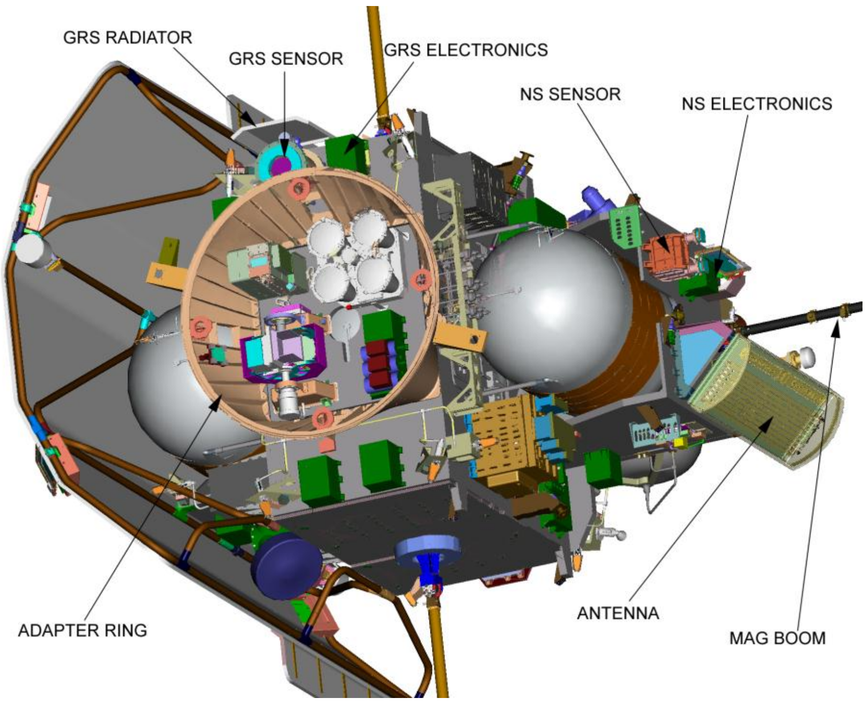
MESSENGER Neutron Spectrometer Calibrated and Derived Data Record Software Interface Specification

Version 3.9
February 9, 2016



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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.

David Lawrence, MESSENGER NS 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
04/20/09	Initial Version	Draft, DJL	1.0
05/05/09	All	Draft edits, JGW	1.1
06/02/09	All	Draft edits, JGW	1.2
06/17/09	6.2.1-6.5.1, 6.8.2, 7.4.1-7.4.4, 7.5.1-7.5.4	Added data product size estimates, updated all labels, added missing units to format file column definitions.	1.3
07/06/09	5.1, 5.2, 6.2.1, 6.3.1, 6.4.1, 7.4.1	Edits from internal review.	1.4
09/17/09	All	Edits from peer review.	1.5
11/16/09	6.6.1, Table 6.5	Changed NSINDEX.* to INDEX.*. Increased PRODUCT_ID bytes from 21 to 24..	1.6
6/15/11	Document Review, Tables 6-1, 6-2, 6-3, 6-4 Section 7.5	Replaced signature page with document review information. Changed “periherm” to “apoherm” in orbit start descriptions for orbit numbering.	1.7
12/15/11	Section 6.6, 7.5	Added NS_CDR_GAB data product and made minor header/footer edits.	1.8
1/27/12	TBD Log, Section 6.1.3, 6.7.1, 6.7.2, 7.4	Updated TBD Log, updated label file keyword definitions with new NS_CDR_GAB data product; added NS_CDR_GAB.FMT to LABEL directory contents, NS_CDR_GAB data product size estimates, and NS_CDR_GAB example label.	1.9
4/10/12	All	Added new DDR data product.	2.0
4/12/12	Table 6.8	Added DDR index information.	2.1
5/4/12	Sections 6.7, 6.8, 7.4.6, 7.5.6	Updated DDR index information. Added sample DDR label, format file, and data product size estimates.	2.2
5/7/12	Table 6.6, Section 7.5.6	Minor format file edits.	2.3
5/18/12	Table 6.7-6.8.	Removed length column from index contents table.	2.4
5/30/12	Sections 5.2, 5.7, 6.8.1	Added science text. Combined EDR2CDR and CDR2DDR documents into 1 processing document.	2.5
5/31/12	Section 5.1	Text updates to paragraph 1.	2.6
6/1/12	Table 6.6, Section 7.5.6	Revised DATA_TYPE in SUN_DISTANCE column of DDR format file.	2.7

9/12/12	6.7.1, TOC	Peer review edits.	2.8
10/5/12	Table 6.6, 7.4.6, 7.5.6	Additional peer review edits.	2.9
4/22/13	All	Editorial changes.	3.0
5/29/13	All	Added new neutron composition DDR.	3.1
6/13/13	All	Minor edits. Draft version submitted for NCP peer review.	3.2
9/16/13	Sections 5.2, 6.8.1, 7.4.7	NCP peer review edits.	3.3
11/11/15	Section 6.2.1	Added data fields to NS_CDR_SPECTRA for final delivery.	3.4
11/18/15	1.2, 5.3.4, 6.1.3, 7.4, 7.5.1	Updated for version 2 of the data sets. Revised NS_CDR_SPECTRA sample format file.	3.5
12/9/15	All	Miscellaneous final edits.	3.6
1/16/16	All	Final mission edits.	3.7
2/2/16	All	Fixed minor typos.	3.8
2/9/16	6.9.1	Fixed minor typo.	3.9

TBD Log

	DESCRIPTION
The following changes to the data products/format files will be implemented before the first PDS delivery:	
1.	The reference frame for geometry keywords will be changed from Mercury-centric to target-centric. The target is defined using the TARGET_NAME keyword in the PDS label. In most cases, TARGET_NAME = MERCURY, however for data acquired during the Venus Flyby, TARGET_NAME = VENUS. In this case, the reference frame will be Venus-centric. For TARGET_NAME= CALIBRATION (Cruise Phase), the reference frame will be Mercury-centric with geometry values calculated using Mercury as the target, however these values are essentially meaningless for data interpretation purposes. *This change was implemented with PDS release 5 (first release of NS CDRs).*
2.	A data quality flag will be added for each spectrum. *In lieu of this, the NS team has added a table to CATALOG/DATASET.CAT that lists the times of the solar particle events.*
3.	All spectra will be corrected for deadtime, as appropriate. *It has been determined that the deadtime correction for nominal solar quiet conditions is minimal and is therefore not being applied. Deadtime remains an important uncorrected effect for periods of intense solar activity. However, those periods of intense solar activity, which are listed in the data confidence note in CATALOG/DATASET.CAT, do not provide valid planetary data and are not used in the normal planetary data processing.*
The following changes to the data products/format files will be implemented at a future date:	
4.	An additional data product, Gamma Burst CDRs, will be added to the CDR dataset. Burst records will be in ASCII format with UTC time tags. *These data products were added with PDS Release 7.*
5.	The 3-angle nadir-centric spacecraft attitude coordinates used in the GRNS SciBox and GRS CDR may be included in addition to or in place of the 9-element rotation matrix for the NS_CDR_SPECTRA CDRs. *The NS Team has decided not to include this information.*

Table of Contents

1 Purpose and Scope of Document

1.1 Purpose

This document provides users of the MESSENGER Neutron Spectrometer (NS) data products with a detailed description of the NS and Calibrated and Derived Data Record (CDR/DDR) generation, validation, and storage. Please note that the Gamma Ray and Neutron Spectrometer instruments are generally referred to as the GRNS instrument. However, they are two separate sensors, each with its own Event Processing Unit (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 product 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 NS CDR and DDR PDS archived data.

This document describes the calibrated and derived data products for the MESSENGER NS. These data products correspond to National Research Council Committee on Data Management and Computation (CODMAC) levels 3 and 4, respectively. These data levels are described more fully in *Appendix B: CODMAC/NASA Definition of Processing Levels,* Section 7.2.

This document has been updated for version 2 of the CDR and DDR data sets (MESS-E/V/H-GRNS-3-NS-CDR-V2.0 and MESS-E/V/H-GRNS-4-NS-DDR-V2.0).

2 Applicable Documents

The MESSENGER NS CDR/DDR SIS is responsive to the following documents:

- Planetary Data System Archive Preparation Guide, NASA/JPL, August 29, 2006, Version 1.1, JPL D-31224.
- Planetary Data System Standards Reference, February 27, 2009, Version 3.8. JPL D-7669, Part-2.
- MESSENGER Instrument Neutron Spectrometer (NS) Flight Software Specification, JHU/APL 7386-9042, a, October 17, 2006.
- MESSENGER EDR Software Interface Specification for the Neutron Spectrometer.
- MESSENGER Data Management and Archiving Plan. The Johns Hopkins University, APL. Document ID number 7384-9019.
- MESSENGER Project Archive Generation, Validation, and Distribution Plan.
- MESSENGER MErcury: Surface, Space ENvironment, GEochemistry, and Ranging; A mission to Orbit and Explore the Planet Mercury, Concept Study, March 1999. Document ID number FG632/ 99-0479.
- [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.

- Evidence for Water Ice Near Mercury's North Pole from MESSENGER Neutron Spectrometer Measurements, Science 339, 292-296, 2013.

3 Relationships with Other Interfaces

The NS CDR and DDR data products are dependent on the NS Experiment Data Record (EDR) data products. Changes to the EDR product require revisions to the associated CDR/DDR products. The NS CDR/DDR data products are also dependent on valid Spacecraft, Planet, Instrument, C-matrix Events (SPICE) Kernel generation for timing and spatial information (see *Appendix A*, Section 7.1). Changes or revisions to the SPICE Kernel generally result in revisions to the NS CDR/DDR products. Changes to data processing programs that convert EDR data to CDR/DDR data may also result in revised CDR/DDR data products.

4 Roles and Responsibilities

The roles and responsibilities of the instrument teams, Applied Physics Laboratory (APL), Applied Coherent Technology Corp. (ACT), and the 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 launched in August 2004 and used flybys of Earth, Venus, and Mercury to achieve an orbit insertion around Mercury in March 2011. MESSENGER completed its Primary Mission in March 2012, operated for an additional year in its First Extended Mission which was completed in March 2013, followed by an additional two years of orbital operations in its Second Extended mission which completed as planned with the impact of the MESSENGER spacecraft on the surface of Mercury on April 30, 2015. Observations from orbit are designed to answer questions about the nature and composition of Mercury's crust, tectonic history, structure of the atmosphere/magnetosphere, and the nature of polar deposits. A year of data analysis and distribution followed the end of operations. (See the "MESSENGER Data Management and Archiving Plan" for further details.)

The Neutron Spectrometer (NS) is one of the instruments onboard the MESSENGER spacecraft. It is designed to observe the neutrons emitted from Mercury's surface in the thermal, epithermal, and fast energy ranges, from ~ 0.01 eV to 7 MeV, that are produced by nuclear reactions by the cosmic ray background (CRB). The NS is designed to separately measure thermal and epithermal neutrons using the Doppler filter technique. With this technique, an enhancement of thermal neutrons is measured when the spacecraft velocity vector is in line with the sensor normal vector, while a relative decrease in thermal neutrons is measured when the spacecraft velocity vector is anti-parallel to the sensor normal. No Doppler effect occurs when the spacecraft velocity vector is perpendicular to the sensor normal vector. Elements that can be most readily identified by the NS include those that strongly moderate and absorb neutrons (hydrogen and rare earths). The approximate average element atomic mass can also be estimated.

The MESSENGER NS consists of a sandwich of three scintillators that are optically decoupled from each other. The first and third scintillators are lithium (^{6}Li)-glass scintillators (LiG), which respond to a combination of thermal and epithermal neutrons that span the range between 0 eV and about 1 keV. (Thermal neutrons correspond to 0 to ~ 0.025 eV and epithermal neutrons correspond to ~ 0.025 eV up to ~ several keV.) The middle scintillator is a borated plastic (BP) scintillator that responds only to epithermal and fast neutrons, since it is surrounded by thermal neutron absorbers (LiG on each end and wrapped with a sheet of gadolinium). When a neutron interacts with one of these scintillators, a charge is generated in its electronics. The charge is converted into one of 64 LiG channels or 64 BP channels, which are correlated to the energy deposited in the scintillators. Over a commanded integration time period the distribution of events (neutron interactions) as a function of equivalent-electron energy (channel number) is recorded. The result is a histogram of the number of events in each channel accumulated over the integration period, which is designated as a singles prompt neutron spectrum. Three such spectra are produced, one by each lithium-glass (LiG) scintillator and one by the borated plastic (BP) scintillator. These spectra are called singles spectra because only events are recorded in each spectrum that are not time-coincident with events in the other two scintillators, and they are called prompt because only events are recorded that occur instantaneously (within much less than a microsecond) after the first interaction of a neutron in the scintillator.

Time-correlated events in the BP scintillator provide a measure of the neutron energies of the flux of fast neutrons (0.7 MeV < E < 7 MeV). These events are defined by a time-correlated pair of pulses in the BP scintillator. The first pulse corresponds to a neutron that loses all of its energy (above detection threshold and thermal neutron energies) in the BP scintillator, and the second pulse corresponds to the energy released by the $^{10}B(n,\alpha)^{7}Li$ reaction after the neutron has slowed down to thermal energies and has been absorbed in the scintillator. The signature of the time-correlated events includes the pulse height (measure of energy) of the first event (called the prompt energy, E_p), the pulse height of the second event that corresponds to the Q-value of the $^{10}B\ (n,\alpha)^{7}Li$ reaction (called the capture energy, E_c), and the time between first and second events (or Time To Second Pulse, TTSP). When a fast neutron interacts with the BP scintillator, a charge is generated corresponding to E_p. The charge is converted to channel number, which correlates to neutron energy. A similar signal is generated for the capture pulse, E_c. Over a commanded integration time period the distribution of E_p events as a function of energy (channel number) is recorded. The result is a histogram of the number of events in each channel accumulated over the integration period for TTSP values that fall between 0.3 μs and 5.4 μs and with E_c values that fall within a commanded range of values defined as the capture window. The resulting histogram is designated as the time-correlated early spectrum. A time-correlated late spectrum is also accumulated, for events whose second pulse occurs substantially later than expected, for TTSP values between 20 and 25 μs as a measure of spectrum background. The early and late prompt spectra each have 256 channels.

5.2 Data Product Overview

There are five NS CDR standard data products: Spectra (NS_CDR_SPECTRA), Counts (NS_CDR_COUNTS), Galactic Cosmic Ray (NS_CDR_GCR_SPECTRA), Engineering (NS_CDR_ENG), and Gamma Ray Burst (NS_CDR_GAB). Each CDR contains all the data of a given type recorded for a given day of Earth year. The following operations are applied to the EDRs to arrive at calibrated spectra (CDRs):

- Normalization of total counts to the accumulation time, so that the units are in counts per second.
- Corrections (if needed) for gain variations in the spectra data.
- Corrections (if needed) for GCR variations in the spectra and counting rates.
- Corrections for deadtime (if needed) in the spectra and counting rates.

All of these corrections are reversible such that the EDR and CDR datasets can be derived from each other. See *messns_processing.pdf* located in the CALIB directory for additional information.

There is one NS DDR standard data product (Neutron Count Rate, NS_DDR_NCR) and one NS DDR special data product (Neutron Composition, NS_DDR_NCP). The NCR data products are derived data consisting of net (background subtracted) neutron count rates from each of the three NS sensors, namely the two lithium glass (LG) sensors and the epithermal neutron singles data from the borated plastic (BP) sensor. Net fast neutron data do not need to be provided in the NCR dataset as those values can be easily derived from the CDR data using time-corrected (TC) count rates and spectra. Each DDR NCR data file contains all the data of a given type recorded for a given day of Earth year.

The NCP data product contains latitude-binned relative neutron count rates taken during the primary MESSENGER mission from 26 March 2011 to 25 February 2012. Specifically, these data are the exact data points given in Figure 2 and Figure 3A from Lawrence et al., *Science*, 339, 292-296, 2013. The delivered values include measured and simulated data for fast and epithermal neutron data within 2 degree wide latitude bins; the latitude values are the midpoint values within each bin and the data are the average values within each latitude bin. The simulated data include two cases: one case assumes there is no hydrogen in Mercury's north polar radar bright regions; the other case assumes that the north polar radar bright regions contain 100 wt.% H_2O.

Details of how the DDR data are derived are given in the document *messns_processing.pdf* located in the CALIB directory.

Table 5.1 is an overview of the CDR and DDR data products.

Data Product	**Product Description**
NS_CDR_SPECTRA (section 6.2)	• Detached PDS label file (*.lbl). • Binary table (*.dat) - LG1 singles, LG2 singles, BP singles, Time Correlated (TC) early, TC late (fast neutron spectra = TC early – TC late), along with associated timing, spatial, and engineering data.
NS_CDR_COUNTS (section 6.3)	• Detached PDS label file (*.lbl). • Binary table (*.dat) - NS counting rate data for 17 different monitored counting rates, along with associated timing, spatial, and engineering data.

NS_CDR_GCR_SPECTRA (section 6.4)	• Detached PDS label file (*.lbl). • Binary table (*.dat) - Spectra from LG1 and LG2 when a coincidence condition is detected in both LG sensors and the BP sensor, along with associated timing, spatial, and engineering data.
NS_CDR_ENG (section 6.5)	• Detached PDS label file (*.lbl). • ASCII table (*.tab) - NS instrumental engineering data.
NS_CDR_GAB (section 6.6)	• Detached PDS label file (*.lbl). • ASCII table (*.tab) – Contains the values from the NS Gamma Ray Burst EDR in ASCII format. Data is time sensitive, so rendering it in ASCII format helps real-time coordination with ground-based sensors.
NS_DDR_NCR (section 6.7)	• Detached PDS label file (*.lbl). • ASCII table (*.tab) – Net neutron count rates, along with associated timing, spatial, and engineering data.
NS_DDR_NCP (section 6.8)	• Detached PDS label file (ns_ddr_ncp.lbl). • ASCII table (ns_ddr_ncp.tab) – Fast and epithermal count rates and one-sigma uncertainties as a function of latitude, along with simulated count rates for the cases of no hydrogen and for a thick layer of 100 wt. % water ice in all radar bright regions. Latitude values are the midpoint values for 2 degree wide latitude bins; the data are the average values within each latitude bin.

Table 5.1. Data Product Overview

With the exception of the DDR NCP, each CDR and DDR consists of three files. One file contains the data itself, arranged in binary (*.DAT) or ASCII (*.TAB) table format (e.g., NS_CDR_SPE2008003ZZZ.DAT, NS_CDR_ENG2008010ZZZ.TAB, etc.). Another file is a label that describes the content of the data file (e.g., NS_CDR_SPE2008003ZZZ.LBL, NS_CDR_ENG2008010ZZZ.LBL, etc.). 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 table file itself. Instead, the PDS label file contains a reference pointer to a separate format file (e.g., NS_CDR_SPECTRA.FMT, NS_CDR_ENG.FMT, etc.). 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 the archive volume LABEL directory, because it applies to the structure of all the associated table files. The DDR NCP does not contain an associated format file; instead, the table structure is described in the label file.

5.3 Data Processing

5.3.1 Data Processing Level

The CDR and DDR use the Committee on Data Management and Computation (CODMAC) data level numbering system to describe the processing level of the NS data products. NS CDR 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). NS DDR products are considered a CODMAC “Level 4” (Resampled) or NASA “Level 1B,” which are irreversibly transformed (e.g. resampled, remapped, calibrated) values of the instrument measurements (e.g. radiances, magnetic field strength). For a more detailed description, see *Appendix B: CODMAC/NASA Definition of Processing Levels,* Section 7.2.

5.3.2 Data Product Generation

The NS CDR/DDR files were produced by APL and provided to the MESSENGER Science Operations Center (SOC), operated jointly by APL and ACT. ACT was responsible for converting the data to the proper PDS labeled format. See *messns_processing.pdf* in the CALIB directory for information on how the EDRs are converted to CDRs and DDRs. The CDR/DDR 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.

5.3.3 Data Flow

The MESSENGER SOC generated and validated data archives under the auspices of the MESSENGER Project Scientist. The SOC supported and worked with the Mission Operations Center (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 during the MESSENGER mission. Inputs to the SOC consisted of telemetry in the form of CCSDS packets. Files were received from the SOC and delivered to the SOC via ftp (See Figure 1). In the case of the NS CDR/DDR data products, APL read NS EDR data from the SOC, transformed the data into valid CDR/DDR data products, and returned the data to the SOC for storage and distribution.

The MESSENGER SOC delivered data for the NS CDR/DDR archive volume to the PDS Geosciences Node in standard product packages. Each package comprises data and files organized into directory structures consistent with the volume design described in section 6.9.

The following describes the electronic transfer process used in releasing data to PDS. In preparation for delivery the directory structure was compressed into a single ‘zip archive’ file for transmittal to the PDS node. The zip archive preserves the directory structure internally so that it can be recreated after electronic delivery to the PDS node. The ‘zip archive’ file was transmitted to the PDS node via FTP to an account set up by the receiving node. Also transmitted was a checksum file created using the MD5 algorithm. This provided an independent method of verifying the integrity of the zip file after it was sent. Within days of transmittal the PDS node acknowledged receipt of the archive and checksum file. If acknowledgement was not received, or if problems were reported, the MESSENGER SOC immediately took corrective action.

After transmittal the PDS node uncompressed the zip archive file and checked for data integrity using the checksum file. The node then performed any additional verification and validation of the data provided and reported any discrepancies or problems to the MESSENGER SOC. After inspection was completed to the satisfaction of the PDS node, the node issued to the MESSENGER SOC acknowledgement of successful receipt of the data. Following receipt of a data delivery the PDS node organized the data into a PDS archive volume structure within its online data system. Newly delivered data are made available publicly from PDS once accompanying labels and other documentation are validated.

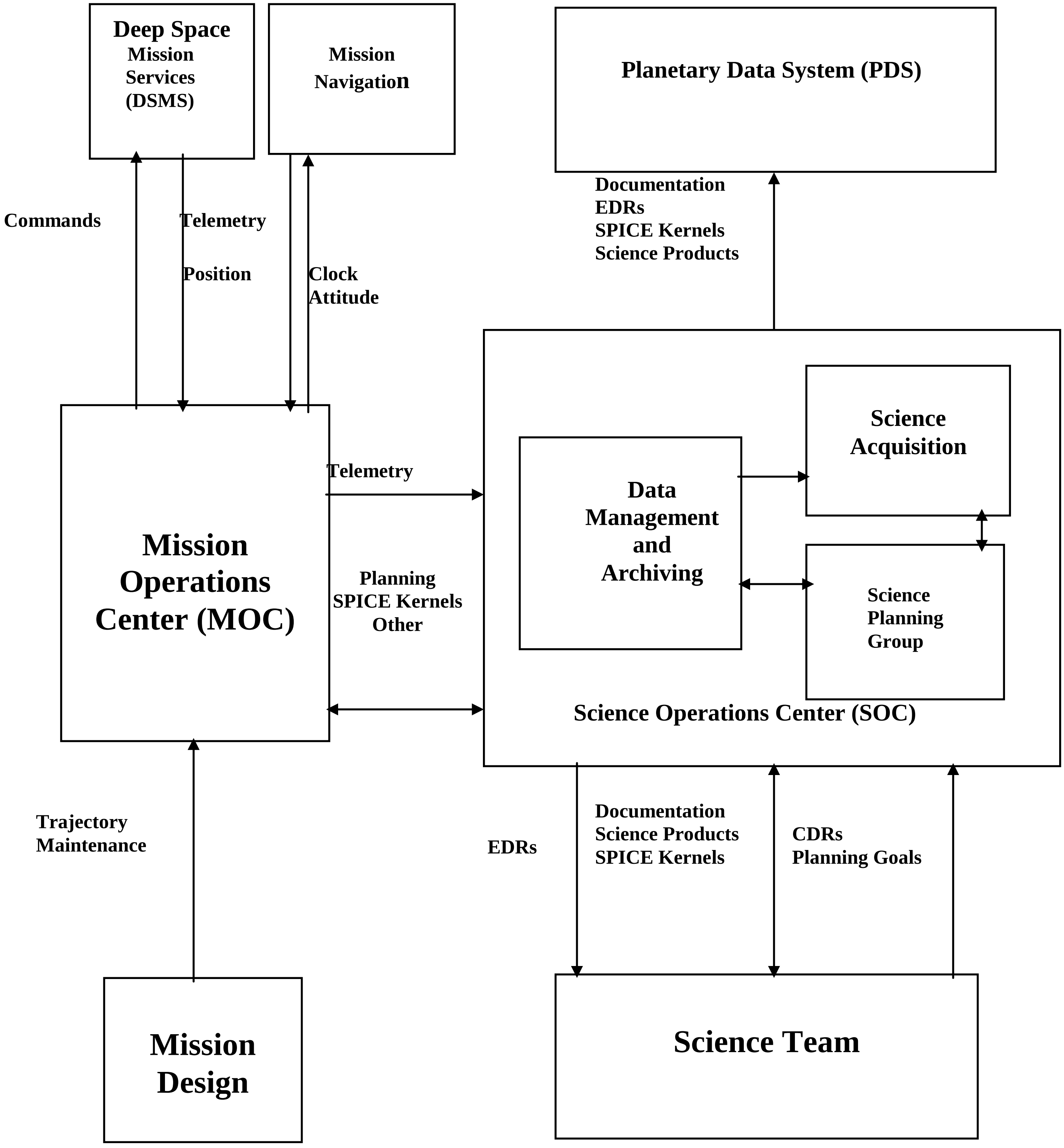

Figure 1. MESSENGER Data Flow

5.3.4 Labeling and Identification

There is a corresponding detached PDS label file for each NS CDR/DDR data file. Detached means that the label file is separate from the data file, as opposed to being in the header portion of the data file. See sections 7.4 and 7.5 for sample PDS label and format files and section 6 for a complete description of the included keywords.

The data set ID assigned by PDS to the NS CDR data set is “MESS-E/V/H-GRNS-3-NS-CDR-V2.0.” The data set ID assigned by PDS to the NS DDR data set is “MESS-E/V/H-GRNS-4-NS-DDR-V2.0.”

5.4 Standards Used in Generating Data Products

5.4.1 PDS Standards

The NS CDR/DDR data products comply with Planetary Data System standards for file formats and labels as specified in the PDS Standards Reference. Each NS CDR/DDR data product includes the following:

- Data File - A binary or ASCII table object containing the data.
- Detached Label File - A high-level description of the parameters that correspond to the table object.
- Format File - A detached file located in the LABEL directory which describes the structure of the table file. There is 1 format file for each of the 5 CDR standard data products and the DDR NCR data product. The DDR NCP does not have an associated format file.

5.4.2 Coordinate Systems

There are two general coordinate systems in use for the MESSENGER project:

- The celestial reference system used for target and spacecraft position and velocity vectors and camera pointing.
- 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.

For planetary orbital and flyby data, the NS-specific data also have two additional coordinate systems for expressing spacecraft velocity and attitude data: the nadir fixed coordinate system and the spacecraft fixed coordinate system.

The nadir fixed coordinate system is defined as follows:

- The z-axis is defined as the vector from the spacecraft center to the flyby or orbiting planet center.
- The nadir fixed y-axis is defined as the cross product of the nadir z-axis and the spacecraft velocity vector (where both are expressed in the J2000 coordinate system).
- The nadir fixed x-axis is defined as the cross product of the nadir fixed y-axis with the nadir fixed z-axis.

The spacecraft fixed coordinate system is defined as follows:

- The spacecraft fixed x-axis is the vector normal to the NS LG1 sensor and is parallel to the spacecraft solar panel booms.
- The spacecraft fixed y-axis is in the direction from the spacecraft down the magnetometer boom.
- The spacecraft fixed z-axis is the viewing direction from the instrument deck.

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

- The beginning time of observation is used for the geometric element computations.
- 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.
- 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 A*, Section 7.1).

5.4.3 Data Storage Conventions

The data are organized following PDS standards and stored on hard disk and an SQL (Structured Query Language) relational database for rapid access during mission operations. The MESSENGER SOC transfers data to PDS via electronic transfer and delivery methods as detailed in section 5.3.3. After verification of the data transfer PDS provides public access to MESSENGER science data products through its online data distribution system.

5.5 Data Validation

The NS CDR/DDR data products were validated by the NS Instrument Scientist for science content and for compliance with PDS archive standards [Applicable Document: MESSENGER Data Management and Archiving Plan].

The NS CDR/DDR data products and documentation have been approved by a peer review committee according to PDS policy.

5.6 Software

No NS-specific software is required to read these data products. As PDS-compliant binary and ASCII tables, they can be read using the PDS-supplied program NASAView and other software designed to read PDS data. NASAView is available at no charge from the PDS web site 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.

6 Detailed Data Product Specifications

6.1 Common Elements of Calibrated and Derived Data

6.1.1 Handling Errors

Even with data validation procedures applied to the archive volume, it is inevitable that errors are introduced. 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 NS data processing facility. An errata report file (errata.txt) was maintained to track and document all discovered errors, including any CDRs/DDRs that were revised during the course of the mission. Revised CDRs/DDRs or CDRs/DDRs that were missing from a previous PDS delivery were provided at the next scheduled PDS delivery or at the final PDS delivery as needed. 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 NS CDR/DDR 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. See *Appendix A*, Section 7.1 for more information.

6.1.3 PDS Label File Keywords

Each NS CDR/DDR table is accompanied by a PDS label. See *Appendix D*, Section 7.4 for sample PDS label files.

Below are the keyword definitions for the detached PDS label file, in alphabetical order:

BYTES
Indicates the number of bytes allocated for a particular data representation.

COLUMNS
Identifies the number of columns (fields) in the table. The NS_CDR_SPECTRA, NS_CDR_COUNTS, NS_CDR_GCR_SPECTRA, NS_CDR_GAB, NS_CDR_ENG, NS_DDR_NCR, and NS_DDR_NCP data products have 26, 25, 10, 11, 98, 29, and 13 columns, respectively.

DATA_SET_ID
The DATA_SET_ID element is a unique alphanumeric identifier for a data set or a data product. The DATA_SET_ID value for a given data set or product is constructed according to flight project naming conventions. The DATA_SET_IDs for the NS CDRs and DDRs are MESS-E/V/H-GRNS-3-NS-CDR-V2.0 and MESS-E/V/H-GRNS-4-NS-DDR-V2.0, respectively.

DESCRIPTION
Specifies a description of the table object. Each data product (NS_CDR_SPECTRA, NS_CDR_COUNTS, NS_CDR_GCR_SPECTRA, NS_CDR_GAB, NS_CDR_ENG, NS_DDR_NCR, NS_DDR_NCP) has a unique description.

FILE_RECORDS
The FILE_RECORDS element indicates the number of physical file records in the detached data file.

^HEADER
Pointer to the external data file that contains the header object.

HEADER_TYPE
Identifies a specific type of header data structure. HEADER_TYPE = TEXT for the DDR NCP data products.

INSTRUMENT_HOST_NAME
The full name of the host on which the instrument is based: MESSENGER.

INSTRUMENT_ID
Unique ID associated with the instrument: NS.

INSTRUMENT_NAME
Full, unabbreviated name of the instrument: NEUTRON SPECTROMETER.

INTERCHANGE_FORMAT
Specifies the file format. NS_CDR_SPECTRA, NS_CDR_COUNTS, and NS_CDR_GCR_SPECTRA data products are in BINARY format. The NS_CDR_ENG, NS_CDR_GAB, NS_DDR_NCR, and NS_DDR_NCP data products are in ASCII format.

MISSION_PHASE_NAME
Provides the commonly used identifier of a mission phase. There are 19 possible phase names for MESSENGER: LAUNCH, EARTH CRUISE, EARTH FLYBY, VENUS 1 CRUISE, VENUS 1 FLYBY, VENUS 2 CRUISE, VENUS 2 FLYBY, MERCURY 1 CRUISE, MERCURY 1 FLYBY, MERCURY 2 CRUISE, MERCURY 2 FLYBY, MERCURY 3 CRUISE, MERCURY 3 FLYBY, MERCURY 4 CRUISE,

MERCURY ORBIT, MERCURY ORBIT YEAR 2, MERCURY ORBIT YEAR 3, MERCURY ORBIT YEAR 4, and MERCURY ORBIT YEAR 5.

OBJECT=HEADER

Specifies the header portion of the DDR NCP table. The header references information and column headings to improve usability. The header object contains its own elements which are defined alphabetically in this section. **NOTE**: The end of the object definition is always marked with an END_OBJECT line.

OBJECT=TABLE

Specifies that the CDR/DDR is a PDS TABLE object. This object contains its own elements which are defined alphabetically in this section. **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.

PRODUCT_CREATION_TIME

Stores the time that the data product was created, in UTC time.

PRODUCT_ID

The PRODUCT_ID data element represents a permanent, unique identifier assigned to a data product by its producer. For the NS_CDR_SPECTRA, NS_CDR_COUNTS, and NS_CDR_GCR_SPECTRA binary standard data products, the product_id is the file name with ".DAT" replaced by "_DAT." For the NS_CDR_ENG, NS_CDR_GAB, and NS_DDR_NCR ASCII standard data products, the product_id is the file name with ".TAB" replaced by "_TAB." For the NS_DDR_NCP special data product, the product_id is NS_DDR_NCP_TAB.
Note: In the PDS, the value assigned to PRODUCT_ID must be unique within its data set.

PRODUCT_TYPE

Data products are identified as a CDR (Calibration Data Record) or DDR (Derived Data Record).

PRODUCT_VERSION_ID

Version number of an individual product within a data set.

RECORDS

Identifies the number of physical records in a file or other data object.

RECORD_BYTES

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

RECORD_TYPE

The RECORD_TYPE element indicates the record format of a file. The FIXED_LENGTH value is used for the table object used in the MESSENGER NS CDR/DDR data products.

ROW_BYTES

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

ROWS

Number of rows in the table.

SOFTWARE_NAME

Identifies the name of the software system that created the data products, NS_CDR_GEN or NS_DDR_GEN.

SOFTWARE_VERSION_ID

Version number of the program or program library used by the instrument to collect observations.

SPACECRAFT_CLOCK_START_COUNT
Clock count of the spacecraft computer at the start of the observation.

SPACECRAFT_CLOCK_STOP_COUNT
Clock count of the spacecraft computer at the end of the observation.

STANDARD_DATA_PRODUCT_ID
Used to link a NS file to one of the 7 types of standard data products defined in the NS CDR/DDR SIS: NS_CDR_SPECTRA, NS_CDR_COUNTS, NS_CDR_GCR_SPECTRA, NS_CDR_GAB, NS_CDR_ENG, NS_DDR_NCR, and NS_DDR_NCP.

START_TIME
Start time in UTC of the observation.

STOP_TIME
Time in UTC when the instrument stopped collecting measurements.

^STRUCTURE
Pointer to the external file that provides the structure definition for the table object. For the NS_CDR_SPECTRA, NS_CDR_COUNTS, NS_CDR_GCR_SPECTRA, NS_CDR_GAB, NS_CDR_ENG, and NS_DDR_NCR standard data products, the external files are named NS_CDR_SPECTRA.FMT, NS_CDR_COUNTS.FMT, NS_CDR_GCR_SPECTRA.FMT, NS_CDR_GAB.FMT, NS_CDR_ENG.FMT, and NS_DDR_NCR.FMT, respectively.

TARGET_NAME
The target of the observation. The TARGET_NAME defines the reference frame for the geometry keywords listed in the data product tables. For TARGET_NAME = CALIBRATION, the reference frame is Mercury-centric, however these values are essentially meaningless for data interpretation purposes.

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

6.1.4 Format File Keywords

With the exception of the DDR NCP, each NS CDR/DDR PDS label contains a pointer to the column format file. This file describes the structure of the NS binary or ASCII table that includes column name, byte size, data type, applicable units, and a description of the value assigned to the column. See *Appendix E*, Section 7.5 for the column format files.

The following describes the keywords used in the format file, in alphabetical order:

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.

DESCRIPTION
Brief description of the value assigned to the column, including units where applicable.

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

ITEM_BYTES
Represents the size of each individual item within the column field.

NAME
Indicates a literal value representing the common term used to identify an element or object.

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.

UNIT
Unit of measurement in which the value is expressed.

6.2 NS Spectra – NS_CDR_SPECTRA

6.2.1 Data Product Structure and Organization

The NS_CDR_SPECTRA are calibrated neutron spectra that have the timing, spatial and engineering readings taken at the beginning of the associated spectral collection period. Each NS_CDR_SPECTRA data product is organized as a binary data file containing calibrated spectra and associated data collected over a 24 hour time period, with a detached ASCII text PDS label file. The files are grouped by month (MM) within the DATA directory (see figure 2). Table 6.1 lists the values that make up the NS_CDR_SPECTRA files.

Data Value	**Data Type**	**Length (bytes)**	**Description**
MISSION_ELAPSED_TIME	MSB_UNSIGNED_INTEGER	4	Time tag in seconds of the start of the associated reporting/accumulation period.
UTC_TIME	CHARACTER	19	UTC time at start of data collection. Format: YYYY-MM-DDTHH:MM:SS.
UTC_TIME_JULDAY	IEEE_REAL	8	UTC time at start of data collection given in Julian Day.
ORBIT_NUMBER	MSB_UNSIGNED_INTEGER	4	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 (see GEOMETRY/geominfo.txt). Orbit numbering does not start until MESSENGER performs the Mercury orbit insertion. Until that time the value for orbit number is 0.
ACTUAL_ACCUM	MSB_UNSIGNED_INTEGER	4	Actual accumulation period in seconds for software counters and energy histograms.
SC_ALTITUDE	IEEE_REAL	4	Spacecraft altitude above the subsatellite point on the target in units of km.
SC_LATITUDE	IEEE_REAL	4	Target-centric latitude of the spacecraft subsatellite

			point in degrees.
SC_LONGITUDE	IEEE_REAL	4	Target-centric longitude of the spacecraft subsatellite point in degrees.
VEL_NORM	IEEE_REAL	4	Magnitude of the spacecraft velocity as expressed in the nadir-fixed coordinate system in units of km/second.
V_DOT_X	IEEE_REAL	4	Velocity normalized dot product of the vector velocity and the spacecraft x-axis unit vector expressed as a unitless number from -1 to 1.
V_DOT_Y	IEEE_REAL	4	Velocity normalized dot product of the vector velocity and the spacecraft y-axis unit vector expressed as a unitless number from -1 to 1.
V_DOT_Z	IEEE_REAL	4	Velocity normalized dot product of the vector velocity and the spacecraft z-axis unit vector expressed as a unitless number from -1 to 1.
NADIR_ANGLE	IEEE_REAL	4	Spacecraft orientation angle of the spacecraft z-axis and the spacecraft-to-planet center vector in units of degrees.
XAXIS_ANGLE	IEEE_REAL	4	Spacecraft orientation angle of the spacecraft x-axis and the spacecraft-to-planet center vector in units of degrees.
YAXIS_ANGLE	IEEE_REAL	4	Spacecraft orientation angle of the spacecraft y-axis and the spacecraft-to-planet center vector in units of degrees.
THETA_ANGLE	IEEE_REAL	4	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).
PHI_ANGLE	IEEE_REAL	4	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.
BETA_ANGLE	IEEE_REAL	4	Angle of the normal of the spacecraft orbital plane with respect to Mercury-to-Sun vector in degrees.
SUN_DISTANCE	IEEE_REAL	4	Distance of the spacecraft to the Sun in units of km.
VEL_VECTOR	IEEE_REAL	12	Three element spacecraft velocity vector expressed in the nadir-fixed coordinate system with each component in units of km/second.
SC_TO_NADIR_ROT	IEEE_REAL	36	Nine-element rotation matrix that converts the spacecraft attitude from instrument fixed coordinates to nadir fixed coordinates.
LG1_SPECTRA	IEEE_REAL	256	LG1 singles spectra in counts per second.
LG2_SPECTRA	IEEE_REAL	256	LG2 singles spectra in counts per second.
BP_SPECTRA	IEEE_REAL	256	Borated plastic singles spectra in counts per second.
TC_EARLY_SPECTRA	IEEE_REAL	1024	Borated plastic Time Correlated (TC) first interaction spectra from the early time window in counts per second.
TC_LATE_SPECTRA	IEEE_REAL	1024	Borated plastic Time Correlated (TC) first interaction spectra from the late time window in counts per second.

Table 6.1. Data values for the NS_CDR_SPECTRA data product.

6.2.2 Data Format Descriptions

The data format for the NS_CDR_SPECTRA is a 26-column binary table. Columns vary in width from 4 to 1024 bytes. Column structure and start byte are described in *Appendix E*, Section 7.5.1. 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 general form of the NS_CDR_SPECTRA file name is:

"**NS_CDR_ZZZYYYYDDDWWW.XXX**", where

NS instrument identifier: represents the NS instrument

CDR data product identifier: CDR

ZZZ data product name

SPE – NS CDR Spectra with associated engineering, timing and spatial data.

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

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

WWW reserved character string to 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 (.DAT).

6.2.4 Label Description

The NS_CDR_SPECTRA 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 NS Counts Data – NS_CDR_COUNTS

6.3.1 Data Product Structure and Organization

The NS_CDR_COUNTS files contain NS counter data that have the timing, spatial and engineering readings taken at the beginning of the associated spectral collection period. Each NS_CDR_COUNTS data product is organized as a binary data file containing counting rates and associated data collected over a 24 hour time period, with a detached ASCII text PDS label file. The files are grouped by month (MM) within the DATA directory (see figure 2). Table 6.2 lists the values that make up the NS_CDR_COUNTS files.

Data Value	**Data Type**	**Length (bytes)**	**Description**
MISSION_ELAPSED_TIME	MSB_UNSIGNED_INTEGER	4	Time tag in seconds of the start of the associated reporting/accumulation period.
UTC_TIME	CHARACTER	19	UTC time at start of data collection. Format: YYYY-MM-DDTHH:MM:SS.
UTC_TIME_JULDAY	IEEE_REAL	8	UTC time at start of data collection given in Julian Day.
ORBIT_NUMBER	MSB_UNSIGNED_INTEGER	4	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 (see GEOMETRY/geominfo.txt). Orbit numbering does not start until MESSENGER performs the Mercury orbit insertion. Until that time the value for orbit number is 0.
ACTUAL_ACCUM	MSB_UNSIGNED_INTEGER	4	Actual accumulation period in seconds for software counters and energy histograms.
SC_ALTITUDE	IEEE_REAL	4	Spacecraft altitude above the subsatellite point on the target in units of km.
SC_LATITUDE	IEEE_REAL	4	Target-centric latitude of the spacecraft subsatellite point in degrees.
SC_LONGITUDE	IEEE_REAL	4	Target-centric longitude of the spacecraft subsatellite point in degrees.
LG1_RAW_EVENTS	IEEE_REAL	4	LG1 raw events in counts per second.
LG2_RAW_EVENTS	IEEE_REAL	4	LG2 raw events in counts per second.
BP_RAW_EVENTS	IEEE_REAL	4	BP raw events in counts per second.
SW_TOTAL_EVENTS	IEEE_REAL	4	Total software counts in counts per second.
DEAD_TIME	IEEE_REAL	4	Dead time counter in units of counts.
LG1_RESET	IEEE_REAL	4	LG1 resets in counts per second.

LG2_RESET	IEEE_REAL	4	LG2 resets in counts per second.
BP_RESET	IEEE_REAL	4	BP resets in counts per second.
BPP_LGXS	IEEE_REAL	4	Fast neutrons moderated in the borated plastic but captured in the lithium glass. LG1 and LG2 are combined, thus the LGX designation.
LG1_OVER_RANGE	IEEE_REAL	4	LG1 over range counts per second.
LG2_OVER_RANGE	IEEE_REAL	4	LG2 over range counts per second.
BP_OVER_RANGE	IEEE_REAL	4	BP over range counts per second.
LG1_BPP_COIN	IEEE_REAL	4	Number of LG1-prompt BP coincidence counts per second.
LG2_BPP_COIN	IEEE_REAL	4	Number of LG2-prompt BP coincidence counts per second.
LG1_BPP_LG2_COIN	IEEE_REAL	4	Number of LG1-LG2-prompt BP triple coincidence counts per second.
TC_EARLY	IEEE_REAL	4	Number of time correlated early counts per second.
TC_LATE	IEEE_REAL	4	Number of time correlated late counts per second.

Table 6.2. Data values for the NS_CDR_COUNTS data product.

6.3.2 Data Format Descriptions

The data format for the NS_CDR_COUNTS files is a 25-column binary table. Columns vary in width from 4 to 17 bytes. Column structure and start byte are described in *Appendix E,* Section 7.5.2. 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

The general form of the NS_CDR_COUNTS file name is:

"**NS_CDR_ZZZYYYYDDDWWW.XXX**", where

NS instrument identifier: represents the NS instrument.

CDR data product identifier: CDR

ZZZ data product name

CTS – NS CDR Counts with associated engineering, timing, and spatial data.

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

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

WWW reserved character string to 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 (.DAT).

6.3.4 Label Description

The NS_CDR_COUNTS 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 NS Galactic Cosmic Ray Spectra – NS_CDR_GCR_SPECTRA

6.4.1 Data Product Structure and Organization

The NS_CDR_GCR_SPECTRA are LG1 and LG2 64-channel spectra data taken when a coincidence condition is detected in both LG sensors and the BP sensor. Since only high energy charged particles (>~100 MeV) can penetrate all three sensors to provide a coincidence, these spectra are called GCR spectra for Galactic Cosmic Rays (GCR). Associated timing, spatial and engineering readings taken at the beginning of the associated spectral collection period are also provided in the NS_CDR_GCR_SPECTRA files. Each NS_CDR_GCR_SPECTRA data product is organized as a binary data file containing calibrated spectra and associated data collected over a 24 hour time period, with a detached ASCII text PDS label file. The files are grouped by month (MM) within the DATA directory (see figure 2). Table 6.3 lists the values that make up the NS_CDR_COUNTS files.

Data Value	**Data Type**	**Length (bytes)**	**Description**
MISSION_ELAPSED_TIME	MSB_UNSIGNED_INTEGER	4	Time tag in seconds of the start of the associated reporting/accumulation period.

UTC_TIME	CHARACTER	19	UTC time at start of data collection. Format: YYYY-MM-DDTHH:MM:SS.
UTC_TIME_JULDAY	IEEE_REAL	8	UTC time at start of data collection given in Julian Day.
ORBIT_NUMBER	MSB_UNSIGNED_INTEGER	4	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 (see GEOMETRY/geominfo.txt). Orbit numbering does not start until MESSENGER performs the Mercury orbit insertion. Until that time the value for orbit number is 0.
ACTUAL_ACCUM	MSB_UNSIGNED_INTEGER	4	Actual accumulation period in seconds for software counters and energy histograms.
SC_ALTITUDE	IEEE_REAL	4	Spacecraft altitude above the subsatellite point on the target in units of km.
SC_LATITUDE	IEEE_REAL	4	Target-centric latitude of the spacecraft subsatellite point in degrees.
SC_LONGITUDE	IEEE_REAL	4	Target-centric longitude of the spacecraft subsatellite point in degrees.
LG1_GCR_SPECTRA	IEEE_REAL	256	LG1 GCR spectra in counts per channel per spectra.
LG2_GCR_SPECTRA	IEEE_REAL	256	LG2 GCR spectra in counts per channel per spectra.

Table 6.3. Data values for the NS_CDR_GCR_SPECTRA data product.

6.4.2 Data Format Descriptions

The data format for the NS_ CDR_GCR_SPECTRA is a 10-column binary table. Columns vary in width from 4 to 256 bytes. Column structure and start byte are described in *Appendix E*, Section 7.5.3. 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

The general form of the NS_CDR_GCR_SPECTRA file name is:

"**NS_CDR_ZZZYYYYDDDWWW.XXX**", where

NS instrument identifier: represents the NS instrument.

CDR data product identifier: CDR

ZZZ data product name

GCR – NS CDR Galactic Cosmic Ray spectra with associated engineering, timing and spatial data.

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

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

WWW reserved character string to 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 (.DAT).

6.4.4 Label Description

The NS_ CDR_GCR_SPECTRA 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 NS Engineering Data – NS_CDR_ENG

6.5.1 Data Product Structure and Organization

The NS_CDR_ENG data product is organized as an ASCII table containing a time series of engineering parameters taken over a 24 hour time period, with a detached ASCII text PDS label file. Individual records are a single data collection interval that is variable in duration. In general, temperatures are reported in Celsius, currents in Amps, and potentials in Volts. The files are grouped by month (MM) within the DATA directory (see figure 2). Table 6.4 lists the values that make up the NS_CDR_ENG files. In general, the data values in the NS_CDR_ENG files are carried over without correction from the NS EDR status files. Thus, the definitive explanations of these data are given in the NS EDR SIS. However, for quantities with physical units, a conversion has been made to change the engineering units to physical units. A description of how this conversion is done is given in the NS calibration document (messns_edr2cdr2ddr.pdf in the CALIB directory). Another change in these files compared to the EDR data is that UTC times, instead of the spacecraft clock values of MET, are appended to the data. This allows a simple, direct comparison in time of these engineering data with other NS spectra and counting rate data.

Data Value	Data Type	Length (bytes)	Description
MISSION_ELAPSED_TIME	ASCII_INTEGER	12	Time tag in seconds of the start of the associated reporting/accumulation period.
UTC_TIME	CHARACTER	19	UTC time at start of data collection. Format: YYYY-MM-DDTHH:MM:SS.
UTC_TIME_JULDAY	ASCII_REAL	18	UTC time at start of data collection given in Julian Day.
ORBIT_NUMBER	ASCII_INTEGER	8	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 (see GEOMETRY/geominfo.txt). Orbit numbering does not start until MESSENGER performs the Mercury orbit insertion. Until that time the value for orbit number is 0.
STATUS_INTERVAL	ASCII_INTEGER	8	Status interval in seconds. Valid values: 1-65535 (0=off). Defines the interval at which status is reported. Not an accumulation interval. All status fields are either stationary values of registers or 1-second accumulations (such as for hardware counters).
MACRO_BLOCKS	ASCII_INTEGER	8	Number of macro blocks free.
TLM_VOLUME	ASCII_INTEGER	8	Telemetry volume produced (kB) by NS (compressed data with telemetry headers, etc.). For telemetry control purposes.
WATCH_ADDR	ASCII_INTEGER	8	Memory watch address. Address loaded for peaking into memory for diagnostic purposes.
WATCH_MEM	ASCII_INTEGER	8	Memory watch address id (page number) loaded to complete 20-bit address.
WATCH_DATA1	ASCII_INTEGER	8	Watched memory, byte 1 value of the stack-errors word maintained by the common code.
WATCH_DATA2	ASCII_INTEGER	8	Watched memory, byte 2 value of the stack-errors word maintained by the common code.
SW_VERSION	ASCII_INTEGER	8	Software version number.
ALARM_ID	ASCII_INTEGER	8	=15, BP (HV1) has reached Level 1 safing due to high event rate. =16, BP (HV1) has reached Level 2 safing due to persistent high event rate. =17, LG (HV2) has reached Level 1 safing due to high event rate. =18, LG (HV2) has reached Level 2 safing due to persistent high event rate. Values and description taken from Table 2.12 of MESSENGER Instrument Neutron Spectrometer (NS) Flight Software Specification, cited in Applicable Documents section of NS CDR SIS. Compiled in Monitor limits.
ALARM_TYPE	ASCII_INTEGER	8	Latest alarm type. =0 Persistent. =1

			Transient.
ALARM_COUNT	ASCII_INTEGER	8	Count of alarms.
CMD_EXEC	ASCII_INTEGER	8	Number of commands executed.
CMD_REJECT	ASCII_INTEGER	8	Number of commands rejected.
MAC_EXEC	ASCII_INTEGER	8	Number of macro commands executed.
MAC_REJECT	ASCII_INTEGER	8	Number of macro commands rejected.
MACRO_ID	ASCII_INTEGER	8	ID of most recent macro executed.
MACRO_LEARN	ASCII_INTEGER	8	Macro learn mode. =0 not learning, =1 learning.
MONITOR_RESP	ASCII_INTEGER	8	Monitor response. =0 disabled, =1 enabled.
WRITE_ENABLE	ASCII_INTEGER	8	Memory write enable. =0 disabled, =1 enabled.
PLUS_5V	ASCII_REAL	8	+5 volt monitor (LVPS) in volts.
NEG_5V	ASCII_REAL	8	-5 volt monitor (LVPS) in volts.
PLUS_12V	ASCII_REAL	8	+12 volt monitor (LVPS) in volts.
NEG_12V	ASCII_REAL	8	-12 volt monitor (LVPS) in volts.
EXTERNAL_CH1	ASCII_REAL	8	External channel 1 (LVPS). ADC board temperature in units of degrees Celsius.
EXTERNAL_CH2	ASCII_REAL	8	External channel 2 (LVPS). Pre-amp board temperature in units of degrees Celsius.
EXTERNAL_CH3	ASCII_INTEGER	8	External channel 3 (LVPS).
EXTERNAL_CH4	ASCII_REAL	8	External channel 4 (LVPS). NS sensor temperature in units of degrees Celsius.
EXTERNAL_CH5	ASCII_INTEGER	8	External channel 5 (LVPS).
PLUS5V_I	ASCII_REAL	8	+5V current monitor (LVPS) in amps.
NEG5V_I	ASCII_REAL	8	-5V current monitor (LVPS) in amps.
PLUS12V_I	ASCII_REAL	8	+12V current monitor (LVPS) in amps.
NEG12V_I	ASCII_REAL	8	-12V current monitor (LVPS) in amps.
TEMP_MON	ASCII_REAL	8	Temperature monitor (LVPS) in degrees Celsius.
PRIMARY_I	ASCII_REAL	8	Primary current monitor (LVPS) in amps.
SWITCHED_PRI_I	ASCII_REAL	8	Switched primary current monitor (LVPS) in amps.
VOLT_LG_HVPS	ASCII_REAL	8	Voltage of LG HVPS(1) in volts.
VOLT_BP_HVPS	ASCII_REAL	8	Voltage of BP HVPS(2) in volts.
TEMP_LG	ASCII_REAL	8	Temperature of LG in degrees Celsius.
TEMP_BP	ASCII_REAL	8	Temperature of BP in degrees Celsius.
HVPS_SPARE1	ASCII_REAL	8	Spare column. Any values contained are a consequence of the flight software and should be ignored.
HVPS_SPARE2	ASCII_REAL	8	Spare column. Any values contained are a consequence of the flight software and should be ignored.
CAPTURE_E_LIMIT	ASCII_INTEGER	8	Capture energy limit in units of channels.
EVENT_MODE_LEN	ASCII_INTEGER	8	Event mode length in numbers of events.
FAILED_PACKETS	ASCII_INTEGER	8	Failed packets.
POWER_MANAGEMENT	ASCII_INTEGER	8	Power management bit register. Defines various circuit parameters, including normal and sleep modes.
TRIG_SAMPLE_TAP	ASCII_INTEGER	8	Trigger sample tap.
GAIN_DAC	ASCII_INTEGER	8	Controls BP channel gain by changing ADC reference voltage.
BP_CHARGE_RESET	ASCII_INTEGER	8	BP charge reset in units of counts (1-sec accumulation).

BP_PRMPT_THRESH	ASCII_INTEGER	8	Channel 0 (BP) prompt trigger threshold in channels.
BP_SEC_THRESH	ASCII_INTEGER	8	Channel 0 (BP) secondary trigger threshold in channels.
LG1_TRIG_THRESH	ASCII_INTEGER	8	Channel 1 (LG) trigger threshold in channels.
LG2_TRIG_THRESH	ASCII_INTEGER	8	Channel 2 (LG) trigger threshold in channels.
BP_RAW_EVENT	ASCII_INTEGER	8	Channel 0 (BP) raw event hardware counter (1-sec accumulation) in counts.
LG1_RAW_EVENT	ASCII_INTEGER	8	Channel 1 (LG1) raw event hardware counter (1-sec accumulation) in counts.
LG2_RAW_EVENT	ASCII_INTEGER	8	Channel 2 (LG2) raw event hardware counter (1-sec accumulation) in counts.
LG_SAFING_STATE	ASCII_INTEGER	8	LG current sensor state. =0 Nominal, =1 Seeking, =2 Level 1 Rampdown, =3 Level 1 Waiting, =4 Level 1 Seeking, =5 Level 2 Safing.
BP_SAFING_STATE	ASCII_INTEGER	8	BP current sensor state. =0 Nominal, =1 Seeking, =2 Level 1 Rampdown, =3 Level 1 Waiting, =4 Level 1 Seeking, =5 Level 2 Safing.
SCREEN_ON_DQ	ASCII_INTEGER	8	Set calibration/diagnostic mode to screen out data with DQ bit set. =0 No Screen, =1 Screen.
NON_COMP_SCI_DATA	ASCII_INTEGER	8	This column has been retired. Non-compressed science data packets have not been generated by the instrument during flight. Ignore any value in this column.
FAST_COMP_SCI_DATA	ASCII_INTEGER	8	When SW_VERSION=4 this value reflects whether FAST compression of the science packet was enabled. When SW_VERSION=5 this value reflects whether the full science packet was enabled. =1 Enabled, =0 Disabled.
LOG_COMP_SCI_DATA	ASCII_INTEGER	8	Log compression of software counters enabled. =1 Enabled, =0 Disabled.
DIAG_DATA_PACKET	ASCII_INTEGER	8	Diagnostic packet enabled. =1 Enabled, =0 Disabled.
SPARE_DATA_PACKET	ASCII_INTEGER	8	Spare data packet enabled. =1 Enabled, =0 Disabled.
HV1_ENABLED	ASCII_INTEGER	8	HV1 (BP) enabled. =1 Enabled, =0 Disabled.
HV2_ENABLED	ASCII_INTEGER	8	HV2 (LG1 or LG2) enabled. =1 Enabled, =0 Disabled.
ACCUM_FLAG	ASCII_INTEGER	8	Flag for instrument accumulation. =0 Not Accumulating, =1 Accumulating.
ACCUM_PERIOD	ASCII_INTEGER	8	Currently commanded accumulation period in units of seconds.
REPORT_PERIOD	ASCII_INTEGER	8	Currently commanded reporting period in units of seconds.
LG1_ULD	ASCII_INTEGER	8	LG1 Upper-Level Discriminator. Raw ADC units.
LG2_ULD	ASCII_INTEGER	8	LG2 Upper-Level Discriminator. Raw ADC units.
BP_ULD	ASCII_INTEGER	8	BPP Upper-Level Discriminator. Raw ADC units.
HI_VOLT_SETP_BP	ASCII_INTEGER	8	Currently commanded High Voltage set point

			for BP HVPS.
HI_VOLT_SEPT_LG	ASCII_INTEGER	8	Currently commanded High Voltage set point for LG HVPS.
HVPS_1_MAX_VAL	ASCII_INTEGER	8	Maximum commandable HVPS 1 value.
HVPS_2_MAX_VAL	ASCII_INTEGER	8	Maximum commandable HVPS 2 value.
SAFING_RETRY	ASCII_INTEGER	8	Sensor safing retry value.
SAFING_INTERVAL	ASCII_INTEGER	8	Sensor safing interval value.
SAFING_THRESHOLD	ASCII_INTEGER	8	LG1, LG2, BP safing threshold.
EARLY_CAPTURE_START	ASCII_INTEGER	8	Early capture window start time.
EARLY_CAPTURE_END	ASCII_INTEGER	8	Early capture window end time.
LATE_CAPTURE_START	ASCII_INTEGER	8	Late capture window start time.
LATE_CAPTURE_END	ASCII_INTEGER	8	Late capture window end time.
CH0_LATCH_UPS	ASCII_INTEGER	8	Total number of latch-ups on Channel 0 since last boot.
CH1_2_LATCH_UPS	ASCII_INTEGER	8	Total number of latch-ups on Channels 1 and 2 since last boot.
GAMMA_BURST_CNT	ASCII_INTEGER	8	Cumulative number of gamma ray bursts (mod 256).
TELEMETRY_PRIORITY	ASCII_INTEGER	8	Priority level for science telemetry.
GCR_COINCIDENCE_MODE	ASCII_INTEGER	8	Galactic Cosmic Ray coincidence mode. Value is set to 0 when SW_VERSION is less than 5 due to non-existence of this telemetry point in prior software versions. Otherwise values are =1 Doubles, =2 Triples, =3 Either.
GCR_PACKET	ASCII_INTEGER	8	Galactic Cosmic Ray packet enabled. Value is set to 0 when SW_VERSION is less than 5 due to the non-existence of this telemetry point in prior software versions. =0 Disabled, =1 Enabled.
GAMMARAY_BURST_RESPONSE	ASCII_INTEGER	8	Gamma Ray burst response macro enabled. Value is set to 0 when SW_VERSION is less than 5 due to the non-existence of this telemetry point in prior software versions. =0 Disabled, =1 Enabled.
GAMMA_BURST_THRESH	ASCII_INTEGER	8	Gamma Ray burst threshold value.
GAMMA_CH_LIMIT	ASCII_INTEGER	8	Gamma Ray (processed count) channel limit.
GAMMA_MODE	ASCII_INTEGER	8	Gamma Ray mode. =0 raw count, =1 processed count.
TC_COUNTERS	ASCII_INTEGER	8	Time-correlated counters mode enabled. Value is set to 0 when SW_VERSION is less than 5 due to the non-existence of this telemetry point in prior software versions.
GAMMA_POST_TRIG_LEN	ASCII_INTEGER	8	Gamma Ray post trigger length.

Table 6.4 Data values for the NS_CDR_ENG data product

6.5.2 Data Format Descriptions

The data format for the NS_CDR_ENG data product is a 98-column ASCII table. Columns vary in width from 8 to 18 bytes. Column structure and start byte are described in *Appendix E*, Section

7.5.4. 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

The general form of the NS_CDR_ENG file name is:

"**NS_CDR_ZZZYYYYDDDWWW.XXX** ", where

NS instrument identifier: represents the NS instrument.

CDR data product identifier: CDR

ZZZ data product name

ENG – Engineering data.

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

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

WWW reserved character string to 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 (.TAB).

6.5.4 Label Description

The NS_CDR_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. 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.

6.6 NS Gamma Ray Burst – NS_CDR_GAB

6.6.1 Data Product Structure and Organization

The NS_CDR_GAB data product is organized as an ASCII table containing a time series of gamma ray burst data taken over a 24 hour time period, with a detached ASCII text PDS label file. Individual records are a single data collection interval that is variable in duration. It contains the same data values as in the NS Gamma Ray Burst (GAB) EDR, only in ASCII form. This was done to provide a data product that was easy to analyze, such that the user did not have to develop tools to read clock kernels and keep track of which oscillator was being used. The data values in the NS_CDR_GAB files are carried over without correction from the NS GAB EDR. UTC date and time, derived from the spacecraft clock MET, are appended to the data. This allows a simple, direct comparison in UTC time of these engineering data with other external data sources.

Data Value	**Data Type**	**Length (bytes)**	**Description**
MET	ASCII_INTEGER	12	Time tag in seconds of the gamma-ray burst trigger.
CMD_UTC_DATE	CHARACTER	10	UTC date in YYYY-MM-DD format derived from the MET using SPICE kernels.
CMD_UTC_TIME	CHARACTER	12	UTC time in HH:MM:SS.SSS format derived from the MET using SPICE kernels.
CMD_UTC_SEC	CHARACTER	9	UTC time as seconds since 00:00:00 derived from MET using SPICE kernels.
ORBIT_NUMBER	ASCII_INTEGER	6	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.
GAMMA_RAY_MODE	ASCII_INTEGER	1	Gamma Ray mode.
BP_CH_UPPER_LIMIT	ASCII_INTEGER	2	The highest BP channel used as part of the source of the Gamma-Ray burst BP counts.
TRIG_BOXCAR_ACCUM	ASCII_INTEGER	6	Number of counts in the running box car accumulator at the time of the trigger.
BURST_THRESHOLD	ASCII_INTEGER	5	Burst lower pulse threshold for trigger in raw ADC.
POST_TRIGGER_COUNTS	ASCII_INTEGER	3	Number of post trigger counts.
GAMMA_RAY_BURST	ASCII_INTEGER	5 x 164	Collection of 164 (1-sec) BP counts.

Table 6.5 Data values for the NS_CDR_GAB data product

6.6.2 Data Format Descriptions

The data format for the NS_CDR_GAB data product is an 11-column ASCII table. Column structure and start byte are described in *Appendix E*, Section 7.5.5. 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

The general form of the NS_CDR_GAB file name is:

"**NS_CDR_ZZZYYYYDDDWWW.XXX** ", where

NS	instrument identifier: represents the NS instrument.
CDR	data product identifier: CDR
ZZZ	data product name
	GAB – Gamma-Ray Burst
YYYY	four-digit year corresponding to the start-time of the first record in the NS_CDR_GAB data file.
DDD	three-digit day of the year corresponding to the start time of the first record in the NS_CDR_GAB data file.
WWW	reserved character string to 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 (.TAB).

6.6.4 Label Description

The NS_CDR_GAB 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 NS Net Neutron Count Rates – NS_DDR_NCR

6.7.1 Data Product Structure and Organization

The NS_DDR_NCR files contain net neutron count rate data as derived from the LG and BP singles spectra. The net count rates are given in units of counts per second for each accumulation time interval. Derived uncertainty values for each count rate are also provided for each time step. Each NS_DDR_NCR file is organized as an ASCII text file and contains data collected over one Earth day. In addition to the count rates, spacecraft time and geometry information associated with each measurement are provided. These time and geometry values are the same as is given in the CDR files for each corresponding measurement. Three main processing steps are carried out for the derivation of the net neutron count rate data. First, data selections are made to exclude data taken during times of solar particle events when the charged particle flux is sufficiently high to affect the background in the NS sensors. The times of these exclusions are given in the data confidence notes associated with each delivery (see *catalog/ddr_ds.cat*). Second, gain corrections are made to the NS spectra prior to deriving any net neutron counts. Finally, background subtraction algorithms are applied to the NS spectra through which the net neutron counts are derived. Details of the processing are given in the document *messns_processing.pdf* located in the CALIB directory. Please note that DDRs were generated for data collected during the “Mercury Orbit” phase only.

Data Value	**Data Type**	**Length (bytes)**	**Description**
JULIAN_DAY	ASCII_REAL	13	UTC time at *midpoint* of data collection given in Julian day.
UTC_TIME	CHARACTER	19	UTC time at *midpoint* of data collection. Format: YYYY-MM-DDTHH:MM:SS.
MET	ASCII_INTEGER	12	Time tag in seconds at the start of the associated reporting/accumulation period.
ORBIT_NUMBER	ASCII_INTEGER	4	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 (see GEOMETRY/geominfo.txt). Orbit numbering does not start until MESSENGER performs the Mercury orbit insertion. Until that time the value for orbit number is 0.
ACTUAL_ACCUM	ASCII_INTEGER	4	Actual accumulation period in seconds for software counters and energy histograms.
SENSOR_TEMP	ASCII_REAL	7	NS sensor temperature in units of degree C.
ALTITUDE	ASCII_REAL	10	Spacecraft altitude above the subsatellite

			point on the target in units of km.
LATITUDE	ASCII_REAL	7	Target-centric latitude of the spacecraft subsatellite point in degrees.
LONGITUDE	ASCII_REAL	8	Target-centric longitude of the spacecraft subsatellite point in degrees.
LOCAL_TIME	ASCII_REAL	10	Local time of the spacecraft subsatellite point in hours from 0 to 24.
VELOCITY_VECTOR	ASCII_REAL	26	Three element spacecraft velocity vector expressed in the nadir-fixed coordinate system with each component in units of km/second.
VEL_NORM	ASCII_REAL	8	Magnitude of the spacecraft velocity as expressed in the nadir-fixed coordinate system in units of km/second.
SC_TO_NADIR_ROT	ASCII_REAL	80	Nine element rotation matrix that converts the spacecraft attitude from instrument-fixed coordinates to nadir-fixed coordinates.
VDOT_X	ASCII_REAL	8	Velocity normalized dot product of the vector velocity and the spacecraft x-axis unit vector expressed as a unitless number from -1 to 1.
VDOT_Y	ASCII_REAL	8	Velocity normalized dot product of the vector velocity and the spacecraft y-axis unit vector expressed as a unitless number from -1 to 1.
VDOT_Z	ASCII_REAL	8	Velocity normalized dot product of the vector velocity and the spacecraft z-axis unit vector expressed as a unitless number from -1 to 1.
NADIR_ANGLE	ASCII_REAL	8	Spacecraft orientation angle of the spacecraft z-axis and the spacecraft-to-planet center vector in units of degrees.
YAXIS_ANGLE	ASCII_REAL	8	Spacecraft orientation angle of the spacecraft y-axis and the spacecraft-to-planet center vector in units of degrees.
XAXIS_ANGLE	ASCII_REAL	8	Spacecraft orientation angle of the spacecraft x-axis and the spacecraft-to-planet center vector in units of degrees.
THETA_ANGLE	ASCII_REAL	8	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).
PHI_ANGLE	ASCII_REAL	8	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.
BETA_ANGLE	ASCII_REAL	8	Angle of the normal of the spacecraft orbital plane with respect to Mercury-to-Sun vector in degrees.
SUN_DISTANCE	ASCII_REAL	12	Distance of the spacecraft to the Sun in units of km.
LG1_CPS	ASCII_REAL	7	Net neutron count rate from the LG1 sensor in units of counts per second.

LG1_ERR_CPS	ASCII_REAL	7	Net uncertainty (error) in the the LG1 count rate in units of counts per second.
LG2_CPS	ASCII_REAL	7	Net neutron count rate from the LG2 sensor in units of counts per second.
LG2_ERR_CPS	ASCII_REAL	7	Net uncertainty (error) in the the LG2 count rate in units of counts per second.
BP_CPS	ASCII_REAL	7	Net neutron count rate from the BP sensor in units of counts per second.
BP_ERR_CPS	ASCII_REAL	7	Net uncertainty (error) in the the BP count rate in units of counts per second.

Table 6.6 Data Values for the NS DDR NCR data product

6.7.2 Data Format Descriptions

The data format for the NS_DDR_NCR data product is a 29-column ASCII table. Column structure and start byte are described in *Appendix E*, Section 7.5.6. 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

The general form of the NS_DDR_NCR file name is:

"**NS_DDR_ZZZYYYYDDDWWW.XXX** ", where

NS instrument identifier: represents the NS instrument.

DDR data product identifier: DDR

ZZZ data product name

NCR – Neutron Count Rates

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

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

WWW reserved character string to 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 (.TAB).

6.7.4 Label Description

The NS_DDR_NCR 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 NS Neutron Composition Product – NS_DDR_NCP

6.8.1 Data Product Structure and Organization

The NCP data product contains latitude-binned relative neutron count rates taken during the primary MESSENGER mission from 26 March 2011 to 25 February 2012. Specifically, these data are the exact data points given in Figure 2 and Figure 3A from Lawrence et al., *Science*, 339, 292-296, 2013. The delivered values include measured and simulated data for fast and epithermal neutron data within 2 degree wide latitude bins; the latitude values are the midpoint values within each bin and the data are the average values within each latitude bin. The simulated data include two cases: one case assumes there is no hydrogen in Mercury's north polar radar bright regions; the other case assumes that the north polar radar bright regions contain 100 wt.% H_2O. Table 6.7 lists the values that make up the NS_DDR_NCP file.

Details of the processing are given in the document *messns_processing.pdf* located in the CALIB directory.

Data Value	**Data Type**	**Length (bytes)**	**Description**
LATITUDE_BIN	ASCII_REAL	10	Latitude in degrees north at the midpoint of a 2-degree wide latitude bin.
EPI_SIM_NO_H	ASCII_REAL	10	Simulated epithermal neutron data for the case of no hydrogen in the radar bright regions.
EPI_SIM_NO_H_STD	ASCII_REAL	10	Simulated epithermal neutron one-sigma uncertainties for the case of no hydrogen in the radar bright regions.
EPI_SIM_YES_H	ASCII_REAL	10	Simulated epithermal neutron data for the case of 100 wt.% water equivalent hydrogen in the radar bright regions.

EPI_SIM_YES_H_STD	ASCII_REAL	10	Simulated epithermal neutron one-sigma uncertainties for the case of 100 wt.% water equivalent hydrogen in the radar bright regions.
EPI_DATA	ASCII_REAL	10	Measured relative epithermal neutron counts.
EPI_STD	ASCII_REAL	10	Measured epithermal neutron one-sigma uncertainties.
FAST_SIM_NO_H	ASCII_REAL	10	Simulated fast neutron data for the case of no hydrogen in the radar bright regions.
FAST_SIM_NO_H_STD	ASCII_REAL	10	Simulated fast neutron one-sigma uncertainties for the case of no hydrogen in the radar bright regions.
FAST_SIM_YES_H	ASCII_REAL	10	Simulated fast neutron data for the case of 100 wt.% water equivalent hydrogen in the radar bright regions.
FAST_SIM_YES_H_STD	ASCII_REAL	10	Simulated fast neutron one-sigma uncertainties for the case of 100 wt.% water equivalent hydrogen in the radar bright regions.
FAST_DATA	ASCII_REAL	10	Measured relative fast neutron counts.
FAST_STD	ASCII_REAL	10	Measured fast neutron one-sigma uncertainties.

Table 6.7 Data Values for the NS DDR NCP data product

6.8.2 Data Format Descriptions

The data format for the NS_DDR_NCP data product is a 13-column ASCII table. Column structure and start byte are described in the data product label, ns_ddr_ncp.lbl.

6.8.3 File Naming Conventions

The general form of the NS_DDR_NCP file name is:

"**NS_DDR_ZZZ.XXX** ", where

NS instrument identifier: represents the NS instrument.

DDR data product identifier: DDR

ZZZ data product name

NCP – Neutron Composition Product

.XXX the file extension (.TAB).

6.8.4 Label Description

The NS_DDR_NCP data product has a detached PDS label 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.

6.9 Directory Structure and Contents for NS CDR/DDR Archive Volume

The following illustration (Figure 2) shows the directory structure overview for the NS CDR/DDR archive volume, which bears the PDS-assigned volume ID MESSNS_2101. Empty directories, which occur when no data are received for a given orbit or day in which data were expected, are not included on the volume. The archive volume was delivered to PDS with the first release of NS CDR products. Subsequent deliveries of NS CDR/DDR products consisted of a partial volume containing only new and changed files.

```
                                    <ROOT>
 _______________________________________|____________________________________
     |         |           |            |            |          |         |
<CATALOG>   <CALIB>   <DOCUMENT>     <DATA>    <GEOMETRY>   <LABEL>   <INDEX>
                   ____________________|____________________
                    |                                      |
                    |                                      |
                  <CDR>                                  <DDR>
                    |                                      |
____________________|_____      __________________________|_________________
  |       |           |          |       |            |       |
  |       |           |          |       |            |       |
<2004>  <2005>...   <2010>     <2004>  <2005>...   <2010>    NS_DDR_NCP.TAB
  |                              |                           NS_DDR_NCP.LBL
__|_______________________     __|________________________
  |       |           |          |       |            |
 <01>    <02>...     <12>      <01>    <02>...      <12>
```

Figure 2. Directory Structure Overview

6.9.1 Directory Contents

<ROOT> Directory
AAREADME.TXT: General information file. Provides users with information about the MESSENGER NS data products. Directs user to more detailed documents on the volume.

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 NS data products.

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

CDR_DS.CAT: Describes the general content of the CDR data set and includes information about the duration of the mission and the person or group responsible for producing the data.

DDR_DS.CAT: Describes the general content of the DDR data set and includes information about the duration of the mission and the person or group responsible for producing the data.

NS_INST.CAT: Describes physical attributes of the NS instrument and provides relevant references to published literature.

INSTRUMENT_HOST.CAT: Describes the MESSENGER spacecraft.

MISSION.CAT: Describes the scientific goals and objectives of the MESSENGER program.

PERSON.CAT: Lists and provides contact information for the people involved with the GRNS instrument on the MESSENGER mission.

REF.CAT: Provides references (reference objects) to scientific papers and other publications of interest to those using the data, both for NS and the mission as a whole.

<CALIB> Directory

CALINFO.TXT: Description of calibration directory files.

MESSNS_PROCESSING.TXT: 'MESSENGER Neutron Spectrometer EDR-to-CDR-to-DDR Processing' document in ASCII text format.

MESSNS_PROCESSING.PDF: 'MESSENGER Neutron Spectrometer EDR-to-CDR-to-DDR Processing' document in Adobe Acrobat format.

MESSNS_PROCESSING.LBL: The detached label for the two MESSNS_PROCESSING files.

<DOCUMENT> Directory

DOCINFO.TXT: Identifies and describes the function of each file in the DOCUMENT directory.

NS_CDR_DDR_SIS.TXT: The NS CDR/DDR SIS: 'MESSENGER Neutron Spectrometer Calibrated and Derived Data Record Software Interface Specification' in ASCII text format. Only the text is provided; for illustrations, tables, etc., the PDF should be consulted.

NS_CDR_DDR_SIS.PDF: The NS CDR/DDR SIS: 'MESSENGER Neutron Spectrometer Calibrated and Derived Data Record Software Interface Specification' in Adobe Acrobat format. Note that, in contrast to the .TXT version, the illustrations, tables, etc. will display appropriately.

NS_CDR_DDR_SIS.LBL: The detached label for the two NS CDR/DDR SIS files.

<DATA> Directory

This is the top level of the directories containing CDRs and DDRs.

<DATA/CDR> Directory

A sub-directory of the <DATA> directory for the CDRs. The 5 CDR standard data products are located in the YYYY/MM subdirectories below this level.

<DATA/DDR> Directory

A sub-directory of the <DATA> directory for the DDRs. The DDR NCP is located at this level, while the DDR NCR data products are in the YYYY/MM subdirectories below.

<DATA/CDR/YYYY> Directory

A sub-directory of the <CDR> directory for each year.

<DATA/DDR/YYYY> Directory

A sub-directory of the <DDR> directory for each year.

<DATA/CDR/YYYY/MM> Directory
A sub-directory of the <DATA/CDR/YYYY> directory for each month of the year where MM ranges from 01 through 12.

<DATA/DDR/YYYY/MM> Directory
A sub-directory of the <DATA/DDR/YYYY> directory for each month of the year where MM ranges from 01 through 12.

<GEOMETRY> Directory
GEOMINFO.TXT: Description of geometry directory files. See *Appendix A*, Section 7.1.

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

NS_CDR_SPECTRA.FMT: Format file for the NS_CDR_SPECTRA standard data products.

NS_CDR_COUNTS.FMT: Format file for the NS_CDR_COUNTS standard data products.

NS_CDR_GCR_SPECTRA.FMT: Format file for the NS_CDR_GCR_SPECTRA standard data products.

NS_CDR_ENG.FMT: Format file for the NS_CDR_ENG standard data products.

NS_CDR_GAB.FMT: Format file for the NS_CDR_GAB standard data products.

NS_DDR_NCR.FMT: Format file for the NS_DDR_NCR standard data products.

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

MD5.TAB: Provides the MD5 checksum (message digest) for each file in the archive, with the exception of the MD5.TAB file itself.

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

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

CDR_INDEX.LBL: Detached PDS label for CDR_INDEX.TAB. It contains the INDEX_TABLE object which identifies and describes the columns of the NS index table.

DDR_INDEX.TAB: The DDR index file is organized as a table. In the table, there is a row for each DDR data product on the volume. The table columns contain parameters that describe the observation, instrument, and spacecraft parameters.

DDR_INDEX.LBL: Detached PDS label for DDR_INDEX.TAB. It contains the INDEX_TABLE object which identifies and describes the columns of the NS index table.

Column	Format	Example
VOLUME_ID	CHARACTER	MESSNS_2101
FILE_SPECIFICATION_NAME	CHARACTER	DATA/CDR/2008/01/ NS_CDR_SPE2008001ZZZ.LBL
MISSION_PHASE_NAME	CHARACTER	MERCURY 1 FLYBY
TARGET_NAME	CHARACTER	MERCURY
PRODUCT_ID	CHARACTER	NS_CDR_SPE2008001ZZZ_DAT
PRODUCT_VERSION_ID	CHARACTER	V2
PRODUCT_CREATION_TIME	TIME	2009-05-29T19:22:13
DATA_SET_ID	CHARACTER	MESS-E/V/H-GRNS-3-NS-CDR-V2.0
STANDARD_DATA_PRODUCT_ID	CHARACTER	NS_CDR_SPECTRA
START_TIME	TIME	2008-01-01T00:00:48
STOP_TIME	TIME	2008-01-01T23:59:58
START_MET_PARTITION	ASCII_INTEGER	1
SPACECRAFT_CLOCK_START_COUNT	ASCII_ INTEGER	107633029
SPACECRAFT_CLOCK_STOP_COUNT	ASCII_ INTEGER	107719379

Table 6.8. CDR index table columns.

Column	Format	Example
VOLUME_ID	CHARACTER	MESSNS_2101
FILE_SPECIFICATION_NAME	CHARACTER	DATA/DDR/2012/04/ NS_DDR_NCR2012117ZZZ.LBL
MISSION_PHASE_NAME	CHARACTER	MERCURY ORBIT YEAR 2
TARGET_NAME	CHARACTER	MERCURY
PRODUCT_ID	CHARACTER	NS_DDR_NCR2012117ZZZ.TAB
PRODUCT_VERSION_ID	CHARACTER	V2
PRODUCT_CREATION_TIME	TIME	2012-04-30T23:24:21
DATA_SET_ID	CHARACTER	MESS-E/V/H-GRNS-4-NS-DDR-V2.0
STANDARD_DATA_PRODUCT_ID	CHARACTER	NS_DDR_NCR
START_TIME	TIME	2012-04-26T00:00:20
STOP_TIME	TIME	2012-04-26T15:09:04
START_MET_PARTITION	ASCII_INTEGER	1
SPACECRAFT_CLOCK_START_COUNT	ASCII_ INTEGER	243885876
SPACECRAFT_CLOCK_STOP_COUNT	ASCII_ INTEGER	243940400

Table 6.9. DDR index table columns.

6.9.2 Data Product Sizes

The following table shows sizes in bytes of each data product and total estimated size of the NS CDR/DDR data sets.

Product Type	Time Span Covered	Typical Product Size	Estimated Mission Total
NS_CDR_SPECTRA	1 Earth day	5 MB	1.8 GB
NS_CDR_COUNTS	1 Earth day	200 kB	72 MB

NS_CDR_GCR_SPECTRA	1 Earth day	1 MB	360 MB
NS_CDR_ENG	1 Earth day	300 kB	100 MB
NS_CDR_GAB	1 Earth day	200 kB	20 MB
NS_DDR_NCR	1 Earth day	500 kB	500 MB
NS_DDR_NCP	26 March 2011 to 25 February 2012	6.8 kB	6.8 kB

Table 6.10. Data product sizes.

7 Appendices

7.1 Appendix A: 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 file naming convention specified by the MESSENGER project. See geominfo.txt in the GEOMETRY directory for more information.

*.bsp:
Messenger spacecraft ephemeris file

*.bc:
Messenger spacecraft orientation file.

*.tsc:
Messenger spacecraft clock coefficients file.

*.tpc:
Planetary constants file.

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

7.2 Appendix B: CODMAC/NASA Definition of Processing Levels

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 Experiment 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 records (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 Computational (CODMAC) data levels.

Table 7.1. **CODMAC/NASA Definition of Processing Levels for Science Data Sets**

7.3 Appendix C: NS Glossary and Acronym List

ACT	Applied Coherent Technology Corporation
APL	The Johns Hopkins University Applied Physics Laboratory
ASCII	American Standard Code for Information Interchange
BP	Borated Plastic NS Scintillator
CCSDS	Consultative Committee for Space Data Systems
CDR	Calibrated Data Record
CoDMAC	Committee on Data Management and Computation
DDR	Derived Data Record
EDR	Experiment Data Record
EPU	Event Processing Unit
ET	Ephemeris Time
FTP	File Transfer protocol
GCR	Galactic Cosmic Ray
GRNS	Gamma Ray and Neutron Spectrometer
GRS	Gamma Ray Spectrometer
JPL	Jet Propulsion Laboratory
LG1	Lithium (^{6}Li)-glass (LiG) NS Scintillator 1
LG2	Lithium (^{6}Li)-glass (LiG) NS Scintillator 2
MESSENGER	Mercury Surface, Space Environment, Geochemistry and Ranging
MET	Mission Elapsed Time
MOC	Mission Operations Center
NAIF	Navigation and Ancillary Information Facility
NS	Neutron Spectrometer
ODL	Object Description Language
PDS	Planetary Data System
SOC	Science Operations Center
SPICE	Spacecraft, Planet, Instrument, C-matrix Events (see GEOMETRY/geominfo.txt)
TDB	Barycentric Dynamical Time, the same as ET in the SPICE system
UTC	Coordinated Universal Time

7.4 Appendix D: NS PDS Label Files

7.4.1 NS_CDR_SPECTRA

```
PDS_VERSION_ID                 = "PDS3"

/*** FILE FORMAT ***/
FILE_RECORDS                   = 1727
RECORD_TYPE                    = FIXED_LENGTH
RECORD_BYTES                   = 2959

/*** GENERAL DATA DESCRIPTION PARAMETERS ***/
PRODUCT_ID                     = "NS_CDR_SPE2008001ZZZ_DAT"
PRODUCT_VERSION_ID             = "V1"
PRODUCT_CREATION_TIME          = 2015-10-31T19:48:05
PRODUCT_TYPE                   = "CDR"
STANDARD_DATA_PRODUCT_ID       = "NS_CDR_SPECTRA"
SOFTWARE_NAME                  = "NS_CDR_GEN"
SOFTWARE_VERSION_ID            = "1.0"
INSTRUMENT_HOST_NAME           = "MESSENGER"
INSTRUMENT_NAME                = "NEUTRON SPECTROMETER"
INSTRUMENT_ID                  = "NS"
DATA_SET_ID                    = "MESS-E/V/H-GRNS-3-NS-CDR-V2.0"
MISSION_PHASE_NAME             = "MERCURY 1 FLYBY"
TARGET_NAME                    = "MERCURY"
START_TIME                     = 2008-01-01T00:00:48
STOP_TIME                      = 2008-01-01T23:59:58
SPACECRAFT_CLOCK_START_COUNT   = "1/107633029"
SPACECRAFT_CLOCK_STOP_COUNT    = "1/107719379"
^TABLE                         = "NS_CDR_SPE2008001ZZZ.DAT"

/* NS BINARY TABLE DEFINITION */
OBJECT                         = TABLE
   COLUMNS                     = 26
   INTERCHANGE_FORMAT          = BINARY
   ROWS                        = 1727
   ROW_BYTES                   = 2959
   /* DESCRIPTIVE data elements */
   DESCRIPTION                 = "
    This table contains one set of calibrated spectra collected from the
    MESSENGER Neutron Spectrometer (NS) plus timing, spatial, and engineering
    information taken during the spectral collection period. A set is
    defined as all data with timestamps corresponding to a given day
    of year.
    "
^STRUCTURE                  = "NS_CDR_SPECTRA.FMT"
END_OBJECT                     = TABLE
END
```

7.4.2 NS_CDR_COUNTS

```
PDS_VERSION_ID                 = "PDS3"

/*** FILE FORMAT ***/
FILE_RECORDS                   = 1727
RECORD_TYPE                    = FIXED_LENGTH
RECORD_BYTES                   = 119

/*** GENERAL DATA DESCRIPTION PARAMETERS ***/
PRODUCT_ID                     = "NS_CDR_CTS2008001ZZZ_DAT"
PRODUCT_VERSION_ID             = "V1"
PRODUCT_CREATION_TIME          = 2015-11-02T21:43:31
PRODUCT_TYPE                   = "CDR"
STANDARD_DATA_PRODUCT_ID       = "NS_CDR_COUNTS"
SOFTWARE_NAME                  = "NS_CDR_GEN"
SOFTWARE_VERSION_ID            = "1.0"
INSTRUMENT_HOST_NAME           = "MESSENGER"
INSTRUMENT_NAME                = "NEUTRON SPECTROMETER"
INSTRUMENT_ID                  = "NS"
DATA_SET_ID                    = "MESS-E/V/H-GRNS-3-NS-CDR-V2.0"
MISSION_PHASE_NAME             = "MERCURY 1 FLYBY"
TARGET_NAME                    = "MERCURY"
START_TIME                     = 2008-01-01T00:00:48
STOP_TIME                      = 2008-01-01T23:59:58
SPACECRAFT_CLOCK_START_COUNT   = "1/107633029"
SPACECRAFT_CLOCK_STOP_COUNT    = "1/107719379"
^TABLE                         = "NS_CDR_CTS2008001ZZZ.DAT"

/* NS BINARY TABLE DEFINITION */
OBJECT                         = TABLE
   COLUMNS                     = 25
   INTERCHANGE_FORMAT          = BINARY
   ROWS                        = 1727
   ROW_BYTES                   = 119
   /* DESCRIPTIVE data elements */
   DESCRIPTION                 = "
    This table contains one set of counter data collected from the MESSENGER
    Neutron Spectrometer (NS) plus timing, spatial, and engineering
    information taken during the spectral collection period. A set is
    defined as all data with timestamps corresponding to a given day
    of year.
    "
^STRUCTURE                  = "NS_CDR_COUNTS.FMT"
END_OBJECT                     = TABLE
END
```

7.4.3 NS_CDR_GCR_SPECTRA

```
PDS_VERSION_ID                  = "PDS3"

/*** FILE FORMAT ***/
FILE_RECORDS                    = 1727
RECORD_TYPE                     = FIXED_LENGTH
RECORD_BYTES                    = 563

/*** GENERAL DATA DESCRIPTION PARAMETERS ***/
PRODUCT_ID                      = "NS_CDR_GCR2008001ZZZ_DAT"
PRODUCT_VERSION_ID              = "V1"
PRODUCT_CREATION_TIME           = 2015-11-01T20:37:49
PRODUCT_TYPE                    = "CDR"
STANDARD_DATA_PRODUCT_ID        = "NS_CDR_GCR_SPECTRA"
SOFTWARE_NAME                   = "NS_CDR_GEN"
SOFTWARE_VERSION_ID             = "1.0"
INSTRUMENT_HOST_NAME            = "MESSENGER"
INSTRUMENT_NAME                 = "NEUTRON SPECTROMETER"
INSTRUMENT_ID                   = "NS"
DATA_SET_ID                     = "MESS-E/V/H-GRNS-3-NS-CDR-V2.0"
MISSION_PHASE_NAME              = "MERCURY 1 FLYBY"
TARGET_NAME                     = "MERCURY"
START_TIME                      = 2008-01-01T00:00:48
STOP_TIME                       = 2008-01-01T23:59:58
SPACECRAFT_CLOCK_START_COUNT    = "1/107633029"
SPACECRAFT_CLOCK_STOP_COUNT     = "1/107719379"
^TABLE                          = "NS_CDR_GCR2008001ZZZ.DAT"

/* NS BINARY TABLE DEFINITION */
OBJECT                          = TABLE
   COLUMNS                      = 10
   INTERCHANGE_FORMAT           = BINARY
   ROWS                         = 1727
   ROW_BYTES                    = 563
   /* DESCRIPTIVE data elements */
   DESCRIPTION                  = "
    This table contains one set of galactic cosmic ray spectra collected
    from the MESSENGER Neutron Spectrometer (NS) plus timing, spatial, and
    engineering information taken during the spectral collection period. A
    set is defined as all data with timestamps corresponding to a given day
    of year.
    "
^STRUCTURE                   = "NS_CDR_GCR_SPECTRA.FMT"
END_OBJECT                      = TABLE
END
```

7.4.4 NS_CDR_ENG

```
PDS_VERSION_ID                = "PDS3"

/*** FILE FORMAT ***/
FILE_RECORDS                  = 288
RECORD_TYPE                   = FIXED_LENGTH
RECORD_BYTES                  = 908

/*** GENERAL DATA DESCRIPTION PARAMETERS ***/
PRODUCT_ID                    = "NS_CDR_ENG2008001ZZZ_TAB"
PRODUCT_VERSION_ID            = "V1"
PRODUCT_CREATION_TIME         = 2015-10-31T19:36:27
PRODUCT_TYPE                  = "CDR"
STANDARD_DATA_PRODUCT_ID      = "NS_CDR_ENG"
SOFTWARE_NAME                 = "NS_CDR_GEN"
SOFTWARE_VERSION_ID           = "1.0"
INSTRUMENT_HOST_NAME          = "MESSENGER"
INSTRUMENT_NAME               = "NEUTRON SPECTROMETER"
INSTRUMENT_ID                 = "NS"
DATA_SET_ID                   = "MESS-E/V/H-GRNS-3-NS-CDR-V2.0"
MISSION_PHASE_NAME            = "MERCURY 1 FLYBY"
TARGET_NAME                   = "MERCURY"
START_TIME                    = 2008-01-01T00:04:11
STOP_TIME                     = 2008-01-01T23:59:07
SPACECRAFT_CLOCK_START_COUNT  = "1/107633228"
SPACECRAFT_CLOCK_STOP_COUNT   = "1/107719328"
^TABLE                        = "NS_CDR_ENG2008001ZZZ.TAB"

/* NS ASCII TABLE DEFINITION */
OBJECT                        = TABLE
   COLUMNS                    = 98
   INTERCHANGE_FORMAT         = ASCII
   ROWS                       = 288
   ROW_BYTES                  = 908
   /* DESCRIPTIVE data elements */
   DESCRIPTION                = "
    This table contains one set of NS engineering data. A set is
    defined as all data with timestamps corresponding to a given day of
    year.
    "
^STRUCTURE                 = "NS_CDR_ENG.FMT"
END_OBJECT                    = TABLE
END
```

7.4.5 NS_CDR_GAB

```
PDS_VERSION_ID                  = "PDS3"

/*** FILE FORMAT ***/
FILE_RECORDS                    = 7
RECORD_TYPE                     = FIXED_LENGTH
RECORD_BYTES                    = 1061

/*** GENERAL DATA DESCRIPTION PARAMETERS ***/
PRODUCT_ID                      = "NS_CDR_GAB2010001ZZZ_TAB"
PRODUCT_VERSION_ID              = "V1"
PRODUCT_CREATION_TIME           = 2010-05-07T17:17:48
PRODUCT_TYPE                    = "CDR"
STANDARD_DATA_PRODUCT_ID        = "NS_CDR_GAMMA_BURST"
SOFTWARE_NAME                   = "NS_CDR_GEN"
SOFTWARE_VERSION_ID             = "1.0"
INSTRUMENT_HOST_NAME            = "MESSENGER"
INSTRUMENT_NAME                 = "NEUTRON SPECTROMETER"
INSTRUMENT_ID                   = "NS"
DATA_SET_ID                     = "MESS-E/V/H-GRNS-3-NS-CDR-V2.0"
MISSION_PHASE_NAME              = "MERCURY 4 CRUISE"
TARGET_NAME                     = "CALIBRATION"
START_TIME                      = 2010-01-01T02:28:56
STOP_TIME                       = 2010-01-01T21:31:04
SPACECRAFT_CLOCK_START_COUNT    = "170800410"
SPACECRAFT_CLOCK_STOP_COUNT     = "170868938"
^TABLE                          = "NS_CDR_GAB2010001ZZZ.TAB"

/* NS ASCII TABLE DEFINITION */
OBJECT                          = TABLE
   COLUMNS                      = 11
   INTERCHANGE_FORMAT           = ASCII
   ROWS                         = 7
   ROW_BYTES                    = 1061
   /* DESCRIPTIVE data elements */
DESCRIPTION                     = "
 This table contains one set of Gamma burst data collected from the
 MESSENGER Neutron Spectrometer (NS). A set is defined as all data with
 time stamps corresponding to a given Earth day.
"
^STRUCTURE                   = "NS_CDR_GAB.FMT"
END_OBJECT                      = TABLE
END
```

7.4.6 NS_DDR_NCR

```
PDS_VERSION_ID                  = "PDS3"
/*** FILE FORMAT ***/
FILE_RECORDS                    = 1156
RECORD_TYPE                     = FIXED_LENGTH
RECORD_BYTES                    = 365

/*** GENERAL DATA DESCRIPTION PARAMETERS ***/
PRODUCT_ID                      = "NS_DDR_NCR2012117ZZZ_TAB"
PRODUCT_VERSION_ID              = "V1"
PRODUCT_CREATION_TIME           = 2012-04-30T23:24:21
PRODUCT_TYPE                    = "DDR"
SOFTWARE_NAME                   = "NS_DDR_GEN"
SOFTWARE_VERSION_ID             = "1.0"
INSTRUMENT_HOST_NAME            = "MESSENGER"
INSTRUMENT_NAME                 = "NEUTRON SPECTROMETER"
INSTRUMENT_ID                   = "NS"
DATA_SET_ID                     = "MESS-E/V/H-GRNS-4-NS-DDR-V2.0"
MISSION_PHASE_NAME              = "MERCURY ORBIT YEAR 2"
TARGET_NAME                     = "MERCURY"
START_TIME                      = 2012-04-26T00:00:20
STOP_TIME                       = 2012-04-26T15:09:04
SPACECRAFT_CLOCK_START_COUNT    = "243885876"
SPACECRAFT_CLOCK_STOP_COUNT     = "243940400"
^HEADER                         = ("NS_DDR_NCR2012117ZZZ.TAB", 1)
^TABLE                          = ("NS_DDR_NCR2012117ZZZ.TAB", 2)

OBJECT                     =  HEADER
  HEADER_TYPE                =  TEXT
  INTERCHANGE_FORMAT         =  ASCII
  RECORDS                    =  1
  BYTES                      =  334
  DESCRIPTION                   = "The first record of this
    file is the header section. The header contains column
    headings to improve usability."
END_OBJECT                 =  HEADER

/* NS ASCII TABLE DEFINITION */
OBJECT                          = TABLE
   COLUMNS                      = 29
   INTERCHANGE_FORMAT           = ASCII
   ROWS                         = 1155
   ROW_BYTES                    = 365
   /* DESCRIPTIVE data elements */
   DESCRIPTION                  = "
    This table contains one set of calibrated spectra collected from the
    MESSENGER Neutron Spectrometer (NS) plus timing, spatial, and engineering
    information taken during the spectral collection period. A set is
    defined as all data with timestamps corresponding to a given day
    of year.
    "
^STRUCTURE                    = "NS_DDR_NCR.FMT"
END_OBJECT                      = TABLE
END
```

7.4.7 NS_DDR_NCP

```
PDS_VERSION_ID                = "PDS3"

/* ** FILE FORMAT ** */
FILE_RECORDS                  = 60
RECORD_TYPE                   = FIXED_LENGTH
RECORD_BYTES                  = 132

/* ** GENERAL DATA DESCRIPTION PARAMETERS ** */
PRODUCT_ID                    = "NS_DDR_NCP_TAB"
PRODUCT_VERSION_ID            = "01"
PRODUCT_CREATION_TIME         = 2013-05-25T19:49:14
PRODUCT_TYPE                  = "DDR"
STANDARD_DATA_PRODUCT_ID      = "NS_DDR_NCP"
SOFTWARE_NAME                 = "NS_DDR_GEN"
SOFTWARE_VERSION_ID           = "1.0"
INSTRUMENT_HOST_NAME          = "MESSENGER"
INSTRUMENT_NAME                = "NEUTRON SPECTROMETER"
INSTRUMENT_ID                  = "NS"
DATA_SET_ID                    = "MESS-E/V/H-GRNS-4-NS-DDR-V2.0"
MISSION_PHASE_NAME            = "MERCURY ORBIT"
TARGET_NAME                   = "MERCURY"
SPACECRAFT_CLOCK_START_COUNT  = "1/209585068"
START_TIME                    = 2011-03-26T00:00:00
SPACECRAFT_CLOCK_STOP_COUNT   = "1/238701865"
STOP_TIME                     = 2012-02-26T23:59:59
^HEADER                       = ("NS_DDR_NCP.TAB", 1)
^ASCII_TABLE                  = ("NS_DDR_NCP.TAB", 19)

OBJECT                        = HEADER
  HEADER_TYPE                   = TEXT
  INTERCHANGE_FORMAT            = "ASCII"
  RECORDS                       = 18
  BYTES                         = 132
  DESCRIPTION                 = "The first nineteen records of this
    file are the header section. The header references information and
    column headings to improve usability."
END_OBJECT                    = HEADER


OBJECT                        = ASCII_TABLE
  COLUMNS                       = 13
  INTERCHANGE_FORMAT            = ASCII
  ROW_BYTES                     = 132
  ROWS                          = 42
  DESCRIPTION                 = "This table contains latitude-binned
    fast and epithermal count rates, along with simulated count rates for
    the cases of no hydrogen and for a thick layer of 100 wt percent water
    ice in all radar bright regions. Each 2 degree wide latitude bin
    contains the average of the data points that fall within its latitude
    range."
  OBJECT                       = COLUMN
    NAME                       = LATITUDE_BIN
    COLUMN_NUMBER              = 1
    START_BYTE                 = 1
```

```
    BYTES                       = 10
    DATA_TYPE                   = ASCII_REAL
    UNIT                        = DEGREE
    DESCRIPTION                 = "Latitude in degrees north at the midpoint
      of a 2-degree wide latitude bin."
  END_OBJECT = COLUMN

  OBJECT                        = COLUMN
    NAME                        = EPI_SIM_NO_H
    COLUMN_NUMBER               = 2
    START_BYTE                  = 11
    BYTES                       = 10
    DATA_TYPE                   = ASCII_REAL
    UNIT                        = "COUNTS/SECOND"
    DESCRIPTION                 = "Simulated epithermal neutron data for the
      case of no hydrogen in the radar bright regions."
  END_OBJECT = COLUMN

  OBJECT                        = COLUMN
    NAME                        = EPI_SIM_NO_H_STD
    COLUMN_NUMBER               = 3
    START_BYTE                  = 21
    BYTES                       = 10
    DATA_TYPE                   = ASCII_REAL
    UNIT                        = "COUNTS/SECOND"
    DESCRIPTION                 = "Simulated epithermal neutron one-sigma
      uncertainties for the case of no hydrogen in the radar bright regions."
  END_OBJECT = COLUMN

  OBJECT                        = COLUMN
    NAME                        = EPI_SIM_YES_H
    COLUMN_NUMBER               = 4
    START_BYTE                  = 31
    BYTES                       = 10
    DATA_TYPE                   = ASCII_REAL
    UNIT                        = "COUNTS/SECOND"
    DESCRIPTION                 = "Simulated epithermal neutron data for the
      case of 100 wt percent water equivalent hydrogen in the radar bright
      regions."
  END_OBJECT = COLUMN

  OBJECT                        = COLUMN
    NAME                        = EPI_SIM_YES_H_STD
    COLUMN_NUMBER               = 5
    START_BYTE                  = 41
    BYTES                       = 10
    DATA_TYPE                   = ASCII_REAL
    UNIT                        = "COUNTS/SECOND"
    DESCRIPTION                 = "Simulated epithermal neutron one-sigma
      uncertainties for the case of 100 wt percent water equivalent hydrogen
      in the radar bright regions."
  END_OBJECT = COLUMN

  OBJECT                        = COLUMN
    NAME                        = EPI_DATA
    COLUMN_NUMBER               = 6
    START_BYTE                  = 51
```

```
    BYTES                        = 10
    DATA_TYPE                    = ASCII_REAL
    UNIT                         = "COUNTS/SECOND"
    DESCRIPTION                  = "Measured relative epithermal neutron
      counts."
  END_OBJECT                     = COLUMN

  OBJECT                         = COLUMN
    NAME                         = EPI_STD
    COLUMN_NUMBER                = 7
    START_BYTE                   = 61
    BYTES                        = 10
    DATA_TYPE                    = ASCII_REAL
    UNIT                         = "COUNTS/SECOND"
    DESCRIPTION                  = "Measured epithermal neutron one-sigma
      uncertainties."
  END_OBJECT                     = COLUMN

  OBJECT                         = COLUMN
    NAME                         = FAST_SIM_NO_H
    COLUMN_NUMBER                = 8
    START_BYTE                   = 71
    BYTES                        = 10
    DATA_TYPE                    = ASCII_REAL
    UNIT                         = "COUNTS/SECOND"
    DESCRIPTION                  = "Simulated fast neutron data for the case of
      no hydrogen in the radar bright regions."
  END_OBJECT                     = COLUMN

  OBJECT                         = COLUMN
    NAME                         = FAST_SIM_NO_H_STD
    COLUMN_NUMBER                = 9
    START_BYTE                   = 81
    BYTES                        = 10
    DATA_TYPE                    = ASCII_REAL
    UNIT                         = "COUNTS/SECOND"
    DESCRIPTION                  = "Simulated fast neutron one-sigma
      uncertainties for the case of no hydrogen in the radar bright regions."
  END_OBJECT                     = COLUMN

  OBJECT                         = COLUMN
    NAME                         = FAST_SIM_YES_H
    COLUMN_NUMBER                = 10
    START_BYTE                   = 91
    BYTES                        = 10
    DATA_TYPE                    = ASCII_REAL
    UNIT                         = "COUNTS/SECOND"
    DESCRIPTION                  = "Simulated fast neutron data for the case of
      100 wt percent water equivalent hydrogen in the radar bright regions."
  END_OBJECT                     = COLUMN

  OBJECT                         = COLUMN
    NAME                         = FAST_SIM_YES_H_STD
    COLUMN_NUMBER                = 11
    START_BYTE                   = 101
    BYTES                        = 10
    DATA_TYPE                    = ASCII_REAL
```

```
    UNIT                         = "COUNTS/SECOND"
    DESCRIPTION                  = "Simulated fast neutron one-sigma
      uncertainties for the case of 100 wt percent water equivalent hydrogen
      in the radar bright regions."
  END_OBJECT                     = COLUMN

  OBJECT                         = COLUMN
    NAME                         = FAST_DATA
    COLUMN_NUMBER                = 12
    START_BYTE                   = 111
    BYTES                        = 10
    DATA_TYPE                    = ASCII_REAL
    UNIT                         = "COUNTS/SECOND"
    DESCRIPTION                  = "Measured relative fast neutron counts."
  END_OBJECT                     = COLUMN

  OBJECT                         = COLUMN
    NAME                         = FAST_STD
    COLUMN_NUMBER                = 13
    START_BYTE                   = 121
    BYTES                        = 10
    DATA_TYPE                    = ASCII_REAL
    UNIT                         = "COUNTS/SECOND"
    DESCRIPTION                  = "Measured fast neutron one-sigma
      uncertainties."
  END_OBJECT                     = COLUMN

END_OBJECT                      =  ASCII_TABLE
END
```

7.5 Appendix E: NS PDS FMT Files

7.5.1 NS_CDR_SPECTRA.FMT

```
OBJECT        = COLUMN
   NAME           = MISSION_ELAPSED_TIME
   COLUMN_NUMBER  = 1
   BYTES          = 4
   DATA_TYPE      = MSB_UNSIGNED_INTEGER
   START_BYTE     = 1
   UNIT           = SECOND
   DESCRIPTION    = "Time tag in seconds of the start of the associated
   reporting/accumulation period."
END_OBJECT    = COLUMN

OBJECT        = COLUMN
   NAME           = UTC_TIME
   COLUMN_NUMBER  = 2
   BYTES          = 19
   DATA_TYPE      = CHARACTER
   START_BYTE     = 5
   DESCRIPTION    = "UTC time at start of data collection.
   Format: YYYY-MM-DDTHH:MM:SS."
END_OBJECT    = COLUMN

OBJECT        = COLUMN
   NAME           = UTC_TIME_JULDAY
   COLUMN_NUMBER  = 3
   BYTES          = 8
   DATA_TYPE      = IEEE_REAL
   START_BYTE     = 24
   DESCRIPTION    = "UTC time at start of data collection given in
   Julian day."
END_OBJECT    = COLUMN

OBJECT        = COLUMN
   NAME           = ORBIT_NUMBER
   COLUMN_NUMBER  = 4
   BYTES          = 4
   DATA_TYPE      = MSB_UNSIGNED_INTEGER
   START_BYTE     = 32
   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
   (see GEOMETRY/geominfo.txt). 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           = ACTUAL_ACCUM
   COLUMN_NUMBER  = 5
   BYTES          = 4
   DATA_TYPE      = MSB_UNSIGNED_INTEGER
   START_BYTE     = 36
```

```
   UNIT           = SECOND
   DESCRIPTION    = "Actual accumulation period in seconds for software
   counters and energy histograms."
END_OBJECT    = COLUMN

OBJECT        = COLUMN
   NAME           = SC_ALTITUDE
   COLUMN_NUMBER  = 6
   BYTES          = 4
   DATA_TYPE      = IEEE_REAL
   START_BYTE     = 40
   UNIT           = KM
   DESCRIPTION    = "Spacecraft altitude above the subsatellite point
   on the target in units of km."
END_OBJECT    = COLUMN

OBJECT        = COLUMN
   NAME           = SC_LATITUDE
   COLUMN_NUMBER  = 7
   BYTES          = 4
   DATA_TYPE      = IEEE_REAL
   START_BYTE     = 44
   UNIT           = DEGREE
   DESCRIPTION    = "Target-centric latitude of the spacecraft
   subsatellite point in degrees."
END_OBJECT    = COLUMN

OBJECT        = COLUMN
   NAME           = SC_LONGITUDE
   COLUMN_NUMBER  = 8
   BYTES          = 4
   DATA_TYPE      = IEEE_REAL
   START_BYTE     = 48
   UNIT           = DEGREE
   DESCRIPTION    = "Target-centric longitude of the spacecraft
   subsatellite point in degrees."
END_OBJECT    = COLUMN

OBJECT        = COLUMN
   NAME           = VEL_NORM
   COLUMN_NUMBER  = 9
   BYTES          = 4
   DATA_TYPE      = IEEE_REAL
   START_BYTE     = 52
   UNIT           = "KM/S"
   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           = V_DOT_X
   COLUMN_NUMBER  = 10
   BYTES          = 4
   DATA_TYPE      = IEEE_REAL
   START_BYTE     = 56
   UNIT           = "UNITLESS"
   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            = V_DOT_Y
   COLUMN_NUMBER  = 11
   BYTES           = 4
   DATA_TYPE       = IEEE_REAL
   START_BYTE      = 60
   UNIT            = "UNITLESS"
   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            = V_DOT_Z
   COLUMN_NUMBER  = 12
   BYTES           = 4
   DATA_TYPE       = IEEE_REAL
   START_BYTE      = 64
   UNIT            = "UNITLESS"
   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  = 13
   BYTES           = 4
   DATA_TYPE       = IEEE_REAL
   START_BYTE      = 68
   UNIT            = "DEGREE"
   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            = XAXIS_ANGLE
   COLUMN_NUMBER  = 14
   BYTES           = 4
   DATA_TYPE       = IEEE_REAL
   START_BYTE      = 72
   UNIT            = "DEGREE"
   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            = YAXIS_ANGLE
   COLUMN_NUMBER  = 15
   BYTES           = 4
   DATA_TYPE       = IEEE_REAL
   START_BYTE      = 76
   UNIT            = "DEGREE"
```

```
   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           = THETA_ANGLE
   COLUMN_NUMBER  = 16
   BYTES          = 4
   DATA_TYPE      = IEEE_REAL
   START_BYTE     = 80
   UNIT           = "DEGREE"
   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  = 17
   BYTES          = 4
   DATA_TYPE      = IEEE_REAL
   START_BYTE     = 84
   UNIT           = "DEGREE"
   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  = 18
   BYTES          = 4
   DATA_TYPE      = IEEE_REAL
   START_BYTE     = 88
   UNIT           = "DEGREE"
   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  = 19
   BYTES          = 4
   DATA_TYPE      = IEEE_REAL
   START_BYTE     = 92
   UNIT           = "KM"
   DESCRIPTION    = "Distance of the spacecraft to the Sun in units of km."
END_OBJECT    = COLUMN

OBJECT        = COLUMN
   NAME           = VEL_VECTOR
   COLUMN_NUMBER  = 20
   BYTES          = 12
   DATA_TYPE      = IEEE_REAL
   START_BYTE     = 96
```

```
   ITEMS          = 3
   ITEM_BYTES     = 4
   UNIT           = "KM/S"
   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           = SC_TO_NADIR_ROT
   COLUMN_NUMBER  = 21
   BYTES          = 36
   DATA_TYPE      = IEEE_REAL
   START_BYTE     = 108
   ITEMS          = 9
   ITEM_BYTES     = 4
   UNIT           = "UNITLESS"
   DESCRIPTION    = "Nine element rotation matrix that converts the
   spacecraft attitude from instrument-fixed coordinates to nadir-fixed
   coordinates."
END_OBJECT    = COLUMN

OBJECT        = COLUMN
   NAME           = LG1_SPECTRA
   COLUMN_NUMBER  = 22
   BYTES          = 256
   DATA_TYPE      = IEEE_REAL
   START_BYTE     = 144
   ITEMS          = 64
   ITEM_BYTES     = 4
   UNIT           = "COUNTS/SECOND"
   DESCRIPTION    = "LG1 singles spectra in counts per second."
END_OBJECT    = COLUMN

OBJECT        = COLUMN
   NAME           = LG2_SPECTRA
   COLUMN_NUMBER  = 23
   BYTES          = 256
   DATA_TYPE      = IEEE_REAL
   START_BYTE     = 400
   ITEMS          = 64
   ITEM_BYTES     = 4
   UNIT           = "COUNTS/SECOND"
   DESCRIPTION    = "LG2 singles spectra in counts per second."
END_OBJECT    = COLUMN

OBJECT        = COLUMN
   NAME           = BP_SPECTRA
   COLUMN_NUMBER  = 24
   BYTES          = 256
   DATA_TYPE      = IEEE_REAL
   START_BYTE     = 656
   ITEMS          = 64
   ITEM_BYTES     = 4
   UNIT           = "COUNTS/SECOND"
   DESCRIPTION    = "Borated plastic singles spectra in counts per
   second."
```

```
END_OBJECT    = COLUMN

OBJECT        = COLUMN
   NAME           = TC_EARLY_SPECTRA
   COLUMN_NUMBER  = 25
   BYTES          = 1024
   DATA_TYPE      = IEEE_REAL
   START_BYTE     = 912
   ITEMS          = 256
   ITEM_BYTES     = 4
   UNIT           = "COUNTS/SECOND"
   DESCRIPTION    = "Borated plastic Time Correlated (TC) first
   interaction spectra from the early time window in counts per
   second."
END_OBJECT    = COLUMN

OBJECT        = COLUMN
   NAME           = TC_LATE_SPECTRA
   COLUMN_NUMBER  = 26
   BYTES          = 1024
   DATA_TYPE      = IEEE_REAL
   START_BYTE     = 1936
   ITEMS          = 256
   ITEM_BYTES     = 4
   UNIT           = "COUNTS/SECOND"
   DESCRIPTION    = "Borated plastic Time Correlated (TC) first
   interaction spectra from the late time window in counts per
   second."
END_OBJECT    = COLUMN
```

7.5.2 NS_CDR_COUNTS.FMT

```
OBJECT          = COLUMN
   NAME             = MISSION_ELAPSED_TIME
   COLUMN_NUMBER  = 1
   BYTES            = 4
   DATA_TYPE        = MSB_UNSIGNED_INTEGER
   START_BYTE       = 1
   UNIT             = SECOND
   DESCRIPTION      = "Time tag in seconds of the start of the associated
   reporting/accumulation period."
END_OBJECT      = COLUMN

OBJECT          = COLUMN
   NAME             = UTC_TIME
   COLUMN_NUMBER  = 2
   BYTES            = 19
   DATA_TYPE        = CHARACTER
   START_BYTE       = 5
   DESCRIPTION      = "UTC time at start of data collection.
   Format: YYYY-MM-DDTHH:MM:SS."
END_OBJECT      = COLUMN

OBJECT          = COLUMN
   NAME             = UTC_TIME_JULDAY
   COLUMN_NUMBER  = 3
   BYTES            = 8
   DATA_TYPE        = IEEE_REAL
   START_BYTE       = 24
   DESCRIPTION      = "UTC time at start of data collection given in
   Julian day."
END_OBJECT      = COLUMN

OBJECT          = COLUMN
   NAME             = ORBIT_NUMBER
   COLUMN_NUMBER  = 4
   BYTES            = 4
   DATA_TYPE        = MSB_UNSIGNED_INTEGER
   START_BYTE       = 32
   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
   (see GEOMETRY/geominfo.txt). 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             = ACTUAL_ACCUM
   COLUMN_NUMBER  = 5
   BYTES            = 4
   DATA_TYPE        = MSB_UNSIGNED_INTEGER
   START_BYTE       = 36
   UNIT             = SECOND
   DESCRIPTION      = "Actual accumulation period in seconds for software
   counters and energy histograms."
```

```
END_OBJECT    = COLUMN

OBJECT        = COLUMN
   NAME           = SC_ALTITUDE
   COLUMN_NUMBER  = 6
   BYTES          = 4
   DATA_TYPE      = IEEE_REAL
   START_BYTE     = 40
   UNIT           = KM
   DESCRIPTION    = "Spacecraft altitude above the subsatellite point
   on the target in units of km."
END_OBJECT    = COLUMN

OBJECT        = COLUMN
   NAME           = SC_LATITUDE
   COLUMN_NUMBER  = 7
   BYTES          = 4
   DATA_TYPE      = IEEE_REAL
   START_BYTE     = 44
   UNIT           = DEGREE
   DESCRIPTION    = "Target-centric latitude of the spacecraft
   subsatellite point in degrees."
END_OBJECT    = COLUMN

OBJECT        = COLUMN
   NAME           = SC_LONGITUDE
   COLUMN_NUMBER  = 8
   BYTES          = 4
   DATA_TYPE      = IEEE_REAL
   START_BYTE     = 48
   UNIT           = DEGREE
   DESCRIPTION    = "Target-centric longitude of the spacecraft
   subsatellite point in degrees."
END_OBJECT    = COLUMN

OBJECT        = COLUMN
   NAME           = LG1_RAW_EVENTS
   COLUMN_NUMBER  = 9
   BYTES          = 4
   DATA_TYPE      = IEEE_REAL
   START_BYTE     = 52
   UNIT           = "COUNTS/SECOND"
   DESCRIPTION    = "LG1 raw events in counts per second."
END_OBJECT    = COLUMN

OBJECT        = COLUMN
   NAME           = LG2_RAW_EVENTS
   COLUMN_NUMBER  = 10
   BYTES          = 4
   DATA_TYPE      = IEEE_REAL
   START_BYTE     = 56
   UNIT           = "COUNTS/SECOND"
   DESCRIPTION    = "LG2 raw events in counts per second."
END_OBJECT    = COLUMN

OBJECT        = COLUMN
   NAME           = BP_RAW_EVENTS
```

```
   COLUMN_NUMBER  = 11
   BYTES          = 4
   DATA_TYPE      = IEEE_REAL
   START_BYTE     = 60
   UNIT           = "COUNTS/SECOND"
   DESCRIPTION    = "BP raw events in counts per second."
END_OBJECT    = COLUMN

OBJECT        = COLUMN
   NAME           = SW_TOTAL_EVENTS
   COLUMN_NUMBER  = 12
   BYTES          = 4
   DATA_TYPE      = IEEE_REAL
   START_BYTE     = 64
   UNIT           = "COUNTS/SECOND"
   DESCRIPTION    = "Total software counts in counts per second."
END_OBJECT    = COLUMN

OBJECT        = COLUMN
   NAME           = DEAD_TIME
   COLUMN_NUMBER  = 13
   BYTES          = 4
   DATA_TYPE      = IEEE_REAL
   START_BYTE     = 68
   UNIT           = COUNTS
   DESCRIPTION    = "Dead time counter in units of counts."
END_OBJECT    = COLUMN

OBJECT        = COLUMN
   NAME           = LG1_RESET
   COLUMN_NUMBER  = 14
   BYTES          = 4
   DATA_TYPE      = IEEE_REAL
   START_BYTE     = 72
   UNIT           = "COUNTS/SECOND"
   DESCRIPTION    = "LG1 resets in counts per second."
END_OBJECT    = COLUMN

OBJECT        = COLUMN
   NAME           = LG2_RESET
   COLUMN_NUMBER  = 15
   BYTES          = 4
   DATA_TYPE      = IEEE_REAL
   START_BYTE     = 76
   UNIT           = "COUNTS/SECOND"
   DESCRIPTION    = "LG2 resets in counts per second."
END_OBJECT    = COLUMN

OBJECT        = COLUMN
   NAME           = BP_RESET
   COLUMN_NUMBER  = 16
   BYTES          = 4
   DATA_TYPE      = IEEE_REAL
   START_BYTE     = 80
   UNIT           = "COUNTS/SECOND"
   DESCRIPTION    = "BP resets in counts per second."
END_OBJECT    = COLUMN
```

```
OBJECT        = COLUMN
   NAME            = BPP_LGXS
   COLUMN_NUMBER   = 17
   BYTES           = 4
   DATA_TYPE       = IEEE_REAL
   START_BYTE      = 84
   UNIT            = "COUNTS/SECOND"
   DESCRIPTION     = "Fast neutrons moderated in the borated plastic but
   captured in the lithium glass. LG1 and LG2 are combined, thus the
   LGX designation."
END_OBJECT    = COLUMN

OBJECT        = COLUMN
   NAME            = LG1_OVER_RANGE
   COLUMN_NUMBER   = 18
   BYTES           = 4
   DATA_TYPE       = IEEE_REAL
   START_BYTE      = 88
   UNIT            = "COUNTS/SECOND"
   DESCRIPTION     = "LG1 over range counts per second."
END_OBJECT    = COLUMN

OBJECT        = COLUMN
   NAME            = LG2_OVER_RANGE
   COLUMN_NUMBER   = 19
   BYTES           = 4
   DATA_TYPE       = IEEE_REAL
   START_BYTE      = 92
   UNIT            = "COUNTS/SECOND"
   DESCRIPTION     = "LG2 over range counts per second."
END_OBJECT    = COLUMN

OBJECT        = COLUMN
   NAME            = BP_OVER_RANGE
   COLUMN_NUMBER   = 20
   BYTES           = 4
   DATA_TYPE       = IEEE_REAL
   START_BYTE      = 96
   UNIT            = "COUNTS/SECOND"
   DESCRIPTION     = "BP over range counts per second."
END_OBJECT    = COLUMN

OBJECT        = COLUMN
   NAME            = LG1_BPP_COIN
   COLUMN_NUMBER   = 21
   BYTES           = 4
   DATA_TYPE       = IEEE_REAL
   START_BYTE      = 100
   UNIT            = "COUNTS/SECOND"
   DESCRIPTION     = "Number of LG1-prompt BP coincidence counts per
   second."
END_OBJECT    = COLUMN

OBJECT        = COLUMN
   NAME            = LG2_BPP_COIN
   COLUMN_NUMBER   = 22
```

```
   BYTES           = 4
   DATA_TYPE       = IEEE_REAL
   START_BYTE      = 104
   UNIT            = "COUNTS/SECOND"
   DESCRIPTION     = "Number of LG2-prompt BP coincidence counts per
   second."
END_OBJECT     = COLUMN

OBJECT         = COLUMN
   NAME            = LG1_BPP_LG2_COIN
   COLUMN_NUMBER   = 23
   BYTES           = 4
   DATA_TYPE       = IEEE_REAL
   START_BYTE      = 108
   UNIT            = "COUNTS/SECOND"
   DESCRIPTION     = "Number of LG1-LG2-prompt BP triple coincidence
   counts per second."
END_OBJECT     = COLUMN

OBJECT         = COLUMN
   NAME            = TC_EARLY
   COLUMN_NUMBER   = 24
   BYTES           = 4
   DATA_TYPE       = IEEE_REAL
   START_BYTE      = 112
   UNIT            = "COUNTS/SECOND"
   DESCRIPTION     = "Number of time correlated early counts per
   second."
END_OBJECT     = COLUMN

OBJECT         = COLUMN
   NAME            = TC_LATE
   COLUMN_NUMBER   = 25
   BYTES           = 4
   DATA_TYPE       = IEEE_REAL
   START_BYTE      = 116
   UNIT            = "COUNTS/SECOND"
   DESCRIPTION     = "Number of time correlated late counts per second."
END_OBJECT     = COLUMN
```

7.5.3 NS_CDR_GCR_SPECTRA.FMT

```
OBJECT         = COLUMN
   NAME            = MISSION_ELAPSED_TIME
   COLUMN_NUMBER  = 1
   BYTES           = 4
   DATA_TYPE       = MSB_UNSIGNED_INTEGER
   START_BYTE      = 1
   UNIT            = SECOND
   DESCRIPTION    = "Time tag in seconds of the start of the associated
   reporting/accumulation period."
END_OBJECT     = COLUMN

OBJECT         = COLUMN
   NAME            = UTC_TIME
   COLUMN_NUMBER  = 2
   BYTES           = 19
   DATA_TYPE       = CHARACTER
   START_BYTE      = 5
   DESCRIPTION    = "UTC time at start of data collection.
   Format: YYYY-MM-DDTHH:MM:SS."
END_OBJECT     = COLUMN

OBJECT         = COLUMN
   NAME            = UTC_TIME_JULDAY
   COLUMN_NUMBER  = 3
   BYTES           = 8
   DATA_TYPE       = IEEE_REAL
   START_BYTE      = 24
   DESCRIPTION    = "UTC time at start of data collection given in
   Julian day."
END_OBJECT     = COLUMN

OBJECT         = COLUMN
   NAME            = ORBIT_NUMBER
   COLUMN_NUMBER  = 4
   BYTES           = 4
   DATA_TYPE       = MSB_UNSIGNED_INTEGER
   START_BYTE      = 32
   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
   (see GEOMETRY/geominfo.txt). 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            = ACTUAL_ACCUM
   COLUMN_NUMBER  = 5
   BYTES           = 4
   DATA_TYPE       = MSB_UNSIGNED_INTEGER
   START_BYTE      = 36
   UNIT            = SECOND
   DESCRIPTION    = "Actual accumulation period in seconds for software
   counters and energy histograms."
```

```
END_OBJECT     = COLUMN

OBJECT         = COLUMN
   NAME            = SC_ALTITUDE
   COLUMN_NUMBER   = 6
   BYTES           = 4
   DATA_TYPE       = IEEE_REAL
   START_BYTE      = 40
   UNIT            = KM
   DESCRIPTION     = "Spacecraft altitude above the subsatellite point
   on the target in units of km."
END_OBJECT     = COLUMN

OBJECT         = COLUMN
   NAME            = SC_LATITUDE
   COLUMN_NUMBER   = 7
   BYTES           = 4
   DATA_TYPE       = IEEE_REAL
   START_BYTE      = 44
   UNIT            = DEGREE
   DESCRIPTION     = "Target-centric latitude of the spacecraft
   subsatellite point in degrees."
END_OBJECT     = COLUMN

OBJECT         = COLUMN
   NAME            = SC_LONGITUDE
   COLUMN_NUMBER   = 8
   BYTES           = 4
   DATA_TYPE       = IEEE_REAL
   START_BYTE      = 48
   UNIT            = DEGREE
   DESCRIPTION     = "Target-centric longitude of the spacecraft
   subsatellite point in degrees."
END_OBJECT     = COLUMN

OBJECT         = COLUMN
   NAME            = LG1_GCR_SPECTRA
   COLUMN_NUMBER   = 9
   BYTES           = 256
   DATA_TYPE       = IEEE_REAL
   START_BYTE      = 52
   ITEMS           = 64
   ITEM_BYTES      = 4
   UNIT            = "COUNTS/CHANNEL/SPECTRA"
   DESCRIPTION     = "LG1 GCR spectra in counts per channel per
   spectra."
END_OBJECT     = COLUMN

OBJECT         = COLUMN
   NAME            = LG2_GCR_SPECTRA
   COLUMN_NUMBER   = 10
   BYTES           = 256
   DATA_TYPE       = IEEE_REAL
   START_BYTE      = 308
   ITEMS           = 64
   ITEM_BYTES      = 4
   UNIT            = "COUNTS/CHANNEL/SPECTRA"
```

```
   DESCRIPTION    = "LG2 GCR spectra in counts per channel per
   spectra."
END_OBJECT    = COLUMN
```

7.5.4 NS_CDR_ENG.FMT

```
OBJECT         = COLUMN
   NAME           = MISSION_ELAPSED_TIME
   COLUMN_NUMBER  = 1
   BYTES          = 12
   DATA_TYPE      = ASCII_INTEGER
   START_BYTE     = 1
   UNIT           = SECOND
   DESCRIPTION    = "Time tag in seconds of the start of the associated
   reporting/accumulation period."
END_OBJECT     = COLUMN

OBJECT         = COLUMN
   NAME           = UTC_TIME
   COLUMN_NUMBER  = 2
   BYTES          = 19
   DATA_TYPE      = CHARACTER
   START_BYTE     = 14
   DESCRIPTION    = "UTC time at start of data collection.
   Format: YYYY-MM-DDTHH:MM:SS."
END_OBJECT     = COLUMN

OBJECT         = COLUMN
   NAME           = UTC_TIME_JULDAY
   COLUMN_NUMBER  = 3
   BYTES          = 18
   DATA_TYPE      = ASCII_REAL
   START_BYTE     = 34
   DESCRIPTION    = "UTC time at start of data collection given in
   Julian day."
END_OBJECT     = COLUMN

OBJECT         = COLUMN
   NAME           = ORBIT_NUMBER
   COLUMN_NUMBER  = 4
   BYTES          = 8
   DATA_TYPE      = ASCII_INTEGER
   START_BYTE     = 53
   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
   (see GEOMETRY/geominfo.txt). 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           = STATUS_INTERVAL
   COLUMN_NUMBER  = 5
   BYTES          = 8
   DATA_TYPE      = ASCII_INTEGER
   START_BYTE     = 62
   UNIT           = SECOND
   DESCRIPTION    = "Status interval in seconds. Valid values: 1-65535
   (0=off). Defines the interval at which status is reported. Not an
```

```
   accumulation interval. All status fields are either stationary
   values of registers or 1-second accumulations (such as for hardware
   counters)."
END_OBJECT    = COLUMN

OBJECT        = COLUMN
   NAME            = MACRO_BLOCKS
   COLUMN_NUMBER   = 6
   BYTES           = 8
   DATA_TYPE       = ASCII_INTEGER
   START_BYTE      = 71
   DESCRIPTION     = "Number of macro blocks free."
END_OBJECT    = COLUMN

OBJECT        = COLUMN
   NAME            = TLM_VOLUME
   COLUMN_NUMBER   = 7
   BYTES           = 8
   DATA_TYPE       = ASCII_INTEGER
   START_BYTE      = 80
   UNIT            = KB
   DESCRIPTION     = "Telemetry volume produced (kB) by NS (compressed
   data with telemetry headers, etc.). For telemetry control purposes."
END_OBJECT    = COLUMN

OBJECT        = COLUMN
   NAME            = WATCH_ADDR
   COLUMN_NUMBER   = 8
   BYTES           = 8
   DATA_TYPE       = ASCII_INTEGER
   START_BYTE      = 89
   DESCRIPTION     = "Memory watch address. Address loaded for peaking
   into memory for diagnostic purposes."
END_OBJECT    = COLUMN

OBJECT        = COLUMN
   NAME            = WATCH_MEM
   COLUMN_NUMBER   = 9
   BYTES           = 8
   DATA_TYPE       = ASCII_INTEGER
   START_BYTE      = 98
   DESCRIPTION     = "Memory watch address id (page number) loaded to
   complete 20-bit address."
END_OBJECT    = COLUMN

OBJECT        = COLUMN
   NAME            = WATCH_DATA1
   COLUMN_NUMBER   = 10
   BYTES           = 8
   DATA_TYPE       = ASCII_INTEGER
   START_BYTE      = 107
   DESCRIPTION     = "Watched memory, byte 1 value of the stack-errors
   word maintained by the common code."
END_OBJECT    = COLUMN

OBJECT        = COLUMN
   NAME            = WATCH_DATA2
```

```
   COLUMN_NUMBER  = 11
   BYTES          = 8
   DATA_TYPE      = ASCII_INTEGER
   START_BYTE     = 116
   DESCRIPTION    = "Watched memory, byte 2 value of the stack-errors
   word maintained by the common code."
END_OBJECT    = COLUMN

OBJECT        = COLUMN
   NAME           = SW_VERSION
   COLUMN_NUMBER  = 12
   BYTES          = 8
   DATA_TYPE      = ASCII_INTEGER
   START_BYTE     = 125
   DESCRIPTION    = "Software version number."
END_OBJECT    = COLUMN

OBJECT        = COLUMN
   NAME           = ALARM_ID
   COLUMN_NUMBER  = 13
   BYTES          = 8
   DATA_TYPE      = ASCII_INTEGER
   START_BYTE     = 134
   DESCRIPTION    = "=15, BP (HV1) has reached Level 1 safing due to
   high event rate. =16, BP (HV1) has reached Level 2 safing due to
   persistent high event rate. =17, LG (HV2) has reached Level 1 safing
   due to high event rate. =18, LG (HV2) has reached Level 2 safing due
   to persistent high event rate. Values and description taken from
   Table 2.12 of MESSENGER Instrument Neutron Spectrometer (NS) Flight
   Software Specification, cited in Applicable Documents section of NS
   CDR SIS. Compiled in Monitor limits."
END_OBJECT    = COLUMN

OBJECT        = COLUMN
   NAME           = ALARM_TYPE
   COLUMN_NUMBER  = 14
   BYTES          = 8
   DATA_TYPE      = ASCII_INTEGER
   START_BYTE     = 143
   DESCRIPTION    = "Latest alarm type. =0 Persistent. =1 Transient."
END_OBJECT    = COLUMN

OBJECT        = COLUMN
   NAME           = ALARM_COUNT
   COLUMN_NUMBER  = 15
   BYTES          = 8
   DATA_TYPE      = ASCII_INTEGER
   START_BYTE     = 152
   DESCRIPTION    = "Count of alarms."
END_OBJECT    = COLUMN

OBJECT        = COLUMN
   NAME           = CMD_EXEC
   COLUMN_NUMBER  = 16
   BYTES          = 8
   DATA_TYPE      = ASCII_INTEGER
   START_BYTE     = 161
```

```
   DESCRIPTION    = "Number of commands executed."
END_OBJECT    = COLUMN

OBJECT        = COLUMN
   NAME           = CMD_REJECT
   COLUMN_NUMBER  = 17
   BYTES          = 8
   DATA_TYPE      = ASCII_INTEGER
   START_BYTE     = 170
   DESCRIPTION    = "Number of commands rejected."
END_OBJECT    = COLUMN

OBJECT        = COLUMN
   NAME           = MAC_EXEC
   COLUMN_NUMBER  = 18
   BYTES          = 8
   DATA_TYPE      = ASCII_INTEGER
   START_BYTE     = 179
   DESCRIPTION    = "Number of macro commands executed."
END_OBJECT    = COLUMN

OBJECT        = COLUMN
   NAME           = MAC_REJECT
   COLUMN_NUMBER  = 19
   BYTES          = 8
   DATA_TYPE      = ASCII_INTEGER
   START_BYTE     = 188
   DESCRIPTION    = "Number of macro commands rejected."
END_OBJECT    = COLUMN

OBJECT        = COLUMN
   NAME           = MACRO_ID
   COLUMN_NUMBER  = 20
   BYTES          = 8
   DATA_TYPE      = ASCII_INTEGER
   START_BYTE     = 197
   DESCRIPTION    = "ID of most recent macro executed."
END_OBJECT    = COLUMN

OBJECT        = COLUMN
   NAME           = MACRO_LEARN
   COLUMN_NUMBER  = 21
   BYTES          = 8
   DATA_TYPE      = ASCII_INTEGER
   START_BYTE     = 206
   DESCRIPTION    = "Macro learn mode. =0 not learning, =1 learning."
END_OBJECT    = COLUMN

OBJECT        = COLUMN
   NAME           = MONITOR_RESP
   COLUMN_NUMBER  = 22
   BYTES          = 8
   DATA_TYPE      = ASCII_INTEGER
   START_BYTE     = 215
   DESCRIPTION    = "Monitor response. =0 disabled, =1 enabled."
END_OBJECT    = COLUMN
```

```
OBJECT         = COLUMN
   NAME            = WRITE_ENABLE
   COLUMN_NUMBER  = 23
   BYTES           = 8
   DATA_TYPE       = ASCII_INTEGER
   START_BYTE      = 224
   DESCRIPTION     = "Memory write enable. =0 disabled, =1 enabled."
END_OBJECT     = COLUMN

OBJECT         = COLUMN
   NAME            = PLUS_5V
   COLUMN_NUMBER  = 24
   BYTES           = 8
   DATA_TYPE       = ASCII_REAL
   START_BYTE      = 233
   UNIT            = VOLT
   DESCRIPTION     = "+5 volt monitor (LVPS) in volts."
END_OBJECT     = COLUMN

OBJECT         = COLUMN
   NAME            = NEG_5V
   COLUMN_NUMBER  = 25
   BYTES           = 8
   DATA_TYPE       = ASCII_REAL
   START_BYTE      = 242
   UNIT            = VOLT
   DESCRIPTION     = "-5 volt monitor (LVPS) in volts."
END_OBJECT     = COLUMN

OBJECT         = COLUMN
   NAME            = PLUS_12V
   COLUMN_NUMBER  = 26
   BYTES           = 8
   DATA_TYPE       = ASCII_REAL
   START_BYTE      = 251
   UNIT            = VOLT
   DESCRIPTION     = "+12 volt monitor (LVPS) in volts."
END_OBJECT     = COLUMN

OBJECT         = COLUMN
   NAME            = NEG_12V
   COLUMN_NUMBER  = 27
   BYTES           = 8
   DATA_TYPE       = ASCII_REAL
   START_BYTE      = 260
   UNIT            = VOLT
   DESCRIPTION     = "-12 volt monitor (LVPS) in volts."
END_OBJECT     = COLUMN

OBJECT         = COLUMN
   NAME            = EXTERNAL_CH1
   COLUMN_NUMBER  = 28
   BYTES           = 8
   DATA_TYPE       = ASCII_REAL
   START_BYTE      = 269
   UNIT            = DEGC
   DESCRIPTION     = "External channel 1 (LVPS). ADC board temperature
```

```
   in units of degrees Celsius."
END_OBJECT    = COLUMN

OBJECT        = COLUMN
   NAME            = EXTERNAL_CH2
   COLUMN_NUMBER  = 29
   BYTES           = 8
   DATA_TYPE       = ASCII_REAL
   START_BYTE      = 278
   UNIT            = DEGC
   DESCRIPTION     = "External channel 2 (LVPS). Pre-amp board
   temperature in units of degrees Celsius."
END_OBJECT    = COLUMN

OBJECT        = COLUMN
   NAME            = EXTERNAL_CH3
   COLUMN_NUMBER  = 30
   BYTES           = 8
   DATA_TYPE       = ASCII_INTEGER
   START_BYTE      = 287
   DESCRIPTION     = "External channel 3 (LVPS)."
END_OBJECT    = COLUMN

OBJECT        = COLUMN
   NAME            = EXTERNAL_CH4
   COLUMN_NUMBER  = 31
   BYTES           = 8
   DATA_TYPE       = ASCII_REAL
   START_BYTE      = 296
   UNIT            = DEGC
   DESCRIPTION     = "External channel 4 (LVPS). NS sensor temperature
   in units of degrees Celsius."
END_OBJECT    = COLUMN

OBJECT        = COLUMN
   NAME            = EXTERNAL_CH5
   COLUMN_NUMBER  = 32
   BYTES           = 8
   DATA_TYPE       = ASCII_INTEGER
   START_BYTE      = 305
   DESCRIPTION     = "External channel 5 (LVPS)."
END_OBJECT    = COLUMN

OBJECT        = COLUMN
   NAME            = PLUS5V_I
   COLUMN_NUMBER  = 33
   BYTES           = 8
   DATA_TYPE       = ASCII_REAL
   START_BYTE      = 314
   UNIT            = AMPERE
   DESCRIPTION     = "+5V current monitor (LVPS) in amps."
END_OBJECT    = COLUMN

OBJECT        = COLUMN
   NAME            = NEG5V_I
   COLUMN_NUMBER  = 34
   BYTES           = 8
```

```
   DATA_TYPE      = ASCII_REAL
   START_BYTE     = 323
   UNIT           = AMPERE
   DESCRIPTION    = "-5V current monitor (LVPS) in amps."
END_OBJECT    = COLUMN

OBJECT        = COLUMN
   NAME           = PLUS12V_I
   COLUMN_NUMBER  = 35
   BYTES          = 8
   DATA_TYPE      = ASCII_REAL
   START_BYTE     = 332
   UNIT           = AMPERE
   DESCRIPTION    = "+12V current monitor (LVPS) in amps."
END_OBJECT    = COLUMN

OBJECT        = COLUMN
   NAME           = NEG12V_I
   COLUMN_NUMBER  = 36
   BYTES          = 8
   DATA_TYPE      = ASCII_REAL
   START_BYTE     = 341
   UNIT           = AMPERE
   DESCRIPTION    = "-12V current monitor (LVPS) in amps."
END_OBJECT    = COLUMN

OBJECT        = COLUMN
   NAME           = TEMP_MON
   COLUMN_NUMBER  = 37
   BYTES          = 8
   DATA_TYPE      = ASCII_REAL
   START_BYTE     = 350
   UNIT           = DEGC
   DESCRIPTION    = "Temperature Monitor (LVPS) in degrees Celsius."
END_OBJECT    = COLUMN

OBJECT        = COLUMN
   NAME           = PRIMARY_I
   COLUMN_NUMBER  = 38
   BYTES          = 8
   DATA_TYPE      = ASCII_REAL
   START_BYTE     = 359
   UNIT           = AMPERE
   DESCRIPTION    = "Primary current Monitor (LVPS) in amps."
END_OBJECT    = COLUMN

OBJECT        = COLUMN
   NAME           = SWITCHED_PRI_I
   COLUMN_NUMBER  = 39
   BYTES          = 8
   DATA_TYPE      = ASCII_REAL
   START_BYTE     = 368
   UNIT           = AMPERE
   DESCRIPTION    = "Switched Primary current Monitor (LVPS) in amps."
END_OBJECT    = COLUMN

OBJECT        = COLUMN
```

```
   NAME            = VOLT_LG_HVPS
   COLUMN_NUMBER   = 40
   BYTES           = 8
   DATA_TYPE       = ASCII_REAL
   START_BYTE      = 377
   UNIT            = VOLT
   DESCRIPTION     = "Voltage of LG HVPS(1) in volts."
END_OBJECT     = COLUMN

OBJECT         = COLUMN
   NAME            = VOLT_BP_HVPS
   COLUMN_NUMBER   = 41
   BYTES           = 8
   DATA_TYPE       = ASCII_REAL
   START_BYTE      = 386
   UNIT            = VOLT
   DESCRIPTION     = "Voltage of BP HVPS(2) in volts."
END_OBJECT     = COLUMN

OBJECT         = COLUMN
   NAME            = TEMP_LG
   COLUMN_NUMBER   = 42
   BYTES           = 8
   DATA_TYPE       = ASCII_REAL
   START_BYTE      = 395
   UNIT            = DEGC
   DESCRIPTION     = "Temperature of LG in degrees Celsius."
END_OBJECT     = COLUMN

OBJECT         = COLUMN
   NAME            = TEMP_BP
   COLUMN_NUMBER   = 43
   BYTES           = 8
   DATA_TYPE       = ASCII_REAL
   START_BYTE      = 404
   UNIT            = DEGC
   DESCRIPTION     = "Temperature of BP in degrees Celsius."
END_OBJECT     = COLUMN

OBJECT         = COLUMN
   NAME            = HVPS_SPARE1
   COLUMN_NUMBER   = 44
   BYTES           = 8
   DATA_TYPE       = ASCII_REAL
   START_BYTE      = 413
   DESCRIPTION     = "Spare column. Any values contained are a
   consequence of the flight software and should be ignored."
END_OBJECT     = COLUMN

OBJECT         = COLUMN
   NAME            = HVPS_SPARE2
   COLUMN_NUMBER   = 45
   BYTES           = 8
   DATA_TYPE       = ASCII_REAL
   START_BYTE      = 422
   DESCRIPTION     = "Spare column. Any values contained are a
   consequence of the flight software and should be ignored."
```

```
END_OBJECT    = COLUMN

OBJECT        = COLUMN
   NAME           = CAPTURE_E_LIMIT
   COLUMN_NUMBER  = 46
   BYTES          = 8
   DATA_TYPE      = ASCII_INTEGER
   START_BYTE     = 431
   DESCRIPTION    = "Capture energy limit in units of channels."
END_OBJECT    = COLUMN

OBJECT        = COLUMN
   NAME           = EVENT_MODE_LEN
   COLUMN_NUMBER  = 47
   BYTES          = 8
   DATA_TYPE      = ASCII_INTEGER
   START_BYTE     = 440
   DESCRIPTION    = "Event mode length in numbers of events."
END_OBJECT    = COLUMN

OBJECT        = COLUMN
   NAME           = FAILED_PACKETS
   COLUMN_NUMBER  = 48
   BYTES          = 8
   DATA_TYPE      = ASCII_INTEGER
   START_BYTE     = 449
   DESCRIPTION    = "Failed packets."
END_OBJECT    = COLUMN

OBJECT        = COLUMN
   NAME           = POWER_MANAGEMENT
   COLUMN_NUMBER  = 49
   BYTES          = 8
   DATA_TYPE      = ASCII_INTEGER
   START_BYTE     = 458
   DESCRIPTION    = "Power Management bit register. Defines various
   circuit parameters, including normal and sleep modes."
END_OBJECT    = COLUMN

OBJECT        = COLUMN
   NAME           = TRIG_SAMPLE_TAP
   COLUMN_NUMBER  = 50
   BYTES          = 8
   DATA_TYPE      = ASCII_INTEGER
   START_BYTE     = 467
   DESCRIPTION    = "Trigger sample tap."
END_OBJECT    = COLUMN

OBJECT        = COLUMN
   NAME           = GAIN_DAC
   COLUMN_NUMBER  = 51
   BYTES          = 8
   DATA_TYPE      = ASCII_INTEGER
   START_BYTE     = 476
   DESCRIPTION    = "Controls BP channel Gain by changing ADC reference
   voltage."
END_OBJECT    = COLUMN
```

```
OBJECT         = COLUMN
   NAME            = BP_CHARGE_RESET
   COLUMN_NUMBER  = 52
   BYTES           = 8
   DATA_TYPE       = ASCII_INTEGER
   START_BYTE      = 485
   UNIT            = COUNTS
   DESCRIPTION     = "BP Charge reset in units of counts (1-sec
   accumulation)."
END_OBJECT     = COLUMN

OBJECT         = COLUMN
   NAME            = BP_PRMPT_THRESH
   COLUMN_NUMBER  = 53
   BYTES           = 8
   DATA_TYPE       = ASCII_INTEGER
   START_BYTE      = 494
   UNIT            = CHANNELS
   DESCRIPTION     = "Channel 0 (BP) Prompt Trigger Threshold in
   channels."
END_OBJECT     = COLUMN

OBJECT         = COLUMN
   NAME            = BP_SEC_THRESH
   COLUMN_NUMBER  = 54
   BYTES           = 8
   DATA_TYPE       = ASCII_INTEGER
   START_BYTE      = 503
   UNIT            = CHANNELS
   DESCRIPTION     = "Channel 0 (BP) Secondary Trigger Threshold in
   channels."
END_OBJECT     = COLUMN

OBJECT         = COLUMN
   NAME            = LG1_TRIG_THRESH
   COLUMN_NUMBER  = 55
   BYTES           = 8
   DATA_TYPE       = ASCII_INTEGER
   START_BYTE      = 512
   UNIT            = CHANNELS
   DESCRIPTION     = "Channel 1 (LG) Trigger Threshold in channels."
END_OBJECT     = COLUMN

OBJECT         = COLUMN
   NAME            = LG2_TRIG_THRESH
   COLUMN_NUMBER  = 56
   BYTES           = 8
   DATA_TYPE       = ASCII_INTEGER
   START_BYTE      = 521
   UNIT            = CHANNELS
   DESCRIPTION     = "Channel 2 (LG) Trigger Threshold in channels."
END_OBJECT     = COLUMN

OBJECT         = COLUMN
   NAME            = BP_RAW_EVENT
   COLUMN_NUMBER  = 57
```

```
   BYTES          = 8
   DATA_TYPE      = ASCII_INTEGER
   START_BYTE     = 530
   UNIT           = COUNTS
   DESCRIPTION    = "Channel 0 (BP) Raw Event Hardware Counter
   (1-second accumulation) in counts."
END_OBJECT    = COLUMN

OBJECT        = COLUMN
   NAME           = LG1_RAW_EVENT
   COLUMN_NUMBER  = 58
   BYTES          = 8
   DATA_TYPE      = ASCII_INTEGER
   START_BYTE     = 539
   UNIT           = COUNTS
   DESCRIPTION    = "Channel 1 (LG1) Raw Event Hardware Counter
   (1-second accumulation) in counts."
END_OBJECT    = COLUMN

OBJECT        = COLUMN
   NAME           = LG2_RAW_EVENT
   COLUMN_NUMBER  = 59
   BYTES          = 8
   DATA_TYPE      = ASCII_INTEGER
   START_BYTE     = 548
   UNIT           = COUNTS
   DESCRIPTION    = "Channel 2 (LG2) Raw Event Counter (1-second
   accumulation) in counts."
END_OBJECT    = COLUMN

OBJECT        = COLUMN
   NAME           = LG_SAFING_STATE
   COLUMN_NUMBER  = 60
   BYTES          = 8
   DATA_TYPE      = ASCII_INTEGER
   START_BYTE     = 557
   DESCRIPTION    = "LG Current sensor state.
   =0 Nominal, =1 Seeking, =2 Level 1 Rampdown, =3 Level 1 Waiting,
   =4 Level 1 Seeking, =5 Level 2 Safing."
END_OBJECT    = COLUMN

OBJECT        = COLUMN
   NAME           = BP_SAFING_STATE
   COLUMN_NUMBER  = 61
   BYTES          = 8
   DATA_TYPE      = ASCII_INTEGER
   START_BYTE     = 566
   DESCRIPTION    = "BP current sensor state.
   =0  Nominal, =1 Seeking, =2 Level 1 Rampdown, =3 Level 1 Waiting,
   =4 Level 1 Seeking, =5 Level 2 Safing."
END_OBJECT    = COLUMN

OBJECT        = COLUMN
   NAME           = SCREEN_ON_DQ
   COLUMN_NUMBER  = 62
   BYTES          = 8
   DATA_TYPE      = ASCII_INTEGER
```

```
   START_BYTE     = 575
   DESCRIPTION    = "Set Calibration/Diagnostic mode to screen out data
   with DQ bit set. =0 No Screen, =1 Screen."
END_OBJECT    = COLUMN

OBJECT        = COLUMN
   NAME           = NON_COMP_SCI_DATA
   COLUMN_NUMBER  = 63
   BYTES          = 8
   DATA_TYPE      = ASCII_INTEGER
   START_BYTE     = 584
   DESCRIPTION    = "This column has been retired. Non-compressed
   science data packets have not been generated by the instrument
   during flight. Ignore any value in this column."
END_OBJECT    = COLUMN

OBJECT        = COLUMN
   NAME           = FAST_COMP_SCI_DATA
   COLUMN_NUMBER  = 64
   BYTES          = 8
   DATA_TYPE      = ASCII_INTEGER
   START_BYTE     = 593
   DESCRIPTION    = "When SW_VERSION=4 this value reflects whether FAST
   compression of the science packet was enabled. When SW_VERSION=5
   this value reflects whether the full science packet was enabled.
   =1 Enabled, =0 Disabled."
END_OBJECT    = COLUMN

OBJECT        = COLUMN
   NAME           = LOG_COMP_SCI_DATA
   COLUMN_NUMBER  = 65
   BYTES          = 8
   DATA_TYPE      = ASCII_INTEGER
   START_BYTE     = 602
   DESCRIPTION    = "Log Compression of Software Counters enabled.
   =1 Enabled, =0 Disabled."
END_OBJECT    = COLUMN

OBJECT        = COLUMN
   NAME           = DIAG_DATA_PACKET
   COLUMN_NUMBER  = 66
   BYTES          = 8
   DATA_TYPE      = ASCII_INTEGER
   START_BYTE     = 611
   DESCRIPTION    = "Diagnostic Packet enabled. =1 Enabled,
   =0 Disabled."
END_OBJECT    = COLUMN

OBJECT        = COLUMN
   NAME           = SPARE_DATA_PACKET
   COLUMN_NUMBER  = 67
   BYTES          = 8
   DATA_TYPE      = ASCII_INTEGER
   START_BYTE     = 620
   DESCRIPTION    = "Spare data packet enabled. =1 Enabled, =0 Disabled."
END_OBJECT    = COLUMN
```

```
OBJECT         = COLUMN
   NAME            = HV1_ENABLED
   COLUMN_NUMBER  = 68
   BYTES           = 8
   DATA_TYPE       = ASCII_INTEGER
   START_BYTE      = 629
   DESCRIPTION     = "HV1 (BP) Enabled. =1 Enabled, =0 Disabled."
END_OBJECT     = COLUMN

OBJECT         = COLUMN
   NAME            = HV2_ENABLED
   COLUMN_NUMBER  = 69
   BYTES           = 8
   DATA_TYPE       = ASCII_INTEGER
   START_BYTE      = 638
   DESCRIPTION     = "HV2 (LG1 and LG2) Enabled. =1 Enabled,
   =0 Disabled."
END_OBJECT     = COLUMN

OBJECT         = COLUMN
   NAME            = ACCUM_FLAG
   COLUMN_NUMBER  = 70
   BYTES           = 8
   DATA_TYPE       = ASCII_INTEGER
   START_BYTE      = 647
   DESCRIPTION     = "Flag for instrument accumulation. =0 Not
   accumulating, =1 Accumulating."
END_OBJECT     = COLUMN

OBJECT         = COLUMN
   NAME            = ACCUM_PERIOD
   COLUMN_NUMBER  = 71
   BYTES           = 8
   DATA_TYPE       = ASCII_INTEGER
   START_BYTE      = 656
   UNIT            = SECOND
   DESCRIPTION     = "Currently commanded accumulation period in units
   of seconds."
END_OBJECT     = COLUMN

OBJECT         = COLUMN
   NAME            = REPORT_PERIOD
   COLUMN_NUMBER  = 72
   BYTES           = 8
   DATA_TYPE       = ASCII_INTEGER
   START_BYTE      = 665
   UNIT            = SECOND
   DESCRIPTION     = "Currently commanded reporting period in units of
   seconds."
END_OBJECT     = COLUMN

OBJECT         = COLUMN
   NAME            = LG1_ULD
   COLUMN_NUMBER  = 73
   BYTES           = 8
   DATA_TYPE       = ASCII_INTEGER
   START_BYTE      = 674
```

```
   DESCRIPTION    = "LG1 Upper-Level Discriminator. Raw ADC units."
END_OBJECT    = COLUMN

OBJECT        = COLUMN
   NAME           = LG2_ULD
   COLUMN_NUMBER  = 74
   BYTES          = 8
   DATA_TYPE      = ASCII_INTEGER
   START_BYTE     = 683
   DESCRIPTION    = "LG2 Upper-Level Discriminator. Raw ADC units."
END_OBJECT    = COLUMN

OBJECT        = COLUMN
   NAME           = BP_ULD
   COLUMN_NUMBER  = 75
   BYTES          = 8
   DATA_TYPE      = ASCII_INTEGER
   START_BYTE     = 692
   DESCRIPTION    = "BPP Upper-Level Discriminator. Raw ADC units."
END_OBJECT    = COLUMN

OBJECT        = COLUMN
   NAME           = HI_VOLT_SETP_BP
   COLUMN_NUMBER  = 76
   BYTES          = 8
   DATA_TYPE      = ASCII_INTEGER
   START_BYTE     = 701
   DESCRIPTION    = "Currently commanded High Voltage set point for BP
   HVPS."
END_OBJECT    = COLUMN

OBJECT        = COLUMN
   NAME           = HI_VOLT_SEPT_LG
   COLUMN_NUMBER  = 77
   BYTES          = 8
   DATA_TYPE      = ASCII_INTEGER
   START_BYTE     = 710
   DESCRIPTION    = "Currently commanded High Voltage set point for LG
   HVPS."
END_OBJECT    = COLUMN

OBJECT        = COLUMN
   NAME           = HVPS_1_MAX_VAL
   COLUMN_NUMBER  = 78
   BYTES          = 8
   DATA_TYPE      = ASCII_INTEGER
   START_BYTE     = 719
   DESCRIPTION    = "Maximum commandable HVPS 1 value."
END_OBJECT    = COLUMN

OBJECT        = COLUMN
   NAME           = HVPS_2_MAX_VAL
   COLUMN_NUMBER  = 79
   BYTES          = 8
   DATA_TYPE      = ASCII_INTEGER
   START_BYTE     = 728
   DESCRIPTION    = "Maximum commandable HVPS 2 value."
```

```
END_OBJECT    = COLUMN

OBJECT        = COLUMN
   NAME           = SAFING_RETRY
   COLUMN_NUMBER  = 80
   BYTES          = 8
   DATA_TYPE      = ASCII_INTEGER
   START_BYTE     = 737
   DESCRIPTION    = "Sensor safing retry value."
END_OBJECT    = COLUMN

OBJECT        = COLUMN
   NAME           = SAFING_INTERVAL
   COLUMN_NUMBER  = 81
   BYTES          = 8
   DATA_TYPE      = ASCII_INTEGER
   START_BYTE     = 746
   DESCRIPTION    = "Sensor safing interval value."
END_OBJECT    = COLUMN

OBJECT        = COLUMN
   NAME           = SAFING_THRESHOLD
   COLUMN_NUMBER  = 82
   BYTES          = 8
   DATA_TYPE      = ASCII_INTEGER
   START_BYTE     = 755
   DESCRIPTION    = "LG1, LG2, BP safing threshold."
END_OBJECT    = COLUMN

OBJECT        = COLUMN
   NAME           = EARLY_CAPTURE_START
   COLUMN_NUMBER  = 83
   BYTES          = 8
   DATA_TYPE      = ASCII_INTEGER
   START_BYTE     = 764
   DESCRIPTION    = "Early capture window start time."
END_OBJECT    = COLUMN

OBJECT        = COLUMN
   NAME           = EARLY_CAPTURE_END
   COLUMN_NUMBER  = 84
   BYTES          = 8
   DATA_TYPE      = ASCII_INTEGER
   START_BYTE     = 773
   DESCRIPTION    = "Early capture window end time."
END_OBJECT    = COLUMN

OBJECT        = COLUMN
   NAME           = LATE_CAPTURE_START
   COLUMN_NUMBER  = 85
   BYTES          = 8
   DATA_TYPE      = ASCII_INTEGER
   START_BYTE     = 782
   DESCRIPTION    = "Late capture window start time."
END_OBJECT    = COLUMN

OBJECT        = COLUMN
```

```
   NAME            = LATE_CAPTURE_END
   COLUMN_NUMBER  = 86
   BYTES           = 8
   DATA_TYPE       = ASCII_INTEGER
   START_BYTE      = 791
   DESCRIPTION     = "Late capture window end time."
END_OBJECT    = COLUMN

OBJECT         = COLUMN
   NAME            = CH0_LATCH_UPS
   COLUMN_NUMBER  = 87
   BYTES           = 8
   DATA_TYPE       = ASCII_INTEGER
   START_BYTE      = 800
   DESCRIPTION     = "Total number of Latch-ups on Channel 0 since last
   boot."
END_OBJECT    = COLUMN

OBJECT         = COLUMN
   NAME            = CH1_2_LATCH_UPS
   COLUMN_NUMBER  = 88
   BYTES           = 8
   DATA_TYPE       = ASCII_INTEGER
   START_BYTE      = 809
   DESCRIPTION     = "Total number of Latch-ups on Channels 1 and 2
   since last boot."
END_OBJECT    = COLUMN

OBJECT         = COLUMN
   NAME            = GAMMA_BURST_CNT
   COLUMN_NUMBER  = 89
   BYTES           = 8
   DATA_TYPE       = ASCII_INTEGER
   START_BYTE      = 818
   DESCRIPTION     = "Cumulative number of gamma ray bursts (mod 256)."
END_OBJECT    = COLUMN

OBJECT         = COLUMN
   NAME            = TELEMETRY_PRIORITY
   COLUMN_NUMBER  = 90
   BYTES           = 8
   DATA_TYPE       = ASCII_INTEGER
   START_BYTE      = 827
   DESCRIPTION     = "Priority level for science telemetry."
END_OBJECT    = COLUMN

OBJECT         = COLUMN
   NAME            = GCR_COINCIDENCE_MODE
   COLUMN_NUMBER  = 91
   BYTES           = 8
   DATA_TYPE       = ASCII_INTEGER
   START_BYTE      = 836
   DESCRIPTION     = "Galactic Cosmic Ray coincidence mode. Value is set
   to 0 when SW_VERSION is less than 5 due to non-existence of this
   telemetry point in prior software versions. Otherwise values are
   =1 Doubles, =2 Triples, =3 Either."
END_OBJECT    = COLUMN
```

```
OBJECT         = COLUMN
   NAME            = GCR_PACKET
   COLUMN_NUMBER   = 92
   BYTES           = 8
   DATA_TYPE       = ASCII_INTEGER
   START_BYTE      = 845
   DESCRIPTION     = "Galactic Cosmic Ray packet enabled. Value is set
   to 0 when SW_VERSION is less than 5 due to the non-existence of this
   telemetry point in prior software versions. =0 Disabled, =1 Enabled."
END_OBJECT     = COLUMN

OBJECT         = COLUMN
   NAME            = GAMMARAY_BURST_RESPONSE
   COLUMN_NUMBER   = 93
   BYTES           = 8
   DATA_TYPE       = ASCII_INTEGER
   START_BYTE      = 854
   DESCRIPTION     = "Gamma Ray Burst Response Macro enabled. Value is
   set to 0 when SW_VERSION is less than 5 due to the non-existence of
   this telemetry point in prior software versions. =0 Disabled,
   =1 Enabled."
END_OBJECT     = COLUMN

OBJECT         = COLUMN
   NAME            = GAMMA_BURST_THRESH
   COLUMN_NUMBER   = 94
   BYTES           = 8
   DATA_TYPE       = ASCII_INTEGER
   START_BYTE      = 863
   DESCRIPTION     = "Gamma Ray burst threshold value."
END_OBJECT     = COLUMN

OBJECT         = COLUMN
   NAME            = GAMMA_CH_LIMIT
   COLUMN_NUMBER   = 95
   BYTES           = 8
   DATA_TYPE       = ASCII_INTEGER
   START_BYTE      = 872
   DESCRIPTION     = "Gamma Ray (processed count) channel limit."
END_OBJECT     = COLUMN

OBJECT         = COLUMN
   NAME            = GAMMA_MODE
   COLUMN_NUMBER   = 96
   BYTES           = 8
   DATA_TYPE       = ASCII_INTEGER
   START_BYTE      = 881
   DESCRIPTION     = "Gamma Ray mode. =0 raw count, =1 processed count."
END_OBJECT     = COLUMN

OBJECT         = COLUMN
   NAME            = TC_COUNTERS
   COLUMN_NUMBER   = 97
   BYTES           = 8
   DATA_TYPE       = ASCII_INTEGER
   START_BYTE      = 890
```

```
   DESCRIPTION    = "Time-correlated (TC) counters mode enabled. Value
   is set to 0 when SW_VERSION is less than 5 due to the non-existence
   of this telemetry point in prior software versions."
END_OBJECT    = COLUMN

OBJECT        = COLUMN
   NAME           = GAMMA_POST_TRIG_LEN
   COLUMN_NUMBER  = 98
   BYTES          = 8
   DATA_TYPE      = ASCII_INTEGER
   START_BYTE     = 899
   DESCRIPTION    = "Gamma Ray post trigger length."
END_OBJECT    = COLUMN
```

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```
OBJECT        = COLUMN
   NAME           = MET
   COLUMN_NUMBER  = 1
   BYTES          = 12
   DATA_TYPE      = ASCII_INTEGER
   START_BYTE     = 1
   DESCRIPTION    = "Time tag in seconds of the gamma-ray burst trigger."
END_OBJECT    = COLUMN

OBJECT        = COLUMN
   NAME           = CMD_UTC_DATE
   COLUMN_NUMBER  = 2
   BYTES          = 10
   DATA_TYPE      = CHARACTER
   START_BYTE     = 14
   DESCRIPTION    = "UTC date in YYYY-MM-DD format derived from the
   MET using SPICE kernels."
END_OBJECT    = COLUMN

OBJECT        = COLUMN
   NAME           = CMD_UTC_TIME
   COLUMN_NUMBER  = 3
   BYTES          = 12
   DATA_TYPE      = CHARACTER
   START_BYTE     = 25
   DESCRIPTION    = "UTC time in HH:MM:SS.SSS format derived from the
   MET using SPICE kernels."
END_OBJECT    = COLUMN

OBJECT        = COLUMN
   NAME           = CMD_UTC_SEC
   COLUMN_NUMBER  = 4
   BYTES          = 9
   DATA_TYPE      = CHARACTER
   START_BYTE     = 38
   DESCRIPTION    = "UTC time as seconds since 00:00:00 derived
   from the MET using SPICE kernels."
END_OBJECT    = COLUMN

OBJECT        = COLUMN
   NAME           = ORBIT_NUMBER
   COLUMN_NUMBER  = 5
   BYTES          = 6
   DATA_TYPE      = ASCII_INTEGER
   START_BYTE     = 48
   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            = GAMMA_RAY_MODE
   COLUMN_NUMBER   = 6
   BYTES           = 1
   DATA_TYPE       = ASCII_INTEGER
   START_BYTE      = 55
   DESCRIPTION     = "Gamma Ray mode. =0 RAW, =1 PROCESSED."
END_OBJECT     = COLUMN

OBJECT         = COLUMN
   NAME            = BP_CH_UPPER_LIMIT
   COLUMN_NUMBER   = 7
   BYTES           = 2
   DATA_TYPE       = ASCII_INTEGER
   START_BYTE      = 57
   DESCRIPTION     = "The highest BP channel that will be used as part of
   the source of the Gamma-Ray burst BP counts."
END_OBJECT     = COLUMN

OBJECT         = COLUMN
   NAME            = TRIG_BOXCAR_ACCUM
   COLUMN_NUMBER   = 8
   BYTES           = 6
   DATA_TYPE       = ASCII_INTEGER
   START_BYTE      = 60
   DESCRIPTION     = "Number of counts in the running box car accumulator at
   the time of the trigger. Box car length is 164 events."
END_OBJECT     = COLUMN

OBJECT         = COLUMN
   NAME            = BURST_THRESHOLD
   COLUMN_NUMBER   = 9
   BYTES           = 5
   DATA_TYPE       = ASCII_INTEGER
   START_BYTE      = 67
   DESCRIPTION     = "Burst lower pulse threshold for trigger in raw ADC
   units."
END_OBJECT     = COLUMN

OBJECT         = COLUMN
   NAME            = POST_TRIGGER_COUNTS
   COLUMN_NUMBER   = 10
   BYTES           = 3
   DATA_TYPE       = ASCII_INTEGER
   START_BYTE      = 73
   DESCRIPTION     = "Number of post trigger counts."
END_OBJECT     = COLUMN

OBJECT         = COLUMN
   NAME            = GAMMA_RAY_BURST
   COLUMN_NUMBER   = 11
   BYTES           = 983
   DATA_TYPE       = ASCII_INTEGER
   START_BYTE      = 77
   ITEMS           = 164
   ITEM_BYTES      = 5
   DESCRIPTION     = "Collection of 164 (1-sec) BP counts."
END_OBJECT     = COLUMN
```

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```
OBJECT         = COLUMN
   NAME            = JULIAN_DAY
   COLUMN_NUMBER  = 1
   BYTES           = 13
   DATA_TYPE       = ASCII_REAL
   START_BYTE      = 1
   FORMAT          = "F13.5"
   DESCRIPTION     = "UTC time at *midpoint* of data collection given in
   Julian day."
END_OBJECT     = COLUMN

OBJECT         = COLUMN
   NAME            = UTC_TIME
   COLUMN_NUMBER  = 2
   BYTES           = 19
   DATA_TYPE       = CHARACTER
   START_BYTE      = 15
   DESCRIPTION     = "UTC time at *midpoint* of data collection.
   Format: YYYY-MM-DDTHH:MM:SS"
END_OBJECT     = COLUMN

OBJECT         = COLUMN
   NAME            = MET
   COLUMN_NUMBER  = 3
   BYTES           = 12
   DATA_TYPE       = ASCII_INTEGER
   START_BYTE      = 35
   DESCRIPTION     = "Time tag in seconds at the start of the associated
   reporting/accumulation period."
END_OBJECT     = COLUMN

OBJECT         = COLUMN
   NAME            = ORBIT_NUMBER
   COLUMN_NUMBER  = 4
   BYTES           = 4
   DATA_TYPE       = ASCII_INTEGER
   START_BYTE      = 48
   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
   (see GEOMETRY/geominfo.txt). 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            = ACTUAL_ACCUM
   COLUMN_NUMBER  = 5
   BYTES           = 4
   DATA_TYPE       = ASCII_INTEGER
   START_BYTE      = 53
   DESCRIPTION     = "Actual accumulation period in seconds for software
   counters and energy histograms."
END_OBJECT     = COLUMN
```

```
OBJECT        = COLUMN
   NAME           = SENSOR_TEMP
   COLUMN_NUMBER  = 6
   BYTES          = 7
   DATA_TYPE      = ASCII_REAL
   START_BYTE     = 58
   FORMAT         = "F7.3"
   DESCRIPTION    = "NS sensor temperature in units of degree C."
END_OBJECT    = COLUMN

OBJECT        = COLUMN
   NAME           = ALTITUDE
   COLUMN_NUMBER  = 7
   BYTES          = 10
   DATA_TYPE      = ASCII_REAL
   START_BYTE     = 66
   FORMAT         = "F10.3"
   DESCRIPTION    = "Spacecraft altitude above the subsatellite point on the
   target in units of km."
END_OBJECT    = COLUMN

OBJECT        = COLUMN
   NAME           = LATITUDE
   COLUMN_NUMBER  = 8
   BYTES          = 7
   DATA_TYPE      = ASCII_REAL
   START_BYTE     = 77
   FORMAT         = "F7.3"
   DESCRIPTION    = "Target-centric latitude of the spacecraft subsatellite
   point in degrees."
END_OBJECT    = COLUMN

OBJECT        = COLUMN
   NAME           = LONGITUDE
   COLUMN_NUMBER  = 9
   BYTES          = 8
   DATA_TYPE      = ASCII_REAL
   START_BYTE     = 85
   FORMAT         = "F8.3"
   DESCRIPTION    = "Target-centric longitude of the spacecraft subsatellite
   point in degrees."
END_OBJECT    = COLUMN

OBJECT        = COLUMN
   NAME           = LOCAL_TIME
   COLUMN_NUMBER  = 10
   BYTES          = 10
   DATA_TYPE      = ASCII_REAL
   START_BYTE     = 94
   FORMAT         = "F10.3"
   DESCRIPTION    = "Local time of the spacecraft subsatellite point in
   hours from 0 to 24."
END_OBJECT    = COLUMN

OBJECT        = COLUMN
   NAME           = VELOCITY_VECTOR
```

```
   COLUMN_NUMBER  = 11
   BYTES          = 26
   DATA_TYPE      = ASCII_REAL
   START_BYTE     = 105
   ITEMS          = 3
   ITEM_BYTES     = 8
   ITEM_OFFSET    = 9
   FORMAT         = "F8.3"
   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  = 12
   BYTES          = 8
   DATA_TYPE      = ASCII_REAL
   START_BYTE     = 132
   FORMAT         = "F8.3"
   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  = 13
   BYTES          = 80
   DATA_TYPE      = ASCII_REAL
   START_BYTE     = 141
   ITEMS          = 9
   ITEM_BYTES     = 8
   ITEM_OFFSET    = 9
   FORMAT         = "F8.3"
   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  = 14
   BYTES          = 8
   DATA_TYPE      = ASCII_REAL
   START_BYTE     = 222
   FORMAT         = "F8.3"
   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  = 15
   BYTES          = 8
   DATA_TYPE      = ASCII_REAL
   START_BYTE     = 231
```

```
   FORMAT         = "F8.3"
   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  = 16
   BYTES          = 8
   DATA_TYPE      = ASCII_REAL
   START_BYTE     = 240
   FORMAT         = "F8.3"
   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  = 17
   BYTES          = 8
   DATA_TYPE      = ASCII_REAL
   START_BYTE     = 249
   FORMAT         = "F8.3"
   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  = 18
   BYTES          = 8
   DATA_TYPE      = ASCII_REAL
   START_BYTE     = 258
   FORMAT         = "F8.3"
   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  = 19
   BYTES          = 8
   DATA_TYPE      = ASCII_REAL
   START_BYTE     = 267
   FORMAT         = "F8.3"
   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  = 20
   BYTES          = 8
   DATA_TYPE      = ASCII_REAL
   START_BYTE     = 276
```

```
   FORMAT         = "F8.3"
   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  = 21
   BYTES          = 8
   DATA_TYPE      = ASCII_REAL
   START_BYTE     = 285
   FORMAT         = "F8.3"
   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  = 22
   BYTES          = 8
   DATA_TYPE      = ASCII_REAL
   START_BYTE     = 294
   FORMAT         = "F8.3"
   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  = 23
   BYTES          = 12
   DATA_TYPE      = ASCII_REAL
   START_BYTE     = 303
   FORMAT         = "F12.3"
   DESCRIPTION   = "Distance of the spacecraft to the Sun in units of km."
END_OBJECT    = COLUMN

OBJECT        = COLUMN
   NAME           = LG1_CPS
   COLUMN_NUMBER  = 24
   BYTES          = 7
   DATA_TYPE      = ASCII_REAL
   START_BYTE     = 316
   FORMAT         = "F7.3"
   DESCRIPTION    = "Net neutron count rate from the LG1 sensor in units of
   counts per second."
END_OBJECT    = COLUMN

OBJECT        = COLUMN
   NAME           = LG1_ERR_CPS
   COLUMN_NUMBER  = 25
   BYTES          = 7
   DATA_TYPE      = ASCII_REAL
```

```
   START_BYTE     = 324
   FORMAT         = "F7.3"
   DESCRIPTION    = "Net uncertainty (error) in the the LG1 count rate in
   units of counts per second."
END_OBJECT    = COLUMN

OBJECT        = COLUMN
   NAME           = LG2_CPS
   COLUMN_NUMBER  = 26
   BYTES          = 7
   DATA_TYPE      = ASCII_REAL
   START_BYTE     = 332
   FORMAT         = "F7.3"
   DESCRIPTION    = "Net neutron count rate from the LG2 sensor in units of
   counts per second."
END_OBJECT    = COLUMN

OBJECT        = COLUMN
   NAME           = LG2_ERR_CPS
   COLUMN_NUMBER  = 27
   BYTES          = 7
   DATA_TYPE      = ASCII_REAL
   START_BYTE     = 340
   FORMAT         = "F7.3"
   DESCRIPTION    = "Net uncertainty (error) in the the LG2 count rate in
   units of counts per second."
END_OBJECT    = COLUMN

OBJECT        = COLUMN
   NAME           = BP_CPS
   COLUMN_NUMBER  = 28
   BYTES          = 7
   DATA_TYPE      = ASCII_REAL
   START_BYTE     = 348
   FORMAT         = "F7.3"
   DESCRIPTION    = "Net neutron count rate from the BP sensor in units of
   counts per second."
END_OBJECT    = COLUMN

OBJECT        = COLUMN
   NAME           = BP_ERR_CPS
   COLUMN_NUMBER  = 29
   BYTES          = 7
   DATA_TYPE      = ASCII_REAL
   START_BYTE     = 356
   FORMAT         = "F7.3"
   DESCRIPTION    = "Net uncertainty (error) in the the BP count rate in
   units of counts per second."
END_OBJECT    = COLUMN
```