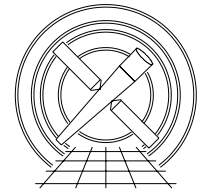




MIT Kavli Institute



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. `asppfile`,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

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

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 `FLSHTIMEin`, `TIMEDELin`, and `TIMEPIXRin`, 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 `CCD_IDin`, `EVTSENTin`, `EXPNOin`, and `TIMEin`, 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

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

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 `DATAMODEout`.

v. If

$$\text{DATAMODE}_{\text{out}} \neq \text{CC33_FAINT} \text{ and} \tag{3}$$

$$\text{DATAMODE}_{\text{out}} \neq \text{CC33_GRADED} \text{ and} \tag{4}$$

$$\text{DATAMODE}_{\text{out}} \neq \text{FAINT} \text{ and} \tag{5}$$

$$\text{DATAMODE}_{\text{out}} \neq \text{FAINT_BIAS} \text{ and} \tag{6}$$

$$\text{DATAMODE}_{\text{out}} \neq \text{GRADED} \text{ and} \tag{7}$$

$$\text{DATAMODE}_{\text{out}} \neq \text{VFAINT}, \tag{8}$$

then `acis_build_chip_gti` exits with an error message.

vi. If

$$\text{DATAMODE}_{\text{out}} = \text{CC33_FAINT} \text{ or} \tag{9}$$

$$\text{DATAMODE}_{\text{out}} = \text{CC33_GRADED}, \tag{10}$$

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 `RA_TARGout` and `DEC_TARGout`, 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 `CCD_IDout` and `EXPNOout`, 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

$$\text{CONTENT} = \text{ASPSOL}, \tag{11}$$

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

$$\text{nominalchip} \neq \text{default and} \quad (12)$$

$$\text{nominalchip} \neq 0 \text{ and} \quad (13)$$

$$\text{nominalchip} \neq 1 \text{ and} \quad (14)$$

$$\text{nominalchip} \neq 2 \text{ and} \quad (15)$$

$$\text{nominalchip} \neq 3 \text{ and} \quad (16)$$

$$\text{nominalchip} \neq 4 \text{ and} \quad (17)$$

$$\text{nominalchip} \neq 5 \text{ and} \quad (18)$$

$$\text{nominalchip} \neq 6 \text{ and} \quad (19)$$

$$\text{nominalchip} \neq 7 \text{ and} \quad (20)$$

$$\text{nominalchip} \neq 8 \text{ and} \quad (21)$$

$$\text{nominalchip} \neq 9, \quad (22)$$

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

$$\text{calc_cc_times} \neq \text{yes and} \quad (23)$$

$$\text{calc_cc_times} \neq \text{no}, \quad (24)$$

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

$$\text{DATAMODE}_{\text{out}} = \text{FAINT or} \quad (25)$$

$$\text{DATAMODE}_{\text{out}} = \text{FAINT_BIAS or} \quad (26)$$

$$\text{DATAMODE}_{\text{out}} = \text{GRADED or} \quad (27)$$

$$\text{DATAMODE}_{\text{out}} = \text{VFAINT}, \quad (28)$$

then

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

(b) If

$$\text{DATAMODE}_{\text{out}} = \text{CC33_FAINT or} \quad (30)$$

$$\text{DATAMODE}_{\text{out}} = \text{CC33_GRADED}, \quad (31)$$

then

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

(i.e. 510/512).

3. Valid `CCD_IDs`:

The set of valid `CCD_IDs` 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 `CCD_IDin` = c or if there are one or more rows (i.e. events) in HDU h_{out} of the `outfile` where `CCD_IDout` = c . If there are no valid `CCD_IDs`, 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

$$\text{CCD_ID}_{\text{in}}[r_{\text{in}}] = c, \quad (33)$$

$$\text{EXPNO}_{\text{in}}[r_{\text{in}}] \geq \text{EXPNO}_{\text{min}}, \quad (34)$$

and

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

$$\text{CCD_ID}_{\text{out}}[r_{\text{out}}] = c \text{ and} \quad (35)$$

$$\text{EXPNO}_{\text{out}}[r_{\text{out}}] = \text{EXPNO}_{\text{in}}[r_{\text{in}}] \quad (36)$$

is zero.

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

$$\text{CCD_ID}_{\text{out}}[r_{\text{out}}] = c \text{ and} \quad (37)$$

$$\text{EXPNO}_{\text{out}}[r_{\text{out}}] = \text{EXPNO}_{\text{in}}[r_{\text{in}}] \quad (38)$$

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

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

$$\text{DATAMODE}_{\text{out}} = \text{FAINT} \text{ or} \quad (39)$$

$$\text{DATAMODE}_{\text{out}} = \text{FAINT_BIAS} \text{ or} \quad (40)$$

$$\text{DATAMODE}_{\text{out}} = \text{GRADED} \text{ or} \quad (41)$$

$$\text{DATAMODE}_{\text{out}} = \text{VFAINT}, \quad (42)$$

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

$$\text{DATAMODE}_{\text{out}} = \text{CC33_FAINT} \text{ or} \quad (43)$$

$$\text{DATAMODE}_{\text{out}} = \text{CC33_GRADED}, \quad (44)$$

then $\text{EXPNO}_{\text{min}} = 4$.

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 EXPNO_i to 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

$$\text{DATAMODE}_{\text{out}} = \text{FAINT} \text{ or} \quad (45)$$

$$\text{DATAMODE}_{\text{out}} = \text{FAINT_BIAS} \text{ or} \quad (46)$$

$$\text{DATAMODE}_{\text{out}} = \text{GRADED} \text{ or} \quad (47)$$

$$\text{DATAMODE}_{\text{out}} = \text{VFAINT}, \quad (48)$$

then

$$\text{START} = \text{TIME}_{\text{in}}[r_{\text{in},i}] - \text{TIMEPIXR}_{\text{in}} \times \text{TIMEDEL}_{\text{in}} - \text{FLSHTIME}_{\text{in}} \text{ and} \quad (49)$$

$$\text{STOP} = \text{TIME}_{\text{in}}[r_{\text{in},j}] + (1 - \text{TIMEPIXR}_{\text{in}}) \times \text{TIMEDEL}_{\text{in}}, \quad (50)$$

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

$$\text{CCD_ID}_{in}[r_{in,i}] = c \text{ and} \quad (51)$$

$$\text{EXPNO}_{in}[r_{in,i}] = \text{EXPNO}_i \quad (52)$$

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

$$\text{CCD_ID}_{in}[r_{in,j}] = c \text{ and} \quad (53)$$

$$\text{EXPNO}_{in}[r_{in,j}] = \text{EXPNO}_j. \quad (54)$$

Note that the GTIs include the FLSHTIME_{in} because DTCOR includes it.

ii. If

$$\text{DATAMODE}_{out} = \text{CC33_FAINT} \text{ or} \quad (55)$$

$$\text{DATAMODE}_{out} = \text{CC33_GRADED} \quad (56)$$

and if the parameter $\text{calc_cc_times} = \text{yes}$, then

$$\text{START} = \text{TIME}_{in}[r_{in,i}] - \text{TIMEPIXR}_{in} \times \text{TIMEDEL}_{in} \text{ and} \quad (57)$$

$$\text{STOP} = \text{TIME}_{in}[r_{in,j}] + (1 - \text{TIMEPIXR}_{in}) \times \text{TIMEDEL}_{in}. \quad (58)$$

iii. If

$$\text{DATAMODE}_{out} = \text{CC33_FAINT} \text{ or} \quad (59)$$

$$\text{DATAMODE}_{out} = \text{CC33_GRADED} \quad (60)$$

and if the parameter $\text{calc_cc_times} = \text{no}$, then

$$\begin{aligned} \text{START} &= \text{TIME}_{in}[r_{in,i}] - \text{TIMEPIXR}_{in} \times \text{TIMEDEL}_{in} + \\ &(\text{CHIPY_TARG}[\text{TIME}_{in}[r_{in,i}]] + 1028) \times 0.00285 \text{ and} \end{aligned} \quad (61)$$

$$\begin{aligned} \text{STOP} &= \text{TIME}_{in}[r_{in,j}] + (1 - \text{TIMEPIXR}_{in}) \times \text{TIMEDEL}_{in} + \\ &(\text{CHIPY_TARG}[\text{TIME}_{in}[r_{in,j}]] + 1028) \times 0.00285, \end{aligned} \quad (62)$$

where $\text{CHIPY_TARG}[\text{TIME}_{in}[r_{in,i}]]$ and $\text{CHIPY_TARG}[\text{TIME}_{in}[r_{in,j}]]$ are the CHIPY locations of the sky coordinates RA_TARG_{out} and DEC_TARG_{out} at the times $\text{TIME}_{in}[r_{in,i}]$ and $\text{TIME}_{in}[r_{in,j}]$, respectively. The `aspfile`, `geompar`, and `pixlib` are used to determine the values of $\text{CHIPY_TARG}[\text{TIME}_{in}[r_{in,i}]]$ and $\text{CHIPY_TARG}[\text{TIME}_{in}[r_{in,j}]]$.

(c) ONTIME_c :

The value of ONTIME_c is given by

$$\text{ONTIME}_c = \sum_k (\text{STOP}_k - \text{START}_k), \quad (63)$$

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

(d) LIVTIME_c :

The value of LIVTIME_c is given by

$$\text{LIVTIME}_c = \text{ONTIME}_c \times \text{DTCOR}. \quad (64)$$

(e) EXPOSUR_c :

The value of EXPOSUR_c is given by

$$\text{EXPOSUR}_c = \text{ONTIME}_c \times \text{DTCOR} \quad (65)$$

(i.e. $\text{EXPOSUR}_c = \text{LIVTIME}_c$).

5. Aim-point CCD:

If the `CCD_ID` $c = c_{\text{aim}}$, where c_{aim} is the `CCD_ID` of the CCD at the aim point, then

$$\text{ONTIME} = \text{ONTIME}c, \tag{66}$$

$$\text{LIVETIME} = \text{LIVETIME}c, \text{ and} \tag{67}$$

$$\text{EXPOSURE} = \text{EXPOSUR}c. \tag{68}$$

6. Write output:

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

- `DTCOR`,
- `EXPOSURE`,
- `EXPOSUR` (one such keyword for each valid `CCD_ID`),
- `LIVETIME`,
- `LIVETIME` (one such keyword for each valid `CCD_ID`),
- `ONTIME`, and
- `ONTIME` (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`, `EXPOSUR`, `LIVETIME`, `LIVETIME`, `ONTIME`, and `ONTIME` 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?