Chandra X-ray Center

AHELP for CIAO 3.4   **times**   Context: chandra

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Synopsis

"Times" used in Chandra datasets and Chandra data analysis

Description

In a Chandra event file several 'times' are recorded both in the header via keywords and in one or several Good Time Intervals auxiliary files (the GTI blocks).

1. TIME and EXPOSURE KEYWORDS

The observation "start" and "stop" times are the most important pieces of data, and are carried in redundant ways as keywords in the file header. The TSTART and TSTOP keywords are the primary carriers of this information; the DATE–OBS, DATE–END and MJD_OBS keywords repeat the information in a format which is easier for the human reader.

For example:

"TSTART 97827899.1339010" is equivalent to and also listed as "DATE–OBS 2001–02–06T06:24:59" and "TSTOP 97880158.2484149933" = "DATE–END 2001–02–06T20:55:58"

The DATE keyword corresponds instead to the date of the FITS file creation.

All Chandra events are time tagged. All time tags in the data, and all TSTART and TSTOP values, are 'mission time' measured in seconds from a Chandra specified mission reference epoch:

- The Chandra reference epoch for calibration data is 1993 Dec 31, 00:00:00 UTC.
- The Chandra reference epoch for flight data is 1998 Jan 1, 00:00:00 TT, or MJD 50814.0 TT. The reference epoch is stored as MJD (modified Julian Date) value in the header keyword MJDREF and it is the mission time zero point.

To convert a time tag TIME to an absolute MJD(TT) the following formula is used:

$$MJD(TT) = MJDREF(TT) + (TIMEZERO + TIME) / 86400$$

where the TIMEZERO header keyword contains a time adjustment in seconds and it is usually zero.

Multiple date/time/exposure keywords are generally found in the header of Chandra event files:

- EXPTIME: this is the "static" exposure time for a frame in the ACIS instrument. This time excludes the time during which charge is moved from the imaging region to the frame store region (0.04104 s). The time is quantized in units of 0.1 s with the shortest EXPTIME = 0.2 s. The standard value of EXPTIME = 3.2 s for TIMED mode ACIS observations. If an observation uses interleaved mode, then there are separate values of EXPTIME for the short and long frames (e.g. 0.2 s and 3.2 s, respectively).
- FLSHTIME: the amount of time required to flush an ACIS CCD before a frame of data is obtained. A nonzero preflush is required if the value of EXPTIME is smaller than the time required to read−out one frame of data. In this case, some time is spent flushing the exposed region of the CCD to avoid transferring charge into the frame store region before the frame store has been entirely read out. Events that occur during a preflush are discarded onboard. Therefore flushes are effectively "dead time." Under most circumstances, the value of FLSHTIME = 0.0 s. If an observation uses interleaved mode, then there are separate values of FLSHTIME for the short and long frames
- TIMEDEL: this records, in general, the time resolution of the data: this is the bin size between rows for a binned dataset or the resolution of the time stamp for event lists. For the ACIS instrument this is static exposure time for a frame plus the time required to transfer charge from the image region to the frame store region (0.04104 s): TIMEDEL = EXPTIME + 0.04104 s. For the standard TIMED mode ACIS observation where EXPTIME = 3.2 s, TIMEDEL = 3.24104 s. If an observation uses interleaved mode, then there are separate values of TIMEDEL for the short and long frames.
- TIMEPIXR: indicates where in each bin the time stamp falls. It has a value between 0.0 and 1.0. Note that the default is 0.5 (center of the bin) and this may create undesired effect in the GTI for program which assume the beginning of the bin as the time stamp.
- ONTIME and ONTIMEn: this is the the sum of the good time intervals (GTIs). For the ACIS instrument ONTIMEn relates to CCD_ID = n, where n = 0, 1, ..., 9 and ONTIME=ONTIMEn for the CCD at the aim point of the telescope. If an observation uses interleaved mode, then there are separate values of ONTIMEn and ONTIME for the short and long frames.
- LIVTIME and LIVTIMEn: this is the total exposure time (i.e. "live time") for an observation. For the ACIS instrument this time excludes the time it takes to transfer charge from the image region to the frame store region (0.04104 s per frame) and time during preflushes (if they are necessary), therefore: LIVTIMEn = DTCOR * ONTIMEn. Since the values of ONTIME can differ from CCD to CCD, there is one LIVTIMEn keyword for each CCD used for an observation. The value of the keyword LIVETIME is the same as the value of the LIVTIMEn of the CCD at the aim point of the telescope. If an observation uses interleaved mode, then there are separate values of LIVTIMEn and LIVETIME for the short and long frames. For the HRC instrument LIVTIME simply records the ONTIME corrected for average dead time corrections (LIVTIME=ONTIME*DTCOR)
- EXPOSURE and EXPOSURn: this is the time corrected for all effects, including spatial ones such as vignetting, that are specified. It is generally equal to LIVETIME in Chandra data. The value of the keywords EXPOSURn should be identically the same as the value of the keywords LIVTIMEn, where n = 0, 1, 2, ..., or 9 for CCD_ID = n. The value of the keyword EXPOSURE is the same as the value of the keyword LIVETIME. If an ACIS observation uses interleaved mode, then there are separate values of EXPOSURn and EXPOSURE for the short and long frames.
- DTCOR: this is equal to LIVETIME/ONTIME and is used to record the dead time correction, in the range 0 to 1. Note that for the HRC instrument the dead time correction factor varies during the observation and the value of DTCOR in the header represent an average. Dead time correction factors as a function of time, are recorded in a different file called the "HRC Deadtime factor file" (DTF1) associated with each HRC event file. In versions of the processing software earlier than DS 6.9 (ASCDSVER header keyword), there was an error in the pipeline derivation of the DTCOR values for ACIS interleaved data; see the CIAO Data Caveats page [http://cxc.harvard.edu/ciao/caveats/] for more information.

As explained above the ONTIME/LIVETIME/EXPOSURE keywords are for the aim chip which, by CXC convention, corresponds to the first GTI. Each chip has different values of each of these keywords. IF someone is doing analysis on an off–aim–chip CCD, AND the values are considerably different for each chip, then the analysis will be impacted. For most observations the values for the different chips are about the same but this can be problem for observations with a lot of telemetry saturation, crowded fields, or period of extended background flares.

EXPOSURE TIME IN PI AND ARF FILES

The EXPOSURE value from the level 2 event file is propagated to the PI (spectrum) file, so that the EXPOSURE in the spectral file is identically the same.

The exposure in the ARF is obtained by summing the column called DURATION in the aspect histogram file; this exposure is only an approximation. Each element in the column duration is an integer multiple of 0.25625 s * DTCOR, where 0.25625 s is the time between adjacent entries in the aspect solution file. That is, the lengths of the DURATIONs are based on the information from the aspect camera, not the ACIS CCDs. Therefore, the exposure derived from the aspect histogram is not exact. It is only an approximation. In most cases, it is a good approximation. The exact exposure (for a point source) is "No. of frames * frame time". The values of EXPOSURE in the ARF and the PI file should be replaced with this value.

2. GOOD TIME INTERVALS (GTI)

Each Chandra event file contains one or more auxiliary blocks which include the good time intervals. In the case of ACIS there is one GTI per CCD. GTIs are table of sorted START and STOP times in units of seconds. For pipeline–produced data, the GTIs give the time periods when the mission time line parameters fell within acceptable ranges (see "ahelp mtl" for more information). Additional temporal filtering by the user – such as to remove background flare events – can further restrict these periods; the data subspace of a file (see "ahelp subspace") lists the GTI filters that have been applied to it.

Additional note for ACIS observations

When an arbitrary time filter/GTI is applied to an ACIS event file it is not guaranteed to be properly aligned at the exposure boundaries of the ACIS exposures. Because the event times for a given CCD and exposure are all assigned the same time (the middle of the exposure), this may result in data from 1 exposure (~3.2 sec for full frame) either being added to or excluded from the extraction on either or both ends of each good time interval. For most observations this effect will be very small; however, when there are many GTI records (say due to telemetry saturation for a large SNR or cluster) the effect may become significant.

Times in Continuous Clocking (CC) mode

In CC mode event data files, the values recorded in the column TIME are the readout times instead of the times of arrival. (Note that the TIME values in timed exposure event data files are the times of arrival.) Before performing timing analyses, the times of arrival at the barycenter of the solar system should be computed. The "Calculate CC–mode Times of Arrival" thread explains how to apply this correction.

Barycentric correction

A tool is provided (see "ahelp axbary") to correct for the difference in photon arrival times as the Earth and Chandra move around the Sun. The "Apply Barycenter Correction" thread explains how to apply this correction.

Timing Accuracy

Timing accuracy is instrument dependent on Chandra. The highest timing resolution is achieved by the HRC instrument with approximately 16 microsec. ACIS time resolution is observing–mode dependent and can vary from approximately 3 millisec in continuous clocking mode to 10 sec in timed exposure mode. Note that 10 sec is the highest possible selectable frame time – i.e. the time in which a CCD collects data. The nominal frame time for six full–frame ACIS chips is 3.2 sec. Highest resolution (40 microsec) can be achieved with ACIS in the so called "transfer streak" for really bright sources. See the Chandra Proposers' Observatory Guide for further information on timing accuracy.

See Also

calibration
> caldb

chandra
> coords, guide, isis, level, pileup

chips
> chips

concept
> autoname, parameter, stack, subspace

dm
> dm, dmbinning, dmcols, dmfiltering, dmimages, dmimfiltering, dmintro, dmopt, dmregions, dmsyntax

gui
> gui

modules
> paramio, pixlib, stackio

slang
> overview, slang, tips

Timing Accuracy