message.

ii. `DATAMODE`:
The `DATAMODE` is read from the HDU h_{in} keyword of the same name. If the HDU h_{in} does not include the keyword `DATAMODE` or if

$$\texttt{DATAMODE} \neq \text{CC33\_FAINT and} \tag{33}$$
$$\texttt{DATAMODE} \neq \text{CC33\_GRADED and} \tag{34}$$
$$\texttt{DATAMODE} \neq \text{FAINT and} \tag{35}$$
$$\texttt{DATAMODE} \neq \text{FAINT\_BIAS and} \tag{36}$$
$$\texttt{DATAMODE} \neq \text{GRADED and} \tag{37}$$
$$\texttt{DATAMODE} \neq \text{VFAINT}, \tag{38}$$

then `acis_process_events` exits with an error message. Hereafter, the value of this keyword is referred to as $\texttt{DATAMODE}_{\rm in}$.

iii. `CONTENT`:
If the `infile` does not have an HDU $h_{\rm in}$ with the keyword

$$\begin{aligned}\texttt{CONTENT} &= \text{EVT0 or} &(39)\\ \texttt{CONTENT} &= \text{EVT1 or} &(40)\\ \texttt{CONTENT} &= \text{TGEVT1 or} &(41)\\ \texttt{CONTENT} &= \text{EVT2,} &(42)\end{aligned}$$

then `acis_process_events` exits with an error message. Hereafter, the value of this keyword is referred to as $\texttt{CONTENT}_{\rm in}$.

iv. `TIME`:
If HDU $h_{\rm in}$ of the `infile` does not include the column `TIME`, then `acis_process_events` exits with an error message. Hereafter, this column is referred to as $\texttt{TIME}_{\rm in}$.

v. `TIME_RO`:
If

$$\begin{aligned}\texttt{DATAMODE}_{\rm in} &= \text{CC33\_FAINT or} &(43)\\ \texttt{DATAMODE}_{\rm in} &= \text{CC33\_GRADED} &(44)\end{aligned}$$

and

$$\begin{aligned}\texttt{CONTENT}_{\rm in} &= \text{EVT1 or} &(45)\\ \texttt{CONTENT}_{\rm in} &= \text{TGEVT1 or} &(46)\\ \texttt{CONTENT}_{\rm in} &= \text{EVT2} &(47)\end{aligned}$$

and HDU $h_{\rm in}$ of the `infile` does not include the column `TIME_RO`, then `acis_process_events` exits with an error message. Hereafter, this column is referred to as $\texttt{TIME\_RO}_{\rm in}$.

vi. `EXPNO`:
If HDU $h_{\rm in}$ the `infile` does not include the column `EXPNO`, then `acis_process_events` exits with an error message. Hereafter, this column is referred to as $\texttt{EXPNO}_{\rm in}$.

vii. `CCD_ID`:

A. If

$$\texttt{CONTENT}_{\rm in} = \text{EVT0} \qquad (48)$$

and HDU $h_{\rm in}$ of the `infile` does not include the keyword `CCD_ID`, then `acis_process_-events` exits with an error message. Hereafter, this keyword is referred to as $\texttt{CCD\_ID}_{\rm in}$.

B. If

$$\begin{aligned}\texttt{CONTENT}_{\rm in} &= \text{EVT1 or} &(49)\\ \texttt{CONTENT}_{\rm in} &= \text{TGEVT1 or} &(50)\\ \texttt{CONTENT}_{\rm in} &= \text{EVT2} &(51)\end{aligned}$$

and HDU $h_{\rm in}$ of the `infile` does not include the column `CCD_ID`, then `acis_process_-events` exits with an error message. Hereafter, this column is referred to as $\texttt{CCD\_ID}_{\rm in}$.

viii. `CCDX`:

A. If

$$\texttt{CONTENT}_{\rm in} = \text{EVT0} \qquad (52)$$

and HDU $h_{\rm in}$ of the `infile` does not include the column `CCDX` and does not include the column `CHIPX`, then `acis_process_events` exits with an error message. Hereafter, these columns are referred to as $\texttt{CCDX}_{\rm in}$ and $\texttt{CHIPX}_{\rm in}$, respectively.

ix. CHIPX:

A. If

$$\texttt{CONTENT}_{\rm in} = \text{EVT1 or} \quad (53)$$
$$\texttt{CONTENT}_{\rm in} = \text{TGEVT1 or} \quad (54)$$
$$\texttt{CONTENT}_{\rm in} = \text{EVT2} \quad (55)$$

and HDU $h_{\rm in}$ of the infile does not include the column CHIPX, then acis_process_events exits with an error message. Hereafter, this column is referred to as $\texttt{CHIPX}_{\rm in}$.

x. CCDY:

A. If

$$\texttt{CONTENT}_{\rm in} = \text{EVT0} \quad (56)$$

and

$$\texttt{DATAMODE}_{\rm in} = \text{FAINT or} \quad (57)$$
$$\texttt{DATAMODE}_{\rm in} = \text{FAINT\_BIAS or} \quad (58)$$
$$\texttt{DATAMODE}_{\rm in} = \text{GRADED or} \quad (59)$$
$$\texttt{DATAMODE}_{\rm in} = \text{VFAINT} \quad (60)$$

and HDU $h_{\rm in}$ of the infile does not include the column CCDY and does not include the column CHIPY, then acis_process_events exits with an error message. Hereafter, these columns are referred to as $\texttt{CCDY}_{\rm in}$ and $\texttt{CHIPY}_{\rm in}$, respectively.

xi. TROW:

A. If

$$\texttt{CONTENT}_{\rm in} = \text{EVT0} \quad (61)$$

and

$$\texttt{DATAMODE}_{\rm in} = \text{CC33\_FAINT or} \quad (62)$$
$$\texttt{DATAMODE}_{\rm in} = \text{CC33\_GRADED} \quad (63)$$

and HDU $h_{\rm in}$ of the infile does not include the column TROW and does not include the column CHIPY, then acis_process_events exits with an error message. Hereafter, these columns are referred to as $\texttt{TROW}_{\rm in}$ and $\texttt{CHIPY}_{\rm in}$, respectively.

xii. CHIPY:

A. If

$$\texttt{CONTENT}_{\rm in} = \text{EVT1 or} \quad (64)$$
$$\texttt{CONTENT}_{\rm in} = \text{TGEVT1 or} \quad (65)$$
$$\texttt{CONTENT}_{\rm in} = \text{EVT2} \quad (66)$$

and HDU $h_{\rm in}$ of the infile does not include the column CHIPY, then acis_process_events exits with an error message. Hereafter, this column is referred to as $\texttt{CHIPY}_{\rm in}$.

xiii. TIMEDEL:

If

$$\texttt{DATAMODE}_{\rm in} = \text{CC33\_FAINT or} \quad (67)$$
$$\texttt{DATAMODE}_{\rm in} = \text{CC33\_GRADED} \quad (68)$$

and HDU $h_{\rm in}$ of the infile does not include the keyword TIMEDEL, then acis_process_events exits with an error message. Hereafter this keyword is referred to as $\texttt{TIMEDEL}_{\rm in}$.

xiv. RA_TARG, DEC_TARG, RA_NOM, DEC_NOM, RA_PNT, DEC_PNT, CHIPY_TG, CHIPY_ZO, and TG_M:
If

$$\text{OBS\_MODE} = \text{pointing or} \quad (69)$$
$$\text{OBS\_MODE} = \text{POINTING} \quad (70)$$

and

$$\text{DATAMODE}_{\text{in}} = \text{CC33\_FAINT or} \quad (71)$$
$$\text{DATAMODE}_{\text{in}} = \text{CC33\_GRADED,} \quad (72)$$

then

A. RA_TARG, DEC_TARG, RA_NOM, DEC_NOM, RA_PNT, DEC_PNT:
If HDU h_{in} of the infile does not include the keywords RA_TARG, DEC_TARG, RA_NOM, DEC_NOM, RA_PNT, and DEC_PNT, then acis_process_events exits with an error message. Hereafter these keywords are referred to as $\text{RA\_TARG}_{\text{in}}$, $\text{DEC\_TARG}_{\text{in}}$, $\text{RA\_NOM}_{\text{in}}$, $\text{DEC\_NOM}_{\text{in}}$, $\text{RA\_PNT}_{\text{in}}$, and $\text{DEC\_PNT}_{\text{in}}$, respectively.

B. CHIPY_TG, CHIPY_ZO, and TG_M:
If

$$\text{CONTENT}_{\text{in}} = \text{TGEVT1} \quad (73)$$

and HDU h_{in} of the infile does not include the columns CHIPY_TG, CHIPY_ZO, and TG_M, then acis_process_events exits with an error message. Hereafter these columns are referred to as $\text{CHIPY\_TG}_{\text{in}}$, $\text{CHIPY\_ZO}_{\text{in}}$, and TG_M_{in}, respectively.

xv. TGAINCOR:
If HDU h_{in} of the infile does not include the keyword TGAINCOR, then this keyword is set to zero. Hereafter, this keyword is referred to as $\text{TGAINCOR}_{\text{in}}$.

5. stop:

(a) Lowercase:
The parameter string is converted to contain only lower case letters.

(b) Validation:

i. Setting:
If

$$\text{stop} \neq \text{none and} \quad (74)$$
$$\text{stop} \neq \text{chip and} \quad (75)$$
$$\text{stop} \neq \text{tdet and} \quad (76)$$
$$\text{stop} \neq \text{det and} \quad (77)$$
$$\text{stop} \neq \text{tan and} \quad (78)$$
$$\text{stop} \neq \text{sky,} \quad (79)$$

then stop is changed to "none" and acis_process_events produces a warning message.

ii. OBS_MODE:
If

$$\text{OBS\_MODE} \neq \text{pointing and} \quad (80)$$
$$\text{OBS\_MODE} \neq \text{POINTING} \quad (81)$$

and

$$\begin{aligned} \texttt{stop} &\neq \text{none and} \quad (82)\\ \texttt{stop} &\neq \text{chip and} \quad (83)\\ \texttt{stop} &\neq \text{tdet,} \quad (84)\end{aligned}$$

then `stop` is changed to "none" and `acis_process_events` produces a warning message.

iii. `acaofffile`:
If

$$\begin{aligned} \texttt{OBS\_MODE} &= \text{pointing or} \quad (85)\\ \texttt{OBS\_MODE} &= \text{POINTING} \quad (86)\end{aligned}$$

and

$$\begin{aligned} \texttt{acaofffile} &= \text{none and} \quad (87)\\ \texttt{stop} &\neq \text{none and} \quad (88)\\ \texttt{stop} &\neq \text{chip and} \quad (89)\\ \texttt{stop} &\neq \text{tdet,} \quad (90)\end{aligned}$$

then `acis_process_events` produces a warning message and `stop` is changed to "none."

iv. `alignmentfile`:
If

$$\begin{aligned} \texttt{OBS\_MODE} &= \text{pointing or} \quad (91)\\ \texttt{OBS\_MODE} &= \text{POINTING} \quad (92)\end{aligned}$$

and

$$\begin{aligned} \texttt{alignmentfile} &= \text{none and} \quad (93)\\ \texttt{stop} &\neq \text{none and} \quad (94)\\ \texttt{stop} &\neq \text{chip and} \quad (95)\\ \texttt{stop} &\neq \text{tdet,} \quad (96)\end{aligned}$$

then `acis_process_events` produces a warning message and `stop` is changed to "none."

6. `doevtgrade`:

(a) Lowercase:
The parameter string is converted to contain only lower case letters.

(b) Validation:
If

$$\begin{aligned} \texttt{doevtgrade} &\neq \text{yes and} \quad (97)\\ \texttt{doevtgrade} &\neq \text{no,} \quad (98)\end{aligned}$$

then `acis_process_events` exits with an error message.

7. `apply_cti`:

(a) Lowercase:
The parameter string is converted to contain only lower case letters.

(b) Validation:

i. Setting:
If

$$\texttt{apply\_cti} \neq \text{yes and} \tag{99}$$
$$\texttt{apply\_cti} \neq \text{no,} \tag{100}$$

then `acis_process_events` exits with an error message.

ii. `PHAS`:
If

$$\texttt{apply\_cti} = \text{yes} \tag{101}$$

and the `infile` does not include the column `PHAS`, then `apply_cti` is changed to "no" and `acis_process_events` produces a warning message.

iii. `doevtgrade`:
If

$$\texttt{apply\_cti} = \text{yes and} \tag{102}$$
$$\texttt{doevtgrade} = \text{no,} \tag{103}$$

then `apply_cti` is changed to "no" and `acis_process_events` produces a warning message.

8. `badpixfile`:

(a) Validation:

i. Existence:
If

$$\texttt{badpixfile} \neq \text{none and} \tag{104}$$
$$\texttt{badpixfile} \neq \text{NONE} \tag{105}$$

and the `badpixfile` does not exist, then `badpixfile` is changed to "none" and `acis_process_events` produces a warning message.

ii. Permission:
If

$$\texttt{badpixfile} \neq \text{none and} \tag{106}$$
$$\texttt{badpixfile} \neq \text{NONE} \tag{107}$$

and the file permissions do not allow it to be read, then `badpixfile` is changed to "none" and `acis_process_events` produces a warning message.

iii. `CONTENT`:
If

$$\texttt{badpixfile} \neq \text{none and} \tag{108}$$
$$\texttt{badpixfile} \neq \text{NONE} \tag{109}$$

and the `badpixfile` does not have one or more HDUs h_{badpix} with the keyword

$$\texttt{CONTENT} = \text{BADPIX or} \tag{110}$$
$$\texttt{CONTENT} = \text{CDB\_ACIS\_BADPIX,} \tag{111}$$

then `badpixfile` is changed to "none" and `acis_process_events` produces a warning message.

iv. Keyword:
If

$$\texttt{badpixfile} \neq \text{none and} \tag{112}$$
$$\texttt{badpixfile} \neq \text{NONE} \tag{113}$$

and the HDU(s) $h_{\rm badpix}$ of the `badpixfile` do not include the keyword `CCD_ID`, then `badpixfile` is changed to "none" and `acis_process_events` produces a warning message. Hereafter this keyword is referred to as $\texttt{CCD\_ID}_{\rm badpix}$.

v. Columns:
If

$$\texttt{badpixfile} \neq \text{none and} \tag{114}$$
$$\texttt{badpixfile} \neq \text{NONE} \tag{115}$$

and the HDU(s) $h_{\rm badpix}$ of the `badpixfile` do not include the columns `CHIPX`, `CHIPY`, `TIME`, `TIME_STOP`, and `STATUS`, then `badpixfile` is changed to "none" and `acis_process_events` produces a warning message. Hereafter these columns are referred to as $\texttt{CHIPX}_{\rm badpix}$, $\texttt{CHIPY}_{\rm badpix}$, $\texttt{TIME}_{\rm badpix}$, $\texttt{TIME\_STOP}_{\rm badpix}$, and $\texttt{STATUS}_{\rm badpix}$, respectively.

9. `ctifile`:

(a) Validation:
If

$$\texttt{ctifile} \neq \text{caldb and} \tag{116}$$
$$\texttt{ctifile} \neq \text{CALDB,} \tag{117}$$

then

i. Existence:
If the `ctifile` does not exist, then `apply_cti` is changed to "no" and `acis_process_events` produces a warning message.

ii. Permission:
If the `ctifile` exists and the file permissions do not allow it to be read, then `apply_cti` is changed to "no" and `acis_process_events` produces a warning message.

iii. `CONTENT`:
If the `ctifile` does not have one or more HDUs $h_{\rm cti}$ with the keyword

$$\texttt{CONTENT} = \text{CDB\_ACIS\_CTI,} \tag{118}$$

then `apply_cti` is changed to "no" and `acis_process_events` produces a warning message.

iv. Columns:
If the first such HDU of the `ctifile` does not include the columns `CCD_ID`, `CHIPX_LO`, `CHIPX_HI`, `CHIPY_LO`, `CHIPY_HI`, `PHA`, `VOLUME_X`, `VOLUME_Y`, `FRCTRLX`, `FRCTRLY`, `TCTIX`, and `TCTIY`, then `apply_cti` is changed to "no" and `acis_process_events` produces a warning message.

10. `clobber`:

(a) Lowercase:
The parameter string is converted to contain only lower case letters.

(b) Validation:

i. Setting:
If

$$\texttt{clobber} \neq \text{yes and} \tag{119}$$
$$\texttt{clobber} \neq \text{no,} \tag{120}$$

then clobber is changed to "no" and acis_process_events produces a warning message.

ii. Permission:
If

$$\texttt{clobber} = \text{yes} \tag{121}$$

and the outfile exists and the file permissions of the outfile do not allow it to be overwritten, then acis_process_events exits with an error message.

iii. Don't overwrite:
If

$$\texttt{clobber} = \text{no} \tag{122}$$

and the outfile exists, then acis_process_events exits with an error message.

11. pix_adj:

(a) Lowercase:
The parameter string is converted to contain only lower case letters.

(b) Validation:

i. Setting:
If

$$\texttt{pix\_adj} \neq \text{centroid and} \tag{123}$$
$$\texttt{pix\_adj} \neq \text{edser and} \tag{124}$$
$$\texttt{pix\_adj} \neq \text{none and} \tag{125}$$
$$\texttt{pix\_adj} \neq \text{randomize,} \tag{126}$$

then pix_adj is changed to "none" and acis_process_events produces a warning message.

ii. OBS_MODE:
If

$$\texttt{OBS\_MODE} \neq \text{pointing and} \tag{127}$$
$$\texttt{OBS\_MODE} \neq \text{POINTING} \tag{128}$$

and

$$\texttt{pix\_adj} \neq \text{none,} \tag{129}$$

then pix_adj is changed to "none" and acis_process_events produces a warning message.

iii. stop:
If

$$\texttt{pix\_adj} = \text{centroid or} \tag{130}$$
$$\texttt{pix\_adj} = \text{edser or} \tag{131}$$
$$\texttt{pix\_adj} = \text{randomize} \tag{132}$$

and

$$\texttt{stop} \neq \text{sky,} \tag{133}$$

then pix_adj is changed to "none" and acis_process_events produces a warning message.

iv. PHAS:
If

$$\texttt{pix\_adj} = \text{centroid} \tag{134}$$

and the infile does not include the column PHAS, then pix_adj is changed to "none" and acis_process_events produces a warning message.

v. FLTGRADE:
If

$$\texttt{pix\_adj} = \text{edser} \tag{135}$$

and the infile does not include the column FLTGRADE, then pix_adj is changed to "none" and acis_process_events produces a warning message.

12. subpixfile:

(a) If

$$\texttt{pix\_adj} = \text{edser}, \tag{136}$$

then

i. Existence:
If the subpixfile does not exist, then pix_adj is changed to "none" and acis_process_events produces a warning message.

ii. Permission:
If the subpixfile exists and the file permissions do not allow it to be read, then pix_adj is changed to "none" and acis_process_events produces a warning message.

iii. Validation:

A. CONTENT:
If the subpixfile does not have one or more HDUs $h_{\rm subpix}$ with the keyword

$$\texttt{CONTENT} = \text{AXAF\_SUBPIX}, \tag{137}$$

then pix_adj is changed to "none" and acis_process_events produces a warning message.

B. Keyword:
If the HDUs $h_{\rm subpix}$ of the subpixfile do not include the keyword CCD_ID, then pix_adj is changed to "none" and acis_process_events produces a warning message.

C. Columns:
If the HDUs $h_{\rm subpix}$ of the subpixfile do not include binary tables with the columns FLTGRADE, NPOINTS, ENERGY, CHIPX_OFFSET, and CHIPY_OFFSET, then pix_adj is changed to "none" and acis_process_events produces a warning message. Hereafter these columns are referred to as $\texttt{FLTGRADE}_{\rm subpix}$, $\texttt{NPOINTS}_{\rm subpix}$, $\texttt{ENERGY}_{\rm subpix}$, $\texttt{CHIPX\_OFFSET}_{\rm subpix}$, and $\texttt{CHIPY\_OFFSET}_{\rm subpix}$, respectively.

1.5.2 Initializations

1. Focal-point CCD:
If

$$\texttt{OBS\_MODE} = \text{pointing or} \tag{138}$$

$$\texttt{OBS\_MODE} = \text{POINTING} \tag{139}$$

and

$$\texttt{DATAMODE}_{\rm in} = \text{CC33\_FAINT or} \tag{140}$$
$$\texttt{DATAMODE}_{\rm in} = \text{CC33\_GRADED,} \tag{141}$$

then the values of $\texttt{RA\_PNT}_{\rm in}$ and $\texttt{DEC\_PNT}_{\rm in}$ are used to determine the `CCD_ID` associated with the focal point. Hereafter this value is referred to as $\texttt{CCD\_ID}_{\rm focus}$.*

2. `acaofffile`:
   If

$$\texttt{OBS\_MODE} = \text{pointing or} \tag{142}$$
$$\texttt{OBS\_MODE} = \text{POINTING} \tag{143}$$

and

$$\texttt{acaofffile} \neq \text{none and} \tag{144}$$
$$\texttt{alignmentfile} \neq \text{none,} \tag{145}$$

then

   (a) $\texttt{TIME}_{\rm min}$ and $\texttt{TIME}_{\rm max}$:
   The `acaofffile` data are processed to determine the earliest and latest times for which there is aspect information:

$$\texttt{TIME}_{\rm min} = \min\left(\texttt{TIME}_{\rm acaoff}\right) \text{ and} \tag{146}$$
$$\texttt{TIME}_{\rm max} = \max\left(\texttt{TIME}_{\rm acaoff}\right). \tag{147}$$

   (b) $\texttt{CHIPX\_TARG}_{\rm acaoff,med}$, $\texttt{CHIPY\_TARG}_{\rm acaoff,med}$:
   The values of $\texttt{CHIPX\_TARG}_{\rm acaoff}$ and $\texttt{CHIPY\_TARG}_{\rm acaoff}$ are computed from the values of `RA_TARG` and `DEC_TARG` using the orientation of the telescope (i.e. `RA`, `DEC`, and `ROLL`) and the orientation of the SIM (i.e. `DY`, `DZ`, and `DTHETA`) and the `TIME`s in the `acaofffile`. The values of $\texttt{CHIPX\_TARG}_{\rm acaoff}$ and $\texttt{CHIPY\_TARG}_{\rm acaoff}$ are processed to obtain the median values:

$$\texttt{CHIPX\_TARG}_{\rm acaoff,med} = \text{median}(\texttt{CHIPX\_TARG}_{\rm acaoff}) \text{ and} \tag{148}$$
$$\texttt{CHIPY\_TARG}_{\rm acaoff,med} = \text{median}(\texttt{CHIPY\_TARG}_{\rm acaoff}). \tag{149}$$

1.5.3 Loop over events

The following steps are performed, in sequence, for each event.

1. `STATUS`:

   (a) Exists:
   If HDU $h_{\rm in}$ of the `infile` includes a 32-bit column named `STATUS`, then

      i. The values of the bits for an event are read from the `infile`.
      ii. The value of `STATUS`$[k]$ is set to zero for bits k = 1–5, 14, 16–19, and 23 (of 0–31), bits that can be set by `acis_process_events`.

*The focal point is the location associated with the optical axis in the absence of dither. This location should not be confused with the aim point, which is the location illuminated by an undithered point source provided that the source is not offset from the target location.

iii. If

$$\texttt{doevtgrade} = \text{yes}, \tag{150}$$

then the value of STATUS[20], the other bit that can be set by acis_process_events, is set to zero.

(b) Does not exist:
If HDU h_{in} does not include a 32-bit column named STATUS, then

i. A set of 32 bits are allocated for the event.
ii. The values of the 32 bits are initialized to zero.

2. EXPNO:

(a) Read:
The value of EXPNO for an event is given by $\texttt{EXPNO}_{\text{in}}$.

(b) Validation:
If

$$\texttt{EXPNO} < 0 \text{ or} \tag{151}$$
$$\texttt{EXPNO} \geq 10^8, \tag{152}$$

then acis_process_events produces a warning upon completion with a count of the total number of events for which one or the other of these conditions is true. These values should not occur.

3. CCD_ID:

(a) Read:
The value of CCD_ID for an event is given by $\texttt{CCD\_ID}_{\text{in}}$.

(b) Validation:
If

$$\texttt{CCD\_ID} < 0 \text{ or} \tag{153}$$
$$\texttt{CCD\_ID} > 9, \tag{154}$$

then acis_process_events exits with an error message because CCD_ID-dependent computations could fail if the value of CCD_ID is unphysical.

4. CHIPX:

(a) Read:

i. If the infile includes the column CHIPX, then the value of CHIPX for an event is given by

$$\texttt{CHIPX} = \texttt{CHIPX}_{\text{in}}. \tag{155}$$

ii. If the infile does not include the column CHIPX, then the value of CHIPX for an event is given by

$$\texttt{CHIPX} = \texttt{CCDX}_{\text{in}} + 1. \tag{156}$$

(b) Validation:

i. Unphysical:
If

$$\begin{aligned} \texttt{CHIPX} &< 1 \text{ or} & (157)\\ \texttt{CHIPX} &> 1024, & (158) \end{aligned}$$

then acis_process_events exits with an error message because CHIPX-dependent computations could fail if the value of CHIPX is unphysical.

ii. Unexpected:
If

$$\begin{aligned} \texttt{CHIPX} &= 1 \text{ or} & (159)\\ \texttt{CHIPX} &= 1024, & (160) \end{aligned}$$

then acis_process_events produces a warning upon completion with a count of the total number of events for which one or the other of these conditions is true. Although these values are not unphysical, they should not occur.

5. CHIPX_ADJ:

(a) Initialize:

$$\texttt{CHIPX\_ADJ} = \texttt{CHIPX}. \quad (161)$$

6. NODE_ID:

(a) Calculate:
The NODE_ID of an event is given by

$$\texttt{NODE\_ID} = \text{int}\left(\frac{\texttt{CHIPX} - 1}{256}\right), \quad (162)$$

where "int" means the integer portion of (i.e. truncate or round down) the quantity in parentheses.

7. CHIPY:

(a) Read:

i. If the infile includes the column CHIPY, then the value of CHIPY for an event is given by

$$\texttt{CHIPY} = \texttt{CHIPY}_{\text{in}}. \quad (163)$$

ii. If the infile does not include the column CHIPY and

$$\begin{aligned} \texttt{DATAMODE}_{\text{in}} &= \text{FAINT or} & (164)\\ \texttt{DATAMODE}_{\text{in}} &= \text{FAINT\_BIAS or} & (165)\\ \texttt{DATAMODE}_{\text{in}} &= \text{GRADED or} & (166)\\ \texttt{DATAMODE}_{\text{in}} &= \text{VFAINT}, & (167) \end{aligned}$$

then the value of CHIPY for an event is given by

$$\texttt{CHIPY} = \texttt{CCDY}_{\text{in}} + 1. \quad (168)$$

iii. If the infile does not include the column CHIPY and

$$\texttt{DATAMODE}_{\rm in} = \text{CC33\_FAINT or} \quad (169)$$
$$\texttt{DATAMODE}_{\rm in} = \text{CC33\_GRADED,} \quad (170)$$

then the value of CHIPY for an event is given by

$$\texttt{CHIPY} = \texttt{TROW}_{\rm in} + 1. \quad (171)$$

(b) Validation:

i. Unphysical:

A. Timed-exposure mode:
If

$$\texttt{DATAMODE}_{\rm in} = \text{FAINT or} \quad (172)$$
$$\texttt{DATAMODE}_{\rm in} = \text{FAINT\_BIAS or} \quad (173)$$
$$\texttt{DATAMODE}_{\rm in} = \text{GRADED or} \quad (174)$$
$$\texttt{DATAMODE}_{\rm in} = \text{VFAINT} \quad (175)$$

and

$$\texttt{CHIPY} < 1 \text{ or} \quad (176)$$
$$\texttt{CHIPY} > 1024, \quad (177)$$

then acis_process_events exits with an error message because CHIPY-dependent computations could fail if the value of CHIPY is unphysical.

B. Continuous-clocking mode:
If

$$\texttt{DATAMODE}_{\rm in} = \text{CC33\_FAINT or} \quad (178)$$
$$\texttt{DATAMODE}_{\rm in} = \text{CC33\_GRADED} \quad (179)$$

and

$$\texttt{CHIPY} < 1 \text{ or} \quad (180)$$
$$\texttt{CHIPY} > 512, \quad (181)$$

then acis_process_events exits with an error message because the CHIPY value is out of range and CHIPY-dependent computations could fail if the value of CHIPY is unphysical (especially if it is less than 1).

ii. Unexpected:

A. FAINT, FAINT_BIAS, or GRADED:
If

$$\texttt{DATAMODE}_{\rm in} = \text{FAINT or} \quad (182)$$
$$\texttt{DATAMODE}_{\rm in} = \text{FAINT\_BIAS or} \quad (183)$$
$$\texttt{DATAMODE}_{\rm in} = \text{GRADED} \quad (184)$$

and

$$\texttt{CHIPY} = 1 \text{ or} \quad (185)$$
$$\texttt{CHIPY} = 1024, \quad (186)$$

then acis_process_events produces a warning upon completion with a count of the total number of events for which one or the other of these conditions is true. Although these values are not unphysical, they should not occur.

B. VFAINT:
If

$$\texttt{DATAMODE}_{\text{in}} = \text{VFAINT} \tag{187}$$

and

$$\texttt{CHIPY} = 1 \text{ or} \tag{188}$$
$$\texttt{CHIPY} = 2 \text{ or} \tag{189}$$
$$\texttt{CHIPY} = 1023 \text{ or} \tag{190}$$
$$\texttt{CHIPY} = 1024, \tag{191}$$

then acis_process_events produces a warning upon completion with a count of the total number of events for which one or another of these conditions is true. Although these values are not unphysical, they should not occur.

C. CC33_FAINT or CC33_GRADED:
If

$$\texttt{DATAMODE}_{\text{in}} = \text{CC33\_FAINT or} \tag{192}$$
$$\texttt{DATAMODE}_{\text{in}} = \text{CC33\_GRADED} \tag{193}$$

and

$$\texttt{CHIPY} = 1 \text{ or} \tag{194}$$
$$\texttt{CHIPY} = 512, \tag{195}$$

then acis_process_events produces a warning upon completion with a count of the total number of events for which one or the other of these conditions is true. Although these values are not unphysical, they should not occur.

8. $\texttt{CHIPX\_TARG}_{\text{evt}}$, $\texttt{CHIPY\_TARG}_{\text{evt}}$, and $\texttt{CHIPY\_TARG}_{\text{eff}}$:
The coordinate $\texttt{CHIPY\_TARG}_{\text{eff}}$ is used to compute the coordinates X, Y, and SKY_1D.

(a) Approximate:
If

$$\texttt{DATAMODE}_{\text{in}} = \text{CC33\_FAINT or} \tag{196}$$
$$\texttt{DATAMODE}_{\text{in}} = \text{CC33\_GRADED} \tag{197}$$

and

$$\texttt{acaofffile} \neq \text{none and} \tag{198}$$
$$\texttt{acaofffile} \neq \text{NONE,} \tag{199}$$

then:

i. Initial values:
The values of $\texttt{CHIPX\_TARG}_{\text{evt}}$ and $\texttt{CHIPY\_TARG}_{\text{evt}}$ are computed from the values of RA_TARG and DEC_TARG using the value of $\texttt{CCD\_ID}_{\text{focus}}$ and using the orientation of the telescope (i.e. RA, DEC, and ROLL) and the orientation of the SIM (i.e. DY, DZ, and DTHETA) at the time given by $\texttt{TIME\_RO} - (\texttt{CHIPY\_TARG}_{\text{acaoff,med}} + 1028) \times \texttt{TIMEDEL}$. The value of $\texttt{CHIPY\_TARG}_{\text{evt}}$ can be negative.

ii. ACIS-I0 or -I2:
If

$$\texttt{CCD\_ID}_{\rm focus} = 0 \text{ or} \tag{200}$$
$$\texttt{CCD\_ID}_{\rm focus} = 2, \tag{201}$$

then

A. If

$$\texttt{CCD\_ID} = 0 \text{ or} \tag{202}$$
$$\texttt{CCD\_ID} = 2, \tag{203}$$

then

$$\texttt{CHIPY\_TARG}_{\rm eff} = \texttt{CHIPY\_TARG}_{\rm evt}. \tag{204}$$

B. If

$$\texttt{CCD\_ID} = 1 \text{ or} \tag{205}$$
$$\texttt{CCD\_ID} = 3, \tag{206}$$

then

$$\texttt{CHIPY\_TARG}_{\rm eff} = 512 - (\texttt{CHIPY\_TARG}_{\rm evt} - \texttt{CHIPY\_TARG}_{\rm acaoff,med}). \tag{207}$$

C. If

$$\texttt{CCD\_ID} \geq 4, \tag{208}$$

then

$$\texttt{CHIPY\_TARG}_{\rm eff} = 512 - (\texttt{CHIPX\_TARG}_{\rm evt} - \texttt{CHIPX\_TARG}_{\rm acaoff,med}). \tag{209}$$

iii. ACIS-I1 or -I3:
If

$$\texttt{CCD\_ID}_{\rm focus} = 1 \text{ or} \tag{210}$$
$$\texttt{CCD\_ID}_{\rm focus} = 3, \tag{211}$$

then

A. If

$$\texttt{CCD\_ID} = 0 \text{ or} \tag{212}$$
$$\texttt{CCD\_ID} = 2, \tag{213}$$

then

$$\texttt{CHIPY\_TARG}_{\rm eff} = 512 - (\texttt{CHIPY\_TARG}_{\rm evt} - \texttt{CHIPY\_TARG}_{\rm acaoff,med}). \tag{214}$$

B. If

$$\texttt{CCD\_ID} = 1 \text{ or} \tag{215}$$
$$\texttt{CCD\_ID} = 3, \tag{216}$$

then

$$\texttt{CHIPY\_TARG}_{\rm eff} = \texttt{CHIPY\_TARG}_{\rm evt}. \tag{217}$$

C. If

$$\texttt{CCD\_ID} \geq 4, \tag{218}$$

then

$$\texttt{CHIPY\_TARG}_{\rm eff} = 512 + (\texttt{CHIPX\_TARG}_{\rm evt} - \texttt{CHIPX\_TARG}_{\rm acaoff,med}). \tag{219}$$

iv. ACIS-S:
If

$$\texttt{CCD\_ID}_{\rm focus} \geq 4, \tag{220}$$

then

A. If

$$\texttt{CCD\_ID} = 0 \text{ or} \tag{221}$$
$$\texttt{CCD\_ID} = 2, \tag{222}$$

then

$$\texttt{CHIPY\_TARG}_{\rm eff} = 512 + (\texttt{CHIPX\_TARG}_{\rm evt} - \texttt{CHIPX\_TARG}_{\rm acaoff,med}). \tag{223}$$

B. If

$$\texttt{CCD\_ID} = 1 \text{ or} \tag{224}$$
$$\texttt{CCD\_ID} = 3, \tag{225}$$

then

$$\texttt{CHIPY\_TARG}_{\rm eff} = 512 - (\texttt{CHIPX\_TARG}_{\rm evt} - \texttt{CHIPX\_TARG}_{\rm acaoff,med}). \tag{226}$$

C. If

$$\texttt{CCD\_ID} \geq 4, \tag{227}$$

then

$$\texttt{CHIPY\_TARG}_{\rm eff} = \texttt{CHIPY\_TARG}_{\rm evt}. \tag{228}$$

(b) Validation:
If

$$\texttt{CHIPY\_TARG}_{\rm eff} < -256 \text{ or} \tag{229}$$
$$\texttt{CHIPY\_TARG}_{\rm eff} \geq 1280, \tag{230}$$

then `acis_process_events` produces a warning message.

9. `TG_M`:

(a) Continuous-clocking mode with gratings:
If

$$\texttt{OBS\_MODE} = \text{pointing or} \tag{231}$$
$$\texttt{OBS\_MODE} = \text{POINTING} \tag{232}$$

and

$$\texttt{DATAMODE}_{\rm in} = \text{CC33\_FAINT or} \quad (233)$$
$$\texttt{DATAMODE}_{\rm in} = \text{CC33\_GRADED} \quad (234)$$

and

$$\texttt{CONTENT}_{\rm in} = \text{TGEVT1}, \quad (235)$$

then

i. Read:
The value of TG_M for an event is given by $\texttt{TG\_M}_{\rm in}$.

ii. Validation:

A. If

$$\texttt{TG\_M} < -99, \quad (236)$$

then

$$\texttt{TG\_M} = -99 \quad (237)$$

and **acis_process_events** produces a warning upon completion with a count of the total number of events for which this condition is true. These values should not occur.

B. If

$$\texttt{TG\_M} > 99, \quad (238)$$

then

$$\texttt{TG\_M} = 99 \quad (239)$$

and **acis_process_events** produces a warning upon completion with a count of the total number of events for which this condition is true. These values should not occur.

10. CHIPY_TG:

(a) Continuous-clocking mode with gratings:
If

$$\texttt{OBS\_MODE} = \text{pointing or} \quad (240)$$
$$\texttt{OBS\_MODE} = \text{POINTING} \quad (241)$$

and

$$\texttt{DATAMODE}_{\rm in} = \text{CC33\_FAINT or} \quad (242)$$
$$\texttt{DATAMODE}_{\rm in} = \text{CC33\_GRADED} \quad (243)$$

and

$$\texttt{CONTENT}_{\rm in} = \text{TGEVT1}, \quad (244)$$

then

i. Read:
The value of CHIPY_TG for an event is given by $\texttt{CHIPY\_TG}_{\rm in}$.

ii. Validation:

A. If

$$\begin{aligned} \texttt{TG\_M} &> -99 \text{ and} & (245)\\ \texttt{TG\_M} &< 99 \text{ and} & (246)\\ \texttt{CHIPY\_TG} &\neq \text{NULL} & (247) \end{aligned}$$

and

$$\begin{aligned} \texttt{CHIPY\_TG} &\leq 0 \text{ or} & (248)\\ \texttt{CHIPY\_TG} &\geq 1025, & (249) \end{aligned}$$

then `acis_process_events` exits with an error message because `CHIPY_TG`-dependent computations could fail if the value of `CHIPY_TG` is unphysical.

B. If

$$\begin{aligned} \texttt{TG\_M} &> -99 \text{ and} & (250)\\ \texttt{TG\_M} &< 99 \text{ and} & (251)\\ \texttt{CHIPY\_TG} &\neq \text{NULL and} & (252)\\ \texttt{CHIPY\_TG} &< 1, & (253) \end{aligned}$$

then

$$\texttt{CHIPY\_TG} = 1. \qquad (254)$$

C. If

$$\begin{aligned} \texttt{TG\_M} &> -99 \text{ and} & (255)\\ \texttt{TG\_M} &< 99 \text{ and} & (256)\\ \texttt{CHIPY\_TG} &\neq \text{NULL and} & (257)\\ \texttt{CHIPY\_TG} &> 1024, & (258) \end{aligned}$$

then

$$\texttt{CHIPY\_TG} = 1024. \qquad (259)$$

11. `CHIPY_ZO`:

(a) Continuous-clocking mode with gratings:
If

$$\begin{aligned} \texttt{OBS\_MODE} &= \text{pointing or} & (260)\\ \texttt{OBS\_MODE} &= \text{POINTING} & (261) \end{aligned}$$

and

$$\begin{aligned} \texttt{DATAMODE}_{\text{in}} &= \text{CC33\_FAINT or} & (262)\\ \texttt{DATAMODE}_{\text{in}} &= \text{CC33\_GRADED} & (263) \end{aligned}$$

and

$$\texttt{CONTENT}_{\text{in}} = \text{TGEVT1}, \qquad (264)$$

then

i. Read:
The value of `CHIPY_ZO` for an event is given by $\texttt{CHIPY\_ZO}_{\rm in}$.

12. `TIME_RO`:

(a) Continuous-clocking mode:
If

$$\begin{aligned} \texttt{DATAMODE}_{\rm in} &= \text{CC33\_FAINT or} && (265) \\ \texttt{DATAMODE}_{\rm in} &= \text{CC33\_GRADED,} && (266) \end{aligned}$$

then

i. Read:

A. Level 0:
If

$$\texttt{CONTENT}_{\rm in} = \text{EVT0,} \tag{267}$$

then the value of `TIME_RO` for an event is given by $\texttt{TIME}_{\rm in}$.

B. Level 1, 1.5, or 2:
If

$$\begin{aligned} \texttt{CONTENT}_{\rm in} &= \text{EVT1 or} && (268) \\ \texttt{CONTENT}_{\rm in} &= \text{TGEVT1 or} && (269) \\ \texttt{CONTENT}_{\rm in} &= \text{EVT2} && (270) \end{aligned}$$

and

$$\texttt{TIME\_RO}_{\rm in} > 0, \tag{271}$$

then

$$\texttt{TIME\_RO} = \texttt{TIME\_RO}_{\rm in}. \tag{272}$$

If

$$\begin{aligned} \texttt{CONTENT}_{\rm in} &= \text{EVT1 or} && (273) \\ \texttt{CONTENT}_{\rm in} &= \text{TGEVT1 or} && (274) \\ \texttt{CONTENT}_{\rm in} &= \text{EVT2} && (275) \end{aligned}$$

and

$$\texttt{TIME\_RO}_{\rm in} = 0, \tag{276}$$

then

$$\texttt{TIME\_RO} = \texttt{TIME}_{\rm in}. \tag{277}$$

ii. Validation:
If

$$\begin{aligned} \texttt{TIME\_RO} &< 0 \text{ or} && (278) \\ \texttt{TIME\_RO} &\geq 3 \times 10^9, && (279) \end{aligned}$$

then `acis_process_events` produces a warning upon completion with a count of the total number of events for which one or the other of these conditions is true. These values should not occur.

13. TIME and CHIPY_ADJ:
For continuous-clocking mode observations, the value of CHIPY_ADJ is used to compute the TIME, pulse heights, and the coordinates TDETX, TDETY, DETX, and DETY.

(a) Calculate:

i. Timed exposure mode:
If

$$\texttt{DATAMODE}_{\rm in} = \text{FAINT or} \quad (280)$$
$$\texttt{DATAMODE}_{\rm in} = \text{FAINT\_BIAS or} \quad (281)$$
$$\texttt{DATAMODE}_{\rm in} = \text{GRADED or} \quad (282)$$
$$\texttt{DATAMODE}_{\rm in} = \text{VFAINT,} \quad (283)$$

then

$$\texttt{TIME} = \texttt{TIME}_{\rm in}\text{and} \quad (284)$$
$$\texttt{CHIPY\_ADJ} = \texttt{CHIPY}. \quad (285)$$

ii. Continuous-clocking mode:
If

$$\texttt{DATAMODE}_{\rm in} = \text{CC33\_FAINT or} \quad (286)$$
$$\texttt{DATAMODE}_{\rm in} = \text{CC33\_GRADED} \quad (287)$$

then

A. Set

$$\texttt{CHIPY\_ADJ} = 512 \text{ and} \quad (288)$$
$$\texttt{TIME}' = \texttt{TIME\_RO} - (\texttt{CHIPY\_ADJ} + 1028) \times \texttt{TIMEDEL}. \quad (289)$$

B. If

$$\texttt{acaofffile} \neq \text{none and} \quad (290)$$
$$\texttt{acaofffile} \neq \text{NONE,} \quad (291)$$

then

$$\texttt{CHIPY\_ADJ}' = \texttt{CHIPY\_TARG}_{\rm eff} \text{ and} \quad (292)$$
$$\texttt{TIME}' = \texttt{TIME\_RO} - (\texttt{CHIPY\_ADJ}' + 1028) \times \texttt{TIMEDEL}, \quad (293)$$

and CHIPY_ADJ is computed from the values of RA_TARG and DEC_TARG using the orientation of the telescope (i.e. RA, DEC, and ROLL) and the orientation of the SIM (i.e. DY, DZ, and DTHETA) at the time TIME′. At this step, the value of CHIPY_ADJ can be negative.

C. If

$$\texttt{CONTENT} = \text{TGEVT1 and} \quad (294)$$
$$\texttt{TG\_M} > -99 \text{ and} \quad (295)$$
$$\texttt{TG\_M} < 99 \text{ and} \quad (296)$$
$$\texttt{CHIPY\_TG} \neq \text{NULL,} \quad (297)$$

then

$$\texttt{CHIPY\_ADJ} = \texttt{CHIPY\_TG}. \quad (298)$$

D. If

$$\texttt{CONTENT} = \text{TGEVT1} \tag{299}$$

and

$$\texttt{TG\_M} = -99 \text{ or} \tag{300}$$
$$\texttt{TG\_M} = 99, \tag{301}$$

then

$$\texttt{CHIPY\_ADJ} = 512. \tag{302}$$

E. If

$$\texttt{acaofffile} \neq \text{none and} \tag{303}$$
$$\texttt{acaofffile} \neq \text{NONE} \tag{304}$$

and

$$\texttt{TIME}' < \texttt{TIME}_{\text{min}} \text{ or} \tag{305}$$
$$\texttt{TIME}' \geq \texttt{TIME}_{\text{max}}, \tag{306}$$

then

$$\texttt{CHIPY\_ADJ} = 512. \tag{307}$$

F. If

$$\texttt{acaofffile} \neq \text{none and} \tag{308}$$
$$\texttt{acaofffile} \neq \text{NONE} \tag{309}$$

and

$$\texttt{TIME}' < \texttt{TIME}_{\text{min}} \text{ or} \tag{310}$$
$$\texttt{TIME}' \geq \texttt{TIME}_{\text{max}}, \tag{311}$$

and

$$\texttt{CCD\_ID}_{\text{focus}} = 0 \text{ or} \tag{312}$$
$$\texttt{CCD\_ID}_{\text{focus}} = 2 \tag{313}$$

and

$$\texttt{CCD\_ID} = 0 \text{ or} \tag{314}$$
$$\texttt{CCD\_ID} = 2, \tag{315}$$

then

$$\texttt{CHIPY\_ADJ} = \texttt{CHIPY\_TARG}_{\text{acaoff,med}}. \tag{316}$$

G. If

$$\texttt{acaofffile} \neq \text{none and} \tag{317}$$
$$\texttt{acaofffile} \neq \text{NONE} \tag{318}$$

and

$$\texttt{TIME}' < \texttt{TIME}_{\rm min} \text{ or} \tag{319}$$
$$\texttt{TIME}' \geq \texttt{TIME}_{\rm max}, \tag{320}$$

and

$$\texttt{CCD\_ID}_{\rm focus} = 1 \text{ or} \tag{321}$$
$$\texttt{CCD\_ID}_{\rm focus} = 3 \tag{322}$$

and

$$\texttt{CCD\_ID} = 1 \text{ or} \tag{323}$$
$$\texttt{CCD\_ID} = 3, \tag{324}$$

then

$$\texttt{CHIPY\_ADJ} = \texttt{CHIPY\_TARG}_{\rm acaoff,med}. \tag{325}$$

H. If

$$\texttt{acaofffile} \neq \text{none and} \tag{326}$$
$$\texttt{acaofffile} \neq \text{NONE} \tag{327}$$

and

$$\texttt{TIME}' < \texttt{TIME}_{\rm min} \text{ or} \tag{328}$$
$$\texttt{TIME}' \geq \texttt{TIME}_{\rm max}, \tag{329}$$

and

$$\texttt{CCD\_ID}_{\rm focus} \geq 4 \text{ and} \tag{330}$$
$$\texttt{CCD\_ID} \geq 4, \tag{331}$$

then

$$\texttt{CHIPY\_ADJ} = \texttt{CHIPY\_TARG}_{\rm acaoff,med}. \tag{332}$$

I. If

$$\texttt{acaofffile} = \text{none or} \tag{333}$$
$$\texttt{acaofffile} = \text{NONE} \tag{334}$$

and

$$\texttt{CONTENT} \neq \text{TGEVT1}, \tag{335}$$

then

$$\texttt{CHIPY\_ADJ} = 512. \tag{336}$$

J. If

$$\texttt{CCD\_ID}_{\rm focus} \leq 3 \text{ and} \tag{337}$$
$$\texttt{CCD\_ID} \geq 4, \tag{338}$$

then

$$\texttt{CHIPY\_ADJ} = 512. \tag{339}$$

K. If

$$\mathtt{CCD\_ID}_{\rm focus} \geq 4 \text{ and} \quad (340)$$
$$\mathtt{CCD\_ID} \leq 3, \quad (341)$$

then

$$\mathtt{CHIPY\_ADJ} = 512. \quad (342)$$

L. If

$$\mathtt{obs\_mode} = \text{secondary or} \quad (343)$$
$$\mathtt{obs\_mode} = \text{SECONDARY}, \quad (344)$$

then

$$\mathtt{CHIPY\_ADJ} = 512. \quad (345)$$

M. If

$$\mathtt{CHIPY\_ADJ} < 0.5 \text{ or} \quad (346)$$
$$\mathtt{CHIPY\_ADJ} \geq 1024.5 \quad (347)$$

then

$$\mathtt{CHIPY\_ADJ} = 512. \quad (348)$$

N. Set

$$\mathtt{TIME} = \mathtt{TIME\_RO} - (\mathtt{CHIPY\_ADJ} + 1028) \times \mathtt{TIMEDEL}. \quad (349)$$

In continuous-clocking mode, the coordinate CHIPY_ADJ is used to compute the time, the pulse heights, and the coordinates (except for X, Y, and SKY_1D).

(b) Validation:

i. If

$$\mathtt{TIME} < 0 \text{ or} \quad (350)$$
$$\mathtt{TIME} \geq 3 \times 10^9, \quad (351)$$

then acis_process_events produces a warning upon completion with a count of the total number of events for which one or the other of these conditions is true. These values should not occur.

ii. If

$$\mathtt{CHIPY\_ADJ} < 0.5 \text{ or} \quad (352)$$
$$\mathtt{CHIPY\_ADJ} \geq 1024.5, \quad (353)$$

then acis_process_events exits with an error message because CHIPY_ADJ-dependent computations could fail if the value of CHIPY_ADJ is unphysical.

14. Bad pixel:

(a) If

$$\texttt{badpixfile} \neq \text{none and} \quad (354)$$

$$\texttt{badpixfile} \neq \text{NONE} \quad (355)$$

and the badpixfile includes a valid HDU h_{badpix} where $\texttt{CCD\_ID}_{\text{badpix}} = \texttt{CCD\_ID}$, then the HDU h_{badpix} is searched as follows to determine if the event should have one or more STATUS bits set to one.

i. If $\texttt{DATAMODE}_{\text{in}}$ = CC33_FAINT or $\texttt{DATAMODE}_{\text{in}}$ = CC33_GRADED and there are one or more rows r in HDU h_{badpix} where

$$\texttt{CHIPX} \geq \texttt{CHIPX}_{\text{badpix},r}[0] \text{ and} \quad (356)$$

$$\texttt{CHIPX} \leq \texttt{CHIPX}_{\text{badpix},r}[1] \text{ and} \quad (357)$$

$$\texttt{TIME} \geq \texttt{TIME}_{\text{badpix},r} \text{ and} \quad (358)$$

$$\texttt{TIME} < \texttt{TIME\_STOP}_{\text{badpix},r} \quad (359)$$

and

$$\texttt{STATUS}_{\text{badpix},r}[5] = 1 \text{ or} \quad (360)$$

$$\texttt{STATUS}_{\text{badpix},r}[6] = 1 \text{ or} \quad (361)$$

$$\texttt{STATUS}_{\text{badpix},r}[9] = 1, \quad (362)$$

then

$$\texttt{STATUS}[0] = 1 \quad (363)$$

for the event. Here $\texttt{CCD\_ID}_{\text{badpix}}$ is the value of the keyword CCD_ID in HDU h_{badpix} of the badpixfile, $\texttt{CHIPX}_{\text{badpix},r}[0]$ and $\texttt{CHIPX}_{\text{badpix},r}[1]$ are the first and second values in the vector column named CHIPX of row r of HDU h_{badpix} of the badpixfile, and $\texttt{TIME}_{\text{badpix},r}$ and $\texttt{TIME\_STOP}_{\text{badpix},r}$ are the values in the columns named TIME and TIME_STOP, respectively, of row r of HDU h_{badpix} of the badpixfile.

ii. If $\texttt{DATAMODE}_{\text{in}}$ = CC33_FAINT or $\texttt{DATAMODE}_{\text{in}}$ = CC33_GRADED and there are one or more rows r in HDU h_{badpix} where

$$\texttt{CHIPX} \geq \texttt{CHIPX}_{\text{badpix},r}[0] \text{ and} \quad (364)$$

$$\texttt{CHIPX} \leq \texttt{CHIPX}_{\text{badpix},r}[1] \text{ and} \quad (365)$$

$$\texttt{TIME} \geq \texttt{TIME}_{\text{badpix},r} \text{ and} \quad (366)$$

$$\texttt{TIME} < \texttt{TIME\_STOP}_{\text{badpix},r} \quad (367)$$

and

$$\texttt{STATUS}_{\text{badpix},r}[0] = 1 \text{ or} \quad (368)$$

$$\texttt{STATUS}_{\text{badpix},r}[1] = 1 \text{ or} \quad (369)$$

$$\texttt{STATUS}_{\text{badpix},r}[7] = 1 \text{ or} \quad (370)$$

$$\texttt{STATUS}_{\text{badpix},r}[11] = 1 \text{ or} \quad (371)$$

$$\texttt{STATUS}_{\text{badpix},r}[12] = 1 \text{ or} \quad (372)$$

$$\texttt{STATUS}_{\text{badpix},r}[13] = 1 \text{ or} \quad (373)$$

$$\texttt{STATUS}_{\text{badpix},r}[14] = 1 \text{ or} \quad (374)$$

$$\texttt{STATUS}_{\text{badpix},r}[16] = 1, \quad (375)$$

then

$$\texttt{STATUS}[4] = 1 \quad (376)$$

for the event.

iii. If $\mathtt{DATAMODE}_{\mathrm{in}}$ = CC33_FAINT or $\mathtt{DATAMODE}_{\mathrm{in}}$ = CC33_GRADED and there are one or more rows r in HDU h_{badpix} where

$$\begin{aligned}
\mathtt{CHIPX} &\geq \mathtt{CHIPX}_{\mathrm{badpix},r}[0] \text{ and} && (377)\\
\mathtt{CHIPX} &\leq \mathtt{CHIPX}_{\mathrm{badpix},r}[1] \text{ and} && (378)\\
\mathtt{TIME} &\geq \mathtt{TIME}_{\mathrm{badpix},r} \text{ and} && (379)\\
\mathtt{TIME} &< \mathtt{TIME_STOP}_{\mathrm{badpix},r} && (380)
\end{aligned}$$

and

$$\begin{aligned}
\mathtt{STATUS}_{\mathrm{badpix},r}[8] &= 1 \text{ or} && (381)\\
\mathtt{STATUS}_{\mathrm{badpix},r}[10] &= 1, && (382)
\end{aligned}$$

then

$$\mathtt{STATUS}[5] = 1 \quad (383)$$

for the event.

iv. If $\mathtt{DATAMODE}_{\mathrm{in}}$ = CC33_FAINT or $\mathtt{DATAMODE}_{\mathrm{in}}$ = CC33_GRADED and there are one or more rows r in HDU h_{badpix} where

$$\begin{aligned}
\mathtt{CHIPX} &\geq \mathtt{CHIPX}_{\mathrm{badpix},r}[0] \text{ and} && (384)\\
\mathtt{CHIPX} &\leq \mathtt{CHIPX}_{\mathrm{badpix},r}[1] \text{ and} && (385)\\
\mathtt{TIME} &\geq \mathtt{TIME}_{\mathrm{badpix},r} \text{ and} && (386)\\
\mathtt{TIME} &< \mathtt{TIME_STOP}_{\mathrm{badpix},r} && (387)
\end{aligned}$$

and

$$\mathtt{STATUS}_{\mathrm{badpix},r}[3] = 1, \quad (388)$$

then

$$\mathtt{STATUS}[6] = 1 \quad (389)$$

for the event.

v. If $\mathtt{DATAMODE}_{\mathrm{in}}$ = CC33_FAINT or $\mathtt{DATAMODE}_{\mathrm{in}}$ = CC33_GRADED and there are one or more rows r in HDU h_{badpix} where

$$\begin{aligned}
\mathtt{CHIPX} &\geq \mathtt{CHIPX}_{\mathrm{badpix},r}[0] \text{ and} && (390)\\
\mathtt{CHIPX} &\leq \mathtt{CHIPX}_{\mathrm{badpix},r}[1] \text{ and} && (391)\\
\mathtt{TIME} &\geq \mathtt{TIME}_{\mathrm{badpix},r} \text{ and} && (392)\\
\mathtt{TIME} &< \mathtt{TIME_STOP}_{\mathrm{badpix},r} && (393)
\end{aligned}$$

and

$$\begin{aligned}
\mathtt{STATUS}_{\mathrm{badpix},r}[2] &= 1 \text{ or} && (394)\\
\mathtt{STATUS}_{\mathrm{badpix},r}[4] &= 1, && (395)
\end{aligned}$$

then

$$\mathtt{STATUS}[8] = 1 \quad (396)$$

for the event.

vi. If $\texttt{DATAMODE}_{\text{in}}$ = CC33_FAINT or $\texttt{DATAMODE}_{\text{in}}$ = CC33_GRADED and there are one or more rows r in HDU h_{badpix} where

$$\texttt{CHIPX} \geq \texttt{CHIPX}_{\text{badpix},r}[0] \text{ and} \quad (397)$$

$$\texttt{CHIPX} \leq \texttt{CHIPX}_{\text{badpix},r}[1] \text{ and} \quad (398)$$

$$\texttt{TIME} \geq \texttt{TIME}_{\text{badpix},r} \text{ and} \quad (399)$$

$$\texttt{TIME} < \texttt{TIME\_STOP}_{\text{badpix},r} \quad (400)$$

and

$$\texttt{STATUS}_{\text{badpix},r}[15] = 1, \quad (401)$$

then

$$\texttt{STATUS}[16] = 1 \quad (402)$$

for the event.

vii. In summary, the mapping between a bad-pixel STATUS bit and the corresponding event STATUS bit is listed in Table 1.

Table 1: Bad-pixel to event STATUS bit mapping

Bad-pixel STATUS bit	Event STATUS bit
0	4
1	4
2	8
3	6
4	8
5	0
6	0
7	4
8	5
9	0
10	5
11	4
12	4
13	4
14	4
15	16
16	4

15. PHAS:

(a) If HDU 1 of the `infile` includes the column PHAS, then

i. the values of PHAS for an event are read from the `infile`.

ii. If PHAS[4] < the split threshold, then STATUS[k] = 1 for bit $k = 1$.

iii. If PHAS[4] ≤ PHAS[j] for one or more j = 0–3 or 5–8, then STATUS[k] = 1 for bit $k = 1$.

iv. If PHAS[j] > 4095 for one or more j = 0–8, then STATUS[k] = 1 for bit $k = 2$.

16. PHAS_ADJ:

(a) If HDU 1 of the `infile` includes $\texttt{DATAMODE}_{\text{in}}$ = CC33_FAINT and the parameter `apply_cti` = yes and the `ctifile` and `mtlfile` are specified, then the CTI-adjusted pulse heights are computed as follows.

i. The real-valued arrays for the serial CTI adjustment Δ_x, the parallel CTI adjustment Δ_y, and the adjusted pulse heights PHAS_ADJ are initialized such that

$$\begin{aligned}\Delta_x[j] &= 0, && (403)\\ \Delta_y[j] &= 0, \text{ and} && (404)\\ \texttt{PHAS\_ADJ}[j] &= \texttt{PHAS}[j] && (405)\end{aligned}$$

for every element j = 0–8, where the starting point for the adjusted pulse heights are the unadjusted pulse heights PHAS. Note that the values of the unadjusted pulse heights PHAS remain unchanged to ensure that it is possible to remove the CTI adjustment or to reapply the adjustment if the algorithm or calibration data are modified.

ii. The CTI iteration counter n is initialized such that

$$n = 1. \tag{406}$$

iii. The temporary variables Δ'_x, Δ'_y, and PHAS_ADJ$'$ are set such that

$$\begin{aligned}\Delta'_x[j] &= \Delta_x[j], && (407)\\ \Delta'_y[j] &= \Delta_y[j], \text{ and} && (408)\\ \texttt{PHAS\_ADJ}'[j] &= \texttt{PHAS\_ADJ}[j] && (409)\end{aligned}$$

for each element j.

iv. A. If there is a serial CTI trap-density map in the ctifile for CCD_ID and NODE_ID = 0 or 2, then the values of Δ_x are given by

$$\begin{aligned}
\Delta_x[0] &= c_x[0]s_x\rho_x[0]V_x[0], && (410)\\
\Delta_x[1] &= c_x[1]s_x\rho_x[1]V_x[1] - c'_x[0]s_x\rho_x[0]V_x[0], && (411)\\
\Delta_x[2] &= c_x[2]s_x\rho_x[2]V_x[2] - c'_x[1]s_x\rho_x[1]V_x[1], && (412)\\
\Delta_x[3] &= c_x[3]s_x\rho_x[3]V_x[3], && (413)\\
\Delta_x[4] &= c_x[4]s_x\rho_x[4]V_x[4] - c'_x[3]s_x\rho_x[3]V_x[3], && (414)\\
\Delta_x[5] &= c_x[5]s_x\rho_x[5]V_x[5] - c'_x[4]s_x\rho_x[4]V_x[4], && (415)\\
\Delta_x[6] &= c_x[6]s_x\rho_x[6]V_x[6], && (416)\\
\Delta_x[7] &= c_x[7]s_x\rho_x[7]V_x[7] - c'_x[6]s_x\rho_x[6]V_x[6], \text{ and} && (417)\\
\Delta_x[8] &= c_x[8]s_x\rho_x[8]V_x[8] - c'_x[7]s_x\rho_x[7]V_x[7], && (418)
\end{aligned}$$

where

$$c_x[j] = \begin{cases} 0 & \left\{\begin{array}{l}\texttt{PHAS}[j] + \Delta'_x[j] + \Delta'_y[j] < \text{ split threshold}\\ \quad\text{(for all } j),\end{array}\right.\\ \texttt{FRCTRLX} & \left\{\begin{array}{l}\texttt{PHAS}[j] + \Delta'_x[j] + \Delta'_y[j] \geq \text{ split threshold and}\\ \texttt{PHAS}[j] + \Delta'_x[j] + \Delta'_y[j] <\\ \quad \texttt{PHAS}[j-1] + \Delta'_x[j-1] + \Delta'_y[j-1]\\ \quad\text{(for } j = 1,2,4,5,7,8),\end{array}\right.\\ 1 & \left\{\begin{array}{l}\texttt{PHAS}[j] + \Delta'_x[j] + \Delta'_y[j] \geq \text{ split threshold}\\ \quad\text{(for } j = 0,3,6)\\ \texttt{PHAS}[j] + \Delta'_x[j] + \Delta'_y[j] \geq \text{ split threshold and}\\ \texttt{PHAS}[j] + \Delta'_x[j] + \Delta'_y[j] \geq\\ \quad \texttt{PHAS}[j-1] + \Delta'_x[j-1] + \Delta'_y[j-1]\\ \quad\text{(for } j = 1,2,4,5,7,8),\end{array}\right.\end{cases}$$

$$
c'_x[j] = \begin{cases} 0 & \begin{cases} \texttt{PHAS}[j] + \Delta'_x[j] + \Delta'_y[j] < \text{ split threshold or} \\ \texttt{PHAS}[j+1] + \Delta'_x[j+1] + \Delta'_y[j+1] < \text{ split threshold or} \\ j \rightarrow \texttt{CHIPX} = 1, 256, 513, \text{ or } 768 \\ \quad (\text{for } j = 0, 1, 3, 4, 6, 7), \end{cases} \\ \texttt{FRCTRLX} & \begin{cases} \texttt{PHAS}[j] + \Delta'_x[j] + \Delta'_y[j] > \\ \quad \texttt{PHAS}[j+1] + \Delta'_x[j+1] + \Delta'_y[j+1] \text{ and} \\ \texttt{PHAS}[j+1] + \Delta'_x[j+1] + \Delta'_y[j+1] \geq \text{ split threshold} \\ \quad (\text{for } j = 0, 1, 3, 4, 6, 7), \end{cases} \\ 1 & \begin{cases} \texttt{PHAS}[j] + \Delta'_x[j] + \Delta'_y[j] \leq \\ \quad \texttt{PHAS}[j+1] + \Delta'_x[j+1] + \Delta'_y[j+1] \text{ and} \\ \texttt{PHAS}[j] + \Delta'_x[j] + \Delta'_y[j] \geq \text{ split threshold} \\ \quad (\text{for } j = 0, 1, 3, 4, 6, 7), \end{cases} \end{cases}
$$

$$
s_x = 1 + \texttt{TCTIX}\,(T - \texttt{FP\_TEMP0})\,, \tag{419}
$$

$$
\begin{cases} s_x \text{ is a temperature dependent scaling factor,} \\ \texttt{TCTIX} \text{ is the } \texttt{CCD\_ID} \text{ dependent value in the column } \texttt{TCTIX} \text{ of the} \\ \quad \texttt{ctifile}, \\ \texttt{FP\_TEMP0} \text{ is the name of a keyword in the } \texttt{ctifile}, \end{cases}
$$

$$
T = \left(\frac{t' - t'_k}{t'_{k+1} - t'_k} \right) (\texttt{FP\_TEMP}_{k+1} - \texttt{FP\_TEMP}_k) + \texttt{FP\_TEMP}_k, \tag{420}
$$

$$
\{ \; T \text{ is the time dependent focal plane temperature,}
$$

$$
t' = t + \texttt{TIMEDEL}_{\text{in}}\,(\texttt{TIMEPIXR}_{\text{evt}} - 0.5)\,, \tag{421}
$$

$$
\begin{cases} t \text{ is the } \texttt{TIME} \text{ of the event,} \\ \texttt{TIMEPIXR}_{\text{evt}} \text{ is a keyword in the } \texttt{infile}, \end{cases}
$$

$$
t'_k = \texttt{TIME}_k + \texttt{TIMEDEL}_{\text{mtl}}\,(\texttt{TIMEPIXR}_{\text{mtl}} - 0.5)\,, \tag{422}
$$

$$
\begin{cases} \texttt{TIME}_k \text{ is the } k^{\text{th}} \text{ element of the column } \texttt{TIME} \text{ in the } \texttt{mtlfile}, \\ t'_k \leq t', \\ \text{If } t' < t'_k \text{ for } k = 0, \text{ then } k = 0, \\ \texttt{FP\_TEMP}_k \text{ is the } k^{\text{th}} \text{ element of the column } \texttt{FP\_TEMP} \text{ in the } \texttt{mtlfile}, \\ \texttt{TIMEDEL}_{\text{mtl}} \text{ is a keyword in the } \texttt{mtlfile}, \\ \texttt{TIMEPIXR}_{\text{mtl}} \text{ is a keyword in the } \texttt{mtlfile}, \end{cases}
$$

$$
t'_{k+1} = \texttt{TIME}_{k+1} + \texttt{TIMEDEL}_{\text{mtl}}\,(\texttt{TIMEPIXR}_{\text{mtl}} - 0.5)\,, \tag{423}
$$

$$
\begin{cases} \texttt{TIME}_{k+1} \text{ is the } (k+1)^{\text{th}} \text{ element of the column } \texttt{TIME} \text{ in the } \texttt{mtlfile}, \\ t'_{k+1} > t', \\ \text{If } t' > t'_k \text{ for } k = n, \text{ where } n \text{ is the last element, then } k = n, \\ \texttt{FP\_TEMP}_{k+1} \text{ is the } (k+1)^{\text{th}} \text{ element of the column } \texttt{FP\_TEMP} \text{ in the} \\ \quad \texttt{mtlfile}, \end{cases}
$$

$$
\rho_x[j] = \text{serial trap density,} \tag{424}
$$

$$
\begin{cases} \rho_x[j] \text{ depends upon the } \texttt{CCD\_ID} \text{ and upon the } \texttt{CHIPX} \text{ and nint(}\texttt{CHIPY\_ADJ}) \\ \quad \text{coordinates associated with element } j \text{ of } \texttt{PHAS\_ADJ}[j] \text{ (see Fig. 1),} \end{cases}
$$

$$
V_x[j] = \left(\frac{\texttt{PHAS}[j] + \Delta'_x[j] + \Delta'_y[j] - \texttt{PHA}_l}{\texttt{PHA}_{l+1} - \texttt{PHA}_l} \right) (\texttt{VOLUME\_X}_{l+1} - \texttt{VOLUME\_X}_l) + \texttt{VOLUME\_X}_l, \tag{425}
$$

$$\begin{cases} \texttt{PHA}_l \text{ is the } l^{\text{th}} \text{ element of the column } \texttt{PHA} \text{ in the } \texttt{ctifile}, \\ \texttt{PHA}_l \text{ (and } \texttt{PHA}_{l+1}\text{) are } \texttt{CCD\_ID} \text{ depdendent}, \\ \texttt{PHA}_l \leq \texttt{PHAS}[j] + \Delta'_x[j] + \Delta'_y[j], \\ \text{If } \texttt{PHA}_l > \texttt{PHAS}[j] + \Delta'_x[j] + \Delta'_y[j] \text{ for } l = 0, \text{ then } l = 0, \\ \texttt{PHA}_{l+1} \text{ is the } (l+1)^{\text{th}} \text{ element of the column } \texttt{PHA} \text{ in the } \texttt{ctifile}, \\ \texttt{PHA}_{l+1} > \texttt{PHAS}[j] + \Delta'_x[j] + \Delta'_y[j], \\ \text{If } \texttt{PHA}_{l+1} \leq \texttt{PHAS}[j] + \Delta'_x[j] + \Delta'_y[j] \text{ for } l = n, \text{ where } n \text{ is the last} \\ \quad \text{element, then } l = n, \\ \texttt{VOLUME\_X}_l \text{ is the } l^{\text{th}} \text{ element of the column } \texttt{VOLUME\_X} \text{ in the } \texttt{ctifile}, \\ \texttt{VOLUME\_X}_l, \text{ which is } \texttt{CCD\_ID} \text{ depdendent, is associated with } \texttt{PHA}_l, \\ \texttt{VOLUME\_X}_{l+1} \text{ is the } (l+1)^{\text{th}} \text{ element of the column } \texttt{VOLUME\_X} \text{ in the} \\ \quad \texttt{ctifile}, \text{ and} \\ \texttt{VOLUME\_X}_{l+1}, \text{ which is } \texttt{CCD\_ID} \text{ depdendent, is associated with } \texttt{PHA}_{l+1} \end{cases}$$

B. If there is a serial CTI trap-density map in the `ctifile` for CCD_ID and NODE_ID $= 1$ or 3, then the values of Δ_x are given by

$$\Delta_x[0] = c_x[0]s_x\rho_x[0]V_x[0] - c'_x[1]s_x\rho_x[1]V_x[1], \quad (426)$$
$$\Delta_x[1] = c_x[1]s_x\rho_x[1]V_x[1] - c'_x[2]s_x\rho_x[2]V_x[2], \quad (427)$$
$$\Delta_x[2] = c_x[2]s_x\rho_x[2]V_x[2], \quad (428)$$
$$\Delta_x[3] = c_x[3]s_x\rho_x[3]V_x[3] - c'_x[4]s_x\rho_x[4]V_x[4], \quad (429)$$
$$\Delta_x[4] = c_x[4]s_x\rho_x[4]V_x[4] - c'_x[5]s_x\rho_x[5]V_x[5], \quad (430)$$
$$\Delta_x[5] = c_x[5]s_x\rho_x[5]V_x[5], \quad (431)$$
$$\Delta_x[6] = c_x[6]s_x\rho_x[6]V_x[6] - c'_x[7]s_x\rho_x[7]V_x[7], \quad (432)$$
$$\Delta_x[7] = c_x[7]s_x\rho_x[7]V_x[7] - c'_x[8]s_x\rho_x[8]V_x[8], \text{ and} \quad (433)$$
$$\Delta_x[8] = c_x[8]s_x\rho_x[8]V_x[8], \quad (434)$$

where

$$c_x[j] = \begin{cases} 0 & \begin{cases} \texttt{PHAS}[j] + \Delta'_x[j] + \Delta'_y[j] < \text{ split threshold} \\ \quad \text{(for all } j\text{)}, \end{cases} \\ \texttt{FRCTRLX} & \begin{cases} \texttt{PHAS}[j] + \Delta'_x[j] + \Delta'_y[j] \geq \text{ split threshold and} \\ \texttt{PHAS}[j] + \Delta'_x[j] + \Delta'_y[j] < \\ \quad \texttt{PHAS}[j+1] + \Delta'_x[j+1] + \Delta'_y[j+1] \\ \quad \text{(for } j = 0,1,3,4,6,7\text{)}, \end{cases} \\ 1 & \begin{cases} \texttt{PHAS}[j] + \Delta'_x[j] + \Delta'_y[j] \geq \text{ split threshold} \\ \quad \text{(for } j = 2,5,8\text{)} \\ \texttt{PHAS}[j] + \Delta'_x[j] + \Delta'_y[j] \geq \text{ split threshold and} \\ \texttt{PHAS}[j] + \Delta'_x[j] + \Delta'_y[j] \geq \\ \quad \texttt{PHAS}[j+1] + \Delta'_x[j+1] + \Delta'_y[j+1] \\ \quad \text{(for } j = 0,1,3,4,6,7\text{)}, \end{cases} \end{cases}$$

$$c'_x[j] = \begin{cases} 0 & \begin{cases} \texttt{PHAS}[j] + \Delta'_x[j] + \Delta'_y[j] < \text{ split threshold or} \\ \texttt{PHAS}[j-1] + \Delta'_x[j-1] + \Delta'_y[j-1] < \text{ split threshold or} \\ j \rightarrow \texttt{CHIPX} = 257, 512, 769, \text{ or } 1024 \\ \quad (\text{for } j = 1,2,4,5,7,8), \end{cases} \\ \texttt{FRCTRLX} & \begin{cases} \texttt{PHAS}[j] + \Delta'_x[j] + \Delta'_y[j] > \\ \quad \texttt{PHAS}[j-1] + \Delta'_x[j-1] + \Delta'_y[j-1] \text{ and} \\ \texttt{PHAS}[j-1] + \Delta'_x[j-1] + \Delta'_y[j-1] \geq \text{ split threshold} \\ \quad (\text{for } j = 1,2,4,5,7,8), \end{cases} \\ 1 & \begin{cases} \texttt{PHAS}[j] + \Delta'_x[j] + \Delta'_y[j] \leq \\ \quad \texttt{PHAS}[j-1] + \Delta'_x[j-1] + \Delta'_y[j-1] \text{ and} \\ \texttt{PHAS}[j] + \Delta'_x[j] + \Delta'_y[j] \geq \text{ split threshold} \\ \quad (\text{for } j = 1,2,4,5,7,8), \end{cases} \end{cases}$$

and s_x, T, t', t'_k, t'_{k+1}, $\rho_x[j]$, and $V_x[j]$ are given by equations. 419, 420, 421, 422, 423, 424, and 425, respectively.

v. If there is a parallel CTI trap-density map in the `ctifile` for `CCD_ID`, then the values of Δ_y are given by

$$\Delta_y[0] = c_y[0] s_y \rho_y[0] V_y[0], \tag{435}$$
$$\Delta_y[1] = c_y[1] s_y \rho_y[1] V_y[1], \tag{436}$$
$$\Delta_y[2] = c_y[2] s_y \rho_y[2] V_y[2], \tag{437}$$
$$\Delta_y[3] = c_y[3] s_y \rho_y[3] V_y[3] - c'_y[0] s_y \rho_y[0] V_y[0], \tag{438}$$
$$\Delta_y[4] = c_y[4] s_y \rho_y[4] V_y[4] - c'_y[1] s_y \rho_y[1] V_y[1], \tag{439}$$
$$\Delta_y[5] = c_y[5] s_y \rho_y[5] V_y[5] - c'_y[2] s_y \rho_y[2] V_y[2], \tag{440}$$
$$\Delta_y[6] = c_y[6] s_y \rho_y[6] V_y[6] - c'_y[3] s_y \rho_y[3] V_y[3], \tag{441}$$
$$\Delta_y[7] = c_y[7] s_y \rho_y[7] V_y[7] - c'_y[4] s_y \rho_y[4] V_y[4], \text{ and} \tag{442}$$
$$\Delta_y[8] = c_y[8] s_y \rho_y[8] V_y[8] - c'_y[5] s_y \rho_y[5] V_y[5], \tag{443}$$

where

$$c_y[j] = \begin{cases} 0 & \begin{cases} \texttt{PHAS}[j] + \Delta'_x[j] + \Delta'_y[j] < \text{ split threshold} \\ \quad (\text{for all } j), \end{cases} \\ \texttt{FRCTRLY} & \begin{cases} \texttt{PHAS}[j] + \Delta'_x[j] + \Delta'_y[j] \geq \text{ split threshold and} \\ \texttt{PHAS}[j] + \Delta'_x[j] + \Delta'_y[j] < \\ \quad \texttt{PHAS}[j-3] + \Delta'_x[j-3] + \Delta'_y[j-3] \\ \quad (\text{for } j = 3,4,5,6,7,8), \end{cases} \\ 1 & \begin{cases} \texttt{PHAS}[j] + \Delta'_x[j] + \Delta'_y[j] \geq \text{ split threshold} \\ \quad (\text{for } j = 0,1,2) \\ \texttt{PHAS}[j] + \Delta'_x[j] + \Delta'_y[j] \geq \text{ split threshold and} \\ \texttt{PHAS}[j] + \Delta'_x[j] + \Delta'_y[j] \geq \\ \quad \texttt{PHAS}[j-3] + \Delta'_x[j-3] + \Delta'_y[j-3] \\ \quad (\text{for } j = 3,4,5,6,7,8), \end{cases} \end{cases}$$

$$
c'_y[j] = \begin{cases} 0 & \begin{cases} \texttt{PHAS}[j] + \Delta'_x[j] + \Delta'_y[j] < \text{ split threshold or} \\ \texttt{PHAS}[j+3] + \Delta'_x[j+3] + \Delta'_y[j+3] < \text{ split threshold or} \\ j \rightarrow \texttt{CHIPY} = 1 \text{or } 1024 \\ \quad (\text{for } j = 1,2,3,4,5), \end{cases} \\ \texttt{FRCTRLY} & \begin{cases} \texttt{PHAS}[j] + \Delta'_x[j] + \Delta'_y[j] > \\ \quad \texttt{PHAS}[j+3] + \Delta'_x[j+3] + \Delta'_y[j+3] \text{ and} \\ \texttt{PHAS}[j+3] + \Delta'_x[j+3] + \Delta'_y[j+3] \geq \text{ split threshold} \\ \quad (\text{for } j = 0,1,2,3,4,5), \end{cases} \\ 1 & \begin{cases} \texttt{PHAS}[j] + \Delta'_x[j] + \Delta'_y[j] \leq \\ \quad \texttt{PHAS}[j+3] + \Delta'_x[j+3] + \Delta'_y[j+3] \text{ and} \\ \texttt{PHAS}[j] + \Delta'_x[j] + \Delta'_y[j] \geq \text{ split threshold} \\ \quad (\text{for } j = 0,1,2,3,4,5), \end{cases} \end{cases}
$$

$$
s_y = 1 + \texttt{TCTIY}\,(T - \texttt{FP\_TEMPO})\,, \tag{444}
$$

$$
\begin{cases} s_y \text{ is a temperature dependent scaling factor,} \\ \texttt{TCTIY} \text{ is the } \texttt{CCD\_ID} \text{ dependent value in the column } \texttt{TCTIY} \text{ of the} \\ \quad \texttt{ctifile}, \\ \texttt{FP\_TEMPO} \text{ is the name of a keyword in the } \texttt{ctifile}, \end{cases}
$$

$$
\rho_y[j] = \text{parallel trap density,} \tag{445}
$$

$$
\begin{cases} \rho_y[j] \text{ depends upon the } \texttt{CCD\_ID} \text{ and upon the } \texttt{CHIPX} \text{ and nint(}\texttt{CHIPY\_ADJ}\text{)} \\ \quad \text{coordinates associated with element } j \text{ of } \texttt{PHAS\_ADJ}[j] \text{ (see Fig. 1),} \end{cases}
$$

$$
V_y[j] = \left(\frac{\texttt{PHAS}[j] + \Delta'_x[j] + \Delta'_y[j] - \texttt{PHA}_l}{\texttt{PHA}_{l+1} - \texttt{PHA}_l} \right) (\texttt{VOLUME\_Y}_{l+1} - \texttt{VOLUME\_Y}_l) + \texttt{VOLUME\_Y}_l, \tag{446}
$$

$$
\begin{cases} \texttt{PHA}_l \text{ is the } l^{\text{th}} \text{ element of the column } \texttt{PHA} \text{ in the } \texttt{ctifile}, \\ \texttt{PHA}_l \text{ (and } \texttt{PHA}_{l+1}\text{) are } \texttt{CCD\_ID} \text{ depdendent,} \\ \texttt{PHA}_l \leq \texttt{PHAS}[j] + \Delta'_x[j] + \Delta'_y[j], \\ \text{If } \texttt{PHA}_l > \texttt{PHAS}[j] + \Delta'_x[j] + \Delta'_y[j] \text{ for } l = 0, \text{ then } l = 0, \\ \texttt{PHA}_{l+1} \text{ is the } (l+1)^{\text{th}} \text{ element of the column } \texttt{PHA} \text{ in the } \texttt{ctifile}, \\ \texttt{PHA}_{l+1} > \texttt{PHAS}[j] + \Delta'_x[j] + \Delta'_y[j], \\ \text{If } \texttt{PHA}_{l+1} \leq \texttt{PHAS}[j] + \Delta'_x[j] + \Delta'_y[j] \text{ for } l = n, \text{ where } n \text{ is the last} \\ \quad \text{element, then } l = n, \\ \texttt{VOLUME\_Y}_l \text{ is the } l^{\text{th}} \text{ element of the column } \texttt{VOLUME\_Y} \text{ in the } \texttt{ctifile}, \\ \texttt{VOLUME\_Y}_l, \text{ which is } \texttt{CCD\_ID} \text{ depdendent, is associated with } \texttt{PHA}_l, \\ \texttt{VOLUME\_Y}_{l+1} \text{ is the } (l+1)^{\text{th}} \text{ element of the column } \texttt{VOLUME\_Y} \text{ in the} \\ \quad \texttt{ctifile}, \\ \texttt{VOLUME\_Y}_{l+1}, \text{ which is } \texttt{CCD\_ID} \text{ depdendent, is associated with } \texttt{PHA}_{l+1}, \end{cases}
$$

and T, t', t'_k, and t'_{k+1}, are given by equations. 420, 421, 422, and 423, respectively.

vi. The CTI-adjusted pulse heights

$$
\texttt{PHAS\_ADJ}[j] = \texttt{PHAS}[j] + \Delta_x[j] + \Delta_y[j] \tag{447}
$$

for all j.

vii. A. If

$$
|\texttt{PHAS\_ADJ}'[j] - \texttt{PHAS\_ADJ}[j]| < \texttt{cticonverge} \text{ (for all } j\text{) and} \tag{448}
$$

$$
n \leq \texttt{max\_cti\_iter}, \tag{449}
$$

then the computation of PHAS_ADJ is complete for the event.

B. If

$$|\texttt{PHAS\_ADJ}'[j] - \texttt{PHAS\_ADJ}[j]| \geq \texttt{cticonverge} \text{ (for one or more } j\text{) and} \tag{450}$$
$$n < \texttt{max\_cti\_iter}, \tag{451}$$

then $n = n + 1$ and steps 1.5.16(a)iii–1.5.16(a)vii are repeated.

C. If

$$|\texttt{PHAS\_ADJ}'[j] - \texttt{PHAS\_ADJ}[j]| \geq \texttt{cticonverge} \text{ (for one or more } j\text{) and} \tag{452}$$
$$n \geq \texttt{max\_cti\_iter}, \tag{453}$$

then no additional iterations are performed, the values of PHAS_ADJ[j] from the most recent iteration are used as are, and STATUS[k] = 1 for bit $k = 20$ to indicate that the CTI adjustment did not converge.

17. FLTGRADE:

(a) If

$$\texttt{DATAMODE}_{\rm in} = \text{CC33\_FAINT and} \tag{454}$$
$$\texttt{apply\_cti} = \text{yes}, \tag{455}$$

then

$$\texttt{FLTGRADE} = c_{\rm f}[0] + 2c_{\rm f}[1] + 4c_{\rm f}[2] + 8c_{\rm f}[3] + 16c_{\rm f}[5] + 32c_{\rm f}[6] + 64c_{\rm f}[7] + 128c_{\rm f}[8], \tag{456}$$

where

$$c_{\rm f}[j] = \begin{cases} 0 & \text{if } \texttt{PHAS\_ADJ}[j] < \text{split threshold} \\ 1 & \text{otherwise,} \end{cases} \tag{457}$$

and the elements $j = 0$–3 and 5–8 of PHAS_ADJ are depicted in Figure 1.

(b) If

$$\texttt{DATAMODE}_{\rm in} = \text{CC33\_FAINT and} \tag{458}$$
$$\texttt{apply\_cti} = \text{no}, \tag{459}$$

then

$$\texttt{FLTGRADE} = c_{\rm f}[0] + 2c_{\rm f}[1] + 4c_{\rm f}[2] + 8c_{\rm f}[3] + 16c_{\rm f}[5] + 32c_{\rm f}[6] + 64c_{\rm f}[7] + 128c_{\rm f}[8], \tag{460}$$

where

$$c_{\rm f}[j] = \begin{cases} 0 & \text{if } \texttt{PHAS}[j] < \text{split threshold} \\ 0 & \text{if } \texttt{PHAS}[j] > 4095 \\ 0 & \text{if } \texttt{PHAS}[j] > \texttt{PHAS}[4] \text{ for } j = 0-3) \\ 0 & \text{if } \texttt{PHAS}[j] \geq \texttt{PHAS}[4] \text{ for } j = 5-8) \\ 1 & \text{otherwise.} \end{cases} \tag{461}$$

(c) If

$$\texttt{DATAMODE}_{\rm in} = \text{CC33\_GRADED}, \tag{462}$$

then the FLTGRADE of an event is equal to the value of FLTGRADE for the event in the infile.

18. GRADE:

(a) If the gradefile is specified, then the GRADE of an event is determined from the FLTGRADE of the event as follows.

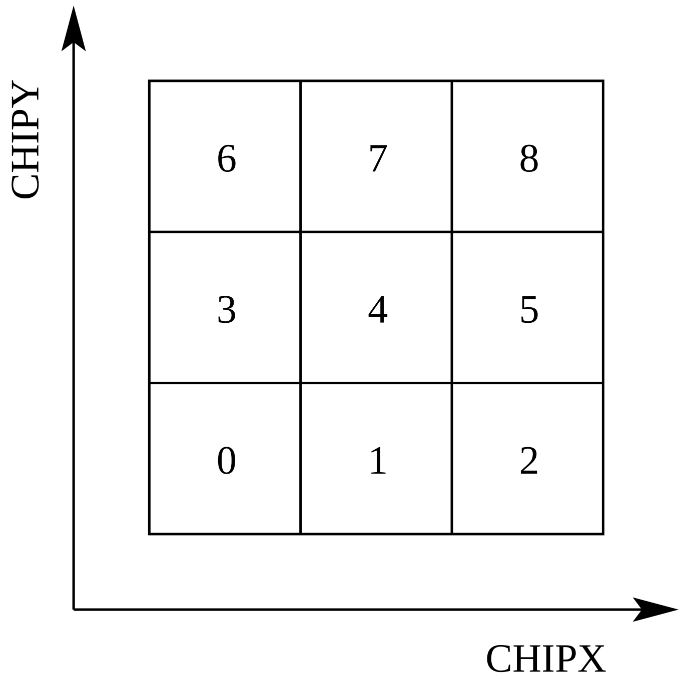

Figure 1: The relative `CHIPX` and `CHIPY` coordinates of the nine elements $j = 0$–8 of a 3 pixel × 3 pixel event island `PHAS`$[j]$ or `PHAS_ADJ`$[j]$.

i. The appropriate HDU of the `gradefile` is identified. This HDU is the one where the header keyword `CBD10001` includes the $\texttt{DATAMODE}_{\rm in}$ of HDU 1 of the `infile`.

ii. The row i of the appropriate HDU of the `gradefile` is identified. This row is the one where

$$\texttt{FLTGRADE}_{{\rm grade},i} = \texttt{FLTGRADE}, \tag{463}$$

where $\texttt{FLTGRADE}_{\rm grade}$ is a column in the `gradefile`.

iii. The `GRADE` of the event is given by

$$\texttt{GRADE} = \texttt{GRADE}_{{\rm grade},i}, \tag{464}$$

where $\texttt{GRADE}_{\rm grade}$ is a column in the `gradefile`.

19. `PHA_RO`:

(a) Not GRADED:
If

$$\texttt{DATAMODE}_{\rm in} = \text{CC33\_FAINT or} \tag{465}$$
$$\texttt{DATAMODE}_{\rm in} = \text{FAINT or} \tag{466}$$
$$\texttt{DATAMODE}_{\rm in} = \text{FAINT\_BIAS or} \tag{467}$$
$$\texttt{DATAMODE}_{\rm in} = \text{VFAINT}, \tag{468}$$

then

i. Compute, if possible:
If

$$\texttt{doevtgrade} = \text{yes}, \tag{469}$$

then

$$\mathtt{PHA\_RO} = \sum_{j=0}^{8} \beta[j] p[j], \tag{470}$$

where

A.

$$p[j] = \mathtt{PHAS}[j], \tag{471}$$

the pulse height that does not have cti- and time-dependent gain adjustments.

B. The elements $j = 0$–8 of PHAS are depicted in Figure 1.

C.

$$\beta[j] = 0 \quad \text{if} \quad p[j] < \text{split threshold}. \tag{472}$$

D.

$$\beta[j] = 0 \text{ if } \begin{cases} p[j] > p[4] \text{ (for } j = 0\text{–}3) \\ p[j] \geq p[4] \text{ (for } j = 5\text{–}8) \end{cases} \tag{473}$$

E. If CORNERS $= -1$, then

$$\beta[0] = \beta[2] = \beta[6] = \beta[8] = 0. \tag{474}$$

F. If CORNERS $= 0$, then there are no additional constraints on $\beta[0]$, $\beta[2]$, $\beta[6]$, and $\beta[8]$.

G. If CORNERS $= 1$, then

$$\beta[0] = 0 \quad \text{if} \quad \beta[1] = 0 \text{ and } \beta[3] = 0. \tag{475}$$
$$\beta[2] = 0 \quad \text{if} \quad \beta[1] = 0 \text{ and } \beta[5] = 0. \tag{476}$$
$$\beta[6] = 0 \quad \text{if} \quad \beta[3] = 0 \text{ and } \beta[7] = 0. \tag{477}$$
$$\beta[8] = 0 \quad \text{if} \quad \beta[5] = 0 \text{ and } \beta[7] = 0. \tag{478}$$

H. If CORNERS $= 2$, then

$$\beta[0] = 0 \quad \text{if} \quad \beta[1] = 0 \text{ or } \beta[3] = 0 \text{ or } \mathtt{GRADE} \neq 6. \tag{479}$$
$$\beta[2] = 0 \quad \text{if} \quad \beta[1] = 0 \text{ or } \beta[5] = 0 \text{ or } \mathtt{GRADE} \neq 6. \tag{480}$$
$$\beta[6] = 0 \quad \text{if} \quad \beta[3] = 0 \text{ or } \beta[7] = 0 \text{ or } \mathtt{GRADE} \neq 6. \tag{481}$$
$$\beta[8] = 0 \quad \text{if} \quad \beta[5] = 0 \text{ or } \beta[7] = 0 \text{ or } \mathtt{GRADE} \neq 6. \tag{482}$$

ii. Otherwise copy:
If

$$\mathtt{doevtgrade} = \text{no} \tag{483}$$

and the `infile` includes the column PHA_RO, then

$$\mathtt{PHA\_RO} = \mathtt{PHA\_RO}_{\text{in}}. \tag{484}$$

iii. Error:
If

$$\mathtt{doevtgrade} = \text{no} \tag{485}$$

and the `infile` does not include the column PHA_RO, then

$$\mathtt{PHA\_RO} = \text{NULL}. \tag{486}$$

(b) Not GRADED:
If

$$\texttt{DATAMODE}_{\rm in} = \text{CC33\_GRADED or} \tag{487}$$
$$\texttt{DATAMODE}_{\rm in} = \text{GRADED,} \tag{488}$$

then

i. Copy PHA_RO, if possible:
If the infile includes the column PHA_RO, then

$$\texttt{PHA\_RO} = \texttt{PHA\_RO}_{\rm in}. \tag{489}$$

ii. Otherwise copy PHA:
If the infile does not include the column PHA_RO and

$$\texttt{TGAINCOR}_{\rm in} = 0, \tag{490}$$

then

$$\texttt{PHA\_RO} = \texttt{PHA}_{\rm in}. \tag{491}$$

iii. Error:
If the infile does not include the column PHA_RO and

$$\texttt{TGAINCOR}_{\rm in} = 1, \tag{492}$$

then

$$\texttt{PHA\_RO} = \text{NULL}. \tag{493}$$

(c) Validation:
If PHA_RO is less than the split threshold, then

$$\texttt{PHA\_RO} = \text{NULL}. \tag{494}$$

20. PHA, including time-dependent gain:

(a) If

$$\texttt{DATAMODE}_{\rm in} = \text{CC33\_FAINT}, \tag{495}$$

then

$$\texttt{PHA} = \sum_{j=0}^{8} \beta[j]p[j], \tag{496}$$

where

i.

$$p[j] = \begin{cases} \texttt{PHAS\_ADJ}[j] & \text{if } \texttt{apply\_cti} = \text{yes} \\ \texttt{PHAS}[j] & \text{if } \texttt{apply\_cti} = \text{no} \end{cases} \tag{497}$$

ii. The elements $j = 0$–8 of PHAS_ADJ (or PHAS) are depicted in Figure 1.

iii.

$$\beta[j] = 0 \quad \text{if} \quad p[j] < \text{split threshold}. \tag{498}$$

iv. If the CTI adjustment is not performed, then

$$\beta[j] = 0 \text{ if } \begin{cases} p[j] > p[4] \text{ (for } j = 0\text{–}3) \\ p[j] \geq p[4] \text{ (for } j = 5\text{–}8) \end{cases} \tag{499}$$

v. If CORNERS $= -1$, then

$$\beta[0] = \beta[2] = \beta[6] = \beta[8] = 0. \tag{500}$$

vi. If CORNERS $= 0$, then there are no additional constraints on $\beta[0]$, $\beta[2]$, $\beta[6]$, and $\beta[8]$.

vii. If CORNERS $= 1$, then

$$\beta[0] = 0 \quad \text{if} \quad \beta[1] = 0 \text{ and } \beta[3] = 0. \tag{501}$$
$$\beta[2] = 0 \quad \text{if} \quad \beta[1] = 0 \text{ and } \beta[5] = 0. \tag{502}$$
$$\beta[6] = 0 \quad \text{if} \quad \beta[3] = 0 \text{ and } \beta[7] = 0. \tag{503}$$
$$\beta[8] = 0 \quad \text{if} \quad \beta[5] = 0 \text{ and } \beta[7] = 0. \tag{504}$$

viii. If CORNERS $= 2$, then

$$\beta[0] = 0 \quad \text{if} \quad \beta[1] = 0 \text{ or } \beta[3] = 0 \text{ or } \texttt{GRADE} \neq 6. \tag{505}$$
$$\beta[2] = 0 \quad \text{if} \quad \beta[1] = 0 \text{ or } \beta[5] = 0 \text{ or } \texttt{GRADE} \neq 6. \tag{506}$$
$$\beta[6] = 0 \quad \text{if} \quad \beta[3] = 0 \text{ or } \beta[7] = 0 \text{ or } \texttt{GRADE} \neq 6. \tag{507}$$
$$\beta[8] = 0 \quad \text{if} \quad \beta[5] = 0 \text{ or } \beta[7] = 0 \text{ or } \texttt{GRADE} \neq 6. \tag{508}$$

(b) If

$$\texttt{DATAMODE}_{\text{in}} = \text{CC33\_GRADED}, \tag{509}$$

then the value of PHA for the event is read from the infile.

(c) If

$$\texttt{apply\_tgain} = \text{yes}, \tag{510}$$

then

$$\texttt{PHA} = \texttt{PHA} - \text{int}\left[\left(\frac{\texttt{TIME} - \texttt{EPOCH1}}{\texttt{EPOCH2} - \texttt{EPOCH1}}\right)(\delta_2 - \delta_1) + \delta_1 - \epsilon\right], \tag{511}$$

where

$$\text{int} = \text{the integer portion of (i.e. truncate or round down),} \tag{512}$$
$$\texttt{TIME} = \text{the time of the event,} \tag{513}$$
$$\texttt{EPOCH1} = \text{a keyword in the } \texttt{tgainfile}, \tag{514}$$
$$\texttt{EPOCH2} = \text{a keyword in the } \texttt{tgainfile}, \tag{515}$$
$$\delta_1 = \left(\frac{\texttt{PHA} - \texttt{PHA}_m[r]}{\texttt{PHA}_{m+1}[r] - \texttt{PHA}_m[r]}\right)(\texttt{DELTPHA1}_{m+1}[r] - \texttt{DELTPHA1}_m[r]) + \tag{516}$$
$$\texttt{DELTPHA1}_m[r], \tag{517}$$

$$\left\{\begin{array}{l} r \text{ is the row of the } \texttt{tgainfile} \text{ where} \\ \quad \left\{\begin{array}{l} \texttt{CCD\_ID}[r] = \texttt{CCD\_ID}, \\ \texttt{CHIPX\_LO}[r] \leq \texttt{CHIPX}, \\ \texttt{CHIPX\_HI}[r] \geq \texttt{CHIPX}, \\ \texttt{CHIPY\_LO}[r] \leq \text{nint}(\texttt{CHIPY\_ADJ}), \text{ and} \\ \texttt{CHIPY\_HI}[r] \geq \text{nint}(\texttt{CHIPY\_ADJ}). \end{array}\right. \\ m \text{ is the element of row } r \text{ where} \\ \quad \left\{\begin{array}{l} \texttt{PHA}_m[r] \leq \texttt{PHA} \text{ and} \\ \texttt{PHA}_{m+1}[r] > \texttt{PHA}. \\ \text{If } \texttt{PHA} < \texttt{PHA}_m[r] \text{ for } m = 0, \text{ then } m = 0. \\ \text{If } \texttt{PHA} \geq \texttt{PHA}_m[r] \text{ for } m = M \text{ and } M \text{ is the last element of } \texttt{PHA}[r], \\ \quad \text{then } m = M - 1. \end{array}\right. \\ \text{The } \texttt{tgainfile} \text{ includes a binary table with columns named} \\ \quad \texttt{CCD\_ID}, \texttt{CHIPX\_LO}, \texttt{CHIPX\_HI}, \texttt{CHIPY\_LO}, \texttt{CHIPY\_HI}, \texttt{PHA}, \texttt{DELTPHA1}, \text{ and} \\ \quad \texttt{DELTPHA2}. \end{array}\right. \tag{518}$$

$$\delta_2 = \left(\frac{\texttt{PHA} - \texttt{PHA}_m[r]}{\texttt{PHA}_{m+1}[r] - \texttt{PHA}_m[r]}\right)(\texttt{DELTPHA2}_{m+1}[r] - \texttt{DELTPHA2}_m[r]) + \tag{519}$$

$$\texttt{DELTPHA2}_m[r], \tag{520}$$

$$\epsilon = \text{is a uniform random deviate in the range } [0, 1), \tag{521}$$

$$\left\{ \text{If } \texttt{rand\_pha} = \text{no}, \text{ then } \epsilon = 0. \right. \tag{522}$$

(d) If

$$\texttt{PHA} \geq 32767, \tag{523}$$

then $\texttt{STATUS}[k] = 1$ for bit $k = 3$.

21. CORN_PHA:

(a) If

$$\texttt{DATAMODE}_{\text{in}} = \text{CC33\_GRADED}, \tag{524}$$

then the value of CORN_PHA is read from the `infile`.

22. ENERGY:

(a) If the parameter `calculate_pi` = yes and the parameter `gainfile` is specified and $\texttt{PHA} > 0$, then

i. The row i in the `gainfile` is identified such that

$$\texttt{CCD\_ID} = \texttt{CCD\_ID}_{\text{gain},i}, \tag{525}$$

$$\texttt{CHIPX\_MIN}_{\text{gain},i} \leq \texttt{CHIPX} \leq \texttt{CHIPX\_MAX}_{\text{gain},i}, \quad \text{and} \tag{526}$$

$$\texttt{CHIPY\_MIN}_{\text{gain},i} \leq \text{nint}(\texttt{CHIPY\_ADJ}) \leq \texttt{CHIPY\_MAX}_{\text{gain},i}, \tag{527}$$

where $\texttt{CCD\_ID}_{\text{gain}}$, $\texttt{CHIPX\_MIN}_{\text{gain}}$, $\texttt{CHIPX\_MAX}_{\text{gain}}$, $\texttt{CHIPY\_MIN}_{\text{gain}}$, and $\texttt{CHIPY\_MAX}_{\text{gain}}$ are columns in the `gainfile`.

ii. A uniform random deviate Δp is computed over the interval from $[-0.5, +0.5)$.

iii. The element j of row i of $\texttt{PHA}_{\text{gain}}$ is identified such that

$$\texttt{PHA}_{\text{gain},i}[j] \leq (\texttt{PHA} + \Delta p) < \texttt{PHA}_{\text{gain},i}[j+1], \tag{528}$$

where $\texttt{PHA}_{\text{gain}}$ is a vector column in the `gainfile`. If $\texttt{PHA} + \Delta p < \texttt{PHA}_{\text{gain},i}[0]$, then $j = 0$. If $\texttt{PHA}_{\text{gain},i}[\texttt{NPOINTS} - 2] \leq \texttt{PHA} + \Delta p$, then $j = \texttt{NPOINTS} - 2$, where NPOINTS is a column in the `gainfile`.

iv. The $\mathtt{ENERGY}$ of an event is computed from the $\mathtt{PHA}$ of the event:

$$\mathtt{ENERGY} = \left(\frac{\mathtt{PHA} + \Delta p - \mathtt{PHA}_{\mathrm{gain},i}[j]}{\mathtt{PHA}_{\mathrm{gain},i}[j+1] - \mathtt{PHA}_{\mathrm{gain},i}[j]}\right)(\mathtt{ENERGY}_{\mathrm{gain},i}[j+1] - \mathtt{ENERGY}_{\mathrm{gain},i}[j]) + \mathtt{ENERGY}_{\mathrm{gain},i}[j], \tag{529}$$

where $\mathtt{ENERGY}_{\mathrm{gain}}$ is a vector column in the `gainfile`.

v. If $\mathtt{ENERGY} < 0$, then $\mathtt{ENERGY} = 0$.

(b) If the parameter `calculate_pi` = yes and the parameter `gainfile` is specified and $\mathtt{PHA} \leq 0$, then $\mathtt{ENERGY} = 0$.

(c) If the parameter `calculate_pi` = no or if the parameter `gainfile` is not specified, then

i. If the `infile` includes the `ENERGY` of an event, then the `ENERGY` of the event is equal to the `ENERGY` in the `infile`.

ii. If the `infile` does not include the `ENERGY` of an event, then $\mathtt{ENERGY} = 0$.

23. `PI`:

(a) If

$$\mathtt{calculate\_pi} = \mathrm{yes}, \tag{530}$$

then

i.

$$\mathtt{PI} = \mathrm{int}\left(\frac{\mathtt{ENERGY}}{\mathtt{pi\_bin\_width}}\right) + 1, \tag{531}$$

where "int" indicates the integer portion of what is in parentheses (i.e. the value is truncated or rounded down).

ii. If

$$\mathtt{PI} < 1, \tag{532}$$

then $\mathtt{PI} = 1$.

iii. If

$$\mathtt{PI} > \mathtt{pi\_num\_bins}, \tag{533}$$

then $\mathtt{PI} = \mathtt{pi\_num\_bins}$.

(b) If

$$\mathtt{calculate\_pi} = \mathrm{no} \tag{534}$$

and the `infile` includes the value of `PI` for an event, then the value of `PI` is read from the `infile`.

24. `pix_adj`:

(a) centroid:

i. If

$$\mathtt{pix\_adj} = \mathrm{centroid} \tag{535}$$

and

$$\mathtt{DATAMODE}_{\mathrm{in}} = \mathrm{CC33\_FAINT\ or} \tag{536}$$
$$\mathtt{DATAMODE}_{\mathrm{in}} = \mathrm{FAINT\ or} \tag{537}$$
$$\mathtt{DATAMODE}_{\mathrm{in}} = \mathrm{FAINT\_BIAS\ or} \tag{538}$$
$$\mathtt{DATAMODE}_{\mathrm{in}} = \mathrm{VFAINT}, \tag{539}$$

then

$$\texttt{CHIPX\_ADJ} = \texttt{CHIPX\_ADJ} - w'[0] + w'[2] - w'[3] + w'[5] - w'[6] + w'[8] \text{ and} \quad (540)$$
$$\texttt{CHIPY\_ADJ} = \texttt{CHIPY\_ADJ} - w'[0] - w'[1] - w'[2] + w'[6] + w'[7] + w'[8], \quad (541)$$

where

$$w'[j] = \frac{w[j]}{\sum_{j=0}^{8} w[j]}, \quad (542)$$

$$w[j] = \begin{cases} p[j] & \text{if the pixel is valid} \\ 0 & \text{if the pixel is invalid,} \end{cases} \quad (543)$$

$$p[j] = \begin{cases} \texttt{PHAS\_ADJ}[j] & \text{if } \texttt{apply\_cti} = \text{yes} \\ \texttt{PHAS}[j] & \text{if } \texttt{apply\_cti} = \text{no,} \end{cases} \quad (544)$$

and the pixel is invalid if

$$\beta[j] = 0 \text{ or} \quad (545)$$
$$\texttt{STATUS}[0] = 1 \text{ or} \quad (546)$$
$$\texttt{STATUS}[1] = 1 \text{ or} \quad (547)$$
$$\texttt{STATUS}[2] = 1 \text{ or} \quad (548)$$
$$\texttt{STATUS}[3] = 1 \text{ or} \quad (549)$$
$$\texttt{STATUS}[4] = 1 \text{ or} \quad (550)$$
$$\texttt{STATUS}[11] = 1 \text{ or} \quad (551)$$
$$\texttt{STATUS}[13] = 1 \text{ or} \quad (552)$$
$$\texttt{STATUS}[14] = 1 \text{ or} \quad (553)$$
$$\texttt{STATUS}[15] = 1 \text{ or} \quad (554)$$
$$\texttt{STATUS}[16] = 1. \quad (555)$$

ii. If

$$\texttt{pix\_adj} = \text{centroid and} \quad (556)$$
$$\texttt{DATAMODE}_{\text{in}} = \text{CC33\_FAINT,} \quad (557)$$

then

$$\texttt{TIME} = \texttt{TIME} + (w'[0] + w'[1] + w'[2] - w'[6] - w'[7] - w'[8]) \times \texttt{TIMEDEL}_{\text{in}}. \quad (558)$$

Note that it is possible for the centroid algorithm to yield adjustments to CHIPX_ADJ and/or CHIPY_ADJ that are greater than half a pixel. However, the adjustment cannot equal or exceed one pixel.

(b) edser:

i. If

$$\texttt{pix\_adj} = \text{edser} \quad (559)$$

and

$$\texttt{DATAMODE}_{\text{in}} = \text{CC33\_FAINT or} \quad (560)$$
$$\texttt{DATAMODE}_{\text{in}} = \text{CC33\_GRADED or} \quad (561)$$
$$\texttt{DATAMODE}_{\text{in}} = \text{FAINT or} \quad (562)$$
$$\texttt{DATAMODE}_{\text{in}} = \text{FAINT\_BIAS or} \quad (563)$$
$$\texttt{DATAMODE}_{\text{in}} = \text{GRADED or} \quad (564)$$
$$\texttt{DATAMODE}_{\text{in}} = \text{VFAINT,} \quad (565)$$

then

A. If

$$\texttt{ENERGY} \neq \text{NaN and} \quad (566)$$
$$\texttt{ENERGY} > 0, \quad (567)$$

then

$$\texttt{CHIPX\_ADJ} = \texttt{CHIPX\_ADJ} + \left(\frac{\texttt{ENERGY} - E[k]}{E[k+1] - E[k]}\right)(\Delta X[k+1] - \Delta X[k]) + \Delta X[k] \quad (568)$$

and

$$\texttt{CHIPY\_ADJ} = \texttt{CHIPY\_ADJ} + \left(\frac{\texttt{ENERGY} - E[k]}{E[k+1] - E[k]}\right)(\Delta Y[k+1] - \Delta Y[k]) + \Delta Y[k], \quad (569)$$

where $E[k]$ and $E[k+1]$, $\Delta X[k]$ and $\Delta X[k+1]$, and $\Delta Y[k]$ and $\Delta Y[k+1]$ are the k and $(k+1)^{th}$ elements of the vector columns $\texttt{ENERGY}_{\text{subpix}}$, $\texttt{CHIPX\_OFFSET}_{\text{subpix}}$, and $\texttt{CHIPY\_OFFSET}_{\text{subpix}}$, respectively. These columns are in the HDU of the subpixfile where the value of the keyword CCD_ID is equal to the value of the CCD_ID of the event. The appropriate row of these columns is the one where $\texttt{FLTGRADE}_{\text{subpix}} = \texttt{FLTGRADE}$. The values of k are the ones where

$$\texttt{ENERGY} \geq E[k] \text{ and} \quad (570)$$
$$\texttt{ENERGY} < E[k+1]. \quad (571)$$

Note that if

$$\texttt{ENERGY} \leq E[0], \quad (572)$$

then $k = 0$. Similarly, if

$$\texttt{ENERGY} \geq E[\texttt{NPOINTS}_{\text{subpix}} - 2], \quad (573)$$

then $k = \texttt{NPOINTS}_{\text{subpix}} - 2$.

B. If

$$\texttt{ENERGY} = \text{NaN or} \quad (574)$$
$$\texttt{ENERGY} \leq 0, \quad (575)$$

then the CHIPX_ADJ and CHIPY_ADJ coordinates are not modified.

ii. If

$$\texttt{pix\_adj} = \text{edser} \quad (576)$$

and

$$\texttt{DATAMODE}_{\text{in}} = \text{CC33\_FAINT or} \quad (577)$$
$$\texttt{DATAMODE}_{\text{in}} = \text{CC33\_GRADED}, \quad (578)$$

then

A. If

$$\texttt{ENERGY} \neq \text{NaN and} \quad (579)$$
$$\texttt{ENERGY} > 0, \quad (580)$$

then

$$\texttt{TIME} = \texttt{TIME} - \left(\left(\frac{\texttt{ENERGY} - E[k]}{E[k+1] - E[k]}\right)(\Delta Y[k+1] - \Delta Y[k]) + \Delta Y[k]\right) \times \texttt{TIMEDEL}_{\text{in}} \quad (581)$$

B. If

$$\texttt{ENERGY} = \text{NaN or} \quad (582)$$
$$\texttt{ENERGY} \leq 0, \quad (583)$$

then the TIME is not modified.

(c) none:
If

$$\texttt{pix\_adj} = \text{none}, \quad (584)$$

then

$$\texttt{CHIPX\_ADJ} = \texttt{CHIPX\_ADJ} \text{ and} \quad (585)$$
$$\texttt{CHIPY\_ADJ} = \texttt{CHIPY\_ADJ} \text{ and} \quad (586)$$
$$\texttt{TIME} = \texttt{TIME}. \quad (587)$$

No sub-pixel adjustments are applied to the values of CHIPX_ADJ and CHIPY_ADJ (for timed exposure mode) or CHIPX_ADJ and TIME (for continuous-clocking mode).

(d) randomize:

i. If

$$\texttt{pix\_adj} = \text{randomize}, \quad (588)$$

then

$$\texttt{CHIPX\_ADJ} = \texttt{CHIPX\_ADJ} + \epsilon_x \text{ and} \quad (589)$$
$$\texttt{CHIPY\_ADJ} = \texttt{CHIPY\_ADJ} + \epsilon_y, \quad (590)$$

where ϵ_x and ϵ_y are a uniform random deviates in the range $[-0.5, +0.5)$ pixel.

ii. If

$$\texttt{DATAMODE}_{\text{in}} = \text{CC33\_FAINT or} \quad (591)$$
$$\texttt{DATAMODE}_{\text{in}} = \text{CC33\_GRADED}, \quad (592)$$

then

$$\texttt{TIME} = \texttt{TIME} - \epsilon_y \times \texttt{TIMEDEL}_{\text{in}}. \quad (593)$$

(e) If

$$\texttt{CHIPX\_ADJ} < 0.5, \quad (594)$$

then

$$\texttt{CHIPX\_ADJ} = 1. \quad (595)$$

(f) If

$$\texttt{CHIPX\_ADJ} \geq 1024.5, \quad (596)$$

then

$$\texttt{CHIPX\_ADJ} = 1024. \quad (597)$$

(g) If

$$\texttt{CHIPY\_ADJ} < 0.5, \quad (598)$$

then

$$\texttt{CHIPY\_ADJ} = 1. \quad (599)$$

(h) If

$$\texttt{CHIPY\_ADJ} \geq 1024.5, \quad (600)$$

then

$$\texttt{CHIPY\_ADJ} = 1024. \quad (601)$$

25. X and Y:

(a) If

$$\texttt{stop} = \text{sky}, \quad (602)$$

then

i. If

$$\texttt{DATAMODE}_{\text{in}} = \text{FAINT or} \quad (603)$$
$$\texttt{DATAMODE}_{\text{in}} = \text{FAINT\_BIAS or} \quad (604)$$
$$\texttt{DATAMODE}_{\text{in}} = \text{GRADED or} \quad (605)$$
$$\texttt{DATAMODE}_{\text{in}} = \text{VFAINT}, \quad (606)$$

then the values of X and Y are computed using the real-valued coordinates CHIPX_ADJ and CHIPY_ADJ and the orientation of the telescope (i.e. RA, DEC, and ROLL) at the time TIME.

ii. If

$$\texttt{DATAMODE}_{\text{in}} = \text{CC33\_FAINT or} \quad (607)$$
$$\texttt{DATAMODE}_{\text{in}} = \text{CC33\_GRADED}, \quad (608)$$

then the values of X and Y are computed using the real-valued coordinates CHIPX_ADJ and $\texttt{CHIPY\_TARG}_{\text{eff}}$ and the orientation of the telescope (i.e. RA, DEC, and ROLL) at the time TIME.

iii. If

$$\texttt{acaofffile} \neq \text{none and} \quad (609)$$
$$\texttt{acaofffile} \neq \text{NONE} \quad (610)$$

and

$$\texttt{CONTENT} \neq \text{TGEVT1} \quad (611)$$

and

$$\texttt{TIME} < \texttt{TIME}_{\text{min}} \text{ or} \quad (612)$$
$$\texttt{TIME} \geq \texttt{TIME}_{\text{max}}, \quad (613)$$

then

$$\texttt{X} = \text{NaN and} \quad (614)$$
$$\texttt{Y} = \text{NaN}. \quad (615)$$

26. SKY_1D:

(a) If

$$\texttt{DATAMODE}_{\rm in} = \text{CC33\_FAINT or} \quad (616)$$
$$\texttt{DATAMODE}_{\rm in} = \text{CC33\_GRADED} \quad (617)$$

and

$$\texttt{stop} = \text{sky}, \quad (618)$$

then

i. The value of SKY_1D is computed using the real-valued coordinates CHIPX_ADJ and $\texttt{CHIPY\_TARG}_{\rm eff}$ and the orientation of the telescope (i.e. RA, DEC, and ROLL) at the time TIME.

ii. If

$$\texttt{acaofffile} \neq \text{none and} \quad (619)$$
$$\texttt{acaofffile} \neq \text{NONE} \quad (620)$$

and

$$\texttt{CONTENT} \neq \text{TGEVT1} \quad (621)$$

and

$$\texttt{TIME} < \texttt{TIME}_{\rm min} \text{ or} \quad (622)$$
$$\texttt{TIME} \geq \texttt{TIME}_{\rm max}, \quad (623)$$

then

$$\texttt{SKY\_1D} = \text{NaN}. \quad (624)$$

27. DETX and DETY:

(a) If

$$\texttt{stop} = \text{det or} \quad (625)$$
$$\texttt{stop} = \text{tan or} \quad (626)$$
$$\texttt{stop} = \text{sky}, \quad (627)$$

then

i. The values of DETX and DETY are computed using the real-valued coordinates CHIPX_ADJ and CHIPY_ADJ and the orientation of the SIM (i.e. DY, DZ, and DTHETA) at the time TIME.

ii. If

$$\texttt{acaofffile} \neq \text{none and} \quad (628)$$
$$\texttt{acaofffile} \neq \text{NONE} \quad (629)$$

and

$$\texttt{CONTENT} \neq \text{TGEVT1} \quad (630)$$

and

$$\texttt{TIME} < \texttt{TIME}_{\rm min} \text{ or} \quad (631)$$
$$\texttt{TIME} \geq \texttt{TIME}_{\rm max}, \quad (632)$$

then

$$\texttt{DETX} = \text{NaN and} \quad (633)$$
$$\texttt{DETY} = \text{NaN.} \quad (634)$$

28. TDETX and TDETY:

(a) If

$$\texttt{stop} = \text{tdet or} \quad (635)$$
$$\texttt{stop} = \text{det or} \quad (636)$$
$$\texttt{stop} = \text{tan or} \quad (637)$$
$$\texttt{stop} = \text{sky} \quad (638)$$

then

i. The values of TDETX and TDETY are computed using the values of nint(CHIPX_ADJ) and nint(CHIPY_ADJ). Here, "nint" indicates that the real-valued coordinate is rounded to the nearest integer.

ii. If

$$\texttt{acaofffile} \neq \text{none and} \quad (639)$$
$$\texttt{acaofffile} \neq \text{NONE} \quad (640)$$

and

$$\texttt{CONTENT} \neq \text{TGEVT1} \quad (641)$$

and

$$\texttt{TIME} < \texttt{TIME}_{\text{min}} \text{ or} \quad (642)$$
$$\texttt{TIME} \geq \texttt{TIME}_{\text{max}}, \quad (643)$$

then

$$\texttt{TDETX} = \text{NULL and} \quad (644)$$
$$\texttt{TDETY} = \text{NULL.} \quad (645)$$

1.5.4 Write outfile

1. PIX_ADJ:

(a) If

$$\texttt{pix\_adj} = \text{centroid,} \quad (646)$$

then

$$\texttt{PIX\_ADJ} = \text{CENTROID.} \quad (647)$$

(b) If

$$\texttt{pix\_adj} = \text{edser,} \quad (648)$$

then

$$\texttt{PIX\_ADJ} = \text{EDSER.} \quad (649)$$

(c) If

$$\texttt{pix\_adj} = \text{none}, \tag{650}$$

then

$$\texttt{PIX\_ADJ} = \text{NONE}. \tag{651}$$

(d) If

$$\texttt{pix\_adj} = \text{randomize}, \tag{652}$$

then

$$\texttt{PIX\_ADJ} = \text{RANDOMIZE}. \tag{653}$$

2. RAND_SKY:

(a) If

$$\texttt{pix\_adj} = \text{centroid}, \tag{654}$$

then

$$\texttt{RAND\_SKY} = 0.0. \tag{655}$$

(b) If

$$\texttt{pix\_adj} = \text{edser}, \tag{656}$$

then

$$\texttt{RAND\_SKY} = 0.0. \tag{657}$$

(c) If

$$\texttt{pix\_adj} = \text{none}, \tag{658}$$

then

$$\texttt{RAND\_SKY} = 0.0. \tag{659}$$

(d) If

$$\texttt{pix\_adj} = \text{randomize}, \tag{660}$$

then

$$\texttt{RAND\_SKY} = 0.5. \tag{661}$$

3. TIME_ADJ:

(a) Timed-exposure mode:
If

$$\texttt{DATAMODE}_{\text{in}} = \text{FAINT or} \tag{662}$$
$$\texttt{DATAMODE}_{\text{in}} = \text{FAINT\_BIAS or} \tag{663}$$
$$\texttt{DATAMODE}_{\text{in}} = \text{GRADED or} \tag{664}$$
$$\texttt{DATAMODE}_{\text{in}} = \text{VFAINT}, \tag{665}$$

then

$$\texttt{TIME\_ADJ} = \text{NONE}. \tag{666}$$

(b) Continuous-clocking mode:

i. Set

$$\texttt{TIME\_ADJ} = \text{MIDCHIP}. \tag{667}$$

ii. If

$$\texttt{OBS\_MODE} = \text{pointing or} \tag{668}$$
$$\texttt{OBS\_MODE} = \text{POINTING} \tag{669}$$

and

$$\texttt{acaofffile} \neq \text{none and} \tag{670}$$
$$\texttt{acaofffile} \neq \text{NONE,} \tag{671}$$

then

$$\texttt{TIME\_ADJ} = \text{TARGET}. \tag{672}$$

iii. If

$$\texttt{OBS\_MODE} = \text{pointing or} \tag{673}$$
$$\texttt{OBS\_MODE} = \text{POINTING} \tag{674}$$

and

$$\texttt{CONTENT}_{\text{in}} = \text{TGEVT1,} \tag{675}$$

then

$$\texttt{TIME\_ADJ} = \text{GRATING}. \tag{676}$$

2 TBD

- Complete the spec to include all of the timed exposure mode processing.
- Complete sections 1.1, 1.2, 1.3, and 1.4.
- Should CONTENTs other than EVT0, EVT1, TGEVT1, and EVT2 be included?
- Should CONTENT = EVT2 be dropped?
- Should DATAMODEs other than CC33_FAINT, CC33_GRADED, FAINT, FAINT_BIAS, GRADED, and VFAINT be included?
- Are the RA_TARG, DEC_TARG, RA_NOM, DEC_NOM, and TIMEDEL keywords in the output of afe (need obsfile sometimes)?
- What if TIME_RO is not in the infile (output of afe? EVT2 files?)?
- Make sure that the STATUS bits are unset and reset properly.
- What about aoff and soff files instead of asol files?
- Are the β in PHA_RO the same as the β in PHA?
- Should something be done about SKY_1D?
- Drop the hack when pix_chip_to_fpc can handle negative $\texttt{CHIPY\_TARG}_{\text{eff}}$ coordinates while computing the coordinates X, Y, and SKY_1D.