MIT
Center for Space Research **Chandra X-Ray Center**

MEMORANDUM

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To: Martin Elvis, SDS Group Leader
From: Glenn Allen, SDS, and David Huenemoerder, MIT-SDS Manager
Subject: Computation of Times of Arrival and Sky Coordinates for Events in Continuous-Clocking Event-Data Files
Revision: 4.1

The event times in ACIS continuous-clocking event-data files are associated with the times events are read. The times are not the times of arrival of the particles that deposit charge in the detector. Therefore, analyses of the event times to search for evidence of pulsations may be complicated by the time it takes to read out an event, the motion of the source on the detector as the telescope dither, the motion of the SIM relative to the telescope, and the use of the gratings. Analyses of the sky coordinates of continuous-clocking mode event data was difficult because the effects of dither had not been removed and because the source events were arbitrarily assumed to have CHIPY value of 512 independent of the location of the source on the detector. To make it easier for users to analyze continuous-clocking mode data, we propose that acis_process_events be modified to compute the times of arrival of events for a given source location and to improve the computation of the sky coordinates. This memo describes the specification for these computations.

1 acis_process_events

The tool acis_process_events should be modified to create a new column called TIME_RO. The contents of this column correspond to the times events are read. The contents of the column TIME are the estimated times of arrival of events from the source location. The times of arrival are derived from the read-out times, the source location specified by RA_TARG and DEC_TARG, and the aspect solution. The celestial coordinates and the aspect solution are used to determine the position of the source on the detector as a function of time. This information and the times in the column TIME_RO of the event file (i.e. the read-out times) are used to compute the sky coordinates of the events and the times that charge was deposited in the detector. Since it is not possible to discriminate between events associated with the source and background events, all events are handled in the same manner.

Additional Parameters

1. None.

Input

1. An ACIS continuous-clocking event-data file that includes the column TIME.

2. An associated aspect solution file.

3. The right ascension (RA_TARG) and declination (DEC_TARG) of the observed source in J2000.0 coordinates.

Output

1. An ACIS event-data file that includes the column TIME_RO.

2. The header of the output file should contain the keyword HDUCLAS3 = 'CC_CORRECTED' to confirm that the values in the column TIME are the estimated times of arrival instead of the read-out times.

Processing

1. Check for input errors: Verify that the input event files are continuous-clocking mode data files and contain a column named TIME. Verify that the keywords RA_TARG and DEC_TARG exist.

2. Read the values of the keywords RA_TARG, DEC_TARG, and TIMEDEL.

3. Read the values of TIME, CCD_ID, CHIPX, and CHIPY for event i.

4. Copy the value of TIME to the column TIME_RO if and only if the column TIME_RO does not already exist in the input file. If the input file has a column named TIME_RO, copy the contents of the column TIME_RO from the input file to the output file.

5. Estimate the time of arrival of the event. This estimate is to be used only to compute the values of $\mathrm{CCD\_ID}_{\mathrm{TARG}_i}$, $\mathrm{CHIPX}_{\mathrm{TARG}_i}$, and $\mathrm{CHIPY}_{\mathrm{TARG}_i}$ associated with the source location. (See step 6.) The time of arrival that is written to the output file is the time of arrival computed in step 7 below. For the first event in the input event data file, the estimated time of arrival

$$t_1 = \mathrm{TIME\_RO}_1 - (512 + 1028) \times \mathrm{TIMEDEL},$$

   where $\mathrm{TIME\_RO}_1$ is the read-out time of the first event. For all subsequent events in the input file, the estimated times of arrival

$$t_i = \mathrm{TIME\_RO}_i - (\mathrm{CHIPY}_{\mathrm{TARG}_{i-1}} + 1028) \times \mathrm{TIMEDEL},$$

   where $\mathrm{TIME\_RO}_i$ is the read-out time of the i^{th} event and $\mathrm{CHIPY}_{\mathrm{TARG}_{i-1}}$ is the CHIPY coordinate associated with the source location (RA_TARG, DEC_TARG) at the time of arrival of the $i-1^{\mathrm{th}}$ event. The value of $\mathrm{CHIPY}_{\mathrm{TARG}_{i-1}}$ is the value computed in step 6.

6. Compute the $\mathrm{CCD\_ID}_{\mathrm{TARG}_i}$, $\mathrm{CHIPX}_{\mathrm{TARG}_i}$, and $\mathrm{CHIPY}_{\mathrm{TARG}_i}$ location of the source (RA_TARG, DEC_TARG) on the ACIS detector using the aspect solution and the estimated time of arrival of event i (t_i). This computation compensates for the effects of dither and the SIM offsets. Jonathan McDowell has already developed the code to perform this computation. The coordinate $\mathrm{CHIPY}_{\mathrm{TARG}_i}$ is also used to estimate the time of arrival of the $i+1^{\mathrm{th}}$ event. (See step 5.)

7. Compute the time of arrival of event i:

$$\mathrm{TIME}_i = \mathrm{TIME\_RO}_i - (\mathrm{CHIPY}_{\mathrm{TARG}_i} + 1028) \times \mathrm{TIMEDEL}.$$

   Note that the contents of the column TIME are modified to contain the estimated times of arrival instead of the read-out times.

8. Compute the X and Y coordinates of event i using CCD_ID_i, the coordinates CHIPX_i and $\text{CHIPY}_{\text{TARG}_i}$, the time TIME_i (as computed in step 7), and the aspect solution. The resulting coordinates are free of the effects of dither and the motion of the SIM. The sky image is a thin (one or a few pixels wide) line that passes through the source location (RA_TARG, DEC_TARG). Jonathan McDowell has already developed the code to perform this computation.

9. Repeat steps 3–8 for each event in the input event data file.

10. Copy the contents of the input event file to the output event file. Add the column TIME_RO to the output file. Add appropriate HISTORY keywords to the output file if it does not exist in the input file.

2 Related Issues

1. Ensure that the GTI boundaries are computed using the correct set of times.

2. Create an ARD that contains the number 1028.

3. Modify the parameter eventdef.

4. Modify tg_resolve_events to compute the time of arrival offset for dispersed events.

3 Acknowledgements

The development of the algorithms to compute the sky positions and times of arrival of the events relied heavily on the assistance of Ian Evans, Peter Ford, Kenny Glotfelty, David Huenemoerder, Jonathan McDowell, Herman Marshall, Joe Masters, Arnold Rots, Divas Sanwal, and Allyn Tennant. Jonathan McDowell produced much of the code to compute the sky positions of the events and Herman Marshall and Allyn Tennant provided a great deal of help with the algorithm to compute the times of arrival.

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