MEMORANDUM

April 2, 1999

To: CXC ACIS, ACIS IPI, and MSFC Science Teams
From: Joel H. Kastner
Subject: CXC implementation of ACIS event grading schemes (V1.1)

1 Overview

This memo summarizes the existing and proposed systems for assigning grades to ACIS events, and describes the CXC's implementation of these systems.

1.1 Nomenclature and conventions

1.1.1 The two meanings of "grade"

Generally, two "grades" are assigned to events during ACIS data processing. Understanding the distinction between these grades is crucial to their correct use in filtering and analyzing event data.

The first, more fundamental grade, which we will refer to as the *flight grade*, is derived from a bitmap representation of the 3×3 (timed exposure "faint" mode) island of event pixel pulse heights (ADU values). Specifically, a bit is set for each of 8 pixels surrounding the central pixel, if the pulse height of that pixel meets or exceeds the event "split threshold." Since the representation is 8 bits, the result is an integer between 0 (no surrounding pixels meet or exceed split threshold) and 255 (all pixels meet or exceed split threshold). For 1×3 (continuous clocking mode) event islands, the representation is 2 bits, i.e., an integer between 0 and 3.

We refer to the second grade as the *binned grade*, as it consists of rebinning, or grouping, the possible values of flight grade into a set of more readily interpretable grades. The only such system in practice thus far is that designed for the ASCA mission. It may be useful to think of the first (flight) grade as describing the event *geometry*, while the second (binned) grade is an indication of event *quality*.

1.1.2 Pulse height summation

The flight grade and binned grade systems are accompanied by rules governing the summation of pixel pulse heights, in particular those of corner pixels, that are at or above split threshold. As described below, the rules regarding inclusion or exclusion of corner pixel pulse heights are different for the flight grade and ASCA binned grade systems. Hence, it is not possible to maintain complete consistency between flight and ASCA binned grade systems if both of these grades *as well as* a unique total pulse height (PHA) are to be assigned to each event.

1.2 CXC Data System implementation

The data processing involved in event grading is accomplished by the CXC Data System tool `acis_grade_events`, which is a subprocess of `acis_process_events`. The extent of data processing required depends on the data acquisition (telemetry packing) mode of ACIS. In "faint" mode, both flight and binned grades must be calculated. The flight grade is determined using the method described in the ACIS Flight Software Requirements Specification. In "graded" mode, the flight grade is provided in telemetry, so only the binned grade is calculated. For either mode, the binned grade is derived from the flight grade by means of an Analysis Reference Data (FITS) lookup table file that specifies the mapping from the flight system to the binned grade system of choice, as well as the rules to be applied in including corner pixels in total event PHA. Both flight and binned grades, as well as total event PHA, are written to the resulting (Level 1) output event files. General rules regarding inclusion or exclusion of corner pixels in PHA are summarized below.

2 ASCA Binned Grade System

The ASCA binned grade system consists of grades from 0 to 7. Generally speaking, the larger the grade in the ASCA system, the greater the number of pixels that are at or above split threshold. The mapping between the flight grade and ASCA binned grade systems is summarized in Table 1.

2.1 Discrepancies between ASCA and ACIS flight PHA summation rules

As noted above, and as Table 1 indicates, the summation of pixel pulse heights is not handled consistently by the flight and ASCA binned systems. In general terms, the ASCA system tends to reject most corner pixels from total event PHA (with the exception of ASCA G6 events), whereas the flight system will include such pixels if an adjacent (side) pixel is at or above split threshold.

Note that, whereas all 9 (3) pixel pulse heights are telemetered to the ground in the timed exposure (continuous clocking) "faint" data acquisition modes of ACIS, in the "graded" data acquisition mode, only the total event PHA is telemetered. Hence, in the case of graded mode, the flight grade system rules for pulse height summation have already been (irreversibly) applied, prior to ground processing to convert flight grades to binned grades under the ASCA system. In faint data acquisition modes, flight software PHA filters may be in use to limit reporting of events into telemetry. Events tested against these filters will be evaluated according to the flight grade system rules governing PHA summation. Thus, for certain combinations of grades under the ASCA system, it may not be possible to establish a consistent set of flight software grade and PHA filters, if the ASCA corner summation rules are applied during ground processing of faint mode data.

While it might seem logical to assume that a User desiring use of the ASCA system would want to preserve its rules for pulse height summation, the lack of consistency with the flight software summation rules (and the resulting inconsistency in event PHA as produced by flight and ground processing software) is the overriding concern here. Thus, *the CXC software adopts the ACIS flight software convention for inclusion/exclusion of corner pixel pulse heights in total PHA, even when assigning grades to events according to the ASCA system.*[1]

[1]Note that application of corner pixel summation rules is governed by a keyword in the grade system Analysis Reference Data (ARD) file; see the ACIS ARD ICD.

Table 1: Mapping between flight grade and ASCA binned grade systems

binned grade	flight grade	PHA summation
0	0	Same pulse height
1	1,4,5,32,33,36,37,128 129,132,133,160,161, 164,165	Same pulse height
2	2,34,64,65,68,69, 130,162	Same pulse height
3*	8,12,136,140	Same pulse height
4*	16,17,48,49	Same pulse height
5	3,6,9,13,20,21,35,38, 40,44,52,53,96,97,100, 101,131,134,137,141, 144,145,163,166, 168,172,176,177,192, 193,196,197	Different pulse heights
6	10,11,18,22,50,54,72, 76,80,81,104,108,138, 139,208,209	Same pulse height
7	all others	Generally different pulse hts

* Depends on readout node.

Table 2: Mapping between flight grade and ASCA binned grade systems, CC mode

binned grade	flight grade	PHA summation
0	0	Same pulse height
3*	1	Same pulse height
4*	2	Same pulse height
7	3	Same pulse height

* Depends on readout node.

2.2 Timed exposure vs. continuous clocking mode

Strictly speaking, under the ASCA system, event grades are defined only for the timed exposure (TE) readout mode of ACIS. No ASCA grades are *a priori* defined for continuous clocking (CC) mode[2]. Hence the CXC has defined the grade mapping for CC mode described in Table 2. This mapping is designed to maintain some consistency between TE and CC modes in terms of interpreting the pixel distributions of events with a given ASCA grade.

2.3 TE Very faint mode

At present, there are no plans for a separate mapping for "very faint" mode, in which a 5×5 pixel island is telemetered for each event. Instead, the central 9 pixels of the event pixel island are used to compute both the flight grade and the ASCA binned grade, according to Table 1.

3 ACIS Binned Grade (or "Family") System

3.1 TE Faint mode

The proposed ACIS binned grade (or "grade family") system for faint mode data was described in a memo by K. Glotfelty, and is summarized in Table 3. The rationale behind this system was described in detail in the Glotfelty memo. Here, we have rearranged the order of these ACIS grades somewhat from Glotfelty's original proposal, and have added two new grades to represent horizontal and vertical 3-pixel splits. *For simplicity and consistency in determining total event PHA under the ACIS binned grade system, the CXC adopts the flight grade system convention for including or excluding corner pixel pulse heights.*

3.2 Continuous clocking mode

The CXC has defined the ACIS binned grade mapping for CC mode as described in Table 4. As for ASCA, this mapping is designed to maintain some consistency between TE and CC modes.

[2]ASCA's "fast" mode data, which are analogous to CC mode event data, are processed differently from either "faint" or "bright" modes by ASCA ground processing software; grades are not assigned.

Table 3: Mapping between flight grade and ACIS binned grade systems, TE mode

ACIS	flight	ASCA	Description
0	0	0	Single Pixel Events
1	64	2	Vertical split up
2	2	2	Vertical split down
3	16	4/3*	Horizontal split right
4	8	3/4*	Horizontal split left
5	72, 104	6	"L" & Quad, upper left
6	10, 11	6	"L" & Quad, down left
7	18, 22	6	"L" & Quad, down right
8	80, 208	6	"L" & Quad, up right
9	1,4,32,128	1	Single diagonal split
10	3,6,20,144, 96,192,9,40	5	"L" shaped split/with corner
11	24	7	3-pix horizontal split
12	66	7	3-pix vertical split
13	all other	all other	Catch all
14	255	7	All pixels

* Depends on readout node.

Table 4: Mapping between flight grade and ACIS binned grade systems, CC mode

binned grade	flight grade	description
0	0	single pixel
4	1	Horizontal split left
3	2	Horizontal split right
11	3	3-pix horizontal split

3.3 TE Very faint mode

As in the case of ASCA grades, there are no present plans to designate a separate grade mapping for "very faint" mode. Instead, the central 9 pixels of the event pixel island are used to compute both the flight grade and the ACIS binned grade, according to Table 3.

4 Relevant Documents

1. K.J. Glotfelty, "ACIS Grading Scheme Recommendation,"
   `http://hea-www.harvard.edu/acis/xrcf/grade.html`
   (original proposal for ACIS grade "family" system).

2. J. Kastner, "ASC ACIS Processing Tools,"
   `http://space.mit.edu/ASC/docs/docs.html`
   (specification of `acis_grade_events`).

3. J. Kastner, "ACIS Analysis Reference Data ICD,"
   `http://space.mit.edu/ASC/docs/docs.html`
   (specification of binned grade system reference data files).

4. Description of ASCA grade system and corner pixel PHA summation rules
   `http://heasarc.gsfc.nasa.gov/0/docs/asca/sis_grade.gif`

5. ACIS Flight Software Requirements Specification, Rev. J,
   `http://acis.mit.edu/acis/sreqj/`
   (specification of flight grade system, including pulse height summation; Secs. 3.2.2.3.14, 3.2.2.3.16, and 3.2.3.3.14).