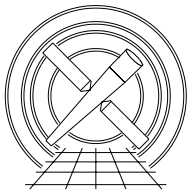

MIT Kavli Institute **Chandra X-Ray Center**

MEMORANDUM
June 22, 2014

To:	Jonathan McDowell, SDS Group Leader
From:	Glenn E. Allen, SDS
Subject:	`acis_build_chip_gti`
Revision:	2.0
URL:	http://space.mit.edu/CXC/docs/docs.html#gti
File:	/inconceivable/d0/SDS/specs/acis_build_chip_gti/acis_build_chip_gti_2.0.tex

1 `acis_build_chip_gti`

1.1 Description

For an ACIS CCD, a good-time interval (GTI) is a continuous set of frames during which the detector operated nominally.

1.2 Input

1. A Level 1 exposure-statistics file (acis*stat1.fits)
2. A Level 1 event-data file (acis*evt1.fits)
   (This file is also the output file.)
3. One or more Level 1 aspect-solution file(s) (pcad*asol1.fits)
4. A parameter file that includes a list of the CALDB files used by pixlib
5. The `CCD_ID` of the aim-point CCD
6. A parameter that indicates whether continuous-clocking mode event times are the times of arrival or the read-out times

1.3 Output

The input Level 1 event-data file is modified to include

- several exposure-related keywords and
- one GTI HDU for each valid CCD.

1.4 Parameters

1. `infile`,f,a,“”,,,“Name of input exposure-statistics file”
2. `outfile`,f,a,“”,,,“Name of event-data file to be modified”
3. `aspfile`,f,a,“”,,,“Name(s) of input aspect-solution file(s)”
4. `geompar`,f,h,“geom”,,,“Name of input pixlib parameter file”
5. `nominalchip`,s,h,“default”,default|0|1|2|3|4|5|6|7|8|9,,“Aim-point CCD_ID”
6. `calc_cc_times`,b,h,“yes”,yes|no,,“Are the event times for a CC-mode observation the times of arrival?”
7. `verbose`,i,h,0,0,5,“Amount of messages produced (0=none, 5=most)”
8. `mode`,s,h,“ql”,,,

1.5 Processing

1. Error checking:
   (a) `infile`:
      i. If the `infile` does not exist, then `acis_build_chip_gti` exits with an error message.
      ii. If the `infile` exists, but the file permissions do not allow it to be read, then `acis_build_chip_gti` exits with an error message.
      iii. If the `infile` does not have an HDU $h_{\rm in}$ with the keyword
      $$\texttt{CONTENT} = \text{EXPSTATS}, \tag{1}$$
      then `acis_build_chip_gti` exits with an error message.
      iv. If HDU $h_{\rm in}$ does not include the header keywords
      - `FLSHTIME`,
      - `TIMEDEL`, and
      - `TIMEPIXR`,

      then `acis_build_chip_gti` exits with an error message. Hereafter the values of these keywords are referred to as $\texttt{FLSHTIME}_{\rm in}$, $\texttt{TIMEDEL}_{\rm in}$, and $\texttt{TIMEPIXR}_{\rm in}$, respectively.
      v. If HDU $h_{\rm in}$ does not include a binary table with the columns
      - `CCD_ID`,
      - `EVTSENT`,
      - `EXPNO`, and
      - `TIME`,

      then `acis_build_chip_gti` exits with an error message. Hereafter these columns are referred to as $\texttt{CCD\_ID}_{\rm in}$, $\texttt{EVTSENT}_{\rm in}$, $\texttt{EXPNO}_{\rm in}$, and $\texttt{TIME}_{\rm in}$, respectively.
   (b) `outfile`:
      i. If the `outfile` does not exist, then `acis_build_chip_gti` exits with an error message.
      ii. If the `outfile` exists, but the file permissions do not allow it to be read and modified, then `acis_build_chip_gti` exits with an error message.
      iii. If the `outfile` does not have an HDU $h_{\rm out}$ with the keyword
      $$\texttt{CONTENT} = \text{EVT1}, \tag{2}$$
      then `acis_build_chip_gti` exits with an error message.

iv. If HDU $h_{\rm out}$ of the `outfile` does not include the header keyword
- `DATAMODE`,

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

v. If

$$\texttt{DATAMODE}_{\rm out} \neq \text{CC33\_FAINT and} \quad (3)$$
$$\texttt{DATAMODE}_{\rm out} \neq \text{CC33\_GRADED and} \quad (4)$$
$$\texttt{DATAMODE}_{\rm out} \neq \text{FAINT and} \quad (5)$$
$$\texttt{DATAMODE}_{\rm out} \neq \text{FAINT\_BIAS and} \quad (6)$$
$$\texttt{DATAMODE}_{\rm out} \neq \text{GRADED and} \quad (7)$$
$$\texttt{DATAMODE}_{\rm out} \neq \text{VFAINT,} \quad (8)$$

then `acis_build_chip_gti` exits with an error message.

vi. If

$$\texttt{DATAMODE}_{\rm out} = \text{CC33\_FAINT or} \quad (9)$$
$$\texttt{DATAMODE}_{\rm out} = \text{CC33\_GRADED,} \quad (10)$$

if the parameter `calc_cc_times` = no, and if HDU $h_{\rm out}$ does not include the keywords `RA_TARG` and `DEC_TARG`, then `acis_build_chip_gti` exits with an error message. Hereafter the values of these keywords are referred to as $\texttt{RA\_TARG}_{\rm out}$ and $\texttt{DEC\_TARG}_{\rm out}$, respectively.

vii. If HDU $h_{\rm out}$ does not include a binary table with the columns
- `CCD_ID` and
- `EXPNO`,

then `acis_build_chip_gti` exits with an error message. Hereafter these columns are referred to as $\texttt{CCD\_ID}_{\rm out}$ and $\texttt{EXPNO}_{\rm out}$, respectively.

(c) `aspfile`:

i. If the `aspfile` does not exist, then `acis_build_chip_gti` exits with an error message.

ii. If the `aspfile` exists, but the file permissions do not allow it to be read, then `acis_build_chip_gti` exits with an error message.

iii. If the `aspfile` does not have an HDU $h_{\rm asp}$ that has the keyword

$$\texttt{CONTENT} = \text{ASPSOL,} \quad (11)$$

then `acis_build_chip_gti` exits with an error message.

iv. If HDU $h_{\rm asp}$ does not include a binary table with the columns
- `DEC`,
- `DTHETA`,
- `DY`,
- `DZ`,
- `RA`,
- `ROLL`, and
- `TIME`

then `acis_build_chip_gti` exits with an error message.

(d) `nominalchip`:

i. The parameter string `nominalchip` is converted to contain only lower case letters.

ii. If

$$\texttt{nominalchip} \neq \text{default and} \tag{12}$$
$$\texttt{nominalchip} \neq 0 \text{ and} \tag{13}$$
$$\texttt{nominalchip} \neq 1 \text{ and} \tag{14}$$
$$\texttt{nominalchip} \neq 2 \text{ and} \tag{15}$$
$$\texttt{nominalchip} \neq 3 \text{ and} \tag{16}$$
$$\texttt{nominalchip} \neq 4 \text{ and} \tag{17}$$
$$\texttt{nominalchip} \neq 5 \text{ and} \tag{18}$$
$$\texttt{nominalchip} \neq 6 \text{ and} \tag{19}$$
$$\texttt{nominalchip} \neq 7 \text{ and} \tag{20}$$
$$\texttt{nominalchip} \neq 8 \text{ and} \tag{21}$$
$$\texttt{nominalchip} \neq 9, \tag{22}$$

then `acis_build_chip_gti` exits with an error message.

(e) `calc_cc_times`:

i. The parameter string `calc_cc_times` is converted to contain only lower case letters.

ii. If

$$\texttt{calc\_cc\_times} \neq \text{yes and} \tag{23}$$
$$\texttt{calc\_cc\_times} \neq \text{no}, \tag{24}$$

then `acis_build_chip_gti` exits with an error message.

2. `DTCOR`:
The value of `DTCOR`, which does not depend on the `CCD_ID`, is given by the following expressions.

(a) If

$$\texttt{DATAMODE}_{\text{out}} = \text{FAINT or} \tag{25}$$
$$\texttt{DATAMODE}_{\text{out}} = \text{FAINT\_BIAS or} \tag{26}$$
$$\texttt{DATAMODE}_{\text{out}} = \text{GRADED or} \tag{27}$$
$$\texttt{DATAMODE}_{\text{out}} = \text{VFAINT}, \tag{28}$$

then

$$\texttt{DTCOR} = \frac{\texttt{TIMEDEL}_{\text{in}} - 0.04104}{\texttt{TIMEDEL}_{\text{in}} + \texttt{FLSHTIME}_{\text{in}}}. \tag{29}$$

(b) If

$$\texttt{DATAMODE}_{\text{out}} = \text{CC33\_FAINT or} \tag{30}$$
$$\texttt{DATAMODE}_{\text{out}} = \text{CC33\_GRADED}, \tag{31}$$

then

$$\texttt{DTCOR} = 0.99609375 \tag{32}$$

(i.e. 510/512).

3. Valid `CCD_ID`s:
The set of valid `CCD_ID`s is identified. Here, `CCD_ID` c is defined as valid if there are one or more rows (i.e. frames) in HDU h_{in} of the `infile` where $\texttt{CCD\_ID}_{\text{in}} = c$ or if there are one or more rows (i.e. events) in HDU h_{out} of the `outfile` where $\texttt{CCD\_ID}_{\text{out}} = c$. If there are no valid `CCD_ID`s, then `acis_build_chip_gti` exits with an error message.

4. For each valid CCD_ID:
   The following steps are performed for each valid CCD_ID c.

   (a) Identify the valid EXPNOs:
   An EXPNO is valid for CCD_ID c if

$$\begin{aligned} \texttt{CCD\_ID}_{\rm in}[r_{\rm in}] &= c, & (33)\\ \texttt{EXPNO}_{\rm in}[r_{\rm in}] &\geq \texttt{EXPNO}_{\rm min}, & (34) \end{aligned}$$

   and

   i. if $\texttt{EVTSENT}_{\rm in}[r_{\rm in}] = 0$, then the total number of rows $N_{\rm out}$ where

$$\begin{aligned} \texttt{CCD\_ID}_{\rm out}[r_{\rm out}] &= c \text{ and} & (35)\\ \texttt{EXPNO}_{\rm out}[r_{\rm out}] &= \texttt{EXPNO}_{\rm in}[r_{\rm in}] & (36) \end{aligned}$$

   is zero.

   ii. if $\texttt{EVTSENT}_{\rm in}[r_{\rm in}] > 0$, then the total number of rows $N_{\rm out}$ where

$$\begin{aligned} \texttt{CCD\_ID}_{\rm out}[r_{\rm out}] &= c \text{ and} & (37)\\ \texttt{EXPNO}_{\rm out}[r_{\rm out}] &= \texttt{EXPNO}_{\rm in}[r_{\rm in}] & (38) \end{aligned}$$

   is equal to $\texttt{EVTSENT}_{\rm in}[r_{\rm in}]$.

   Here $r_{\rm in}$ and $r_{\rm out}$ are rows in HDUs $h_{\rm in}$ and $h_{\rm out}$ of the `infile` and `outfile`, respectively. The value of $\texttt{EXPNO}_{\rm min}$ is specified as follows. If

$$\begin{aligned} \texttt{DATAMODE}_{\rm out} &= \text{FAINT or} & (39)\\ \texttt{DATAMODE}_{\rm out} &= \text{FAINT\_BIAS or} & (40)\\ \texttt{DATAMODE}_{\rm out} &= \text{GRADED or} & (41)\\ \texttt{DATAMODE}_{\rm out} &= \text{VFAINT}, & (42) \end{aligned}$$

   then $\texttt{EXPNO}_{\rm min} = 3$. If

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

   then $\texttt{EXPNO}_{\rm min} = 4$.
   If there are no valid EXPNOs for CCD_ID c, then `acis_build_chip_gti` exits with an error message.

   (b) GTI START and STOP times:
   Each consecutive set of valid EXPNOs from $\texttt{EXPNO}_i$ to $\texttt{EXPNO}_j$ for CCD_ID c is a GTI for the CCD. The GTI START and STOP times associated with this set of EXPNOs is given by the following expressions.

   i. If

$$\begin{aligned} \texttt{DATAMODE}_{\rm out} &= \text{FAINT or} & (45)\\ \texttt{DATAMODE}_{\rm out} &= \text{FAINT\_BIAS or} & (46)\\ \texttt{DATAMODE}_{\rm out} &= \text{GRADED or} & (47)\\ \texttt{DATAMODE}_{\rm out} &= \text{VFAINT}, & (48) \end{aligned}$$

   then

$$\begin{aligned} \texttt{START} &= \texttt{TIME}_{\rm in}[r_{{\rm in},i}] - \texttt{TIMEPIXR}_{\rm in} \times \texttt{TIMEDEL}_{\rm in} - \texttt{FLSHTIME}_{\rm in} \text{ and} & (49)\\ \texttt{STOP} &= \texttt{TIME}_{\rm in}[r_{{\rm in},j}] + (1 - \texttt{TIMEPIXR}_{\rm in}) \times \texttt{TIMEDEL}_{\rm in}, & (50) \end{aligned}$$

where the row $r_{\mathrm{in},i}$ is the one where

$$\mathtt{CCD\_ID}_{\mathrm{in}}[r_{\mathrm{in},i}] = c \text{ and} \tag{51}$$
$$\mathtt{EXPNO}_{\mathrm{in}}[r_{\mathrm{in},i}] = \mathtt{EXPNO}_i \tag{52}$$

and the row $r_{\mathrm{in},j}$ is the one where

$$\mathtt{CCD\_ID}_{\mathrm{in}}[r_{\mathrm{in},j}] = c \text{ and} \tag{53}$$
$$\mathtt{EXPNO}_{\mathrm{in}}[r_{\mathrm{in},j}] = \mathtt{EXPNO}_j. \tag{54}$$

Note that the GTIs include the $\mathtt{FLSHTIME}_{\mathrm{in}}$ because DTCOR includes it.

ii. If

$$\mathtt{DATAMODE}_{\mathrm{out}} = \text{CC33\_FAINT or} \tag{55}$$
$$\mathtt{DATAMODE}_{\mathrm{out}} = \text{CC33\_GRADED} \tag{56}$$

and if the parameter calc_cc_times = yes, then

$$\mathtt{START} = \mathtt{TIME}_{\mathrm{in}}[r_{\mathrm{in},i}] - \mathtt{TIMEPIXR}_{\mathrm{in}} \times \mathtt{TIMEDEL}_{\mathrm{in}} \text{ and} \tag{57}$$
$$\mathtt{STOP} = \mathtt{TIME}_{\mathrm{in}}[r_{\mathrm{in},j}] + (1 - \mathtt{TIMEPIXR}_{\mathrm{in}}) \times \mathtt{TIMEDEL}_{\mathrm{in}}. \tag{58}$$

iii. If

$$\mathtt{DATAMODE}_{\mathrm{out}} = \text{CC33\_FAINT or} \tag{59}$$
$$\mathtt{DATAMODE}_{\mathrm{out}} = \text{CC33\_GRADED} \tag{60}$$

and if the parameter calc_cc_times = no, then

$$\begin{aligned}\mathtt{START} = {} & \mathtt{TIME}_{\mathrm{in}}[r_{\mathrm{in},i}] - \mathtt{TIMEPIXR}_{\mathrm{in}} \times \mathtt{TIMEDEL}_{\mathrm{in}} + \\ & (\mathtt{CHIPY\_TARG}[\mathtt{TIME}_{\mathrm{in}}[r_{\mathrm{in},i}]] + 1028) \times 0.00285 \text{ and}\end{aligned} \tag{61}$$
$$\begin{aligned}\mathtt{STOP} = {} & \mathtt{TIME}_{\mathrm{in}}[r_{\mathrm{in},j}] + (1 - \mathtt{TIMEPIXR}_{\mathrm{in}}) \times \mathtt{TIMEDEL}_{\mathrm{in}} + \\ & (\mathtt{CHIPY\_TARG}[\mathtt{TIME}_{\mathrm{in}}[r_{\mathrm{in},j}]] + 1028) \times 0.00285,\end{aligned} \tag{62}$$

where $\mathtt{CHIPY\_TARG}[\mathtt{TIME}_{\mathrm{in}}[r_{\mathrm{in},i}]]$ and $\mathtt{CHIPY\_TARG}[\mathtt{TIME}_{\mathrm{in}}[r_{\mathrm{in},j}]]$ are the CHIPY locations of the sky coordinates $\mathtt{RA\_TARG}_{\mathrm{out}}$ and $\mathtt{DEC\_TARG}_{\mathrm{out}}$ at the times $\mathtt{TIME}_{\mathrm{in}}[r_{\mathrm{in},i}]$ and $\mathtt{TIME}_{\mathrm{in}}[r_{\mathrm{in},j}]$, respectively. The aspfile, geompar, and pixlib are used to determine the values of $\mathtt{CHIPY\_TARG}[\mathtt{TIME}_{\mathrm{in}}[r_{\mathrm{in},i}]]$ and $\mathtt{CHIPY\_TARG}[\mathtt{TIME}_{\mathrm{in}}[r_{\mathrm{in},j}]]$.

(c) ONTIMEc:
The value of ONTIMEc is given by

$$\mathtt{ONTIME}c = \sum_k \left(\mathtt{STOP}_k - \mathtt{START}_k\right), \tag{63}$$

where $\mathtt{START}_k$ and $\mathtt{STOP}_k$ are the START and STOP times, respectively, of the k^{th} GTI for CCD_ID c.

(d) LIVTIMEc:
The value of LIVTIMEc is given by

$$\mathtt{LIVTIME}c = \mathtt{ONTIME}c \times \mathtt{DTCOR}. \tag{64}$$

(e) EXPOSURc:
The value of EXPOSURc is given by

$$\mathtt{EXPOSUR}c = \mathtt{ONTIME}c \times \mathtt{DTCOR} \tag{65}$$

(i.e. EXPOSURc = LIVTIMEc).

5. Aim-point CCD:
   If the CCD_ID $c = c_{\rm aim}$, where $c_{\rm aim}$ is the CCD_ID of the CCD at the aim point, then

$$\texttt{ONTIME} = \texttt{ONTIME}c, \tag{66}$$
$$\texttt{LIVETIME} = \texttt{LIVTIME}c, \text{ and} \tag{67}$$
$$\texttt{EXPOSURE} = \texttt{EXPOSUR}c. \tag{68}$$

6. Write output:

   (a) The HDU $h_{\rm out}$ of the outfile is modified to include the keywords

   - DTCOR,
   - EXPOSURE,
   - EXPOSURc (one such keyword for each valid CCD_ID),
   - LIVETIME,
   - LIVTIMEc (one such keyword for each valid CCD_ID),
   - ONTIME, and
   - ONTIMEc (one such keyword for each valid CCD_ID),

   (b) The outfile is modified to include a GTI HDU for each valid CCD. Each one of these HDUs includes a binary table with the columns

   - START and
   - STOP.

   These columns include one row for each GTI for the CCD.

1.6 TBD

- Should there be error checking for the parameter geompar?
- Are there DATAMODEs other than CC33_FAINT, CC33_GRADED, FAINT, FAINT_BIAS, GRADED, and VFAINT that should be included?
- How is the aim-point CCD_ID determined? DETNAM? SIM_Z? $(X, Y) = (4096.5, 4096.5)$?
- Are the keywords DTCOR, EXPOSURE, EXPOSUREc, LIVETIME, LIVTIMEc, ONTIME, and ONTIMEc written by acis_build_chip_gti, or are they written after the acis_build_chip_gti GTIs are merged with the mtl GTIs?
- Is there a systematic offset for the mission-timeline GTIs with respect to the GTIs produced by acis_build_chip_gti?
- How can the mission-timeline GTIs be merged with the acis_build_chip_gti GTIs so that they are aligned with the frame boundaries?