MIT Kavli Institute

Chandra X-Ray Center

MEMORANDUM
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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_{in} with the keyword

$$\texttt{CONTENT} = \text{EXPSTATS}, \tag{1}$$

      then `acis_build_chip_gti` exits with an error message.
      iv. If HDU h_{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 $\texttt{FLSHTIME}_{\text{in}}$, $\texttt{TIMEDEL}_{\text{in}}$, and $\texttt{TIMEPIXR}_{\text{in}}$, respectively.
      v. If HDU h_{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 $\texttt{CCD\_ID}_{\text{in}}$, $\texttt{EVTSENT}_{\text{in}}$, $\texttt{EXPNO}_{\text{in}}$, and $\texttt{TIME}_{\text{in}}$, 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_{out} with the keyword

$$\texttt{CONTENT} = \text{EVT1}, \tag{2}$$

      then `acis_build_chip_gti` exits with an error message.

iv. If HDU h_{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 $\mathtt{DATAMODE}_{\mathrm{out}}$.

v. If

$$\begin{aligned}
\mathtt{DATAMODE}_{\mathrm{out}} &\neq \text{CC33_FAINT and} && (3)\\
\mathtt{DATAMODE}_{\mathrm{out}} &\neq \text{CC33_GRADED and} && (4)\\
\mathtt{DATAMODE}_{\mathrm{out}} &\neq \text{FAINT and} && (5)\\
\mathtt{DATAMODE}_{\mathrm{out}} &\neq \text{FAINT_BIAS and} && (6)\\
\mathtt{DATAMODE}_{\mathrm{out}} &\neq \text{GRADED and} && (7)\\
\mathtt{DATAMODE}_{\mathrm{out}} &\neq \text{VFAINT,} && (8)
\end{aligned}$$

then `acis_build_chip_gti` exits with an error message.

vi. If

$$\begin{aligned}
\mathtt{DATAMODE}_{\mathrm{out}} &= \text{CC33_FAINT or} && (9)\\
\mathtt{DATAMODE}_{\mathrm{out}} &= \text{CC33_GRADED,} && (10)
\end{aligned}$$

if the parameter `calc_cc_times` = no, and if HDU h_{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 $\mathtt{RA\_TARG}_{\mathrm{out}}$ and $\mathtt{DEC\_TARG}_{\mathrm{out}}$, respectively.

vii. If HDU h_{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 $\mathtt{CCD\_ID}_{\mathrm{out}}$ and $\mathtt{EXPNO}_{\mathrm{out}}$, 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_{asp} that has the keyword

$$\mathtt{CONTENT} = \text{ASPSOL,} \qquad (11)$$

then `acis_build_chip_gti` exits with an error message.

iv. If HDU h_{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

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

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

$$
\begin{aligned}
\texttt{calc\_cc\_times} &\neq \text{yes and} && (23)\\
\texttt{calc\_cc\_times} &\neq \text{no,} && (24)
\end{aligned}
$$

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

$$
\begin{aligned}
\texttt{DATAMODE}_{\text{out}} &= \text{FAINT or} && (25)\\
\texttt{DATAMODE}_{\text{out}} &= \text{FAINT\_BIAS or} && (26)\\
\texttt{DATAMODE}_{\text{out}} &= \text{GRADED or} && (27)\\
\texttt{DATAMODE}_{\text{out}} &= \text{VFAINT,} && (28)
\end{aligned}
$$

then

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

(b) If

$$
\begin{aligned}
\texttt{DATAMODE}_{\text{out}} &= \text{CC33\_FAINT or} && (30)\\
\texttt{DATAMODE}_{\text{out}} &= \text{CC33\_GRADED,} && (31)
\end{aligned}
$$

then

$$\texttt{DTCOR} = 0.99609375 \quad (32)$$

(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

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

   and

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

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

      is zero.

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

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

      is equal to $\mathtt{EVTSENT}_{\text{in}}[r_{\text{in}}]$.

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

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

   then $\mathtt{EXPNO}_{\text{min}} = 3$. If

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

   then $\mathtt{EXPNO}_{\text{min}} = 4$.
   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 $\mathtt{EXPNO}_i$ to $\mathtt{EXPNO}_j$ 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

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

      then

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

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

$$\begin{aligned} \texttt{CCD\_ID}_{\mathrm{in}}[r_{\mathrm{in},i}] &= c \text{ and} && (51)\\ \texttt{EXPNO}_{\mathrm{in}}[r_{\mathrm{in},i}] &= \texttt{EXPNO}_i && (52) \end{aligned}$$

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

$$\begin{aligned} \texttt{CCD\_ID}_{\mathrm{in}}[r_{\mathrm{in},j}] &= c \text{ and} && (53)\\ \texttt{EXPNO}_{\mathrm{in}}[r_{\mathrm{in},j}] &= \texttt{EXPNO}_j. && (54) \end{aligned}$$

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

ii. If

$$\begin{aligned} \texttt{DATAMODE}_{\mathrm{out}} &= \text{CC33\_FAINT or} && (55)\\ \texttt{DATAMODE}_{\mathrm{out}} &= \text{CC33\_GRADED} && (56) \end{aligned}$$

and if the parameter calc_cc_times = yes, then

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

iii. If

$$\begin{aligned} \texttt{DATAMODE}_{\mathrm{out}} &= \text{CC33\_FAINT or} && (59)\\ \texttt{DATAMODE}_{\mathrm{out}} &= \text{CC33\_GRADED} && (60) \end{aligned}$$

and if the parameter calc_cc_times = no, then

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

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

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

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

where $\texttt{START}_k$ and $\texttt{STOP}_k$ 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

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

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

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

(i.e. EXPOSURc = LIVTIMEc).

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

$$\begin{aligned} \texttt{ONTIME} &= \texttt{ONTIME}c, & (66)\\ \texttt{LIVETIME} &= \texttt{LIVTIME}c, \text{ and} & (67)\\ \texttt{EXPOSURE} &= \texttt{EXPOSUR}c. & (68) \end{aligned}$$

6. Write output:
   (a) The HDU h_{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?