AXAF Science Center

Grating Data Products:
Level 1.5 to ASC Archive Interface Control Document

(`http://space.mit.edu/ASC/docs/ICD_L1.5.ps.gz`)

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Document and Change Control Log

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23 Dec 97	0.9	all	Initial Draft
3 Feb 98	1.0	all	Revisions as per review by DS
18 Feb 98	1.1	all	Revisions as per comments of AR, JCM, JHK, AD; generic FITS material removed and referenced to ASC FITS document. Added FITS region specifications. Specified HRC columns to drop.
20 Feb 98	1.2	all	Minor edits, as per AR comments. Major changes to REGION section: cast as BINTABLE extension instead of a file. Added TNULL*i* keywords to grating columns as appropriate.
27 Apr 98	1.3	all	Various edits as per A.Alexov, W.McLaughlin comments. Fixed inconsistency in tg_part labels. Added schematic figure showing region specification. Updated file-naming convention.

Unresolved Issues

The following is a list of unresolved, un-reviewed, or un-implemented items:

1. 980427: Need data-model keywords on region extension. (page 13)
2. 980427: Need full region header sample (page 12)
3. 980218: Sample files are needed. (page 15)

Contents

List of Tables

1 Introduction

This document describes the interface to be employed in transferring the products of grating (HETG, the High Energy Transmission Grating, or LETG, the Low Energy Transmission Grating) obervations Standard Data Processing from the ASC Level 1.5 processing pipeline to the ASC Data Archive, according to the requirements stipulated in the "ASC Data System Requirements" (Applicable Document 3).

Formatting NOTE: Text formatted between horizontal rules (like this block) provide some historical context regarding alternative choices considered, which may still be debated.

Items boxed in the right margin (like this) are questions to be answered or TBD's to be replaced.

1.1 Purpose

TG (generically referring to HETG and LETG Transmission Grating instruments) Level 1.5 processing, described in Applicable Document 3, consists of event processing of HRC or ACIS Level 1 products (which are described in Applicable Documents 8 and 9) to add grating-specific coordinates and associated values. Level 1.5 denotes an intermediate stage between Level 1 (primarily re-formatting and coordinate transformations) and Level 2 (primarily source analysis), since some minimal analysis is necessary on grating observations before coordinate transformations can be done (e.g., source detection). This document describes the *additional* structure and content of the resulting event files and of region and summary files that are generated from Level 1 products during Level 1.5 processing.

1.2 Scope

This interface shall apply to all TG-specific data products that are generated by ASC Level 1.5 pipelines and distributed to the ASC Data Archive (see Applicable Document 3 and the "ASC Data System Software Design," Applicable Document 4) during the course of the AXAF mission.

1.3 Applicable Documents

The Applicable Documents required for background and detail on grating Level 1.5 products are as follows:

1. AXAF Data Products Guide
   `http://hea-www.harvard.edu/asclocal/sds/CDR2/dp.ps`
2. AXAF Coordinate Systems
   `http://hea-www.harvard.edu/~jcm/asc/coords`
3. ASC AMO-2400 (SE03)
   ASC Data System Requirements (ASC.302.93.0008)
4. ASC AMO-2401 (DS01)
   ASC Data System Software Design (ASC.500.93.0006)
5. NOST 100-1.1, Definition of the Flexible Image Transport System (FITS)
   `http://www.cv.nrao.edu/fits/`

6. HEASARC FITS Standards:
   `http://heasarc.gsfc.nasa.gov/docs/heasarc/ofwg/ofwg_intro.html`

7. ASC FITS File Designers' Guide
   `http://hea-www.harvard.edu/~arots/asc/fits/ascfits.ps`

8. HRC Data Products Guide:
   Level 1 to ASC Archive Interface Control Document
   `http://hea-www.harvard.edu/asclocal/sds/ICD/l1icd.ps.gz`

9. ACIS Data Products Guide:
   Level 1 to ASC Archive Interface Control Document
   `http://space.mit.edu/ASC/docs/acis_l1.ps.gz`

10. FITS File Names for the AXAF Archive:
    `http://hea-www.harvard.edu/~arots/asc/archive/files.html`

11. FITS REGION Binary Table Design (ASC-FITS-REGION-1.0)
    `http://hea-www.harvard.edu/~arots/asc/fits/region.ps`

1.4 Functional Description

1.4.1 Data Content Summary

All TG data sets generated by the Level 1.5 processing pipeline shall consist of data files conforming to the FITS format (Applicable Document 5) and further conforming to HEASARC standards (Applicable Document 6) and the ASC conventions (Applicable Document 7). These files contain header keyword entries and binary table (BINTABLE) extensions. Following rules outlined in Applicable Document 7, all these files will contain a null primary header followed by a main binary table (the "principal HDU") and auxiliary extensions ("auxiliary HDU").

Any other types of files will either be of types in common use (e.g., PostScript), or fully described here (e.g., ASCII region files of IRAF/PROS).

1.4.2 Recipients and Utilization

The primary recipients of TG Level 1.5 data products, via distribution from the archive, are AXAF observers, who will utilize these data products for scientific data analysis. The ASC may also make use of specific Level 1.5 data products for instrument calibration, instrument and/or spacecraft monitoring and trends analysis, and validation and verification of the Level 0, Level 1, and Level 1.5 software and of the data products themselves. Level 1.5 data products will also be used in Level 2 (standard data analysis) pipelines, the products of which will be used for all of the above purposes.

1.4.3 Pertinent Relationships with Other Interfaces

Changes to the definition of HRC or ACIS Level 1 data products, as described in Applicable Documents 8 and 9, may affect the Level 1.5 data products described in the current document.

1.5 Assumptions and Constraints

For each TG science event run reported in the AXAF telemetry stream, Level 1.5 processing shall generate a set of product files as described in Section 2.1. The products depend upon possibly time-dependent calibration data for coordinate transformations and region definitions.

The natural subdivision of TG Level 1.5 processing is the Observation Interval (ObI). Each ObI may span several TG science runs, which are the atomic unit of the scientific instrument's telemetry. TG data will therefore be processed by ObI by the Level 1.5 pipeline. The pipeline will accept a list of one or more ObIs and process each independently.

1.6 Products Not Covered

TG Level 1.5 products that are used for maintenance and diagnostic purposes (those that are not supplied to the user for scientific data analysis), or which are generic AXAF Level 1.5 products (those parts of the product which are common to ACIS and HRC Level 1 products), are not currently included within the interface defined by this document.

2 Detailed Interface Specifications

2.1 Labeling and Identification

The data files generated by the Level 1.5 processing pipeline shall be assigned external names as defined by the following general convention, (specified in "FITS File Names for the AXAF Archive", Applicable Document 10): `<i><s><t><v>_[<f>_]<c><l>[<sl>].<type>`
where the mnemonics are:

`<i>` instrument: "acis", "hrci", "hrcs", ...

`<s>` data source: "x", "f", "t", "b", "s", "u"

`<t>` TSTART (integer part): "#########"

`<v>` processing run (version): "N###"

`<f>` optional discriminator (e.g., FEP Id)

`<c>` contents: "evt", "prf", "hst", "src", "win", "bias", ...

`<l>` processing level: single digit: "0", "1", "2"

`<sl>` sublevel: single lower case letter; e.g., 1.5 is "1a"

`<type>` superfluous: usually "fits"

Relevant values for instrument (`<i>`) are `acis` or `hrc`; for data source (`<s>`) is "f" for flight. The appropriate designation for the file contents, processing level, and sublevel (`<c><l><sl>`) is `_evt1a`. The spatial spectral extraction region mask is encoded as an extension in the Level 1.5 FITS file, but may optionally be provided as an ASCII file following the above conventions, but with a `<type>` equal to `reg`.

No additional non-instrument-specific data products are output by the TG Level 1.5 processing pipeline.

2.2 Substructure Definition and Format

The "ASC FITS Designers' Guide" (Applicable Document 7) defines and lists header components for the primary header and for all binary table extensions. Since grating data are always obtained with either the HRC or ACIS detectors, file content is also described in detail by the HRC and ACIS Level 1 Interface Control Documents (Applicable Documents 8 and 9).

2.2.1 Header/Trailer Description Details

Table 1 shows the associated keywords that differ from ACIS or HRC L1 files to specify the TG Level 1.5 products.

```
GRATING = 'HETG    '            / HETG, LETG or NONE
HDUCLASS= 'ASC     '            /
HDUCLAS1= 'EVENTS  '            /
HDUCLAS2= 'ALL     '            /
HDUCLAS3= 'RESOLVED'            / ASC definition for TG coord. events
HDUSPEC = 'Grating Data Products: Level 1.5 ICD, V1.1' / ICD ref.
HDUDOC  = 'ASC-FITS-1.0: McDowell, Rots: ASC FITS Designers Guide' /
```

Table 1: *Level 1.5 - specific FITS Header Keywords*

The binary tables are further described by an extension header that immediately follows the keyword header (since the primary data unit is empty). In the file definition tables that follow, only the associated fields added to the Level 1 products by Level 1.5 processing or which require additional explanation are defined.

```
ACSYS1  = 'ASC-GDP-x.x'         / (optional) grating diffraction pixel coords
TCTYP1  = 'GDPX      '          / Grating Diffraction Pixels
TCRVL1  =                0.0    / Nominal angle
TCRPX1  =            16384.5    / Reference pixel
TCDLT1  = 1.59265544165e-5      / [degrees/pixel]
TDBIN1  = 10                    / default [pixels/bin]
TCUNI1  = 'deg'                 / Unit of GDP
ACSYS2  = 'ASC-GDP-x.x'         / (optional) grating diffraction pixel coords
TCTYP2  = 'GDPY      '          / Grating Diffraction Pixels
TCRVL2  =                0.0    / Nominal angle
TCRPX2  =            16384.5    / Reference pixel
TCDLT2  = 1.59265544165e-5      / [degrees/pixel]
TDBIN2  = 10                    / default [pixels/bin]
TCUNI2  = 'deg'                 / Unit of GDP
```

Table 2: *Special Keywords for TG Columns with coordinate systems. Grating coordinates can be specified either by angle, wavelength, or pixel. The pixel system requires a coordinate system.*

2.2.2 Keywords Describing Calibration Data

Resolution of HETGS (HETG + ACIS-S) photons into diffraction orders requires application of the calibration from wavelength to pulse-height (PI, for Pulse-

Invariant signal), and information on the distribution of the response. To do this, a special table is read, which was in turn generated from the CCD response matrices (RMFs), for a given fractional enclosed energy. Subsequent processing will require knowledge of this filter, so keywords are stored in the event extension header, as defined in Table 3.

```
COMMENT Order-sorting lookup tables:
COMMENT   Tables of PI_min and PI_max vs E used for order-sorting,
COMMENT   constructed for a specific fractional enclosed probability
COMMENT Reference ICD for file definition is: TBD.
COMMENT
ACISDPIF='acis_fi_95_V0.0.fits'     /delta-PI vs energy table, FI CCD
ACISDPIB='acis_bi_95_V0.0.fits'     /delta-PI vs energy table, BI CCD
```

Table 3: *Special Keywords describing calibration files.*

TBD: Need reference ICD for order sorting table.

2.3 Event Data Files (*_evt1a.fits)

During Level 1.5 processing, event coordinates undergo several transformations. Given a zero-order centroid in sky coordinates, a region angle, and region width, events within each region are given several new coordinates. Proper interpretation of the spectrum requires consistent selection on several coordinates. For example, a (TG_R, TG_D) image should only be made for a selection on TG_SRCID.

TG_SRCID is the source number, as output from the detection algorithm. There is a limit of 10 sources per L1.5 event-list (but the actual IDs can be greater than 10, as determined by detect algorithms). A TG_SRCID of 0 means background — the photon has not been associated with a detected source. (The maximum of 10 was a compromise between implementation efficiency and a feasible maximum number of sources for a grating observation; 32-bits were allocated, with 3 bits per source.)

TG_PART identifies the region of the spectrum of which the photon is a part. This can have only specific values as follows:

- **0:** zero order;
- **1:** HEG part of the spectrum;
- **2:** MEG part;
- **3:** LETG photon;
- **4–7:** LETG/HESF parts of the spectrum;
- **99:** background.

The region components are shown in a schematic image in Figure 2.3.

TG_R**:** diffraction angle, parallel to the dispersion. For an on-axis source, the angle ranges from −0.5 to +0.5 degrees for HETGS, and about twice that for LETGS. Offset-pointing can increase the range somewhat.

For background or zero-order photons, TG_R is undefined, and stored as NaN.

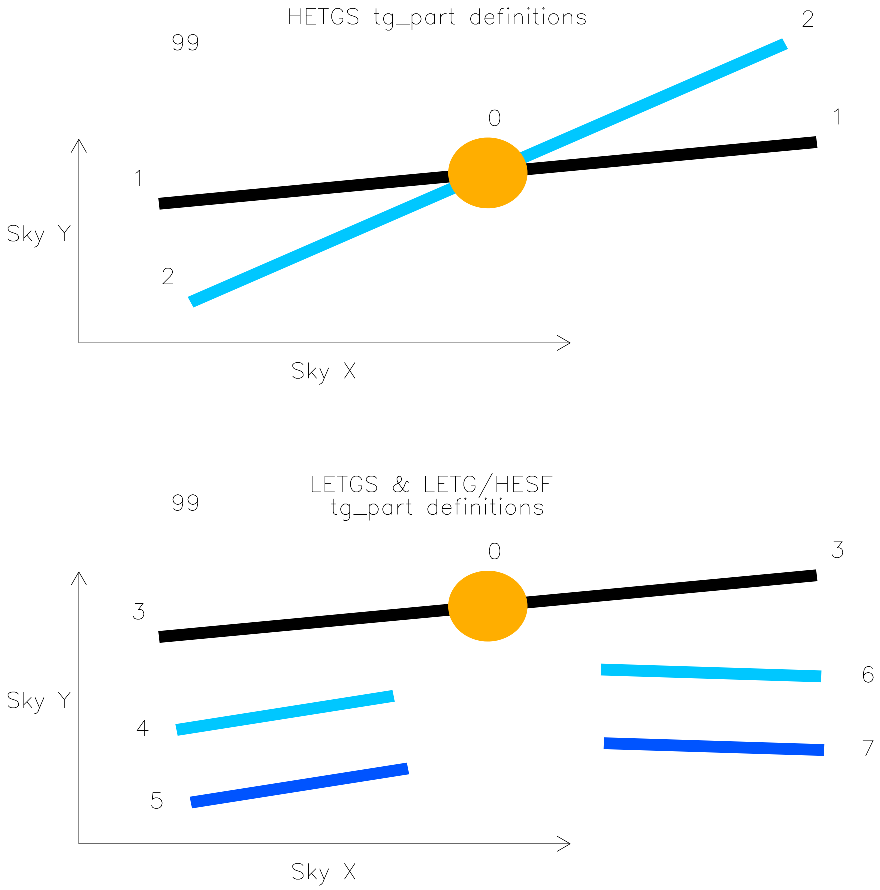

Figure 1: This is a schematic representation of the grating region showing the different parts of the spectrum. On the top is the HETG specification, and on the bottom, LETG. For the LETG, the parts, 4–7 are optional, only being required if the HESF is in the beam. Scales are arbitrary. There has been a small rotation applied, to emphasize the fact that in sky coordinates, the spectrum can have any orientation.

TG_D: cross-dispersion (spatial) angle. For an on-axis source, this ranges from about −0.1 to 0.1 degrees for HETGS or LETGS. In practice, it is generally restricted to much less (−0.001 to 0.001 degrees), though in backup modes (e.g., HETG/HRC-I), it could conceivably be as large as 1 degree.

For background or zero-order photons, *TG_D* is undefined, and stored as *NaN*.

TG_MLAM: The diffraction order times the wavelength. This can range from about −200Å to 200 Å for on-axis data (LETGS). Off-axis pointing theoretically allows −400 to 400 Å (though with a severe penalty in resolution!)

For background or zero-order photons, *TG_MLAM* is undefined, and stored as *NaN*.

TG_M: The diffraction order, if resolved. This is a small integer, not likely to be of absolute value greater than 10 for HETG/ACIS-S. The value, 99, is used as a flag for "unresolved" or background photons.

For LETGS photons (detector is HRC, *TG_PART* is 3-7), *TG_M* will be either +1 or −1 (since HRC cannot resolve the orders via a pulse-height).

The physically meaningful geometric limit set by the ACIS-S array with HETG is about ±62. This is for a 10 keV photon observed with the aim-point at one end of the ACIS-S array, and the detected phton at the other end. It is not a likely scenario, but is used to define allowed physically conceivable data ranges.

TG_LAM: Photon wavelength, if resolved.

For LETGS events (*TG_PART* is 3–7), *TG_LAM* will be set to the first-order wavelength at that position.

For background or zero-order photons, *TG_LAM* is undefined, and stored as *NaN*.

TG_SMAP: Source map. This is a bitmap which matches photons to multiple sources. This is partially redundant with *TG_SRCID*, but is used in the case of multiple sources observed with HETG in which MEG and HEG parts from different sources cross. Then, if photons cannot be resolved to a specific source (e.g., it could resolve to either of two sources), the bits will indicate which sources it could belong to.

Ten bits are allocated for the up-to-ten sources in the region specification. The least significant bit is assigned to the first source in the region, the next-to-least significant to the next source, etc. Note that the sources themselves may not be numbered sequentially from 1 to 10. Thus, if the region specification has three sources enumerated 1, 3, and 4, then if a photon could not be resolved between source 1 and 4, the bitmap would have the binary value, 101. To continue the example, consider the following table:

source #	tg_srcid	smap bits
1	1	001
2	3	010
3	4	100

The first three sources in the region have ID's of 1, 3, and 4. Each gets a bit of the *TG_SMAP* field. Any photons which are un-resolved between different sources (and are *not* background), have TG_SMAP set to the "OR" of the appropriate "smap bits".

$GDPX$**,** $GDPY$ (optional) refer to coordinates in Grating Diffraction Pixels. These are analogous to TG_R and TG_D. They are intermediate coordinates, and optional in L1.5 files.

For background or zero-order photons, $GDPX$ and $GDPY$ are undefined, and stored as 0.

TTYPE	TUNIT	TFORM	TLMIN	TLMAX	TDBIN	TNULL	Comment
TG_R	deg	1D | 1E	−2.0	2.0	$1.593E-4$	NaN^*	diffraction angle
TG_D	deg	1D | 1E	−2.0	2.0	$1.593E-4$	NaN^*	cross-dispersion angle
TG_MLAM	angstrom	1D | 1E	−400.0	400.0	$2.0E-3$	NaN^*	$m \times \lambda$
TG_M		1I	−62	62	N/A	99	order (m)
TG_LAM	angstrom	1D | 1E	-400	400	$2.0E-3$	NaN^*	wavelength (λ)
TG_PART		1I	0	99	N/A	N/A	component (HEG, MEG, LEG, . . .)
TG_SMAP		1I	0	32767	N/A	N/A	source map
TG_SRCID		1I	0	TBD	N/A	N/A	source ID
GDPX	pixel	1J	1	2^{16} (65536)	10	0	grating diffraction pixel, dispersion direction (optional)
GDPY	pixel	1J	1	2^{15} (32768)	10	0	grating diffraction pixel, cross-dispersion (optional)
* Not actually indicated in the header, but implied as a missing or undefined by the FITS standard.							

Table 4: *FITS Event Data File binary table contents (one entry per event). "N/A" means "Not Applicable". "NaN" is the IEEE standard for "Not A Number".*

2.3.1 Columns Dropped from Level 1 Files

There are some columns in Level 1 input files which are seldom used, so it is not necessary to carry them into Level 1.5. They will always be available in Level 1 products.

HRC columns to omit:

```
CRSV
CRSU
AMP_SF
AV1
AV2
AV3
AU1
AU2
AU3
RAWX
RAWY
SUMAMPS
```

ACIS columns to omit: `PHAS`

2.4 Grating Spectral Region Definitions (`REGION BINTABLE` extension or `*.reg` `ASCII` file)

For each ObI, a regional mask is created for each observation, as defined by the zero-order sky coordinates output from source detection and width and angle parameters. The source regions are designed to be of generous dimensions, such that the L1.5 product is a superset of photons likely to be selected for analysis, thus avoiding re-running the L1.5 pipeline for alternate selection criteria. It is defined in sky (X, Y) coordinates (typically a right-ascension and declination tangent-plane system) and is used to filter the events for transformation to grating diffraction coordinates.

2.4.1 `*.reg` (ASCII) Region File Definition

The `ASCII` file is the current implementation and is included here until replaced by the `FITS` implementation. We will keep this specification, since the `FITS` file will be a *T*ransport mechanism, and usage may remain `ASCII`.

The `ASCII` region file follows the `IRAF/PROS` Region File definition (see the documentation avialible in IRAF/XRAY via "help regions", for example), with some pipeline directives added in comment fields. The coordinates are given as sky pixel values, whose coordinate system can be obtained from the event-file's (`*_evt1.fits`) extension header keywords for columns labeled `X` and `Y`.

- The first line of the `*.reg` file contains a comment line of the format `#.mode` where mode is `HETG, LETG, DRAKE, HEG,` or `MEG`. Note that the modes `HEG` and `MEG` are special, in that one cannot observe in flight with them separately; they are for special processing purposes of ground-calibration data, simulations, or specially filtered flight data.
- The second line of the file contains a comment line of the format "`#.SRC` n" where n is the current source id.
- For any given source, a maximum of 8 distinct parts (neglecting background) exist. These parts are: zero order, heg arm, meg arm, letg, drake 1, drake 2, drake 3, and drake 4. For any given source, not all of these parts will be listed.
- Relevant parts of a source are listed one per line. The ordering of the parts depends on the type of data The parts for each mode are, in region-file line order: check for consistency and accuracy w/ other tables

HETG	0—	Zero-order
	1—	HEG
	2—	MEG
LETG	0—	Zero-order
	3—	LEG
DRAKE (HESF)	0—	Zero-order
	3—	LEG
	4—	Drake 1
	5—	Drake 2
	6—	Drake 3
	7—	Drake 4
HEG	0—	Zero-order
	1—	HEG
MEG	0—	Zero-order
	2—	MEG

- Parts that belong to a source are identified as follows:

  `physical; <format> ;`

  where `<format>` is any of the following:

  BOX `xcenter ycenter xwidth yheight [angle]`

  CIRCLE `xcenter ycenter radius`

  ROTBOX `xcenter ycenter xwidth yheight angle`

- abbreviations `b, c,` or `r` may also be used for `BOX, CIRCLE,` and `ROTBOX`, respectively.
- blank lines are ignored; they may be used to make the `*.reg` more readable to users, but are not used by the code.
- a separate source comment line (e.g. `#.SRC 3`) must be supplied before each source included in the region file. A region file may specify multiple sources.
- `ASCII` characters may be in upper or lowercase.
- Lines beginning with "`#.`" are processed as instructions by Level 1.5 software. They are treated as normal comments by other region parsers.
- Lines starting with a "`#`" and succeeded by any other characters other than "`.`" are considered comments.

In *ALL* cases, the zero-order part is *optional.* (The zero-order could have been off the detector, or deleted via intentional detector modes prior to telemetry.)

Example — A single HETG source, source ID of 1:

```
#.HETG
#.SRC 1
physical; circle 3200.1 3200.349 70;
physical; rotbox 3200 3200 3300 119 -5.3d;
physical; rotbox 3200 3200 3300 119 5.00d;
```

Example — Two LETG sources, source IDs of 2 and 4:

```
#.LETG
#.SRC 2
physical; c 2000.1, 2000.0249, 100;
physical; box 2000, 2000 2000 140;

#.SRC 4
physical; c 4000, 4000, 100;
physical; box 4000, 4000 3500 150;
```

2.4.2 FITS Region Extension Definition

The generic definition of an ASC FITS region is given in the "FITS REGION Binary Table Design" (Applicable Document 11. The region HDU will be a single `REGION` auxiliary extension, whose header is comprised of:

- a mandatory `REGION`-content header,
- table coordinate system and ranges,
- short configuration control,
- short timing, and
- short observation information components.

The components which differ substantially from the event file's other extensions (events, GTI) are the mandatory `REGION` keywords, and the table coordinate system. A region specification is in general specific to the ObI.

The `REGION` definition for Level 1.5 spectral mask are comprised of components described by a circle for zero-order and rotated boxes for diffracted orders. There are generally multiple components for each spectrum and possibly multiple sources per observation.

Radius coord keywords TBR.

The conditional interpretation of the `COMPONENT` upon `GRATING` value is shown in Table 7.

The interpretation of the coordinate vectors for grating region shapes, as given in the FITS region specification (Applicable Document 11) is:

`CIRCLE:` First element of X, Y, R vectors specifies center and radius.

`ROTBOX:` First element of each X and Y vectors specify the center of a rectangle. The first element of `ROTANG` specifies counter-clockwise rotation of the rectangle with respect to X and Y axes. The center of the rotation is the center of the rectangle (given by X, Y).

Other elements of X, Y are undefined. The first two elements of R specify the full-widths of X and Y, respectively.

For both grating types, component 0 is optional (e.g., if the zero-order was not imaged onto the detector). For the LETG, components 4–7 are optional (e.g., the source was not imaged onto the HESF (Drake Flat)).

2.4.3 Example: Full Region Extension Header

The following is a sample header for a region describing a field with two HETG sources.

TBS: Insert a sample region header here.

EXTNAME =	'REGION '	/ Region specification table
CONTENT =	'REGION '	
HDUCLASS=	'ASC '	
HDUCLAS1=	'REGION '	
HDUCLAS2=	'STANDARD'	
MTYPE1 =	'pos '	
MFORM1 =	'X,Y '	
TCTYP2 =	'RA---TAN'	/ sky X WCS
TCRVL2 =	0.0	/ Nominal angle
TCRPX2 =	16384.5	/ Reference pixel
TCDLT2 =	1.59265544165e-5	/ [degrees/pixel]
TDBIN2 =	10	/ default [pixels/bin]
TCUNI2 =	'deg'	/ Unit of X
TCTYP3 =	'DEC--TAN '	/ Sky Y WCS
TCRVL3 =	0.0	/ Nominal angle
TCRPX3 =	16384.5	/ Reference pixel
TCDLT3 =	1.59265544165e-5	/ [degrees/pixel]
TDBIN3 =	10	/ default [degrees/bin]
TCUNI3 =	'deg'	/ Unit of Y
TCTYP4 =	'TBS '	/ Sky XY WCS - for a radius value
TCDLT4 =	1.59265544165e-5	/ [degrees/pixel]
TDBIN4 =	10	/ default [pixels/bin]
TCUNI4 =	'deg'	/ Unit of radius

Table 5: *Special Keywords for grating* `REGION` *FITS File. region coordinates are specified in terms of sky* (X, Y)*, so that coordinate system must be specified.*

TTYPE	TUNIT	TFORM	TLMIN	TLMAX	Comment
SHAPE	-	16A	-	-	Shape of region: may be CIRCLE, ROTBOX, or BOX.
X	pixel	$4E$	0.5	65534.5	sky X (RA) coordinate vector for SHAPE.
Y	pixel	$4E$	0.5	65534.5	sky Y (Dec) coordinate vector for SHAPE.
R	pixel	$4E$	0	65534.5	radius vector for SHAPE (sky units)
ROTANG	deg	$4E$	0	360	Rotation angle for SHAPE, in degrees.
COMPONENT	-	I	0	7	Component number that SHAPE belongs to (default is 1). Interpretation of this depends upon the GRATING column.
INCLUDE	-	I	0	1	Inclusion (1; default) or exclusion (0).
SOURCE	-	I	0	10	Source number.
GRATING	-	16A	-	-	Applicable grating; one of: HETG or LETG

Table 6: *FITS grating region file binary table contents.*

GRATING	COMPONENT	Meaning
HETG	0	Zero-order (optional)
	1	HEG arm
	2	MEG arm
LETG	0	Zero-order (optional)
	3	LEG arm
	4	HESF (Drake Flat) region 1 (optional)
	5	HESF (Drake Flat) region 2 (optional)
	6	HESF (Drake Flat) region 3 (optional)
	7	HESF (Drake Flat) region 4 (optional)

Table 7: *Region table component interpretation. Zero-order regions are optional. Grating is either HETG or LETG. If Grating is LETG, then HESF parts are also optional.*

2.5 Volume, Size, and Frequency Estimates

The columns added to an HRC or ACIS Level 1 file in Level 1.5 processing add about 48 to 64 bytes per photon. A 10-source HETG region file extension is about 720 bytes.

3 Example Files

```
TBS: HETG/ACIS-S 2 src FITS events, region, summary
     LETG/HRC_S 2 src
     LETG/HESF TBD.
```