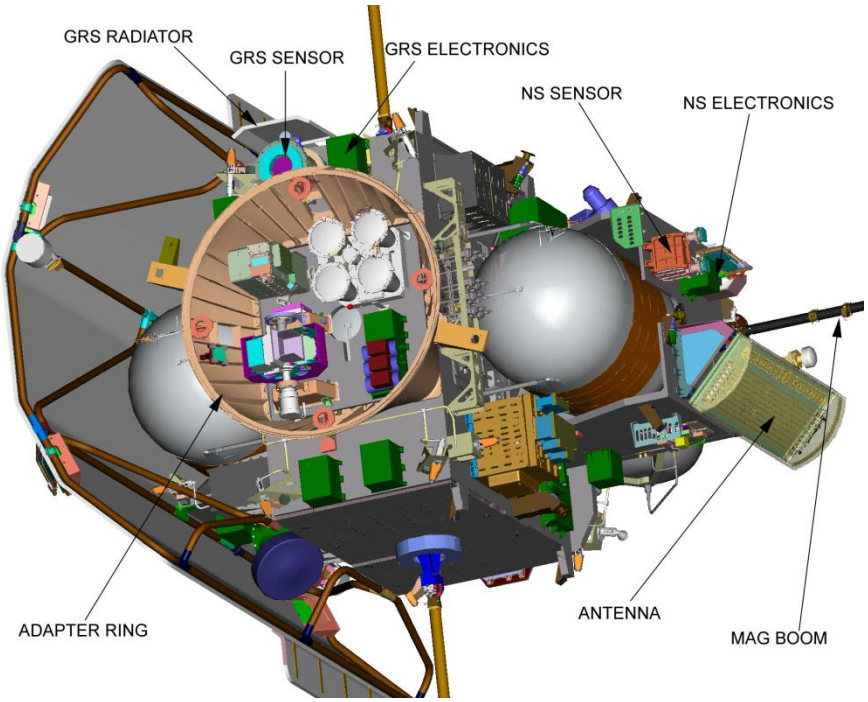
MESSENGER Gamma Ray Spectrometer Calibrated Data Record, Reduced Data Record, and Derived Analysis Product Software Interface Specification

Version 1.51
November 18, 2015



Prepared by Karl Harshman (version 1.39 and earlier)
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Document Review

This document and the archive it describes have been through PDS Peer Review and have been accepted into the PDS archive.

Patrick Peplowski, GRS Instrument Scientist, has reviewed and approved this document.

Susan Slavney, PDS Geosciences Node Representative, has reviewed and approved this document.

Susan Ensor, MESSENGER Science Operations Center Lead, has reviewed and approved this document.

Change Log

DATE	SECTIONS CHANGED	REASON FOR CHANGE	REVISION
08/17/06	Added PDS labels	Draft	1.0b
08/21/06	Changed numbering scheme	Draft	1.0c
07/01/08	Corrected typos	Draft	1.3
10/29/08	All	Draft	1.4
10/29/08	All	Draft	1.5
11/03/08	All	Draft	1.6
02/10/09	All	Draft	1.7
03/03/09	All	Draft	1.8
03/10/09	All	Draft	1.9
03/19/09	All	Draft	1.10
03/23/09	All	Draft	1.11
03/24/09	All	Draft	1.12
04/03/09	All	Draft	1.13
04/07/09	All	Draft	1.14
04/14/09	All	Draft	1.15
04/14/09	All	Draft	1.16
04/17/09	All	Added search indexes info	1.17
04/29/09	All	Added NAME attribute to OBJECTs in GRS_ENG LBL file. Changed GRS_ENG.FMT file to have raw data type of MSB_INTEGER.	1.18

05/08/09	All	Added 3 S/C orientation columns to the GRS_CAL_AC, GRS_CAL_RAW and GRS_CAL_SH files. Added Susan Slavney changes.	1.19
06/12/09	All	Modified Appendix with GRS_CAL_AC.FMT, GRS_CAL_RAW.FMT and GRS_CAL_SH.FMT to have spectra with each item being an IEEE_REAL 4 byte float instead. Also modified the archive's DATA sub-directory under the month sub-directory to be named after the day of the month not the day of the year.	1.20
8/31/09	All	Modified Document to reflect comments from the PDS Peer Review	1.21
1/19/10	6.7	Added md5 files	1.22
2/7/10	8.4, 8.5.4, 8.5, 8.7.4, document headers	Updated engineering conversions. Removed DETECTOR_ID from the ENG format file. Updated index description. Minor updates to document headers.	1.23
2/8/10	TOC, 5.6, 8.5, 8.7.1, 8.7.4	Updated TOC page numbers. Edited software description. Minor sample label edits to match delivered files. Sample index.lbl formatting, fixed VOLUME_ID. Edited column 13 NAME in GRS_CAL_RAW.FMT and column 5 DESCRIPTION in GRS_ENG.FMT to match delivered files. Additional minor edits/formatting.	1.24
2/11/10	6.7.1	Changed name of SOFTWARE directory file from software.txt to softinfo.txt.	1.25
12/14/10	6.5, 6.8.2, 8.5.4, 8.7.4	Added new Shield data product	1.26
5/16/11	5.2	Added GRS_CAL_SH2 into table and added a description of the flight software change	1.26
5.16.11	6.2.1, 6.3.1. 6.4.1, 6,5,1	Removed the phrase (see Section 6, *Detailed Data Product Specifications*, on page 20 for each binary file)	1.26
5/16/11	8.5.4	Added the keyword STANDARD_DATA_PRODUCT_ID to the sample label, correct column count to 45	1.26
6/2/11	8.6, 8.7	Change "periherm" to "apoherm" in descriptions of orbit start time	1.27
6/14/11	Document Review 8.6	Added document review information. Adjusted table formatting.	1.28
8/4/11	All	Changed GRS_CAL_SH_2 to	1.29

		GRS_CAL_SH2.	
3/16/12	6.7, 6.9.2, 8.5.6, 8.6, 8.7.6	Added RDR_SUM data type	1.30
5/16/12	2, 4, 5.5	Change “Data Management and Science Analysis Plan” to “Data Management and Archiving Plan:	1.31
5/22/12	Document Review	Change MESSENGER GRNS reviewer to Patrick Peplowski	1.32
6/7/12	8.5.6, 8.7.7, 8.6, 6.7, 6.9.2	Add new columns to RDR_SUM product, added RDR product size, added information about sum types	1.33
8/21/12	8.6, 8.7.7	Correct type of gain and offset in RDR_SUM.	1.34
9/27/12	6.7.1	Minor corrections from peer review liens.	1.35
12/7/12	8.6, 8.72-8.75	Revised BAD_DATA_FLAG descriptions.	1.36
1/15/13	8.7.7	Fixed units in GRS_RDR_SUMS.FMT.	1.37
2/4/13	All	Editorial changes	1.38
4/22/13	1.1	Editorial changes.	1.39
6/7/13	All	Added new count rate and abundance map data product.	1.40
6/12/13	Document Review, Table 6.2	Revised “Document Review” section and Table 6.2. Version submitted for DAP peer review.	1.41
10/4/13	5.2, 6.6, 6.7, 8.5.5, 8.5.6, 8.7.5, 8.7.6	Added description of new data products resulting from flight software update.	1.42
10/16/13	6.1.3, 6.10.1, 6.12.1, 8.5.9, 8.5.10	DAP peer review revisions.	1.43
11/21/13	5.1, 6.7.1, 8.5.6, 8.6, 8.7.5, 8.7.6	Edits resulting from review of new shield sensor products.	1.44
1/10/14	8.5.9	Minor edits.	1.45
5/21/14	8.4, 8.5.5, 8.5.6, 8.6, 8.7.5, 8.7.6	Removed references to “AZI_ANG”, added “DEADTIME_FRAC” to CDR descriptions. Revised associated SCR and SH3 CDR sample labels and format files.	1.46
11/13/14	8.5.5, 8.5.6, 8.5.10, 8.7.5, 8.7.6	Revised “ALTITUDE” column in SCR and SH3 CDR format files. Updated sample labels accordingly. Replaced sample index label with current version.	1.47
10/16/15	8.6, 8.7	Updated data column descriptions, FMT files.	1.48
10/28/15	8.5, 8.7, TBD Log	Matched sample labels and format files with archived files. Removed TBD log.	1.49

11/13/15	All	Editorial updates to reflect completion of data acquisition and PDS deliveries.	1.50
11/18/15	5.3.2, 6.7.1	Minor typo and editorial fixes.	1.51

1 Purpose and Scope of Document

1.1 Purpose

This document provides users of the MESSENGER Gamma-Ray Spectrometer (GRS) data products with a detailed description of the GRS instrument, CDR/RDR/DAP (Calibrated Data Record/Reduced Data Record/Derived Analysis Product) generation, validation, and storage. Note that the Gamma Ray and Neutron Spectrometer instruments were generally referred to as the GRNS instrument. However, they were two separate sensors, each with its own EPU, and the data products are described within the specific Software Interface Specification (SIS) of each sensor.

1.2 Scope

The goal of this document is to provide thorough and complete information so that Planetary Data System (PDS) users can read and understand the data products long after the completion of the MESSENGER mission. As such, this document provides a common reference for scientists, data analysts, software engineers, and researchers to access and understand the MESSENGER Gamma Ray Spectrometer CDR/RDR/DAP PDS archived data.

This document describes the intermediate and advanced data products for the MESSENGER GRS. These data products correspond to National Research Council Committee on Data Management and Computation (CODMAC) levels 3-5. These data levels are described more fully in Section 8.2, *Appendix: CODMAC/NASA Definition of Processing Levels.*

2 Applicable Documents

The MESSENGER GRS CDR/RDR/DAP SIS is responsive to the following documents:

- Planetary Data System Standards Reference, February 27, 2009, Version 3.8. JPL D-7669, Part-2.
- Planetary Data System Archive Preparation Guide, April 1, 2010, Version 1.4, JPL D-31224.
- GRS Flight Software Specification, Draft Dec. 15, 2003.
- MESSENGER Experiment Data Record (EDR) Software Interface Specification for the Gamma Ray Spectrometer.
- MESSENGER Data Management and Archiving Plan. The Johns Hopkins University, APL.
- MESSENGER Project Archive Generation, Validation, and Distribution Plan.
- MESSENGER Mercury: Surface, Space Environment, Geochemistry, Ranging; A mission to Orbit and Explore the Planet Mercury, Concept Study, March 1999.
- [PLR] Appendix 7 to the Discovery Program Plan; Program Level Requirement for the MESSENGER Discovery project, June 20, 2001.
- The MESSENGER Gamma-Ray and Neutron Spectrometer, Space Science Reviews 131, 339-391, 2007.

3 Relationships with Other Interfaces

The GRS CDR/RDR/DAP data products are dependent on the GRS Experiment Data Record (EDR) data products. Changes to the EDR product have required revisions to the associated CDR/RDR/DAP products. The GRS CDR/RDR/DAP data products are also dependent on valid SPICE Kernel generation for timing and spatial information. Changes or revisions to the SPICE Kernel have also required revisions to the GRS CDR/RDR/DAP products. Changes to data processing programs (see Section 6, *Detailed Data Product Specifications*) that convert EDR data to CDR/RDR/DAP data have also resulted in revised CDR/RDR/DAP data products.

4 Roles and Responsibilities

The roles and responsibilities of the instrument teams, Applied Physics Laboratory (APL), Applied Coherent Technology (ACT), and the Planetary Data System (PDS) are defined in the MESSENGER Data Management and Archiving Plan.

5 Data Product Characteristics and Environment

5.1 Instrument Overview

The Mercury Surface, Space ENvironment, GEochemistry, and Ranging (MESSENGER) mission was designed to orbit Mercury following one Earth flyby, two of Venus, and three of Mercury. It launched in August 2004 and achieved orbit insertion around Mercury on 18 March 2011. Initial data collection began during the three flybys of Mercury and consisted primarily of global mapping and measurements of the surface, atmosphere, and magnetosphere composition. The nominal one-Earth-year long mission ended on 17 March 2012. This was immediately followed by the start of a one-year-long extended mission. A second and final two-year-long second extended mission ended on 30 April, 2015, when the MESSENGER spacecraft impacted the surface as expected. MESSENGER orbital observations provide data to answer questions about the nature and composition of Mercury's crust, tectonic history, structure of the atmosphere/magnetosphere, and the nature of the polar caps.

The Gamma Ray Spectrometer (GRS) instrument onboard the MESSENGER spacecraft was designed to observe the spectrum of gamma rays emitted from Mercury's surface in the energy range from 0.1 MeV to 10 MeV. Gamma rays are produced either directly from radioactive decay (of K, Th, U) or indirectly when activated by the cosmic ray background. The relatively low absorption rate of these gamma rays allows the estimation of the surface composition to depths of ~10's of cm, depending on the energy of the gamma ray.

The GRS consisted of two separate sensors. Gamma-ray measurements were made using a high-purity germanium (HPGe) cylindrical semiconductor crystal encapsulated in aluminum. The HPGe was surrounded by a shield of plastic scintillator (BC-454) that is sensitive to charged particles and neutrons. The encapsulated HPGe was contained within a cryostat made of a nest of gold-plated cans and suspended by a network of Kevlar strings. This was done to provide thermal and electrical isolation. The

HPGe required a mechanical cryocooler to maintain the required ~90K temperatures in order to detect gamma rays. The cryocooler failed on 15 June, 2012 after approximately 9,000 hours of operation. This exceeded the expected 8,000 hour lifetime of the cooler. Following the cooler failure, new flight software was uploaded to the GRS on 25 February, 2013 for the purpose of optimizing the instrument for neutron and charged particle measurements with the BC-454 shield. These changes included the addition of a high time cadence measure of the local particle flux, which is useful for characterizing the charged particle environment near Mercury. ACS measurements were acquired nearly continuously until the end of the mission.

When gamma rays interact with the bulk HPGe, a charge is generated. The electrical charge was amplified, measured, and then digitally converted into one of the 16,384 (2^{14}) channels (bins) of the detector. After a specified accumulation time, a histogram was produced that shows the distribution of events (number of strikes) that accrued during that period as a function of energy (channel number). Due to the low count rates usually encountered, accumulation times of minutes to hours are normal. The raw science data product is the counts in each in each of the 16,384 bins after this accumulation period. This histogram is counted as one gamma ray spectrum (GRS_CAL_RAW product).

In addition to the HPGe, the GRS used the plastic scintillator as an anticoincidence shield, primarily to reduce the background signal in the HPGe from cosmic-ray-originating neutrons and gamma rays created within the spacecraft. In a scintillator, the interaction of the gamma ray results in a brief fluorescence, with an intensity proportional to the energy. The light pulse was amplified by a photo-multiplier tube and then buffered, shaped and digitized with a separate analysis chain from the HPGe. The shield scintillator has a much lower energy resolution than the HPGe and its spectrum has no well-defined energy peaks, so detected events in the shield are binned to only 1024 channels by the EPU (GRS_CAL_AC product). Scintillator-incident neutrons were detected though the $^{10}B(n,\gamma)$ reaction, as the BC-454 is enriched in ^{10}B. Additionally, charged particles may be detected though the ionization they induce while passing through the scintillator.

If events were found to occur in both detectors within some short time interval, a coincidence condition is flagged. This may have been caused by a single high-energy particle depositing energy in both detectors as it passed through or by secondary photons created after an initial gamma ray or neutron interaction or by two independent events occurring simultaneously (false coincidence or “accidental”). In either case, the energies measured cannot be related to the initial event without additional interpretation. Separate spectra are maintained to accumulate both raw (unprocessed) and anticoincidence HPGe events (GRS_CAL_SH product).

The 25 February 2013 flight software upload included the addition of a new data product, called “shield count rate”. This product measures the total count rate at high time cadence (10 ms) in order to provide new insights into the charged particle environment around Mercury, particularly the energetic electron events. The total count rate on the detector was measured every 10 ms and stored in a 16,384 channel long array. For short integration periods, this array is too large and the remaining values are set to zero. When a data integration period would require more than 16,384 channels, the values past this length are stored in the final channel. The first approximately 50 entries of the shield count rate product are always zero, and reflect the 0.5-second-long interval at the beginning of the accumulation period during which the GRS electronics busy performing other tasks and are unable to processes the total shield count rates.

5.2 Data Product Overview

The GRS CDR/RDR/DAP archive includes nine data products: 7 CDR, 1 RDR, and 1 DAP. A CDR data file contains all the data of a given type recorded for a given day of the Earth year. RDR and DAP products contain summed information acquired over a range of times. The data products are as follows:

Data Product	Product Description	Example Filename
GRS_CAL_RAW	• Detached PDS label file. • Spectra data file – HPGe raw spectra, and associated timing, spatial, and engineering data in binary table.	GRS_CRA2008265ZZZ.DAT See section 6.2.3 for details.
GRS_CAL_AC	• Detached PDS label file. • Spectra data file – HPGe anti-coincident spectra and associated timing, spatial, and engineering data in binary table.	GRS_CAC2008265ZZZ.DAT See section 6.3.3 for details.
GRS_CAL_SH	• Detached PDS label file. • Shield Spectra data file – shield spectra and associated timing, spatial, and engineering data in binary table. This product was generated prior to September 17, 2010.	GRS_CSH2008265ZZZ.DAT See section 6.4.3 for details.
GRS_CAL_SH2	• Detached PDS label file. • Shield Spectra data file – shield spectra and associated timing, spatial, and engineering data in binary table. This product was generated after September 17, 2010.	GRS_CS22008265ZZZ.DAT See section 6.5.3 for details.
GRS_CAL_SH3	• Detached PDS label file. • Shield Spectra data file – shield spectra and associated timing, spatial, and engineering data in ASCII table. This product was generated after March 17, 2013.	GRS_CS32013151ZZZ.TAB See section 6.6.3 for details.
GRS_CAL_SCR	• Detached PDS label file. • Shield count rate file – shield count rate and associated timing, spatial, and engineering data in ASCII table. This product was generated after March 17, 2013.	GRS_CSC2013091ZZZ.TAB See section 6.7.3 for details.
GRS_ENG	• Detached PDS label file. • Engineering data file – GRS instrumental engineering data in	GRS_E012008265ZZZ.DAT See section 6.8.3 for details

	binary table.	
GRS_RDR_SUM	• Detached PDS label file. • Spectral Sum in binary table.	GRS_RS12008265ZZZ.DAT See section 6.9.3 for details
GRS_DAP	• Detached PDS label file. • Map of gamma-ray count rates or elemental abundances derived from summed GRS data.	GRS_DAP_K_ABD_MAP.JP2 See section 6.10.3 for details

Each MESSENGER GRS CDR/RDR product consists of three files. One file contains the data itself and is arranged in binary or ASCII table format. Another file is a label file that describes the content of the data file. The label file defines the start time and end time of the observation, product creation time, etc. It does not describe the structure of the data file itself. Instead, the PDS label file contains a reference pointer to a separate format file (*.FMT). The format file describes the structure of the table and each of the different fields within the table. This format file resides in the top level of a LABEL directory in a data archive volume, because it applies to the structure of all the table files. The GRS DAPs do not contain associated format files; rather, the file structure is fully described by the label.

On 17 September 2010, new flight software was loaded onto the spacecraft to produce the GRS_CAL_SH2 data format. The new software added fast-neutron detection capability to the GRS by employing a new mode of operation between the anticoincidence shield and the germanium detector. The CAL_SH column of the GRS_CAL_SH data product was transformed into 12 separate columns in the GRS_CAL_SH2 data product. These columns are described in section 8.7.4. The column range is from NUM_BUFFERED_EVENTS through SHIELD_FAST.

Measurement of the fast-neutron flux near the GRS is needed to reduce the uncertainty in the spacecraft contribution to important elemental lines in the GRS gamma-ray spectrum. The previous shield spectrum data product was a full 1024 bins and extended well beyond the region of interest. The four thermal and fast events spectra are all obtained using coincidence events with the HPGe detector in the 478-keV region of the HPGe spectrum. The 478-keV region contains the gamma-ray emitted in a thermal neutron capture reaction with ^{10}B present in the borated-plastic shield. It was found that the spectra of these coincidence events best isolated the neutron signal, while minimizing the gamma-ray background, but it is not certain what fraction of these events are actually neutrons or gamma-rays. The HPGE_THERMAL and SHIELD_THERMAL events spectra contain events within a narrow $\pm 0.1\mu s$ coincidence window and likely represent mostly thermal neutrons. The HPGE_FAST and SHIELD_FAST events spectra contain events with positive coincidence times $> 0.1\mu s$ and likely represent mostly fast neutrons. The HPGE_THERMAL and HPGE_FAST events spectra provide the corresponding 478-keV HPGe peak along with sufficient background channels on either side of the peak to allow background subtraction, while the SHIELD_THERMAL and SHIELD_FAST events spectra contain the corresponding shield spectrum.

On 25 February 2013, new flight software was loaded onto the spacecraft. This software added the shield count rate data product, and changed the gain of the anti-coincidence shield in order to facilitate peak fitting of the GRC_CAL_SH2 spectra. Additionally, the format of the gain-modified SH2 EDR was changed, resulting in the SH3 product.

5.3 Data Processing

5.3.1 Data Processing Level

The CODMAC data level numbering system is used to describe the processing level of the GRS data products. GRS CDR/RDR products are considered a CODMAC “Level 3” (Calibrated) or NASA “Level 1A,” which are edited data that are still in units produced by the instrument, but have been transformed (e.g., calibrated, rearranged) in a reversible manner and packaged with needed ancillary and auxiliary data (e.g., temperatures with calibration equations applied). The GRS DAP products are a CODMAC "Level 5" (Derived) or NASA "Level 3," which are derived results such as maps, reports, graphics, etc. For a more detailed description, see Section 8.2, *Appendix: CODMAC/NASA Definition of Processing Levels*.

5.3.2 Data Product Generation

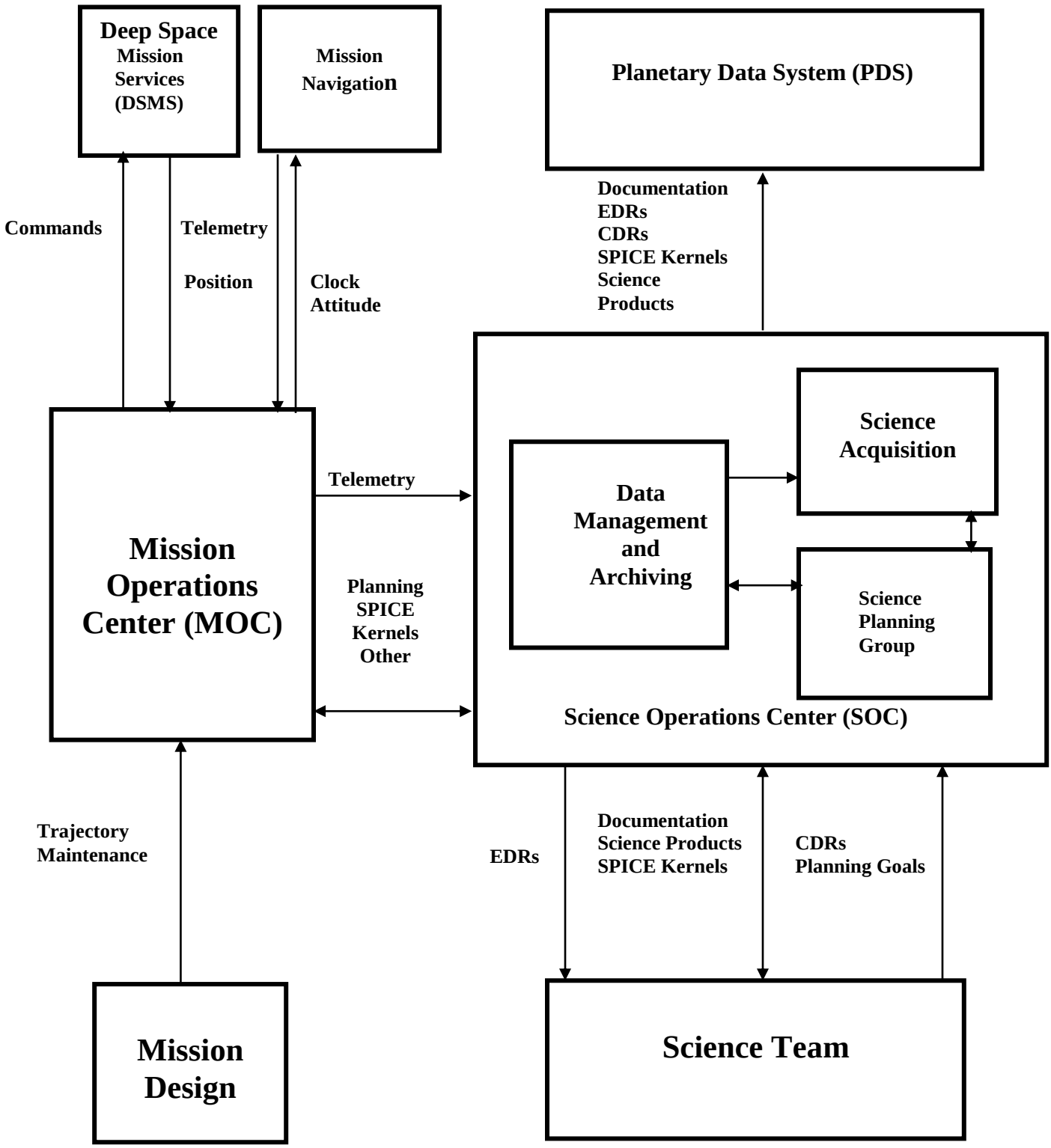
The GRS CDR/RDR files with the exception of the SH3 and SCR CDRs were produced by the University of Arizona (UA) and provided to the MESSENGER Science Operations Center (SOC) operated jointly by APL and Applied Coherent Technology Corporation (ACT). The University of Arizona was responsible for converting the data to the proper PDS labeled format, with the exception of the SH3 and SCR products, which were produced by APL. The CDR/RDR data products were made available to the MESSENGER Science Team for initial evaluation and validation. At the end of the evaluation and validation period, the data were organized and stored on the best determined media and made available to the PDS for distribution to the science community. These products are used for engineering support, direct science analysis, and construction of other science products. DAPs were created by APL and ACT.

5.3.3 Data Flow

The MESSENGER SOC planned data acquisition during the operational period and generated and validated data archives under the auspices of the MESSENGER Project Scientist. The SOC supported and worked with the MOC, the Science Team, instrument scientists, and the PDS.

A primary data server residing at the SOC, located at APL, served as the data storage facility for all MESSENGER instruments. Inputs to the SOC consisted of telemetry in the form of Consultative Committee for Space Data Systems (CCSDS) packets. Files were received from the SOC and delivered to the SOC via ftp. (See figure 1, MESSENGER data flow.) In the case of the GRS CAL_RAW, CAL_AC, CAL_SH, CAL_SH2, ENG, and RDR_SUM data products, UA received GRS EDR data from the SOC, transformed the data into valid CDR/RDR data products, and returned the data to the SOC for storage and distribution. CAL_SH3, CAL_SCR, and DAP products were produced at APL and returned to the SOC for storage and distribution.

Figure 1 MESSENGER data flow



5.3.4 Labeling and Identification

There is a corresponding detached PDS label file for each GRS CDR/RDR/DAP data file. See Section 6, *Detailed Data Product Specifications* for the sample PDS label files and a complete description of each label format. Detached means that the label file is separate from the data file, as opposed to being in the header portion of the data file.

The data set ID assigned by PDS to the GRS CDR/RDR data set is "MESS-E/V/H-GRNS-3-GRS-CDR-V1.0". The data set ID assigned by PDS to the GRS DAP data set is "MESS-E/V/H-GRNS-5-GRS-DAP-V1.0".

5.4 Standards Used in Generating Data Products

5.4.1 PDS Standards

The GRS CDR/RDR/DAP data products comply with the Planetary Data System standards for file formats and labels as specified in the PDS Standards Reference.

The GRS CDR/RDR data products include:
Data File - A binary or ASCII table object containing the data.
Detached Label File - Serves as a high-level description of the parameters that correspond to the table object.
A pointer to a FORMAT file, which describes the structure of the table file.

The GRS DAP data product includes:
Data File - An image object containing the data.
Detached Label File - Describes the parameters and structure of the image object.

5.4.2 Coordinate Systems

There are two coordinate systems in use:

- the celestial reference system used for target and spacecraft position and velocity vectors and camera pointing, and
- the planetary coordinate system for geometry vectors and target location.

The celestial coordinate system is J2000 (Mean of Earth equator and equinox of J2000). The planetary coordinate system is **planetocentric**. The planetocentric system has an origin at the center of mass of the body. The planetocentric latitude is the angle between the equatorial plane and a vector connecting the point of interest and the origin of the coordinate system. Latitudes are defined to be positive in the northern hemisphere of the body, where north is in the direction of Earth's angular momentum vector, i.e., pointing toward the hemisphere north of the solar system invariant plane. Planetocentric longitude is measured around the equator of the body from a prime meridian defined and adopted by international agreement, i.e., Seidelmann et al 2003.

Longitudes increase toward the east making the planetocentric system right-handed. Radius is the distance from the planetary body's center of mass to the point of interest.

The list below describes the computational assumptions for the geometric and viewing data provided in the PDS label:

- The mid-point time of observation is used for the geometric element computations. (The mid-point is calculated using the Start and End times from the EDR set.)

Label parameters reflect observed, not true, geometry. Therefore, light-time and stellar aberration corrections are used as appropriate.

The inertial reference frame is J2000 (also called EME2000).

Latitudes and longitudes are planetocentric.

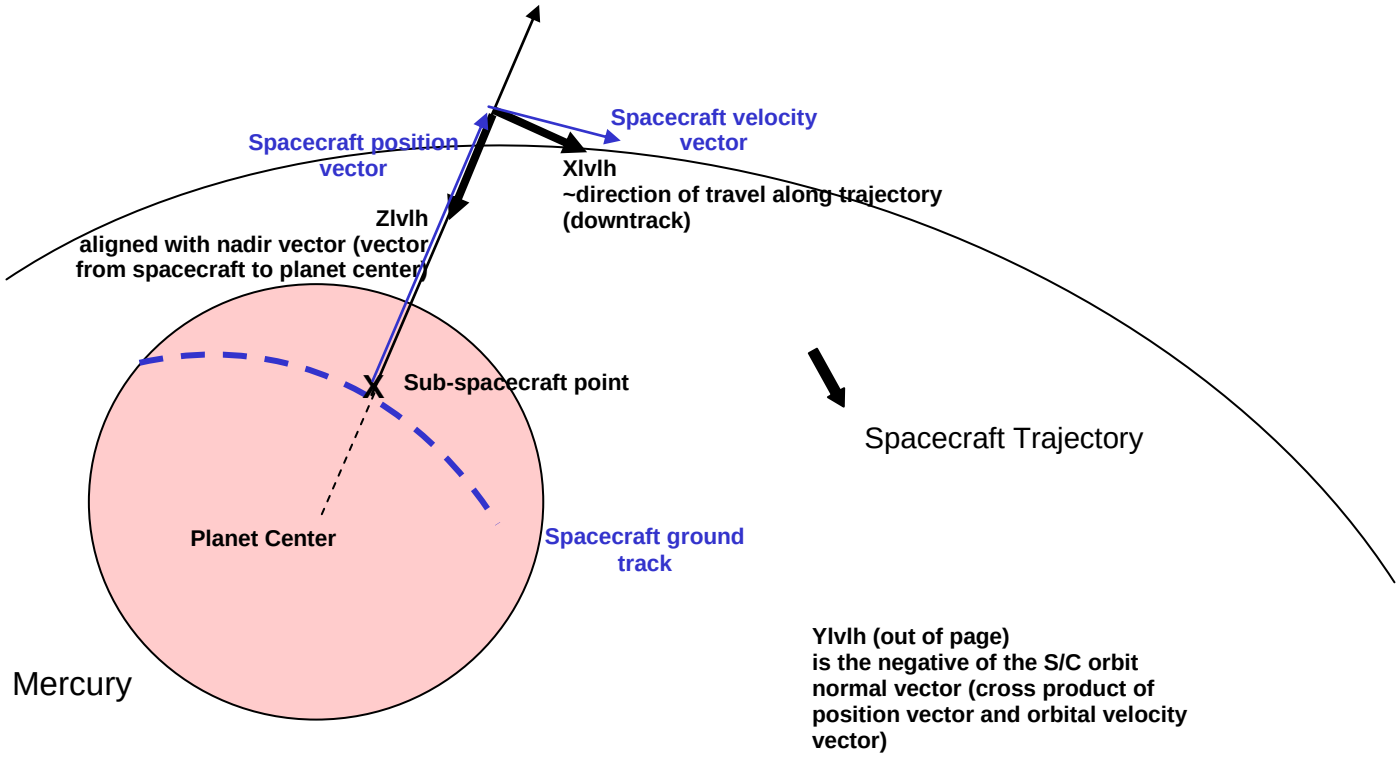
The "sub-point" of a body on a target is defined by the surface intercept of the body-to-target-center vector. This is not the closest point on the body to the observer where the observer is the spacecraft, MESSENGER.

Distances are in km, speeds in km/sec, angles, in degrees, angular rates in degrees/sec, unless otherwise noted.

Angle ranges are 0 to 360 degrees for azimuths and local hour angle. Longitudes range from 0 to 360 degrees (positive to the East). Latitudes range from -90 to 90 degrees.

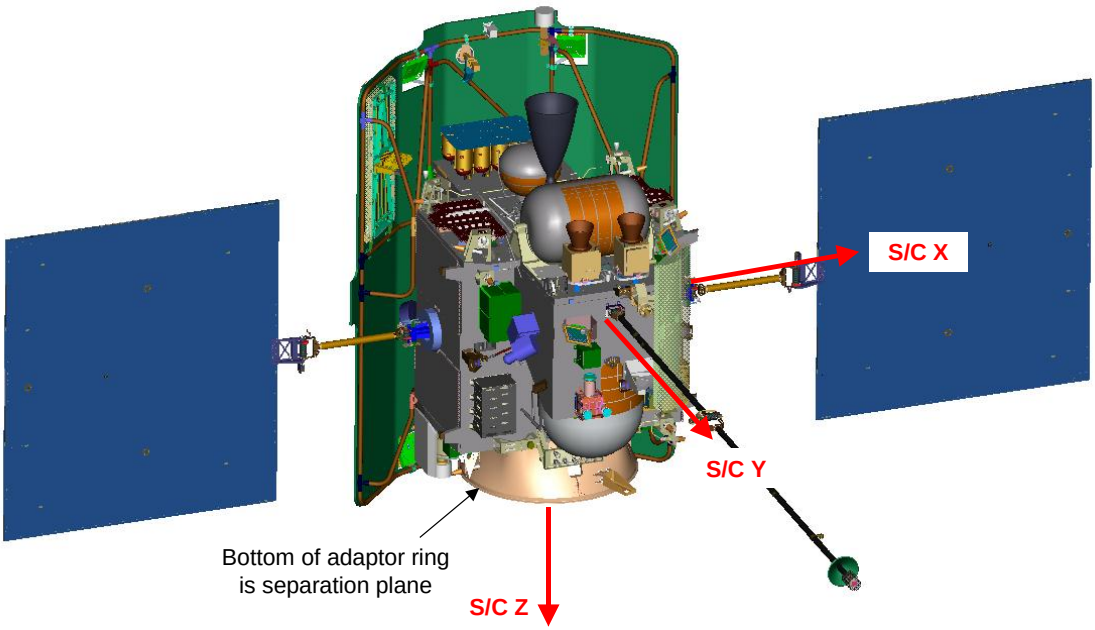
SPICE kernel files are used in the geometric parameters (See Appendix: SPICE Kernel Files Used in MESSENGER Data Products.)

The spacecraft attitude during orbits and flybys is defined by two additional coordinate systems, the GRS LVLH (Local Vertical Local Horizontal) frame and the spacecraft fixed frame, and by the rotation of the spacecraft frame with respect to the GRS LVLH frame. The GRS LVLH frame is illustrated in the figure below.



In the GRS LVLH frame, the Z axis is aligned with the vector from the spacecraft to the planet center (the nadir direction), the Y axis is the negative of the cross product of the position and velocity vectors (into the plane of the paper in the illustration), and the X axis points in the instantaneous direction of motion, completing a right-handed coordinate system.

The spacecraft fixed frame is illustrated in the figure below. The Z axis is along the viewing direction of the instrument deck inside the adapter ring and of the GRS just outside the adapter ring, the Y axis is directed from the spacecraft along the magnetometer boom, and the X-axis is parallel to the solar panel booms, forming a right-handed coordinate system.



The spacecraft attitude is specified by the rotation of the spacecraft fixed frame Z axis in the GRS LVLH frame and a twist angle about the Z axis. The Z axis rotation is given by a nadir angle and an azimuth angle, where the nadir angle is 0 degrees when the spacecraft Z axis points along the + Z LVLH axis and 180 degrees when it points along –Z in the LVLH frame, and the LVLH azimuth angle is measured counterclockwise about the Z LVLH axis from the X LVLH axis. The twist angle is measured positive about the +Z spacecraft axis.

5.4.3 Data Storage Conventions

The data are organized following PDS standards. The CAL_RAW, CAL_AC, CAL_SH, CAL_SH2, ENG, and RDR_SUM data are stored in binary files as floating-point, signed and unsigned integer data in most-significant-first (big-endian) byte order. The CAL_SH3 and CAL_SCR data are stored as ASCII files. The DAPs are stored as jpeg2000 image files. See jp2info.txt in the DOCUMENT directory for additional information on the JP2 data format.

5.5 Data Validation

The GRS CDR/RDR/DAP data products were validated by the GRS Instrument Scientist for science content and for compliance with PDS archive standards.

The GRS CDR/RDR/DAP data products and documentation were submitted to a peer review committee for science review according to PDS policy.

5.6 Software

As PDS-compliant tables, most CDR/RDR data can be read using the PDS-supplied program NASAView and other software designed to read PDS data. However, NASAView will not read GRS engineering files because it does not support a one-label-to-many-files relationship. Since NASAView cannot support the GRS engineering CDRs, the GRS team supplies software to read these files. This software is available from the PDS Geosciences node. (See softinfo.txt in the SOFTWARE directory for details.) NASAView is available at no charge from the PDS website http://pds.nasa.gov. The information in the PDS labels includes complete software-readable descriptions of data file formats, so that users may write custom software to read the products if desired.

Please refer to jp2info.txt located in the DOCUMENT directory for information on software to view the DAP JP2 files.

6 Detailed Data Product Specifications

6.1 Common Elements of Calibrated Data

6.1.1 Handling Errors

Even with data validation procedures applied to the volumes, it is inevitable that errors will be introduced into the archive. A plan is required to handle errors discovered in data volumes that have already been produced.

As errors were discovered, they were reported to the GRS data processing facility. The files were corrected and sent on to the PDS. A text file called "ERRATA.TXT" located in the top level of the data volume was maintained to track and document all discovered errors. The keywords PRODUCT_VERSION_ID and PRODUCT_CREATION_TIME were updated in the PDS labels of corrected files.

6.1.2 Geometric Elements

The timing and spatial information that is packaged with the GRS CDR/RDR/DAP data products are the timing and spatial values derived from the appropriate SPICE kernels collected for each day of the mission. SPICE is an acronym for **S**pacecraft, **P**lanet, **I**nstrument, **C**-matrix, and **E**vent kernels. SPICE kernels are provided by the Navigational Ancillary Information Facility (NAIF) at the Jet Propulsion Laboratory, and are the standard for all timing and spatial data transformations.

6.1.3 PDS Label File Format

Below are the keyword definitions for the detached PDS label files:

A_AXIS_RADIUS
Provides the value of the semimajor axis of the ellipsoid that defines the approximate shape of a target body.

B_AXIS_RADIUS
Provides the value of the intermediate axis of the ellipsoid that defines the approximate shape of a target body.

C_AXIS_RADIUS
Provides the value of the semiminor axis of the ellipsoid that defines the approximate shape of a target body.

CENTER_LATITUDE
Provides a reference latitude for certain map projections.

CENTER_LONGITUDE
Provides a reference longitude for certain map projections.

COLUMNS
Identifies the number of columns (fields) in a table.

COORDINATE_SYSTEM_NAME
Provides the full name of the coordinate system to which the state vectors are referenced, in this case "MEAN EARTH/POLAR AXIS OF DE421".

COORDINATE_SYSTEM_TYPE
One of the three basic types of coordinate systems, in this case "BODY-FIXED ROTATING".

DATA_SET_ID
Uniquely identifies the CDR/RDR/DAP file as part of a volume collection, organized by sensor, mission phase, and version number. The GRS CDR/RDR DATA_SET_ID is “MESS-E/V/H-GRNS-3-GRS-CDR-V1.0” and the GRS DAP DATA_SET_ID is “MESS-E/V/H-GRNS-5-GRS-DAP-V1.0”.

^DATA_SET_MAP_PROJECTION
Pointer to the data set map projection catalog file.

DERIVED_MINIMUM
Indicates the smallest value occurring in a given instance of the data object after the application of a scaling factor and/or offset.

DERIVED_MAXIMUM
Indicates the largest value occurring in a given instance of the data object after the application of a scaling factor and/or offset.

DESCRIPTION
Specifies a description of the object.

DETECTOR_ID
The detector_id element identifies a particular instrument detector.

EASTERNMOST_LONGITUDE
For Planetocentric coordinates and for Planetographic coordinates in which longitude increases toward the east, the easternmost (rightmost) longitude of a spatial area (e.g.,a map, mosaic, bin, feature or region) is the maximum numerical value of longitude unless it crosses the Prime Meridian.

ENCODING_TYPE
Indicates the type of compression or encryption used for data storage.

ENCODING_TYPE_VERSION_NAME
Indicates the version of a standard or specification with which a particular ENCODING_TYPE complies.

FILE_NAME
Provides the location independent name of a file.

FILE_RECORDS
Indicates the number of physical file records in the detached data file.

^IMAGE
Pointer to the image data file.

INSTRUMENT_HOST_NAME
A unique identifier for (name of) the spacecraft on which the instrument is hosted, in this case "MESSENGER".

INSTRUMENT_ID
Unique ID associated with the instrument, in this case "GRS".

INSTRUMENT_NAME
Full, unabbreviated name of the instrument, in this case "GAMMA RAY SPECTROMETER".

INTERCHANGE_FORMAT
Specifies the table format, binary or ASCII.

KEYWORD_LATITUDE_TYPE
Identifies the type of latitude (planetographic or planetocentric) used in the labels, in this case it is planetocentric.

LINE_FIRST_PIXEL
Provides the line index for the first pixel that was physically recorded at the beginning of the image array.

LINE_LAST_PIXEL
Provides the line index for the last pixel that was physically recorded at the end of the image array.

LINE_PROJECTION_OFFSET
Provides the line offset value of the map projection origin position from the line and sample 1,1 (line and sample 1,1 is considered the upper left corner of the digital array).

LINE_SAMPLES
Indicates the total number of data instances along the horizontal axis of an image.

LINES
Indicates the total number of data instances along the vertical axis of an image.

MAP_PROJECTION_ROTATION
Provides the clockwise rotation, in degrees, of the line and sample coordinates with respect to the map projection origin (line_projection_offset, line_projection_offset). This parameter is used to indicate where 'up' is in the projection.

MAP_PROJECTION_TYPE
Identifies the type of projection characteristic of a given map, in this case "SIMPLE CYLINDRICAL".

MAP_RESOLUTION

Identifies the scale of a given map in pixel/degree. The scale is defined as the ratio of the actual distance between two points on the surface of the target body to the distance between the corresponding points on the map. The map_scale references the scale of a map at a certain point or line.

MAP_SCALE

Identifies the scale of a given map in km/pixel. The scale is defined as the ratio of the actual distance between two points on the surface of the target body to the distance between the corresponding points on the map. The map_scale references the scale of a map at a certain point or line.

MAXIMUM_LATITUDE

Specifies the northernmost latitude of a spatial area.

MAXIMUM_LONGITUDE

Specifies the westernmost (left_most) longitude of a spatial area.

MISSION_PHASE_NAME

The name of the mission phase during which data were collected. See the dataset.cat file for a table identifying the mission phases with start and end dates.

MISSING_CONSTANT

Supplies the value used to indicate that no data were available.

NAME

Name of the file or time_series object. This parameter is used in the engineering CDR to specify the engineering parameter name and associated files and time series.

OBJECT=FILE

Specifies that the CDR/RDR is a PDS FILE object. This object contains its own elements; name, record_type, record_bytes, file_records, ^time_series, product_id, product_type, and description. **NOTE**: The end of the object definition is always marked with an END_OBJECT line.

OBJECT=IMAGE

Specifies that the DAP is a PDS IMAGE object. This object contains its own elements; name, lines, line_samples, sample_type, sample_bits, unit, scaling_factor, derived_minimum, derived_maximum, and missing_constant. **NOTE**: The end of the object definition is always marked with an END_OBJECT line.

OBJECT=TABLE

Specifies that the CDR/RDR is a PDS TABLE object. This object contains its own elements; columns, interchange_format, rows, row_bytes, description and ^structure. **NOTE**: The end of the object definition is always marked with an END_OBJECT line.

OBJECT=TIME_SERIES

Specifies that the CDR is a PDS TIME_SERIES object. This object contains its own elements; name, interchange_format, rows, row_bytes, sampling_parameter_name, sampling_parameter_unit, sampleing_parameter_interval, columns and ^structure. **NOTE**: The end of the object definition is always marked with an END_OBJECT line.

PDS_VERSION_ID

Represents the version number of the PDS standards document that is valid when a data product label is created. PDS3 is used for the MESSENGER data products.

POSITIVE_LONGITUDE_DIRECTION

Identifies the direction of longitude (e.g. EAST, WEST) for a planet, in this case "EAST".

PRODUCER_FULL_NAME
Provides the full_name of the individual mainly responsible for the production of a data set.

PRODUCER_ID
Provides a short name or acronym for the producer or producing team/group of a dataset.

PRODUCER_INSTITUTION_NAME
Identifies a university, research center, NASA center or other institution associated with the production of a data set.

PRODUCT_CREATION_TIME
Stores the time that the data product was created, in UTC time in the format YYYY-MM-DDTHH:MM:SS.

PRODUCT_ID
The product_id data element represents a permanent, unique identifier assigned to a data product by its producer. Note: In the PDS, the value assigned to product_id must be unique within its data set. See section 6 for product naming conventions.

PRODUCT_TYPE
Spectral and engineering data products are identified as a CDR (Calibrated Data Record) , RDR (Reduced Data Record, or DAP (Derived Analysis Product).

PRODUCT_VERSION_ID
The product_version_id element identifies the version of an individual product within a data set. Example: 1.0, 2A, 1.2.3C. Note: This is not the same as the data set version that is an element of the data_set_id value. product_version_id is intended to identify separate iterations of a given product, which also have unique file_names.

RECORD_BYTES
This element indicates the number of bytes in a physical file record, including record terminators and separators.

RECORD_TYPE
This element indicates the record format of a file.

REQUIRED_STORAGE_BYTES
Provides the number of bytes required to store an uncompressed file.

ROWS
Number of rows in the table.

ROW_BYTES
Specifies the number of bytes for each row in the table.

SAMPLE_BITS
Indicates the stored number of bits, or units of binary information, contained in a line_sample value.

SAMPLE_FIRST_PIXEL
Provides the sample index for the first pixel that was physically recorded at the beginning of the image array.

SAMPLE_LAST_PIXEL
Provides the sample index for the last pixel that was physically recorded at the end of the image array.

SAMPLE_PROJECTION_OFFSET

Provides the sample offset value of the map projection origin position from line and sample 1,1 (line and sample 1,1 is considered the upper left corner of the digital array). Note: that the positive direction is to the right and down.

SAMPLE_TYPE
Indicates the data storage representation of sample value.

SAMPLING_PARAMETER_NAME
Identifies the sampling parameter name. In the GRS_ENG data products the sampling parameter is time.

SAMPLING_PARAMETER_UNIT
Identifies the sampling parameter unit. In the GRS_ENG data the sampling parameter unit is seconds.

SAMPLING_PARAMETER_INTERVAL
Identifies the sampling parameter interval, which is undefined for the GRS_ENG.

SCALING_FACTOR
Provides the constant value by which the stored value is multiplied.

SOFTWARE_NAME
Identifies the name of the software system that created the data products.

SOFTWARE_VERSION_ID
Identifies the version of software used to generate the data product.

SPACECRAFT_CLOCK_START_COUNT
Mission elapsed time clock count in seconds of the spacecraft computer at the start of the observation.

SPACECRAFT_CLOCK_STOP_COUNT
Mission elapsed time clock count in seconds of the spacecraft computer at the end of the observation.

STANDARD_DATA_PRODUCT_ID
Used to link a data product (file) to a standard data product (collection of similar files) described within software interface specification document for a particular data set.

START_TIME
Start time of the observation in UTC in the format YYYY-MM_DDTHH:MM:SS.nnn.

STOP_TIME
Time when the instrument stopped collecting measurements in UTC in the format YYYY-MM_DDTHH:MM:SS.nnn.

^STRUCTURE
Pointer to the external file which provides the structure definition for the table object. In the CDR/RDR data set the structure is found in a *.FMT file named similarly to the data product and located in the LABEL directory.

^TABLE
Pointer to the external data file that contains the table object.

TARGET_NAME
Target of the observation, in this case "MERCURY".

^TIME_SERIES
Pointer to the external file which provides the data for the file object.

UNCOMPRESSED_FILE_NAME

Provides the location independent name of a file. In the case of the .JP2 files in the DAP dataset, this is the name of the .IMG file you would get if you uncompressed the .JP2 file. This .IMG file doesn't actually exist on the volume.

UNIT

Provides the full name or standard abbreviation of a unit of measurement in which a value is expressed.

WESTERNMOST_LONGITUDE

For Planetocentric coordinates and for Planetographic coordinates in which longitude increases toward the east, the westernmost (leftmost) longitude of a spatial area (e.g.,a map, mosaic, bin, feature or region) is the minimum numerical value of longitude unless it crosses the Prime Meridian this case Mercury.

6.1.4 Table File Formats

Each GRS CDR/RDR PDS label contains a pointer to the column format file. This file describes the structure of the GRS table that includes column name, byte size, data type, applicable units, and a description of the value assigned to the column. See Appendix 8.7 for the format files.

6.1.5 Format File Keyword Definitions

The following describes the keywords used in the format file:

BYTES

Specifies the total number of bytes allocated for this particular column element.

COLUMN_NUMBER

Identifies the location of the column within the larger table data object. For tables consisting of rows (I= 1, N) and columns (j = 1, M), the column_number is the j-th index of any row.

DATA_TYPE

Specifies the internal representation and/or mathematical properties of the value being stored in this column.

FORMAT

A specified or predetermined arrangement of data within a file or on a storage medium. Note: In the PDS, the format element indicates the display specification for a collection of data. It is equivalent to the FORTRAN language format specification. Example values: 'Ew.deEXP', A6, I5.

ITEMS

Defines the number of multiple, identical occurrences of a single data item.

ITEM_BYTES

Represents the size in each individual item within the column field.

NAME

Indicates a literal value representing the common term used to identify an element or object.
NOTE: In the PDS data dictionary, name is restricted to 30 characters and must conform to PDS nomenclature standards.

OBJECT=COLUMN

Identifies the object as a column field within a table.

START_BYTE

Identifies the location of the first byte of the particular column, counting from 1.

6.2 Raw Spectra – GRS_CAL_RAW

6.2.1 Data Product Structure and Organization

The GRS_CAL_RAW are raw gamma spectra that have the timing, spatial, and engineering readings taken at the mid-point of the spectral collection period associated with it. This association of spectra with all necessary ancillary data supports calibration of the spectra from a counts per channel regime (EDR and CDR data) to a counts per energy bin regime (RDR data). These spectra have been temperature-corrected; see MESSGRS_PROCESSING.PDF in the DOCUMENT directory for a complete description of the correction process. The GRS_CAL_RAW data product is structured as a time series, 59-column data table. See Appendix 8.7.1 for the GRS_CAL_RAW table structure.

The GRS_CAL_RAW data product is organized as a binary data file containing raw spectra and associated data collected over a 24-hour time period, with a detached ASCII text PDS label file. The 24 hour data files are grouped by Earth day. Data folders are labeled by Earth date in the format YYYY/MM/DD.

6.2.2 Data Format Descriptions

The data format for the GRS_CAL_RAW is a 59-column binary table. Columns vary in width from 1 to 32,768 bytes. Column structure and start byte are described in Appendix 8.7.1. The number of rows in a data table depends on the number of collection intervals during the time frame of the data file (i.e., one Earth day).

6.2.3 File Naming Conventions

The file names developed for PDS data volumes are restricted to a 36-character file name and a 3 character extension name with a period separating the file and extension names. The general form of the GRS_CAL_RAW file name is:

"**GRS__ZZZYYYYDDDWWW.XXX**", where:

GRS	instrument identifier: represents the GRS instrument
ZZZ	Data product name–
	CRA – Raw GRS Spectra with associated engineering, timing and spatial data.
YYYY	four-digit year corresponding to the start-time of the first record in the GRS data file.
DDD	three-digit day of the year corresponding to the start time of the first record in the GRS CDR data file.

WWW	reserved character string used during the course of the mission as necessary to identify “special” data products. Nominal data products are identified by ZZZ.
.XXX	the file extension. The binary table file has the extension .DAT.

6.2.4 Label Description

The GRS_CAL_RAW data product has detached PDS labels stored as ASCII text. A PDS label is object-oriented and describes the objects in the data file. The PDS label contains keywords for product identification and for data object definitions. The label also contains descriptive information needed to interpret or process the data objects in the file. The detached label file has the same name as the data file it describes, except that it has the extension LBL instead of DAT.

PDS labels are written in Object Description Language (ODL). PDS label statements have the form of "keyword = value". Each label statement is terminated with a carriage return character (ASCII 13) and a line feed character (ASCII 10) sequence to allow the label to be read by many operating systems. Pointer statements with the following format are used to indicate the location of data objects:

^object = location

where the carat character (^, also called a pointer) is followed by the name of the specific data object. The location is the name of the file that contains the data object.

6.3 Anticoincidence Spectra – GRS_CAL_AC

6.3.1 Data Product Structure and Organization

The GRS_CAL_AC are anticoincidence spectra that have the timing, spatial and engineering readings taken at the mid-point of the spectral collection period associated with it. This association of spectra with all necessary ancillary data supports calibration of the spectra from a counts per channel regime (EDR and CDR data) to a counts per energy bin regime (RDR data). These spectra have been temperature corrected, see MESSGRS_PROCESSING.PDF in the DOCUMENT directory for a complete description of the correction process. The GRS_CAL_AC data product is structured as a time series, 59-column data table. See Appendix 8.7.2 for the GRS_CAL_AC table structure.

The GRS_CAL_AC data product is organized as a binary data file containing corrected spectra and associated data collected over a 24 hour time period, with a detached ASCII text PDS label file . The 24 hour data files are grouped by Earth day. Data folders are labeled by Earth date in the format YYYY/MM/DD.

6.3.2 Data Format Descriptions

The data format for the GRS_CAL_AC is a 59-column binary table. Columns vary in width from 1 to 32,768 bytes. Column structure and start byte are described in Appendix 8.7.2. The number of rows in a data table depends on the number of collection intervals during the time frame of the data file (i.e., one Earth day).

6.3.3 File Naming Conventions

"**GRS__ZZZYYYYDDDWWW.XXX**", where:

GRS	instrument identifier: represents the GRS instrument
ZZZ	Data product name–
	CAC – Anti-coincident GRS Spectra with associated engineering, timing and spatial data.
YYYY	four-digit year corresponding to the start-time of the first record in the GRS data file.
DDD	three-digit day of the year corresponding to the start time of the first record in the GRS CDR data file.
WWW	reserved character string used during the course of the mission as necessary to identify “special” data products. Nominal data products are identified by ZZZ.
.XXX	the file extension. The binary table file has the extension .DAT.

6.3.4 Label Description

The GRS_CAL_AC data product has detached PDS labels stored as ASCII text. A PDS label is object-oriented and describes the objects in the data file. The PDS label contains keywords for product identification and for data object definitions. The label also contains descriptive information needed to interpret or process the data objects in the file. The detached label file has the same name as the data file it describes, except that it has the extension LBL instead of DAT.

PDS labels are written in Object Description Language (ODL). PDS label statements have the form of "keyword = value". Each label statement is terminated with a carriage return character (ASCII 13) and a line feed character (ASCII 10) sequence to allow the label to be read by many operating systems. Pointer statements with the following format are used to indicate the location of data objects:

^object = location

where the carat character (^, also called a pointer) is followed by the name of the specific data object. The location is the name of the file that contains the data object.

6.4 Shield Spectra – GRS_CAL_SH

6.4.1 Data Product Structure and Organization

This format for the shield data is used for data acquired before September 17th 2010. A new version of flight software was loaded which produced a new format (GRS_CAL_SH2). The GRS_CAL_SH are shield spectra that have the timing, spatial and engineering readings taken at the mid-point of the spectral collection period associated with it. This association of spectra with all necessary ancillary data supports calibration of the spectra from a counts per channel regime (EDR and CDR data) to a counts per energy bin regime (RDR data).The GRS_CAL_SH data product is structured as a time series, 35-column data table. See Appendix 8.7.3 for the GRS_CAL_SH table structure.

The GRS_CAL_SH data product is organized as a binary data file containing corrected spectra and associated data collected over a 24 hour time period, with a detached ASCII text PDS label file. The 24 hour data files are grouped by Earth day. Data folders are labeled by Earth date in the format YYYY/MM/DD.

6.4.2 Data Format Descriptions

The data format for the GRS_CAL_SH is a 35-column binary table. Columns vary in width from 1 to 32,768 bytes. Column structure and start byte are described in Appendix 8.7.3. The number of rows in a data table depends on the number of collection intervals during the time frame of the data file (i.e., one Earth day).

6.4.3 File Naming Conventions

"**GRS__ZZZYYYYDDDWWW.XXX**", where:

GRS	instrument identifier: represents the GRS instrument
ZZZ	Data product name–
	CSH – Shield GRS Spectra with associated engineering, timing and spatial data.
YYYY	four-digit year corresponding to the start-time of the first record in the GRS data file.
DDD	three-digit day of the year corresponding to the start time of the first record in the GRS_SH data file.

WWW	reserved character string used during the course of the mission as necessary to identify “special” data products. Nominal data products are identified by ZZZ.
.XXX	the file extension. The binary table file has the extension .DAT.

6.4.4 Label Description

The GRS_CAL_SH data product has detached PDS labels stored as ASCII text. A PDS label is object-oriented and describes the objects in the data file. The PDS label contains keywords for product identification and for data object definitions. The label also contains descriptive information needed to interpret or process the data objects in the file. The detached label file has the same name as the data file it describes, except that it has the extension LBL instead of DAT.

PDS labels are written in Object Description Language (ODL). PDS label statements have the form of "keyword = value". Each label statement is terminated with a carriage return character (ASCII 13) and a line feed character (ASCII 10) sequence to allow the label to be read by many operating systems. Pointer statements with the following format are used to indicate the location of data objects:

^object = location

where the carat character (^, also called a pointer) is followed by the name of the specific data object. The location is the name of the file that contains the data object.

6.5 Shield Spectra – GRS_CAL_SH2

6.5.1 Data Product Structure and Organization

This format for the shield data is used for data acquired after September 17th 2010. A new version of flight software was loaded to produce this new format. The GRS_CAL_SH2 are shield spectra that have the timing, spatial and engineering readings taken at the mid-point of the spectral collection period associated with it. This association of spectra with all necessary ancillary data supports calibration of the spectra from a counts per channel regime (EDR and CDR data) to a counts per energy bin regime (RDR data) .The GRS_CAL_SH2 data product is structured as a time series, 45-column data table. See Appendix 8.7.4 for the GRS_CAL_SH2 table structure.

The GRS_CAL_SH2 data product is organized as a binary data file containing corrected spectra and associated data collected over a 24 hour time period, with a detached ASCII text PDS label file. The 24 hour data files are grouped by Earth day. Data folders are labeled by Earth date in the format YYYY/MM/DD.

6.5.2 Data Format Descriptions

The data format for the GRS_CAL_SH2 is a 45-column binary table. Columns vary in width from 1 to 256 bytes. Column structure and start byte are described in Appendix 8.7.4. The number of rows in a data table depends on the number of collection intervals during the time frame of the data file (i.e., one Earth day).

6.5.3 File Naming Conventions

"**GRS__ZZZYYYYDDDWWW.XXX**", where:

GRS	instrument identifier: represents the GRS instrument
ZZZ	Data product name–
	CS2 – Shield GRS Spectra with associated engineering, timing and spatial data.
YYYY	four-digit year corresponding to the start-time of the first record in the GRS data file.
DDD	three-digit day of the year corresponding to the start time of the first record in the GRS_CAL_SH2 data file.
WWW	reserved character string used during the course of the mission as necessary to identify “special” data products. Nominal data products are identified by ZZZ.
.XXX	the file extension. The binary table file has the extension .DAT.

6.5.4 Label Description

The GRS_CAL_SH2 data product has detached PDS labels stored as ASCII text. A PDS label is object-oriented and describes the objects in the data file. The PDS label contains keywords for product identification and for data object definitions. The label also contains descriptive information needed to interpret or process the data objects in the file. The detached label file has the same name as the data file it describes, except that it has the extension LBL instead of DAT.

PDS labels are written in Object Description Language (ODL). PDS label statements have the form of "keyword = value". Each label statement is terminated with a carriage return character (ASCII 13) and a line feed character (ASCII 10) sequence to allow the label to be read by many operating systems. Pointer statements with the following format are used to indicate the location of data objects:

^object = location

where the carat character (^, also called a pointer) is followed by the name of the specific data object. The location is the name of the file that contains the data object.

6.6 Shield Spectra – GRS_CAL_SH3

6.6.1 Data Product Structure and Organization

This format for the shield data is used for data acquired after 17 March 2013. A new version of flight software was loaded to produce this new format. The GRS_CAL_SH3 are shield spectra that have the timing, spatial and engineering readings taken at the mid-point of the spectral collection period associated with it. This association of spectra with all necessary ancillary data supports calibration of the spectra from a counts per channel regime (EDR and CDR data) to a counts per energy bin regime (RDR data). The GRS_CAL_SH3 data product is structured as a time series, 32-column data table. See Appendix 8.7.5 for the GRS_CAL_SH3 table structure.

The GRS_CAL_SH3 data product is organized as an ASCII data file containing corrected spectra and associated data collected over a 24 hour time period, with a detached ASCII text PDS label file. The 24 hour data files are grouped by Earth day. Data folders are labeled by Earth month in the format YYYY/MM.

6.6.2 Data Format Descriptions

The data format for the GRS_CAL_SH3 is a 32-column ASCII table. Column structure and start byte are described in Appendix 8.7.5. The number of rows in a data table depends on the number of collection intervals during the time frame of the data file (i.e., one Earth day).

6.6.3 File Naming Conventions

"**GRS__ZZZYYYYDDDWWW.XXX**", where:

GRS	instrument identifier: represents the GRS instrument
ZZZ	Data product name–
	CS3 – Shield GRS Spectra with associated engineering, timing and spatial data.
YYYY	four-digit year corresponding to the start-time of the first record in the GRS data file.
DDD	three-digit day of the year corresponding to the start time of the first record in the GRS_CAL_SH3 data file.

WWW	reserved character string used during the course of the mission as necessary to identify “special” data products. Nominal data products are identified by ZZZ.
.XXX	the file extension. The ASCII table file has the extension .TAB.

6.6.4 Label Description

The GRS_CAL_SH3 data product has detached PDS labels stored as ASCII text. A PDS label is object-oriented and describes the objects in the data file. The PDS label contains keywords for product identification and for data object definitions. The label also contains descriptive information needed to interpret or process the data objects in the file. The detached label file has the same name as the data file it describes, except that it has the extension LBL instead of TAB.

PDS labels are written in Object Description Language (ODL). PDS label statements have the form of "keyword = value". Each label statement is terminated with a carriage return character (ASCII 13) and a line feed character (ASCII 10) sequence to allow the label to be read by many operating systems. Pointer statements with the following format are used to indicate the location of data objects:

^object = location

where the carat character (^, also called a pointer) is followed by the name of the specific data object. The location is the name of the file that contains the data object.

6.7 Shield Spectra – GRS_CAL_SCR

6.7.1 Data Product Structure and Organization

This data product was created following the February 25, 2013 flight software upload. After a commissioning phase, the final product was produced beginning on March 18, 2013. The GRS_CAL_SCR are time series measurements of the total count rate measured by the GRS anti-coincidence shield, and are due to incident particles (primarily electrons, but also gamma-rays, protons, and neutrons). Each data product, which is associated with a given measurement time, is subdivided into 10-ms-cadence measurements of the count rate, which are sequentially assigned to the 16,384 channels in the spectrum array. For short integration periods, this array is not filled and the remaining entries as set to zero. For longer integration periods, the array fills up and the final channel contains the sum of all subsequent events. This typically occurred when the spacecraft was far from Mercury, and therefore the measurements of less interest. These products have the timing, spatial and engineering readings taken at the mid-point of the spectral collection period associated with it. The GRS_CAL_SCR data product is structured as a time series, 32-column data table. See Appendix 8.7.6 for the GRS_CAL_SCR table structure.

The GRS_CAL_SCR data product is organized as an ASCII data file containing corrected spectra and associated data collected over a 24 hour time period, with a detached ASCII text

PDS label file. The 24 hour data files are grouped by Earth day. Data folders are labeled by Earth month in the format YYYY/MM.

6.7.2 Data Format Descriptions

The data format for the GRS_CAL_SCR is a 32-column binary table. Column structure and start byte are described in Appendix 8.7.6. The number of rows in a data table depends on the number of collection intervals during the time frame of the data file (i.e., one Earth day).

6.7.3 File Naming Conventions

"**GRS__ZZZYYYYDDDWWW.XXX**", where:

GRS	instrument identifier: represents the GRS instrument
ZZZ	Data product name–
	CSC – Shield GRS Count Rate measurements with associated engineering, timing and spatial data.
YYYY	four-digit year corresponding to the start-time of the first record in the GRS data file.
DDD	three-digit day of the year corresponding to the start time of the first record in the GRS_CAL_SCR data file.
WWW	reserved character string used during the course of the mission as necessary to identify “special” data products. Nominal data products are identified by ZZZ.
.XXX	the file extension. The ASCII table file has the extension .TAB.

6.7.4 Label Description

The GRS_CAL_SCR data product has detached PDS labels stored as ASCII text. A PDS label is object-oriented and describes the objects in the data file. The PDS label contains keywords for product identification and for data object definitions. The label also contains descriptive information needed to interpret or process the data objects in the file. The detached label file has the same name as the data file it describes, except that it has the extension LBL instead of TAB.

PDS labels are written in Object Description Language (ODL). PDS label statements have the form of "keyword = value". Each label statement is terminated with a carriage return character (ASCII 13) and a line feed character (ASCII 10) sequence to allow the label to be read by many

operating systems. Pointer statements with the following format are used to indicate the location of data objects:

^object = location

where the carat character (^, also called a pointer) is followed by the name of the specific data object. The location is the name of the file that contains the data object.

6.8 Engineering Data – GRS_ENG

6.8.1 Data Product Structure and Organization

The GRS_ENG are time series records for each engineering parameter taken over the course of a day. Data files are grouped in the ENG folder and are labeled with the engineering parameter name. Individual records are a single data collection interval that is variable in duration. Engineering values are reported in individual binary tables by parameter name and include collection time, raw value, and engineering value. Engineering values (physical units) are calculated from the raw DN values using the polynomial coefficients given in Appendix 8.4, which were derived during instrument calibration. In general, temperatures are reported in Celsius (except that HPGe crystal temperatures are reported in Kelvin), currents in amperes, and potentials in volts. GRS_ENG parameters and engineering units are listed in Table 6.1 Engineering Parameter Names and Units.

Table 6.1 Engineering Parameter Names and Units

GRS_ENG Index	GRS_ENG Parameter Name	Engineering Units
01	LVPS_PLUS5V	Volts
02	LVPS_NEG5V	Volts
03	LVPS_PLUS12V	Volts
04	LVPS_NEG12V	Volts
05	LVPS_PLUS5V_I	Amps
06	LVPS_NEG5V_I	Amps
07	LVPS_PLUS12V_I	Amps
08	LVPS_NEG12V_I	Amps
09	LVPS_TEMP	Celsius
10	LVPS_PRI_I	Amps
11	LVPS_SEC_I	Amps
12	HVPS_TEMP	Celsius
13	HVPS_VOLT	Volts
14	HVPS_REF_VOLT	Digital Number
15	HPGE_TEMP_1	Kelvin
16	HPGE_TEMP_2	Kelvin
17	HPGE_DET_LEAK	Pico-amps
18	HVPS_TEMP_2	Celsius
19	PREAMP_TEMP	Celsius
20	SHAPER_TEMP	Celsius
21	AD_TEMP	Celsius
22	HV_MONITOR	Volts
23	REF_2_5V	Counts*
24	REF_2_5V_DIV2	Counts*
25	REF_2_5V_DIV3	Counts*

26	CONTROL_BOARD_TEMP	Celsius
27	ANNEAL_PRI_VOLT	Volts
28	COOLER_PRI_VOLT	Volts
29	ANNEAL_SEC_I	Milliamps
30	COOLER_SEC_I	Milliamps
31	COOLER_PRI_I	Milliamps
32	ANNEAL_PRI_I	Milliamps
33	COOLER_POWER_BOARD_TEMP	Celsius
34	COOLER_TEMP	Celsius
35	CMD_SCIENCE_MODE	Digital Number
36	CMD_HPGE_HV	Volts
37	CMD_SHIELD_HV	Volts
38	CALIB_AVG_DET_TEMP	Kelvin
39	HPGE_HV_SAFING_LVL	Digital Number
40	SHLD_HV_SAFING_LVL	Digital Number
41	COOLER_TEMP_SETPOINT	Kelvin

*ADC digital counts associated with reference voltage (assumed constant), to correct ADC for temperature dependence.

6.8.2 Data Format Descriptions

The data format for the GRS_ENG data are 41 individual binary tables containing 5 data columns. The 5 data columns are structured and labeled identically in all 41 data tables. Columns vary in width from 2 to 23 bytes. Column structure and start byte are described in Appendix 8.7.7. The number of rows in a data table depends on the number of collection intervals during the time frame of the data file (i.e., one Earth day).

6.8.3 File Naming Conventions

Engineering data are contained in a subfolder named GRS ENG with files named according to the following naming convention,

"**GRS__ZZZYYYYDDDWWW**", where:

GRS — instrument identifier: represents the GRS instrument

ZZZ — Data product name–

EXX – Engineering data where XX is the Index.

YYYY — four-digit year corresponding to the start-time of the first record in the GRS data file.

DDD — three-digit day of the year corresponding to the start time of the first record in the GRS Engineering data file.

WWW	reserved character string used during the course of the mission as necessary to identify “special” data products. Nominal data products are identified by ZZZ.

Each of the 41 individual binary data tables resides in this folder, and is labeled with the appropriate engineering parameter name (e.g. GRS_E022012044ZZZ.DAT).

6.8.4 Label Description

The GRS_ENG data product has detached PDS labels stored as ASCII text. A PDS label is object-oriented and describes the objects in the data file. The PDS label contains keywords for product identification and for data object definitions. The label also contains descriptive information needed to interpret or process the data objects in the file. For the GRS_ENG data product, a single PDS label describes the 41 binary tables that make up one product. This label is named GRS_ENGYYYYDDD.LBL according to the above scheme.

PDS labels are written in Object Description Language (ODL). PDS label statements have the form of "keyword = value". Each label statement is terminated with a carriage return character (ASCII 13) and a line feed character (ASCII 10) sequence to allow the label to be read by many operating systems. Pointer statements with the following format are used to indicate the location of data objects:

^object = location

where the carat character (^, also called a pointer) is followed by the name of the specific data object. The location is the name of the file that contains the data object.

6.9 Summed Spectra – GRS_RDR_SUM

6.9.1 Data Product Structure and Organization

The GRS_RDR_SUM is a reduced data product that is derived from the GRS_CAL_AC and GRS_CAL_RAW. The GRS_RDR_SUM are summed spectra over certain spatial and temporal regions. The GRS_RDR_SUM data product is structured as a, 52-column data table. See Appendix 8.7.8 for the GRS_RDR_SUM table structure. See Appendix 8.6, SUM_TYPE for the different types of sums. Only spectra that are not marked as BAD were used in making sums.

The GRS_RDR_SUM data product is organized as a binary data file containing summed spectra and associated data collected over an Earth year, with a detached ASCII text PDS label file. The files are grouped by Earth year. Data folders are labeled by Earth date, format YYYY/MM/DD.

Summed spectra are limited to data acquired when the angle between the detector boresight and the spacecraft-to-planet-center vectors (hereafter referred to as the nadir angle) was less than 15°. This is because the photopeak detection efficiency of the MESSENGER Gamma-Ray Spectrometer is a function of the energy and the incident angle of the detected gamma rays [Peplowski et al., 2012]. The orientation-dependency is primarily the result of the placement of the GRS on the instrument deck of the spacecraft [Goldsten et al., 2007], which results in

attenuation of the planet-originating signal by instrument-surrounding components such as the adapter ring and sunshade [Rhodes et al., 2011]. Attenuation becomes significant for gamma-rays incident at angles larger than 45 degrees, although some attenuation is experienced for angles as small as ~20 degrees. As a result, summed spectra are limited to GRS data acquired at nadir angles of <= 15 degrees, a choice that limits the nadir-angle induced variability in the detection efficiency and facilitates comparison of the summed data products.

References for these issues:

Goldsten, J. O., Rhodes, E. A., Boynton, W. V., Feldman, W. C., Lawrence, D. J., Trombka, J. I., Smith, D. M., Evans, L. G., White, J., Madden, N. W., Berg. P. C., Murphy, G. A., Gurnee, R. S., Strobehn, K., Williams, B. D., Schaefer, E. D., Monaco, C. A., Cork, C. A., Eckels, J. D., Miller, W. O., Burks, M. T., Hagler, L. B., DeTeresa, S. J. and Witte, M. C., (2007), The MESSENGER Gamma-Ray and Neutron Spectrometer, *Space Sci. Rev.,* doi:10.1007/s11214-007-9262-7.

Rhodes, E. A., Evans, L. G. Nittler, L. R., Starr, R. D., Sprague, A. L., Lawrence, D. J., McCoy, T. J., Stockstill-Cahill, K. R., Goldsten, J. O., Peplowski, P. N., Hamara, D. K., Boynton, W. V., and Solomon, S. C., (2011), Analysis of MESSENGER Gamma-Ray Spectrometer data from the Mercury flybys, *Planet Space Sci.,* doi:10.1016/j.pss.2011.07.018.

Peplowski, P.N., Lawrence, D. J., Rhodes, E. A., Sprague, A. L., McCoy, T. J., Denevi, B. W., Evans, L. G., Head, J. W., Nittler, L. R., Solomon, S. C., Stockstill-Cahill, K. R., and Weider, S. Z., (2012), Variations in the abundances of potassium and thorium on the surface of Mercury: Results from the MESSENGER Gamma-Ray Spectrometer, *J. Geophys. Res.,* doi:10.1029/2012JE004141 .

6.9.2 Data Format Descriptions

The data format for the GRS_RDR_SUM is a 52-column binary table. Columns vary in width from 1 to 65,536 bytes. Column structure and start byte are described in Appendix 8.7.8. The number of rows in a data table depends on the spatial area for the type of sum.

6.9.3 File Naming Conventions

"**GRS__ZZZYYYYDDDWWW.XXX**", where:

GRS	instrument identifier: represents the GRS instrument
ZZZ	Data product name–
	RSS – Reduced spectral sum.
YYYY	four-digit year corresponding to the start-time of the first record in the GRS data file.

DDD	three-digit day of the year corresponding to the start time of the first record in the GRS_RDR_SUM data file.
WWW	reserved character string for use during the course of the mission as necessary to identify “special” data products. Nominal data products are identified by ZZZ.
.XXX	the file extension. The binary table file has the extension .DAT.

6.9.4 Label Description

The GRS_RDR_SUM data product has detached PDS labels stored as ASCII text. A PDS label is object-oriented and describes the objects in the data file. The PDS label contains keywords for product identification and for data object definitions. The label also contains descriptive information needed to interpret or process the data objects in the file. The detached label file has the same name as the data file it describes, except that it has the extension LBL instead of DAT.

PDS labels are written in Object Description Language (ODL). PDS label statements have the form of "keyword = value". Each label statement is terminated with a carriage return character (ASCII 13) and a line feed character (ASCII 10) sequence to allow the label to be read by many operating systems. Pointer statements with the following format are used to indicate the location of data objects:

^object = location,

where the carat character (^, also called a pointer) is followed by the name of the specific data object. The location is the name of the file that contains the data object.

6.10 Count Rate and Abundance Maps – GRS_DAP

6.10.1 Data Product Structure and Organization

The GRS_DAP is an advanced data product that is derived from calibrated data records in a manner that is similar to the creation of the reduced data records (e.g. GRS_ RDR_SUM). The GRS_DAPs are 720 x 360 pixel maps of gamma-ray count rates or count-rate-derived elemental abundances. Each map pixel corresponds to 0.5° × 0.5° surface elements, and range from –180° to 180° longitude and –90° to 90° latitude. The data are mapped in larger surface elements whose size is variable but are typically larger than 15° × 15°. The value for each surface element was derived from multiple data records (GRS_CAL_AC) summed using the process described for deriving GRS_RDR_SUM records. Values of zero denote regions that were not mapped by the GRS due to the high orbital altitudes of the spacecraft, which limited the statistical significance of measurements in equatorial and southern latitudes.

The maps were created using multiple GRS_CAL_AC spectra that were summed according to the subspacecraft latitude and longitude and were limited to data acquired when the angle between the detector boresight and the spacecraft-to-planet-center vectors was less than 15°.

There are a total of 8 GRS_DAP maps: a potassium (K) abundance map, silicon (Si), oxygen (O), and K gamma-ray count rate maps, along with 4 maps of the one-standard-deviation statistical significance of these measurements. The maps have spatial coverage that is limited to the northern hemisphere as a result of the highly elliptical orbit of MESSENGER about Mercury (with periapse location at mid-to-high northern latitudes) and the strong altitude-dependence of the GRS measurements. The spatial resolution of the measurements as shown in the maps is variable to ensure comparable statistical significance for each measurement pixel [Peplowski et al., 2012].

The data reduction process used to create these maps is presented in the document MESSGRS_PROCESSING.PDF, located in the DOCUMENT directory.

Reference:

Peplowski, P.N., Lawrence, D. J., Rhodes, E. A., Sprague, A. L., McCoy, T. J., Denevi, B. W., Evans, L. G., Head, J. W., Nittler, L. R., Solomon, S. C., Stockstill-Cahill, K. R., and Weider, S. Z., (2012), Variations in the abundances of potassium and thorium on the surface of Mercury: Results from the MESSENGER Gamma-Ray Spectrometer, *J. Geophys. Res.,* doi:10.1029/2012JE004141.

6.10.2 Data Format Descriptions

There are a total of 8 DAP maps: a potassium (K) abundance map, silicon (Si), oxygen (O), and K gamma-ray count rate maps, along with error maps for each. Each GRS_DAP is a 720 × 360 jpeg2000 image with a detached ASCII text PDS label. See jp2info.txt in the DOCUMENT directory for additional information on the JP2 data format.

6.10.3 File Naming Conventions

"**GRS_ZZZ_Y_WWW_VVV.XXX**", where:

GRS	instrument identifier: represents the GRS instrument
ZZZ	data product name–
	DAP – Derived Analysis Product.
Y	element name in periodic table: Potassium (K), Silicon (Si), or Oxygen (O).
WWW	map type: abundance (ABD) or gamma-ray count rate (GCR).
VVV	data map (MAP) or error map (ERR).
.XXX	the file extension: jpeg2000 (JP2).

6.10.4 Label Description

The GRS_DAP data products have detached PDS labels stored as ASCII text. A PDS label is object-oriented and describes the objects in the data file. The PDS label contains keywords for product identification and for data object definitions. The label also contains descriptive information needed to interpret or process the data objects in the file. The detached label file has the same name as the data file it describes, except that it has the extension LBL instead of JP2.

PDS labels are written in Object Description Language (ODL). PDS label statements have the form of "keyword = value". Each label statement is terminated with a carriage return character (ASCII 13) and a line feed character (ASCII 10) sequence to allow the label to be read by many operating systems. Pointer statements with the following format are used to indicate the location of data objects:

^object = location,

where the carat character (^, also called a pointer) is followed by the name of the specific data object. The location is the name of the file that contains the data object.

6.11 Archive Volume

Both the GRS CDR/RDR/DAP documentation and data needed to analyze the CDRs, RDRs, and DAPs are stored on a single archive volume. The following documentation is included in the archive:

1. All required PDS catalog files for the CDR/RDR/DAP archive (dataset, instrument, mission, etc.).
2. The CDR/RDR/DAP SIS document.
3. A GRS calibration procedures document. This contains appropriate pseudo-code for calibrating the data, converting the time word (MET to UTC), and transforming the data into useful coordinate systems.
4. Other documents considered useful by the MESSENGER project or MESSENGER team (i.e., “data processing guide”).

The archive volume bears the PDS-assigned volume ID MESSGRS_2001.

The archive volume was delivered to PDS with the first release of GRS CDR/RDR/DAP data products. Subsequent deliveries of the GRS CDR/RDR/DAP productconsisted of volumes containing only new and changed files.

6.12 Directory Structure and Contents for GRS Archive Volume

The following illustration shows the directory structure overview for the data volumes. Below the root directory are the LABEL, GEOMETRY, INDEX, DATA, CATALOG, DOCUMENT and SOFTWARE directories. A detailed description of the directory tree is provided in Figure 2.

Empty directories are not included on the volume. (Empty directories occur when no data were received for a given orbit or day in which data were expected.) Please note that the day folders (DD) are excluded for data acquired after March 17, 2013.

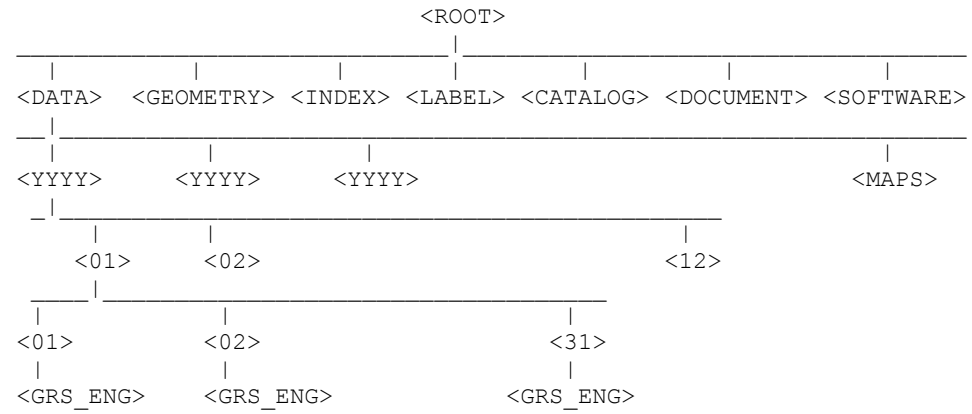


Figure 2 Directory Structure Overview for GRS CDR/RDR/DAP Archive Volume

6.12.1 Directory Contents

<ROOT> Directory
AAREADME.TXT - General information file. Provides users with information about the MESSENGER GRS CDR/RDR/DAP data products.

VOLDESC.CAT - PDS file containing labels that describe the volume data products. Information includes: production date, producer name and institution, volume ID, etc.

ERRATA.TXT - Text file for tracking and recording discovered errors in the MESSENGER GRS CDR/RDR/DAP data products.

<DATA> Directory
This is the top level of the directories containing CDRs, RDRs, and DAPs.

<DATA/MAPS> Directory
A sub-directory of the <DATA> directory containing the DAPs.

<DATA/YYYY> Directory
A sub-directory of the <DATA> directory for each year.

<DATA/YYYY/MM> Directory
A sub-directory of the <DATA/YYYY> directory for each month of the year where MM ranges from 01 through 12. Data acquired after March 17, 2013 (GRS_CAL_SH3, GRS_CAL_SCR) are included in the MM directories. Data acquired prior to this date reside in the DD directories (see below).

<DATA/YYYY/MM/DD> Directories
Sub-directories of a <DATA/YYYY/MM> directory, these are the top level directories for the CDR and RDR data products. The names of the data directories identify day of the month for the start time of the data products contained in the directories. Please note that the day folders (DD) are excluded for data acquired after March 17, 2013.

<DATA/YYYY/MM/DD/GRS_ENG> Directories
Sub-directories of a <DATA/YYYY/MM/DD > directory, these are the top level directories for the CDR engineering data products.

<GEOMETRY> Directory
GEOMINFO.TXT - Description of geometry directory files. See section 6.1.

<INDEX> Directory
INDXINFO.TXT - Text file describing contents of <INDEX> directory.

INDEX.TAB - The CDR/RDR/DAP index file is organized as a table. In the table, there is a row for each data product on the volume. The table columns contain parameters that describe the observation and instrument and spacecraft parameters.

The following columns, at minimum, are present in the index table:

VOLUME_ID	MISSION_PHASE_NAME
PATH_NAME	TARGET_NAME
FILE_NAME	START_TIME
PRODUCT_ID	STOP_TIME
PRODUCT_TYPE	START_MET_PARTITION
PRODUCT_CREATION_TIME	SPACECRAFT_CLOCK_START_COUNT
PRODUCT_VERSION_ID	SPACECRAFT_CLOCK_STOP_COUNT
RELEASE_ID	

INDEX.LBL - Detached PDS label for INDEX.TAB. It contains the INDEX_TABLE object which identifies and describes the columns of the GRS CDR/RDR/DAP index table. See appendix 8.5.8.

MD5.TAB - List of md5 sums for the archive volume.

MD5.LBL - Detached PDS label for MD5.TAB.

< LABEL > Directory
LABINFO.TXT - Description of label directory files that include additional PDS labels and files that are not packaged with the data products.

<CATALOG> Directory
CATINFO.TXT - Description of catalog directory files.

***.CAT** - Description of PDS catalog mission, spacecraft, instrument and data sets as ASCII text files in PDS-specified formats, to be entered into the PDS online catalog for searching.

<DOCUMENT> Directory
The documentation files exist in several forms in order to facilitate access to the documents:

Extension '**TXT**' or '**ASC**' - ASCII text files (that virtually all text editors can read).

Extension '**PDF**' - Adobe Portable Document File.

Extension **'HTM'** - Hypertext Markup files, which are read in a web browser.

<SOFTWARE> Directory
SOFTINFO.TXT - Description of software directory files. Software files are to view data products.

6.12.2 Data Product Sizes

The following table shows sizes in bytes of each data product and total estimated size of the GRS CDR/RDR/DAP data set.

Table 6.2. Data Product Sizes

Product Type	Time span covered	Typical product size (bytes)	Estimated mission total
GRS_CAL_RAW	1 Earth day	19500000	14000000000
GRS_CAL_AC	1 Earth day	19500000	14000000000
GRS_CAL_SH / SH2	1 Earth day	370000	270000000
GRS_CAL_SH3	1 Earth day	20926913	17500000000
GRS_CAL_SCR	1 Earth day	164236	120000000
GRS_ENG	1 Earth day	68000	2100000000
GRS_RDR_SUM	04 Mar 2011 to 11 Oct 2011	28416000	56832000
GRS_DAP	04 Mar 2011 to 11 Oct 2011	5000	40000

7 Product Delivery

7.1 Product Delivery Mechanism

The GRS CDR and RDR components of the archive volume were delivered separately to ACT in files created with gzip and tar. These files were delivered on a periodic basis to ACT. ACT extracted the volume contents from the delivered files and created the index files. The initial delivery had a PRODUCT_VERSION_ID of 1.0 and a SOFTWARE_VERSION_ID of 1.0.

The GRS DAP components of the archive volume were delivered by APL to ACT. ACT created the DAP labels and index file.

7.2 Product Redelivery

The products were redelivered to ACT when a previously delivered product has changed. Reasons for redelivery included:

- The software that converts the EDRs into CDRs changed. This resulted in a change to the data delivered. The PRODUCT_VERSION_ID and the SOFTWARE_VERSION_ID were incremented by 1 in the .LBL files of the redelivered product.

- The data in the BAD_DATA_FLAG column in a GRS_CACYYYYDDDZZZ.DAT, GRS_CRAYYYYDDDZZZ.DAT or GRS_CSHYYYYDDDZZZ.DAT changed. The PRODUCT_VERSION_ID was incremented by 1 in the .LBL files of the redelivered product.

- GRS_CDR-RDR-DAP_SIS document changed.

- MESSGRS_PROCESSING document changed.

8 Appendices

8.1 Appendix: SPICE Kernel Files Used in MESSENGER Data Products

The following SPICE files were used to compute the UTC time and any geometric quantities found in the PDS labels. Kernel files were generated throughout the mission with a filenaming convention specified by the MESSENGER project.

*.bsp:
MESSENGER spacecraft ephemeris file

*.bc:
MESSENGER spacecraft orientation file.

*.tsc:
MESSENGER spacecraft clock coefficients file.

*.tpc:
Planetary constants file.

*.tls
NAIF leapseconds kernel file, used for converting between Universal Time Coordinated (UTC) and Barycentric Dynamical Time (TDB, also called Ephemeris Time, or ET).

8.2 Appendix: CODMAC/NASA Definition of Processing Levels

Table 8.1. **CODMAC/NASA Definition of Processing Levels for Science Data Sets**

CODMAC Level	Proc. Type	Data Processing Level Description
1	Raw Data	Telemetry data stream as received at the ground station, with science and engineering data embedded. Corresponds to NASA packet data.
2	Edited Data	Instrument science data (e.g. raw voltages, counts) at full resolution, time ordered, with duplicates and transmission errors removed. Referred to in the MESSENGER program as Experimental Data Records (EDRs). Corresponds to NASA Level 0 data.
3	Calibrated Data	Edited data that are still in units produced by instrument, but have been transformed (e.g. calibrated, rearranged) in a reversible manner and packaged with needed ancillary and auxiliary data (e.g. radiances with calibration equations applied). Referred to in the MESSENGER Program as Calibrated Data Records (CDRs). In some cases, these also qualify as derived data products (DDRs). Corresponds to NASA Level 1A.
4	Resampled data	Irreversibly transformed (e.g. resampled, remapped, calibrated) values of the instrument measurements (e.g. radiances, magnetic field strength). Referred to in the MESSENGER program as either derived data products (DDPs) or derived analysis products (DAPs). Corresponds to NASA Level 1B.
5	Derived Data	Derived results such as maps, reports, graphics, etc. Corresponds to NASA Levels 2 through 5
6	Ancillary Data	Non-Science data needed to generate calibrated or resampled data sets. Consists of instrument gains, offsets, pointing information for scan platforms, etc.
7	Corrective Data	Other science data needed to interpret space-borne data sets. May include ground based data observations, such as soil type or ocean buoy wind drift measurements.
8	User Description	Description of why the data were required, any peculiarities associated with the data sets and enough documentation to allow the secondary user to extract information from the data.

The above is based on the National Research Council Committee on Data Management and Computation (CODMAC) data levels.

8.3 Appendix: GRS Glossary and Acronym List

ACT	Applied Coherent Technology Corporation
AGC	Automatic Gain Control
AIAA	American Institute of Aeronautics and Astronautics
AM	Atmosphere and Magnetosphere Group
APL	The Johns Hopkins University Applied Physics Laboratory
ASCII	American Standard Code for Information Interchange
ATDF	Archival Tracking Data File
B-frame	Body Frame
C&DH	Command and Data Handler
CA	Closest Approach
CAS	Canned Activity sequence
CCD	Charged-Coupled Device
CCSDS	Consultative Committee for Space Data Systems
CDF	Common Data Format
CFDP	CCSDS File Delivery Protocol
CK	Camera Kernel (SPICE)
CLCW	Command Link Control Word
CLTU	Command Link Transfer Unit
CoDMAC	Committee on Data Management and Computation
Co-I	Co-Investigator
COP	Command Operation Procedure
CUCC	CSDS Unsegmented Time Code
DAP	Derived Analysis Product
DPU	Data Processing Unit
EDR	Experimental Data Records
EK	Event Kernel
EPPS	Energetic Particle and Plasma Spectrometer
ET	Ephemeris Time
FIPS	Fast Imaging Plasma Spectrometer
FITS	Flexible Image Transport System
FOP	Frame Operation Procedure
FOV	Field-of-View
FPA	Focal Plane Assembly
FTP	File Transfer protocol
GC	Geochemistry Group
GP	Geophysics Group
GRNS	Gamma-ray and Neutron Spectrometer
GRS	Gamma Ray Spectrometer
GSFC	Goddard Space Flight Center
I&T	Integration and Test
I2C	Inter-Integrated Circuit
IEM	Integrated Electronic Module
IK	Instrument Measurement Kernel (SPICE)
IMU	Inertial Measurement unit
ISI	Integral Systems Incorporated (EPOCH)
LSK	Leapseconds Kernel (SPICE)
MAG	Magnetometer
MASCS	Mercury Atmospheric and Surface Composition Spectrometer
MCP	Monitor and Control Processor (DSN station)
MDIS	Mercury Dual Imaging System
MESSENGER	Mercury, Surface, Space ENvironment, GEochemistry, and Ranging
MET	Mission Elapsed Time
MIA	Monitor Interface Assembly (DSN station)
NAIF	Navigation and Ancillary Information Facility
NSSDC	National Space Science Data Center
ODF	Orbit Data File
ODL	Object Description Language
OWLT	One-Way Light Time
PCK	Planetary Constant Kernel (SPICE)
PDR	Preliminary Design Review

PDR	Packetized Data Records
PDS	Planetary Data System
SCET	Space Craft Event Time
SCLK	Space Clock Kernel (SPICE)
SCPS	Space Communication Protocol Standards
SFDU	Standard Formatted Data Unit
SPICE	Spacecraft, Planet, Instrument, C-matrix Events
SPK	Spacecraft and Planets Kernel (SPICE)
TDB	Barycentric Dynamical Time, the same an ET in the SPICE system
TDT	Terrestrial Dynamical Time
TMOD	Telecommunications and Mission Operations Directorate
USN	Universal Space Net
UTC	Coordinated Universal Time
VC	Virtual Channel
XRS	X-Ray Spectrometer

8.4 Appendix: Engineering Transformations

The following table contains the coefficients of a 6th-order polynomial equation for generating calibrated engineering data from the GRS_STATUS EDR data:

CDR Index	NAME	DESCRIPTION	Units	Optional Ref Column	Polynomial Coefficients (highest order term first)						
1	LVPS_PLUS5V	LVPS +5 volt monitor	V		0	0	0	0	0	0.002479	0
2	LVPS_NEG5V	LVPS -5 volt monitor	V		0	0	0	0	0	0.002479	0
3	LVPS_PLUS12V	LVPS +12 volt monitor	V		0	0	0	0	0	0.002479	0
4	LVPS_NEG12V	LVPS -12 volt monitor	V		0	0	0	0	0	0.002479	0
5	LVPS_PLUS5V_I	LVPS +5V current	A		0	0	0	0	0	0.000244	0
6	LVPS_NEG5V_I	LVPS -5V current	A		0	0	0	0	0	0.000244	0
7	LVPS_PLUS12V_I	LVPS +12V current	A		0	0	0	0	0	0.000244	0
8	LVPS_NEG12V_I	LVPS -12V current	A		0	0	0	0	0	0.000244	0
9	LVPS_TEMP	LVPS Temperature	ºC		0	0	0	1.1254E-10	3.5855E-07	0.012218	-38.889
10	LVPS_PRI_I	LVPS Primary Current	A		0	0	0	0	0	0.000244	0
11	LVPS_SEC_I	LVPS Switched Primary Current (Op Heater)	A		0	0	0	0	0	0.000244	-0.0173
12	HVPS_TEMP*	Shield HVPS Temperature	ºC	14	0	0	0	0	0	0.03372	-277.3
13	HVPS_VOLT*	Shield HVPS Voltage	V	14	0	0	0	0	0	0.032050597	0
14	HVPS_REF_VOLT	Shield HVPS Reference Voltage, nom value = 46852	DN		0	0	0	0	0	1	0
15	HPGE_TEMP_1*	ADC0 Channel 0, HPGE Detector Temperature 1	K	23	-6.01731E-23	1.94306E-17	-2.61457E-12	1.87671E-07	-0.007579695	163.3708647	-1468809.947
16	HPGE_TEMP_2*	ADC0 Channel 1, HPGE Detector Temperature 2	K	23	-6.01731E-23	1.94306E-17	-2.61457E-12	1.87671E-07	-0.007579695	163.3708647	-1468809.947
17	HPGE_DET_LEAK*	ADC0 Channel 2, HPGE Detector Leakage current	pA	23	0	0	0	0	0	0.91618	19341.47598
18	HVPS_TEMP_2*	ADC0 Channel 3, HPGE HVPS Temperature	ºC	23	-2.8067E-25	3.1611E-20	-1.3066E-15	2.052E-11	6.2608E-08	-7.6038E-03	1.2109E+02
19	PREAMP_TEMP*	ADC0 Channel 4, Pre Amp Temperature	ºC	23	-2.8067E-25	3.1611E-20	-1.3066E-15	2.052E-11	6.2608E-08	-7.6038E-03	1.2109E+02
20	SHAPER_TEMP*	ADC0 Channel 5, Shaper Temperature	ºC	23	-2.8067E-25	3.1611E-20	-1.3066E-15	2.052E-11	6.2608E-08	-7.6038E-03	1.2109E+02
21	AD_TEMP*	ADC0 Channel 6, AD Temperature	ºC	23	-2.8067E-25	3.1611E-20	-1.3066E-15	2.052E-11	6.2608E-08	-7.6038E-03	1.2109E+02
22	HV_MONITOR*	ADC0 Channel 7, HPGE HV Monitor	V	23	0	0	0	0	0	0.06387	0
23	REF_2_5V	ADC0 Channel 8, 2.5V reference, nom value=43059	DN		0	0	0	0	0	1	0
24	REF_2_5V_DIV2	ADC0 Channel 9, 2.5V reference divided by 2	DN		0	0	0	0	0	1	0
25	REF_2_5V_DIV3	ADC0 Channel A, 2.5V reference divided by 3	DN		0	0	0	0	0	1	0
26	CONTROL_BOARD_TEMP	ADC0 Channel B, Controller Board temperature	ºC		0	-6.7391E-21	7.7051E-16	-3.6142E-11	8.771E-07	-0.013407	137.01
27	ANNEAL_PRI_VOLT	ADC1 Channel 0, Anneal +12V monitor	V		0	0	0	0	0	0.0004392	-0.0051
28	COOLER_PRI_VOLT	ADC1 Channel 1, Cooler +15V monitor	V		0	0	0	0	0	0.0004392	-0.0002

CDR Index	NAME	DESCRIPTION	Units	Optional Ref Column	Polynomial Coefficients (highest order term first)						
29	ANNEAL_SEC_I	ADC1 Channel 2, Anneal +12V current	mA		0	0	0	0	0	0.04611	-0.5
30	COOLER_SEC_I	ADC1 Channel 3, Cooler +15V current	mA		0	0	0	0	0	0.04562	0.8
31	COOLER_PRI_I	ADC1 Channel 4, Cooler primary current	mA		0	0	0	0	0	0.04627	-12
32	ANNEAL_PRI_I	ADC1 Channel 5, Anneal primary current	mA		0	0	0	0	0	0.04545	7
33	COOLER_POWER_BOARD_TEMP	ADC1 Channel 6, Cooler power board temperature	ºC		0	-6.7391E-21	7.7051E-16	-3.6142E-11	8.771E-07	-0.013407	137.01
34	COOLER_TEMP	ADC1 Channel 7, Cooler Stator temperature	ºC		0	0	0	0	2.3554E-06	0.04321	-238.87
35	CMD_SCIENCE_MODE	Commanded to event classification	DN		0	0	0	0	0	1	0
36	CMD_HPGE_HV	Commanded HPGe HV level	V		0	0	0	0	0	1.220703125	0
37	CMD_SHIELD_HV	Commanded Shield HV level	V		0	0	0	0	0	0.732421875	0
38	CALIB_AVG_DET_TEMP	Calibrated, averaged detector temperature	K		-6.01731E-23	1.94306E-17	-2.61457E-12	1.87671E-07	-0.007579695	163.3708647	-1468809.947
39	HPGE_HV_SAFING_LVL	Current safing level	DN		0	0	0	0	0	1	0
40	SHLD_HV_SAFING_LVL	Current safing level	DN		0	0	0	0	0	1	0
41	COOLER_TEMP_SETPOINT	Cooler temperature set point	K		-6.01731E-23	1.94306E-17	-2.61457E-12	1.87671E-07	-0.007579695	163.3708647	-1468809.947

********** *Enhanced correction using on-board voltage reference values

Column(s)	Correction Formula	Description
12	raw' = 46852*raw(12)/raw(14)	Pre-correct using Column 14, then apply polynomial
13	value = 1500*raw(13)/raw(14)	Direct value, polynomial not req'd
15-16	raw' = 65535-43059*(65535-raw(n))/raw(23)	Bit-wise invert, correct using Column 23, reinvert, then apply polynomial
17-22	raw' = 43059*raw(n)/raw(23)	Pre-correct using Column 23, then apply polynomial

GRS_CAL_SH3 and GRS_CAL_SCR include the "DEADTIME_FRAC" value, which is derived from the "ACCUMULATED_DEAD_TIME" entry (column 5) in the software counter (SWC) EDR for each GRS measurement as:

$$\text{DEADTIME\_FRAC} = 16\text{x}10^{-6} \text{ x } (\text{ACCUMULATED\_DEAD\_TIME}/\text{ACCUM\_TIME}),$$

where "ACCUM_TIME" is the accumulation period for the spectrum of interest as listed in the corresponding CDR entry. See sections 8.6, 8.7.5, and 8.7.6 for additional information on this entry.

8.5 Appendix: GRS PDS Label Files

8.5.1 GRS_CAL_RAW

```
PDS_VERSION_ID                = "PDS3"

/*** FILE FORMAT ***/
FILE_RECORDS                  = 296
RECORD_TYPE                   = FIXED_LENGTH
RECORD_BYTES                  = 65831

/*** GENERAL DATA DESCRIPTION PARAMETERS ***/
PRODUCT_ID                    = "GRS_CRA2011315ZZZ_DAT"
PRODUCT_VERSION_ID            = "4.0"
PRODUCT_CREATION_TIME         = 2015-09-21T15:04:03
PRODUCT_TYPE                  = "CDR"
SOFTWARE_NAME                 = "GRS_CDR_GEN"
SOFTWARE_VERSION_ID           = "1.0"
INSTRUMENT_HOST_NAME          = "MESSENGER"
INSTRUMENT_NAME               = "GAMMA RAY SPECTROMETER"
INSTRUMENT_ID                 = "GRS"
DETECTOR_ID                   = "HPGE"
DATA_SET_ID                   = "MESS-E/V/H-GRNS-3-GRS-CDR-V1.0"
MISSION_PHASE_NAME            = "MERCURY ORBIT"
TARGET_NAME                   = "MERCURY"
START_TIME                    = 2011-11-11T00:10:29.380
STOP_TIME                     = 2011-11-11T23:50:23.381
SPACECRAFT_CLOCK_START_COUNT  = "1/229457696"
SPACECRAFT_CLOCK_STOP_COUNT   = "1/229542890"
^TABLE                        = "GRS_CRA2011315ZZZ.DAT"

OBJECT                        = TABLE
   COLUMNS                    = 59
   INTERCHANGE_FORMAT         = BINARY
   ROWS                       = 296
   ROW_BYTES                  = 65831
   DESCRIPTION                = "
    This table contains one set of corrected raw spectra collected from the
    high purity Germanium (HPGe) detector plus spatial and temporal
    information and relevant engineering and counter and pulser data
    from the time the spectra was taken. A set is defined as all data
    with timestamps corresponding to a given day of year.
"
   ^STRUCTURE                 = "GRS_CAL_RAW.FMT"
END_OBJECT                    = TABLE
END
```

8.5.2 GRS_CAL_AC

```
PDS_VERSION_ID                = "PDS3"

/*** FILE FORMAT ***/
FILE_RECORDS                  = 296
RECORD_TYPE                   = FIXED_LENGTH
RECORD_BYTES                  = 65831

/*** GENERAL DATA DESCRIPTION PARAMETERS ***/
PRODUCT_ID                    = "GRS_CAC2011315ZZZ_DAT"
PRODUCT_VERSION_ID            = "4.0"
PRODUCT_CREATION_TIME         = 2015-09-21T15:03:58
PRODUCT_TYPE                  = "CDR"
SOFTWARE_NAME                 = "GRS_CDR_GEN"
SOFTWARE_VERSION_ID           = "1.0"
INSTRUMENT_HOST_NAME          = "MESSENGER"
INSTRUMENT_NAME               = "GAMMA RAY SPECTROMETER"
INSTRUMENT_ID                 = "GRS"
DETECTOR_ID                   = "HPGE"
DATA_SET_ID                   = "MESS-E/V/H-GRNS-3-GRS-CDR-V1.0"
MISSION_PHASE_NAME            = "MERCURY ORBIT"
TARGET_NAME                   = "MERCURY"
START_TIME                    = 2011-11-11T00:10:29.380
STOP_TIME                     = 2011-11-11T23:50:23.381
SPACECRAFT_CLOCK_START_COUNT  = "1/229457696"
SPACECRAFT_CLOCK_STOP_COUNT   = "1/229542890"
^TABLE                        = "GRS_CAC2011315ZZZ.DAT"

OBJECT                        = TABLE
   COLUMNS                    = 59
   INTERCHANGE_FORMAT         = BINARY
   ROWS                       = 296
   ROW_BYTES                  = 65831
   DESCRIPTION                ="
    This table contains one set of Anti-Coincident (AC) spectra
    collected from the high purity Germanium (HPGe) detector plus
    spatial and temporal information and relevant engineering and
    counter and pulser data from the time the spectra was taken.
    A set is defined as all data with timestamps corresponding to
    a given day of year.
"
   ^STRUCTURE                 = "GRS_CAL_AC.FMT"
END_OBJECT                    = TABLE
END
```

8.5.3 GRS_CAL_SH

```
PDS_VERSION_ID                = "PDS3"

/*** FILE FORMAT ***/
FILE_RECORDS                  = 200
RECORD_TYPE                   = FIXED_LENGTH
RECORD_BYTES                  = 4301

/*** GENERAL DATA DESCRIPTION PARAMETERS ***/
PRODUCT_ID                    = "GRS_CSH2004316ZZZ_DAT"
PRODUCT_VERSION_ID            = "4.0"
PRODUCT_CREATION_TIME         = 2015-09-21T14:03:32
PRODUCT_TYPE                  = "CDR"
SOFTWARE_NAME                 = "GRS_CDR_GEN"
SOFTWARE_VERSION_ID           = "1.0"
INSTRUMENT_HOST_NAME          = "MESSENGER"
INSTRUMENT_NAME               = "GAMMA RAY SPECTROMETER"
INSTRUMENT_ID                 = "GRS"
DETECTOR_ID                   = "SHIELD"
DATA_SET_ID                   = "MESS-E/V/H-GRNS-3-GRS-CDR-V1.0"
MISSION_PHASE_NAME            = "EARTH CRUISE"
TARGET_NAME                   = "CALIBRATION"
START_TIME                    = 2004-11-11T01:27:27.344
STOP_TIME                     = 2004-11-11T23:49:27.939
SPACECRAFT_CLOCK_START_COUNT  = "1/8623641"
SPACECRAFT_CLOCK_STOP_COUNT   = "1/8704161"
^TABLE                        = "GRS_CSH2004316ZZZ.DAT"

OBJECT                        = TABLE
   COLUMNS                    = 35
   INTERCHANGE_FORMAT         = BINARY
   ROWS                       = 200
   ROW_BYTES                  = 4301
   DESCRIPTION                ="
    This table contains one set of Shield (SHI) spectra
    collected from the high purity Germanium (HPGe) detector plus
    spatial and temporal information and relevant engineering and
    counter and pulser data from the time the spectra was taken.
    A set is defined as all data with time stamps corresponding to
    a given day of year.
"
   ^STRUCTURE                 = "GRS_CAL_SH.FMT"
END_OBJECT                    = TABLE
END
```

8.5.4 GRS_CAL_SH2

```
PDS_VERSION_ID                = "PDS3"

/*** FILE FORMAT ***/
FILE_RECORDS                  = 37
RECORD_TYPE                   = FIXED_LENGTH
RECORD_BYTES                  = 1245

/*** GENERAL DATA DESCRIPTION PARAMETERS ***/
PRODUCT_ID                    = "GRS_CS22010260ZZZ_DAT"
PRODUCT_VERSION_ID            = "3.0"
PRODUCT_CREATION_TIME         = 2015-09-21T14:15:32
PRODUCT_TYPE                  = "CDR"
SOFTWARE_NAME                 = "GRS_CDR_GEN"
SOFTWARE_VERSION_ID           = "1.0"
INSTRUMENT_HOST_NAME          = "MESSENGER"
INSTRUMENT_NAME               = "GAMMA RAY SPECTROMETER"
INSTRUMENT_ID                 = "GRS"
DETECTOR_ID                   = "SHIELD"
DATA_SET_ID                   = "MESS-E/V/H-GRNS-3-GRS-CDR-V1.0"
MISSION_PHASE_NAME            = "MERCURY 4 CRUISE"
TARGET_NAME                   = "CALIBRATION"
START_TIME                    = 2010-09-17T20:55:35.892
STOP_TIME                     = 2010-09-17T23:55:35.892
SPACECRAFT_CLOCK_START_COUNT  = "1/193244409"
SPACECRAFT_CLOCK_STOP_COUNT   = "1/193255209"
^TABLE                        = "GRS_CS22010260ZZZ.DAT"

OBJECT                        = TABLE
   COLUMNS                    = 45
   INTERCHANGE_FORMAT         = BINARY
   ROWS                       = 37
   ROW_BYTES                  = 1245
   DESCRIPTION                ="
    This table contains one set of Shield (SHI) spectra
    collected from the high purity Germanium (HPGe) detector plus
    spatial and temporal information and relevant engineering and
    counter and pulser data from the time the spectra was taken.
    A set is defined as all data with time stamps corresponding to
    a given day of year.
"
   ^STRUCTURE                 = "GRS_CAL_SH2.FMT"
END_OBJECT                    = TABLE
END
```

8.5.5 GRS_CAL_SH3

```
PDS_VERSION_ID                = "PDS3"

/*** FILE FORMAT ***/
FILE_RECORDS                  = 1972
RECORD_TYPE                   = FIXED_LENGTH
RECORD_BYTES                  = 6547

/*** GENERAL DATA DESCRIPTION PARAMETERS ***/
PRODUCT_ID                    = "GRS_CS32013100ZZZ_TAB"
PRODUCT_VERSION_ID            = "4.0"
PRODUCT_CREATION_TIME         = 2015-10-22T15:39:28
PRODUCT_TYPE                  = "CDR"
STANDARD_DATA_PRODUCT_ID      = "GRS_CAL_SH3"
SOFTWARE_NAME                 = "GRSEDR2CDR"
SOFTWARE_VERSION_ID           = "3.0"
INSTRUMENT_HOST_NAME          = "MESSENGER"
INSTRUMENT_NAME               = "GAMMA RAY SPECTROMETER"
INSTRUMENT_ID                 = "GRS"
DETECTOR_ID                   = "SHIELD"
DATA_SET_ID                   = "MESS-E/V/H-GRNS-3-GRS-CDR-V1.0"
MISSION_PHASE_NAME            = "MERCURY ORBIT YEAR 3"
TARGET_NAME                   = "MERCURY"
START_TIME                    = 2013-04-10T00:00:10
STOP_TIME                     = 2013-04-10T23:59:45
SPACECRAFT_CLOCK_START_COUNT  = "2/7876010"
SPACECRAFT_CLOCK_STOP_COUNT   = "2/7962385"
^TABLE                        = "GRS_CS32013100ZZZ.TAB"

OBJECT                        = TABLE
COLUMNS                       = 32
INTERCHANGE_FORMAT            = ASCII
ROWS                          = 1972
ROW_BYTES                     = 6547
DESCRIPTION                   = "
    This table contains one set of calibrated shield spectra from the SHIELD
    detector, MESSENGER Gamma Ray Spectrometer (GRS). A set is defined as
    all data with MET timestamps corresponding to a given Earth day. The
    complete column definitions are contained in an external file found in
    the LABEL directory of the archive volume. Additional details are
    contained in the CDR-RDR-DAP SIS document.
"
^STRUCTURE                    = "GRS_CAL_SH3.FMT"
END_OBJECT                    = TABLE
END
```

8.5.6 GRS_CAL_SCR

```
PDS_VERSION_ID                = "PDS3"

/*** FILE FORMAT ***/
FILE_RECORDS                  = 1972
RECORD_TYPE                   = FIXED_LENGTH
RECORD_BYTES                  = 98707

/*** GENERAL DATA DESCRIPTION PARAMETERS ***/
PRODUCT_ID                    = "GRS_CSC2013100ZZZ_TAB"
PRODUCT_VERSION_ID            = "4.0"
PRODUCT_CREATION_TIME         = 2015-10-21T14:17:13
PRODUCT_TYPE                  = "CDR"
STANDARD_DATA_PRODUCT_ID      = "GRS_CAL_SCR"
SOFTWARE_NAME                 = "GRSEDR2CDR"
SOFTWARE_VERSION_ID           = "3.0"
INSTRUMENT_HOST_NAME          = "MESSENGER"
INSTRUMENT_NAME               = "GAMMA RAY SPECTROMETER"
INSTRUMENT_ID                 = "GRS"
DETECTOR_ID                   = "ACS"
DATA_SET_ID                   = "MESS-E/V/H-GRNS-3-GRS-CDR-V1.0"
MISSION_PHASE_NAME            = "MERCURY ORBIT YEAR 3"
TARGET_NAME                   = "MERCURY"
START_TIME                    = 2013-04-10T00:00:10
STOP_TIME                     = 2013-04-10T23:59:45
SPACECRAFT_CLOCK_START_COUNT  = "2/7876010"
SPACECRAFT_CLOCK_STOP_COUNT   = "2/7962385"
^TABLE                        = "GRS_CSC2013100ZZZ.TAB"

OBJECT                        = TABLE
COLUMNS                       = 32
INTERCHANGE_FORMAT            = ASCII
ROWS                          = 1972
ROW_BYTES                     = 98707
DESCRIPTION                   = "
    This table contains one set of calibrated high-time-resolution count
    rate measurements in the GRS anti-coincidence shield. Each entry
    contains an array that is populated with values corresponding to the
    total number of events registered by the GRS Anti-Coincidence Shield
    (ACS) in 10-ms-long increments. When the accumulation period is
    insufficient to populate all 16384 channels, the remaining entries are
    assigned values of zero. For arrays exceeding 16384 entries in length,
    the final channel records the sum of all subsequent entries. A set is
    defined as all data with MET timestamps corresponding to a given day.
    The complete column definitions are contained in an external file found
    in the LABEL directory of the archive volume. Additional details are
    contained in the CDR-RDR-DAP SIS document."

^STRUCTURE                    = "GRS_CAL_SCR.FMT"
END_OBJECT                    = TABLE
END
```

8.5.7 GRS_ENG

```
PDS_VERSION_ID                = "PDS3"

/*** GENERAL DATA DESCRIPTION PARAMETERS ***/
PRODUCT_VERSION_ID            = "2.0"
PRODUCT_CREATION_TIME         = 2011-08-11T15:16:45
STANDARD_DATA_PRODUCT_ID      = "GRS_ENG2008015"
SOFTWARE_NAME                 = "GRS_CDR_GEN"
SOFTWARE_VERSION_ID           = "1.0"
INSTRUMENT_HOST_NAME          = "MESSENGER"
INSTRUMENT_NAME               = "GAMMA RAY SPECTROMETER"
INSTRUMENT_ID                 = "GRS"
DATA_SET_ID                   = "MESS-E/V/H-GRNS-3-GRS-CDR-V1.0"
MISSION_PHASE_NAME            = "MERCURY 1 FLYBY"
TARGET_NAME                   = "MERCURY"
START_TIME                    = 2008-01-15T00:00:13.096
STOP_TIME                     = 2008-01-15T23:59:56.098
SPACECRAFT_CLOCK_START_COUNT   = "108842594"
SPACECRAFT_CLOCK_STOP_COUNT    = "108928977"

/* The complete column definitions are contained in an external */
/* file found in the LABEL directory of the archive disk.       */
OBJECT                        = E01_FILE
   /* FILE CHARACTERISTICS */
   FILE_NAME                     = "GRS_E012008015ZZZ.DAT"
   RECORD_TYPE                   = FIXED_LENGTH
   RECORD_BYTES                  = 47
   FILE_RECORDS                  = 4111
   /* POINTERS TO DATA OBJECTS */
   ^TIME_SERIES                  = "GRS_E012008015ZZZ.DAT"
   /* IDENTIFICATION DATA ELEMENTS */
   PRODUCT_ID                    = "LVPS_PLUS5V_2008015"
   PRODUCT_TYPE                  = "LVPS_PLUS5V"
   /* DESCRIPTIVE data elements */
   DESCRIPTION                   = "LVPS_PLUS5V voltage, in Volts."
   /* DATA OBJECT DEFINITION */
   OBJECT                        = E01_TIME_SERIES
      NAME                          = LVPS_PLUS5V
      INTERCHANGE_FORMAT            = BINARY
      ROWS                          = 4111
      ROW_BYTES                     = 47
      SAMPLING_PARAMETER_NAME       = TIME
      SAMPLING_PARAMETER_UNIT       = SECONDS
      SAMPLING_PARAMETER_INTERVAL   = "N/A"
      COLUMNS                       = 5
      ^STRUCTURE                    = "GRS_ENG.FMT"
   END_OBJECT                    = E01_TIME_SERIES
END_OBJECT                    = E01_FILE
OBJECT                        = E02_FILE
   FILE_NAME                     = "GRS_E022008015ZZZ.DAT"
   RECORD_TYPE                   = FIXED_LENGTH
   RECORD_BYTES                  = 47
   FILE_RECORDS                  = 4111
   /* POINTERS TO DATA OBJECTS */
   ^TIME_SERIES                  = "GRS_E022008015ZZZ.DAT"
   /* IDENTIFICATION DATA ELEMENTS */
   PRODUCT_ID                    = "LVPS_NEG5V_2008015"
   PRODUCT_TYPE                  = "LVPS_NEG5V"
   /* DESCRIPTIVE data elements */
   DESCRIPTION                   = "LVPS_NEG5V voltage, in Volts."
   /* DATA OBJECT DEFINITION */
   OBJECT                        = E02_TIME_SERIES
      NAME                          = LVPS_NEG5V
      INTERCHANGE_FORMAT            = BINARY
      ROWS                          = 4111
      ROW_BYTES                     = 47
      SAMPLING_PARAMETER_NAME       = TIME
      SAMPLING_PARAMETER_UNIT       = SECONDS
      SAMPLING_PARAMETER_INTERVAL   = "N/A"
```

```
      COLUMNS                        = 5
      ^STRUCTURE                     = "GRS_ENG.FMT"
   END_OBJECT                     = E02_TIME_SERIES
END_OBJECT                     = E02_FILE
OBJECT                         = E03_FILE
   FILE_NAME                      = "GRS_E032008015ZZZ.DAT"
   RECORD_TYPE                    = FIXED_LENGTH
   RECORD_BYTES                   = 47
   FILE_RECORDS                   = 4111
   /* POINTERS TO DATA OBJECTS */
   ^TIME_SERIES                   = "GRS_E032008015ZZZ.DAT"
   /* IDENTIFICATION DATA ELEMENTS */
   PRODUCT_ID                     = "LVPS_PLUS12V_2008015"
   PRODUCT_TYPE                   = "LVPS_PLUS12V"
   /* DESCRIPTIVE data elements */
   DESCRIPTION                    = "LVPS_PLUS12V voltage, in Volts."
   /* DATA OBJECT DEFINITION */
   OBJECT                         = E03_TIME_SERIES
      NAME                         = LVPS_PLUS12V
      INTERCHANGE_FORMAT           = BINARY
      ROWS                         = 4111
      ROW_BYTES                    = 47
      SAMPLING_PARAMETER_NAME      = TIME
      SAMPLING_PARAMETER_UNIT      = SECONDS
      SAMPLING_PARAMETER_INTERVAL  = "N/A"
      COLUMNS                      = 5
      ^STRUCTURE                   = "GRS_ENG.FMT"
   END_OBJECT                     = E03_TIME_SERIES
END_OBJECT                     = E03_FILE
OBJECT                         = E04_FILE
   FILE_NAME                      = "GRS_E042008015ZZZ.DAT"
   RECORD_TYPE                    = FIXED_LENGTH
   RECORD_BYTES                   = 47
   FILE_RECORDS                   = 4111
   /* POINTERS TO DATA OBJECTS */
   ^TIME_SERIES                   = "GRS_E042008015ZZZ.DAT"
   /* IDENTIFICATION DATA ELEMENTS */
   PRODUCT_ID                     = "LVPS_NEG12V_2008015"
   PRODUCT_TYPE                   = "LVPS_NEG12V"
   /* DESCRIPTIVE data elements */
   DESCRIPTION                    = "LVPS_NEG12V voltage, in Volts."
   /* DATA OBJECT DEFINITION */
   OBJECT                         = E04_TIME_SERIES
      NAME                         = LVPS_NEG12V
      INTERCHANGE_FORMAT           = BINARY
      ROWS                         = 4111
      ROW_BYTES                    = 47
      SAMPLING_PARAMETER_NAME      = TIME
      SAMPLING_PARAMETER_UNIT      = SECONDS
      SAMPLING_PARAMETER_INTERVAL  = "N/A"
      COLUMNS                      = 5
      ^STRUCTURE                   = "GRS_ENG.FMT"
   END_OBJECT                     = E04_TIME_SERIES
END_OBJECT                     = E04_FILE
OBJECT                         = E05_FILE
   FILE_NAME                      = "GRS_E052008015ZZZ.DAT"
   RECORD_TYPE                    = FIXED_LENGTH
   RECORD_BYTES                   = 47
   FILE_RECORDS                   = 4111
   /* POINTERS TO DATA OBJECTS */
   ^TIME_SERIES                   = "GRS_E052008015ZZZ.DAT"
   /* IDENTIFICATION DATA ELEMENTS */
   PRODUCT_ID                     = "LVPS_PLUS5V_I_2008015"
   PRODUCT_TYPE                   = "LVPS_PLUS5V_I"
   /* DESCRIPTIVE data elements */
   DESCRIPTION                    = "LVPS_PLUS5V_I current, in Amps."
   /* DATA OBJECT DEFINITION */
   OBJECT                         = E05_TIME_SERIES
      NAME                         = LVPS_PLUS5V_I
      INTERCHANGE_FORMAT           = BINARY
      ROWS                         = 4111
```

```
      ROW_BYTES                       = 47
      SAMPLING_PARAMETER_NAME         = TIME
      SAMPLING_PARAMETER_UNIT         = SECONDS
      SAMPLING_PARAMETER_INTERVAL     = "N/A"
      COLUMNS                         = 5
      ^STRUCTURE                      = "GRS_ENG.FMT"
   END_OBJECT                      = E05_TIME_SERIES
END_OBJECT                     = E05_FILE
OBJECT                         = E06_FILE
   FILE_NAME                       = "GRS_E062008015ZZZ.DAT"
   RECORD_TYPE                     = FIXED_LENGTH
   RECORD_BYTES                    = 47
   FILE_RECORDS                    = 4111
   /* POINTERS TO DATA OBJECTS */
   ^TIME_SERIES                    = "GRS_E062008015ZZZ.DAT"
   /* IDENTIFICATION DATA ELEMENTS */
   PRODUCT_ID                      = "LVPS_NEG5V_I_2008015"
   PRODUCT_TYPE                    = "LVPS_NEG5V_I"
   /* DESCRIPTIVE data elements */
   DESCRIPTION                     = "LVPS_NEG5V_I current, in Amps."
   /* DATA OBJECT DEFINITION */
   OBJECT                          = E06_TIME_SERIES
      NAME                            = LVPS_NEG5V_I
      INTERCHANGE_FORMAT              = BINARY
      ROWS                            = 4111
      ROW_BYTES                       = 47
      SAMPLING_PARAMETER_NAME         = TIME
      SAMPLING_PARAMETER_UNIT         = SECONDS
      SAMPLING_PARAMETER_INTERVAL     = "N/A"
      COLUMNS                         = 5
      ^STRUCTURE                      = "GRS_ENG.FMT"
   END_OBJECT                      = E06_TIME_SERIES
END_OBJECT                     = E06_FILE
OBJECT                         = E07_FILE
   FILE_NAME                       = "GRS_E072008015ZZZ.DAT"
   RECORD_TYPE                     = FIXED_LENGTH
   RECORD_BYTES                    = 47
   FILE_RECORDS                    = 4111
   /* POINTERS TO DATA OBJECTS */
   ^TIME_SERIES                    = "GRS_E072008015ZZZ.DAT"
   /* IDENTIFICATION DATA ELEMENTS */
   PRODUCT_ID                      = "LVPS_PLUS12V_I_2008015"
   PRODUCT_TYPE                    = "LVPS_PLUS12V_I"
   /* DESCRIPTIVE data elements */
   DESCRIPTION                     = "LVPS_PLUS12V_I current, in Amps."
   /* DATA OBJECT DEFINITION */
   OBJECT                          = E07_TIME_SERIES
      NAME                            = LVPS_PLUS12V_I
      INTERCHANGE_FORMAT              = BINARY
      ROWS                            = 4111
      ROW_BYTES                       = 47
      SAMPLING_PARAMETER_NAME         = TIME
      SAMPLING_PARAMETER_UNIT         = SECONDS
      SAMPLING_PARAMETER_INTERVAL     = "N/A"
      COLUMNS                         = 5
      ^STRUCTURE                      = "GRS_ENG.FMT"
   END_OBJECT                      = E07_TIME_SERIES
END_OBJECT                     = E07_FILE
OBJECT                         = E08_FILE
   FILE_NAME                       = "GRS_E082008015ZZZ.DAT"
   RECORD_TYPE                     = FIXED_LENGTH
   RECORD_BYTES                    = 47
   FILE_RECORDS                    = 4111
   /* POINTERS TO DATA OBJECTS */
   ^TIME_SERIES                    = "GRS_E082008015ZZZ.DAT"
   /* IDENTIFICATION DATA ELEMENTS */
   PRODUCT_ID                      = "LVPS_NEG12V_I_2008015"
   PRODUCT_TYPE                    = "LVPS_NEG12V_I"
   /* DESCRIPTIVE data elements */
   DESCRIPTION                     = "LVPS_NEG12V_I current, in Amps."
   /* DATA OBJECT DEFINITION */
```

```
   OBJECT                          = E08_TIME_SERIES
      NAME                            = LVPS_NEG12V_I
      INTERCHANGE_FORMAT              = BINARY
      ROWS                            = 4111
      ROW_BYTES                       = 47
      SAMPLING_PARAMETER_NAME         = TIME
      SAMPLING_PARAMETER_UNIT         = SECONDS
      SAMPLING_PARAMETER_INTERVAL     = "N/A"
      COLUMNS                         = 5
      ^STRUCTURE                      = "GRS_ENG.FMT"
   END_OBJECT                      = E08_TIME_SERIES
END_OBJECT                     = E08_FILE
OBJECT                         = E09_FILE
   FILE_NAME                       = "GRS_E092008015ZZZ.DAT"
   RECORD_TYPE                     = FIXED_LENGTH
   RECORD_BYTES                    = 47
   FILE_RECORDS                    = 4111
   /* POINTERS TO DATA OBJECTS */
   ^TIME_SERIES                    = "GRS_E092008015ZZZ.DAT"
   /* IDENTIFICATION DATA ELEMENTS */
   PRODUCT_ID                      = "LVPS_TEMP_2008015"
   PRODUCT_TYPE                    = "LVPS_TEMP"
   /* DESCRIPTIVE data elements */
   DESCRIPTION                     = "LVPS_TEMP temperature, in Celsius."
   /* DATA OBJECT DEFINITION */
   OBJECT                          = E09_TIME_SERIES
      NAME                            = LVPS_TEMP
      INTERCHANGE_FORMAT              = BINARY
      ROWS                            = 4111
      ROW_BYTES                       = 47
      SAMPLING_PARAMETER_NAME         = TIME
      SAMPLING_PARAMETER_UNIT         = SECONDS
      SAMPLING_PARAMETER_INTERVAL     = "N/A"
      COLUMNS                         = 5
      ^STRUCTURE                      = "GRS_ENG.FMT"
   END_OBJECT                      = E09_TIME_SERIES
END_OBJECT                     = E09_FILE
OBJECT                         = E10_FILE
   FILE_NAME                       = "GRS_E102008015ZZZ.DAT"
   RECORD_TYPE                     = FIXED_LENGTH
   RECORD_BYTES                    = 47
   FILE_RECORDS                    = 4111
   /* POINTERS TO DATA OBJECTS */
   ^TIME_SERIES                    = "GRS_E102008015ZZZ.DAT"
   /* IDENTIFICATION DATA ELEMENTS */
   PRODUCT_ID                      = "LVPS_PRI_I_2008015"
   PRODUCT_TYPE                    = "LVPS_PRI_I"
   /* DESCRIPTIVE data elements */
   DESCRIPTION                     = "LVPS_PRI_I current, in Amps."
   /* DATA OBJECT DEFINITION */
   OBJECT                          = E10_TIME_SERIES
      NAME                            = LVPS_PRI_I
      INTERCHANGE_FORMAT              = BINARY
      ROWS                            = 4111
      ROW_BYTES                       = 47
      SAMPLING_PARAMETER_NAME         = TIME
      SAMPLING_PARAMETER_UNIT         = SECONDS
      SAMPLING_PARAMETER_INTERVAL     = "N/A"
      COLUMNS                         = 5
      ^STRUCTURE                      = "GRS_ENG.FMT"
   END_OBJECT                      = E10_TIME_SERIES
END_OBJECT                     = E10_FILE
OBJECT                         = E11_FILE
   FILE_NAME                       = "GRS_E112008015ZZZ.DAT"
   RECORD_TYPE                     = FIXED_LENGTH
   RECORD_BYTES                    = 47
   FILE_RECORDS                    = 4111
   /* POINTERS TO DATA OBJECTS */
   ^TIME_SERIES                    = "GRS_E112008015ZZZ.DAT"
   /* IDENTIFICATION DATA ELEMENTS */
   PRODUCT_ID                      = "LVPS_SEC_I_2008015"
```

```
   PRODUCT_TYPE                  = "LVPS_SEC_I"
   /* DESCRIPTIVE data elements */
   DESCRIPTION                   = "LVPS_SEC_I current, in Amps."
   /* DATA OBJECT DEFINITION */
   OBJECT                        = E11_TIME_SERIES
      NAME                          = LVPS_SEC_I
      INTERCHANGE_FORMAT            = BINARY
      ROWS                          = 4111
      ROW_BYTES                     = 47
      SAMPLING_PARAMETER_NAME       = TIME
      SAMPLING_PARAMETER_UNIT       = SECONDS
      SAMPLING_PARAMETER_INTERVAL   = "N/A"
      COLUMNS                       = 5
      ^STRUCTURE                    = "GRS_ENG.FMT"
   END_OBJECT                    = E11_TIME_SERIES
END_OBJECT                    = E11_FILE
OBJECT                        = E12_FILE
   FILE_NAME                     = "GRS_E122008015ZZZ.DAT"
   RECORD_TYPE                   = FIXED_LENGTH
   RECORD_BYTES                  = 47
   FILE_RECORDS                  = 4111
   /* POINTERS TO DATA OBJECTS */
   ^TIME_SERIES                  = "GRS_E122008015ZZZ.DAT"
   /* IDENTIFICATION DATA ELEMENTS */
   PRODUCT_ID                    = "HVPS_TEMP_2008015"
   PRODUCT_TYPE                  = "HVPS_TEMP"
   /* DESCRIPTIVE data elements */
   DESCRIPTION                   = "HVPS_TEMP temperature, in Celsius."
   /* DATA OBJECT DEFINITION */
   OBJECT                        = E12_TIME_SERIES
      NAME                          = HVPS_TEMP
      INTERCHANGE_FORMAT            = BINARY
      ROWS                          = 4111
      ROW_BYTES                     = 47
      SAMPLING_PARAMETER_NAME       = TIME
      SAMPLING_PARAMETER_UNIT       = SECONDS
      SAMPLING_PARAMETER_INTERVAL   = "N/A"
      COLUMNS                       = 5
      ^STRUCTURE                    = "GRS_ENG.FMT"
   END_OBJECT                    = E12_TIME_SERIES
END_OBJECT                    = E12_FILE
OBJECT                        = E13_FILE
   FILE_NAME                     = "GRS_E132008015ZZZ.DAT"
   RECORD_TYPE                   = FIXED_LENGTH
   RECORD_BYTES                  = 47
   FILE_RECORDS                  = 4111
   /* POINTERS TO DATA OBJECTS */
   ^TIME_SERIES                  = "GRS_E132008015ZZZ.DAT"
   /* IDENTIFICATION DATA ELEMENTS */
   PRODUCT_ID                    = "HVPS_VOLT_2008015"
   PRODUCT_TYPE                  = "HVPS_VOLT"
   /* DESCRIPTIVE data elements */
   DESCRIPTION                   = "HVPS_VOLT voltage, in Volts."
   /* DATA OBJECT DEFINITION */
   OBJECT                        = E13_TIME_SERIES
      NAME                          = HVPS_VOLT
      INTERCHANGE_FORMAT            = BINARY
      ROWS                          = 4111
      ROW_BYTES                     = 47
      SAMPLING_PARAMETER_NAME       = TIME
      SAMPLING_PARAMETER_UNIT       = SECONDS
      SAMPLING_PARAMETER_INTERVAL   = "N/A"
      COLUMNS                       = 5
      ^STRUCTURE                    = "GRS_ENG.FMT"
   END_OBJECT                    = E13_TIME_SERIES
END_OBJECT                    = E13_FILE
OBJECT                        = E14_FILE
   FILE_NAME                     = "GRS_E142008015ZZZ.DAT"
   RECORD_TYPE                   = FIXED_LENGTH
   RECORD_BYTES                  = 47
   FILE_RECORDS                  = 4111
```

```
   /* POINTERS TO DATA OBJECTS */
   ^TIME_SERIES                  = "GRS_E142008015ZZZ.DAT"
   /* IDENTIFICATION DATA ELEMENTS */
   PRODUCT_ID                    = "HVPS_REF_VOLT_2008015"
   PRODUCT_TYPE                  = "HVPS_REF_VOLT"
   /* DESCRIPTIVE data elements */
   DESCRIPTION                =
   "HVPS_REF_VOLT current reference, in Volts."
   /* DATA OBJECT DEFINITION */
   OBJECT                        = E14_TIME_SERIES
      NAME                          = HVPS_REF_VOLT
      INTERCHANGE_FORMAT            = BINARY
      ROWS                          = 4111
      ROW_BYTES                     = 47
      SAMPLING_PARAMETER_NAME       = TIME
      SAMPLING_PARAMETER_UNIT       = SECONDS
      SAMPLING_PARAMETER_INTERVAL   = "N/A"
      COLUMNS                       = 5
      ^STRUCTURE                    = "GRS_ENG.FMT"
   END_OBJECT                    = E14_TIME_SERIES
END_OBJECT                    = E14_FILE
OBJECT                        = E15_FILE
   FILE_NAME                     = "GRS_E152008015ZZZ.DAT"
   RECORD_TYPE                   = FIXED_LENGTH
   RECORD_BYTES                  = 47
   FILE_RECORDS                  = 4111
   /* POINTERS TO DATA OBJECTS */
   ^TIME_SERIES                  = "GRS_E152008015ZZZ.DAT"
   /* IDENTIFICATION DATA ELEMENTS */
   PRODUCT_ID                    = "HPGE_TEMP_1_2008015"
   PRODUCT_TYPE                  = "HPGE_TEMP_1"
   /* DESCRIPTIVE data elements */
   DESCRIPTION                   = "HPGE_TEMP_1 temperature, in Kelvin."
   /* DATA OBJECT DEFINITION */
   OBJECT                        = E15_TIME_SERIES
      NAME                          = HPGE_TEMP_1
      INTERCHANGE_FORMAT            = BINARY
      ROWS                          = 4111
      ROW_BYTES                     = 47
      SAMPLING_PARAMETER_NAME       = TIME
      SAMPLING_PARAMETER_UNIT       = SECONDS
      SAMPLING_PARAMETER_INTERVAL   = "N/A"
      COLUMNS                       = 5
      ^STRUCTURE                    = "GRS_ENG.FMT"
   END_OBJECT                    = E15_TIME_SERIES
END_OBJECT                    = E15_FILE
OBJECT                        = E16_FILE
   FILE_NAME                     = "GRS_E162008015ZZZ.DAT"
   RECORD_TYPE                   = FIXED_LENGTH
   RECORD_BYTES                  = 47
   FILE_RECORDS                  = 4111
   /* POINTERS TO DATA OBJECTS */
   ^TIME_SERIES                  = "GRS_E162008015ZZZ.DAT"
   /* IDENTIFICATION DATA ELEMENTS */
   PRODUCT_ID                    = "HPGE_TEMP_2_2008015"
   PRODUCT_TYPE                  = "HPGE_TEMP_2"
   /* DESCRIPTIVE data elements */
   DESCRIPTION                   = "HPGE_TEMP_2 temperature, in Kelvin."
   /* DATA OBJECT DEFINITION */
   OBJECT                        = E16_TIME_SERIES
      NAME                          = HPGE_TEMP_2
      INTERCHANGE_FORMAT            = BINARY
      ROWS                          = 4111
      ROW_BYTES                     = 47
      SAMPLING_PARAMETER_NAME       = TIME
      SAMPLING_PARAMETER_UNIT       = SECONDS
      SAMPLING_PARAMETER_INTERVAL   = "N/A"
      COLUMNS                       = 5
      ^STRUCTURE                    = "GRS_ENG.FMT"
   END_OBJECT                    = E16_TIME_SERIES
END_OBJECT                    = E16_FILE
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OBJECT                          = E17_FILE
   FILE_NAME                       = "GRS_E172008015ZZZ.DAT"
   RECORD_TYPE                     = FIXED_LENGTH
   RECORD_BYTES                    = 47
   FILE_RECORDS                    = 4111
   /* POINTERS TO DATA OBJECTS */
   ^TIME_SERIES                    = "GRS_E172008015ZZZ.DAT"
   /* IDENTIFICATION DATA ELEMENTS */
   PRODUCT_ID                      = "HPGE_DET_LEAK_2008015"
   PRODUCT_TYPE                    = "HPGE_DET_LEAK"
   /* DESCRIPTIVE data elements */
   DESCRIPTION                     = "HPGE_DET_LEAK current, in Pico-amps."
   /* DATA OBJECT DEFINITION */
   OBJECT                          = E17_TIME_SERIES
      NAME                           = HPGE_DET_LEAK
      INTERCHANGE_FORMAT             = BINARY
      ROWS                           = 4111
      ROW_BYTES                      = 47
      SAMPLING_PARAMETER_NAME        = TIME
      SAMPLING_PARAMETER_UNIT        = SECONDS
      SAMPLING_PARAMETER_INTERVAL    = "N/A"
      COLUMNS                        = 5
      ^STRUCTURE                     = "GRS_ENG.FMT"
   END_OBJECT                      = E17_TIME_SERIES
END_OBJECT                      = E17_FILE
OBJECT                          = E18_FILE
   FILE_NAME                       = "GRS_E182008015ZZZ.DAT"
   RECORD_TYPE                     = FIXED_LENGTH
   RECORD_BYTES                    = 47
   FILE_RECORDS                    = 4111
   /* POINTERS TO DATA OBJECTS */

   ^TIME_SERIES                    = "GRS_E182008015ZZZ.DAT"
   /* IDENTIFICATION DATA ELEMENTS */
   PRODUCT_ID                      = "HVPS_TEMP_2_2008015"
   PRODUCT_TYPE                    = "HVPS_TEMP_2"
   /* DESCRIPTIVE data elements */
   DESCRIPTION                     = "HVPS_TEMP_2 temperature, in Celsius."
   /* DATA OBJECT DEFINITION */
   OBJECT                          = E18_TIME_SERIES
      NAME                           = HVPS_TEMP_2
      INTERCHANGE_FORMAT             = BINARY
      ROWS                           = 4111
      ROW_BYTES                      = 47
      SAMPLING_PARAMETER_NAME        = TIME
      SAMPLING_PARAMETER_UNIT        = SECONDS
      SAMPLING_PARAMETER_INTERVAL    = "N/A"
      COLUMNS                        = 5
      ^STRUCTURE                     = "GRS_ENG.FMT"
   END_OBJECT                      = E18_TIME_SERIES
END_OBJECT                      = E18_FILE
OBJECT                          = E19_FILE
   FILE_NAME                       = "GRS_E192008015ZZZ.DAT"
   RECORD_TYPE                     = FIXED_LENGTH
   RECORD_BYTES                    = 47
   FILE_RECORDS                    = 4111
   /* POINTERS TO DATA OBJECTS */
   ^TIME_SERIES                    = "GRS_E192008015ZZZ.DAT"
   /* IDENTIFICATION DATA ELEMENTS */
   PRODUCT_ID                      = "PREAMP_TEMP_2008015"
   PRODUCT_TYPE                    = "PREAMP_TEMP"
   /* DESCRIPTIVE data elements */
   DESCRIPTION                     = "PREAMP_TEMP temperature, in Celsius."
   /* DATA OBJECT DEFINITION */
   OBJECT                          = E19_TIME_SERIES
      NAME                           = PREAMP_TEMP
      INTERCHANGE_FORMAT             = BINARY
      ROWS                           = 4111
      ROW_BYTES                      = 47
      SAMPLING_PARAMETER_NAME        = TIME
      SAMPLING_PARAMETER_UNIT        = SECONDS
```

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      SAMPLING_PARAMETER_INTERVAL    = "N/A"
      COLUMNS                        = 5
      ^STRUCTURE                     = "GRS_ENG.FMT"
   END_OBJECT                     = E19_TIME_SERIES
END_OBJECT                     = E19_FILE
OBJECT                         = E20_FILE
   FILE_NAME                      = "GRS_E202008015ZZZ.DAT"
   RECORD_TYPE                    = FIXED_LENGTH
   RECORD_BYTES                   = 47
   FILE_RECORDS                   = 4111
   /* POINTERS TO DATA OBJECTS */
   ^TIME_SERIES                   = "GRS_E202008015ZZZ.DAT"
   /* IDENTIFICATION DATA ELEMENTS */
   PRODUCT_ID                     = "SHAPER_TEMP_2008015"
   PRODUCT_TYPE                   = "SHAPER_TEMP"
   /* DESCRIPTIVE data elements */
   DESCRIPTION                    = "SHAPER_TEMP temperature, in Celsius."
   /* DATA OBJECT DEFINITION */
   OBJECT                         = E20_TIME_SERIES
      NAME                           = SHAPER_TEMP
      INTERCHANGE_FORMAT             = BINARY
      ROWS                           = 4111
      ROW_BYTES                      = 47
      SAMPLING_PARAMETER_NAME        = TIME
      SAMPLING_PARAMETER_UNIT        = SECONDS
      SAMPLING_PARAMETER_INTERVAL    = "N/A"
      COLUMNS                        = 5
      ^STRUCTURE                     = "GRS_ENG.FMT"
   END_OBJECT                     = E20_TIME_SERIES
END_OBJECT                     = E20_FILE
OBJECT                         = E21_FILE
   FILE_NAME                      = "GRS_E212008015ZZZ.DAT"
   RECORD_TYPE                    = FIXED_LENGTH
   RECORD_BYTES                   = 47
   FILE_RECORDS                   = 4111
   /* POINTERS TO DATA OBJECTS */
   ^TIME_SERIES                   = "GRS_E212008015ZZZ.DAT"
   /* IDENTIFICATION DATA ELEMENTS */
   PRODUCT_ID                     = "AD_TEMP_2008015"
   PRODUCT_TYPE                   = "AD_TEMP"
   /* DESCRIPTIVE data elements */
   DESCRIPTION                    = "AD_TEMP temperature, in Celsius."
   /* DATA OBJECT DEFINITION */
   OBJECT                         = E21_TIME_SERIES
      NAME                           = AD_TEMP
      INTERCHANGE_FORMAT             = BINARY
      ROWS                           = 4111
      ROW_BYTES                      = 47
      SAMPLING_PARAMETER_NAME        = TIME
      SAMPLING_PARAMETER_UNIT        = SECONDS
      SAMPLING_PARAMETER_INTERVAL    = "N/A"
      COLUMNS                        = 5
      ^STRUCTURE                     = "GRS_ENG.FMT"
   END_OBJECT                     = E21_TIME_SERIES
END_OBJECT                     = E21_FILE
OBJECT                         = E22_FILE
   FILE_NAME                      = "GRS_E222008015ZZZ.DAT"
   RECORD_TYPE                    = FIXED_LENGTH
   RECORD_BYTES                   = 47
   FILE_RECORDS                   = 4111
   /* POINTERS TO DATA OBJECTS */
   ^TIME_SERIES                   = "GRS_E222008015ZZZ.DAT"
   /* IDENTIFICATION DATA ELEMENTS */
   PRODUCT_ID                     = "HV_MONITOR_2008015"
   PRODUCT_TYPE                   = "HV_MONITOR"
   /* DESCRIPTIVE data elements */
   DESCRIPTION                    = "HV_MONITOR voltage, in Volts."
   /* DATA OBJECT DEFINITION */
   OBJECT                         = E22_TIME_SERIES
      NAME                           = HV_MONITOR
      INTERCHANGE_FORMAT             = BINARY
```

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      ROWS                          = 4111
      ROW_BYTES                     = 47
      SAMPLING_PARAMETER_NAME       = TIME
      SAMPLING_PARAMETER_UNIT       = SECONDS
      SAMPLING_PARAMETER_INTERVAL   = "N/A"
      COLUMNS                       = 5
      ^STRUCTURE                    = "GRS_ENG.FMT"
   END_OBJECT                    = E22_TIME_SERIES
END_OBJECT                    = E22_FILE
OBJECT                        = E23_FILE
   FILE_NAME                     = "GRS_E232008015ZZZ.DAT"
   RECORD_TYPE                   = FIXED_LENGTH
   RECORD_BYTES                  = 47
   FILE_RECORDS                  = 4111
   /* POINTERS TO DATA OBJECTS */
   ^TIME_SERIES                  = "GRS_E232008015ZZZ.DAT"
   /* IDENTIFICATION DATA ELEMENTS */
   PRODUCT_ID                    = "REF_2_5V_2008015"
   PRODUCT_TYPE                  = "REF_2_5V"
   /* DESCRIPTIVE data elements */
   DESCRIPTION                   = "REF_2_5V voltage, in Counts."
   /* DATA OBJECT DEFINITION */
   OBJECT                        = E23_TIME_SERIES
      NAME                          = REF_2_5V
      INTERCHANGE_FORMAT            = BINARY
      ROWS                          = 4111
      ROW_BYTES                     = 47
      SAMPLING_PARAMETER_NAME       = TIME
      SAMPLING_PARAMETER_UNIT       = SECONDS
      SAMPLING_PARAMETER_INTERVAL   = "N/A"
      COLUMNS                       = 5
      ^STRUCTURE                    = "GRS_ENG.FMT"
   END_OBJECT                    = E23_TIME_SERIES
END_OBJECT                    = E23_FILE
OBJECT                        = E24_FILE
   FILE_NAME                     = "GRS_E242008015ZZZ.DAT"
   RECORD_TYPE                   = FIXED_LENGTH
   RECORD_BYTES                  = 47
   FILE_RECORDS                  = 4111
   /* POINTERS TO DATA OBJECTS */
   ^TIME_SERIES                  = "GRS_E242008015ZZZ.DAT"
   /* IDENTIFICATION DATA ELEMENTS */
   PRODUCT_ID                    = "REF_2_5V_DIV2_2008015"
   PRODUCT_TYPE                  = "REF_2_5V_DIV2"
   /* DESCRIPTIVE data elements */
   DESCRIPTION                   = "REF_2_5V_DIV2 voltage ref, in Counts."
   /* DATA OBJECT DEFINITION */
   OBJECT                        = E24_TIME_SERIES
      NAME                          = REF_2_5V_DIV2
      INTERCHANGE_FORMAT            = BINARY
      ROWS                          = 4111
      ROW_BYTES                     = 47
      SAMPLING_PARAMETER_NAME       = TIME
      SAMPLING_PARAMETER_UNIT       = SECONDS
      SAMPLING_PARAMETER_INTERVAL   = "N/A"
      COLUMNS                       = 5
      ^STRUCTURE                    = "GRS_ENG.FMT"
   END_OBJECT                    = E24_TIME_SERIES
END_OBJECT                    = E24_FILE
OBJECT                        = E25_FILE
   FILE_NAME                     = "GRS_E252008015ZZZ.DAT"
   RECORD_TYPE                   = FIXED_LENGTH
   RECORD_BYTES                  = 47
   FILE_RECORDS                  = 4111
   /* POINTERS TO DATA OBJECTS */
   ^TIME_SERIES                  = "GRS_E252008015ZZZ.DAT"
   /* IDENTIFICATION DATA ELEMENTS */
   PRODUCT_ID                    = "REF_2_5V_DIV3_2008015"
   PRODUCT_TYPE                  = "REF_2_5V_DIV3"
   /* DESCRIPTIVE data elements */
   DESCRIPTION                   = "REF_2_5V_DIV3 current ref, in Counts."
```

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   /* DATA OBJECT DEFINITION */
   OBJECT                          = E25_TIME_SERIES
      NAME                           = REF_2_5V_DIV3
      INTERCHANGE_FORMAT             = BINARY
      ROWS                           = 4111
      ROW_BYTES                      = 47
      SAMPLING_PARAMETER_NAME        = TIME
      SAMPLING_PARAMETER_UNIT        = SECONDS
      SAMPLING_PARAMETER_INTERVAL    = "N/A"
      COLUMNS                        = 5
      ^STRUCTURE                     = "GRS_ENG.FMT"
   END_OBJECT                      = E25_TIME_SERIES
END_OBJECT                     = E25_FILE
OBJECT                         = E26_FILE
   FILE_NAME                      = "GRS_E262008015ZZZ.DAT"
   RECORD_TYPE                    = FIXED_LENGTH
   RECORD_BYTES                   = 47
   FILE_RECORDS                   = 4111
   /* POINTERS TO DATA OBJECTS */
   ^TIME_SERIES                   = "GRS_E262008015ZZZ.DAT"
   /* IDENTIFICATION DATA ELEMENTS */
   PRODUCT_ID                     = "CONTROL_BOARD_TEMP_2008015"
   PRODUCT_TYPE                   = "CONTROL_BOARD_TEMP"
   /* DESCRIPTIVE data elements */
   DESCRIPTION                 =
   "CONTROL_BOARD_TEMP temperature, in Celsius."
   /* DATA OBJECT DEFINITION */
   OBJECT                         = E26_TIME_SERIES
      NAME                           = CONTROL_BOARD_TEMP
      INTERCHANGE_FORMAT             = BINARY
      ROWS                           = 4111
      ROW_BYTES                      = 47
      SAMPLING_PARAMETER_NAME        = TIME
      SAMPLING_PARAMETER_UNIT        = SECONDS
      SAMPLING_PARAMETER_INTERVAL    = "N/A"
      COLUMNS                        = 5
      ^STRUCTURE                     = "GRS_ENG.FMT"
   END_OBJECT                      = E26_TIME_SERIES
END_OBJECT                     = E26_FILE
OBJECT                         = E27_FILE
   FILE_NAME                      = "GRS_E272008015ZZZ.DAT"
   RECORD_TYPE                    = FIXED_LENGTH
   RECORD_BYTES                   = 47
   FILE_RECORDS                   = 4111
   /* POINTERS TO DATA OBJECTS */
   ^TIME_SERIES                   = "GRS_E272008015ZZZ.DAT"
   /* IDENTIFICATION DATA ELEMENTS */
   PRODUCT_ID                     = "ANNEAL_PRI_VOLT_2008015"
   PRODUCT_TYPE                   = "ANNEAL_PRI_VOLT"
   /* DESCRIPTIVE data elements */
   DESCRIPTION                    = "ANNEAL_PRI_VOLT voltage, in Volts."
   /* DATA OBJECT DEFINITION */
   OBJECT                         = E27_TIME_SERIES
      NAME                           = ANNEAL_PRI_VOLT
      INTERCHANGE_FORMAT             = BINARY
      ROWS                           = 4111
      ROW_BYTES                      = 47
      SAMPLING_PARAMETER_NAME        = TIME
      SAMPLING_PARAMETER_UNIT        = SECONDS
      SAMPLING_PARAMETER_INTERVAL    = "N/A"
      COLUMNS                        = 5
      ^STRUCTURE                     = "GRS_ENG.FMT"
   END_OBJECT                      = E27_TIME_SERIES
END_OBJECT                     = E27_FILE
OBJECT                         = E28_FILE
   FILE_NAME                      = "GRS_E282008015ZZZ.DAT"
   RECORD_TYPE                    = FIXED_LENGTH
   RECORD_BYTES                   = 47
   FILE_RECORDS                   = 4111
   /* POINTERS TO DATA OBJECTS */
   ^TIME_SERIES                   = "GRS_E282008015ZZZ.DAT"
```

```
   /* IDENTIFICATION DATA ELEMENTS */
   PRODUCT_ID                    = "COOLER_PRI_VOLT_2008015"
   PRODUCT_TYPE                  = "COOLER_PRI_VOLT"
   /* DESCRIPTIVE data elements */
   DESCRIPTION                   = "COOLER_PRI_VOLT readings, in Volts."
   /* DATA OBJECT DEFINITION */
   OBJECT                        = E28_TIME_SERIES
      NAME                         = COOLER_PRI_VOLT
      INTERCHANGE_FORMAT           = BINARY
      ROWS                         = 4111
      ROW_BYTES                    = 47
      SAMPLING_PARAMETER_NAME      = TIME
      SAMPLING_PARAMETER_UNIT      = SECONDS
      SAMPLING_PARAMETER_INTERVAL  = "N/A"
      COLUMNS                      = 5
      ^STRUCTURE                   = "GRS_ENG.FMT"
   END_OBJECT                    = E28_TIME_SERIES
END_OBJECT                    = E28_FILE
OBJECT                        = E29_FILE
   FILE_NAME                     = "GRS_E292008015ZZZ.DAT"
   RECORD_TYPE                   = FIXED_LENGTH
   RECORD_BYTES                  = 47
   FILE_RECORDS                  = 4111
   /* POINTERS TO DATA OBJECTS */
   ^TIME_SERIES                  = "GRS_E292008015ZZZ.DAT"
   /* IDENTIFICATION DATA ELEMENTS */
   PRODUCT_ID                    = "ANNEAL_SEC_I_2008015"
   PRODUCT_TYPE                  = "ANNEAL_SEC_I"
   /* DESCRIPTIVE data elements */
   DESCRIPTION                   = "ANNEAL_SEC_I readings, in Milliamps."
   /* DATA OBJECT DEFINITION */
   OBJECT                        = E29_TIME_SERIES
      NAME                         = ANNEAL_SEC_I
      INTERCHANGE_FORMAT           = BINARY
      ROWS                         = 4111
      ROW_BYTES                    = 47
      SAMPLING_PARAMETER_NAME      = TIME
      SAMPLING_PARAMETER_UNIT      = SECONDS
      SAMPLING_PARAMETER_INTERVAL  = "N/A"
      COLUMNS                      = 5
      ^STRUCTURE                   = "GRS_ENG.FMT"
   END_OBJECT                    = E29_TIME_SERIES
END_OBJECT                    = E29_FILE
OBJECT                        = E30_FILE
   FILE_NAME                     = "GRS_E302008015ZZZ.DAT"
   RECORD_TYPE                   = FIXED_LENGTH
   RECORD_BYTES                  = 47
   FILE_RECORDS                  = 4111
   /* POINTERS TO DATA OBJECTS */
   ^TIME_SERIES                  = "GRS_E302008015ZZZ.DAT"
   /* IDENTIFICATION DATA ELEMENTS */
   PRODUCT_ID                    = "COOLER_SEC_I_2008015"
   PRODUCT_TYPE                  = "COOLER_SEC_I"
   /* DESCRIPTIVE data elements */
   DESCRIPTION                   = "COOLER_SEC_I readings, in Milliamps."
   /* DATA OBJECT DEFINITION */
   OBJECT                        = E30_TIME_SERIES
      NAME                         = COOLER_SEC_I
      INTERCHANGE_FORMAT           = BINARY
      ROWS                         = 4111
      ROW_BYTES                    = 47
      SAMPLING_PARAMETER_NAME      = TIME
      SAMPLING_PARAMETER_UNIT      = SECONDS
      SAMPLING_PARAMETER_INTERVAL  = "N/A"
      COLUMNS                      = 5
      ^STRUCTURE                   = "GRS_ENG.FMT"
   END_OBJECT                    = E30_TIME_SERIES
END_OBJECT                    = E30_FILE
OBJECT                        = E31_FILE
   FILE_NAME                     = "GRS_E312008015ZZZ.DAT"
   RECORD_TYPE                   = FIXED_LENGTH
```

```
   RECORD_BYTES                  = 47
   FILE_RECORDS                  = 4111
   /* POINTERS TO DATA OBJECTS */
   ^TIME_SERIES                  = "GRS_E312008015ZZZ.DAT"
   /* IDENTIFICATION DATA ELEMENTS */
   PRODUCT_ID                    = "COOLER_PRI_I_2008015"
   PRODUCT_TYPE                  = "COOLER_PRI_I"
   /* DESCRIPTIVE data elements */
   DESCRIPTION                   = "COOLER_PRI_I readings, in Milliamps."
   /* DATA OBJECT DEFINITION */
   OBJECT                        = E31_TIME_SERIES
      NAME                         = COOLER_PRI_I
      INTERCHANGE_FORMAT           = BINARY
      ROWS                         = 4111
      ROW_BYTES                    = 47
      SAMPLING_PARAMETER_NAME      = TIME
      SAMPLING_PARAMETER_UNIT      = SECONDS
      SAMPLING_PARAMETER_INTERVAL  = "N/A"
      COLUMNS                      = 5
      ^STRUCTURE                   = "GRS_ENG.FMT"
   END_OBJECT                    = E31_TIME_SERIES
END_OBJECT                    = E31_FILE
OBJECT                        = E32_FILE
   FILE_NAME                     = "GRS_E322008015ZZZ.DAT"
   RECORD_TYPE                   = FIXED_LENGTH
   RECORD_BYTES                  = 47
   FILE_RECORDS                  = 4111
   /* POINTERS TO DATA OBJECTS */
   ^TIME_SERIES                  = "GRS_E322008015ZZZ.DAT"
   /* IDENTIFICATION DATA ELEMENTS */
   PRODUCT_ID                    = "ANNEAL_PRI_I_2008015"
   PRODUCT_TYPE                  = "ANNEAL_PRI_I"
   /* DESCRIPTIVE data elements */
   DESCRIPTION                   = "ANNEAL_PRI_I readings, in Milliamps."
   /* DATA OBJECT DEFINITION */
   OBJECT                        = E32_TIME_SERIES
      NAME                         = ANNEAL_PRI_I
      INTERCHANGE_FORMAT           = BINARY
      ROWS                         = 4111
      ROW_BYTES                    = 47
      SAMPLING_PARAMETER_NAME      = TIME
      SAMPLING_PARAMETER_UNIT      = SECONDS
      SAMPLING_PARAMETER_INTERVAL  = "N/A"
      COLUMNS                      = 5
      ^STRUCTURE                   = "GRS_ENG.FMT"
   END_OBJECT                    = E32_TIME_SERIES
END_OBJECT                    = E32_FILE
OBJECT                        = E33_FILE
   FILE_NAME                     = "GRS_E332008015ZZZ.DAT"
   RECORD_TYPE                   = FIXED_LENGTH
   RECORD_BYTES                  = 47
   FILE_RECORDS                  = 4111
   /* POINTERS TO DATA OBJECTS */
   ^TIME_SERIES                  = "GRS_E332008015ZZZ.DAT"
   /* IDENTIFICATION DATA ELEMENTS */
   PRODUCT_ID                    = "COOLER_PWR_BOARD_TEMP_2008015"
   PRODUCT_TYPE                  = "COOLER_POWER_BOARD_TEMP"
   /* DESCRIPTIVE data elements */
   DESCRIPTION                =
   "COOLER_POWER_BOARD_TEMP readings, in Celsius."
   /* DATA OBJECT DEFINITION */
   OBJECT                        = E33_TIME_SERIES
      NAME                         = COOLER_POWER_BOARD_TEMP
      INTERCHANGE_FORMAT           = BINARY
      ROWS                         = 4111
      ROW_BYTES                    = 47
      SAMPLING_PARAMETER_NAME      = TIME
      SAMPLING_PARAMETER_UNIT      = SECONDS
      SAMPLING_PARAMETER_INTERVAL  = "N/A"
      COLUMNS                      = 5
      ^STRUCTURE                   = "GRS_ENG.FMT"
```

```
   END_OBJECT                    = E33_TIME_SERIES
END_OBJECT                    = E33_FILE
OBJECT                        = E34_FILE
   FILE_NAME                     = "GRS_E342008015ZZZ.DAT"
   RECORD_TYPE                   = FIXED_LENGTH
   RECORD_BYTES                  = 47
   FILE_RECORDS                  = 4111
   /* POINTERS TO DATA OBJECTS */
   ^TIME_SERIES                  = "GRS_E342008015ZZZ.DAT"
   /* IDENTIFICATION DATA ELEMENTS */
   PRODUCT_ID                    = "COOLER_TEMP_2008015"
   PRODUCT_TYPE                  = "COOLER_TEMP"
   /* DESCRIPTIVE data elements */
   DESCRIPTION                   = "COOLER_TEMP readings, in Celsius."
   /* DATA OBJECT DEFINITION */
   OBJECT                        = E34_TIME_SERIES
      NAME                          = COOLER_TEMP
      INTERCHANGE_FORMAT            = BINARY
      ROWS                          = 4111
      ROW_BYTES                     = 47
      SAMPLING_PARAMETER_NAME       = TIME
      SAMPLING_PARAMETER_UNIT       = SECONDS
      SAMPLING_PARAMETER_INTERVAL   = "N/A"
      COLUMNS                       = 5
      ^STRUCTURE                    = "GRS_ENG.FMT"
   END_OBJECT                    = E34_TIME_SERIES
END_OBJECT                    = E34_FILE
OBJECT                        = E35_FILE
   FILE_NAME                     = "GRS_E352008015ZZZ.DAT"
   RECORD_TYPE                   = FIXED_LENGTH
   RECORD_BYTES                  = 47
   FILE_RECORDS                  = 4111
   /* POINTERS TO DATA OBJECTS */
   ^TIME_SERIES                  = "GRS_E352008015ZZZ.DAT"
   /* IDENTIFICATION DATA ELEMENTS */
   PRODUCT_ID                    = "CMD_SCIENCE_MODE_2008015"
   PRODUCT_TYPE                  = "CMD_SCIENCE_MODE"
   /* DESCRIPTIVE data elements */
   DESCRIPTION                =
   "CMD_SCIENCE_MODE commanded to event classification."
   /* DATA OBJECT DEFINITION */
   OBJECT                        = E35_TIME_SERIES
      NAME                          = CMD_SCIENCE_MODE
      INTERCHANGE_FORMAT            = BINARY
      ROWS                          = 4111
      ROW_BYTES                     = 47
      SAMPLING_PARAMETER_NAME       = TIME
      SAMPLING_PARAMETER_UNIT       = SECONDS
      SAMPLING_PARAMETER_INTERVAL   = "N/A"
      COLUMNS                       = 5
      ^STRUCTURE                    = "GRS_ENG.FMT"
   END_OBJECT                    = E35_TIME_SERIES
END_OBJECT                    = E35_FILE
OBJECT                        = E36_FILE
   FILE_NAME                     = "GRS_E362008015ZZZ.DAT"
   RECORD_TYPE                   = FIXED_LENGTH
   RECORD_BYTES                  = 47
   FILE_RECORDS                  = 4111
   /* POINTERS TO DATA OBJECTS */
   ^TIME_SERIES                  = "GRS_E362008015ZZZ.DAT"
   /* IDENTIFICATION DATA ELEMENTS */
   PRODUCT_ID                    = "CMD_HPGE_HV_2008015"
   PRODUCT_TYPE                  = "CMD_HPGE_HV"
   /* DESCRIPTIVE data elements */
   DESCRIPTION                   = "CMD_HPGE_HV level, in Volts."
   /* DATA OBJECT DEFINITION */
   OBJECT                        = E36_TIME_SERIES
      NAME                          = CMD_HPGE_HV
      INTERCHANGE_FORMAT            = BINARY
      ROWS                          = 4111
      ROW_BYTES                     = 47
```

```
      SAMPLING_PARAMETER_NAME        = TIME
      SAMPLING_PARAMETER_UNIT        = SECONDS
      SAMPLING_PARAMETER_INTERVAL    = "N/A"
      COLUMNS                        = 5
      ^STRUCTURE                     = "GRS_ENG.FMT"
   END_OBJECT                     = E36_TIME_SERIES
END_OBJECT                     = E36_FILE
OBJECT                         = E37_FILE
   FILE_NAME                      = "GRS_E372008015ZZZ.DAT"
   RECORD_TYPE                    = FIXED_LENGTH
   RECORD_BYTES                   = 47
   FILE_RECORDS                   = 4111
   /* POINTERS TO DATA OBJECTS */
   ^TIME_SERIES                   = "GRS_E372008015ZZZ.DAT"
   /* IDENTIFICATION DATA ELEMENTS */
   PRODUCT_ID                     = "CMD_SHIELD_HV_2008015"
   PRODUCT_TYPE                   = "CMD_SHIELD_HV"
   /* DESCRIPTIVE data elements */
   DESCRIPTION                    = "CMD_SHIELD_HV level, in Volts."
   /* DATA OBJECT DEFINITION */
   OBJECT                         = E37_TIME_SERIES
      NAME                           = CMD_SHIELD_HV
      INTERCHANGE_FORMAT             = BINARY
      ROWS                           = 4111
      ROW_BYTES                      = 47
      SAMPLING_PARAMETER_NAME        = TIME
      SAMPLING_PARAMETER_UNIT        = SECONDS
      SAMPLING_PARAMETER_INTERVAL    = "N/A"
      COLUMNS                        = 5
      ^STRUCTURE                     = "GRS_ENG.FMT"
   END_OBJECT                     = E37_TIME_SERIES
END_OBJECT                     = E37_FILE
OBJECT                         = E38_FILE
   FILE_NAME                      = "GRS_E382008015ZZZ.DAT"
   RECORD_TYPE                    = FIXED_LENGTH
   RECORD_BYTES                   = 47
   FILE_RECORDS                   = 4111
   /* POINTERS TO DATA OBJECTS */
   ^TIME_SERIES                   = "GRS_E382008015ZZZ.DAT"
   /* IDENTIFICATION DATA ELEMENTS */
   PRODUCT_ID                     = "CALIB_AVG_DET_TEMP_2008015"
   PRODUCT_TYPE                   = "CAL_AVG_DET_TEMP"
   /* DESCRIPTIVE data elements */
   DESCRIPTION                    = "CAL_AVG_DET_TEMP temperature, in Kelvin."
   /* DATA OBJECT DEFINITION */
   OBJECT                         = E38_TIME_SERIES
      NAME                           = CAL_AVG_DET_TEMP
      INTERCHANGE_FORMAT             = BINARY
      ROWS                           = 4111
      ROW_BYTES                      = 47
      SAMPLING_PARAMETER_NAME        = TIME
      SAMPLING_PARAMETER_UNIT        = SECONDS
      SAMPLING_PARAMETER_INTERVAL    = "N/A"
      COLUMNS                        = 5
      ^STRUCTURE                     = "GRS_ENG.FMT"
   END_OBJECT                     = E38_TIME_SERIES
END_OBJECT                     = E38_FILE
OBJECT                         = E39_FILE
   FILE_NAME                      = "GRS_E392008015ZZZ.DAT"
   RECORD_TYPE                    = FIXED_LENGTH
   RECORD_BYTES                   = 47
   FILE_RECORDS                   = 4111
   /* POINTERS TO DATA OBJECTS */
   ^TIME_SERIES                   = "GRS_E392008015ZZZ.DAT"
   /* IDENTIFICATION DATA ELEMENTS */
   PRODUCT_ID                     = "HPGE_HV_SAFING_LVL_2008015"
   PRODUCT_TYPE                   = "HPGE_HV_SAFING_LVL"
   /* DESCRIPTIVE data elements */
   DESCRIPTION                    = "HPGE_HV_SAFING_LVL current safing level."
   /* DATA OBJECT DEFINITION */
   OBJECT                         = E39_TIME_SERIES
```

```
      NAME                          = HPGE_HV_SAFING_LVL
      INTERCHANGE_FORMAT            = BINARY
      ROWS                          = 4111
      ROW_BYTES                     = 47
      SAMPLING_PARAMETER_NAME       = TIME
      SAMPLING_PARAMETER_UNIT       = SECONDS
      SAMPLING_PARAMETER_INTERVAL   = "N/A"
      COLUMNS                       = 5
      ^STRUCTURE                    = "GRS_ENG.FMT"
   END_OBJECT                     = E39_TIME_SERIES
END_OBJECT                     = E39_FILE
OBJECT                         = E40_FILE
   FILE_NAME                      = "GRS_E402008015ZZZ.DAT"
   RECORD_TYPE                    = FIXED_LENGTH
   RECORD_BYTES                   = 47
   FILE_RECORDS                   = 4111
   /* POINTERS TO DATA OBJECTS */
   ^TIME_SERIES                   = "GRS_E402008015ZZZ.DAT"
   /* IDENTIFICATION DATA ELEMENTS */
   PRODUCT_ID                     = "SHLD_HV_SAFING_LVL_2008015"
   PRODUCT_TYPE                   = "SHLD_SAFING_LVL"
   /* DESCRIPTIVE data elements */
   DESCRIPTION                    = "SHLD_SAFING_LVL current safing level."
   /* DATA OBJECT DEFINITION */
   OBJECT                         = E40_TIME_SERIES
      NAME                          = SHLD_SAFING_LVL
      INTERCHANGE_FORMAT            = BINARY
      ROWS                          = 4111
      ROW_BYTES                     = 47
      SAMPLING_PARAMETER_NAME       = TIME
      SAMPLING_PARAMETER_UNIT       = SECONDS
      SAMPLING_PARAMETER_INTERVAL   = "N/A"
      COLUMNS                       = 5
      ^STRUCTURE                    = "GRS_ENG.FMT"
   END_OBJECT                     = E40_TIME_SERIES
END_OBJECT                     = E40_FILE
OBJECT                         = E41_FILE
   FILE_NAME                      = "GRS_E412008015ZZZ.DAT"
   RECORD_TYPE                    = FIXED_LENGTH
   RECORD_BYTES                   = 47
   FILE_RECORDS                   = 4111
   /* POINTERS TO DATA OBJECTS */
   ^TIME_SERIES                   = "GRS_E412008015ZZZ.DAT"
   /* IDENTIFICATION DATA ELEMENTS */
   PRODUCT_ID                     = "COOLER_TEMP_SETPOINT_2008015"
   PRODUCT_TYPE                   = "COOLER_TEMP_SETPOINT"
   /* DESCRIPTIVE data elements */
   DESCRIPTION                    = "COOLER_TEMP_SETPOINT, in Kelvin."
   /* DATA OBJECT DEFINITION */
   OBJECT                         = E41_TIME_SERIES
      NAME                          = COOLER_TEMP_SETPOINT
      INTERCHANGE_FORMAT            = BINARY
      ROWS                          = 4111
      ROW_BYTES                     = 47
      SAMPLING_PARAMETER_NAME       = TIME
      SAMPLING_PARAMETER_UNIT       = SECONDS
      SAMPLING_PARAMETER_INTERVAL   = "N/A"
      COLUMNS                       = 5
      ^STRUCTURE                    = "GRS_ENG.FMT"
   END_OBJECT                     = E41_TIME_SERIES
END_OBJECT                     = E41_FILE
END
```

8.5.8 GRS_RDR_SUM

```
PDS_VERSION_ID                = "PDS3"

/*** FILE FORMAT ***/
FILE_RECORDS                  = 16
RECORD_TYPE                   = FIXED_LENGTH
RECORD_BYTES                  = 262373

/*** GENERAL DATA DESCRIPTION PARAMETERS ***/
PRODUCT_ID                    = "GRS_RSS2011083ZZZ_DAT"
PRODUCT_VERSION_ID            = "3.0"
PRODUCT_CREATION_TIME         = 2015-10-20T09:49:20
PRODUCT_TYPE                  = "RDR"
STANDARD_DATA_PRODUCT_ID      = "GRS_RDR_SUM"
SOFTWARE_NAME                 = "GRS_CDR_GEN"
SOFTWARE_VERSION_ID           = "1.0"
INSTRUMENT_HOST_NAME          = "MESSENGER"
INSTRUMENT_NAME               = "GAMMA RAY SPECTROMETER"
INSTRUMENT_ID                 = "GRS"
DATA_SET_ID                   = "MESS-E/V/H-GRNS-3-GRS-CDR-V1.0"
MISSION_PHASE_NAME            = "MERCURY ORBIT"
TARGET_NAME                   = "MERCURY"
START_TIME                    = 2011-03-24T01:23:45.669
STOP_TIME                     = 2011-09-19T15:21:33.251
SPACECRAFT_CLOCK_START_COUNT  = "1/209417293"
SPACECRAFT_CLOCK_STOP_COUNT   = "1/224933159"
^TABLE                        = "GRS_RSS2011083ZZZ.DAT"

OBJECT                        = TABLE
   COLUMNS                    = 52
   INTERCHANGE_FORMAT         = BINARY
   ROWS                       = 16
   ROW_BYTES                  = 262373
   DESCRIPTION                =
   "This table contains one set of summed spectra
   collected from the high purity Germanium (HPGe) detector plus
   spatial and temporal information and relevant data from the
   time the spectra was taken. A set is defined as all data with
   timestamps corresponding to one earth year period.
   "
   ^STRUCTURE                 = "GRS_RDR_SUMS.FMT"
END_OBJECT                    = TABLE
END
```

8.5.9 GRS_DAP

```
PDS_VERSION_ID                = "PDS3"

PRODUCT_VERSION_ID            = "1.0"
DATA_SET_ID                   = "MESS-E/V/H-GRNS-5-GRS-DAP-V1.0"
PRODUCT_ID                    = "GRS_DAP_K_ABD_MAP.JP2"
INSTRUMENT_HOST_NAME          = "MESSENGER"
INSTRUMENT_NAME               = "GAMMA RAY SPECTROMETER"
INSTRUMENT_ID                 = "GRS"
MISSION_PHASE_NAME            = "MERCURY ORBIT"
TARGET_NAME                   = "MERCURY"
START_TIME                    = 2011-03-24T00:00:00
STOP_TIME                     = 2011-10-11T23:59:59
SPACECRAFT_CLOCK_START_COUNT  = "1/209412268"
SPACECRAFT_CLOCK_STOP_COUNT   = "1/226865065"
PRODUCT_CREATION_TIME         = 2013-12-19T16:23:56.000
PRODUCER_ID                   = GRS_TEAM
PRODUCER_FULL_NAME            = "PATRICK PEPLOWSKI"
PRODUCER_INSTITUTION_NAME     = "APPLIED PHYSICS LABORATORY"

DESCRIPTION                   = "

Pixel map of count-rate-derived potassium abundances. The image is linearly
scaled such that the maximum pixel value (255) corresponds to a potassium
abundance of 2430 parts per million (ppm). Conversion from Digital Number
(DN) to science value is given by the equation:

SCIENCE_VALUE = (DN * 9.530)

"

/* The COMPRESSED_FILE object describes the JPEG2000 image file. */
OBJECT                      = COMPRESSED_FILE
 FILE_NAME                    = "GRS_DAP_K_ABD_MAP.JP2"
 RECORD_TYPE                  = UNDEFINED
 FILE_RECORDS                 = UNK
 ENCODING_TYPE                = JP2
 ENCODING_TYPE_VERSION_NAME   = "ISO/IEC15444-1:2004"
 INTERCHANGE_FORMAT           = BINARY
 UNCOMPRESSED_FILE_NAME       = "GRS_DAP_K_ABD_MAP.IMG"
 REQUIRED_STORAGE_BYTES       = "1036800"
 ^DESCRIPTION                 = "JP2INFO.TXT"
END_OBJECT                  = COMPRESSED_FILE

/* The UNCOMPRESSED_FILE object describes the image that would result */
/* from uncompressing the JPEG2000 file.                              */
OBJECT                      = UNCOMPRESSED_FILE
 RECORD_TYPE                  = FIXED_LENGTH
 FILE_RECORDS                 = 360
 RECORD_BYTES                 = 2880
 ^IMAGE                       = "GRS_DAP_K_ABD_MAP.IMG"
 OBJECT                       = IMAGE
   NAME                         = "GRS POTASSIUM ABUNDANCE MAP"
   LINES                        = 360
   LINE_SAMPLES                 = 720
   SAMPLE_TYPE                  = IEEE_REAL
   SAMPLE_BITS                  = 32
   UNIT                         = PPM
   SCALING_FACTOR               = 9.530
   DERIVED_MINIMUM              = 0
   DERIVED_MAXIMUM              = 2430
   MISSING_CONSTANT             = 0
 END_OBJECT                   = IMAGE
END_OBJECT                  = UNCOMPRESSED_FILE

OBJECT                      = IMAGE_MAP_PROJECTION
 ^DATA_SET_MAP_PROJECTION     = "DSMAP.CAT"
 MAP_PROJECTION_TYPE          = "SIMPLE CYLINDRICAL"
 KEYWORD_LATITUDE_TYPE        = "PLANETOCENTRIC"
```

```
 MAP_RESOLUTION               = 2 <pix/degree>
 A_AXIS_RADIUS                = 2440. <km>
 B_AXIS_RADIUS                = 2440. <km>
 C_AXIS_RADIUS                = 2440. <km>
 POSITIVE_LONGITUDE_DIRECTION  = "EAST"
 CENTER_LATITUDE              = 0.0 <deg>
 CENTER_LONGITUDE             = 0.0 <deg>
 LINE_FIRST_PIXEL             = 1
 LINE_LAST_PIXEL              = 360
 SAMPLE_FIRST_PIXEL           = 1
 SAMPLE_LAST_PIXEL            = 720
 MAP_PROJECTION_ROTATION      = 0.0
 MAP_SCALE                    = 21 <km/pix>
 MAXIMUM_LATITUDE             = 90 <deg>
 MINIMUM_LATITUDE             = -90 <deg>
 WESTERNMOST_LONGITUDE        = -180 <deg>
 EASTERNMOST_LONGITUDE        = 180 <deg>
 LINE_PROJECTION_OFFSET       = 180.0
 SAMPLE_PROJECTION_OFFSET     = 360.0
 COORDINATE_SYSTEM_TYPE       = "BODY-FIXED ROTATING"
 COORDINATE_SYSTEM_NAME       = "PLANETOCENTRIC"
END_OBJECT                  = IMAGE_MAP_PROJECTION

END
```

8.5.10INDEX

```
PDS_VERSION_ID               = PDS3
RECORD_TYPE                  = FIXED_LENGTH
RECORD_BYTES                 = 328
FILE_RECORDS                 = 73952
^INDEX_TABLE                 = "INDEX.TAB"
VOLUME_ID                    = MESSGRS_2001
DATA_SET_ID                  = {"MESS-E/V/H-GRNS-3-GRS-CDR-V1.0",
                                "MESS-E/V/H-GRNS-5-GRS-DAP-V1.0"}
MISSION_NAME                 = "MESSENGER"
INSTRUMENT_NAME              = "GAMMA RAY SPECTROMETER"
START_TIME                   = 2004-08-12T22:01:55.7
STOP_TIME                    = 2014-09-17T23:38:32.0
PRODUCT_CREATION_TIME        = 2014-11-10T12:55:13.0
DESCRIPTION                  = "This index file lists information
   about each of the MESSENGER GRS CDR/RDR/DAP data products contained on
   this archive volume."

OBJECT                       = INDEX_TABLE
  INTERCHANGE_FORMAT         = ASCII
  ROW_BYTES                  = 328
  ROWS                       = 73952
  COLUMNS                    = 15
  INDEX_TYPE                 = SINGLE

  OBJECT                     = COLUMN
    COLUMN_NUMBER            = 1
    NAME                     = VOLUME_ID
    DATA_TYPE                = CHARACTER
    START_BYTE               = 2
    BYTES                    = 12
    DESCRIPTION              = "The volume on which a data product is
                                stored."
  END_OBJECT                 = COLUMN

  OBJECT                     = COLUMN
    COLUMN_NUMBER            = 2
    NAME                     = PATH_NAME
    DATA_TYPE                = CHARACTER
    START_BYTE               = 17
    BYTES                    = 24
    DESCRIPTION              = "The full directory path to the file
                                relative to the volume root directory."
  END_OBJECT                 = COLUMN

  OBJECT                     = COLUMN
    COLUMN_NUMBER            = 3
    NAME                     = FILE_NAME
    DATA_TYPE                = CHARACTER
    START_BYTE               = 44
    BYTES                    = 31
    DESCRIPTION              = "The name of the file containing a data
                                product's PDS label."
  END_OBJECT                 = COLUMN

  OBJECT                     = COLUMN
    COLUMN_NUMBER            = 4
    NAME                     = PRODUCT_ID
    DATA_TYPE                = CHARACTER
    START_BYTE               = 78
    BYTES                    = 36
    DESCRIPTION              = "Unique identifier for a GRS CDR/RDR product."
  END_OBJECT                 = COLUMN

  OBJECT                     = COLUMN
    COLUMN_NUMBER            = 5
    NAME                     = PRODUCT_TYPE
    DATA_TYPE                = CHARACTER
    START_BYTE               = 117
```

```
  BYTES                       = 27
  DESCRIPTION                 = "Type of GRS product."
END_OBJECT                    = COLUMN

OBJECT                        = COLUMN
  COLUMN_NUMBER               = 6
  NAME                        = PRODUCT_CREATION_TIME
  DATA_TYPE                   = TIME
  START_BYTE                  = 146
  BYTES                       = 24
  DESCRIPTION                 = "UTC date and time that a product
                                 was created, in the format
                                 yyyy-mm-ddThh:mm:ss."
END_OBJECT                    = COLUMN

OBJECT                        = COLUMN
  COLUMN_NUMBER               = 7
  NAME                        = PRODUCT_VERSION_ID
  DATA_TYPE                   = CHARACTER
  START_BYTE                  = 172
  BYTES                       = 10
  DESCRIPTION                 = "The version identifier of the product.
                                 The first version of a product is
                                 version 1.0. If the product is revised
                                 and re-released, the version ID is
                                 incremented."
END_OBJECT                    = COLUMN

OBJECT                        = COLUMN
  COLUMN_NUMBER               = 8
  NAME                        = RELEASE_ID
  DATA_TYPE                   = CHARACTER
  START_BYTE                  = 185
  BYTES                       = 4
  DESCRIPTION                 = "The ID of the Messenger mission data
                                 release. The first release is 0001,
                                 followed by 0002, etc."
END_OBJECT                    = COLUMN

OBJECT                        = COLUMN
  COLUMN_NUMBER               = 9
  NAME                        = MISSION_PHASE_NAME
  DATA_TYPE                   = CHARACTER
  START_BYTE                  = 192
  BYTES                       = 30
  DESCRIPTION                 = "Common identifier for a given phase
                                 of the mission."
END_OBJECT                    = COLUMN

OBJECT                        = COLUMN
  COLUMN_NUMBER               = 10
  NAME                        = TARGET_NAME
  DATA_TYPE                   = CHARACTER
  START_BYTE                  = 225
  BYTES                       = 11
  DESCRIPTION                 = "Planetary body that is the target of
                                 observation; e.g., MERCURY."
END_OBJECT                    = COLUMN

OBJECT                        = COLUMN
  COLUMN_NUMBER               = 11
  NAME                        = START_TIME
  DATA_TYPE                   = TIME
  START_BYTE                  = 238
  BYTES                       = 24
  DESCRIPTION                 = "UTC date and time at the beginning
                                 of data acquisition for this product,
                                 in the format yyyy-mm-ddThh:mm:ss."
END_OBJECT                    = COLUMN

OBJECT                        = COLUMN
```

```
    COLUMN_NUMBER            = 12
    NAME                     = STOP_TIME
    DATA_TYPE                = TIME
    START_BYTE               = 263
    BYTES                    = 24
    DESCRIPTION              = "UTC date and time at the end of
                               data acquisition for this product,
                               in the format yyyy-mm-ddThh:mm:ss."
  END_OBJECT                 = COLUMN

  OBJECT                     = COLUMN
    NAME                     = START_MET_PARTITION
    COLUMN_NUMBER            = 13
    START_BYTE               = 288
    BYTES                    = 3
    DATA_TYPE                = ASCII_INTEGER
    DESCRIPTION              = "The MET partition (roll-over count)
                               associated with the
                               SPACECRAFT_CLOCK_START_COUNT value (column
                               14). This value is incremented by 1 for
                               every instance where MET values have been
                               reset."
  END_OBJECT                 = COLUMN

  OBJECT                     = COLUMN
    COLUMN_NUMBER            = 14
    NAME                     = SPACECRAFT_CLOCK_START_COUNT
    DATA_TYPE                = CHARACTER
    START_BYTE               = 293
    BYTES                    = 15
    DESCRIPTION              = "Value of the spacecraft clock at
                               the beginning of data acquisition
                               for this product."
  END_OBJECT                 = COLUMN

  OBJECT                     = COLUMN
    COLUMN_NUMBER            = 15
    NAME                     = SPACECRAFT_CLOCK_STOP_COUNT
    DATA_TYPE                = CHARACTER
    START_BYTE               = 311
    BYTES                    = 15
    DESCRIPTION              = "Value of the spacecraft clock at
                               the end of data acquisition for this
                               product."
  END_OBJECT                 = COLUMN

END_OBJECT                   = INDEX_TABLE
END
```

8.6 Appendix: GRS CDR/RDR Data Columns

This table lists the columns in all GRS CDR/RDR files in alphabetical order. The format of each type of data, including column locations, sizes, data types, units and full descriptions, can be found in the format files (*.FMT) in the LABEL directory.

Column Name	Description	Appears In
ACCUM_TIME	Accumulation time, in seconds, of the HPGe detector. Accumulation time, in seconds, of the Shield detector. The time period over which the rates were accumulated.	GRS_CAL_AC GRS_CAL_RAW GRS_CAL_SH GRS_CAL_SH2 GRS_CAL_SH3 GRS_CAL_SCR
ACCUMULATED_DEAD_TIME	Counter for accumulated dead time	GRS_CAL_AC GRS_CAL_RAW GRS_CAL_SH GRS_CAL_SH2
AC_GAMMA_SPECTRUM	Summed uncorrected anti-coincidence gamma spectrum representing cumulative counts of gamma rays at the detector, binned over TBD latitude and longitude, and one Earth year	GRS_RDR_SUM
AD_TEMP	Channel 06, AD Temperature, smoothed and interpolated to the center of the collection interval.	GRS_CAL_SH GRS_CAL_SH2
ALL_CH0_CH1_EVENTS	All channel 0 and channel 1 events. Excludes inverted Channel 0, Pileups, and Pulser events	GRS_CAL_AC GRS_CAL_RAW
ALL_CH0_EVENTS	All single Channel 0 events - either singlet or fails crossing time criterion	GRS_CAL_AC GRS_CAL_RAW
ALL_CH1_EVENTS	All single Channel 1 events - either singlet or fails crossing time criterion	GRS_CAL_AC GRS_CAL_RAW
ALL_EVENTS	total count of gamma events	GRS_CAL_AC GRS_CAL_RAW
ALL_VALID_COINCIDENT	All valid coincidence events - both Channel 0 and Channel 1 valid.	GRS_CAL_AC GRS_CAL_RAW
ALTITUDE	Spacecraft altitude above the subsatellite point on the target in units of km.	GRS_CAL_SH3 GRS_CAL_SCR
ALTITUDE_MIN	Minimum altitude during the period of the SUM	GRS_RDR_SUM
ALTITUDE_MAX	Maximum altitude during the period of the SUM	GRS_RDR_SUM
ALTITUDE_MEAN	Mean altitude during the period of the SUM	GRS_RDR_SUM
ALTITUDE_STD	Standard deviation of altitude during the period of the SUM	GRS_RDR_SUM
AZIMUTH	Spacecraft LVLH (Local Vertical/Local Horizontal) azimuth is measured counterclockwise about Z LVLH axis from X LVLH axis where the spacecraft z-axis is aligned with the vector from planet center to the spacecraft, y axis is aligned with the instaneous orbit angular momentum and the x-axis completes a right-handed coordinate system and points in the direction of motion along the orbit	GRS_CAL_AC GRS_CAL_RAW GRS_CAL_SH GRS_CAL_SH2
BAD_DATA_FLAG	Intended for use as a bit-string bad data flag to indicate specific problems associated with the data. Values are expected to be assigned to specific bits as problems are identified during the course of the mission. Bit 1 - The high voltage is not on, is being ramped or has not been stable long enough. Bit 2 - Indicates a change in the analog pulse processing system gain setting. Bit 3 - Indicates a spectrum where the temperatures used for correction have fluctuated by greater than 5 percent from previous readings. Bit 4 - Indicates gamma spectra collected during a solar particle event. These spectra should not be combined with spectra collected under normal solar conditions. Bit 5 - Pulser data is not combined with the spectrum.	GRS_CAL_AC GRS_CAL_RAW GRS_CAL_SH GRS_CAL_SH2 GRS_RDR_SUM

	Bit 6 - Indicates gamma spectra collected during a solar flare event. These spectra should not be combined with spectra collected under normal solar conditions. Bit 7 - Indicates gamma spectra collected during periods of decreased GS detector spectral resolution. These spectra should not be combined with spectra collected under "normal" detector conditions. Bit 8 - Not all data channels were received on the ground. Bit 9 - Indicates a unique problem with single spectrum. Bit 10 - The high voltage has not been stable long enough. Bit 11 - This data was taken during a time when the spectra were particularly noisy. Many channels have far too many counts, especially the lower channels. Indicates data quality via flag of “0” or “1”. Values of 1 indicate that the data quality is poor, for example increased backgrounds due to solar particle events, or that the detector was not operating nominally, for example the bias voltage was off. Values of 0 indicate that the data are clean and suited for analysis.	GRS_CAL_SH3 GRS_CAL_SCR
BETA_ANGLE	Angle of the normal of the spacecraft orbital plane with respect to Mercury-to-Sun vector in degrees.	GRS_CAL_SH3 GRS_CAL_SCR
CAL_AC	Temperature corrected Anti-coincidence spectrum	GRS_CAL_AC
CALIB_AVG_DET_TEMP	Calibrated, averaged detector temperature, smoothed and interpolated to the center of the collection interval	GRS_CAL_AC GRS_CAL_RAW
CALIB_AVG_DET_TEMP_MIN	Minimum temp during the period of the SUM	GRS_RDR_SUM
CALIB_AVG_DET_TEMP_MAX	Maximum temp during the period of the SUM	GRS_RDR_SUM
CALIB_AVG_DET_TEMP_MEAN	Mean temp during the period of the SUM	GRS_RDR_SUM
CALIB_AVG_DET_TEMP_STD	Standard deviation of temp during the period of the SUM	GRS_RDR_SUM
CAL_RAW	Temperature corrected Raw spectrum	GRS_CAL_RAW
CAL_SH	Spectra of light pulses produced from interaction of a gamma ray with the plastic scintillator shield. Contains the corrected counts in each of the 1024 bins after 1 accumulation period.	GRS_CAL_SH
CH0_PILEUP_REJECT	Channel 0 pileup rejected events. Only if pileup rejection is enabled.	GRS_CAL_AC GRS_CAL_RAW
CLOCK_TIME	Sum of collection durations	GRS_RDR_SUM
CORRECTED_AC_GAMMA_SPECTRUM	Summed corrected anti-coincidence gamma spectrum representing cumulative counts of gamma rays at the detector, binned over TBD latitude and longitude, and one Earth year.	GRS_RDR_SUM
CORRECTED_GAMMA_SPECTRUM	Summed corrected raw gamma spectrum representing cumulative counts of gamma rays at the detector, binned over some latitude and longitude, and one Earth year.	GRS_RDR_SUM
DEADTIME_FRAC	Fraction of accumulation time (ACCUM_TIME) for which the GRS electronics were unable to process an event and were therefore insensitive to possible additional events. Calculated from the raw engineering value ACCUMULATED_DEAD_TIME.	GRS_CAL_SCR GRS_CAL_SH3
DELTA_ANGLE	Difference between instrument +y direction and true north at the middle of the collection interval.	GRS_CAL_AC GRS_CAL_RAW GRS_CAL_SH GRS_CAL_SH2
ENG_VAL	Raw value transformed to a physical unit.	GRS_ENG
FIFO_FULL_COUNT	Hardware FIFO full flag tested for all events.	GRS_CAL_AC GRS_CAL_RAW
GAIN	Default value of gain, keV / channel.	GRS_RDR_SUM
GRS_PRIORITY_LEVEL	Indicates the type of priority assigned to the science packet. The priority level is tied to the ApID of the packet. Priority level varies from 0-3, 0 being highest and 3 being lowest priority.	GRS_CAL_AC GRS_CAL_RAW GRS_CAL_SCR GRS_CAL_SH GRS_CAL_SH2 GRS_CAL_SH3
HPGE_AC	Anti-coincident (AC) spectra accumulated by the HPGe detector. Contains the counts in each of the 16384 bins after accumulation period.	GRS_CAL_AC

HPGE_CHARGE_RESETS	Number of HPGe charge resets	GRS_CAL_AC GRS_CAL_RAW
HPGE_FAST	Fast Neutron spectrum about the 478-keV line, normalized to 0.60 keV energy bins.	GRS_CAL_SH2
HPGE_RAW_EVENTS	Counter of HPGe Raw events	GRS_CAL_AC GRS_CAL_RAW GRS_CAL_SH GRS_CAL_SH2
HPGE_TEMP_1	Channel 00, HPGE Detector Temperature 1, smoothed and interpolated to the center of the collection interval	GRS_CAL_AC GRS_CAL_RAW
HPGE_TEMP_1_MIN	Minimum temp during the period of the SUM	GRS_RDR_SUM
HPGE_TEMP_1_MAX	Maximum temp during the period of the SUM	GRS_RDR_SUM
HPGE_TEMP_1_MEAN	Mean temp during the period of the SUM	GRS_RDR_SUM
HPGE_TEMP_1_STD	Standard deviation of temp during the period of the SUM	GRS_RDR_SUM
HPGE_TEMP_2	Channel 01, HPGE Detector Temperature 2, smoothed and interpolated to the center of the collection interval	GRS_CAL_AC GRS_CAL_RAW
HPGE_TEMP_2_MIN	Minimum temp during the period of the SUM	GRS_RDR_SUM
HPGE_TEMP_2_MAX	Maximum temp during the period of the SUM	GRS_RDR_SUM
HPGE_TEMP_2_MEAN	Mean temp during the period of the SUM	GRS_RDR_SUM
HPGE_TEMP_2_STD	Standard deviation of temp during the period of the SUM	GRS_RDR_SUM
HPGE_THERMAL	Thermal Neutron spectrum about the 478-keV line, normalized to 0.60 keV energy bins.	GRS_CAL_SH2
HV_MONITOR	Channel 07, HV Monitor, smoothed, and interpolated to the center of the collection interval	GRS_CAL_AC GRS_CAL_RAW GRS_CAL_SH GRS_CAL_SH2
HV_MONITOR_MIN	Minimum volt during the period of the SUM	GRS_RDR_SUM
HV_MONITOR_MAX	Maximum volt during the period of the SUM	GRS_RDR_SUM
HV_MONITOR_MEAN	Mean volt during the period of the SUM	GRS_RDR_SUM
HV_MONITOR_STD	Standard deviation of volt during the period of the SUM	GRS_RDR_SUM
HVPS_REF_VOLT	HVPS Reference Voltage, smoothed, and interpolated to the center of the collection interval.	GRS_CAL_SH GRS_CAL_SH2
HVPS_TEMP	Channel 03, HVPS Temperature, smoothed and interpolated to the center of the collection interval.	GRS_CAL_SH GRS_CAL_SH2
HVPS_VOLT	HVPS Voltage, smoothed and interpolated to the center of the collection interval.	GRS_CAL_SH GRS_CAL_SH2
INITIAL_ENERGY	The energy of the middle of the first bin of the FAST and THERMAL NEURTON HPGE spectra.	GRS_CAL_SH2
INSTR_BORESIGHT_MERCURY	Sub instrument boresight (x,y,z) in Mercury fixed coordinates at the middle of the collection interval.	GRS_CAL_AC GRS_CAL_RAW GRS_CAL_SH GRS_CAL_SH2
INTERSECTING	True if the pointing vector intersects Mercury.	GRS_CAL_AC GRS_CAL_RAW GRS_CAL_SH GRS_CAL_SH2
INVALID_COINCIDENT_CH0	Channel 0 out-of-range coincidence events	GRS_CAL_AC GRS_CAL_RAW
INVALID_COINCIDENT_CH1	Channel 1 out-of-range coincidence events.	GRS_CAL_AC GRS_CAL_RAW
INVALID_PULSER_EVENTS	Out-of-range pulser events.	GRS_CAL_AC GRS_CAL_RAW
INVALID_SINGLE_CH0	Single channel 0 out-of-range events	GRS_CAL_AC GRS_CAL_RAW
INVALID_SINGLE_CH1	Single channel 1 out-of-range events	GRS_CAL_AC GRS_CAL_RAW
INVERTED_CH0	Channel 0 events flagged 'inverted' by the hardware.	GRS_CAL_AC GRS_CAL_RAW
J2000_ET	Ephemeris time converted from MESSENGER MET.	GRS_CAL_SH3 GRS_CAL_SCR
JDAY	Julian date at the start of the time period of interest. Julian date is defined as an integer count of days elapsed since	GRS_CAL_SH3 GRS_CAL_SCR

	noon, January 1, 4713 B.C. The value includes the fractional portion of the Julian day.	
LATITUDE	Target-centric latitude of the spacecraft subsatellite point in degrees. Center latitude of a spectral sum.	GRS_CAL_SH3 GRS_CAL_SCR GRS_RDR_SUM
LATITUDE_MIN	Minimum latitude during the period of the SUM	GRS_RDR_SUM
LATITUDE _MAX	Maximum latitude during the period of the SUM	GRS_RDR_SUM
LATITUDE _MEAN	altitude adjusted Mean latitude during the period of the SUM	GRS_RDR_SUM
LATITUDE _STD	Standard deviation of latitude during the period of the SUM	GRS_RDR_SUM
LOCAL_HOUR	Local Sun hour at the sub-spacecraft point.	GRS_CAL_AC GRS_CAL_RAW GRS_CAL_SH GRS_CAL_SH2
LOCAL_MINUTE	Local Sun minute at the sub-spacecraft point.	GRS_CAL_AC GRS_CAL_RAW GRS_CAL_SH GRS_CAL_SH2
LOCAL_TIME	Local time of the spacecraft subsatellite point in hours from 0 to 24.	GRS_CAL_SH3 GRS_CAL_SCR
LONGITUDE	Target-centric longitude of the spacecraft subsatellite point in degrees. Center longitude of a spectral sum.	GRS_CAL_SH3 GRS_CAL_SCR GRS_RDR_SUM
LONGITUDE_MIN	Minimum longitude during the period of the SUM	GRS_RDR_SUM
LONGITUDE _MAX	Maximum llongitude during the period of the SUM	GRS_RDR_SUM
LONGITUDE _MEAN	altitude adjusted Mean longitude during the period of the SUM	GRS_RDR_SUM
LONGITUDE _STD	Standard deviation of longitude during the period of the SUM	GRS_RDR_SUM
MERCURY_SOL	Longitude of the Sun at 0 hours UT on the date of the record. Taken from the Association of Lunar and Planetary Observers 'Ephemeris for Physical Observation of Mercury'.	GRS_CAL_AC GRS_CAL_RAW GRS_CAL_SH GRS_CAL_SH2
MERCURY_CENTRIC_LATITUDE	Sub spacecraft latitude in Mercury fixed coordinates at the middle of the collection interval.	GRS_CAL_AC GRS_CAL_RAW GRS_CAL_SH GRS_CAL_SH2
MERCURY_CENTRIC_LONGITUDE	Sub spacecraft longitude in Mercury fixed coordinates at the middle of the collection interval. Longitude increases towards the East.	GRS_CAL_AC GRS_CAL_RAW GRS_CAL_SH GRS_CAL_SH2
MET	Mission elapsed time, in seconds, corresponding to the start of the accumulation period for the spectra.	GRS_CAL_AC GRS_CAL_RAW GRS_CAL_SCR GRS_CAL_SH GRS_CAL_SH2 GRS_CAL_SH3 GRS_ENG
MIDPOINT_MET	The mission elapsed time at the midpoint of the HPGE Raw observation. Defined as: MET at the start of the observation + (ACCUM_TIME / 2).	GRS_CAL_AC GRS_CAL_RAW GRS_CAL_SH GRS_CAL_SH2
MET_START_TIME	Mission elapsed time, in seconds, corresponding to the start of the SUM	GRS_RDR_SUM
MET_STOP_TIME	Mission elapsed time, in seconds, corresponding to the end of the SUM	GRS_RDR_SUM

MISSING_DATA_PACKETS	The value represents a 16-bit binary number where each bit indicates whether an HPGe Raw telemetry packet is missing from the EDR. Each HPGe Raw EDR consists of information extracted from 16 telemetry packets in a complete observation. The least significant bit is a flag corresponding to the first of 16 packets and the most significant bit is a flag corresponding to the 16th packet. A bit value of 1 indicates that a given packet is missing from the EDR. For example, a value of 0 in this column indicates that the spectra from all 16 packets have been downloaded and included in the HPGE_RAW spectra for this EDR. A value of 3 indicates that the spectra information from the first and second packets are missing and therefore spectral bins 0-2047 should be discounted from analysis of the HPGE_RAW spectra.	GRS_CAL_AC GRS_CAL_RAW
NADIR_ANGLE	Spacecraft LVLH (Local Vertical/Local Horizontal) elevation angle plus 90 degrees where the LVLH elevation angle is measured from the XY LVLH plane positive in the +z LVLH half-plane (away from the planet) where the spacecraft z-axis is aligned with the vector from the planet center to the spacecraft, y axis is aligned with the instaneous orbit angular momentum and the x-axis completes a right-handed coordinate system and points in the direction of motion along the orbit. Spacecraft orientation angle of the spacecraft z-axis and the spacecraft-to-planet center vector in units of degrees.	GRS_CDR_AC GRS_CDR_RAW GRS_CDR_SH GRS_CALSH2 GRS_CAL_SH3 GRS_CAL_SCR
NEUTRON_EVENTS	Coincidence events that meet neutron criterion.	GRS_CAL_AC GRS_CAL_RAW
NUMBER_OF_BINS	Number of bins in the raw spectra. Number of bins in the shield spectra.	GRS_CAL_AC GRS_CAL_RAW GRS_CAL_SH GRS_CAL_SH3 GRS_CAL_SCR
NUM_BUFFERED_EVENTS	The number of bytes in the raw event buffer. The number of events in the raw event buffer is (Raw Bytes-16)/8. The number of raw events in the buffer will range from 0 to 126. Note there must be at least one event in the buffer before the Event Buffer Header will be generated.	GRS_CAL_SH2
NUM_RAW_EVENTS	This value contains a count of the total number of raw events detected and is not limited by the length of the buffer. This counter will rollover if the count exceeds 65,535.	GRS_CAL_SH2
OFFSET	The correction offset	GRS_RDR_SUM
ORBIT_NUMBER	Orbit number is a unique identifier for a given orbit of the MESSENGER spacecraft around Mercury. Orbit number is defined as starting at apoherm and is calculated using the MET value and the appropriate SPICE kernels. Orbit numbering does not start until MESSENGER performs the Mercury orbit insertion. Until that time the value for orbit number is 0.	GRS_CAL_AC GRS_CAL_RAW GRS_CAL_SCR GRS_CAL_SH GRS_CAL_SH2 GRS_CAL_SH3
PHI_ANGLE	Azimuthal angle look direction (in a theta,phi spherical geometry) of the spacecraft in the spacecraft-fixed coordinate system. PHI_ANGLE = 0 degrees is when the spacecraft x-axis points along the direction of travel.	GRS_CAL_SH3 GRS_CAL_SCR
POINTING	True if pointing data was available.	GRS_CAL_AC GRS_CAL_RAW GRS_CAL_SH GRS_CAL_SH2
PREAMP_TEMP	Channel 04, Pre Amp Temperature, smoothed and interpolated to the center of the collection interval	GRS_CAL_AC GRS_CAL_RAW GRS_CAL_SCR GRS_CAL_SH GRS_CAL_SH2 GRS_CAL_SH3
PREAMP_TEMP_MIN	Minimum temp during the period of the SUM	GRS_RDR_SUM
PREAMP_TEMP_MAX	Maximum temp during the period of the SUM	GRS_RDR_SUM
PREAMP_TEMP_MEAN	Mean temp during the period of the SUM	GRS_RDR_SUM

PREAMP_TEMP_STD	Standard deviation of temp during the period of the SUM	GRS_RDR_SUM
PULSER_ENERGY_SUM	Pulser energy sum. Summation of (Pulser Ener–y - Offset).	GRS_CAL_AC GRS_CAL_RAW
PULSER_ENERGY_SUM2	Pulser energy sum squared. Summation of square of (Pulser Ener–y - Offset).	GRS_CAL_AC GRS_CAL_RAW
PULSER_EVENTS	Number of valid pulser events.	GRS_CAL_AC GRS_CAL_RAW
PULSER_OFFSET	Pulser energy offset used to form PULSER_ENERGY_SUM and PULSER_ENERGY_SUM2.	GRS_CAL_AC GRS_CAL_RAW
RAW_GAMMA_SPECTRUM	Summed uncorrected raw gamma spectrum representing cumulative counts of gamma rays at the detector, binned over some latitude and longitude, and one Earth year.	GRS_RDR_SUM
RAW_VAL	The raw digital value of the reading as output from the analog-to-digital converter.	GRS_ENG
RECORD_COUNT	Number of records summed	GRS_RDR_SUM
SCALT	Mercury centric altitude of the sub-spacecraft point in Mercury-fixed rotating frame at the middle of the collection interval.	GRS_CAL_AC GRS_CAL_RAW GRS_CAL_SH GRS_CAL_SH2
SC_TO_NADIR_ROT	Nine element rotation matrix that converts the spacecraft attitude from instrument-fixed coordinates to nadir-fixed coordinates.	GRS_CAL_SH3 GRS_CAL_SCR
SHAPER_TEMP	Channel 05, Shaper Temperature, smoothed and interpolated to the center of the collection interval	GRS_CAL_AC GRS_CAL_RAW GRS_CAL_SCR GRS_CAL_SH GRS_CAL_SH2 GRS_CAL_SH3
SHAPER_TEMP_MIN	Minimum temp during the period of the SUM	GRS_RDR_SUM
SHAPER_TEMP_MAX	Maximum temp during the period of the SUM	GRS_RDR_SUM
SHAPER_TEMP_MEAN	Mean temp during the period of the SUM	GRS_RDR_SUM
SHAPER_TEMP_STD	Standard deviation of temp during the period of the SUM	GRS_RDR_SUM
SHIELD	Spectra of light pulses produced from interaction of a gamma ray with the plastic scintillator shield. Contains the counts in each of the 1024 bins after 1 accumulation period.	GRS_CAL_SH GRS_CAL_SH3
SHIELD_CHARGE_RESETS	Number of SHIELD charge resets.	GRS_CAL_AC GRS_CAL_RAW
SHIELD_COUNT_SPECTRA	High-time-resolution counter of the total event rate in the shield detector. Counter operates at a 10ms cadence for the duration of the accumulation period, resulting in a series of measurements that populate the 16384 channel spectrum. When fewer than 16384 channels are required, the remainder are set to zero. When more than 16384 channels are required, the last channel represents the sum of all measurements made after the array is filled. For all cases, the first approximately fifty channels are zero due to signal processing deadtime in the GRS electronics.	GRS_CAL_SCR
SHIELD_FAST	Raw Fast Neutron spectrum about the 478-keV line.	GRS_CAL_SH2
SHIELD_RAW_EVENTS	Counter for SHIELD raw events	GRS_CAL_AC GRS_CAL_RAW GRS_CAL_SH GRS_CAL_SH2
SHIELD_SHIFTS_NEUTRON	The number of right shifts (divide by 2s) that are applied to raw shield pulse heights prior to binning in either the Shield Thermal Events spectrum or the Shield Fast Events spectrum. Possible values are 2 or 3. A value of two effectively increases the binning resolution but decreases the dynamic range (maximum binned energy).	GRS_CAL_SH2
SHIELD_SHIFTS_RAW	The number of right shifts (divide by 2s) that are applied to raw shield pulse heights prior to binning in the Shield All Events spectrum. Possible values are 2 or 3. A value of two effectively increases the binning resolution but decreases the dynamic range (maximum binned energy).	GRS_CAL_SH2
SHIELD_THERMAL	Raw Thermal Neutron spectrum about the 478-keV line.	GRS_CAL_SH2

SHLD_CHRG_RSET_1SEC	Hardware Shield charge reset 1-second total.	GRS_CAL_SH3 GRS_CAL_SCR
SMOOTH_VAL	Raw value transformed to a physical unit.	GRS_ENG
START_BIN	Start Bin of the HPGe detector. Start Bin of the Shield detector. Starting bin for the Shield Count Rate measurements. Initially values may be zero due to detector electronics deadtime.	GRS_CAL_AC GRS_CAL_RAW GRS_CAL_SH GRS_CAL_SH3 GRS_CAL_SCR
SUM_TYPE	The type of sum, 0 - Full Planet, 1 - Full Planet less than 2000 kilometer altitude, 2 - Full Planet altitude between 2000 and 8000 kilometers, 3 - Full Planet altitude greater than 8000 kilometers, 4 - Full Planet altitude greater than 15000 kilometers, 5 - North pole (latitude >= 80) with altitude < 2000 kilometers, 6 - 15 x 15 degree cells above 45 degrees latitude with altitude < 2000 kilometers, 7 - 45 x 45 degree cells between 0 and 45 degrees latitude with altitude < 2000 kilometers.	GRS_RDR_SUM
SUN_DISTANCE	Distance of the spacecraft to the Sun in units of km.	GRS_CAL_SH3 GRS_CAL_SCR
THETA_ANGLE	Polar angle look direction (in a theta,phi spherical geometry) of the spacecraft in the spacecraft-fixed coordinate system. THETA_ANGLE = 0 degrees is when the spacecraft z-axis points in the same direction as the spacecraft-to-planet center vector (nadir pointing).	GRS_CAL_SH3 GRS_CAL_SCR
TRIPLE	Triple coincidence count rate in the MESSENGER Neutron Spectrometer. This value is a known proxy for the spacecraft-incident galactic cosmic ray flux.	GRS_CAL_SH3 GRS_CAL_SCR
TWIST_ANGLE	Spacecraft LVLH (Local Vertical/Local Horizontal) twist angle is measured positive about +z body axis where the spacecraft z-axis is aligned with the vector from planet center to the spacecraft, y axis is aligned with the instantaneous orbit angular momentum and the x-axis completes a right-handed coordinate system and points in the direction of motion along the orbit.	GRS_CDR_AC GRS_CDR_RAW GRS_CDR_SH GRS_CDR_SH2
UTC	MET converted to UTC, stored as yyyy-mm-ddThh:mm:ss.sss.	GRS_ENG
UTC_MIDPOINT_MET	MIDPOINT_MET converted to UTC, stored as yyyy-mm-ddThh:mm:ss.sss.	GRS_CAL_AC GRS_CAL_RAW GRS_CAL_SH GRS_CAL_SH2
UTC_START_TIME	Start UTC of a SUM	GRS_RDR_SUM
UTC_STOP_TIME	Stop UTC of a SUM	GRS_RDR_SUM
VALID_COINCIDENT_CH0	Coincidence channel 0 valid events	GRS_CAL_AC GRS_CAL_RAW
VALID_COINCIDENT_CH1	Coincidence channel 1 valid events.	GRS_CAL_AC GRS_CAL_RAW
VALID_SINGLE_CH0	Single channel 0 valid events only	GRS_CAL_AC GRS_CAL_RAW
VALID_SINGLE_CH1	Single channel 1 valid events only.	GRS_CAL_AC GRS_CAL_RAW
VDOT_X	Velocity normalized dot product of the vector velocity and the spacecraft x-axis unit vector expressed as a unitless number from -1 to 1.	GRS_CAL_SH3 GRS_CAL_SCR
VDOT_Y	Velocity normalized dot product of the vector velocity and the spacecraft y-axis unit vector expressed as a unitless number from -1 to 1.	GRS_CAL_SH3 GRS_CAL_SCR
VDOT_Z	Velocity normalized dot product of the vector velocity and the spacecraft z-axis unit vector expressed as a unitless number from -1 to 1.	GRS_CAL_SH3 GRS_CAL_SCR
VEl_NORM	Magnitude of the spacecraft velocity as expressed in the nadir-fixed coordinate system in units of km/second.	GRS_CAL_SH3 GRS_CAL_SCR

VELOCITY_VECTOR	Three element spacecraft velocity vector expressed in the nadir-fixed coordinate system with each component in units of km/second.	GRS_CAL_SH3 GRS_CAL_SCR
XAXIS_ANGLE	Spacecraft orientation angle of the spacecraft x-axis and the spacecraft-to-planet center vector in units of degrees.	GRS_CAL_SH3 GRS_CAL_SCR
YAXIS_ANGLE	Spacecraft orientation angle of the spacecraft y-axis and the spacecraft-to-planet center vector in units of degrees.	GRS_CAL_SH3 GRS_CAL_SCR
ZCT_FAST_MAX	Window parameter that sets the maximum time difference between shield and HpGe triggers for an event to be considered a fast neutron. Units are 100 ns/tick. Parameter is exclusive, i.e., values equal to this parameter are rejected.	GRS_CAL_SH2
ZCT_FAST_MIN	Window parameter that sets the minimum acceptable time difference between shield and HpGe triggers for an event to be considered a fast neutron. Units are 100 ns/tick. Parameter is inclusive, i.e., values equal to this parameter are accepted.	GRS_CAL_SH2
ZCT_THERM_MAX	Window parameter that sets the maximum acceptable time difference between shield and HpGe triggers for an event to be considered a thermal neutron. Units are 100 ns/tick. Parameter is exclusive, i.e., values equal to this parameter are rejected.	GRS_CAL_SH2
ZCT_THERMAL_MIN	Window parameter that sets the minimum acceptable time difference between shield and HpGe triggers for an event to be considered a thermal neutron. Units are 100 ns/tick. Parameter is inclusive, i.e., values equal to this parameter are accepted.	GRS_CAL_SH2

8.7 Appendix: GRS PDS FMT Files

8.7.1 Appendix: GRS_CAL_RAW.FMT

```
OBJECT     = COLUMN
   NAME          = MET
   COLUMN_NUMBER = 1
   BYTES         = 4
   DATA_TYPE     = MSB_UNSIGNED_INTEGER
   START_BYTE    = 1
   UNIT          = Seconds
   DESCRIPTION   = "Mission elapsed time, in seconds, corresponding to the
    start of the accumulation period for the spectra."
END_OBJECT = COLUMN

OBJECT     = COLUMN
   NAME          = ACCUM_TIME
   COLUMN_NUMBER = 2
   BYTES         = 4
   DATA_TYPE     = MSB_UNSIGNED_INTEGER
   START_BYTE    = 5
   UNIT          = Seconds
   DESCRIPTION   = "Accumulation time, in seconds, of the HPGe detector."
END_OBJECT = COLUMN

OBJECT     = COLUMN
   NAME          = MIDPOINT_MET
   COLUMN_NUMBER = 3
   BYTES         = 4
   DATA_TYPE     = MSB_UNSIGNED_INTEGER
   START_BYTE    = 9
   UNIT          = Seconds
   DESCRIPTION   = "The mission elapsed time at the midpoint of the HPGE Raw
    observation. Defined as:
    MET at the start of the observation + (ACCUM_TIME / 2)."
END_OBJECT = COLUMN

OBJECT     = COLUMN
   NAME          = ORBIT_NUMBER
   COLUMN_NUMBER = 4
   BYTES         = 2
   DATA_TYPE     = MSB_UNSIGNED_INTEGER
   START_BYTE    = 13
   DESCRIPTION   = "Orbit number is a unique identifier for a given orbit of
    the MESSENGER spacecraft around Mercury. Orbit number is defined as
    starting at apoherm and is calculated using the MET value and the
    appropriate SPICE kernels. Orbit numbering does not start until MESSENGER
    performs the Mercury orbit insertion. Until that time the value for orbit
    number is 0."
END_OBJECT = COLUMN

OBJECT     = COLUMN
   NAME  = START_BIN
   COLUMN_NUMBER = 5
   BYTES         = 2
   DATA_TYPE     = MSB_UNSIGNED_INTEGER
   START_BYTE    = 15
   DESCRIPTION   = "Start Bin of the HPGe detector."
END_OBJECT = COLUMN

OBJECT     = COLUMN
   NAME          = NUMBER_OF_BINS
   COLUMN_NUMBER = 6
   BYTES         = 2
   DATA_TYPE     = MSB_UNSIGNED_INTEGER
   START_BYTE    = 17
   DESCRIPTION   = "Number of bins in the raw spectra."
```

```
END_OBJECT = COLUMN

OBJECT     = COLUMN
   NAME          = GRS_PRIORITY_LEVEL
   COLUMN_NUMBER = 7
   BYTES         = 2
   DATA_TYPE     = MSB_UNSIGNED_INTEGER
   START_BYTE    = 19
   DESCRIPTION   = "Indicates the type of priority assigned to the science
    packet. The priority level is tied to the ApID of the packet. Priority
    level varies from 0-3, 0 being highest and 3 being lowest priority."
END_OBJECT = COLUMN

OBJECT     = COLUMN
   NAME          = MISSING_DATA_PACKETS
   COLUMN_NUMBER = 8
   BYTES         = 2
   DATA_TYPE     = MSB_UNSIGNED_INTEGER
   START_BYTE    = 21
   DESCRIPTION   = "The value represents a 16-bit binary number where each bit
    indicates whether an HPGe Raw telemetry packet is missing from the EDR.
    Each HPGe Raw EDR consists of information extracted from 16 telemetry
    packets in a complete observation. The least significant bit is a flag
    corresponding to the first of 16 packets and the most significant bit is
    a flag corresponding to the 16th packet. A bit value of 1 indicates that
    a given packet is missing from the EDR.
    For example, a value of 0 in this column indicates that the spectra from
    all 16 packets have been downloaded and included in the HPGE_RAW spectra
    for this EDR. A value of 3 indicates that the spectra information from
    the first and second packets are missing and therefore spectral bins
    0-2047 should be discounted from analysis of the HPGE_RAW spectra."
END_OBJECT = COLUMN

OBJECT     = COLUMN
   NAME          = BAD_DATA_FLAG
   COLUMN_NUMBER = 9
   BYTES         = 2
   DATA_TYPE     = MSB_UNSIGNED_INTEGER
   START_BYTE    = 23
   DESCRIPTION   = "Intended for use as a bit-string bad data flag to
    indicate specific problems associated with the data. Values are expected
    to be assigned to specific bits as problems are identified during the
    course of the mission.
    Bit 1 - The high voltage is not on, is being ramped or has not
            been stable long enough.
    Bit 2 - Indicates a change in the analog pulse processing system
            gain setting.
    Bit 3 - Indicates a spectrum where the temperatures used for
            correction have fluctuated by greater than 5 percent
            from previous readings.
    Bit 4 - Indicates gamma spectra collected during a solar
            particle event. These spectra should not be combined
            with spectra collected under normal solar conditions.
    Bit 5 - Pulser data is not combined with the spectrum.
    Bit 6 - Indicates gamma spectra collected during a solar flare
            event. These spectra should not be combined with spectra
            collected under normal solar conditions.
    Bit 7 - Indicates gamma spectra collected during periods of
            decreased GS detector spectral resolution. These spectra
            should not be combined with spectra collected under
            'normal' detector conditions.
    Bit 8 - Not all data channels were received on the ground.
    Bit 9 - Indicates a unique problem with single spectrum.
    Bit 10 - The high voltage has not been stable long enough.
    Bit 11 - This data was taken during a time when the spectra
             were particularly noisy. Many channels have far too
             many counts, especially the lower channels."
END_OBJECT = COLUMN

OBJECT     = COLUMN
   NAME          = CAL_RAW
```

```
   COLUMN_NUMBER = 10
   BYTES         = 65536
   DATA_TYPE     = IEEE_REAL
   START_BYTE    = 25
   ITEMS         = 16384
   ITEM_BYTES    = 4
   DESCRIPTION   = "Spectra accumulated by the HPGe detector. Contains
    the corrected counts in each of the 16384 bins after 1 accumulation
    period."
END_OBJECT = COLUMN

OBJECT     = COLUMN
   NAME          = UTC_MIDPOINT_MET
   COLUMN_NUMBER = 11
   BYTES         = 23
   DATA_TYPE     = CHARACTER
   START_BYTE    = 65561
   DESCRIPTION   = "midpoint_met converted to UTC, stored as
    yyyy-mm-ddThh:mm:ss.sss."
END_OBJECT = COLUMN

OBJECT     = COLUMN
   NAME          = MERCURY_CENTRIC_LATITUDE
   COLUMN_NUMBER = 12
   BYTES         = 8
   DATA_TYPE     = IEEE_REAL
   START_BYTE    = 65584
   UNIT          = DEGREE
   DESCRIPTION   = "Sub spacecraft latitude in Mercury fixed coordinates
    at the middle of the collection interval."
END_OBJECT = COLUMN

OBJECT     = COLUMN
   NAME          = MERCURY_CENTRIC_EAST_LONGITUDE
   COLUMN_NUMBER = 13
   BYTES         = 8
   DATA_TYPE     = IEEE_REAL
   START_BYTE    = 65592
   UNIT          = DEGREE
   DESCRIPTION   = "Sub spacecraft longitude in Mercury fixed coordinates at
    the middle of the collection interval. Longitude increases towards the
    East."
END_OBJECT = COLUMN

OBJECT     = COLUMN
   NAME          = INSTR_BORESIGHT_MERCURY_X
   COLUMN_NUMBER = 14
   BYTES         = 8
   DATA_TYPE     = IEEE_REAL
   START_BYTE    = 65600
   UNIT          = Kilometers
   DESCRIPTION   = "Sub instrument boresight (x component) in Mercury fixed
    coordinates at the middle of the collection interval."
END_OBJECT = COLUMN

OBJECT     = COLUMN
   NAME          = INSTR_BORESIGHT_MERCURY_Y
   COLUMN_NUMBER = 15
   BYTES         = 8
   DATA_TYPE     = IEEE_REAL
   START_BYTE    = 65608
   UNIT          = Kilometers
   DESCRIPTION   = "Sub instrument boresight (y component) in Mercury fixed
    coordinates at the middle of the collection interval."
END_OBJECT = COLUMN

OBJECT     = COLUMN
   NAME          = INSTR_BORESIGHT_MERCURY_Z
   COLUMN_NUMBER = 16
   BYTES         = 8
   DATA_TYPE     = IEEE_REAL
```

```
   START_BYTE    = 65616
   UNIT          = Kilometers
   DESCRIPTION   = "Sub instrument boresight (z component) in Mercury fixed
    coordinates at the middle of the collection interval."
END_OBJECT = COLUMN

OBJECT     = COLUMN
   NAME          = SCALT
   COLUMN_NUMBER = 17
   BYTES         = 8
   DATA_TYPE     = IEEE_REAL
   START_BYTE    = 65624
   UNIT          = Kilometers
   DESCRIPTION   = "Mercury centric altitude of the sub-spacecraft point
    in Mercury-fixed rotating frame at the middle of the collection
    interval."
END_OBJECT = COLUMN

OBJECT     = COLUMN
   NAME          = DELTA_ANGLE
   COLUMN_NUMBER = 18
   BYTES         = 8
   DATA_TYPE     = IEEE_REAL
   START_BYTE    = 65632
   UNIT          = DEGREE
   DESCRIPTION   = "Difference between instrument +y direction and true north
    at the middle of the collection interval."
END_OBJECT = COLUMN

OBJECT     = COLUMN
   NAME          = MERCURY_SOL
   COLUMN_NUMBER = 19
   BYTES         = 8
   DATA_TYPE     = IEEE_REAL
   START_BYTE    = 65640
   UNIT          = DEGREE
   DESCRIPTION   = "Longitude of the Sun at 0 hours UT on the date of the
    record. Taken from the Association of Lunar and Planetary Observers
    'Ephemeris for Physical Observation of Mercury'."
END_OBJECT = COLUMN

OBJECT     = COLUMN
   NAME          = LOCAL_HOUR
   COLUMN_NUMBER = 20
   BYTES         = 1
   DATA_TYPE     = MSB_UNSIGNED_INTEGER
   START_BYTE    = 65648
   UNIT          = Hours
   DESCRIPTION   = "Local Sun hour at the sub-spacecraft point."
END_OBJECT = COLUMN

OBJECT     = COLUMN
   NAME          = LOCAL_MINUTE
   COLUMN_NUMBER = 21
   BYTES         = 1
   DATA_TYPE     = MSB_UNSIGNED_INTEGER
   START_BYTE    = 65649
   UNIT          = Minutes
   DESCRIPTION   = "Local Sun minute at the sub-spacecraft point."
END_OBJECT = COLUMN

OBJECT     = COLUMN
   NAME          = POINTING
   COLUMN_NUMBER = 22
   BYTES         = 1
   DATA_TYPE     = BOOLEAN
   START_BYTE    = 65650
   DESCRIPTION   = "True if pointing data was available."
END_OBJECT = COLUMN

OBJECT     = COLUMN
```

```
   NAME          = INTERSECTING
   COLUMN_NUMBER = 23
   BYTES         = 1
   DATA_TYPE     = BOOLEAN
   START_BYTE    = 65651
   DESCRIPTION   = "True if the pointing vector intersects Mercury."
END_OBJECT = COLUMN

OBJECT     = COLUMN
   NAME          = NADIR_ANGLE
   COLUMN_NUMBER = 24
   BYTES         = 8
   DATA_TYPE     = IEEE_REAL
   START_BYTE    = 65652
   UNIT          = DEGREE
   DESCRIPTION = "Spacecraft attitude during orbits and flybys is
   defined by two additional coordinate systems, the GRS LVLH
   (Local Vertical Local Horizontal) frame and the spacecraft fixed
   frame, and by the rotation of the spacecraft frame with respect
   to the GRS LVLH frame. In the GRS LVLH frame, the Z axis is
   aligned with the vector from the spacecraft to the planet center
   (the nadir direction), the Y axis is the negative of the cross
   product of the position and velocity vectors, and the X axis
   points in the instantaneous direction of motion, completing a
   right-handed coordinate system. The Z axis is along the viewing
   direction of the instrument deck inside the adapter ring and of
   the GRS just outside the adapter ring, the Y axis is directed from
   the spacecraft along the magnetometer boom, and the X-axis is
   parallel to the solar panel booms, forming a right-handed
   coordinate system.  The spacecraft attitude is specified by the
   rotation of the spacecraft fixed frame Z axis in the GRS LVLH frame
   and a twist angle about the Z axis. The Z axis rotation is given by
   a nadir angle and an azimuth angle, where the nadir angle is 0
   degrees when the spacecraft Z axis points along the + Z LVLH axis
   and 180 degrees when it points along -Z in the LVLH frame, and the
   LVLH azimuth angle is measured counterclockwise about the Z LVLH
   axis from the X LVLH axis. The twist angle is measured positive
   about the +Z spacecraft axis. See section 5.4.2 in the GRS_CDR_SIS
   for further details."
END_OBJECT = COLUMN

OBJECT     = COLUMN
   NAME          = AZIMUTH
   COLUMN_NUMBER = 25
   BYTES         = 8
   DATA_TYPE     = IEEE_REAL
   START_BYTE    = 65660
   UNIT          = DEGREE
   DESCRIPTION = "Spacecraft attitude during orbits and flybys is
   defined by two additional coordinate systems, the GRS LVLH
   (Local Vertical Local Horizontal) frame and the spacecraft fixed
   frame, and by the rotation of the spacecraft frame with respect
   to the GRS LVLH frame. In the GRS LVLH frame, the Z axis is
   aligned with the vector from the spacecraft to the planet center
   (the nadir direction), the Y axis is the negative of the cross
   product of the position and velocity vectors, and the X axis
   points in the instantaneous direction of motion, completing a
   right-handed coordinate system. The Z axis is along the viewing
   direction of the instrument deck inside the adapter ring and of
   the GRS just outside the adapter ring, the Y axis is directed from
   the spacecraft along the magnetometer boom, and the X-axis is
   parallel to the solar panel booms, forming a right-handed
   coordinate system.  The spacecraft attitude is specified by the
   rotation of the spacecraft fixed frame Z axis in the GRS LVLH frame
   and a twist angle about the Z axis. The Z axis rotation is given by
   a nadir angle and an azimuth angle, where the nadir angle is 0
   degrees when the spacecraft Z axis points along the + Z LVLH axis
   and 180 degrees when it points along -Z in the LVLH frame, and the
   LVLH azimuth angle is measured counterclockwise about the Z LVLH
   axis from the X LVLH axis. The twist angle is measured positive
   about the +Z spacecraft axis. See section 5.4.2 in the GRS_CDR_SIS
```

```
   for further details."
END_OBJECT = COLUMN

OBJECT     = COLUMN
   NAME          = TWIST_ANGLE
   COLUMN_NUMBER = 26
   BYTES         = 8
   DATA_TYPE     = IEEE_REAL
   START_BYTE    = 65668
   UNIT          = DEGREE
   DESCRIPTION = "Spacecraft attitude during orbits and flybys is
   defined by two additional coordinate systems, the GRS LVLH
   (Local Vertical Local Horizontal) frame and the spacecraft fixed
   frame, and by the rotation of the spacecraft frame with respect
   to the GRS LVLH frame. In the GRS LVLH frame, the Z axis is
   aligned with the vector from the spacecraft to the planet center
   (the nadir direction), the Y axis is the negative of the cross
   product of the position and velocity vectors, and the X axis
   points in the instantaneous direction of motion, completing a
   right-handed coordinate system. The Z axis is along the viewing
   direction of the instrument deck inside the adapter ring and of
   the GRS just outside the adapter ring, the Y axis is directed from
   the spacecraft along the magnetometer boom, and the X-axis is
   parallel to the solar panel booms, forming a right-handed
   coordinate system.  The spacecraft attitude is specified by the
   rotation of the spacecraft fixed frame Z axis in the GRS LVLH frame
   and a twist angle about the Z axis. The Z axis rotation is given by
   a nadir angle and an azimuth angle, where the nadir angle is 0
   degrees when the spacecraft Z axis points along the + Z LVLH axis
   and 180 degrees when it points along -Z in the LVLH frame, and the
   LVLH azimuth angle is measured counterclockwise about the Z LVLH
   axis from the X LVLH axis. The twist angle is measured positive
   about the +Z spacecraft axis. See section 5.4.2 in the GRS_CDR_SIS
   for further details."
END_OBJECT = COLUMN

OBJECT     = COLUMN
   NAME          = HPGE_TEMP_1
   COLUMN_NUMBER = 27
   BYTES         = 8
   DATA_TYPE     = IEEE_REAL
   START_BYTE    = 65676
   UNIT          = DEGK
   DESCRIPTION   = "Channel 00, HPGE Detector Temperature 1,
    smoothed and interpolated to the center of the collection interval."
END_OBJECT = COLUMN

OBJECT     = COLUMN
   NAME          = HPGE_TEMP_2
   COLUMN_NUMBER = 28
   BYTES         = 8
   DATA_TYPE     = IEEE_REAL
   START_BYTE    = 65684
   UNIT          = DEGK
   DESCRIPTION   = "Channel 01, HPGE Detector Temperature 2,
    smoothed and interpolated to the center of the collection interval."
END_OBJECT = COLUMN

OBJECT     = COLUMN
   NAME          = CALIB_AVG_DET_TEMP
   COLUMN_NUMBER = 29
   BYTES         = 8
   DATA_TYPE     = IEEE_REAL
   START_BYTE    = 65692
   UNIT          = DEGK
   DESCRIPTION   = "Calibrated, averaged detector temperature,
    smoothed and interpolated to the center of the collection interval."
END_OBJECT = COLUMN

OBJECT     = COLUMN
   NAME          = PREAMP_TEMP
```

```
   COLUMN_NUMBER = 30
   BYTES         = 8
   DATA_TYPE     = IEEE_REAL
   START_BYTE    = 65700
   UNIT          = DEGC
   DESCRIPTION   = "Channel 04, Pre Amp Temperature,
    smoothed and interpolated to the center of the collection interval."
END_OBJECT = COLUMN

OBJECT     = COLUMN
   NAME          = SHAPER_TEMP
   COLUMN_NUMBER = 31
   BYTES         = 8
   DATA_TYPE     = IEEE_REAL
   START_BYTE    = 65708
   UNIT          = DEGC
   DESCRIPTION   = "Channel 05, Shaper Temperature,
    smoothed and interpolated to the center of the collection interval."
END_OBJECT = COLUMN

OBJECT     = COLUMN
   NAME          = HV_MONITOR
   COLUMN_NUMBER = 32
   BYTES         = 8
   DATA_TYPE     = IEEE_REAL
   START_BYTE    = 65716
   UNIT          = Volts
   DESCRIPTION   = "Channel 07, HV Monitor,
    smoothed and interpolated to the center of the collection interval."
END_OBJECT = COLUMN

OBJECT     = COLUMN
   NAME          = HPGE_RAW_EVENTS
   COLUMN_NUMBER = 33
   BYTES         = 4
   DATA_TYPE     = MSB_UNSIGNED_INTEGER
   START_BYTE    = 65724
   DESCRIPTION   = "Counter of HPGe Raw events."
END_OBJECT = COLUMN

OBJECT     = COLUMN
   NAME          = SHIELD_RAW_EVENTS
   COLUMN_NUMBER = 34
   BYTES         = 4
   DATA_TYPE     = MSB_UNSIGNED_INTEGER
   START_BYTE    = 65728
   DESCRIPTION   = "Counter for SHIELD raw events."
END_OBJECT = COLUMN

OBJECT     = COLUMN
   NAME          = ACCUMULATED_DEAD_TIME
   COLUMN_NUMBER = 35
   BYTES         = 4
   DATA_TYPE     = MSB_UNSIGNED_INTEGER
   START_BYTE    = 65732
   DESCRIPTION   = "Counter for accumulated dead time."
END_OBJECT = COLUMN

OBJECT     = COLUMN
   NAME          = HPGE_CHARGE_RESETS
   COLUMN_NUMBER = 36
   BYTES         = 4
   DATA_TYPE     = MSB_UNSIGNED_INTEGER
   START_BYTE    = 65736
   DESCRIPTION   = "Number of HPGe charge resets."
END_OBJECT = COLUMN

OBJECT     = COLUMN
   NAME          = SHIELD_CHARGE_RESETS
   COLUMN_NUMBER = 37
   BYTES         = 4
```

```
   DATA_TYPE     = MSB_UNSIGNED_INTEGER
   START_BYTE    = 65740
   DESCRIPTION   = "Number of SHIELD charge resets."
END_OBJECT = COLUMN

OBJECT     = COLUMN
   NAME          = ALL_EVENTS
   COLUMN_NUMBER = 38
   BYTES         = 4
   DATA_TYPE     = MSB_UNSIGNED_INTEGER
   START_BYTE    = 65744
   DESCRIPTION   = "total count of gamma events."
END_OBJECT = COLUMN

OBJECT     = COLUMN
   NAME          = ALL_CH0_CH1_EVENTS
   COLUMN_NUMBER = 39
   BYTES         = 4
   DATA_TYPE     = MSB_UNSIGNED_INTEGER
   START_BYTE    = 65748
   DESCRIPTION   = "All channel 0 and channel 1 events. Excludes inverted
    Channel 0, Pileups, and Pulser events."
END_OBJECT = COLUMN

OBJECT     = COLUMN
   NAME          = ALL_CH0_EVENTS
   COLUMN_NUMBER = 40
   BYTES         = 4
   DATA_TYPE     = MSB_UNSIGNED_INTEGER
   START_BYTE    = 65752
   DESCRIPTION   = "All single Channel 0 events - either singlet or fails
    crossing time criterion."
END_OBJECT = COLUMN

OBJECT     = COLUMN
   NAME          = ALL_CH1_EVENTS
   COLUMN_NUMBER = 41
   BYTES         = 4
   DATA_TYPE     = MSB_UNSIGNED_INTEGER
   START_BYTE    = 65756
   DESCRIPTION   = "All single Channel 1 events - either singlet or fails
    crossing time criterion."
END_OBJECT = COLUMN

OBJECT     = COLUMN
   NAME          = INVALID_SINGLE_CH0
   COLUMN_NUMBER = 42
   BYTES         = 4
   DATA_TYPE     = MSB_UNSIGNED_INTEGER
   START_BYTE    = 65760
   DESCRIPTION   = "Single channel 0 out-of-range events."
END_OBJECT = COLUMN

OBJECT     = COLUMN
   NAME          = INVALID_SINGLE_CH1
   COLUMN_NUMBER = 43
   BYTES         = 4
   DATA_TYPE     = MSB_UNSIGNED_INTEGER
   START_BYTE    = 65764
   DESCRIPTION   = "Single channel 1 out-of-range events."
END_OBJECT = COLUMN

OBJECT     = COLUMN
   NAME          = INVALID_COINCIDENT_CH0
   COLUMN_NUMBER = 44
   BYTES         = 4
   DATA_TYPE     = MSB_UNSIGNED_INTEGER
   START_BYTE    = 65768
   DESCRIPTION   = "Channel 0 out-of-range coincidence events."
END_OBJECT = COLUMN
```

```
OBJECT     = COLUMN
   NAME          = INVALID_COINCIDENT_CH1
   COLUMN_NUMBER = 45
   BYTES         = 4
   DATA_TYPE     = MSB_UNSIGNED_INTEGER
   START_BYTE    = 65772
   DESCRIPTION   = "Channel 1 out-of-range coincidence events."
END_OBJECT = COLUMN

OBJECT     = COLUMN
   NAME          = VALID_SINGLE_CH0
   COLUMN_NUMBER = 46
   BYTES         = 4
   DATA_TYPE     = MSB_UNSIGNED_INTEGER
   START_BYTE    = 65776
   DESCRIPTION   = "Single channel 0 valid events only."
END_OBJECT = COLUMN

OBJECT     = COLUMN
   NAME          = VALID_COINCIDENT_CH0
   COLUMN_NUMBER = 47
   BYTES         = 4
   DATA_TYPE     = MSB_UNSIGNED_INTEGER
   START_BYTE    = 65780
   DESCRIPTION   = "Coincidence channel 0 valid events."
END_OBJECT = COLUMN

OBJECT     = COLUMN
   NAME          = VALID_SINGLE_CH1
   COLUMN_NUMBER = 48
   BYTES         = 4
   DATA_TYPE     = MSB_UNSIGNED_INTEGER
   START_BYTE    = 65784
   DESCRIPTION   = "Single channel 1 valid events only."
END_OBJECT = COLUMN

OBJECT     = COLUMN
   NAME          = VALID_COINCIDENT_CH1
   COLUMN_NUMBER = 49
   BYTES         = 4
   DATA_TYPE     = MSB_UNSIGNED_INTEGER
   START_BYTE    = 65788
   DESCRIPTION   = "Coincidence channel 1 valid events."
END_OBJECT = COLUMN

OBJECT     = COLUMN
   NAME          = ALL_VALID_COINCIDENT
   COLUMN_NUMBER = 50
   BYTES         = 4
   DATA_TYPE     = MSB_UNSIGNED_INTEGER
   START_BYTE    = 65792
   DESCRIPTION   = "All valid coincidence events - both Channel 0 and Channel
    1 valid."
END_OBJECT = COLUMN

OBJECT     = COLUMN
   NAME          = INVERTED_CH0
   COLUMN_NUMBER = 51
   BYTES         = 4
   DATA_TYPE     = MSB_UNSIGNED_INTEGER
   START_BYTE    = 65796
   DESCRIPTION   = "Channel 0 events flagged 'inverted' by the hardware."
END_OBJECT = COLUMN

OBJECT     = COLUMN
   NAME          = CH0_PILEUP_REJECT
   COLUMN_NUMBER = 52
   BYTES         = 4
   DATA_TYPE     = MSB_UNSIGNED_INTEGER
   START_BYTE    = 65800
   DESCRIPTION   = "Channel 0 pileup rejected events. Only if pileup rejection
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    is enabled."
END_OBJECT = COLUMN

OBJECT     = COLUMN
   NAME          = FIFO_FULL_COUNT
   COLUMN_NUMBER = 53
   BYTES         = 4
   DATA_TYPE     = MSB_UNSIGNED_INTEGER
   START_BYTE    = 65804
   DESCRIPTION   = "Hardware FIFO full flag tested for all events."
END_OBJECT = COLUMN

OBJECT     = COLUMN
   NAME          = PULSER_ENERGY_SUM
   COLUMN_NUMBER = 54
   BYTES         = 4
   DATA_TYPE     = MSB_INTEGER
   START_BYTE    = 65808
   DESCRIPTION   = "Pulser energy sum. Summation of (Pulser Energy - Offset)."
END_OBJECT = COLUMN

OBJECT     = COLUMN
   NAME          = PULSER_ENERGY_SUM2
   COLUMN_NUMBER = 55
   BYTES         = 4
   DATA_TYPE     = MSB_UNSIGNED_INTEGER
   START_BYTE    = 65812
   DESCRIPTION   = "Pulser energy sum squared. Summation of square of
    (Pulser Energy - Offset)."
END_OBJECT = COLUMN

OBJECT     = COLUMN
   NAME          = PULSER_EVENTS
   COLUMN_NUMBER = 56
   BYTES         = 4
   DATA_TYPE     = MSB_UNSIGNED_INTEGER
   START_BYTE    = 65816
   DESCRIPTION   = "Number of valid pulser events."
END_OBJECT = COLUMN

OBJECT     = COLUMN
   NAME          = INVALID_PULSER_EVENTS
   COLUMN_NUMBER = 57
   BYTES         = 4
   DATA_TYPE     = MSB_UNSIGNED_INTEGER
   START_BYTE    = 65820
   DESCRIPTION   = "Out-of-range pulser events."
END_OBJECT = COLUMN

OBJECT     = COLUMN
   NAME          = NEUTRON_EVENTS
   COLUMN_NUMBER = 58
   BYTES         = 4
   DATA_TYPE     = MSB_UNSIGNED_INTEGER
   START_BYTE    = 65824
   DESCRIPTION   = "Coincidence events that meet neutron criterion."
END_OBJECT = COLUMN

OBJECT     = COLUMN
   NAME          = PULSER_OFFSET
   COLUMN_NUMBER = 59
   BYTES         = 4
   DATA_TYPE     = MSB_UNSIGNED_INTEGER
   START_BYTE    = 65828
   DESCRIPTION   = "Pulser energy offset used to form PULSER_ENERGY_SUM
    and PULSER_ENERGY_SUM2."
END_OBJECT = COLUMN
```

8.7.2 Appendix: GRS_CAL_AC.FMT

```
OBJECT     = COLUMN
   NAME          = MET
   COLUMN_NUMBER = 1
   BYTES         = 4
   DATA_TYPE     = MSB_UNSIGNED_INTEGER
   START_BYTE    = 1
   UNIT          = Seconds
   DESCRIPTION   = "Mission elapsed time, in seconds, corresponding to the
    start of the accumulation period for the spectra."
END_OBJECT = COLUMN

OBJECT     = COLUMN
   NAME          = ACCUM_TIME
   COLUMN_NUMBER = 2
   BYTES         = 4
   DATA_TYPE     = MSB_UNSIGNED_INTEGER
   START_BYTE    = 5
   UNIT          = Seconds
   DESCRIPTION   = "Accumulation time, in seconds, of the HPGe detector."
END_OBJECT = COLUMN

OBJECT     = COLUMN
   NAME          = MIDPOINT_MET
   COLUMN_NUMBER = 3
   BYTES         = 4
   DATA_TYPE     = MSB_UNSIGNED_INTEGER
   START_BYTE    = 9
   UNIT          = Seconds
   DESCRIPTION   = "The mission elapsed time at the midpoint of the HPGE Raw
    observation. Defined as:
    MET at the start of the observation + (ACCUM_TIME / 2)."
END_OBJECT = COLUMN

OBJECT     = COLUMN
   NAME          = ORBIT_NUMBER
   COLUMN_NUMBER = 4
   BYTES         = 2
   DATA_TYPE     = MSB_UNSIGNED_INTEGER
   START_BYTE    = 13
   DESCRIPTION   = "Orbit number is a unique identifier for a given orbit of
    the MESSENGER spacecraft around Mercury. Orbit number is defined as
    starting at apoherm and is calculated using the MET value and the
    appropriate SPICE kernels. Orbit numbering does not start until MESSENGER
    performs the Mercury orbit insertion. Until that time the value for orbit
    number is 0."
END_OBJECT = COLUMN

OBJECT     = COLUMN
   NAME          = START_BIN
   COLUMN_NUMBER = 5
   BYTES         = 2
   DATA_TYPE     = MSB_UNSIGNED_INTEGER
   START_BYTE    = 15
   DESCRIPTION   = "Start Bin of the HPGe detector."
END_OBJECT = COLUMN

OBJECT     = COLUMN
   NAME          = NUMBER_OF_BINS
   COLUMN_NUMBER = 6
   BYTES         = 2
   DATA_TYPE     = MSB_UNSIGNED_INTEGER
   START_BYTE    = 17
   DESCRIPTION   = "Number of bins in the raw spectra."
END_OBJECT = COLUMN

OBJECT     = COLUMN
   NAME          = GRS_PRIORITY_LEVEL
   COLUMN_NUMBER = 7
```

```
   BYTES         = 2
   DATA_TYPE     = MSB_UNSIGNED_INTEGER
   START_BYTE    = 19
   DESCRIPTION   = "Indicates the type of priority assigned to the science
    packet. The priority level is tied to the ApID of the packet. Priority
    level varies from 0-3, 0 being highest and 3 being lowest priority."
END_OBJECT = COLUMN

OBJECT     = COLUMN
   NAME          = MISSING_DATA_PACKETS
   COLUMN_NUMBER = 8
   BYTES         = 2
   DATA_TYPE     = MSB_UNSIGNED_INTEGER
   START_BYTE    = 21
   DESCRIPTION   = "The value represents a 16-bit binary number where each bit
    indicates whether an HPGe Raw telemetry packet is missing from the EDR.
    Each HPGe Raw EDR consists of information extracted from 16 telemetry
    packets in a complete observation. The least significant bit is a flag
    corresponding to the first of 16 packets and the most significant bit is
    a flag corresponding to the 16th packet. A bit value of 1 indicates that
    a given packet is missing from the EDR.
    For example, a value of 0 in this column indicates that the spectra from
    all 16 packets have been downloaded and included in the HPGE_RAW spectra
    for this EDR. A value of 3 indicates that the spectra information from
    the first and second packets are missing and therefore spectral bins
    0-2047 should be discounted from analysis of the HPGE_RAW spectra."
END_OBJECT = COLUMN

OBJECT     = COLUMN
   NAME          = BAD_DATA_FLAG
   COLUMN_NUMBER = 9
   BYTES         = 2
   DATA_TYPE     = MSB_UNSIGNED_INTEGER
   START_BYTE    = 23
   DESCRIPTION   = "Intended for use as a bit-string bad data flag to
    indicate specific problems associated with the data. Values are expected
    to be assigned to specific bits as problems are identified during the
    course of the mission.
    Bit 1 - The high voltage is not on, is being ramped or has not
            been stable long enough.
    Bit 2 - Indicates a change in the analog pulse processing system
            gain setting.
    Bit 3 - Indicates a spectrum where the temperatures used for
            correction have fluctuated by greater than 5 percent
            from previous readings.
    Bit 4 - Indicates gamma spectra collected during a solar
            particle event. These spectra should not be combined
            with spectra collected under normal solar conditions.
    Bit 5 - Pulser data is not combined with the spectrum.
    Bit 6 - Indicates gamma spectra collected during a solar flare
            event. These spectra should not be combined with spectra
            collected under normal solar conditions.
    Bit 7 - Indicates gamma spectra collected during periods of
            decreased GS detector spectral resolution. These spectra
            should not be combined with spectra collected under
            'normal' detector conditions.
    Bit 8 - Not all data channels were received on the ground.
    Bit 9 - Indicates a unique problem with single spectrum.
    Bit 10 - The high voltage has not been stable long enough.
    Bit 11 - This data was taken during a time when the spectra
             were particularly noisy. Many channels have far too
             many counts, especially the lower channels."
END_OBJECT = COLUMN

OBJECT     = COLUMN
   NAME          = CAL_AC
   COLUMN_NUMBER = 10
   BYTES         = 65536
   DATA_TYPE     = IEEE_REAL
   START_BYTE    = 25
   ITEMS         = 16384
```

```
   ITEM_BYTES    = 4
   DESCRIPTION   = "Anti-coincident (AC) spectra accumulated by the HPGe
    detector. Contains the corrected counts in each of the 16384 bins after
    1 accumulation period."
END_OBJECT = COLUMN

OBJECT     = COLUMN
   NAME          = UTC_MIDPOINT_MET
   COLUMN_NUMBER = 11
   BYTES         = 23
   DATA_TYPE     = CHARACTER
   START_BYTE    = 65561
   DESCRIPTION   = "midpoint_met converted to UTC, stored as
    yyyy-mm-ddThh:mm:ss.sss."
END_OBJECT = COLUMN

OBJECT     = COLUMN
   NAME          = MERCURY_CENTRIC_LATITUDE
   COLUMN_NUMBER = 12
   BYTES         = 8
   DATA_TYPE     = IEEE_REAL
   START_BYTE    = 65584
   UNIT          = Degree
   DESCRIPTION   = "Sub spacecraft latitude in Mercury fixed coordinates
    at the middle of the collection interval."
END_OBJECT = COLUMN

OBJECT     = COLUMN
   NAME          = MERCURY_CENTRIC_LONGITUDE
   COLUMN_NUMBER = 13
   BYTES         = 8
   DATA_TYPE     = IEEE_REAL
   START_BYTE    = 65592
   UNIT          = Degree
   DESCRIPTION   = "Sub spacecraft longitude in Mercury fixed coordinates at
    the middle of the collection interval. Longitude increases towards the
    East."
END_OBJECT = COLUMN

OBJECT     = COLUMN
   NAME          = INSTR_BORESIGHT_MERCURY_X
   COLUMN_NUMBER = 14
   BYTES         = 8
   DATA_TYPE     = IEEE_REAL
   START_BYTE    = 65600
   UNIT          = Kilometers
   DESCRIPTION   = "Sub instrument boresight (x component) in Mercury fixed
    coordinates at the middle of the collection interval."
END_OBJECT = COLUMN

OBJECT     = COLUMN
   NAME          = INSTR_BORESIGHT_MERCURY_Y
   COLUMN_NUMBER = 15
   BYTES         = 8
   DATA_TYPE     = IEEE_REAL
   START_BYTE    = 65608
   UNIT          = Kilometers
   DESCRIPTION   = "Sub instrument boresight (y component) in Mercury fixed
    coordinates at the middle of the collection interval."
END_OBJECT = COLUMN

OBJECT     = COLUMN
   NAME          = INSTR_BORESIGHT_MERCURY_Z
   COLUMN_NUMBER = 16
   BYTES         = 8
   DATA_TYPE     = IEEE_REAL
   START_BYTE    = 65616
   UNIT          = Kilometers
   DESCRIPTION   = "Sub instrument boresight (z component) in Mercury fixed
    coordinates at the middle of the collection interval."
END_OBJECT = COLUMN
```

```
OBJECT     = COLUMN
   NAME          = SCALT
   COLUMN_NUMBER = 17
   BYTES         = 8
   DATA_TYPE     = IEEE_REAL
   START_BYTE    = 65624
   UNIT          = Kilometers
   DESCRIPTION   = "Mercury centric altitude of the sub-spacecraft point
    in Mercury-fixed rotating frame at the middle of the collection
    interval."
END_OBJECT = COLUMN

OBJECT     = COLUMN
   NAME          = DELTA_ANGLE
   COLUMN_NUMBER = 18
   BYTES         = 8
   DATA_TYPE     = IEEE_REAL
   START_BYTE    = 65632
   UNIT          = Degree
   DESCRIPTION   = "Difference between instrument +y direction and true north
    at the middle of the collection interval."
END_OBJECT = COLUMN

OBJECT    = COLUMN
   NAME          = MERCURY_SOL
   COLUMN_NUMBER = 19
   BYTES         = 8
   DATA_TYPE     = IEEE_REAL
   START_BYTE    = 65640
   UNIT          = Degree
   DESCRIPTION   = "Longitude of the Sun at 0 hours UT on the date of the
    record. Taken from the Association of Lunar and Planetary Observers
    'Ephemeris for Physical Observation of Mercury'."
END_OBJECT = COLUMN

OBJECT    = COLUMN
   NAME          = LOCAL_HOUR
   COLUMN_NUMBER = 20
   BYTES         = 1
   DATA_TYPE     = MSB_UNSIGNED_INTEGER
   START_BYTE    = 65648
   UNIT          = Hours
   DESCRIPTION   = "Local Sun hour at the sub-spacecraft point."
END_OBJECT = COLUMN

OBJECT    = COLUMN
   NAME          = LOCAL_MINUTE
   COLUMN_NUMBER = 21
   BYTES         = 1
   DATA_TYPE     = MSB_UNSIGNED_INTEGER
   START_BYTE    = 65649
   UNIT          = Minutes
   DESCRIPTION   = "Local Sun minute at the sub-spacecraft point."
END_OBJECT = COLUMN

OBJECT    = COLUMN
   NAME          = POINTING
   COLUMN_NUMBER = 22
   BYTES         = 1
   DATA_TYPE     = BOOLEAN
   START_BYTE    = 65650
   DESCRIPTION   = "True if pointing data was available."
END_OBJECT = COLUMN

OBJECT    = COLUMN
   NAME          = INTERSECTING
   COLUMN_NUMBER = 23
   BYTES         = 1
   DATA_TYPE     = BOOLEAN
   START_BYTE    = 65651
```

```
   DESCRIPTION   = "True if the pointing vector intersects Mercury."
END_OBJECT = COLUMN

OBJECT     = COLUMN
   NAME          = NADIR_ANGLE
   COLUMN_NUMBER = 24
   BYTES         = 8
   DATA_TYPE     = IEEE_REAL
   START_BYTE    = 65652
   UNIT          = Degree
   DESCRIPTION = "Spacecraft attitude during orbits and flybys is
   defined by two additional coordinate systems, the GRS LVLH
   (Local Vertical Local Horizontal) frame and the spacecraft fixed
   frame, and by the rotation of the spacecraft frame with respect
   to the GRS LVLH frame. In the GRS LVLH frame, the Z axis is
   aligned with the vector from the spacecraft to the planet center
   (the nadir direction), the Y axis is the negative of the cross
   product of the position and velocity vectors, and the X axis
   points in the instantaneous direction of motion, completing a
   right-handed coordinate system. The Z axis is along the viewing
   direction of the instrument deck inside the adapter ring and of
   the GRS just outside the adapter ring, the Y axis is directed from
   the spacecraft along the magnetometer boom, and the X-axis is
   parallel to the solar panel booms, forming a right-handed
   coordinate system.  The spacecraft attitude is specified by the
   rotation of the spacecraft fixed frame Z axis in the GRS LVLH frame
   and a twist angle about the Z axis. The Z axis rotation is given by
   a nadir angle and an azimuth angle, where the nadir angle is 0
   degrees when the spacecraft Z axis points along the + Z LVLH axis
   and 180 degrees when it points along -Z in the LVLH frame, and the
   LVLH azimuth angle is measured counterclockwise about the Z LVLH
   axis from the X LVLH axis. The twist angle is measured positive
   about the +Z spacecraft axis. See section 5.4.2 in the GRS_CDR_SIS
   for further details."
END_OBJECT = COLUMN

OBJECT     = COLUMN
   NAME          = AZIMUTH
   COLUMN_NUMBER = 25
   BYTES         = 8
   DATA_TYPE     = IEEE_REAL
   START_BYTE    = 65660
   UNIT          = Degree
   DESCRIPTION = "Spacecraft attitude during orbits and flybys is
   defined by two additional coordinate systems, the GRS LVLH
   (Local Vertical Local Horizontal) frame and the spacecraft fixed
   frame, and by the rotation of the spacecraft frame with respect
   to the GRS LVLH frame. In the GRS LVLH frame, the Z axis is
   aligned with the vector from the spacecraft to the planet center
   (the nadir direction), the Y axis is the negative of the cross
   product of the position and velocity vectors, and the X axis
   points in the instantaneous direction of motion, completing a
   right-handed coordinate system. The Z axis is along the viewing
   direction of the instrument deck inside the adapter ring and of
   the GRS just outside the adapter ring, the Y axis is directed from
   the spacecraft along the magnetometer boom, and the X-axis is
   parallel to the solar panel booms, forming a right-handed
   coordinate system.  The spacecraft attitude is specified by the
   rotation of the spacecraft fixed frame Z axis in the GRS LVLH frame
   and a twist angle about the Z axis. The Z axis rotation is given by
   a nadir angle and an azimuth angle, where the nadir angle is 0
   degrees when the spacecraft Z axis points along the + Z LVLH axis
   and 180 degrees when it points along -Z in the LVLH frame, and the
   LVLH azimuth angle is measured counterclockwise about the Z LVLH
   axis from the X LVLH axis. The twist angle is measured positive
   about the +Z spacecraft axis. See section 5.4.2 in the GRS_CDR_SIS
   for further details."

END_OBJECT = COLUMN

OBJECT     = COLUMN
```

```
   NAME          = TWIST_ANGLE
   COLUMN_NUMBER = 26
   BYTES         = 8
   DATA_TYPE     = IEEE_REAL
   START_BYTE    = 65668
   UNIT          = Degree
   DESCRIPTION = "Spacecraft attitude during orbits and flybys is
   defined by two additional coordinate systems, the GRS LVLH
   (Local Vertical Local Horizontal) frame and the spacecraft fixed
   frame, and by the rotation of the spacecraft frame with respect
   to the GRS LVLH frame. In the GRS LVLH frame, the Z axis is
   aligned with the vector from the spacecraft to the planet center
   (the nadir direction), the Y axis is the negative of the cross
   product of the position and velocity vectors, and the X axis
   points in the instantaneous direction of motion, completing a
   right-handed coordinate system. The Z axis is along the viewing
   direction of the instrument deck inside the adapter ring and of
   the GRS just outside the adapter ring, the Y axis is directed from
   the spacecraft along the magnetometer boom, and the X-axis is
   parallel to the solar panel booms, forming a right-handed
   coordinate system.  The spacecraft attitude is specified by the
   rotation of the spacecraft fixed frame Z axis in the GRS LVLH frame
   and a twist angle about the Z axis. The Z axis rotation is given by
   a nadir angle and an azimuth angle, where the nadir angle is 0
   degrees when the spacecraft Z axis points along the + Z LVLH axis
   and 180 degrees when it points along -Z in the LVLH frame, and the
   LVLH azimuth angle is measured counterclockwise about the Z LVLH
   axis from the X LVLH axis. The twist angle is measured positive
   about the +Z spacecraft axis. See section 5.4.2 in the GRS_CDR_SIS
   for further details."
END_OBJECT = COLUMN

OBJECT    = COLUMN
   NAME          = HPGE_TEMP_1
   COLUMN_NUMBER = 27
   BYTES         = 8
   DATA_TYPE     = IEEE_REAL
   START_BYTE    = 65676
   UNIT          = DEGK
   DESCRIPTION   = "Channel 00, HPGE Detector Temperature 1,
    smoothed and interpolated to the center of the collection interval."
END_OBJECT = COLUMN

OBJECT    = COLUMN
   NAME          = HPGE_TEMP_2
   COLUMN_NUMBER = 28
   BYTES         = 8
   DATA_TYPE     = IEEE_REAL
   START_BYTE    = 65684
   UNIT          = DEGK
   DESCRIPTION   = "Channel 01, HPGE Detector Temperature 2,
    smoothed and interpolated to the center of the collection interval."
END_OBJECT = COLUMN

OBJECT    = COLUMN
   NAME          = CALIB_AVG_DET_TEMP
   COLUMN_NUMBER = 29
   BYTES         = 8
   DATA_TYPE     = IEEE_REAL
   START_BYTE    = 65692
   UNIT          = DEGK
   DESCRIPTION   = "Calibrated, averaged detector temperature,
    smoothed and interpolated to the center of the collection interval."
END_OBJECT = COLUMN

OBJECT    = COLUMN
   NAME          = PREAMP_TEMP
   COLUMN_NUMBER = 30
   BYTES         = 8
   DATA_TYPE     = IEEE_REAL
   START_BYTE    = 65700
```

```
   UNIT          = DEGC
   DESCRIPTION   = "Channel 04, Pre Amp Temperature,
    smoothed and interpolated to the center of the collection interval."
END_OBJECT = COLUMN

OBJECT    = COLUMN
   NAME          = SHAPER_TEMP
   COLUMN_NUMBER = 31
   BYTES         = 8
   DATA_TYPE     = IEEE_REAL
   START_BYTE    = 65708
   UNIT          = DEGC
   DESCRIPTION   = "Channel 05, Shaper Temperature,
    smoothed and interpolated to the center of the collection interval."
END_OBJECT = COLUMN

OBJECT    = COLUMN
   NAME          = HV_MONITOR
   COLUMN_NUMBER = 32
   BYTES         = 8
   DATA_TYPE     = IEEE_REAL
   START_BYTE    = 65716
   UNIT          = Volts
   DESCRIPTION   = "Channel 07, HV Monitor,
    smoothed and interpolated to the center of the collection interval."
END_OBJECT = COLUMN

OBJECT    = COLUMN
   NAME          = HPGE_RAW_EVENTS
   COLUMN_NUMBER = 33
   BYTES         = 4
   DATA_TYPE     = MSB_UNSIGNED_INTEGER
   START_BYTE    = 65724
   DESCRIPTION   = "Counter of HPGe Raw events."
END_OBJECT = COLUMN

OBJECT    = COLUMN
   NAME          = SHIELD_RAW_EVENTS
   COLUMN_NUMBER = 34
   BYTES         = 4
   DATA_TYPE     = MSB_UNSIGNED_INTEGER
   START_BYTE    = 65728
   DESCRIPTION   = "Counter for SHIELD raw events."
END_OBJECT = COLUMN

OBJECT    = COLUMN
   NAME          = ACCUMULATED_DEAD_TIME
   COLUMN_NUMBER = 35
   BYTES         = 4
   DATA_TYPE     = MSB_UNSIGNED_INTEGER
   START_BYTE    = 65732
   DESCRIPTION   = "Counter for accumulated dead time."
END_OBJECT = COLUMN

OBJECT    = COLUMN
   NAME          = HPGE_CHARGE_RESETS
   COLUMN_NUMBER = 36
   BYTES         = 4
   DATA_TYPE     = MSB_UNSIGNED_INTEGER
   START_BYTE    = 65736
   DESCRIPTION   = "Number of HPGe charge resets."
END_OBJECT = COLUMN

OBJECT    = COLUMN
   NAME          = SHIELD_CHARGE_RESETS
   COLUMN_NUMBER = 37
   BYTES         = 4
   DATA_TYPE     = MSB_UNSIGNED_INTEGER
   START_BYTE    = 65740
   DESCRIPTION   = "Number of SHIELD charge resets."
END_OBJECT = COLUMN
```

```
OBJECT    = COLUMN
   NAME          = ALL_EVENTS
   COLUMN_NUMBER = 38
   BYTES         = 4
   DATA_TYPE     = MSB_UNSIGNED_INTEGER
   START_BYTE    = 65744
   DESCRIPTION   = "total count of gamma events."
END_OBJECT = COLUMN

OBJECT    = COLUMN
   NAME          = ALL_CH0_CH1_EVENTS
   COLUMN_NUMBER = 39
   BYTES         = 4
   DATA_TYPE     = MSB_UNSIGNED_INTEGER
   START_BYTE    = 65748
   DESCRIPTION   = "All channel 0 and channel 1 events. Excludes inverted
    Channel 0, Pileups, and Pulser events."
END_OBJECT = COLUMN

OBJECT    = COLUMN
   NAME          = ALL_CH0_EVENTS
   COLUMN_NUMBER = 40
   BYTES         = 4
   DATA_TYPE     = MSB_UNSIGNED_INTEGER
   START_BYTE    = 65752
   DESCRIPTION   = "All single Channel 0 events - either singlet or fails
    crossing time criterion."
END_OBJECT = COLUMN

OBJECT    = COLUMN
   NAME          = ALL_CH1_EVENTS
   COLUMN_NUMBER = 41
   BYTES         = 4
   DATA_TYPE     = MSB_UNSIGNED_INTEGER
   START_BYTE    = 65756
   DESCRIPTION   = "All single Channel 1 events - either singlet or fails
    crossing time criterion."
END_OBJECT = COLUMN

OBJECT    = COLUMN
   NAME          = INVALID_SINGLE_CH0
   COLUMN_NUMBER = 42
   BYTES         = 4
   DATA_TYPE     = MSB_UNSIGNED_INTEGER
   START_BYTE    = 65760
   DESCRIPTION   = "Single channel 0 out-of-range events."
END_OBJECT = COLUMN

OBJECT    = COLUMN
   NAME          = INVALID_SINGLE_CH1
   COLUMN_NUMBER = 43
   BYTES         = 4
   DATA_TYPE     = MSB_UNSIGNED_INTEGER
   START_BYTE    = 65764
   DESCRIPTION   = "Single channel 1 out-of-range events."
END_OBJECT = COLUMN

OBJECT    = COLUMN
   NAME          = INVALID_COINCIDENT_CH0
   COLUMN_NUMBER = 44
   BYTES         = 4
   DATA_TYPE     = MSB_UNSIGNED_INTEGER
   START_BYTE    = 65768
   DESCRIPTION   = "Channel 0 out-of-range coincidence events."
END_OBJECT = COLUMN

OBJECT    = COLUMN
   NAME          = INVALID_COINCIDENT_CH1
   COLUMN_NUMBER = 45
   BYTES         = 4
```

```
   DATA_TYPE     = MSB_UNSIGNED_INTEGER
   START_BYTE    = 65772
   DESCRIPTION   = "Channel 1 out-of-range coincidence events."
END_OBJECT = COLUMN

OBJECT    = COLUMN
   NAME          = VALID_SINGLE_CH0
   COLUMN_NUMBER = 46
   BYTES         = 4
   DATA_TYPE     = MSB_UNSIGNED_INTEGER
   START_BYTE    = 65776
   DESCRIPTION   = "Single channel 0 valid events only."
END_OBJECT = COLUMN

OBJECT    = COLUMN
   NAME          = VALID_COINCIDENT_CH0
   COLUMN_NUMBER = 47
   BYTES         = 4
   DATA_TYPE     = MSB_UNSIGNED_INTEGER
   START_BYTE    = 65780
   DESCRIPTION   = "Coincidence channel 0 valid events."
END_OBJECT = COLUMN

OBJECT    = COLUMN
   NAME          = VALID_SINGLE_CH1
   COLUMN_NUMBER = 48
   BYTES         = 4
   DATA_TYPE     = MSB_UNSIGNED_INTEGER
   START_BYTE    = 65784
   DESCRIPTION   = "Single channel 1 valid events only."
END_OBJECT = COLUMN

OBJECT    = COLUMN
   NAME          = VALID_COINCIDENT_CH1
   COLUMN_NUMBER = 49
   BYTES         = 4
   DATA_TYPE     = MSB_UNSIGNED_INTEGER
   START_BYTE    = 65788
   DESCRIPTION   = "Coincidence channel 1 valid events."
END_OBJECT = COLUMN

OBJECT    = COLUMN
   NAME          = ALL_VALID_COINCIDENT
   COLUMN_NUMBER = 50
   BYTES         = 4
   DATA_TYPE     = MSB_UNSIGNED_INTEGER
   START_BYTE    = 65792
   DESCRIPTION   = "All valid coincidence events - both Channel 0 and Channel
    1 valid."
END_OBJECT = COLUMN

OBJECT    = COLUMN
   NAME          = INVERTED_CH0
   COLUMN_NUMBER = 51
   BYTES         = 4
   DATA_TYPE     = MSB_UNSIGNED_INTEGER
   START_BYTE    = 65796
   DESCRIPTION   = "Channel 0 events flagged 'inverted' by the hardware."
END_OBJECT = COLUMN

OBJECT    = COLUMN
   NAME          = CH0_PILEUP_REJECT
   COLUMN_NUMBER = 52
   BYTES         = 4
   DATA_TYPE     = MSB_UNSIGNED_INTEGER
   START_BYTE    = 65800
   DESCRIPTION   = "Channel 0 pileup rejected events. Only if pileup rejection
    is enabled."
END_OBJECT = COLUMN

OBJECT    = COLUMN
```

```
   NAME          = FIFO_FULL_COUNT
   COLUMN_NUMBER = 53
   BYTES         = 4
   DATA_TYPE     = MSB_UNSIGNED_INTEGER
   START_BYTE    = 65804
   DESCRIPTION   = "Hardware FIFO full flag tested for all events."
END_OBJECT = COLUMN

OBJECT    = COLUMN
   NAME          = PULSER_ENERGY_SUM
   COLUMN_NUMBER = 54
   BYTES         = 4
   DATA_TYPE     = MSB_INTEGER
   START_BYTE    = 65808
   DESCRIPTION   = "Pulser energy sum. Summation of (Pulser Energy - Offset)."
END_OBJECT = COLUMN

OBJECT    = COLUMN
   NAME          = PULSER_ENERGY_SUM2
   COLUMN_NUMBER = 55
   BYTES         = 4
   DATA_TYPE     = MSB_UNSIGNED_INTEGER
   START_BYTE    = 65812
   DESCRIPTION   = "Pulser energy sum squared. Summation of square of
    (Pulser Energy - Offset)."
END_OBJECT = COLUMN

OBJECT    = COLUMN
   NAME          = PULSER_EVENTS
   COLUMN_NUMBER = 56
   BYTES         = 4
   DATA_TYPE     = MSB_UNSIGNED_INTEGER
   START_BYTE    = 65816
   DESCRIPTION   = "Number of valid pulser events."
END_OBJECT = COLUMN

OBJECT    = COLUMN
   NAME          = INVALID_PULSER_EVENTS
   COLUMN_NUMBER = 57
   BYTES         = 4
   DATA_TYPE     = MSB_UNSIGNED_INTEGER
   START_BYTE    = 65820
   DESCRIPTION   = "Out-of-range pulser events."
END_OBJECT = COLUMN

OBJECT    = COLUMN
   NAME          = NEUTRON_EVENTS
   COLUMN_NUMBER = 58
   BYTES         = 4
   DATA_TYPE     = MSB_UNSIGNED_INTEGER
   START_BYTE    = 65824
   DESCRIPTION   = "Coincidence events that meet neutron criterion."
END_OBJECT = COLUMN

OBJECT    = COLUMN
   NAME          = PULSER_OFFSET
   COLUMN_NUMBER = 59
   BYTES         = 4
   DATA_TYPE     = MSB_UNSIGNED_INTEGER
   START_BYTE    = 65828
   DESCRIPTION   = "Pulser energy offset used to form PULSER_ENERGY_SUM
    and PULSER_ENERGY_SUM2."
END_OBJECT = COLUMN
```

8.7.3 Appendix: GRS_CAL_SH.FMT

```
OBJECT     = COLUMN
   NAME          = MET
   COLUMN_NUMBER = 1
   BYTES         = 4
   DATA_TYPE     = MSB_UNSIGNED_INTEGER
   START_BYTE    = 1
   UNIT          = Seconds
   DESCRIPTION   = "Mission elapsed time, in seconds, corresponding to the
    start of the accumulation period for the spectra."
END_OBJECT = COLUMN

OBJECT     = COLUMN
   NAME          = ACCUM_TIME
   COLUMN_NUMBER = 2
   BYTES         = 4
   DATA_TYPE     = MSB_UNSIGNED_INTEGER
   START_BYTE    = 5
   UNIT          = Seconds
   DESCRIPTION   = "Accumulation time, in seconds, of the Shield detector."
END_OBJECT = COLUMN

OBJECT     = COLUMN
   NAME          = MIDPOINT_MET
   COLUMN_NUMBER = 3
   BYTES         = 4
   DATA_TYPE     = MSB_UNSIGNED_INTEGER
   START_BYTE    = 9
   UNIT          = Seconds
   DESCRIPTION   = "The mission elapsed time at the midpoint of the shield Raw
    observation. Defined as:
    MET at the start of the observation + (ACCUM_TIME / 2)."
END_OBJECT = COLUMN

OBJECT     = COLUMN
   NAME          = ORBIT_NUMBER
   COLUMN_NUMBER = 4
   BYTES         = 2
   DATA_TYPE     = MSB_UNSIGNED_INTEGER
   START_BYTE    = 13
   DESCRIPTION   = "Orbit number is a unique identifier for a given orbit of
    the MESSENGER spacecraft around Mercury. Orbit number is defined as
    starting at apoherm and is calculated using the MET value and the
    appropriate SPICE kernels. Orbit numbering does not start until MESSENGER
    performs the Mercury orbit insertion. Until that time the value for orbit
    Number is 0."
END_OBJECT = COLUMN

OBJECT     = COLUMN
   NAME          = START_BIN
   COLUMN_NUMBER = 5
   BYTES         = 2
   DATA_TYPE     = MSB_UNSIGNED_INTEGER
   START_BYTE    = 15
   DESCRIPTION   = "Start Bin of the Shield detector."
END_OBJECT = COLUMN

OBJECT     = COLUMN
   NAME          = NUMBER_OF_BINS
   COLUMN_NUMBER = 6
   BYTES         = 2
   DATA_TYPE     = MSB_UNSIGNED_INTEGER
   START_BYTE    = 17
   DESCRIPTION   = "Number of bins in the raw spectra."
END_OBJECT = COLUMN

OBJECT     = COLUMN
   NAME          = GRS_PRIORITY_LEVEL
```

```
   COLUMN_NUMBER = 7
   BYTES         = 2
   DATA_TYPE     = MSB_UNSIGNED_INTEGER
   START_BYTE    = 19
   DESCRIPTION   = "Indicates the type of priority assigned to the science
    packet. The priority level is tied to the ApID of the packet. Priority
    level varies from 0-3, 0 being highest and 3 being lowest priority."
END_OBJECT = COLUMN

OBJECT     = COLUMN
   NAME          = BAD_DATA_FLAG
   COLUMN_NUMBER = 8
   BYTES         = 2
   DATA_TYPE     = MSB_UNSIGNED_INTEGER
   START_BYTE    = 21
   DESCRIPTION   = "Intended for use as a bit-string bad data flag to
    indicate specific problems associated with the data. Values are expected
    to be assigned to specific bits as problems are identified during the
    course of the mission.
    Bit 1 - The high voltage is not on, is being ramped or has not
            been stable long enough.
    Bit 2 - Indicates a change in the analog pulse processing system
            gain setting.
    Bit 3 - Indicates a spectrum where the temperatures used for
            correction have fluctuated by greater than 5 percent
            from previous readings.
    Bit 4 - Indicates gamma spectra collected during a solar
            particle event. These spectra should not be combined
            with spectra collected under normal solar conditions.
    Bit 5 - Pulser data is not combined with the spectrum.
    Bit 6 - Indicates gamma spectra collected during a solar flare
            event. These spectra should not be combined with spectra
            collected under normal solar conditions.
    Bit 7 - Indicates gamma spectra collected during periods of
            decreased GS detector spectral resolution. These spectra
            should not be combined with spectra collected under
            'normal' detector conditions.
    Bit 8 - Not all data channels were received on the ground.
    Bit 9 - Indicates a unique problem with single spectrum.
    Bit 10 - The high voltage has not been stable long enough.
    Bit 11 - This data was taken during a time when the spectra
             were particularly noisy. Many channels have far too
             many counts, especially the lower channels."
END_OBJECT = COLUMN

OBJECT     = COLUMN
   NAME          = CAL_SH
   COLUMN_NUMBER = 9
   BYTES         = 4096
   DATA_TYPE     = IEEE_REAL
   START_BYTE    = 23
   ITEMS         = 1024
   ITEM_BYTES    = 4
   DESCRIPTION   = "Spectra of light pulses produced from interaction of a
    gamma ray with the plastic scintillator shield. Contains the corrected
    counts in each of the 1024 bins after 1 accumulation period."
END_OBJECT = COLUMN

OBJECT     = COLUMN
   NAME          = UTC_MIDPOINT_MET
   COLUMN_NUMBER = 10
   BYTES         = 23
   DATA_TYPE     = CHARACTER
   START_BYTE    = 4119
   DESCRIPTION   = "midpoint_met converted to UTC, stored as
    yyyy-mm-ddThh:mm:ss.sss."
END_OBJECT = COLUMN

OBJECT     = COLUMN
   NAME          = MERCURY_CENTRIC_LATITUDE
   COLUMN_NUMBER = 11
```

```
   BYTES          = 8
   DATA_TYPE      = IEEE_REAL
   START_BYTE     = 4142
   UNIT           = DEGREE
   DESCRIPTION    = "Sub spacecraft latitude in Mercury fixed coordinates
    at the middle of the collection interval."
END_OBJECT = COLUMN

OBJECT     = COLUMN
   NAME           = MERCURY_CENTRIC_LONGITUDE
   COLUMN_NUMBER = 12
   BYTES          = 8
   DATA_TYPE      = IEEE_REAL
   START_BYTE     = 4150
   UNIT           = DEGREE
   DESCRIPTION    = "Sub spacecraft longitude in Mercury fixed coordinates at
    the middle of the collection interval. Longitude increases towards the
    East."
END_OBJECT = COLUMN

OBJECT     = COLUMN
   NAME           = INSTR_BORESIGHT_MERCURY_X
   COLUMN_NUMBER = 13
   BYTES          = 8
   DATA_TYPE      = IEEE_REAL
   START_BYTE     = 4158
   UNIT           = Kilometers
   DESCRIPTION    = "Sub instrument boresight (x component) in Mercury fixed
    coordinates at the middle of the collection interval."
END_OBJECT = COLUMN

OBJECT     = COLUMN
   NAME           = INSTR_BORESIGHT_MERCURY_Y
   COLUMN_NUMBER = 14
   BYTES          = 8
   DATA_TYPE      = IEEE_REAL
   START_BYTE     = 4166
   UNIT           = Kilometers
   DESCRIPTION    = "Sub instrument boresight (y component) in Mercury fixed
    coordinates at the middle of the collection interval."
END_OBJECT = COLUMN

OBJECT     = COLUMN
   NAME           = INSTR_BORESIGHT_MERCURY_Z
   COLUMN_NUMBER = 15
   BYTES          = 8
   DATA_TYPE      = IEEE_REAL
   START_BYTE     = 4174
   UNIT           = Kilometers
   DESCRIPTION    = "Sub instrument boresight (z component) in Mercury fixed
    coordinates at the middle of the collection interval."
END_OBJECT = COLUMN

OBJECT     = COLUMN
   NAME           = SCALT
   COLUMN_NUMBER = 16
   BYTES          = 8
   DATA_TYPE      = IEEE_REAL
   START_BYTE     = 4182
   UNIT           = Kilometers
   DESCRIPTION    = "Mercury centric altitude of the sub-spacecraft point
    in Mercury-fixed rotating frame at the middle of the collection
    interval."
END_OBJECT = COLUMN

OBJECT     = COLUMN
   NAME           = DELTA_ANGLE
   COLUMN_NUMBER = 17
   BYTES          = 8
   DATA_TYPE      = IEEE_REAL
   START_BYTE     = 4190
```

```
   UNIT          = DEGREE
   DESCRIPTION   = "Difference between instrument +y direction and true north
    at the middle of the collection interval."
END_OBJECT = COLUMN

OBJECT     = COLUMN
   NAME          = MERCURY_SOL
   COLUMN_NUMBER = 18
   BYTES         = 8
   DATA_TYPE     = IEEE_REAL
   START_BYTE    = 4198
   UNIT          = DEGREE
   DESCRIPTION   = "Longitude of the Sun at 0 hours UT on the date of the
    record. Taken from the Association of Lunar and Planetary Observers
    'Ephemeris for Physical Observation of Mercury'."
END_OBJECT = COLUMN

OBJECT     = COLUMN
   NAME          = LOCAL_HOUR
   COLUMN_NUMBER = 19
   BYTES         = 1
   DATA_TYPE     = MSB_UNSIGNED_INTEGER
   START_BYTE    = 4206
   UNIT          = Hours
   DESCRIPTION   = "Local Sun hour at the sub-spacecraft point."
END_OBJECT = COLUMN

OBJECT     = COLUMN
   NAME          = LOCAL_MINUTE
   COLUMN_NUMBER = 20
   BYTES         = 1
   DATA_TYPE     = MSB_UNSIGNED_INTEGER
   START_BYTE    = 4207
   UNIT          = Minutes
   DESCRIPTION   = "Local Sun minute at the sub-spacecraft point."
END_OBJECT = COLUMN

OBJECT     = COLUMN
   NAME          = POINTING
   COLUMN_NUMBER = 21
   BYTES         = 1
   DATA_TYPE     = BOOLEAN
   START_BYTE    = 4208
   DESCRIPTION   = "True if pointing data was available."
END_OBJECT = COLUMN

OBJECT     = COLUMN
   NAME          = INTERSECTING
   COLUMN_NUMBER = 22
   BYTES         = 1
   DATA_TYPE     = BOOLEAN
   START_BYTE    = 4209
   DESCRIPTION   = "True if the pointing vector intersects Mercury."
END_OBJECT = COLUMN

OBJECT     = COLUMN
   NAME          = NADIR_ANGLE
   COLUMN_NUMBER = 23
   BYTES         = 8
   DATA_TYPE     = IEEE_REAL
   START_BYTE    = 4210
   UNIT          = DEGREE
   DESCRIPTION = "Spacecraft attitude during orbits and flybys is
   defined by two additional coordinate systems, the GRS LVLH
   (Local Vertical Local Horizontal) frame and the spacecraft fixed
   frame, and by the rotation of the spacecraft frame with respect
   to the GRS LVLH frame. In the GRS LVLH frame, the Z axis is
   aligned with the vector from the spacecraft to the planet center
   (the nadir direction), the Y axis is the negative of the cross
   product of the position and velocity vectors, and the X axis
   points in the instantaneous direction of motion, completing a
```

```
   right-handed coordinate system. The Z axis is along the viewing
   direction of the instrument deck inside the adapter ring and of
   the GRS just outside the adapter ring, the Y axis is directed from
   the spacecraft along the magnetometer boom, and the X-axis is
   parallel to the solar panel booms, forming a right-handed
   coordinate system.  The spacecraft attitude is specified by the
   rotation of the spacecraft fixed frame Z axis in the GRS LVLH frame
   and a twist angle about the Z axis. The Z axis rotation is given by
   a nadir angle and an azimuth angle, where the nadir angle is 0
   degrees when the spacecraft Z axis points along the + Z LVLH axis
   and 180 degrees when it points along -Z in the LVLH frame, and the
   LVLH azimuth angle is measured counterclockwise about the Z LVLH
   axis from the X LVLH axis. The twist angle is measured positive
   about the +Z spacecraft axis. See section 5.4.2 in the GRS_CDR_SIS
   for further details."
END_OBJECT = COLUMN

OBJECT     = COLUMN
   NAME          = AZIMUTH
   COLUMN_NUMBER = 24
   BYTES         = 8
   DATA_TYPE     = IEEE_REAL
   START_BYTE    = 4218
   UNIT          = DEGREE
   DESCRIPTION = "Spacecraft attitude during orbits and flybys is
   defined by two additional coordinate systems, the GRS LVLH
   (Local Vertical Local Horizontal) frame and the spacecraft fixed
   frame, and by the rotation of the spacecraft frame with respect
   to the GRS LVLH frame. In the GRS LVLH frame, the Z axis is
   aligned with the vector from the spacecraft to the planet center
   (the nadir direction), the Y axis is the negative of the cross
   product of the position and velocity vectors, and the X axis
   points in the instantaneous direction of motion, completing a
   right-handed coordinate system. The Z axis is along the viewing
   direction of the instrument deck inside the adapter ring and of
   the GRS just outside the adapter ring, the Y axis is directed from
   the spacecraft along the magnetometer boom, and the X-axis is
   parallel to the solar panel booms, forming a right-handed
   coordinate system.  The spacecraft attitude is specified by the
   rotation of the spacecraft fixed frame Z axis in the GRS LVLH frame
   and a twist angle about the Z axis. The Z axis rotation is given by
   a nadir angle and an azimuth angle, where the nadir angle is 0
   degrees when the spacecraft Z axis points along the + Z LVLH axis
   and 180 degrees when it points along -Z in the LVLH frame, and the
   LVLH azimuth angle is measured counterclockwise about the Z LVLH
   axis from the X LVLH axis. The twist angle is measured positive
   about the +Z spacecraft axis. See section 5.4.2 in the GRS_CDR_SIS
   for further details."
END_OBJECT = COLUMN

OBJECT     = COLUMN
   NAME          = TWIST_ANGLE
   COLUMN_NUMBER = 25
   BYTES         = 8
   DATA_TYPE     = IEEE_REAL
   START_BYTE    = 4226
   UNIT          = DEGREE
   DESCRIPTION = "Spacecraft attitude during orbits and flybys is
   defined by two additional coordinate systems, the GRS LVLH
   (Local Vertical Local Horizontal) frame and the spacecraft fixed
   frame, and by the rotation of the spacecraft frame with respect
   to the GRS LVLH frame. In the GRS LVLH frame, the Z axis is
   aligned with the vector from the spacecraft to the planet center
   (the nadir direction), the Y axis is the negative of the cross
   product of the position and velocity vectors, and the X axis
   points in the instantaneous direction of motion, completing a
   right-handed coordinate system. The Z axis is along the viewing
   direction of the instrument deck inside the adapter ring and of
   the GRS just outside the adapter ring, the Y axis is directed from
   the spacecraft along the magnetometer boom, and the X-axis is
   parallel to the solar panel booms, forming a right-handed
```

```
   coordinate system.  The spacecraft attitude is specified by the
   rotation of the spacecraft fixed frame Z axis in the GRS LVLH frame
   and a twist angle about the Z axis. The Z axis rotation is given by
   a nadir angle and an azimuth angle, where the nadir angle is 0
   degrees when the spacecraft Z axis points along the + Z LVLH axis
   and 180 degrees when it points along -Z in the LVLH frame, and the
   LVLH azimuth angle is measured counterclockwise about the Z LVLH
   axis from the X LVLH axis. The twist angle is measured positive
   about the +Z spacecraft axis. See section 5.4.2 in the GRS_CDR_SIS
   for further details."
END_OBJECT = COLUMN

OBJECT     = COLUMN
   NAME          = AD_TEMP
   COLUMN_NUMBER = 26
   BYTES         = 8
   DATA_TYPE     = IEEE_REAL
   START_BYTE    = 4234
   UNIT          = DEGC
   DESCRIPTION   = "Channel 06, AD Temperature,
    smoothed and interpolated to the center of the collection interval."
END_OBJECT = COLUMN

OBJECT     = COLUMN
   NAME          = HVPS_TEMP
   COLUMN_NUMBER = 27
   BYTES         = 8
   DATA_TYPE     = IEEE_REAL
   START_BYTE    = 4242
   UNIT          = DEGC
   DESCRIPTION   = "HVPS Temperature,
    smoothed and interpolated to the center of the collection interval."
END_OBJECT = COLUMN

OBJECT     = COLUMN
   NAME          = HVPS_VOLT
   COLUMN_NUMBER = 28
   BYTES         = 8
   DATA_TYPE     = IEEE_REAL
   START_BYTE    = 4250
   UNIT          = Volts
   DESCRIPTION   = "HVPS Voltage,
    smoothed and interpolated to the center of the collection interval."
END_OBJECT = COLUMN

OBJECT     = COLUMN
   NAME          = HVPS_REF_VOLT
   COLUMN_NUMBER = 29
   BYTES         = 8
   DATA_TYPE     = IEEE_REAL
   START_BYTE    = 4258
   UNIT          = Volts
   DESCRIPTION   = "HVPS Reference Voltage,
    smoothed and interpolated to the center of the collection interval."
END_OBJECT = COLUMN

OBJECT     = COLUMN
   NAME          = PREAMP_TEMP
   COLUMN_NUMBER = 30
   BYTES         = 8
   DATA_TYPE     = IEEE_REAL
   START_BYTE    = 4266
   UNIT          = DEGC
   DESCRIPTION   = "Channel 04, Pre Amp Temperature,
    smoothed and interpolated to the center of the collection interval."
END_OBJECT = COLUMN

OBJECT     = COLUMN
   NAME          = SHAPER_TEMP
   COLUMN_NUMBER = 31
   BYTES         = 8
```

```
   DATA_TYPE     = IEEE_REAL
   START_BYTE    = 4274
   UNIT          = DEGC
   DESCRIPTION   = "Channel 05, Shaper Temperature,
    smoothed and interpolated to the center of the collection interval."
END_OBJECT = COLUMN

OBJECT     = COLUMN
   NAME          = HV_MONITOR
   COLUMN_NUMBER = 32
   BYTES         = 8
   DATA_TYPE     = IEEE_REAL
   START_BYTE    = 4282
   UNIT          = Volts
   DESCRIPTION   = "Channel 07, HV Monitor,
    smoothed and interpolated to the center of the collection interval."
END_OBJECT = COLUMN

OBJECT     = COLUMN
   NAME          = HPGE_RAW_EVENTS
   COLUMN_NUMBER = 33
   BYTES         = 4
   DATA_TYPE     = MSB_UNSIGNED_INTEGER
   START_BYTE    = 4290
   DESCRIPTION   = "Counter of HPGe Raw events."
END_OBJECT = COLUMN

OBJECT     = COLUMN
   NAME          = SHIELD_RAW_EVENTS
   COLUMN_NUMBER = 34
   BYTES         = 4
   DATA_TYPE     = MSB_UNSIGNED_INTEGER
   START_BYTE    = 4294
   DESCRIPTION   = "Counter for SHIELD raw events."
END_OBJECT = COLUMN

OBJECT     = COLUMN
   NAME          = ACCUMULATED_DEAD_TIME
   COLUMN_NUMBER = 35
   BYTES         = 4
   DATA_TYPE     = MSB_UNSIGNED_INTEGER
   START_BYTE    = 4298
   DESCRIPTION   = "Counter for accumulated dead time."
END_OBJECT = COLUMN
```

8.7.4 Appendix: GRS_CAL_SH2.FMT

```
OBJECT     = COLUMN
   NAME          = MET
   COLUMN_NUMBER = 1
   BYTES         = 4
   DATA_TYPE     = MSB_UNSIGNED_INTEGER
   START_BYTE    = 1
   UNIT          = Seconds
   DESCRIPTION   = "Mission elapsed time, in seconds, corresponding to the
    start of the accumulation period for the spectra."
END_OBJECT = COLUMN

OBJECT     = COLUMN
   NAME          = ACCUM_TIME
   COLUMN_NUMBER = 2
   BYTES         = 4
   DATA_TYPE     = MSB_UNSIGNED_INTEGER
   START_BYTE    = 5
   UNIT          = Seconds
   DESCRIPTION   = "Accumulation time, in seconds, of the Shield detector."
END_OBJECT = COLUMN

OBJECT     = COLUMN
   NAME          = MIDPOINT_MET
   COLUMN_NUMBER = 3
   BYTES         = 4
   DATA_TYPE     = MSB_UNSIGNED_INTEGER
   START_BYTE    = 9
   UNIT          = Seconds
   DESCRIPTION   = "The mission elapsed time at the midpoint of the shield Raw
    observation. Defined as:
    MET at the start of the observation + (ACCUM_TIME / 2)."
END_OBJECT = COLUMN

OBJECT     = COLUMN
   NAME          = ORBIT_NUMBER
   COLUMN_NUMBER = 4
   BYTES         = 2
   DATA_TYPE     = MSB_UNSIGNED_INTEGER
   START_BYTE    = 13
   DESCRIPTION   = "Orbit number is a unique identifier for a given orbit of
    the MESSENGER spacecraft around Mercury. Orbit number is defined as
    starting at apoherm and is calculated using the MET value and the
    appropriate SPICE kernels. Orbit numbering does not start until MESSENGER
    performs the Mercury orbit insertion. Until that time the value for orbit
    Number is 0."
END_OBJECT = COLUMN

OBJECT     = COLUMN
   NAME          = INITIAL_ENERGY
   COLUMN_NUMBER = 5
   BYTES         = 4
   DATA_TYPE     = IEEE_REAL
   START_BYTE    = 15
   DESCRIPTION   = "The energy of the middle of the first bin of the FAST
    and THERMAL NEURTON HPGE spectra."
END_OBJECT = COLUMN

OBJECT     = COLUMN
   NAME          = GRS_PRIORITY_LEVEL
   COLUMN_NUMBER = 6
   BYTES         = 2
   DATA_TYPE     = MSB_UNSIGNED_INTEGER
   START_BYTE    = 19
   DESCRIPTION   = "Indicates the type of priority assigned to the science
    packet. The priority level is tied to the ApID of the packet. Priority
    level varies from 0-3, 0 being highest and 3 being lowest priority."
END_OBJECT = COLUMN
```

```
OBJECT     = COLUMN
   NAME          = BAD_DATA_FLAG
   COLUMN_NUMBER = 7
   BYTES         = 2
   DATA_TYPE     = MSB_UNSIGNED_INTEGER
   START_BYTE    = 21
   DESCRIPTION   = "Intended for use as a bit-string bad data flag to
    indicate specific problems associated with the data. Values are expected
    to be assigned to specific bits as problems are identified during the
    course of the mission.
    Bit 1 - The high voltage is not on, is being ramped or has not
            been stable long enough.
    Bit 2 - Indicates a change in the analog pulse processing system
            gain setting.
    Bit 3 - Indicates a spectrum where the temperatures used for
            correction have fluctuated by greater than 5 percent
            from previous readings.
    Bit 4 - Indicates gamma spectra collected during a solar
            particle event. These spectra should not be combined
            with spectra collected under normal solar conditions.
    Bit 5 - Pulser data is not combined with the spectrum.
    Bit 6 - Indicates gamma spectra collected during a solar flare
            event. These spectra should not be combined with spectra
            collected under normal solar conditions.
    Bit 7 - Indicates gamma spectra collected during periods of
            decreased GS detector spectral resolution. These spectra
            should not be combined with spectra collected under
            'normal' detector conditions.
    Bit 8 - Not all data channels were received on the ground.
    Bit 9 - Indicates a unique problem with single spectrum.
    Bit 10 - The high voltage has not been stable long enough.
    Bit 11 - This data was taken during a time when the spectra
             were particularly noisy. Many channels have far too
             many counts, especially the lower channels."
END_OBJECT = COLUMN

OBJECT     = COLUMN
   NAME          = NUM_BUFFERED_EVENTS
   COLUMN_NUMBER = 8
   BYTES         = 2
   DATA_TYPE     = MSB_UNSIGNED_INTEGER
   START_BYTE    = 23
   DESCRIPTION   = "The number of bytes in the raw event buffer. The number of
    events in the raw event buffer is (Raw Bytes-16)/8.  The number of raw
    events in the buffer will range from 0 to 126.  Note there must be at
    least one event in the buffer before the Event Buffer Header will be
    generated."
END_OBJECT = COLUMN

OBJECT     = COLUMN
   NAME          = NUM_RAW_EVENTS
   COLUMN_NUMBER = 9
   BYTES         = 2
   DATA_TYPE     = MSB_UNSIGNED_INTEGER
   START_BYTE    = 25
   DESCRIPTION   = "This value contains a count of the total number of raw
    events detected and is not limited by the length of the buffer. This
    counter will rollover if the count exceeds 65535."
END_OBJECT = COLUMN

OBJECT     = COLUMN
   NAME          = ZCT_THERMAL_MIN
   COLUMN_NUMBER = 10
   BYTES         = 2
   DATA_TYPE     = MSB_UNSIGNED_INTEGER
   START_BYTE    = 27
   DESCRIPTION   = "Window parameter that sets the minimum acceptable time
    difference between shield and HpGe triggers for an event to be considered
    a thermal neutron.  Units are 100 ns/tick.  Parameter is inclusive,
    i.e., values equal to this parameter are accepted."
END_OBJECT = COLUMN
```

```
OBJECT     = COLUMN
   NAME          = ZCT_THERM_MAX
   COLUMN_NUMBER = 11
   BYTES         = 2
   DATA_TYPE     = MSB_UNSIGNED_INTEGER
   START_BYTE    = 29
   DESCRIPTION   = "Window parameter that sets the maximum acceptable time
    difference between shield and HpGe triggers for an event to be considered
    a thermal neutron. Units are 100 ns/tick.  Parameter is exclusive,
    i.e., values equal to this parameter are rejected"
END_OBJECT = COLUMN

OBJECT     = COLUMN
   NAME          = ZCT_FAST_MIN
   COLUMN_NUMBER = 12
   BYTES         = 2
   DATA_TYPE     = MSB_UNSIGNED_INTEGER
   START_BYTE    = 31
   DESCRIPTION   = "Window parameter that sets the minimum acceptable time
    difference between shield and HpGe triggers for an event to be considered
    a fast neutron. Units are 100 ns/tick.  Parameter is inclusive,
    i.e., values equal to this parameter are accepted."
END_OBJECT = COLUMN

OBJECT     = COLUMN
   NAME          = ZCT_FAST_MAX
   COLUMN_NUMBER = 13
   BYTES         = 2
   DATA_TYPE     = MSB_UNSIGNED_INTEGER
   START_BYTE    = 33
   DESCRIPTION   = "Window parameter that sets the maximum time difference
    between shield and HpGe triggers for an event to be considered a fast
    neutron. Units are 100 ns/tick.  Parameter is exclusive,
    i.e., values equal to this parameter are rejected."
END_OBJECT = COLUMN

OBJECT     = COLUMN
   NAME          = SHIELD_SHIFTS_RAW
   COLUMN_NUMBER = 14
   BYTES         = 2
   DATA_TYPE     = MSB_UNSIGNED_INTEGER
   START_BYTE    = 35
   DESCRIPTION   = "The number of right shifts (divide by 2s) that are
    applied to raw shield pulse heights prior to binning in the Shield
    All Events spectrum.  Possible values are 2 or 3.  A value of two
    effectively increases the binning resolution but decreases the dynamic
    range (maximum binned energy)."
END_OBJECT = COLUMN

OBJECT     = COLUMN
   NAME          = SHIELD_SHIFTS_NEUTRON
   COLUMN_NUMBER = 15
   BYTES         = 2
   DATA_TYPE     = MSB_UNSIGNED_INTEGER
   START_BYTE    = 37
   DESCRIPTION   = "The number of right shifts (divide by 2s) that are
    applied to raw shield pulse heights prior to binning in either the
    Shield Thermal Events spectrum or the Shield Fast Events spectrum.
    Possible values are 2 or 3.  A value of two effectively increases
    the binning resolution but decreases the dynamic range (maximum
    binned energy)."
END_OBJECT = COLUMN

OBJECT     = COLUMN
   NAME          = HPGE_THERMAL
   COLUMN_NUMBER = 16
   BYTES         = 256
   DATA_TYPE     = IEEE_REAL
   START_BYTE    = 39
   ITEMS         = 64
```

```
   ITEM_BYTES    = 4
   DESCRIPTION   = "Thermal Neutron spectrum about the 478-keV line,
    normalized to 0.60 keV energy bins."
END_OBJECT = COLUMN

OBJECT     = COLUMN
   NAME          = HPGE_FAST
   COLUMN_NUMBER = 17
   BYTES         = 256
   DATA_TYPE     = IEEE_REAL
   START_BYTE    = 295
   ITEMS         = 64
   ITEM_BYTES    = 4
   DESCRIPTION   = "Fast Neutron spectrum about the 478-keV line,
    normalized to 0.60 keV energy bins."
END_OBJECT = COLUMN

OBJECT     = COLUMN
   NAME          = SHIELD_THERMAL
   COLUMN_NUMBER = 18
   BYTES         = 256
   DATA_TYPE     = MSB_UNSIGNED_INTEGER
   START_BYTE    = 551
   ITEMS         = 128
   ITEM_BYTES    = 2
   DESCRIPTION   = "Raw Thermal Neutron spectrum about the 478-keV line."
END_OBJECT = COLUMN

OBJECT     = COLUMN
   NAME          = SHIELD_FAST
   COLUMN_NUMBER = 19
   BYTES         = 256
   DATA_TYPE     = MSB_UNSIGNED_INTEGER
   START_BYTE    = 807
   ITEMS         = 128
   ITEM_BYTES    = 2
   DESCRIPTION   = "Raw Fast Neutron spectrum about the 478-keV line."
END_OBJECT = COLUMN

OBJECT     = COLUMN
   NAME          = UTC_MIDPOINT_MET
   COLUMN_NUMBER = 20
   BYTES         = 23
   DATA_TYPE     = CHARACTER
   START_BYTE    = 1063
   DESCRIPTION   = "midpoint_met converted to UTC, stored as
    yyyy-mm-ddThh:mm:ss.sss."
END_OBJECT = COLUMN

OBJECT     = COLUMN
   NAME          = MERCURY_CENTRIC_LATITUDE
   COLUMN_NUMBER = 21
   BYTES         = 8
   DATA_TYPE     = IEEE_REAL
   START_BYTE    = 1086
   UNIT          = DEGREE
   DESCRIPTION   = "Sub spacecraft latitude in Mercury fixed coordinates
    at the middle of the collection interval."
END_OBJECT = COLUMN

OBJECT     = COLUMN
   NAME          = MERCURY_CENTRIC_LONGITUDE
   COLUMN_NUMBER = 22
   BYTES         = 8
   DATA_TYPE     = IEEE_REAL
   START_BYTE    = 1094
   UNIT          = DEGREE
   DESCRIPTION   = "Sub spacecraft longitude in Mercury fixed coordinates at
    the middle of the collection interval. Longitude increases towards the
    East."
END_OBJECT = COLUMN
```

```
OBJECT     = COLUMN
   NAME          = INSTR_BORESIGHT_MERCURY_X
   COLUMN_NUMBER = 23
   BYTES         = 8
   DATA_TYPE     = IEEE_REAL
   START_BYTE    = 1102
   UNIT          = Kilometers
   DESCRIPTION   = "Sub instrument boresight (x component) in Mercury fixed
    coordinates at the middle of the collection interval."
END_OBJECT = COLUMN

OBJECT     = COLUMN
   NAME          = INSTR_BORESIGHT_MERCURY_Y
   COLUMN_NUMBER = 24
   BYTES         = 8
   DATA_TYPE     = IEEE_REAL
   START_BYTE    = 1110
   UNIT          = Kilometers
   DESCRIPTION   = "Sub instrument boresight (y component) in Mercury fixed
    coordinates at the middle of the collection interval."
END_OBJECT = COLUMN

OBJECT     = COLUMN
   NAME          = INSTR_BORESIGHT_MERCURY_Z
   COLUMN_NUMBER = 25
   BYTES         = 8
   DATA_TYPE     = IEEE_REAL
   START_BYTE    = 1118
   UNIT          = Kilometers
   DESCRIPTION   = "Sub instrument boresight (z component) in Mercury fixed
    coordinates at the middle of the collection interval."
END_OBJECT = COLUMN

OBJECT     = COLUMN
   NAME          = SCALT
   COLUMN_NUMBER = 26
   BYTES         = 8
   DATA_TYPE     = IEEE_REAL
   START_BYTE    = 1126
   UNIT          = Kilometers
   DESCRIPTION   = "Mercury centric altitude of the sub-spacecraft point
    in Mercury-fixed rotating frame at the middle of the collection
    interval."
END_OBJECT = COLUMN

OBJECT     = COLUMN
   NAME          = DELTA_ANGLE
   COLUMN_NUMBER = 27
   BYTES         = 8
   DATA_TYPE     = IEEE_REAL
   START_BYTE    = 1134
   UNIT          = DEGREE
   DESCRIPTION   = "Difference between instrument +y direction and true north
    at the middle of the collection interval."
END_OBJECT = COLUMN

OBJECT     = COLUMN
   NAME          = MERCURY_SOL
   COLUMN_NUMBER = 28
   BYTES         = 8
   DATA_TYPE     = IEEE_REAL
   START_BYTE    = 1142
   UNIT          = DEGREE
   DESCRIPTION   = "Longitude of the Sun at 0 hours UT on the date of the
    record. Taken from the Association of Lunar and Planetary Observers
    'Ephemeris for Physical Observation of Mercury'."
END_OBJECT = COLUMN

OBJECT     = COLUMN
   NAME          = LOCAL_HOUR
```

```
   COLUMN_NUMBER = 29
   BYTES         = 1
   DATA_TYPE     = MSB_UNSIGNED_INTEGER
   START_BYTE    = 1150
   UNIT          = Hours
   DESCRIPTION   = "Local Sun hour at the sub-spacecraft point."
END_OBJECT = COLUMN

OBJECT     = COLUMN
   NAME          = LOCAL_MINUTE
   COLUMN_NUMBER = 30
   BYTES         = 1
   DATA_TYPE     = MSB_UNSIGNED_INTEGER
   START_BYTE    = 1151
   UNIT          = Minutes
   DESCRIPTION   = "Local Sun minute at the sub-spacecraft point."
END_OBJECT = COLUMN

OBJECT     = COLUMN
   NAME          = POINTING
   COLUMN_NUMBER = 31
   BYTES         = 1
   DATA_TYPE     = BOOLEAN
   START_BYTE    = 1152
   DESCRIPTION   = "True if pointing data was available."
END_OBJECT = COLUMN

OBJECT     = COLUMN
   NAME          = INTERSECTING
   COLUMN_NUMBER = 32
   BYTES         = 1
   DATA_TYPE     = BOOLEAN
   START_BYTE    = 1153
   DESCRIPTION   = "True if the pointing vector intersects Mercury."
END_OBJECT = COLUMN

OBJECT     = COLUMN
   NAME          = NADIR_ANGLE
   COLUMN_NUMBER = 33
   BYTES         = 8
   DATA_TYPE     = IEEE_REAL
   START_BYTE    = 1154
   UNIT          = DEGREE
   DESCRIPTION = "Spacecraft attitude during orbits and flybys is
   defined by two additional coordinate systems, the GRS LVLH
   (Local Vertical Local Horizontal) frame and the spacecraft fixed
   frame, and by the rotation of the spacecraft frame with respect
   to the GRS LVLH frame. In the GRS LVLH frame, the Z axis is
   aligned with the vector from the spacecraft to the planet center
   (the nadir direction), the Y axis is the negative of the cross
   product of the position and velocity vectors, and the X axis
   points in the instantaneous direction of motion, completing a
   right-handed coordinate system. The Z axis is along the viewing
   direction of the instrument deck inside the adapter ring and of
   the GRS just outside the adapter ring, the Y axis is directed from
   the spacecraft along the magnetometer boom, and the X-axis is
   parallel to the solar panel booms, forming a right-handed
   coordinate system.  The spacecraft attitude is specified by the
   rotation of the spacecraft fixed frame Z axis in the GRS LVLH frame
   and a twist angle about the Z axis. The Z axis rotation is given by
   a nadir angle and an azimuth angle, where the nadir angle is 0
   degrees when the spacecraft Z axis points along the + Z LVLH axis
   and 180 degrees when it points along -Z in the LVLH frame, and the
   LVLH azimuth angle is measured counterclockwise about the Z LVLH
   axis from the X LVLH axis. The twist angle is measured positive
   about the +Z spacecraft axis. See section 5.4.2 in the GRS_CDR_SIS
   for further details."
END_OBJECT = COLUMN

OBJECT     = COLUMN
   NAME          = AZIMUTH
```

```
   COLUMN_NUMBER = 34
   BYTES         = 8
   DATA_TYPE     = IEEE_REAL
   START_BYTE    = 1162
   UNIT          = DEGREE
   DESCRIPTION = "Spacecraft attitude during orbits and flybys is
   defined by two additional coordinate systems, the GRS LVLH
   (Local Vertical Local Horizontal) frame and the spacecraft fixed
   frame, and by the rotation of the spacecraft frame with respect
   to the GRS LVLH frame. In the GRS LVLH frame, the Z axis is
   aligned with the vector from the spacecraft to the planet center
   (the nadir direction), the Y axis is the negative of the cross
   product of the position and velocity vectors, and the X axis
   points in the instantaneous direction of motion, completing a
   right-handed coordinate system. The Z axis is along the viewing
   direction of the instrument deck inside the adapter ring and of
   the GRS just outside the adapter ring, the Y axis is directed from
   the spacecraft along the magnetometer boom, and the X-axis is
   parallel to the solar panel booms, forming a right-handed
   coordinate system.  The spacecraft attitude is specified by the
   rotation of the spacecraft fixed frame Z axis in the GRS LVLH frame
   and a twist angle about the Z axis. The Z axis rotation is given by
   a nadir angle and an azimuth angle, where the nadir angle is 0
   degrees when the spacecraft Z axis points along the + Z LVLH axis
   and 180 degrees when it points along -Z in the LVLH frame, and the
   LVLH azimuth angle is measured counterclockwise about the Z LVLH
   axis from the X LVLH axis. The twist angle is measured positive
   about the +Z spacecraft axis. See section 5.4.2 in the GRS_CDR_SIS
   for further details."
END_OBJECT = COLUMN

OBJECT     = COLUMN
   NAME          = TWIST_ANGLE
   COLUMN_NUMBER = 35
   BYTES         = 8
   DATA_TYPE     = IEEE_REAL
   START_BYTE    = 1170
   UNIT          = DEGREE
   DESCRIPTION = "Spacecraft attitude during orbits and flybys is
   defined by two additional coordinate systems, the GRS LVLH
   (Local Vertical Local Horizontal) frame and the spacecraft fixed
   frame, and by the rotation of the spacecraft frame with respect
   to the GRS LVLH frame. In the GRS LVLH frame, the Z axis is
   aligned with the vector from the spacecraft to the planet center
   (the nadir direction), the Y axis is the negative of the cross
   product of the position and velocity vectors, and the X axis
   points in the instantaneous direction of motion, completing a
   right-handed coordinate system. The Z axis is along the viewing
   direction of the instrument deck inside the adapter ring and of
   the GRS just outside the adapter ring, the Y axis is directed from
   the spacecraft along the magnetometer boom, and the X-axis is
   parallel to the solar panel booms, forming a right-handed
   coordinate system.  The spacecraft attitude is specified by the
   rotation of the spacecraft fixed frame Z axis in the GRS LVLH frame
   and a twist angle about the Z axis. The Z axis rotation is given by
   a nadir angle and an azimuth angle, where the nadir angle is 0
   degrees when the spacecraft Z axis points along the + Z LVLH axis
   and 180 degrees when it points along -Z in the LVLH frame, and the
   LVLH azimuth angle is measured counterclockwise about the Z LVLH
   axis from the X LVLH axis. The twist angle is measured positive
   about the +Z spacecraft axis. See section 5.4.2 in the GRS_CDR_SIS
   for further details."
END_OBJECT = COLUMN

OBJECT     = COLUMN
   NAME          = AD_TEMP
   COLUMN_NUMBER = 36
   BYTES         = 8
   DATA_TYPE     = IEEE_REAL
   START_BYTE    = 1178
   UNIT          = DEGC
```

```
   DESCRIPTION   = "Channel 06, AD Temperature,
    smoothed and interpolated to the center of the collection interval."
END_OBJECT = COLUMN

OBJECT     = COLUMN
   NAME          = HVPS_TEMP
   COLUMN_NUMBER = 37
   BYTES         = 8
   DATA_TYPE     = IEEE_REAL
   START_BYTE    = 1186
   UNIT          = DEGC
   DESCRIPTION   = "HVPS Temperature,
    smoothed and interpolated to the center of the collection interval."
END_OBJECT = COLUMN

OBJECT     = COLUMN
   NAME          = HVPS_VOLT
   COLUMN_NUMBER = 38
   BYTES         = 8
   DATA_TYPE     = IEEE_REAL
   START_BYTE    = 1194
   UNIT          = Volts
   DESCRIPTION   = "HVPS Voltage,
    smoothed and interpolated to the center of the collection interval."
END_OBJECT = COLUMN

OBJECT     = COLUMN
   NAME          = HVPS_REF_VOLT
   COLUMN_NUMBER = 39
   BYTES         = 8
   DATA_TYPE     = IEEE_REAL
   START_BYTE    = 1202
   UNIT          = Volts
   DESCRIPTION   = "HVPS Reference Voltage,
    smoothed and interpolated to the center of the collection interval."
END_OBJECT = COLUMN

OBJECT     = COLUMN
   NAME          = PREAMP_TEMP
   COLUMN_NUMBER = 40
   BYTES         = 8
   DATA_TYPE     = IEEE_REAL
   START_BYTE    = 1210
   UNIT          = DEGC
   DESCRIPTION   = "Channel 04, Pre Amp Temperature,
    smoothed and interpolated to the center of the collection interval."
END_OBJECT = COLUMN

OBJECT     = COLUMN
   NAME          = SHAPER_TEMP
   COLUMN_NUMBER = 41
   BYTES         = 8
   DATA_TYPE     = IEEE_REAL
   START_BYTE    = 1218
   UNIT          = DEGC
   DESCRIPTION   = "Channel 05, Shaper Temperature,
    smoothed and interpolated to the center of the collection interval."
END_OBJECT = COLUMN

OBJECT     = COLUMN
   NAME          = HV_MONITOR
   COLUMN_NUMBER = 42
   BYTES         = 8
   DATA_TYPE     = IEEE_REAL
   START_BYTE    = 1226
   UNIT          = Volts
   DESCRIPTION   = "Channel 07, HV Monitor,
    smoothed and interpolated to the center of the collection interval."
END_OBJECT = COLUMN

OBJECT     = COLUMN
```

```
   NAME           = HPGE_RAW_EVENTS
   COLUMN_NUMBER = 43
   BYTES          = 4
   DATA_TYPE      = MSB_UNSIGNED_INTEGER
   START_BYTE     = 1234
   DESCRIPTION    = "Counter of HPGe Raw events."
END_OBJECT = COLUMN

OBJECT      = COLUMN
   NAME           = SHIELD_RAW_EVENTS
   COLUMN_NUMBER = 44
   BYTES          = 4
   DATA_TYPE      = MSB_UNSIGNED_INTEGER
   START_BYTE     = 1238
   DESCRIPTION    = "Counter for SHIELD raw events."
END_OBJECT = COLUMN

OBJECT      = COLUMN
   NAME           = ACCUMULATED_DEAD_TIME
   COLUMN_NUMBER = 45
   BYTES          = 4
   DATA_TYPE      = MSB_UNSIGNED_INTEGER
   START_BYTE     = 1242
   DESCRIPTION    = "Counter for accumulated dead time."
END_OBJECT = COLUMN
```

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```
OBJECT        = COLUMN
   NAME           = J2000_ET
   COLUMN_NUMBER  = 1
   BYTES          = 16
   DATA_TYPE      = ASCII_REAL
   START_BYTE     = 1
   UNIT           = SECOND
   FORMAT         = "F16.5"
   DESCRIPTION    = "Ephemeris time converted from MESSENGER MET."
END_OBJECT    = COLUMN

OBJECT        = COLUMN
   NAME           = JDAY
   COLUMN_NUMBER  = 2
   BYTES          = 16
   DATA_TYPE      = ASCII_REAL
   START_BYTE     = 17
   FORMAT         = "F16.5"
   DESCRIPTION    = "Julian date at the start of the time period of
   interest. Julian date is defined as an integer count of days elapsed since
   noon, January 1, 4713 B.C. The value includes the fractional portion of
   the Julian day."
END_OBJECT    = COLUMN

OBJECT        = COLUMN
   NAME           = MET
   COLUMN_NUMBER  = 3
   BYTES          = 13
   DATA_TYPE      = ASCII_INTEGER
   START_BYTE     = 33
   DESCRIPTION    = "Mission elapsed time in seconds."
END_OBJECT    = COLUMN

OBJECT        = COLUMN
   NAME           = ACCUM_TIME
   COLUMN_NUMBER  = 4
   BYTES          = 13
   DATA_TYPE      = ASCII_INTEGER
   START_BYTE     = 46
   UNIT           = SECOND
   DESCRIPTION    = "The time period over which the rates were
   accumulated."
END_OBJECT    = COLUMN

OBJECT        = COLUMN
   NAME           = DEADTIME_FRAC
   COLUMN_NUMBER  = 5
   BYTES          = 13
   DATA_TYPE      = ASCII_REAL
   START_BYTE     = 59
   FORMAT         = "F13.5"
   DESCRIPTION    = "The fraction of time for which the detector was
   insensitive to events due to electronics processing of prior events."
END_OBJECT    = COLUMN

OBJECT        = COLUMN
   NAME           = ORBIT_NUMBER
   COLUMN_NUMBER  = 6
   BYTES          = 6
   DATA_TYPE      = ASCII_INTEGER
   START_BYTE     = 72
   DESCRIPTION    = "Unique identifier for a given orbit of MESSENGER
   around Mercury. Orbit number is defined as starting at apoherm and
   is calculated using the MET value and the appropriate SPICE kernels.
   Orbit numbering does not start until MESSENGER performs the Mercury orbit
   insertion. Until that time the value for orbit number is 0."
END_OBJECT    = COLUMN
```

```
OBJECT        = COLUMN
   NAME           = START_BIN
   COLUMN_NUMBER  = 7
   BYTES          = 6
   DATA_TYPE      = ASCII_INTEGER
   START_BYTE     = 78
   DESCRIPTION    = "Start Bin of the Shield detector."
END_OBJECT    = COLUMN

OBJECT        = COLUMN
   NAME           = NUMBER_OF_BINS
   COLUMN_NUMBER  = 8
   BYTES          = 6
   DATA_TYPE      = ASCII_INTEGER
   START_BYTE     = 84
   DESCRIPTION    = "Number of bins in the shield spectra."
END_OBJECT    = COLUMN

OBJECT        = COLUMN
   NAME           = GRS_PRIORITY_LEVEL
   COLUMN_NUMBER  = 9
   BYTES          = 6
   DATA_TYPE      = ASCII_INTEGER
   START_BYTE     = 90
   DESCRIPTION    = "Indicates the type of priority assigned to the science
    packet. The priority level is tied to the ApID of the packet. Priority
    level varies from 0-3, 0 being highest and 3 being lowest priority."
END_OBJECT    = COLUMN

OBJECT        = COLUMN
   NAME           = BAD_DATA_FLAG
   COLUMN_NUMBER  = 10
   BYTES          = 6
   DATA_TYPE      = ASCII_INTEGER
   START_BYTE     = 96
   DESCRIPTION    = "Values of 1 indicate that the data quality is poor, for
    example increased backgrounds due to solar particle events, or that the
    detector was not operating nominally, for example the bias voltage was
    off. Values of 0 indicate that the data are clean and suited for
    analysis."
END_OBJECT    = COLUMN

OBJECT        = COLUMN
   NAME           = TRIPLE
   COLUMN_NUMBER  = 11
   BYTES          = 13
   DATA_TYPE      = ASCII_REAL
   START_BYTE     = 102
   UNIT           = "COUNTS/SECOND"
   FORMAT         = "F13.5"
   DESCRIPTION    = "Triple coincidence count rate in the MESSENGER Neutron
   Spectrometer. This value is a known proxy for the spacecraft-incident
   galactic cosmic ray flux."
END_OBJECT    = COLUMN

OBJECT        = COLUMN
   NAME           = PREAMP_TEMP
   COLUMN_NUMBER  = 12
   BYTES          = 13
   DATA_TYPE      = ASCII_REAL
   START_BYTE     = 115
   UNIT           = DEGC
   FORMAT         = "F13.5"
   DESCRIPTION    = "Temperature of the pre-amplifier."
END_OBJECT    = COLUMN

OBJECT        = COLUMN
   NAME           = SHLD_CHRG_RSET_1SEC
   COLUMN_NUMBER  = 13
   BYTES          = 13
   DATA_TYPE      = ASCII_REAL
```

```
   START_BYTE     = 128
   UNIT           = COUNTS
   FORMAT         = "F13.5"
   DESCRIPTION    = "Hardware Shield charge reset 1-second total."
END_OBJECT    = COLUMN

OBJECT        = COLUMN
   NAME           = SHAPER_TEMP
   COLUMN_NUMBER  = 14
   BYTES          = 13
   DATA_TYPE      = ASCII_REAL
   START_BYTE     = 141
   UNIT           = DEGC
   FORMAT         = "F13.5"
   DESCRIPTION    = "Shaper Temperature."
END_OBJECT    = COLUMN

OBJECT        = COLUMN
   NAME           = ALTITUDE
   COLUMN_NUMBER  = 15
   BYTES          = 10
   DATA_TYPE      = ASCII_REAL
   START_BYTE     = 154
   UNIT           = KM
   FORMAT         = "F10.1"
   DESCRIPTION    = "Spacecraft altitude above the subsatellite point on the
   target in units of km."
END_OBJECT    = COLUMN

OBJECT        = COLUMN
   NAME           = LATITUDE
   COLUMN_NUMBER  = 16
   BYTES          = 9
   DATA_TYPE      = ASCII_REAL
   START_BYTE     = 164
   UNIT           = DEGREE
   FORMAT         = "F9.3"
   DESCRIPTION    = "Target-centric latitude of the spacecraft subsatellite
   point in degrees."
END_OBJECT    = COLUMN

OBJECT        = COLUMN
   NAME           = LONGITUDE
   COLUMN_NUMBER  = 17
   BYTES          = 9
   DATA_TYPE      = ASCII_REAL
   START_BYTE     = 173
   UNIT           = DEGREE
   FORMAT         = "F9.3"
   DESCRIPTION    = "Target-centric longitude of the spacecraft subsatellite
   point in degrees."
END_OBJECT    = COLUMN

OBJECT        = COLUMN
   NAME           = LOCAL_TIME
   COLUMN_NUMBER  = 18
   BYTES          = 9
   DATA_TYPE      = ASCII_REAL
   START_BYTE     = 182
   FORMAT         = "F9.3"
   DESCRIPTION    = "Local time of the spacecraft subsatellite point in
   hours from 0 to 24."
END_OBJECT    = COLUMN

OBJECT        = COLUMN
   NAME           = VELOCITY_VECTOR
   COLUMN_NUMBER  = 19
   BYTES          = 27
   DATA_TYPE      = ASCII_REAL
   START_BYTE     = 191
   UNIT           = "KM/S"
```

```
   ITEMS          = 3
   ITEM_BYTES     = 9
   FORMAT         = "F9.3"
   DESCRIPTION    = "Three element spacecraft velocity vector expressed in
   the nadir-fixed coordinate system with each component in units of
   km/second."
END_OBJECT    = COLUMN

OBJECT        = COLUMN
   NAME           = VEL_NORM
   COLUMN_NUMBER  = 20
   BYTES          = 9
   DATA_TYPE      = ASCII_REAL
   START_BYTE     = 218
   FORMAT         = "F9.3"
   DESCRIPTION    = "Magnitude of the spacecraft velocity as expressed in
   the nadir-fixed coordinate system in units of km/second."
END_OBJECT    = COLUMN

OBJECT        = COLUMN
   NAME           = SC_TO_NADIR_ROT
   COLUMN_NUMBER  = 21
   BYTES          = 81
   DATA_TYPE      = ASCII_REAL
   START_BYTE     = 227
   ITEMS          = 9
   ITEM_BYTES     = 9
   FORMAT         = "F9.3"
   DESCRIPTION    = "Nine element rotation matrix that converts the
   spacecraft attitude from instrument-fixed coordinates to nadir-fixed
   coordinates."
END_OBJECT    = COLUMN

OBJECT        = COLUMN
   NAME           = VDOT_X
   COLUMN_NUMBER  = 22
   BYTES          = 9
   DATA_TYPE      = ASCII_REAL
   START_BYTE     = 308
   FORMAT         = "F9.3"
   DESCRIPTION    = "Velocity normalized dot product of the vector velocity
   and the spacecraft x-axis unit vector expressed as a unitless number from
   -1 to 1."
END_OBJECT    = COLUMN

OBJECT        = COLUMN
   NAME           = VDOT_Y
   COLUMN_NUMBER  = 23
   BYTES          = 9
   DATA_TYPE      = ASCII_REAL
   START_BYTE     = 317
   FORMAT         = "F9.3"
   DESCRIPTION    = "Velocity normalized dot product of the vector velocity
   and the spacecraft y-axis unit vector expressed as a unitless number from
   -1 to 1."
END_OBJECT    = COLUMN

OBJECT        = COLUMN
   NAME           = VDOT_Z
   COLUMN_NUMBER  = 24
   BYTES          = 9
   DATA_TYPE      = ASCII_REAL
   START_BYTE     = 326
   FORMAT         = "F9.3"
   DESCRIPTION    = "Velocity normalized dot product of the vector velocity
   and the spacecraft z-axis unit vector expressed as a unitless number from
   -1 to 1."
END_OBJECT    = COLUMN

OBJECT        = COLUMN
   NAME           = NADIR_ANGLE
```

```
   COLUMN_NUMBER  = 25
   BYTES          = 9
   DATA_TYPE      = ASCII_REAL
   START_BYTE     = 335
   UNIT           = DEGREE
   FORMAT         = "F9.3"
   DESCRIPTION    = "Spacecraft orientation angle of the spacecraft z-axis
   and the spacecraft-to-planet center vector in units of degrees."
END_OBJECT    = COLUMN

OBJECT        = COLUMN
   NAME           = YAXIS_ANGLE
   COLUMN_NUMBER  = 26
   BYTES          = 9
   DATA_TYPE      = ASCII_REAL
   START_BYTE     = 344
   UNIT           = DEGREE
   FORMAT         = "F9.3"
   DESCRIPTION    = "Spacecraft orientation angle of the spacecraft y-axis
   and the spacecraft-to-planet center vector in units of degrees."
END_OBJECT    = COLUMN

OBJECT        = COLUMN
   NAME           = XAXIS_ANGLE
   COLUMN_NUMBER  = 27
   BYTES          = 9
   DATA_TYPE      = ASCII_REAL
   START_BYTE     = 353
   UNIT           = DEGREE
   FORMAT         = "F9.3"
   DESCRIPTION    = "Spacecraft orientation angle of the spacecraft x-axis
   and the spacecraft-to-planet center vector in units of degrees."
END_OBJECT    = COLUMN

OBJECT        = COLUMN
   NAME           = THETA_ANGLE
   COLUMN_NUMBER  = 28
   BYTES          = 9
   DATA_TYPE      = ASCII_REAL
   START_BYTE     = 362
   UNIT           = DEGREE
   FORMAT         = "F9.3"
   DESCRIPTION    = "Polar angle look direction (in a theta,phi spherical
   geometry) of the spacecraft in the spacecraft-fixed coordinate system.
   THETA_ANGLE = 0 degrees is when the spacecraft z-axis points in the same
   direction as the spacecraft-to-planet center vector (nadir pointing)."
END_OBJECT    = COLUMN

OBJECT        = COLUMN
   NAME           = PHI_ANGLE
   COLUMN_NUMBER  = 29
   BYTES          = 9
   DATA_TYPE      = ASCII_REAL
   START_BYTE     = 371
   UNIT           = DEGREE
   FORMAT         = "F9.3"
   DESCRIPTION    = "Azimuthal angle look direction (in a theta,phi spherical
   geometry) of the spacecraft in the spacecraft-fixed coordinate system.
   PHI_ANGLE = 0 degrees is when the spacecraft x-axis points along the
   direction of travel."
END_OBJECT    = COLUMN

OBJECT        = COLUMN
   NAME           = BETA_ANGLE
   COLUMN_NUMBER  = 30
   BYTES          = 9
   DATA_TYPE      = ASCII_REAL
   START_BYTE     = 380
   UNIT           = DEGREE
   FORMAT         = "F9.3"
   DESCRIPTION    = "Angle of the normal of the spacecraft orbital plane
```

```
   with respect to Mercury-to-Sun vector in degrees."
END_OBJECT    = COLUMN

OBJECT        = COLUMN
   NAME           = SUN_DISTANCE
   COLUMN_NUMBER  = 31
   BYTES          = 13
   DATA_TYPE      = ASCII_REAL
   START_BYTE     = 389
   UNIT           = KM
   FORMAT         = "F13.2"
   DESCRIPTION    = "Distance of the spacecraft to the Sun in units of km."
END_OBJECT    = COLUMN

OBJECT        = COLUMN
   NAME           = SHIELD
   COLUMN_NUMBER  = 32
   BYTES          = 6144
   DATA_TYPE      = ASCII_INTEGER
   START_BYTE     = 402
   UNIT           = COUNTS
   ITEMS          = 1024
   ITEM_BYTES     = 6
   DESCRIPTION    = "Spectra of light pulses produced from interaction of a
   gamma ray with the plastic scintillator shield. Contains the counts in
   each of the 1024 bins after 1 accumulation period."
END_OBJECT    = COLUMN
```

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```
OBJECT        = COLUMN
   NAME           = J2000_ET
   COLUMN_NUMBER  = 1
   BYTES          = 16
   DATA_TYPE      = ASCII_REAL
   START_BYTE     = 1
   UNIT           = SECOND
   FORMAT         = "F16.5"
   DESCRIPTION    = "Ephemeris time converted from MESSENGER MET."
END_OBJECT    = COLUMN

OBJECT        = COLUMN
   NAME           = JDAY
   COLUMN_NUMBER  = 2
   BYTES          = 16
   DATA_TYPE      = ASCII_REAL
   START_BYTE     = 17
   FORMAT         = "F16.5"
   DESCRIPTION    = "Julian date at the start of the time period of
   interest. Julian date is defined as an integer count of days elapsed
   since noon, January 1, 4713 B.C. The value includes the fractional
   portion of the Julian day."
END_OBJECT    = COLUMN

OBJECT        = COLUMN
   NAME           = MET
   COLUMN_NUMBER  = 3
   BYTES          = 13
   DATA_TYPE      = ASCII_INTEGER
   START_BYTE     = 33
   UNIT           = SECOND
   DESCRIPTION    = "Mission elapsed time in seconds."
END_OBJECT    = COLUMN

OBJECT        = COLUMN
   NAME           = ACCUM_TIME
   COLUMN_NUMBER  = 4
   BYTES          = 13
   DATA_TYPE      = ASCII_INTEGER
   START_BYTE     = 46
   UNIT           = SECOND
   DESCRIPTION    = "The time period over which the rates were
   accumulated."
END_OBJECT    = COLUMN

OBJECT        = COLUMN
   NAME           = DEADTIME_FRAC
   COLUMN_NUMBER  = 5
   BYTES          = 13
   DATA_TYPE      = ASCII_REAL
   START_BYTE     = 59
   FORMAT         = "F13.5"
   DESCRIPTION    = "The fraction of time for which the detector was
   insensitive to events due to electronics processing of prior events."
END_OBJECT    = COLUMN

OBJECT        = COLUMN
   NAME           = ORBIT_NUMBER
   COLUMN_NUMBER  = 6
   BYTES          = 6
   DATA_TYPE      = ASCII_INTEGER
   START_BYTE     = 72
   DESCRIPTION    = "Unique identifier for a given orbit of MESSENGER
   around Mercury. Orbit number is defined as starting at apoherm and is
   calculated using the MET value and the appropriate SPICE kernels. Orbit
   numbering does not start until MESSENGER performs the Mercury orbit
   insertion. Until that time the value for orbit number is 0."
END_OBJECT    = COLUMN
```

```
OBJECT        = COLUMN
   NAME           = START_BIN
   COLUMN_NUMBER  = 7
   BYTES          = 6
   DATA_TYPE      = ASCII_INTEGER
   START_BYTE     = 78
   DESCRIPTION    = "Starting bin for the Shield Count Rate measurements.
   Initially values may be zero due to detector electronics deadtime."
END_OBJECT    = COLUMN

OBJECT        = COLUMN
   NAME           = NUMBER_OF_BINS
   COLUMN_NUMBER  = 8
   BYTES          = 6
   DATA_TYPE      = ASCII_INTEGER
   START_BYTE     = 84
   DESCRIPTION    = "Number of bins in the shield spectra."
END_OBJECT    = COLUMN

OBJECT        = COLUMN
   NAME           = GRS_PRIORITY_LEVEL
   COLUMN_NUMBER  = 9
   BYTES          = 6
   DATA_TYPE      = ASCII_INTEGER
   START_BYTE     = 90
   DESCRIPTION    = "Indicates the type of priority assigned to the science
    packet. The priority level is tied to the ApID of the packet. Priority
    level varies from 0-3, 0 being highest and 3 being lowest priority."
END_OBJECT    = COLUMN

OBJECT        = COLUMN
   NAME           = BAD_DATA_FLAG
   COLUMN_NUMBER  = 10
   BYTES          = 6
   DATA_TYPE      = ASCII_INTEGER
   START_BYTE     = 96
   DESCRIPTION    = "Values of 1 indicate that the data quality is poor, for
    example increased backgrounds due to solar particle events, or that the
    detector was not operating nominally, for example the bias voltage was
    off. Values of 0 indicate that the data are clean and suited for
    analysis."
END_OBJECT    = COLUMN

OBJECT        = COLUMN
   NAME           = TRIPLE
   COLUMN_NUMBER  = 11
   BYTES          = 13
   DATA_TYPE      = ASCII_REAL
   START_BYTE     = 102
   UNIT           = "COUNTS/SEC"
   FORMAT         = "F13.5"
   DESCRIPTION    = "Triple coincidence count rate in the MESSENGER Neutron
   Spectrometer. This value is a known proxy for the spacecraft-incident
   galactic cosmic ray flux."
END_OBJECT    = COLUMN

OBJECT        = COLUMN
   NAME           = PREAMP_TEMP
   COLUMN_NUMBER  = 12
   BYTES          = 13
   DATA_TYPE      = ASCII_REAL
   START_BYTE     = 115
   UNIT           = DEGC
   FORMAT         = "F13.5"
   DESCRIPTION    = "Temperature of the pre-amplifier."
END_OBJECT    = COLUMN

OBJECT        = COLUMN
   NAME           = SHLD_CHRG_RSET_1SEC
   COLUMN_NUMBER  = 13
```

```
   BYTES          = 13
   DATA_TYPE      = ASCII_REAL
   START_BYTE     = 128
   UNIT           = COUNTS
   FORMAT         = "F13.5"
   DESCRIPTION    = "Hardware Shield charge reset 1-second total."
END_OBJECT    = COLUMN

OBJECT        = COLUMN
   NAME           = SHAPER_TEMP
   COLUMN_NUMBER  = 14
   BYTES          = 13
   DATA_TYPE      = ASCII_REAL
   START_BYTE     = 141
   UNIT           = DEGC
   FORMAT         = "F13.5"
   DESCRIPTION    = "Shaper Temperature."
END_OBJECT    = COLUMN

OBJECT        = COLUMN
   NAME           = ALTITUDE
   COLUMN_NUMBER  = 15
   BYTES          = 10
   DATA_TYPE      = ASCII_REAL
   START_BYTE     = 154
   UNIT           = KM
   FORMAT         = "F10.1"
   DESCRIPTION    = "Spacecraft altitude above the subsatellite point on the
   target in units of km."
END_OBJECT    = COLUMN

OBJECT        = COLUMN
   NAME           = LATITUDE
   COLUMN_NUMBER  = 16
   BYTES          = 9
   DATA_TYPE      = ASCII_REAL
   START_BYTE     = 164
   UNIT           = DEGREE
   FORMAT         = "F9.3"
   DESCRIPTION    = "Target-centric latitude of the spacecraft subsatellite
   point in degrees."
END_OBJECT    = COLUMN

OBJECT        = COLUMN
   NAME           = LONGITUDE
   COLUMN_NUMBER  = 17
   BYTES          = 9
   DATA_TYPE      = ASCII_REAL
   START_BYTE     = 173
   UNIT           = DEGREE
   FORMAT         = "F9.3"
   DESCRIPTION    = "Target-centric longitude of the spacecraft subsatellite
   point in degrees."
END_OBJECT    = COLUMN

OBJECT        = COLUMN
   NAME           = LOCAL_TIME
   COLUMN_NUMBER  = 18
   BYTES          = 9
   DATA_TYPE      = ASCII_REAL
   START_BYTE     = 182
   FORMAT         = "F9.3"
   DESCRIPTION    = "Local time of the spacecraft subsatellite point in
   hours from 0 to 24."
END_OBJECT    = COLUMN

OBJECT        = COLUMN
   NAME           = VELOCITY_VECTOR
   COLUMN_NUMBER  = 19
   BYTES          = 27
   DATA_TYPE      = ASCII_REAL
```

```
   START_BYTE     = 191
   UNIT           = "KM/S"
   ITEMS          = 3
   ITEM_BYTES     = 9
   FORMAT         = "F9.3"
   DESCRIPTION    = "Three element spacecraft velocity vector expressed in
   the nadir-fixed coordinate system with each component in units of
   km/second."
END_OBJECT    = COLUMN

OBJECT        = COLUMN
   NAME           = VEL_NORM
   COLUMN_NUMBER  = 20
   BYTES          = 9
   DATA_TYPE      = ASCII_REAL
   START_BYTE     = 218
   UNIT           = "KM/S"
   FORMAT         = "F9.3"
   DESCRIPTION    = "Magnitude of the spacecraft velocity as expressed
   in the nadir-fixed coordinate system in units of km/second."
END_OBJECT    = COLUMN

OBJECT        = COLUMN
   NAME           = SC_TO_NADIR_ROT
   COLUMN_NUMBER  = 21
   BYTES          = 81
   DATA_TYPE      = ASCII_REAL
   START_BYTE     = 227
   ITEMS          = 9
   ITEM_BYTES     = 9
   FORMAT         = "F9.3"
   DESCRIPTION    = "Nine element rotation matrix that converts the
   spacecraft attitude from instrument-fixed coordinates to nadir-fixed
   coordinates."
END_OBJECT    = COLUMN

OBJECT        = COLUMN
   NAME           = VDOT_X
   COLUMN_NUMBER  = 22
   BYTES          = 9
   DATA_TYPE      = ASCII_REAL
   START_BYTE     = 308
   FORMAT         = "F9.3"
   DESCRIPTION    = "Velocity normalized dot product of the vector velocity
   and the spacecraft x-axis unit vector expressed as a unitless number from
   -1 to 1."
END_OBJECT    = COLUMN

OBJECT        = COLUMN
   NAME           = VDOT_Y
   COLUMN_NUMBER  = 23
   BYTES          = 9
   DATA_TYPE      = ASCII_REAL
   START_BYTE     = 317
   FORMAT         = "F9.3"
   DESCRIPTION    = "Velocity normalized dot product of the vector velocity
   and the spacecraft y-axis unit vector expressed as a unitless number from
   -1 to 1."
END_OBJECT    = COLUMN

OBJECT        = COLUMN
   NAME           = VDOT_Z
   COLUMN_NUMBER  = 24
   BYTES          = 9
   DATA_TYPE      = ASCII_REAL
   START_BYTE     = 326
   FORMAT         = "F9.3"
   DESCRIPTION    = "Velocity normalized dot product of the vector velocity
   and the spacecraft z-axis unit vector expressed as a unitless number from
   -1 to 1."
END_OBJECT    = COLUMN
```

```
OBJECT        = COLUMN
   NAME           = NADIR_ANGLE
   COLUMN_NUMBER  = 25
   BYTES          = 9
   DATA_TYPE      = ASCII_REAL
   START_BYTE     = 335
   UNIT           = DEGREE
   FORMAT         = "F9.3"
   DESCRIPTION    = "Spacecraft orientation angle of the spacecraft z-axis
   and the spacecraft-to-planet center vector in units of degrees."
END_OBJECT    = COLUMN

OBJECT        = COLUMN
   NAME           = YAXIS_ANGLE
   COLUMN_NUMBER  = 26
   BYTES          = 9
   DATA_TYPE      = ASCII_REAL
   START_BYTE     = 344
   UNIT           = DEGREE
   FORMAT         = "F9.3"
   DESCRIPTION    = "Spacecraft orientation angle of the spacecraft y-axis
   and the spacecraft-to-planet center vector in units of degrees."
END_OBJECT    = COLUMN

OBJECT        = COLUMN
   NAME           = XAXIS_ANGLE
   COLUMN_NUMBER  = 27
   BYTES          = 9
   DATA_TYPE      = ASCII_REAL
   START_BYTE     = 353
   UNIT           = DEGREE
   FORMAT         = "F9.3"
   DESCRIPTION    = "Spacecraft orientation angle of the spacecraft x-axis
   and the spacecraft-to-planet center vector in units of degrees."
END_OBJECT    = COLUMN

OBJECT        = COLUMN
   NAME           = THETA_ANGLE
   COLUMN_NUMBER  = 28
   BYTES          = 9
   DATA_TYPE      = ASCII_REAL
   START_BYTE     = 362
   UNIT           = DEGREE
   FORMAT         = "F9.3"
   DESCRIPTION    = "Polar angle look direction (in a theta,phi spherical
   geometry) of the spacecraft in the spacecraft-fixed coordinate system.
   THETA_ANGLE = 0 degrees is when the spacecraft z-axis points in the same
   direction as the spacecraft-to-planet center vector (nadir pointing)."
END_OBJECT    = COLUMN

OBJECT        = COLUMN
   NAME           = PHI_ANGLE
   COLUMN_NUMBER  = 29
   BYTES          = 9
   DATA_TYPE      = ASCII_REAL
   START_BYTE     = 371
   UNIT           = DEGREE
   FORMAT         = "F9.3"
   DESCRIPTION    = "Azimuthal angle look direction (in a theta,phi spherical
   geometry) of the spacecraft in the spacecraft-fixed coordinate system.
   PHI_ANGLE = 0 degrees is when the spacecraft x-axis points along the
   direction of travel."
END_OBJECT    = COLUMN

OBJECT        = COLUMN
   NAME           = BETA_ANGLE
   COLUMN_NUMBER  = 30
   BYTES          = 9
   DATA_TYPE      = ASCII_REAL
   START_BYTE     = 380
```

```
   UNIT           = DEGREE
   FORMAT         = "F9.3"
   DESCRIPTION    = "Angle of the normal of the spacecraft orbital plane
   with respect to Mercury-to-Sun vector in degrees."
END_OBJECT    = COLUMN

OBJECT        = COLUMN
   NAME           = SUN_DISTANCE
   COLUMN_NUMBER  = 31
   BYTES          = 13
   DATA_TYPE      = ASCII_REAL
   START_BYTE     = 389
   UNIT           = KM
   FORMAT         = "F13.2"
   DESCRIPTION    = "Distance of the spacecraft to the Sun in units of km."
END_OBJECT    = COLUMN

OBJECT        = COLUMN
   NAME           = SHIELD_COUNT_SPECTRA
   COLUMN_NUMBER  = 32
   BYTES          = 98304
   DATA_TYPE      = ASCII_INTEGER
   START_BYTE     = 402
   UNIT           = COUNTS
   ITEMS          = 16384
   ITEM_BYTES     = 6
   DESCRIPTION    = "High-time-resolution counter of the total event rate in
   the shield detector. Counter operates at a 10ms cadence for the duration
   of the accumulation period, resulting in a series of measurements that
   populate the 16384 channel spectrum. When fewer than 16384 channels are
   required, the remainder are set to zero. When more than 16384 channels
   are required, the last channel represents the sum of all measurements made
   after the array is filled. For all cases, the first approximately fifty
   channels are zero due to signal processing deadtime in the GRS
   electronics."
END_OBJECT    = COLUMN
```

8.7.7 Appendix: GRS_ENG.FMT

```
OBJECT     = COLUMN
   NAME          = MET
   COLUMN_NUMBER = 1
   BYTES         = 4
   DATA_TYPE     = MSB_UNSIGNED_INTEGER
   START_BYTE    = 1
   DESCRIPTION   = "Mission elapsed time corresponding to the start of the
    accumulation period."
END_OBJECT = COLUMN

OBJECT     = COLUMN
   NAME          = UTC
   COLUMN_NUMBER = 2
   BYTES         = 23
   DATA_TYPE     = CHARACTER
   START_BYTE    = 5
   DESCRIPTION   = "The met converted to UTC."
END_OBJECT = COLUMN

OBJECT     = COLUMN
   NAME          = RAW_VAL
   COLUMN_NUMBER = 3
   BYTES         = 4
   DATA_TYPE     = MSB_INTEGER
   START_BYTE    = 28
   DESCRIPTION   = "The raw digital value of the reading as output from the
    analog-to-digital converter."
END_OBJECT = COLUMN

OBJECT     = COLUMN
   NAME          = ENG_VAL
   COLUMN_NUMBER = 4
   BYTES         = 8
   DATA_TYPE     = IEEE_REAL
   START_BYTE    = 32
   DESCRIPTION   = "Raw value transformed to a physical unit."
END_OBJECT = COLUMN

OBJECT     = COLUMN
   NAME          = SMOOTH_VAL
   COLUMN_NUMBER = 5
   BYTES         = 8
   DATA_TYPE     = IEEE_REAL
   START_BYTE    = 40
   DESCRIPTION   = "Raw value transformed to a smoothed physical
   unit."
END_OBJECT = COLUMN
```

8.7.8 Appendix: GRS_RDR_SUMS.FMT

```
OBJECT = COLUMN
  COLUMN_NUMBER = 1
  NAME = MERCURY_CENTRIC_LATITUDE
  DATA_TYPE = IEEE_REAL
  BYTES = 4
  START_BYTE = 1
  UNIT = DEGREE
  DESCRIPTION = "
  Weighted centerpoint Mercury centric latitude by where spectra were
  taken over the area of the sum.
  "
END_OBJECT = COLUMN

OBJECT = COLUMN
  COLUMN_NUMBER = 2
  NAME = MERCURY_CENTRIC_LONGITUDE
  DATA_TYPE = IEEE_REAL
  BYTES = 4
  START_BYTE = 5
  UNIT = DEGREE
  DESCRIPTION = "
  Weighted centerpoint Mercury centric east longitude by where spectra
  were taken over the area of the sum.
  "
END_OBJECT = COLUMN

OBJECT = COLUMN
  COLUMN_NUMBER = 3
  NAME = UTC_START_TIME
  DATA_TYPE = CHARACTER
  BYTES = 23
  START_BYTE = 9
  DESCRIPTION = "
  UTC time of first spectrum in sum.
  "
END_OBJECT = COLUMN

OBJECT = COLUMN
  COLUMN_NUMBER = 4
  NAME = UTC_STOP_TIME
  DATA_TYPE = CHARACTER
  BYTES = 23
  START_BYTE = 32
  DESCRIPTION = "
  UTC time of last spectrum in sum.
  "
END_OBJECT = COLUMN

OBJECT = COLUMN
  COLUMN_NUMBER = 5
  NAME = MET_START_TIME
  DATA_TYPE = MSB_UNSIGNED_INTEGER
  BYTES = 4
  START_BYTE = 55
  DESCRIPTION = "
  Time of first spectrum in sum, in units of spacecraft clock (second).
  "
END_OBJECT = COLUMN

OBJECT = COLUMN
  COLUMN_NUMBER = 6
  NAME = MET_STOP_TIME
  DATA_TYPE = MSB_UNSIGNED_INTEGER
  BYTES = 4
  START_BYTE = 59
  DESCRIPTION = "
  Time of last spectrum in sum, in units of spacecraft clock (seconds).
```

```
  "
END_OBJECT = COLUMN

OBJECT = COLUMN
  COLUMN_NUMBER = 7
  NAME = SUM_TYPE
  DATA_TYPE = MSB_UNSIGNED_INTEGER
  BYTES = 1
  START_BYTE = 63
  UNIT = SECOND
  DESCRIPTION = "The type of sum,
  0 - Full Planet,
  1 - Full Planet less than 2000 kilometer altitude,
  2 - Full Planet altitude between 2000 and 8000 kilometers,
  3 - Full Planet altitude greater than 8000 kilometers,
  4 - Full Planet altitude greater than 15000 kilometers,
  5 - North pole (latitude >= 80) with altitude < 2000 kilometers,
  6 - 15 x 15 degree cells above 45 degrees latitude
      with altitude < 2000 kilometers,
  7 - 45 x 45 degree cells between 0 and 45 degrees latitude
      with altitude < 2000 kilometers.
  "
END_OBJECT = COLUMN

OBJECT = COLUMN
  COLUMN_NUMBER = 8
  NAME = CLOCK_TIME
  DATA_TYPE = MSB_UNSIGNED_INTEGER
  BYTES = 8
  START_BYTE = 64
  UNIT = SECOND
  DESCRIPTION = "Sum of collection durations.
  "
END_OBJECT = COLUMN

OBJECT = COLUMN
  COLUMN_NUMBER = 9
  NAME = RECORD_COUNT
  DATA_TYPE = MSB_UNSIGNED_INTEGER
  BYTES = 4
  START_BYTE = 72
  DESCRIPTION = "Count of spectra being summed.
  "
END_OBJECT = COLUMN

OBJECT = COLUMN
  COLUMN_NUMBER = 10
  NAME = BAD_DATA_FLAG
  DATA_TYPE = MSB_UNSIGNED_INTEGER
  BYTES = 2
  START_BYTE = 76
  DESCRIPTION = "
  Non-zero if any spectra had bad_data_flags set.
  "
END_OBJECT = COLUMN

OBJECT = COLUMN
  COLUMN_NUMBER = 11
  NAME = HPGE_TEMP_1_MIN
  DATA_TYPE = IEEE_REAL
  BYTES = 4
  START_BYTE = 78
  UNIT = KELVIN
  DESCRIPTION = "
  Minimum value of HPGE Detector Temperature 1.
  "
END_OBJECT = COLUMN

OBJECT = COLUMN
  COLUMN_NUMBER = 12
  NAME = HPGE_TEMP_1_MAX
```

```
  DATA_TYPE = IEEE_REAL
  BYTES = 4
  START_BYTE = 82
  UNIT = KELVIN
  DESCRIPTION = "
  Maximum value of HPGE Detector Temperature 1.
  "
END_OBJECT = COLUMN

OBJECT = COLUMN
  COLUMN_NUMBER = 13
  NAME = HPGE_TEMP_1_MEAN
  DATA_TYPE = IEEE_REAL
  BYTES = 4
  START_BYTE = 86
  UNIT = KELVIN
  DESCRIPTION = "
  Mean value of HPGE Detector Temperature 1.
  "
END_OBJECT = COLUMN

OBJECT = COLUMN
  COLUMN_NUMBER = 14
  NAME = HPGE_TEMP_1_STD
  DATA_TYPE = IEEE_REAL
  BYTES = 4
  START_BYTE = 90
  UNIT = KELVIN
  DESCRIPTION = "
  Standard Deviation of HPGE Detector Temperature 1.
  "
END_OBJECT = COLUMN

OBJECT = COLUMN
  COLUMN_NUMBER = 15
  NAME = HPGE_TEMP_2_MIN
  DATA_TYPE = IEEE_REAL
  BYTES = 4
  START_BYTE = 94
  UNIT = KELVIN
  DESCRIPTION = "
  Minimum value of HPGE Detector Temperature 2.
  "
END_OBJECT = COLUMN

OBJECT = COLUMN
  COLUMN_NUMBER = 16
  NAME = HPGE_TEMP_2_MAX
  DATA_TYPE = IEEE_REAL
  BYTES = 4
  START_BYTE = 98
  UNIT = KELVIN
  DESCRIPTION = "
  Maximum value of HPGE Detector Temperature 2.
  "
END_OBJECT = COLUMN

OBJECT = COLUMN
  COLUMN_NUMBER = 17
  NAME = HPGE_TEMP_2_MEAN
  DATA_TYPE = IEEE_REAL
  BYTES = 4
  START_BYTE = 102
  UNIT = KELVIN
  DESCRIPTION = "
  Mean value of HPGE Detector Temperature 2.
  "
END_OBJECT = COLUMN

OBJECT = COLUMN
  COLUMN_NUMBER = 18
```

```
  NAME = HPGE_TEMP_2_STD
  DATA_TYPE = IEEE_REAL
  BYTES = 4
  START_BYTE = 106
  UNIT = KELVIN
  DESCRIPTION = "
  Standard Deviation of HPGE Detector Temperature 2.
  "
END_OBJECT = COLUMN

OBJECT = COLUMN
  COLUMN_NUMBER = 19
  NAME = CALIB_AVG_DET_TEMP_MIN
  DATA_TYPE = IEEE_REAL
  BYTES = 4
  START_BYTE = 110
  UNIT = KELVIN
  DESCRIPTION = "
  Minimum value of Calibrated, averaged detector temperature.
  "
END_OBJECT = COLUMN

OBJECT = COLUMN
  COLUMN_NUMBER = 20
  NAME = CALIB_AVG_DET_TEMP_MAX
  DATA_TYPE = IEEE_REAL
  BYTES = 4
  START_BYTE = 114
  UNIT = KELVIN
  DESCRIPTION = "
  Maximum value of Calibrated, averaged detector temperature.
  "
END_OBJECT = COLUMN

OBJECT = COLUMN
  COLUMN_NUMBER = 21
  NAME = CALIB_AVG_DET_TEMP_MEAN
  DATA_TYPE = IEEE_REAL
  BYTES = 4
  START_BYTE = 118
  UNIT = KELVIN
  DESCRIPTION = "
  Mean value of Calibrated, averaged detector temperature.
  "
END_OBJECT = COLUMN

OBJECT = COLUMN
  COLUMN_NUMBER = 22
  NAME = CALIB_AVG_DET_TEMP_STD
  DATA_TYPE = IEEE_REAL
  BYTES = 4
  START_BYTE = 122
  UNIT = KELVIN
  DESCRIPTION = "
  Standard Deviation of Calibrated, averaged detector temperature.
  "
END_OBJECT = COLUMN

OBJECT = COLUMN
  COLUMN_NUMBER = 23
  NAME = PREAMP_TEMP_MIN
  DATA_TYPE = IEEE_REAL
  BYTES = 4
  START_BYTE = 126
  UNIT = CELSIUS
  DESCRIPTION = "
  Minimum value of Pre Amp Temperature.
  "
END_OBJECT = COLUMN

OBJECT = COLUMN
```

```
  COLUMN_NUMBER = 24
  NAME = PREAMP_TEMP_MAX
  DATA_TYPE = IEEE_REAL
  BYTES = 4
  START_BYTE = 130
  UNIT = CELSIUS
  DESCRIPTION = "
  Maximum value of Pre Amp Temperature.
  "
END_OBJECT = COLUMN

OBJECT = COLUMN
  COLUMN_NUMBER = 25
  NAME = PREAMP_TEMP_MEAN
  DATA_TYPE = IEEE_REAL
  BYTES = 4
  START_BYTE = 134
  UNIT = CELSIUS
  DESCRIPTION = "
  Mean value of Pre Amp Temperature.
  "
END_OBJECT = COLUMN

OBJECT = COLUMN
  COLUMN_NUMBER = 26
  NAME = PREAMP_TEMP_STD
  DATA_TYPE = IEEE_REAL
  BYTES = 4
  START_BYTE = 138
  UNIT = CELSIUS
  DESCRIPTION = "
  Standard Deviation of Pre Amp Temperature.
  "
END_OBJECT = COLUMN

OBJECT = COLUMN
  COLUMN_NUMBER = 27
  NAME = SHAPER_TEMP_MIN
  DATA_TYPE = IEEE_REAL
  BYTES = 4
  START_BYTE = 142
  UNIT = CELSIUS
  DESCRIPTION = "
  Minimum value of Shaper Temperature.
  "
END_OBJECT = COLUMN

OBJECT = COLUMN
  COLUMN_NUMBER = 28
  NAME = SHAPER_TEMP_MAX
  DATA_TYPE = IEEE_REAL
  BYTES = 4
  START_BYTE = 146
  UNIT = CELSIUS
  DESCRIPTION = "
  Maximum value of Shaper Temperature.
  "
END_OBJECT = COLUMN

OBJECT = COLUMN
  COLUMN_NUMBER = 29
  NAME = SHAPER_TEMP_MEAN
  DATA_TYPE = IEEE_REAL
  BYTES = 4
  START_BYTE = 150
  UNIT = CELSIUS
  DESCRIPTION = "
  Mean value of Shaper Temperature.
  "
END_OBJECT = COLUMN
```

```
OBJECT = COLUMN
  COLUMN_NUMBER = 30
  NAME = SHAPER_TEMP_STD
  DATA_TYPE = IEEE_REAL
  BYTES = 4
  START_BYTE = 154
  UNIT = CELSIUS
  DESCRIPTION = "
  Standard Deviation of Shaper Temperature.
  "
END_OBJECT = COLUMN

OBJECT = COLUMN
  COLUMN_NUMBER = 31
  NAME = HV_MONITOR_MIN
  DATA_TYPE = IEEE_REAL
  BYTES = 4
  START_BYTE = 158
  UNIT = VOLTS
  DESCRIPTION = "
  Minimum value of High Voltage Monitor.
  "
END_OBJECT = COLUMN

OBJECT = COLUMN
  COLUMN_NUMBER = 32
  NAME = HV_MONITOR_MAX
  DATA_TYPE = IEEE_REAL
  BYTES = 4
  START_BYTE = 162
  UNIT = VOLTS
  DESCRIPTION = "
  Maximum value of High Voltage Monitor.
  "
END_OBJECT = COLUMN

OBJECT = COLUMN
  COLUMN_NUMBER = 33
  NAME = HV_MONITOR_MEAN
  DATA_TYPE = IEEE_REAL
  BYTES = 4
  START_BYTE = 166
  UNIT = VOLTS
  DESCRIPTION = "
  Mean value of High Voltage Monitor.
  "
END_OBJECT = COLUMN

OBJECT = COLUMN
  COLUMN_NUMBER = 34
  NAME = HV_MONITOR_STD
  DATA_TYPE = IEEE_REAL
  BYTES = 4
  START_BYTE = 170
  UNIT = VOLTS
  DESCRIPTION = "
  Standard Deviation of High Voltage Monitor.
  "
END_OBJECT = COLUMN

OBJECT = COLUMN
  COLUMN_NUMBER = 35
  NAME = ALTITUDE_MIN
  DATA_TYPE = IEEE_REAL
  BYTES = 4
  START_BYTE = 174
  UNIT = KILOMETERS
  DESCRIPTION = "
  Minimum value of Altitude in kilometers.
  "
END_OBJECT = COLUMN
```

```
OBJECT = COLUMN
  COLUMN_NUMBER = 36
  NAME = ALTITUDE_MAX
  DATA_TYPE = IEEE_REAL
  BYTES = 4
  START_BYTE = 178
  UNIT = KILOMETERS
  DESCRIPTION = "
  Maximum value of Altitude in kilometers.
  "
END_OBJECT = COLUMN

OBJECT = COLUMN
  COLUMN_NUMBER = 37
  NAME = ALTITUDE_MEAN
  DATA_TYPE = IEEE_REAL
  BYTES = 4
  START_BYTE = 182
  UNIT = KILOMETERS
  DESCRIPTION = "
  Mean value of Altitude in kilometers.
  "
END_OBJECT = COLUMN

OBJECT = COLUMN
  COLUMN_NUMBER = 38
  NAME = ALTITUDE_STD
  DATA_TYPE = IEEE_REAL
  BYTES = 4
  START_BYTE = 186
  UNIT = KILOMETERS
  DESCRIPTION = "
  Standard Deviation of Altitude.
  "
END_OBJECT = COLUMN

OBJECT = COLUMN
  COLUMN_NUMBER = 39
  NAME = LATITUDE_MIN
  DATA_TYPE = IEEE_REAL
  BYTES = 4
  START_BYTE = 190
  UNIT = DEGREE
  DESCRIPTION = "
  Minimum value of Latitude in degrees.
  "
END_OBJECT = COLUMN

OBJECT = COLUMN
  COLUMN_NUMBER = 40
  NAME = LATITUDE_MAX
  DATA_TYPE = IEEE_REAL
  BYTES = 4
  START_BYTE = 194
  UNIT = DEGREE
  DESCRIPTION = "
  Maximum value of Latitude in degrees.
  "
END_OBJECT = COLUMN

OBJECT = COLUMN
  COLUMN_NUMBER = 41
  NAME = LATITUDE_MEAN
  DATA_TYPE = IEEE_REAL
  BYTES = 4
  START_BYTE = 198
  UNIT = DEGREE
  DESCRIPTION = "
  Mean value of Latitude in degrees.
  "
```

```
END_OBJECT = COLUMN

OBJECT = COLUMN
  COLUMN_NUMBER = 42
  NAME = LATITUDE_STD
  DATA_TYPE = IEEE_REAL
  BYTES = 4
  START_BYTE = 202
  UNIT = DEGREE
  DESCRIPTION = "
  Standard Deviation of Latitude.
  "
END_OBJECT = COLUMN

OBJECT = COLUMN
  COLUMN_NUMBER = 43
  NAME = LONGITUDE_MIN
  DATA_TYPE = IEEE_REAL
  BYTES = 4
  START_BYTE = 206
  UNIT = DEGREE
  DESCRIPTION = "
  Minimum value of Longitude in degrees.
  "
END_OBJECT = COLUMN

OBJECT = COLUMN
  COLUMN_NUMBER = 44
  NAME = LONGITUDE_MAX
  DATA_TYPE = IEEE_REAL
  BYTES = 4
  START_BYTE = 210
  UNIT = DEGREE
  DESCRIPTION = "
  Maximum value of Longitude in degrees.
  "
END_OBJECT = COLUMN

OBJECT = COLUMN
  COLUMN_NUMBER = 45
  NAME = LONGITUDE_MEAN
  DATA_TYPE = IEEE_REAL
  BYTES = 4
  START_BYTE = 214
  UNIT = DEGREE
  DESCRIPTION = "
  Mean value of Longitude in degrees.
  "
END_OBJECT = COLUMN

OBJECT = COLUMN
  COLUMN_NUMBER = 46
  NAME = LONGITUDE_STD
  DATA_TYPE = IEEE_REAL
  BYTES = 4
  START_BYTE = 218
  UNIT = DEGREE
  DESCRIPTION = "
  Standard Deviation of Longitude.
  "
END_OBJECT = COLUMN

OBJECT = COLUMN
  COLUMN_NUMBER = 47
  NAME = GAIN
  DATA_TYPE = IEEE_REAL
  BYTES = 4
  START_BYTE = 222
  DESCRIPTION = "
  Default value of gain, keV / channel.
  "
```

```
END_OBJECT = COLUMN

OBJECT = COLUMN
  COLUMN_NUMBER = 48
  NAME = OFFSET
  DATA_TYPE = IEEE_REAL
  BYTES = 4
  START_BYTE = 226
  DESCRIPTION = "
  The offset, keV.
  "
END_OBJECT = COLUMN

OBJECT = COLUMN
  COLUMN_NUMBER = 49
  NAME = RAW_GAMMA_SPECTRUM
  DATA_TYPE = IEEE_REAL
  BYTES = 65536
  START_BYTE = 230
  ITEMS = 16384
  ITEM_BYTES = 4
  DESCRIPTION = "
  Summed uncorrected raw gamma spectrum representing cumulative counts of gamma
rays
at the detector, binned over SUM_TYPE latitude and longitude, and one Earth year.
  "
END_OBJECT = COLUMN

OBJECT = COLUMN
  COLUMN_NUMBER = 50
  NAME = CORRECTED_GAMMA_SPECTRUM
  DATA_TYPE = IEEE_REAL
  BYTES = 65536
  START_BYTE = 65766
  ITEMS = 16384
  ITEM_BYTES = 4
  DESCRIPTION = "
  Summed corrected raw gamma spectrum representing cumulative counts of
  gamma rays at the detector, binned over SUM_TYPE latitude and longitude,
  and one Earth year.
  "
END_OBJECT = COLUMN

OBJECT = COLUMN
  COLUMN_NUMBER = 51
  NAME = AC_GAMMA_SPECTRUM
  DATA_TYPE = IEEE_REAL
  BYTES = 65536
  START_BYTE = 131302
  ITEMS = 16384
  ITEM_BYTES = 4
  DESCRIPTION = "
  Summed uncorrected anti-coincidence gamma spectrum representing cumulative
  counts of gamma rays at the detector, binned over SUM_TYPE latitude and
longitude,
  and one Earth year."
END_OBJECT = COLUMN

OBJECT = COLUMN
  COLUMN_NUMBER = 52
  NAME = CORRECTED_AC_GAMMA_SPECTRUM
  DATA_TYPE = IEEE_REAL
  BYTES = 65536
  START_BYTE = 196838
  ITEMS = 16384
  ITEM_BYTES = 4
  DESCRIPTION = "
  Summed corrected anti-coincidence gamma spectrum representing cumulative
  counts of gamma rays at the detector, binned over SUM_TYPE latitude and
  longitude, and one Earth year."
END_OBJECT = COLUMN
```