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

MEMORANDUM
September 9, 2002

To: Martin Elvis, SDS Group Leader
From: Glenn Allen, SDS, and Peter Ford, ACIS
Subject: ACIS Time Keywords Proposal
Revision: 1.2b
URL: http://space.mit.edu/CXC/docs/docs.html#exposure
File: /nfs/cxc/h2/gea/sds/docs/memos/memo_time_keywords_proposal_1.2b.tex

The computation of the FITS header keywords TIMEDEL (including TIMEDELA and TIMEDELB) and DTCOR is inaccurate for interleaved mode observations. Since LIVTIMEn (= EXPOSURn) and LIVETIME (= EXPOSURE) are derived from DTCOR, the values assigned to these keywords are also inaccurate for interleaved mode observations. This memo describes how TIMEDELA, TIMEDELB, TIMEDEL, DTCOR, ONTIMEn, ONTIME, LIVTIMEn, and LIVETIME are computed presently and outlines a new set of algorithms that can be used to accurately compute these keywords for all of the timed-exposure (and continuous-clocking) observing modes.

1 Present Computation Algorithms

At the moment, for interleaved mode observations:

TIMEDELA = the difference between the times reported for the primary frame and the first secondary frame. Since TIMEPIXR = 0.5, TIMEDELA = $\frac{1}{2}T_{\rm A} + \frac{1}{2}T_{\rm B} + T_{\rm FB}$, where $T_{\rm A}$ = the duration of the primary frame (including the frame-shift time of 0.04104 s), $T_{\rm B}$ = the duration of each secondary frame (including the frame-shift time of 0.04104 s), and $T_{\rm FB}$ = the duration of the flush proceeding the secondary frame(s).

TIMEDELB = the difference between the times reported for the last secondary frame of a cycle and the following primary frame. Since TIMEPIXR = 0.5, TIMEDELB = $\frac{1}{2}T_{\rm A} + \frac{1}{2}T_{\rm B} + T_{\rm FA}$, where $T_{\rm FA}$ = the duration of the flush proceeding the primary frame.

TIMEDEL = TIMEDELA + (DTYCYCLE − 1) × TIMEDELB, where DTYCYCLE = the number of secondary frames.

DTCOR = (0.1×EXPTIMEA+DTYCYCLE×0.1×EXPTIMEB)/TIMEDEL, where EXPTIMEA and EXPTIMEB are the commanded durations of the primary and secondary frames (which are quantized in units of 0.1 s).

Table 1. Example of the Problem

Keyword	Value in Header	Actual Value
EXPTIMEA	3 ($\times$0.1 s)	3 ($\times$0.1 s)
EXPTIMEB	32 ($\times$0.1 s)	32 ($\times$0.1 s)
TIMEDELA	1.79104 s	0.34104 s
TIMEDELB	4.92032 s	3.24104 s
TIMEDEL	11.63168 s	13.19344 s
DTCOR	0.85112	0.75037
LIVETIME	851.12 s	750.37 s

ONTIME $= \sum_i$ GTI$_i$.

LIVETIME = EXPOSURE = DTCOR $\times$ ONTIME

As an example, consider an observation using ACIS-S with three (DTYCYCLE = 3) secondary frames of 3.2 s for each 0.3 s primary frame. If the flush time is 3.12928 s and ONTIME = 10 ks, the results are listed in table 1.

2 Proposed Computation Algorithms

A set of algorithms that can be used to accurately determine the values of the keywords for interleaved mode observations as well as regular timed-exposure observations is:

TIMEDELA = 0.1 s $\times$ EXPTIMEA + 0.04104 s.

TIMEDELB = 0.1 s $\times$ EXPTIMEB + 0.04104 s.

TIMEDEL = TIMEDELA or TIMEDELB, as appropriate, for all but Level 0 ACIS data products. Otherwise, tools designed to read TIMEDEL and TIMEPIXR can produce inaccurate results. For the evt0 and exr0 data products, TIMEDEL = TIMEDELA+FLSHTIMA+DTYCYCLE$\times$(TIMEDELB+FLSHTIMB) (i.e. the total cycle time of one set of primary and secondary frames and the associated flushes).

FLSHTIMA and FLSHTIMB are new keywords describing the duration of the pre-flush before the primary (FLSHTIMA) and secondary (FLSHTIMB) frames.

FLSHTIME = FLSHTIMA or FLSHTIMB, as appropriate. This keyword is also new.

ONTIMEn $= \sum_i$ GTI$_i$ for CCD_ID $= n$. ONTIME = ONTIMEm, where m is the CCD_ID number of the CCD at the aim point. ONTIME includes time intervals for frames during which no events are reported, time intervals during which there are flushes, and the 0.04104 s intervals during which frames are shifted. ONTIME does not include time intervals during which frames are dropped and the flushes associated with these frames. For interleaved mode observations, ONTIMEn and ONTIME are computed separately for the primary- and secondary-frame data products. To avoid double counting the time interval associated with each frame, the values of ONTIMEn and ONTIME for the primary-frame data products do not include the time intervals associated with the secondary frames and the values of ONTIMEn and ONTIME for the secondary-frame data products do not include the time intervals associated with the primary frames.

The GTI boundaries are derived from the data in the exposure records file. For events that occur during a timed-exposure frame whose time TIME$_{\rm exr} = t$, the GTI boundaries are given by $t-$TIMEPIXR$_{\rm exr}\times$ TIMEDEL$-$FLSHTIME$_{\rm exr}$ and $t+(1-$TIMEPIXR$_{\rm exr})\times$TIMEDEL, where TIMEDEL, TIMEPIXR$_{\rm exr}$, and $\mathrm{FLSHTIME_{exr}}$ are keywords in the exposure records file. Therefore, timed-exposure GTIs are integer multiples of TIMEDEL + FLSHTIME. For events that occur during a continuous-clocking frame whose time $\mathrm{TIME_{exr}} = t$, the boundaries are given by $t - \mathrm{TIMEPIXR_{exr}} \times \mathrm{TIMEDEL}$ and $t + (512 - \mathrm{TIMEPIXR_{exr}}) \times \mathrm{TIMEDEL}$. Therefore continuous-clocking GTIs are integer multiples of $512 \times$ TIMEDEL.

DTCOR is computed separately for the data products containing events from the primary and secondary frames. For the primary frames,

$$\mathrm{DTCOR} = \frac{0.1\ \mathrm{s} \times \mathrm{EXPTIMEA}}{\mathrm{TIMEDELA} + \mathrm{FLSHTIMA}} \tag{1}$$

For the secondary frames,

$$\mathrm{DTCOR} = \frac{0.1\ \mathrm{s} \times \mathrm{EXPTIMEB}}{\mathrm{TIMEDELB} + \mathrm{FLSHTIMB.}} \tag{2}$$

LIVTIMEn = EXPOSURn = DTCOR $\times$ ONTIMEn. LIVETIME = EXPOSURE = EXPOSURm, where m is the CCD_ID number of the CCD at the aim point. LIVTIMEn and LIVETIME are computed separately for the data products containing events from the primary and secondary frames.

The timed-exposure ACIS data products evt1, evt1a, and evt2 should include the keywords TIMEDEL = TIMEDELA (or TIMEDELB), EXPTIME = 0.1×EXPTIMEA (or EXPTIMEB), FLSHTIME = FLSHTIMA (or FLSHTIMB), ONTIMEn, ONTIME, DTCOR, LIVTIMEn, LIVETIME, EXPOSURn, and EXPOSURE.

3 Continuous-Clocking Observations

Observations using continuous-clocking modes have TIMEDEL (e.g. TIMEDEL = 0.00285 s) and DTCOR = 1.0. The values of ONTIMEn, ONTIME, LIVTIMEn, LIVETIME, EXPOSURn, and EXPOSURE are computed as described in section 2.

4 Illustration

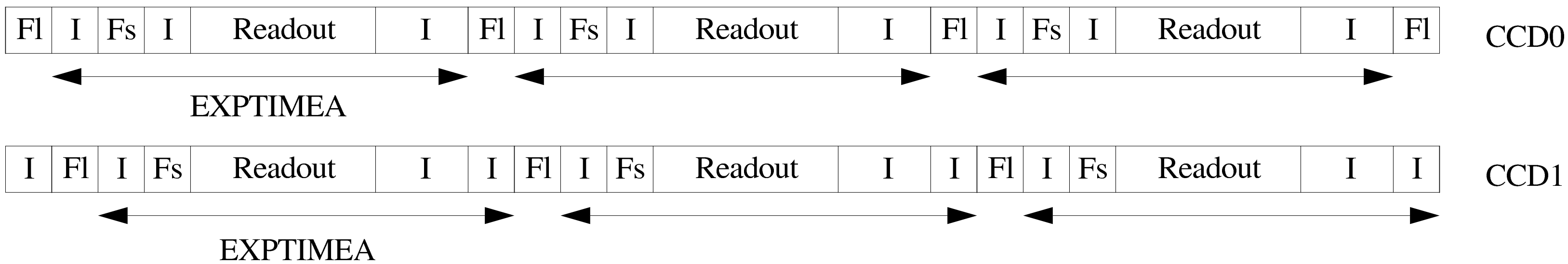
The attached figure illustrates some ACIS clocking sequences. The first example illustrates the clocking sequence used for a timed-exposure observation that has only one frame time. The time intervals during which a CCD is collecting charge and the charge is not being clocked to the frame-store region (i.e. the "static integration times") are indicated by the arrows. The duration of this interval Δt = EXPTIMEA. The static integration time includes intervals during which the detector is idle (I), the frame-store is being flushed (Fs), and the data from the previous frame is being processed (Readout). The integrated charge is clocked to the frame-store region during the intervals indicated by the label "Fl." In this example, EXPTIMEA might be 3.2 s, Fl = 0.04104 s, TIMEDEL = EXPTIMEA + Fl = 3.24104 s, and FLSHTIME = 0.

The second example illustrates the clocking sequence used for a timed-exposure observation that has only one frame time and each frame is preceeded by a "flush." Again the static integration times are indicated by the intervals marked with the arrows. Here, TIMEDEL = EXPTIMEA + Fl and FLSHTIME is the interval that includes the sequece Fl + I + Fs + I + Readout or, equivalently, Fl + I + Fs + Readout + I.

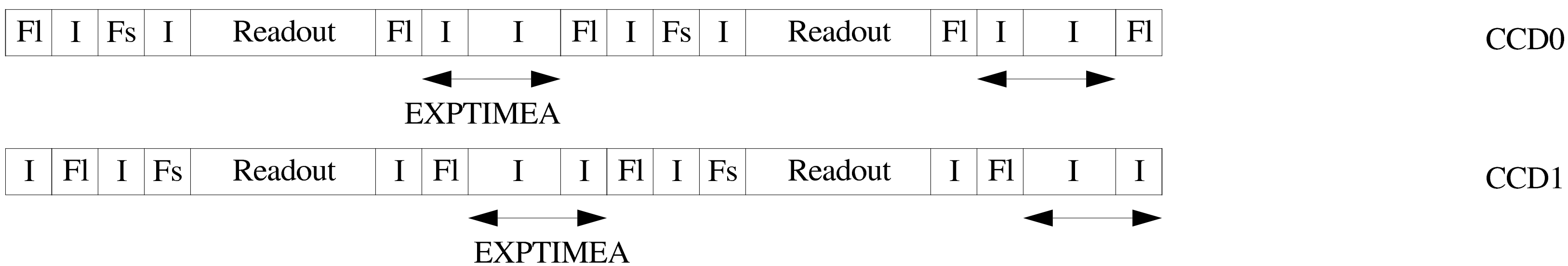
The third example illustrates the clocking sequence used for a timed-exposure observation with interleaved frames. The primary frame (EXPTIMEA) is preceeded by a "flush" (FLSHTIMA) of duration Fl + I + Fs + I + Readout and the secondary frame (EXPTIMEB) has no proceeding flush (FLSHTIMB = 0).

ACIS Clocking

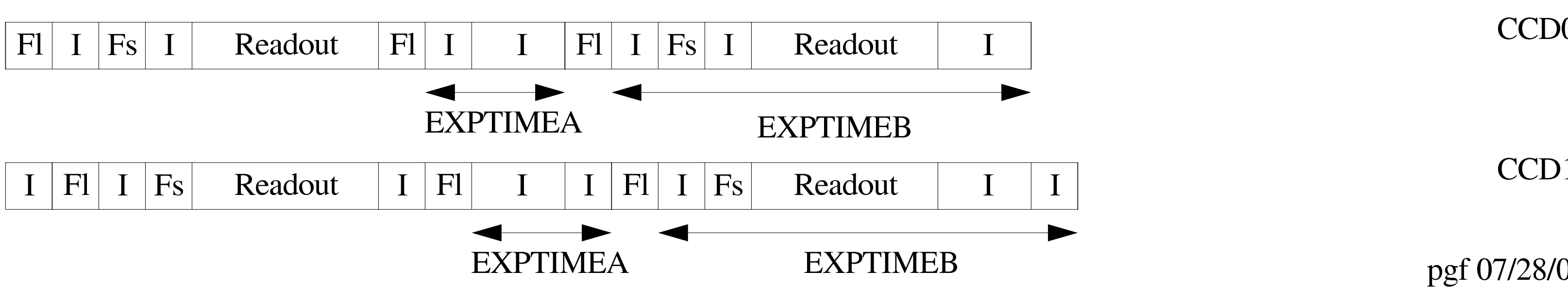
1. Dutycycle = 0, No pre-flush



2. Dutycycle = 0, pre-flush



3. Dutycycle = 1, pre-flush on EXPTIMEA, no pre-flush on EXPTIMEB



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