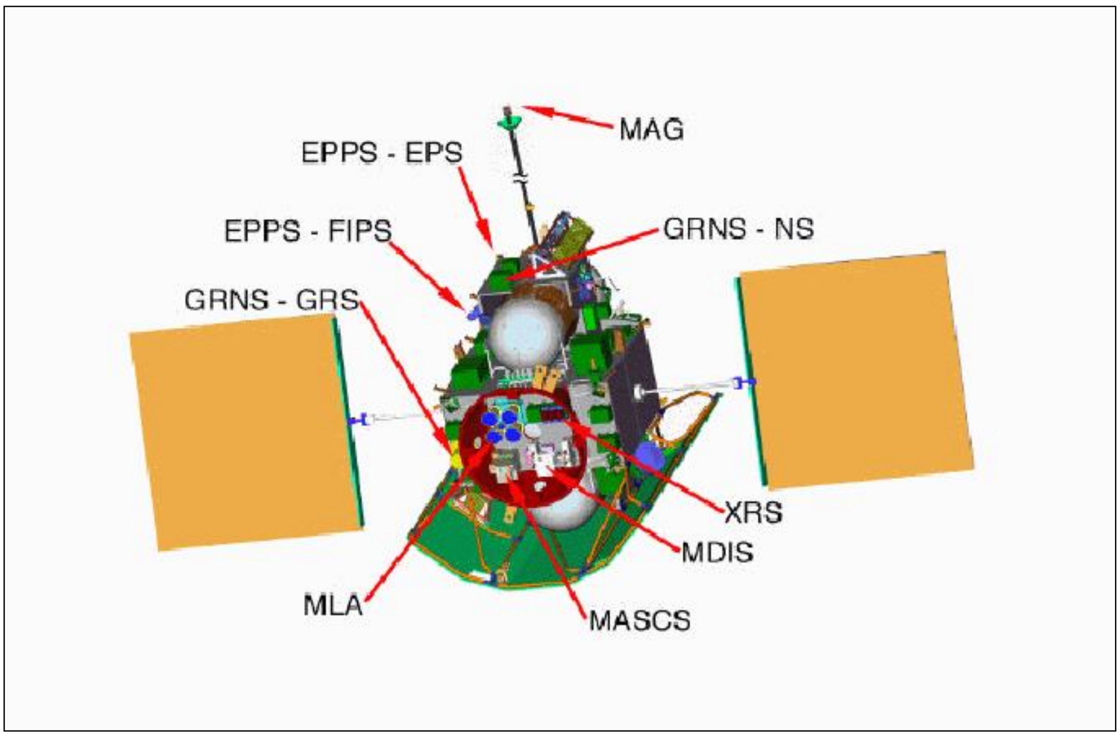
MESSENGER:

Software Interface Specification for the Calibrated Data Records of the Energetic Particle and Plasma Spectrometer

Version 10



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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.

George Ho, MESSENGER EPPS Instrument Scientist, has reviewed and approved this document.

Jim Raines, MESSENGER FIPS Instrument Scientist, has reviewed and approved this document.

Steve Joy, PDS PPI Node Representative, has reviewed and approved this document.

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

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Table 1 Revision History

Version	thor	Date	Description	ctions
1A	L. Nguyen	7/1/2009	Initial revision	All
1B	L. Nguyen	12/3/2009	Addresses issues from first PDS review. Document changes for FSW7.	2, 3, 5, 6, 8
			Add to description of EPS collimator	5.1.2.3
			Document EPS data product changes	5.2.1, inc. table 2
			Add and update sample labels	5.3.4
			Add S/C event time format	5.4.2
			Update PDS archive directory structures	6.7, 6.8
			Add section for FIPS efficiency ancillary data	8.14
1C	L. Nguyen	1/6/2010	Minor changes after PDS re-review	various
1D	M. Reid	1/7/2010	Minor additions of missing files	6.7, 6.8
1E	J. Raines	1/18/2010	Add explanation of unexpected features in EPS data due to TOF issues and negative values in SCAN mode data	.1.1
			Add explanation of criteria for PHA event processing	.1.2
			Change “flux” to “differential intensity” and “velocity” to “normalized velocity”.	5, 8, tables 15-18
			Add description of S/C blocking of FIPS FOV	.2.1

			Add to description of PHA data velocity distribution.	.2.3
			Remove 5.3.4.1.4 FIPS Efficiency Table PDS Label and format table	5.3.4.1.4, 8.15
1F	M. Reid	;/2010	Updated name on signature page; regenerated TOC.	
1G	S. Ensor	6/16/2011	Replaced signature page with document review info.	
1H	S. Ensor	:6/2012	Change [2] from *Data Management and Science Analysis Plan* to *Data Management and Archiving Plan*.	
1I	M. Reid	7/15/2014	Added descriptions of the FIPS Field Of View ancillary/calibration products. Updated document volume directory structure description.	5.2.2.4, 5.3.4.14, 6.5, 6.7, 8.14
1J	M. Reid	7/22/2014	Minor mods to FIPA_F*.LBL example. Included the INDEX directory in the documentation volume description.	5.3.4.14. 6.7
1K	S. Ensor	12/7/2015	Final edits reflecting end of mission; remove TBD items table.	All
1L	J. Raines, S. Ensor	12/10/2015	Additional final edits	All
1M	J. Raines, M. Reid, M. Gannon	12/22/2015	Changed “differential intensity” to “differential flux” to match format files and more closely match common usage. Document formatting.	All
1N	S. Ensor	1/16/2016	Additional minor final edits	All
1O	G. Ho M. Gannon	3/25/2016	Minor final edits	5.2.1.1

1 Purpose and Scope of Document

1.1 Purpose

This document serves to provide users of the MErcury Surface, Space ENvironment, GEochemistry, and Ranging (MESSENGER) Energetic Particle and Plasma Spectrometer (EPPS) data products with a detailed description of the EPPS instrument, data product generation, validation and storage. Note that the EPPS is made up of two instrument subsystems, the Fast Imaging Plasma Spectrometer (FIPS), and the Energetic Particle Spectrometer (EPS). The FIPS and EPS are described in individual sections within this document. They are referred to separately when necessary and referred to as the EPPS instrument when dealing with areas common to both instruments. The FIPS covers the lower energy range and measures the mass per charge (M/Q), energy per charge (E/Q) and incoming direction of each ion. The EPS covers the higher energy range and measures mass, energy, and incoming direction of each particle. The MESSENGER EPPS data products are deliverables to the Planetary Data System (PDS) and the scientific community that it supports. All data formats are based on the PDS standard.

1.2 Scope

The EPPS science data are divided into two categories: Level 2 edited-raw data (referred to as Experiment Data Records or EDRs) and processed data (referred to as reduced data records or RDRs). RDRs are generated from EDRs, and represent data calibrated to a physical unit such as particle intensity (Level 3), resampled Level 4 data products, or derived Level 5 data products. RDRs consist of Calibrated Data Records (CDRs), Derived Data Products (DDP) and Derived Analysis Products (DAP). This SIS describes the EPPS CDR data products.

CDRs consist of processed spectra and pulse-height analysis (PHA) data, including a description of the observation geometry. The CDR data are delivered to the PDS as CODMAC Level 3 data. EPPS's CDR is formatted to include standard PDS labels. A detailed description of all data products in the EPPS's CDR follows.

In addition this SIS describes the EPPS documentation volume, which contains products related to both the EDR and RDR level archives. The contents of the documentation volume enable one to conduct useful analysis of the CDRs. The documentation volume is described in greater detail in section 6.6.

2 Applicable Documents

The MESSENGER EPPS SIS is responsive to the following Documents:

1. Planetary Data System Standards Reference, Feb 27, 2009, Version 3.8. JPL D-7669, Part-2.
2. MESSENGER Data Management and Archiving Plan. The Johns Hopkins University, APL. Document ID number 7384-9019
3. MESSENGER Project Archive Generation, Validation, and Distribution Plan
4. MESSENGER Mercury: Surface, Space Environment, Geochemistry, Ranging; A mission to Orbit and Explore the Planet Mercury, Concept Study, March 1999. Document ID number FG632/ 99-0479
5. [PLR] Appendix 7 to the discovery program Plan; Program Level Requirement for the MESSENGER Discovery project; June 20, 2001.

The following documents may be referenced for details on the EPPS instruments and methods:

6. Livi et al. (The energetic particle spectrometer (EPS) on MESSENGER: Instrument description, characterization, and calibration, MESSENGER Project report, 2004)
7. Zurbuchen et al. (The Fast Ion Plasma Spectrometer (FIPS) calibration report, MESSENGER Project report, 2004)
8. Andrews et al. (The Energetic Particle and Plasma Spectrometer Instrument on the MESSENGER Spacecraft, Space Science Reviews Volume 131, Numbers 1-4, August 2007)
9. Raines et al. (Distribution and compositional variations of plasma ions in Mercury's space environment: The first three Mercury years of MESSENGER observations, *J. Geophys. Res. Space Physics, 118*, 1604–1619, doi:10.1029/2012JA018073, 2013.)

3 Relationships with Other Interfaces

The EPPS CDR data products were stored at the Science Operations Center (SOC) during the MESSENGER mission and transferred to the PDS Planetary Plasma Interactions (PPI) Node according to the delivery schedule in [2]. The data in the CDR files are stored in PDS ASCII TABLE objects unless stated otherwise (section 5.2).

Due to changes in the EPPS instrument flight software, the EPS and FIPS CDR data products contain both pre- and post- flight software change formats. The flight software (FSW) changes affecting EPPS are version 5 (FSW5), version 6 (FSW6), and version 7 (FSW7). FSW5 was uploaded on 9/6/2007, and FSW6 was uploaded on 8/18/2008 and implemented a day later. FSW7 was uploaded on 8/18/2009. The following sections detail the effects of the flight software changes on the CDR data products.

4 Roles and Responsibilities

The roles and responsibilities of the instrument teams, Applied Physics Lab (APL), Applied Coherent Technology (ACT), and the Planetary Data System (PDS) are discussed in sections 5.3.2 and 5.3.3.

5 Data Product Characteristics and Environment

5.1 Instrument Overview

The EPPS system encompasses two instrument subsystems – the Energetic Particle Spectrometer (EPS) and the Fast Imaging Plasma Spectrometer (FIPS). EPS covers the energy range of 25 to >500 keV for electrons, and 10 keV/nucleon to ~3 MeV total energy for ions. FIPS covers the energy/charge range of <50 eV/q to 13 keV/q. The Johns Hopkins University/Applied Physics Laboratory constructed the EPS instrument. It provides electron, high and low-energy ion as well as diagnostic events as a single stream of data that is placed into the EPS event FIFO (First In, First out) for processing by the EPPS flight software. The FIPS instrument was constructed by the University of Michigan Space Physics Research Laboratory. It provides a single serial stream of event data to the EPPS system at rates of up to 50K events/sec. The desired throughput for FIPS charged particle event processing as well as for EPS event processing is 5 kHz. FIPS generates a single 48-bit raw event packet format which includes a 1-bit header that identifies the event as a proton event or a non-proton event; an 11-bit time-of-flight (TOF) value; as well as a Wedge, Strip and ZigZag values (each 12 bits in size). In addition, the FIPS system generates counter and housekeeping information that the EPPS software can access via the Inter-Integrated Circuit (I2C) bus interface. Detailed descriptions of the EPS and FIPS sensor can be found, respectively, in Livi et al. (The energetic particle spectrometer (EPS) on MESSENGER: Instrument description, characterization, and calibration, MESSENGER Project report, 2004) and Zurbuchen et al. (The Fast Ion Plasma Spectrometer (FIPS) calibration report, MESSENGER Project report, 2004).

5.1.1 FIPS Overview

The Fast Imaging Plasma Spectrometer (FIPS) sensor measures the energy per charge (E/q), time-of-flight (TOF) and incident angles for plasma ions entering the sensor. Intensities, velocity distributions and mass per charge (m/q) distributions are derived from these measurements and make up FIPS primary science data. These data are used to understand the kinetic properties, angular distributions and composition of Mercury magnetospheric ions as well as contribute to the characterization of the planetary magnetic field.

Ions measured by FIPS pass through an electrostatic analyzer (ESA), located at the entrance to the sensor, a post acceleration chamber between the output of the ESA and the carbon foil, and a time-of-flight telescope. The ESA at the entrance to FIPS acts as a wide-angle lens for ions, with an effective 1.15 sr field of view. It only allows ions with a specific E/q band to enter through its output plane. This band is stepped through 64 values to complete one measurement cycle (scan), nominally from 0.046-13.3 keV/e. FIPS is normally operated in one of two stepping rates, once step per second (normal mode) or one step per 100 milliseconds (burst mode). When delays due to high voltage ramp-ups are included, these result in cycle times of 64 sec and 8 sec, respectively. The operation of FIPS is highly configurable via table upload. The time spent in each step can, in principal, be set to arbitrary values, different for each step. Associated with each E/q step is a deflection voltage setting, a threshold, a settling time, and an integration (dwell) time.

Ions exit the output plane of the ESA and are then accelerated in the post acceleration chamber. This acceleration is done to give low energy ions sufficient energy to penetrate the carbon foil. The acceleration also helps to reduce energy straggling and angular scattering – effects that cause degradation in mass resolution and imaging. When ions exit the carbon foil, secondary electrons are liberated. These electrons travel to the Start MCP (microchannel plate), providing a timing-start signal and incident angle information via impact location on a position-sensing anode. The ion then travels through the TOF chamber and strikes the Stop MCP, providing a timing-stop signal and allowing computation of TOF. From E/q and TOF, m/q can be computed. FIPS can measure species from H to Fe, 1-60 amu/e (or higher).

Details of FIPS operations can be found in [8].

5.1.2 EPS Overview

EPS is a compact TOF telescope with two main components: a TOF section and a Solid State Detectors (SSD) array. The SSD comprises six ion implanted planar silicon detectors, each with four pixel, two dedicated to ion measurements and two to electron measurements; for a total of 24 SSD elements. Particles enter the system through a mechanical collimator that delimits the look direction into the instrument. Particles that pass through the collimator will then transit through a thin composite Start foil (Polyimide + Aluminum, 10 $\mu g/cm^2$) and onto the TOF region of the instrument.

Electrons are released from the inner surface of the Start foil and focused to a well-defined region on a microchannel plate (MCP) to generate the START signal in a dedicated anode. The incident ions are not significantly affected by the electric fields of the focusing optics. After 6 cm flight path, ions traverse the Stop foil, which is a Polyimide + Palladium (19 $\mu g/cm^2$) composite foil. The secondary electrons released by the stop foil are steered to the MCP and generate the STOP signal. Electron trajectory simulations show that there is less then 2 ns dispersion in the transit time of the secondary electron from the foil to the MCP. Sub-nanosecond dispersion is required so as not to misidentify ion species. If we get both a START and STOP signal (double coincidence), then we can obtain the time, t, for the particle to travel a known distance (d=6 cm). For triple coincidence we must have the START, STOP and energy measured (E_{meas}) by the SSDs. Using these measured parameters, we can calculate the mass (M), and the incident energy (E) of each ion using the following equations:

$$E_{true} = E_{meas} / \gamma$$

$$E_{ToF} = \beta E_{true}$$

$$M = 2(T/d)^2 E_{ToF} = 2(t/d)^2 (\beta E_{meas} / \gamma)$$

E_{meas} takes into account the small energy loss of the ions passing through the front, start and stop foils, and γ is a number less than one that takes into account the energy loss and pulse height defect in the SSDs. E_{ToF} takes into account the even smaller energy loss or gain (β) in the front and start foils, and may also include up to ~2.5 keV electrostatic pre-acceleration of ions that remain charged on exiting the "front" foil. If the energy of the incident particle is not large enough to trigger the SSD such that only t is measured, then the pulse height of the start anode will be used to discriminate whether it is a light (M~1 amu), or heavy (M > 1 amu) ion. At the same value of TOF, heavy ions have been shown to generate substantially more secondary electrons than do protons.

Besides composition measurements, the particle's angular direction can be determined. The pair of start and stop anodes provide the polar entrance angle of the incident particle. The polar angle of +80º to -80º is divided into six equal sectors (nominally 27º).

5.1.2.1 Electron measurements

Energetic electrons have higher penetration power than ions at the same energy. The SSDs dedicated to electron detection in EPS are covered by a thin layer (flashing) of 1μm of Aluminum. This dead layer stops protons with energy less then ~250 keV; on the other hand electrons lose less than 10 keV energy by the interaction with this dead layer. Electrons are identified in EPS by the presence of an energy signal. The TOF spectra collected in the adjacent SSD (without flashing) will be used during ground data analysis for checking and correcting for the proton contamination.

"Calibration" for a particle instrument like EPS means determining the following:

1. Transfer function from counts into flux (physical units)
2. Characteristic of "Rate-out" versus "Rate-in"
3. Response to low energy and high energy particle background
4. Response to visible and ultraviolet light
5. Response to high magnetic field

All these functions need to be characterized and the relevant parameters need to be determined before flight.

5.1.2.2 Transfer Function

Flux, differential intensity, and phase space density

The number of particles N that traverse an area A during a time t can be characterized by the flux F [1/cm2/s]

$$N = A * t * F$$

or by the intensity I [1/cm2/s/sr]

$$N = A * t * \int I \cos(\hat{u})\, d\Omega$$

where Ω is solid angle and û is angle to the area normal. Here, the geometric characteristics of the sensor determine the limits on the integration.

Often used is the quantity differential intensity f [1/cm2/s/sr/keV], defined as the number of particles with energy between E and E+ΔE that traverse the area A during the time t, where

$$N(E) = f(E) * A * t * \Delta\Omega * \Delta E$$

In three dimensions, with θ being the polar angle and φ the azimuthal angle of a polar reference system:

$$d3N(E,\theta,\varphi) = f(E, \theta, \varphi) * A \cos(\hat{u}) * t * dE \cos\theta\, d\theta\, d\varphi$$

Note that f(E, θ, φ) is related to the phase-space density psd (number of particles in the configuration space element d3R and with velocity between v and v+ d3v) by the simple relationship in the non-relativistic limit (valid for ions measured by EPS but not for the higher energy electrons):

$$psd(s3/ cm6)=f(1/cm2/s/sr/keV) * m/v2$$

For relativistic particles, one generally utilizes momentum space rather than velocity space, and the corresponding expression is:

$$psd(s3/gm.cm6) = f(1/cm2/s/sr/keV) / p2$$

Where “p” is momentum.

Definition of sensor transfer function and geometric factor

The number of counts N of particles of mass m, in the energy band around mean energy E, angular band $\Delta\theta$ around mean polar direction θ, and angular band $\Delta\varphi$ around the mean azimuthal direction φ, measured by the instrument during the time δt can be expressed as:

$$N(E, \theta, \varphi; m) = \delta t * \int\Delta E \int\Delta\theta \int\Delta\varphi \quad f(E, \theta, \varphi; m) * A \cos(\hat{u}) * dE \cos\theta \, d\theta \, d\varphi$$

If $f(E, \theta, \varphi)$ is a Dirac δ function (monoenergetic, infinitely narrow beam), then

$$N(E, \theta, \varphi; m) = \delta t * f(E, \theta, \varphi; m) * G(E, \theta, \varphi; m)$$

Where $G(E, \theta, \varphi; m)$ [cm2 sr keV] is the transfer function of the instrument.

In the other limit, when the flux is completely isotropic (all directions the same)

$$N(E; m) = \delta t * f(E; m) * GF(E; m)$$

GF is called geometric factor and represents a measure of the efficiency of the system (count rate/flux), and typically is a function of energy and species.

The goal of the calibration is to characterize the function G(E, θ, φ; m), so that from measurements of the count rates it is possible to constrain f(E, θ, φ; m). Note that an exact inversion of the integral is rarely possible, and we can compute only the coefficients of some tailored expansion of f(E, θ, φ; m), such as in spherical harmonics (Legendre polynomials). The accuracy of these coefficients depends on both the raster coverage of the measurements and on the calibration.

5.1.2.3 Collimator

The EPS collimator consists of four concentric half circular plates that have holes aligned with a common point of origin at the center of the EPS TOF telescope. The size and number of collimator holes define the geometric factor GF of the instrument. The many-holes collimator design minimizes the scattering of ions and electrons at the collimator while restricting the field-of-view (FOV) of the instrument.

GEANT4 simulation shows that the geometry factor for the total SSD area to be 0.016 cm2 sr. The simulation accounted for gaps between the detectors, but did not allow for the guard ring dead area between the large and small pixels or the losses in the two grids used to mount the thin foils. Hence, before grid losses, the total large pixel geometry factor is therefore GFSSD = 0.0152 cm2 sr, and the small pixels would be 0.0008 cm2 sr. The grid losses are actual blockages, so these should be included in the geometry factor. EPS used 40-lines-per-inch grids on the foils that are 86% transmissive. Therefore, for the 12 large pixels, we have a total geometry factor of 0.862x0.0152, or 0.011 cm2 sr, and each large pixel will be 1/12 of that, or GFSSD-Large = 0.001 cm2 sr. For the 12 small pixels, we have a total geometry factor of 5.6x10-4 cm2 sr, or GFSSD-Small = 4.7x10-5 cm2 sr per pixel. The current simulation does not model the scattering of low energy ion and electron in the collimator; hence the current value of GFSSD is constant with energy and look direction. The instrument team may revise the value of GFSSD at a later time when we develop a further understanding of the instrument response as a function of direction, energy and species.

GFTOF for the Low Energy Ions (TOF-only) is roughly twice the SSD values, or ~0.03 cm2 sr. Note that the needed Transfer Factor G depends also on the counting efficiency εkj which depends, in turn, on species and instrument mode. However, these values were never conclusively determined. During the time of instrument check out shortly after launch, EPS's TOF section suffered a failure; subsequently, EPS lost its ability to measure ions by elemental mass species. All in-flight EPS data contains null TOF values, hence, EPS can now only measure

$$N(E) = \delta t * f(E) * GFSSD$$

GFSSD is now the geometric factor and represents a measure of the efficiency of the system (count rate/flux), and is constant with look direction, energy and species. This is the standard approximate conversion of count rate to intensity assuming the channel efficiency is part of the geometry factor. The shape of the energy spectrum will also affect the response.

5.2 Data Product Overview

The CDR data products generated by the EPS and FIPS subsystems are described in this section. For all of the CDR products there is a detached PDS label file which describes the contents of one data file. Each label file has the same base name as the data file it is describing, with the extension ".LBL" to denote a label file. The label file defines the start time and end of the observation, product creation time, and the structure of the ASCII tables. Each data file contains the data collected on a given earth day.

5.2.1 EPS Data Products

The EPS portion of the data archive consists of seven CDR data products, which are in direct correspondence to the EPS EDR products. However, the spectra and PHA data are converted to physical units instead of instrument engineering units. The EPS instrument creates all of its different science data packets during one observation, but the packets are telemetered to the ground at different times based on priority. The different formats of these data packets do not lend themselves to standardization into one CDR file format. For example, the high priority science data packet contains the EPS high priority spectra, housekeeping information, and PHA data. Therefore, different CDR formats were developed, each of which captures one specific data grouping – spectra, housekeeping information, or PHA data. A given CDR data file contains all the observations obtained on the same earth day. Table 2 shows the different EPS data products and their files. Each data product is identified within the PDS label by a STANDARD_DATA_PRODUCT_ID value (shown in parentheses).

The table reflects an instrument flight software (FSW) version 6 upload on 8/18/2008, henceforth known as the FSW6 upload. The purpose of the software change was to consolidate and improve instrument telemetry allocation on EPS. During the time of instrument check out shortly after launch, EPS's time-of-flight section suffered a failure; subsequently, EPS lost its ability to measure ions by elemental mass species (can only now measure ions and electrons). Hence a change of FSW is required to improve EPS's ion and electron data products. This software upload changed the packet formatting such that two EPS CDRs (High Priority Spectra and Medium Priority Spectra) that are available only before the FSW change are replaced by two newer CDRs (High Resolution Spectra and Low Resolution Spectra), available after the FSW change. Two additional CDRs had to be created to store data from two new instrument packets (Summary Spectra and Scan). Finally, the EPS PHA CDR contains some data that is available only before the FSW change, and other data that is available only after the FSW change. The EPS PHA CDR format file column descriptions contain details on data availability. The new flight software code was uploaded on 8/18/2008 and implemented on 8/19/2008. Thus, data on or after 8/19/2008 is generated from FSW6.

Table 2 EPS Data Products

Data Product	Product Description
High Priority EPS Spectra (EPS_HI_SPECTRA) CDR available only before FSW6 (8/18/2008)	• Spectra Data – contains spectral data, hardware and software rate counters in ASCII table format. Data and counter values are taken from the High Priority (order that they download to ground) Science Packet
Medium Priority EPS Spectra (EPS_MED_SPECTRA) CDR available only before FSW6 (8/18/2008)	• Spectra data – contains spectral data, hardware and software rate counters in ASCII table format. Data and counter values are taken from the Medium Priority (order that they download to ground) Science Packet.
EPS Pulse Height (EPS_PULSE_HEIGHT) CDR format change by FSW6 on 8/18/2008	• PHA Data – contains Pulse Height Analysis data in ASCII table format. The PHA data product is generated from the high, medium, or low priority science packet. The priority level is identified within the PDS label. • As of 8/18/2008 the PHA data product is generated from PHA data packets. There is no priority level associated with the PHA CDR since the high, medium, and low priority packets were retired on 8/18/2008.
EPS High Resolution Spectra (EPS_HIRES_SPECTRA) CDR available only after FSW6 (8/18/2008), replaces EPS_HI_SPECTRA	• Data file – high-res (energy channels) ion and electron energy spectra
EPS Low Resolution Spectra (EPS_LORES_SPECTRA) CDR available only after	• Data file – lo-res (energy channels) ion and electron energy spectra and rate counters.

Data Product	Product Description
FSW6 (8/18/2008), replaces EPS_MED_SPECTRA	
EPS Summary Spectra (EPS_SUMMARY_SPECTRA) CDR available only after FSW6 (8/18/2008)	• PDS label file – describes the data product and contains pointers to the data file: • Data file – Contains a subset of rate counters and low resolution energy spectra
EPS Scan (EPS_SCAN_RATES) CDR available only after FSW6 (8/18/2008)	• PDS label file – describes the data product and contains pointers to the data file: • Data file – Contains the integrated hardware counters over four energy thresholds. Each threshold setting and integration lasts ¼ second.

An EPS data quality flag represents the daily status of the scientific quality of the EPS data. When EPS is configured to take nominal science data for that entire day of operation, the flag is set to 0. On the contrary, when EPS is not properly configured to take nominal science data (i.e. initial turn-on, thresholds are not set, etc) during anytime in that particular day, the data quality flag is set to 1. When that happens, users of the EPS data are advised to contact the EPS team for further explanation of the available data during that day. The data quality is specified in the NOTE section of the PDS label for a given data file.

A value of -1.0e-38 in any ASCII Real field means that value is invalid (or not applicable).

5.2.1.1 Spectra Data

The EPS Spectra Data are reported as a differential flux which is treated as constant over the energy range of the given spectral channel. The physical units are thus particles/cm^2-sr-s-keV. The conversion from counts/s to physical unit utilize the various GF_{SSD} given in the prior section. We assume that the geometric factor is constant with energy; we understand the shape of the energy spectrum affects the validity of this assumption. The instrument team routinely conducted in-flight calibration for the GF_{SSD} values, and released the updated values as appropriate in different mission phases. Details can be found in the calibration procedure document, EPPS_EDR2CDR.DOC, in the EPPS documentation volume. Note that this in-flight calibration was done using the science data, EPS does not have dedicated calibration files. The statistical uncertainty of the spectra data is given in the RDR. However, the current uncertainty does not include the uncertainty in the particle flux (~20% for electron, 50% for ion). The spectra are reported within 4 different classes of channels: high-resolution/low-resolution electron channels, and high-resolution/low-resolution ion channels. The channels are defined in Table 3 -

Table 12. The information provided in these tables is given for each of 6 different view directions. Note that the exact boundaries given with either energies or times-of-flight are subject to change via ground commands. Table 3 - Table 12 list electron energy levels as recorded within the onboard sensors and electronics. The translations of those electronic levels to the energies of the incoming particles can be found in [6].

Table 3 EPS High and Medium Priority Spectra Ion Channels (Based on Energy). Valid until 2007-09-06T00:00:00.000.

Channel	E1 (keV)	E2 (keV)	Comments
0	0	80	
1	80	82	
2	82	87	
3	87	103	
4	103	156	
5	156	330	
6	330	897	
7	897	2750	

Table 4 EPS High and Medium Priority Spectra Electron Channels (Based on Energy). Valid until 2007-09-06T00:00:00.000.

Channel	E1 (keV)	E2 (keV)	Comments
0	0	29	
1	29	30	
2	30	32	
3	32	37	
4	37	57	

Channel	E1 (keV)	E2 (keV)	Comments
5	57	120	
6	120	326	
7	326	1000	

Table 5 EPS High and Medium Priority Spectra Ion Channels (Based on Energy). Valid between 2007-09-06T00:00:00.000 and 2008-08-19T00:00:00.000.

Channel	E1 (keV)	E2 (keV)	Comments
0	threshold	55	
1	55	100	
2	100	177	
3	177	316	
4	316	562	
5	567	1000	
6	1000	1778	
7	1778	2750	

Table 6 EPS High and Medium Priority Spectra Electron Channels (Based on Energy). Valid between 2007-09-06T00:00:00.000 and 2008-08-19T00:00:00.000.

Channel	E1 (keV)	E2 (keV)	Comments
0	threshold	20	
1	20	36	
2	36	65	
3	65	115	

Channel	E1 (keV)	E2 (keV)	Comments
4	115	204	
5	204	244	
6	244	434	
7	434	1000	

Table 7 EPS High-resolution Ion Channels (Based on Energy). Valid after 2008-08-19T00:00:00.000.

Channel	E1 (keV)	E2 (keV)	Comments
0	threshold	17	
1	17	20	
2	20	23	
3	23	27	
4	27	31	
5	31	36	
6	36	42	
7	42	49	
8	49	57	
9	57	66	
10	66	77	
11	77	89	
12	89	104	
13	104	120	
14	120	140	

Channel	E1 (keV)	E2 (keV)	Comments
15	140	162	
16	162	188	
17	188	219	
18	219	254	
19	254	295	
20	295	343	
21	343	398	
22	398	462	
23	462	537	
24	537	624	
25	624	724	
26	724	841	
27	841	977	
28	977	1135	
29	1135	1318	
30	1318	1531	
31	1531	1778	
32	1778	2065	
33	2065	2399	
34	2399	2750	
35	2750	5000	Overflow

Table 8 EPS High-resolution Electron Channels (Based on Energy). Valid after 2008-08-19T00:00:00.000.

Channel	E1 (keV)	E2 (keV)	Comments
0	threshold	18	
1	18	20	
2	20	25	
3	25	28	
4	28	32	
5	32	35	
6	35	40	
7	40	45	
8	45	50	
9	50	56	
10	56	63	
11	63	71	
12	71	79	
13	79	89	
14	89	100	
15	100	112	
16	112	126	
17	126	141	
18	141	158	
19	158	178	
20	178	200	
21	200	224	
22	224	251	

Channel	E1 (keV)	E2 (keV)	Comments
23	251	282	
24	282	316	
25	316	355	
26	355	398	
27	398	447	
28	447	501	
29	501	562	
30	562	631	
31	631	708	
32	708	794	
33	794	891	
34	891	1000	
35	1000	5000	Overflow

Table 9 EPS Low-resolution and Summary Spectra Ion Channels (Based on Energy). Valid after 2008-08-19T00:00:00.000.

Channel	E1 (keV)	E2 (keV)	Comments
0	threshold	20	
1	20	27	
2	27	36	
3	36	57	
4	57	89	
5	89	140	

Channel	E1 (keV)	E2 (keV)	Comments
6	140	343	
7	343	537	
8	537	841	
9	841	2065	
10	2065	2750	
11	2750	5000	Overflow

Table 10 EPS Low-resolution and Summary Spectra Electron Channels (Based on Energy). Valid after 2008-08-19T00:00:00.000.

Channel	E1 (keV)	E2 (keV)	Comments
0	threshold	20	
1	20	28	
2	28	35	
3	35	56	
4	56	71	
5	71	112	
6	112	141	
7	141	224	
8	224	447	
9	447	708	
10	708	1000	
11	1000	5000	Overflow

Table 11 EPS Scan Thresholds (keV) Fast Counts

Detector	Offset A Threshold	Offset B Threshold	Offset C Threshold	Offset D Threshold
0	1.221	2.442	3.663	4.884
1	-1.221	0	1.221	2.442
2	1.221	2.442	3.663	4.884
3	-1.221	0	1.221	2.442
4	1.221	2.442	3.663	4.884
5	-1.221	0	1.221	2.442
6	42.735	43.956	45.177	46.398
7	1.221	2.442	3.663	4.884
8	42.735	43.956	45.177	46.398
9	1.221	2.442	3.663	4.884
10	42.735	43.956	45.177	46.398
11	1.221	2.442	3.663	4.884

Table 12 EPS Scan Thresholds (keV) Shaped Counts

Detector	Offset A Threshold	Offset B Threshold	Offset C Threshold	Offset D Threshold
0	-0.977	0.977	2.93	4.884
1	-1.221	0	1.221	2.442
2	-0.977	0.977	2.93	4.884
3	-1.221	0	1.221	2.442
4	-0.977	0.977	2.93	4.884
5	-1.221	0	1.221	2.442
6	40.537	42.491	44.444	46.398

Detector	Offset A Threshold	Offset B Threshold	Offset C Threshold	Offset D Threshold
7	1.221	2.442	3.663	4.884
8	40.537	42.491	44.444	46.398
9	1.221	2.442	3.663	4.884
10	40.537	42.491	44.444	46.398
11	1.221	2.442	3.663	4.884

The element that is not represented in Table 3 - Table 12 is directionality. The nominal total field-of-view (FOV) of EPS is 160° x 12°. Because the electron and ion SSDs are side-by-side, the total electron or high energy ion FOV in the long dimension is about 1/12 smaller (~13° smaller) or about 147°. And, the centers of the ion and electron FOV's are shifted with respect to each other by ~13°. Let us define two angles within the MESSENGER spacecraft coordinate system: "alpha" is the angle from the +Y(s/c) axis and within the Y(s/c)-Z(s/c) plane (with "plus" angles viewing towards the +Z(s/c) axis); "beta" is the angle for rotations away from the Y(s/c)-Z(s/c) plane. With these definitions, the total FOV of EPS is roughly: (-80° < alpha < +80°) and (-6° < beta < +6°). The ion FOV is (-67° < alpha < +80°) and (-6° < beta < +6°). The electron FOV is (-80° < alpha < +67°) and (-6° < beta < +6°). For low energy ions (where the directionality is determined by microchannel plate anodes and not solid state detectors), the field-of-view is : (-80° < alpha < +80°) and (-6° < beta < +6°).

The direction within the ~160 degree field of view is determined for high-energy ions and for electrons with the determination of which SSD was active. With the high-energy ion and electron segments, there are a total of 12 SSD elements active at any one time. The numbering scheme for these detector elements ranges between 0 and 11, with the even SSD elements corresponding to electrons and the odd SSD elements corresponding to ions. The "0" detector (an electron detector) is the one that looks most closely aligned with the –Z(s/c) axis, while the "11" detector looks most closely to the +Z(s/c) axis. In the data that is telemetered to the ground, the directionality of the electrons and ions is represented with a number between 0 and 5. For electrons the directions (0, 1, 2, 3, 4, 5) correspond to SSDs (0, 2, 4, 6, 8, 10). For high-energy ions the directions (0, 1, 2, 3, 4, 5) correspond to SSDs (1, 3, 5, 7, 9, 11).

There is a confusing element in the representation of the directionality of low energy ions (time-of-flight only). The directionality is now determined not with the SSDs but with the microchannel plate anodes. The numbering of the TOF Start-Anodes ranges between 0 and 5. An ion or electron that passes right over Start-Anode "0" (only the ion "stimulates" this start anode) strikes either SSD 10 or SSD 11. Thus, the Start-Anodes 5, 4, 3, 2, 1, and 0 map to SSD's (0, 1), (2, 3), (4, 5), (6, 7), (8, 9), and (10, 11), respectively. The confusing element is that the Low Energy Ion direction “5” (representing the firing of anode “5”) corresponds roughly (not exactly) to the High Energy Ion direction “0”, and the Low Energy Ion direction “0” corresponds to the High Energy Ion direction “5”. This confusing element exists for historical reasons, and because this representation is how the directionalities are indicated on board the instrument, we believed that even more confusion would be introduced if we made a change within the data generated on the ground.

In FSW6, the high-resolution spectral EDR products are integrated for T*N1 seconds, where both T and N1 are commandable parameters. They are sent to the spacecraft as a high priority packet. The low-resolution spectral EDR products contain low energy-resolution spectra as well as rate data. These packets are integrated for T and T*N1 seconds. The high-time resolution (T) packets are sent as a medium priority data product, while the lower time-resolution (T*N1) packets are called Summary Packet and are sent as high priority data, The Summary packet serves as redundant data and also provides a quick-look capability, they can be enabled or disabled by command.

New in the FSW6 is the Scan data. In scan mode, EPS varies the electronic energy thresholds (discriminators) integrating hardware rates (Fast and Shaped) at each threshold setting (defined in Table 3 - Table 12). Each of the six electronics signal processing chains consists of an Amptek charge amplifier followed by a DC-coupled unipolar shaping amplifier. The shaping time is 2.4 μs. Each shaping chain has a dedicated high-speed ADC. A settable discriminator detects the output level of the first stage of a shaping chain, which is the pole-zero compensation stage. This discriminator is called the “Fast” discriminator because the rise time of the first stage pulse is very fast and occurs within 30 ns of the particle entering the SSD. Another settable discriminator is called the “shaped” discriminator because it senses the level of the Gaussian-shaped energy pulse. The thresholds are changed three times, then the base thresholds are restored in each scan. A scan is defined as four threshold settings: three offsets and one nominal. At each threshold step, a subset of the hardware rate counters are accumulated for ¼ second. The Scan mode gives EPS the ability to lower its electronics threshold by temporary suspending the processor operation.

In addition to the rates described above, we also include particle detection error counting rates (e.g. PILEUP_E_DISCARD_RATE, REJECTED_E_RATE), which are described more fully in the EPPS EDR SIS document.

It is worth explaining here some unexpected features of the data:

- As described in section **Error! Reference source not found.**, the Time of Flight segment of the instrument ceased to operate in April 2005. Since early observations were made in a mode where a particle “detection” required a time of flight signal, rates and fluxes for all ION and Electron channels are all zero in the early files. Only FAST and SHAPED rates are nonzero. In later (but still pre-FSW6) measurements, the instrument was run in diagnostic mode so energy channel rates are available. The FSW6 upload allowed for an even more effective usage of the surviving (SSD) detectors.

- The “Delta” values in SCAN mode data are often negative. "Delta" values are an attempt to generate bounded passband-like data, but since this involves subtracting successive measurement intervals from each other, low count rate statistics frequently produce negative values.

5.2.1.2 Pulse Height Analysis (PHA) Event Data

PHA events are stored by the EPPS flight software in either the EPS High, Medium, or Low priority Science packet, for data prior to FSW6. The following explains how PHA event data are collected for data prior to the FSW6 upload on 8/18/2008. PHA events are distributed among the packet buffers in round-robin fashion: the first detected event is stored in the high-priority packet buffer, the next event is stored in the medium-priority packet buffer, and the last event is stored in the low-priority packet buffer. Please note that there is no individual time tag per PHA event.

Each event allocated to a particular buffer is simply stored into the next slot within the buffer until the buffer fills up. Thereafter, a rotating priority PHA replacement scheme is used in deciding which events may be displaced from the filled buffer. The maximum number of PHA events saved per integration period for a particular packet is shown in the following table:

Table 13 Maximum PHA Events Saved

EPS Packet Type	Maximum number of PHA events saved during each accumulation interval
High Priority	10
Medium Priority	20
Low Priority	300

Note that a given EPS science packet (which may or may not contain PHA events) is time tagged with one MET (mission elapsed time) (not per PHA event). PHA events are accumulated within an integration period depending on the priority of the given science packet. Each PHA event is time tagged with the same MET associated with the science packet in which it was contained. Thus, there are a maximum of 10 High Priority events with the same MET, 20 Medium Priority events with the same MET or 300 Low Priority events with the same MET. A given PHA CDR data file contains the observations obtained on the same earth day and arranged in time order. Therefore a given PHA CDR data file contains a set of N PHA events with the same MET, followed by another set of PHA events with the same MET, etc.

The FSW6 upload created a PHA packet for the express purpose of downloading PHA events. The EPS collects data for T*N1 seconds (where T=integration time and N1 is the integration time multiplier). If the integration is aborted then N1 will be the actual value instead of the commanded value. Over the T*N1 integration time, EPS saves PHA data in the order that it is seen. Each PHA packet can record a maximum of 934 PHA events. The events in a single PHA packet are time tagged with one MET time.

FSW6 also retired the high, medium, and low priority packets and consequently the capture of PHA events within those packets. The only packet which contains EPS PHA events is the EPS PHA packet and is sent down as a medium priority packet; the file naming convention reflects that FSW6 PHA CDRs are no longer associated with a priority level.

Certain PHA events are excluded by default in standard instrument team analysis as they are of indeterminate analytical value:

- Events for which the multi-hit flag is set. (See EDR-SIS for more info).
- Events with a negative RAW Energy. For these events, the measured peak energy is less than the measured baseline energy. Presumably something (e.g. scattering off internal structures of the detector or some other non-ideal characteristic of the instrument system) has caused an incorrect measurement of the particle energy.
- Events with Maximum (= 4095) RAW Energy. This usually indicates something has gone wrong with the detection as well.

5.2.2 FIPS Data Products

The FIPS portion of the data archive consists of five CDR data products and two ancillary calibration products. These products generally map directly from EDR data products. However, the original digital units are changed into physical units and specifics of the measurement process are removed as feasible. Additional information is also provided for some products, to facilitate science analysis. This provides the most general version of FIPS data products during the entire MESSENGER mission. Each FIPS CDR data product consists of two files. The first file contains the data in ASCII table fixed format. The second file is a detached PDS label file, which describes the contents of the ASCII table file. The label file defines the start and end time of the observation, product creation time, the structure of the ASCII table and each of the columns within the table. In addition, ancillary data products are needed to fully interpret the CDR products, an energy per charge (E/q) stepping table and a pixel field of view table, described in section 5.2.2.4. There is also a PDS label file for the E/q table file.

At the root of FIPS data are the PHA (pulse-height analyzed) word, the full-capability measurements of single particle events. For each event, FIPS measures the TOF, E/q and location on the start MCP in the form of Wedge, Strip and Zigzag values from the position-sensing anode. The FIPS hardware also classifies the event as proton or heavy ion via an uploaded TOF threshold, different for each E/q step. Because it is not always possible to telemeter all of these PHA words to the ground, other data products are built up from the PHA words. This gives rise to three types of data products upon which FIPS CDR data are based:

Table 14 FIPS Data

Type	Description
Pulse Height Analyzed (PHA) event words	Individual ion event measurements of E/q, TOF and MCP location, along with additional information to allow nearly self-contained data analysis. PHA quantities are given in digital and physical units. Digital units are retained to simplify some data analysis, e.g. digital units provide natural binning for histograms. Time-of-flight is given in channels and nanoseconds. Energy per charge is given in deflection voltage step and keV/e. MCP location is given digital X-Y MCP position and incident zenith and azimuthal angles (degrees). Additional quantities to facilitate self-contained analysis are m/q (amu/e), type (binary, proton (1) or heavy (0)), weight (unitless). The weight represents a combination of instrument-related factors such as efficiency and angle dependence.
Differential flux spectra	Differential flux spectra are 1-D histograms of event differential flux at each E/q step, integrated over incident angle. Differential flux spectra are given in units of counts $(keV/e)^{-1}$ sec^{-1} cm^{-2}.
Velocity Distributions	Velocity distributions are 2-D histograms of event probability at each MCP X-Y location (incident solid angle), summed over E/q step. Normalized velocity distributions are given as unit-less probabilities. A value at a particular X-Y location is the probability of events at that location. Three specific velocity distribution function types are provided as available from the FIPS data stream:

	1) heavy ions (8x8) 2) proton (8x8) 3) high resolution proton (32x32).

5.2.2.1 Pulse Height Analysis (PHA) Event Data

To allow the PHA event data to function as a nearly stand-alone data product, several additional quantities are included in CDR PHA data.

Using a relation derived from calibration data, these MCP X-Y positions are mapped to incident zenith and azimuthal angles. The zenith angle is measured from the FIPS boresight vector (z axis in FIPS Cartesian), the cylindrical symmetry axis of FIPS electrostatic analyzer and given as an angle between 15 and 70 degrees. The azimuthal angle records the angle around this symmetry axis, beginning at the y axis in the FIPS Cartesian coordinate system, as defined in the MESSENGER SPICE Frames Kernel. After conversion to the FIPS Cartesian coordinate system, these angles can be transformed to other coordinate systems by using SPICE. The combination of spacecraft body and heat shield effectively block FIPS field-of-view (FOV) through approximately zenith angles [25,75] and azimuthal angles [270,10] (70 degrees). The solar array on the –X side of the spacecraft, also blocks FIPS FOV to a small and variable degree. Exact locations of blockages, as a function of time, can be extracted from the EPPS-specific SPICE kernel.

To facilitate ion identification, mass per charge (M/q, in AMU/e, where AMU is Atomic Mass Unit) for each PHA word is calculated as a function of E/q step and TOF, according to the following equation:

$$M/q = 2\,(k * U + |Va| - U_L) * TOF^2 / (d^2 * 1040\ \mathrm{ns}^2\ \mathrm{keV} / \mathrm{cm}^2\ \mathrm{amu})$$

where:

k = deflection system constant, approx 1.33

U= deflection system voltage, in kV

Va= post acceleration voltage, in kV

U_L = energy lost to carbon foil

TOF = the measured Time-of-flight, in ns

d = distance over which TOF is measured, in cm.

This equation includes only rudimentary effects of carbon foil energy loss and scattering. These tend to spread the calculated M/q values for each species. The energy lost to the carbon foil was modeled with the TRIMM software package [9], adjusted to match ground calibration data. As data were analyzed throughout the mission, the contribution of these effects was revised to reflect increased understanding of FIPS performance.

The weighting factor represents the weight that each PHA word should be given in analysis, and includes effects from several instrument performance parameters, such as energy and angle-dependent efficiencies. The detailed explanation of this parameter is beyond the scope of this document.

For a subset of these events, the flight software (FSW) performs calculations to reduce the number of bits required for each PHA word, from 53 bits to 28 bits. The least significant bit (LSB) of the TOF value is dropped, 11 to 10 bits. The three 12 bit Wedge (w), Strip (s), and Zigzag (z) values are converted to two 6 bit X and Y positions, using the calculations below (offsets are set by ground command):

w = w – wedge_offset

s = s – strip_offset

z = 14*(z – zigzag_offset)/10

sum = w + s + z

X = 128*(w + (w-z)/5)/sum

Y = 128*(s + (s-z)/5)/sum

There are slight changes to these equations for FSW7, which are detailed below.

5.2.2.2 Differential Flux Spectra

To provide high-level view of ion events, FIPS CDR data includes five one-dimensional differential flux spectra, each with 64 elements (Table 15). The first four differential intensities are based on counters retrieved from FIPS hardware while the fifth differential flux, Events Processed, is based on a software counter. Each of these is recorded at every E/q step to provide an E/q spectrum. Since the instrument can run in several modes with different E/q stepping sequences, care must be taken to match the proper sequence to the data. These inherently 24 bit rate counters are compressed using a 10 bit logarithmic compression code, 5 bits for mantissa and 5 bits for exponent (5/5 compression). While the rate counters have been decompressed as part of the conversion to CDR data, there is a loss in accuracy that remains from the compression. In most contexts these losses are very small and can be ignored in science analysis.

Note: The quantity “differential flux” is analogous to “differential intensity” described in the EPS section **Error! Reference source not found.** above. The term “differential flux” is commonly used in the literature of the thermal plasmas and pick-up ions that are measured by FIPS. It is for that reason that it is used here.

Table 15 Differential Flux Spectra

Data Item	**Description**
Start Differential flux	Differential flux of events which trigger a signal on the start MCP
Stop Differential flux	Differential flux of events which trigger a signal on the stop MCP
Valid Event Differential flux	Differential flux of events which trigger both a start and stop signal.
Proton Differential flux	Differential flux of valid events which are classified as protons by falling under TOF threshold for the E/q step in which they are collected.
Events Processed Differential flux	Differential flux of events which are processed by the FSW.

The Start and Stop differential intensities are not particularly suitable for science analysis. The Valid Event and Proton differential intensities provide a convenient overview of the data (per E/q step) when angular and TOF information is not needed. The heavy ion differential flux can be derived by taking the difference of these two differential intensities, Valid Event – Proton. The Events Processed differential flux can be used to show the fraction of events that have been registered in hardware but not processed in software (due to time limitations) by simply dividing Events Processed differential flux by Valid Event differential flux.

5.2.2.3 Velocity Distributions

FIPS is an imaging instrument that views a region of solid angle that has conical symmetry and is bounded by 2 nested cones, with half angles of ~15 and ~75 degrees. The field of view symmetry axis points in the direction of the following unit vector, (-0.74324, -0.383558, 0.548158), in spacecraft coordinates. Inside the TOF region of FIPS, this field of view is mapped onto a Cartesian X-Y coordinate system on the Start MCP, with binned elements up to a resolution of 64 x 64. Distributions of the X-Y positions for each PHA represent the distributions of the velocity directions of particle events and are stored as 2D arrays of probabilities in CDR data. Furthermore, the value at a given X-Y position represents the fraction of total proton events which fell in that X-Y bin for the scan in question. An estimate of the differential flux for this X-Y bin can be calculated by the product of this probability with the sum of the proton differential flux spectrum for the scan. The resolution of these 2D arrays with respect to the X-Y MCP coordinate system is described below. FIPS produced velocity distributions for protons and heavy ions (via selected M/q ranges) at a variety of angular resolutions. However, only the normalized proton velocity distributions are included in CDR data. Flyby data analysis showed that all heavy ion PHAs were transmitted to the ground with considerable margin. As such, heavy ion velocity distributions, produced at low angular resolution, were found to be inferior to distributions constructed on the ground.

5.2.2.4 Specific CDR Data Products

Due to changes in FSW and downlink capabilities, FIPS data products changed over the course of the mission. These changes, while greatly improving quality of the data, make the mapping of data types into particular CDR data products (i.e. files) a little more complicated. Specific FIPS data products at the CDR level are listed in Table 16.

Data products are time-tagged at the end of the accumulation interval. A given PHA CDR data file contains observations made on the same earth day and arranged in time order.

Table 16 FIPS CDR Data Products

Product	Description
PHA Event Words	Events collected in scans 1-10 of the 10 scan sequence. Sequence and Scan PHA words are 28 bit, while Raw PHA words are the full 53 bits. Maximum number of PHA words which can be stored per scan depends on source packet. Sequence, Scan and Raw packets can store 64, 128 and 617 PHA words, resp. See EPPS EDR SIS for packet details. This information is not required for most science data analysis.

	PHA words are time-tagged for the scan in which they were measured, so multiple PHA words have the same time tag.
High Priority Spectra	Differential flux spectra collected in scan 10 of the 10 scan sequence. Normalized proton velocity distribution (8x8) for scan 10 of the 10 scan sequence. These products were retired after July 7, 2009. Flight Software changes obviated the need for their continued production.
Medium Priority Spectra	Differential flux spectra collected in scans 1-9 of the 10 scan sequence. Normalized proton velocity distribution (8x8) for scans 1-9 of the 10 scan sequence. These products were retired after August 18, 2008. Flight Software changes obviated the need for their continued production.
Scan Spectra	Differential flux spectra collected in scans 1-9 of the 10 scan sequence.
High Resolution Normalized Proton Velocity Distributions	High resolution normalized proton velocity distribution (32x32) for scans 1-10 of the 10 scan sequence. These products were retired after July 7, 2009. Flight Software changes obviated the need for their continued production.

Energy per charge stepping tables (FIPA_E*) and pixel field of view (FIPA_F*) tables are included as an ancillary data product in the CALIBRATION directory of the archive document volume. The Energy per charge stepping files contain the E/q value in keV/e as a function of E/q step number for each of the 8 stepping tables loaded into the instrument. The stepping table used at a particular time is given by the FIPS_SCANTYPE variable in the CDR data. The Pixel Field of View files contain lists of the pixels in the FIPS FOV.

Data quality is assessed in a very simple manner: If FIPS was on in a nominal configuration, the data are marked as good. To minimize the amount of data affected, data quality is reported on a record by record basis.

5.2.2.5 Impact of Flight Software Changes on CDR Data

As flight data were returned from FIPS, bugs in data processing were discovered and areas for improvement of data products identified. The largest motivation for change was the substantial increase in allowed data volume. This came as the mission operations team increased downlink rates and reduced margins from pre-launch predictions, as knowledge of actual system throughput was gained from actual usage in space. The following table summarizes the impacts of these changes on CDR data.

Table 17 Impact of FSW Changes on CDR Data

FSW	Upload Date	Impact of change on CDR data
FSW4[1]	(pre-launch)	n/a
FSW5	06 Sep 2007	Fixed bugs in PHA X-Y calculation which caused overflow values to be mapped into valid range. Added PHA buffer to provide even distribution of PHA words across E/q step. Added Stop differential flux for every step of every scan.
FSW6	18 Aug 2008	Added high-resolution normalized proton velocity distributions (32x32) because flyby data showed that 8x8 resolution was insufficient. PHA X-Y calculation changed to maximize coverage this data product.
FSW7	18 Aug 2009	Simplified data processing to PHAs and differential flux spectra only. Proton events now included as 28 bit PHA event words and decimated according to commanded limits. Heavy ions only transmitted as 53 bit PHA event words and no longer buffered. Velocity distributions eliminated.

Notes: 1) Collection of flight data starts with FSW version 4. FSW versions 1-3 were used only in development and ground testing.

Prioritization of PHA words for downlink was done in a very simple fashion in FSW v4. Two PHA word slots were allocated per E/q step. Slots left unfilled were available for PHAs from subsequent steps. The effect of this scheme was to bias PHA collection toward higher E/q steps, which occur first in the sequence. With FSWv5, a buffered, rotating priority scheme was added which allowed a more even distribution of PHAs in E/q, while maximizing the number of PHA words transmitted within the telemetry limit. As events are collected, the flight software stores up to 12 events per deflection system voltage step in a buffer. At the end of the scan, these events are read out in voltage step order, one from each voltage step. Within a voltage step, PHAs are read out in the same order that they were stored. When no PHA exists for a given voltage step, one is read from the next voltage step which has PHAs remaining, until the allowed number of PHAs (quota as provided in Table 16) for this scan have been selected. In FSW7, the buffering scheme was removed entirely and no per-E/q step limits imposed on the number of PHA words. This change was justified by results of modeling, based on heavy ion count rate profiles from flyby data. This modeling showed that all heavy ion PHA words could be transmitted to the ground with considerable margin, making the buffer unnecessary. Since the buffer decreased processing throughput and was deemed unnecessary, it was removed.

As of FSW7, proton events are included in telemetry as 28 bit PHA words. To limit proton data volume, the FIPS hardware can decimate the proton events, i.e. send only a fraction of those collected, 1 in 2^n, where n is the decimation level. The flight software controls the decimation level, incrementing it when scan or orbit based limits are exceeded. This decimation level is included in CDR data.

Velocity distributions in FSW versions 4 & 5 are very coarse, with the natural 64x64 X-Y coordinates binned into 8x8 arrays. For a particular X-Y pair, the row and column of the bin in which to increment are given by X/8 and Y/8. In FSW v6, a much higher resolution normalized proton velocity distribution of 32x32 bins was added. For this version, the values X/2 and Y/2 are used as the row and column within the velocity distribution matrix to give the bin to be incremented. A slightly different Wedge, Strip, Zigzag to X-Y calculation was used to maximize coverage in these 32x32 normalized proton velocity distribution, detailed in Table 18.

Table 18 Equations for X, Y

FSW4, FSW5, & FSW7	FSW6
X = 128*(w + (w-z)/5)/sum	X = 96*(s + (s-z)/5)/sum
Y = 128*(s + (s-z)/5)/sum	Y = 100*(s + 2*(s-z)/11)/sum

5.3 Data Processing

5.3.1 Data Processing Level

There is one EPPS PDS Documentation Archive Volume and one EPPS PDS Data Archive Volume. The data volume contains level 3 CODMAC (Committee on Data Management and Computation) data products, also known as CDRs. Each product has a unique file name and conforms to the file naming convention in section 6.5. All CDR products were stored at the Applied Physics Laboratory/Science Operations Center (APL/SOC) during the mission. Volumes were transferred to the PDS PPI Node following the procedure in section 5.3.3.

5.3.2 Data Product Generation

The EPPS CDR files were produced by the EPS and FIPS teams. A Java program derived from the MIDL (Mission Independent Data Layer) analysis software developed by APL was used to convert the EPS EDR data to CDRs. The FIPS data were produced using three software routines, written in the IDL programming language: mfips_decode_pha.pro, mfips_decode_rates.pro and mfips_decode_hrpvd.pro. The CDR 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 in the directory structure described in section 6.8 for transfer to the PPI Node. The transfer process is described in the following section, Data Flow. An initial release of the documentation volume accompanied the initial release of the data volume. Thereafter, updates to the documentation volume were made with each data delivery to document the data quality for the delivery, changes to products including calibration updates, and other updates as appropriate. PDS provides public access to the data products through its online distribution system. These products support engineering analysis, direct science analysis, and construction of other science products.

5.3.3 Data Flow

The MESSENGER SOC operates under the auspices of the MESSENGER Project Scientist to plan data acquisition, generate, and validate data archives. The SOC supports and works with the MOC, the Science Team, instrument scientists, and the PDS.

Figure 2 MESSENGER Data Flow shows the flow of data within the MESSENGER project and out to PDS. The MOC handles raw data flow to and from the MESSENGER spacecraft and the SOC converts the raw telemetry into EDRs, which are subsequently converted into CDRs. The Science Team validates the CDRs and implements corrections if needed. Documentation and CDRs are delivered to the PDS Planetary Plasma Interactions (PPI) node. All SPICE kernels used in CDR processing are delivered to the PDS Navigation and Ancillary Information (NAIF) node. The delivery process is detailed below.

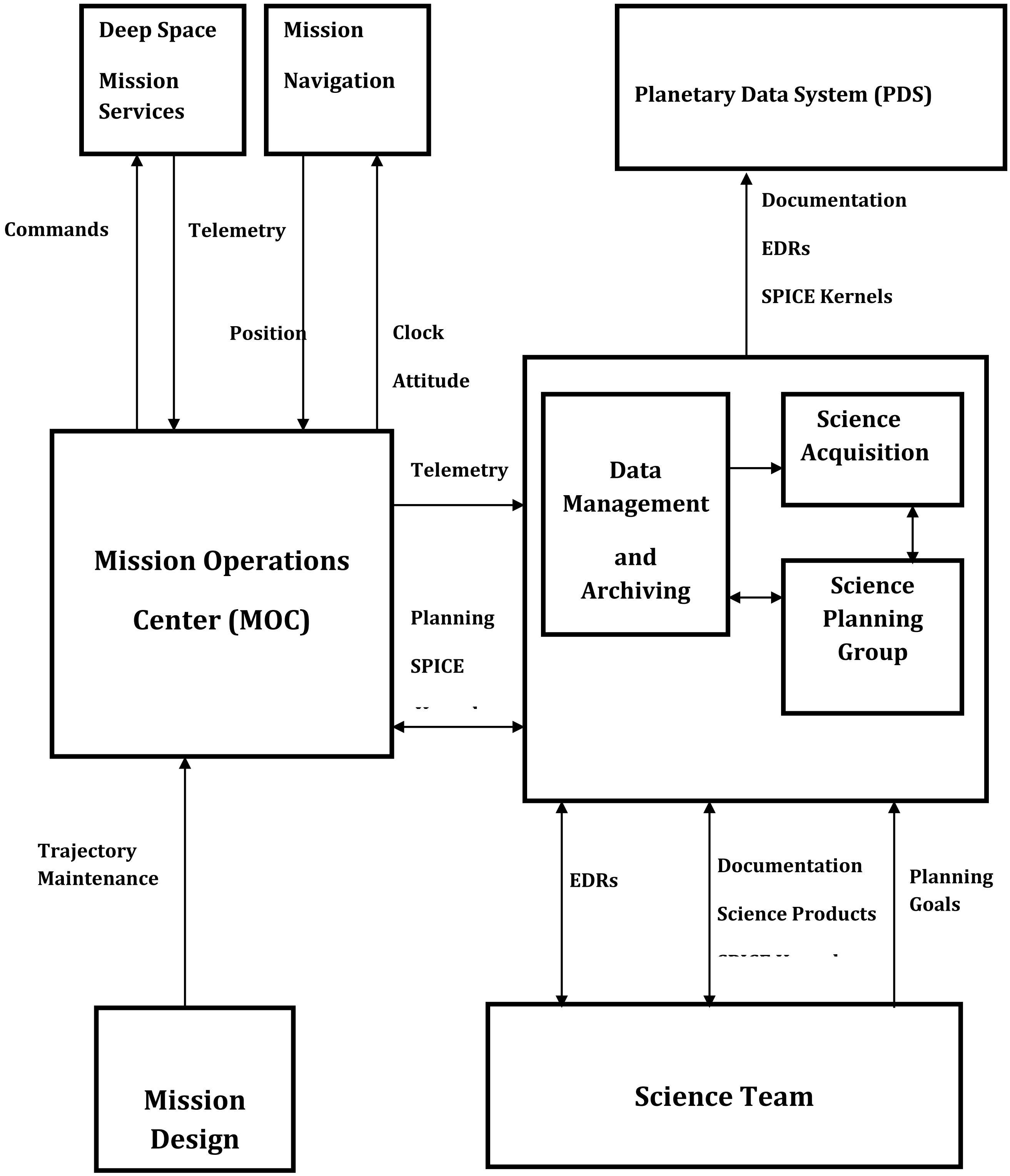

Figure 1 MESSENGER data flow

The MESSENGER SOC delivered data for the EPPS CDR data volume to the PDS PPI Node in standard product packages. Each package comprises data and ancillary data files, organized into directory structures consistent with the volume design described in section 6.8. The initial release contained the documents and required files for the EPPS documentation volume, organized into directory structures as described in section 6.7. Subsequent releases to the EPPS documentation volume contained updates as appropriate.

In preparation for delivery, the directory structure is compressed into a single "zip archive" file for transfer to the PDS node. The zip archive preserves the directory structure internally so that it can be recreated after delivery to the PDS node. Also included in the transfer is a checksum file created using the MD5 algorithm. This provides an independent method of verifying the integrity of the zip file after it has been sent. Within days of receipt of the delivery the PDS node acknowledges receipt of the archive and checksum file. If acknowledgement is not received, or if problems are reported, the MESSENGER SOC immediately takes corrective action to effect successful transfer. Delivery size determines the transfer mechanism: electronic or shipping a hard drive.

The PDS node uncompresses the zip archive file and checks for data integrity using the checksum file. The node performs any additional verification and validation of the data provided and reports any discrepancies or problems to the MESSENGER SOC. The node performs these checks within about two weeks from receipt of the delivery. After inspection has been completed to the satisfaction of the PDS node, the node issues an acknowledgement of successful receipt of the data to the MESSENGER SOC.

Following receipt of a data delivery the PDS node organizes the data into a PDS volume archive structure within its online data system. Newly delivered data are made available publicly from PDS once accompanying labels and other documentation have been validated.

5.3.4 Labeling and Identification

The PDS label conforms to PDS version 3.8 standards. For more information about this standard consult the PDS Standards Reference Document. The label is detached and in a separate PDS label file. The purpose of the PDS label is to describe the data product and provide ancillary information about the data product. There is a PDS label file for every EPPS CDR data file. There is one DATA_SET_ID assigned to the EPPS CDR data. The CDRs are further grouped into data products and are identified by the STANDARD_DATA_PRODUCT_ID keyword and the file naming convention, section 6.5. Example label file content is shown here for every CDR data product. Note that the data are contained within an ASCII table and the details of the table structure are described by an external ASCII format file (*.FMT). The Columns in each format file are described separately in the Appendix.

5.3.4.1 EPS High Priority Spectra PDS Label

```
PDS_VERSION_ID              =  "PDS3"

/* ** FILE FORMAT ** */
FILE_RECORDS                =  940
RECORD_TYPE                 =  FIXED_LENGTH
RECORD_BYTES                =  21680

/* ** GENERAL DATA DESCRIPTION PARAMETERS ** */
PRODUCT_ID                  =  "EPSH_S2008014CDR_V1"
PRODUCT_VERSION_ID          =  "V1"
PRODUCT_CREATION_TIME       =  2010-01-05T17:22:32
PRODUCT_TYPE                =  "CDR"
STANDARD_DATA_PRODUCT_ID    =  "EPS_HI_SPEC_CDR"
SOFTWARE_NAME               =  "MIDLMessengerCDRGenerator"
SOFTWARE_VERSION_ID         =  "1.0"
INSTRUMENT_HOST_NAME        =  "MESSENGER"
INSTRUMENT_NAME             =  "ENERGETIC PARTICLE SPECTROMETER"
INSTRUMENT_ID               =  "EPS"
DATA_SET_ID                 =  "MESS-E/V/H/SW-EPPS-3-EPS-CDR-V1.0"
DATA_SET_NAME               =  "MESSENGER E/V/H/SW EPPS CALIBRATED EPS CDR
V1.0"
MISSION_PHASE_NAME          =  "MERCURY 1 FLYBY"
TARGET_NAME                 =  "MERCURY"
START_TIME                  =  2008-014T00:01:41.123
STOP_TIME                   =  2008-014T23:59:27.081
^HEADER                     =  ("EPSH_S2008014CDR_V1.TAB", 1)
^ASCII_TABLE                =  ("EPSH_S2008014CDR_V1.TAB", 4)
```

```
OBJECT                     =  HEADER
  HEADER_TYPE                =  TEXT
  INTERCHANGE_FORMAT         =  "ASCII"
  RECORDS                    =  3
  BYTES                      =  65040
  DESCRIPTION                  = "The first 3 records of this
    file are the header section. The header contains column
    headings to improve usability."
END_OBJECT                 =  HEADER

OBJECT                     =  ASCII_TABLE
  COLUMNS                    =  114
  INTERCHANGE_FORMAT         =  ASCII
  ROWS                       =  940
  ROW_BYTES                  =  21680
  DESCRIPTION                     = "
    This table contains spectral data collected by the MESSENGER EPS
    instrument in High Priority Mode.
    The complete column definitions are contained in an external file
    found in the LABEL directory of the archive volume.  Additional
    details are contained in the CDR SIS document."
  NOTE                       =  "Data Quality: 0"
  ^STRUCTURE                 =  "EPSHIGH_CDR.FMT"
END_OBJECT                 =  ASCII_TABLE

END
```

5.3.4.2 EPS Medium Priority Spectra PDS Label

```
PDS_VERSION_ID            =  "PDS3"

/* ** FILE FORMAT ** */
FILE_RECORDS              =  2872
RECORD_TYPE               =  FIXED_LENGTH
RECORD_BYTES              =  21392

/* ** GENERAL DATA DESCRIPTION PARAMETERS ** */
PRODUCT_ID                =  "EPSM_S2006059CDR_V1"
PRODUCT_VERSION_ID        =  "V1"
PRODUCT_CREATION_TIME     =  2010-01-05T17:24:46
PRODUCT_TYPE              =  "CDR"
STANDARD_DATA_PRODUCT_ID  =  "EPS_MED_SPEC_CDR"
SOFTWARE_NAME             =  "MIDLMessengerCDRGenerator"
SOFTWARE_VERSION_ID       =  "1.0"
INSTRUMENT_HOST_NAME      =  "MESSENGER"
INSTRUMENT_NAME           =  "ENERGETIC PARTICLE SPECTROMETER"
INSTRUMENT_ID             =  "EPS"
DATA_SET_ID               =  "MESS-E/V/H/SW-EPPS-3-EPS-CDR-V1.0"
DATA_SET_NAME             =  "MESSENGER E/V/H/SW EPPS CALIBRATED EPS CDR
V1.0"
MISSION_PHASE_NAME        =  "VENUS 1 CRUISE"
TARGET_NAME               =  "CALIBRATION"
START_TIME                =  2006-059T00:00:28.084
STOP_TIME                 =  2006-059T23:59:50.150
^HEADER                   =  ("EPSM_S2006059CDR_V1.TAB", 1)
^ASCII_TABLE              =  ("EPSM_S2006059CDR_V1.TAB", 4)

OBJECT                    =  HEADER
  HEADER_TYPE               =  TEXT
```

```
  INTERCHANGE_FORMAT        =  "ASCII"
  RECORDS                   =  3
  BYTES                     =  64176
  DESCRIPTION                 = "The first 3 records of this
    file are the header section. The header contains column
    headings to improve usability."
END_OBJECT                =  HEADER


OBJECT                    =  ASCII_TABLE
  COLUMNS                   =  113
  INTERCHANGE_FORMAT        =  ASCII
  ROW_BYTES                 =  21392
  ROWS                      =  2872
  DESCRIPTION                    = "
    This table contains spectral data collected by the MESSENGER EPS
    instrument in Medium Priority Mode.
    The complete column definitions are contained in an external file
    found in the LABEL directory of the archive volume.  Additional
    details are contained in the CDR SIS document."
  NOTE                      =  "Data Quality: 0"
  ^STRUCTURE                =  "EPSMED_CDR.FMT"
END_OBJECT                =  ASCII_TABLE

END
```

5.3.4.3 EPS PHA PDS Label

The format for the EPS High, Medium, Low Priority PHA PDS Labels are identical in terms of the PDS keywords used. In addition, the format of the PHA TABLE object is the same for all EPS PHA

CDRs. Therefore, only one FORMAT file is used to describe all PHA TABLE objects. The file naming convention distinguishes whether the EPS PHA CDR contains high, medium, or low priority PHA data.

After the FSW6 upload, the only packet which may contain EPS PHA events is the EPS PHA packet. There is no longer any association with high, medium or low priority as of FSW6 for EPS PHA CDRs. Section 6.5 File Naming Conventions explains the designation for N/A priority in the filename.

A sample High Priority PDS PHA label is shown below:

```
PDS_VERSION_ID            =  "PDS3"

/* ** FILE FORMAT ** */
FILE_RECORDS              =  358746
RECORD_TYPE               =  FIXED_LENGTH
RECORD_BYTES              =  359

/* ** GENERAL DATA DESCRIPTION PARAMETERS ** */
PRODUCT_ID                =  "EPSN_P2008014CDR_V1"
PRODUCT_VERSION_ID        =  "V1"
PRODUCT_CREATION_TIME     =  2010-01-05T17:24:57
PRODUCT_TYPE              =  "CDR"
STANDARD_DATA_PRODUCT_ID  =  "EPS_PULSE_HEIGHT_CDR"
SOFTWARE_NAME             =  "MIDLMessengerCDRGenerator"
SOFTWARE_VERSION_ID       =  "1.0"
INSTRUMENT_HOST_NAME      =  "MESSENGER"
INSTRUMENT_NAME           =  "ENERGETIC PARTICLE SPECTROMETER"
INSTRUMENT_ID             =  "EPS"
DATA_SET_ID               =  "MESS-E/V/H/SW-EPPS-3-EPS-CDR-V1.0"
DATA_SET_NAME             =  "MESSENGER E/V/H/SW EPPS CALIBRATED EPS CDR
```

```
V1.0"
MISSION_PHASE_NAME         =  "MERCURY 1 FLYBY"
TARGET_NAME                =  "MERCURY"
START_TIME                 =  2008-014T00:00:09.027
STOP_TIME                  =  2008-014T23:59:56.168
^HEADER                    =  ("EPSN_P2008014CDR_V1.TAB", 1)
^ASCII_TABLE               =  ("EPSN_P2008014CDR_V1.TAB", 3)

OBJECT                     =  HEADER
  HEADER_TYPE                =  TEXT
  INTERCHANGE_FORMAT         =  "ASCII"
  RECORDS                    =  2
  BYTES                      =  718
  DESCRIPTION                  = "The first 2 records of this
    file are the header section. The header contains column
    headings to improve usability."
END_OBJECT                 =  HEADER



OBJECT                     =  ASCII_TABLE
  COLUMNS                    =  21
  INTERCHANGE_FORMAT         =  ASCII
  ROW_BYTES                  =  359
  ROWS                       =  358746
  DESCRIPTION                     = "
    This table contains the Pulse Height Analysis (PHA) data collected by
    the MESSENGER EPS instrument.
    The complete column definitions are contained in an external file found
    in the LABEL directory of the archive volume. Additional details are
    contained in the CDR SIS document."
```

```
  NOTE                          =  "Data Quality: 0"
  ^STRUCTURE                    =  "EPS_PHA_CDR.FMT"
END_OBJECT                    =  ASCII_TABLE

END
```

5.3.4.4 EPS High Resolution Spectra PDS Label

The High Resolution EPS Spectra CDR was created as the result of the FSW6 upload. It stores the high resolution ion and electron spectral data collected by the EPS instrument.

```
PDS_VERSION_ID               =  "PDS3"

/* ** FILE FORMAT ** */
FILE_RECORDS                 =  288
RECORD_TYPE                  =  FIXED_LENGTH
RECORD_BYTES                 =  40496

/* ** GENERAL DATA DESCRIPTION PARAMETERS ** */
PRODUCT_ID                   =  "EPSH_R2008281CDR_V1"
PRODUCT_VERSION_ID           =  "V1"
PRODUCT_CREATION_TIME        =  2010-01-05T17:24:31
PRODUCT_TYPE                 =  "CDR"
STANDARD_DATA_PRODUCT_ID     =  "EPS_HIRES_SPEC_CDR"
SOFTWARE_NAME                =  "MIDLMessengerCDRGenerator"
SOFTWARE_VERSION_ID          =  "1.0"
INSTRUMENT_HOST_NAME         =  "MESSENGER"
INSTRUMENT_NAME              =  "ENERGETIC PARTICLE SPECTROMETER"
INSTRUMENT_ID                =  "EPS"
```

```
DATA_SET_ID                = "MESS-E/V/H/SW-EPPS-3-EPS-CDR-V1.0"
DATA_SET_NAME              = "MESSENGER E/V/H/SW EPPS CALIBRATED EPS CDR
V1.0"
MISSION_PHASE_NAME         = "MERCURY 2 FLYBY"
TARGET_NAME                = "MERCURY"
START_TIME                 = 2008-281T00:01:12.036
STOP_TIME                  = 2008-281T23:56:12.036
^HEADER                    = ("EPSH_R2008281CDR_V1.TAB", 1)
^ASCII_TABLE               = ("EPSH_R2008281CDR_V1.TAB", 4)

OBJECT                     = HEADER
  HEADER_TYPE                = TEXT
  INTERCHANGE_FORMAT         = "ASCII"
  RECORDS                    = 3
  BYTES                      = 121488
  DESCRIPTION                  = "The first 3 records of this
    file are the header section. The header contains column
    headings to improve usability."
END_OBJECT                 = HEADER


OBJECT                     = ASCII_TABLE
  COLUMNS                    = 56
  INTERCHANGE_FORMAT         = ASCII
  ROW_BYTES                  = 40496
  ROWS                       = 288
  DESCRIPTION                     = "
    This table contains high-resolution spectra data collected  by
    the MESSENGER EPS instrument.
```

```
    The complete column definitions are contained in an external file found
    in the LABEL directory of the archive volume. Additional details are
    contained in the CDR SIS document."
  NOTE                       =  "Data Quality: 0"
  ^STRUCTURE                 =  "EPS_HIRES_CDR.FMT"
END_OBJECT                 =  ASCII_TABLE

END
```

5.3.4.5 EPS Low Resolution Spectra PDS Label

The Low Resolution EPS Spectra CDR was created as the result of the FSW6 upload. It stores the low resolution ion and electron spectral data as well as rate counters collected by the EPS instrument.

```
PDS_VERSION_ID             =  "PDS3"

/* ** FILE FORMAT ** */
FILE_RECORDS               =  2878
RECORD_TYPE                =  FIXED_LENGTH
RECORD_BYTES               =  13640

/* ** GENERAL DATA DESCRIPTION PARAMETERS ** */
PRODUCT_ID                 =  "EPSL_R2008281CDR_V1"
PRODUCT_VERSION_ID         =  "V1"
PRODUCT_CREATION_TIME      =  2010-01-05T17:24:38
```

```
PRODUCT_TYPE               =  "CDR"
STANDARD_DATA_PRODUCT_ID   =  "EPS_LORES_SPEC_CDR"
SOFTWARE_NAME              =  "MIDLMessengerCDRGenerator"
SOFTWARE_VERSION_ID        =  "1.0"
INSTRUMENT_HOST_NAME       =  "MESSENGER"
INSTRUMENT_NAME            =  "ENERGETIC PARTICLE SPECTROMETER"
INSTRUMENT_ID              =  "EPS"
DATA_SET_ID                =  "MESS-E/V/H/SW-EPPS-3-EPS-CDR-V1.0"
DATA_SET_NAME              =  "MESSENGER E/V/H/SW EPPS CALIBRATED EPS CDR
V1.0"
MISSION_PHASE_NAME         =  "MERCURY 2 FLYBY"
TARGET_NAME                =  "MERCURY"
START_TIME                 =  2008-281T00:00:12.036
STOP_TIME                  =  2008-281T23:59:42.126
^HEADER                    =  ("EPSL_R2008281CDR_V1.TAB", 1)
^ASCII_TABLE               =  ("EPSL_R2008281CDR_V1.TAB", 4)

OBJECT                     =  HEADER
  HEADER_TYPE                =  TEXT
  INTERCHANGE_FORMAT         =  "ASCII"
  RECORDS                    =  3
  BYTES                      =  40920
  DESCRIPTION                  = "The first 3 records of this
    file are the header section. The header contains column
    headings to improve usability."
END_OBJECT                 =  HEADER


OBJECT                     =  ASCII_TABLE
  COLUMNS                    =  67
```

```
  INTERCHANGE_FORMAT        =  ASCII
  ROW_BYTES                 =  13640
  ROWS                      =  2878
  DESCRIPTION                    = "
    This table contains low-resolution spectra data collected by
    the MESSENGER EPS instrument.
    The complete column definitions are contained in an external file found
    in the LABEL directory of the archive volume. Additional details are
    contained in the CDR SIS document."
  NOTE                      =  "Data Quality: 0"
  ^STRUCTURE                =  "EPS_LORES_CDR.FMT"
END_OBJECT                =  ASCII_TABLE

END
```

5.3.4.6 EPS Summary Spectra PDS Label

The EPS Summary Spectra CDR was created as the result of the FSW6 upload. It contains integrated rates and low resolution spectra collected by the EPS instrument.

```
PDS_VERSION_ID            =  "PDS3"

/* ** FILE FORMAT ** */
FILE_RECORDS              =  288
RECORD_TYPE               =  FIXED_LENGTH
RECORD_BYTES              =  13640

/* ** GENERAL DATA DESCRIPTION PARAMETERS ** */
PRODUCT_ID                =  "EPSS_S2008282CDR_V1"
```

```
PRODUCT_VERSION_ID        =  "V1"

PRODUCT_CREATION_TIME     =  2010-01-05T17:25:22

PRODUCT_TYPE              =  "CDR"

STANDARD_DATA_PRODUCT_ID  =  "EPS_SUM_SPEC_CDR"

SOFTWARE_NAME             =  "MIDLMessengerCDRGenerator"

SOFTWARE_VERSION_ID       =  "1.0"

INSTRUMENT_HOST_NAME      =  "MESSENGER"

INSTRUMENT_NAME           =  "ENERGETIC PARTICLE SPECTROMETER"

INSTRUMENT_ID             =  "EPS"

DATA_SET_ID               =  "MESS-E/V/H/SW-EPPS-3-EPS-CDR-V1.0"

DATA_SET_NAME             =  "MESSENGER E/V/H/SW EPPS CALIBRATED EPS CDR

V1.0"

MISSION_PHASE_NAME        =  "MERCURY 2 FLYBY"

TARGET_NAME               =  "MERCURY"

START_TIME                =  2008-282T00:01:12.036

STOP_TIME                 =  2008-282T23:56:12.036

^HEADER                   =  ("EPSS_S2008282CDR_V1.TAB", 1)

^ASCII_TABLE              =  ("EPSS_S2008282CDR_V1.TAB", 4)


OBJECT                    =  HEADER

  HEADER_TYPE               =  TEXT

  INTERCHANGE_FORMAT        =  "ASCII"

  RECORDS                   =  3

  BYTES                     =  40920

  DESCRIPTION                 = "The first 3 records of this

    file are the header section. The header contains column

    headings to improve usability."

END_OBJECT                =  HEADER
```

```
OBJECT                    =  ASCII_TABLE
  COLUMNS                   =  67
  INTERCHANGE_FORMAT        =  ASCII
  ROW_BYTES                 =  13640
  ROWS                      =  288
  DESCRIPTION                    = "
    This table contains summary spectra data collected by
    the MESSENGER EPS instrument.
    The complete column definitions are contained in an external file found
    in the LABEL directory of the archive volume. Additional details are
    contained in the CDR SIS document."
  NOTE                      =  "Data Quality: 0"
  ^STRUCTURE                =  "EPS_SUM_CDR.FMT"
END_OBJECT                =  ASCII_TABLE

END
```

5.3.4.7 EPS Scan PDS Label

The EPS Scan CDR was created as the result of the FSW6 upload. It contains integrated hardware rates for four energy threshold settings. Each threshold setting and integration lasts ¼ second.

```
PDS_VERSION_ID            =  "PDS3"

/* ** FILE FORMAT ** */
FILE_RECORDS              =  70
RECORD_TYPE               =  FIXED_LENGTH
RECORD_BYTES              =  14000
```

```
/* ** GENERAL DATA DESCRIPTION PARAMETERS ** */

PRODUCT_ID                = "EPSS_R2008280CDR_V1"

PRODUCT_VERSION_ID        = "V1"

PRODUCT_CREATION_TIME     = 2010-01-05T17:25:15

PRODUCT_TYPE              = "CDR"

STANDARD_DATA_PRODUCT_ID  = "EPS_SCAN_SPEC_CDR"

SOFTWARE_NAME             = "MIDLMessengerCDRGenerator"

SOFTWARE_VERSION_ID       = "1.0"

INSTRUMENT_HOST_NAME      = "MESSENGER"

INSTRUMENT_NAME           = "ENERGETIC PARTICLE SPECTROMETER"

INSTRUMENT_ID             = "EPS"

DATA_SET_ID               = "MESS-E/V/H/SW-EPPS-3-EPS-CDR-V1.0"

DATA_SET_NAME             = "MESSENGER E/V/H/SW EPPS CALIBRATED EPS CDR

V1.0"

MISSION_PHASE_NAME        = "MERCURY 2 FLYBY"

TARGET_NAME               = "MERCURY"

START_TIME                = 2008-280T03:35:02.006

STOP_TIME                 = 2008-280T14:46:11.033

^HEADER                   = ("EPSS_R2008280CDR_V1.TAB", 1)

^ASCII_TABLE              = ("EPSS_R2008280CDR_V1.TAB", 4)


OBJECT                    = HEADER

  HEADER_TYPE               = TEXT

  INTERCHANGE_FORMAT        = "ASCII"

  RECORDS                   = 3

  BYTES                     = 42000

  DESCRIPTION                 = "The first 3 records of this

    file are the header section. The header contains column

    headings to improve usability."

END_OBJECT                = HEADER
```

```
OBJECT                         =  ASCII_TABLE
  COLUMNS                       =  56
  INTERCHANGE_FORMAT            =  ASCII
  ROW_BYTES                     =  14000
  ROWS                          =  70
  DESCRIPTION                        = "
    This table contains scan rates collected by the MESSENGER EPS instrument.
    The complete column definitions are contained in an external file found
    in the LABEL directory of the archive volume. Additional details are
    contained in the CDR SIS document."
  NOTE                          =  "Data Quality: 0"
  ^STRUCTURE                    =  "EPS_SCAN_CDR.FMT"
END_OBJECT                     =  ASCII_TABLE

END
```

The following are example label headers for the FIPS CDR products. As with the EPS CDRs all table structures are defined by external format files. The Columns in each format file are defined separately in the Appendix.

5.3.4.8 FIPS High Priority Spectra PDS Label

```
PDS_VERSION_ID                   =  "PDS3"

/* ** FILE FORMAT ** */
FILE_RECORDS                     =  424
```

```
RECORD_TYPE                    =  FIXED_LENGTH
RECORD_BYTES                   =  4277

/* ** GENERAL DATA DESCRIPTION PARAMETERS ** */
PRODUCT_ID                     =  "FIPH_S2008014CDR_V1"
PRODUCT_VERSION_ID             =  "V1"
PRODUCT_CREATION_TIME          =  2010-01-05T17:20:59
PRODUCT_TYPE                   =  "CDR"
STANDARD_DATA_PRODUCT_ID       =  "FIPS_HI_SPECTRA_CDR"
SOFTWARE_NAME                  =  "mfips_decode_rates.pro"
SOFTWARE_VERSION_ID            =  "1.0"
INSTRUMENT_HOST_NAME           =  "MESSENGER"
INSTRUMENT_NAME                =  "FAST IMAGING PLASMA SPECTROMETER"
INSTRUMENT_ID                  =  "FIPS"
DATA_SET_ID                    =  "MESS-E/V/H/SW-EPPS-3-FIPS-CDR-V1.0"
DATA_SET_NAME                  =  "MESSENGER E/V/H/SW EPPS CALIBRATED FIPS CDR
V1.0"
SOURCE_PRODUCT_ID              =  {"FIPA_E2007210CDR_V1.TAB"}
MISSION_PHASE_NAME             =  "MERCURY 1 FLYBY"
TARGET_NAME                    =  "MERCURY"
START_TIME                     =  2008-014T00:11:21.000
STOP_TIME                      =  2008-014T23:59:46.000
SPACECRAFT_CLOCK_START_COUNT   =  "108756862.000"
SPACECRAFT_CLOCK_STOP_COUNT    =  "108842567.000"
^HEADER                        =  ("FIPH_S2008014CDR_V1.TAB",1)
^ASCII_TABLE                   =  ("FIPH_S2008014CDR_V1.TAB",6)

OBJECT                         =  HEADER
  HEADER_TYPE                    =  TEXT
  INTERCHANGE_FORMAT             =  "ASCII"
```

```
  RECORDS                        =  5
  BYTES                          =  21385
  DESCRIPTION                  = "The first 5 records of this
    file are the header section. The header contains column
    headings to improve usability."
END_OBJECT                     =  HEADER


OBJECT                         =  ASCII_TABLE
  COLUMNS                        =  10
  INTERCHANGE_FORMAT             =  ASCII
  ROW_BYTES                      =  4277
  ROWS                           =  424
  DESCRIPTION                     = "
    This table contains the following data gathered by the Fast Imaging
    Plasma Spectrometer (FIPS) in HIGH priority mode:
       -Normalized proton velocity distribution
       -Differential flux spectra
    The complete column definitions are contained in an external file
    found in the LABEL directory of the archive volume. Energy per
    charge (E/q) tables referenced in SOURCE_PRODUCT_ID are located in
    the CALIBRATION directory of the archive volume. Additional details
    are contained in the CDR SIS document."
  ^STRUCTURE                     =  "FIPS_HI_CDR.FMT"
END_OBJECT                     =  ASCII_TABLE

END
```

5.3.4.9 FIPS Medium Priority PDS Label

A FSW6 upload was implemented on 8/19/2008. The upload retired the Medium Priority packet and split the contents into two new packets. As a result, the Medium Priority CDR is no longer created after 8/18/2008. Data from the two new packets are contained in the FIPS Scan and FIPS Hi-Res Normalized proton velocity distribution CDRs.

```
PDS_VERSION_ID              =  "PDS3"

/* ** FILE FORMAT ** */
FILE_RECORDS                =  795
RECORD_TYPE                 =  FIXED_LENGTH
RECORD_BYTES                =  4277

/* ** GENERAL DATA DESCRIPTION PARAMETERS ** */
PRODUCT_ID                  =  "FIPM_S2006060CDR_V1"
PRODUCT_VERSION_ID          =  "V1"
PRODUCT_CREATION_TIME       =  2010-01-05T17:21:12
PRODUCT_TYPE                =  "CDR"
STANDARD_DATA_PRODUCT_ID    =  "FIPS_MED_SPEC_CDR"
SOFTWARE_NAME               =  "mfips_decode_rates.pro"
SOFTWARE_VERSION_ID         =  "1.0"
INSTRUMENT_HOST_NAME        =  "MESSENGER"
INSTRUMENT_NAME             =  "FAST IMAGING PLASMA SPECTROMETER"
INSTRUMENT_ID               =  "FIPS"
DATA_SET_ID                 =  "MESS-E/V/H/SW-EPPS-3-FIPS-CDR-V1.0"
DATA_SET_NAME               =  "MESSENGER E/V/H/SW EPPS CALIBRATED FIPS CDR
V1.0"
SOURCE_PRODUCT_ID           =  {"FIPA_E2006057CDR_V1.TAB"}
MISSION_PHASE_NAME          =  "VENUS 1 CRUISE"
```

```
TARGET_NAME                    =  "CALIBRATION"
START_TIME                     =  2006-060T00:00:02.000
STOP_TIME                      =  2006-060T15:55:58.000
SPACECRAFT_CLOCK_START_COUNT   =  "49658437.000"
SPACECRAFT_CLOCK_STOP_COUNT    =  "49715793.000"
^HEADER                        =  ("FIPM_S2006060CDR_V1.TAB", 1)
^ASCII_TABLE                   =  ("FIPM_S2006060CDR_V1.TAB", 6)

OBJECT                         =  HEADER
  HEADER_TYPE                    =  TEXT
  INTERCHANGE_FORMAT             =  "ASCII"
  RECORDS                        =  5
  BYTES                          =  21385
  DESCRIPTION                  = "The first 5 records of this
    file are the header section. The header contains column
    headings to improve usability."
END_OBJECT                     =  HEADER


OBJECT                         =  ASCII_TABLE
  COLUMNS                        =  10
  INTERCHANGE_FORMAT             =  ASCII
  ROW_BYTES                      =  4277
  ROWS                           =  795
  DESCRIPTION                     = "
    This table contains the following data gathered by the Fast Imaging
    Plasma Spectrometer (FIPS) in MEDIUM priority mode:
       -Normalized proton velocity distribution
       -Differential flux spectra
    The complete column definitions are contained in an external file
```

```
    found in the LABEL directory of the archive volume. Energy per
    charge (E/q) tables referenced in SOURCE_PRODUCT_ID are located in
    the CALIBRATION directory of the archive volume. Additional details
    are contained in the CDR SIS document."
  ^STRUCTURE                   =  "FIPS_MED_CDR.FMT"
END_OBJECT                   =  ASCII_TABLE

END
```

5.3.4.10 FIPS PHA PDS Label

The format for the FIPS High, Medium, Low PHA PDS Labels are identical in terms of the PDS keywords used. In addition, the format of the PHA_TABLE object is the same for all FIPS PHA CDRs. Therefore, only one FORMAT file is used to describe all PHA_TABLE objects.

After the FSW6 upload, the only packets which may contain PHA events are the high priority, low priority, and scan packets (medium priority packets being retired). The file naming conventiondistinguishes whether the FIPS PHA CDR contains PHA events extracted from high or low priority, or scan packets. This is detailed in Section 6.5.

A sample PHA PDS label is shown below:

```
PDS_VERSION_ID               =  "PDS3"

/* ** FILE FORMAT ** */
FILE_RECORDS                 =  7956
RECORD_TYPE                  =  FIXED_LENGTH
RECORD_BYTES                 =  159
```

```
/* ** GENERAL DATA DESCRIPTION PARAMETERS ** */

PRODUCT_ID                     =  "FIPP_P2006059CDR_V1"

PRODUCT_VERSION_ID             =  "V1"

PRODUCT_CREATION_TIME          =  2010-01-05T17:21:20

PRODUCT_TYPE                   =  "CDR"

STANDARD_DATA_PRODUCT_ID       =  "FIPS_PHA_CDR"

SOFTWARE_NAME                  =  "mfips_decode_pha.pro"

SOFTWARE_VERSION_ID            =  "1.0"

INSTRUMENT_HOST_NAME           =  "MESSENGER"

INSTRUMENT_NAME                =  "FAST IMAGING PLASMA SPECTROMETER"

INSTRUMENT_ID                  =  "FIPS"

DATA_SET_ID                    =  "MESS-E/V/H/SW-EPPS-3-FIPS-CDR-V1.0"

DATA_SET_NAME                  =  "MESSENGER E/V/H/SW EPPS CALIBRATED FIPS CDR

V1.0"

SOURCE_PRODUCT_ID              =  {"FIPA_E2006057CDR_V1.TAB","Weight"}

MISSION_PHASE_NAME             =  "VENUS 1 CRUISE"

TARGET_NAME                    =  "CALIBRATION"

START_TIME                     =  2006-059T00:00:05.000

STOP_TIME                      =  2006-059T23:58:57.000

SPACECRAFT_CLOCK_START_COUNT   =  "49572039"

SPACECRAFT_CLOCK_STOP_COUNT    =  "49658372"

^HEADER                        =  ("FIPP_P2006059CDR_V1.TAB", 1)

^ASCII_TABLE                   =  ("FIPP_P2006059CDR_V1.TAB", 5)


OBJECT                         =  HEADER

  HEADER_TYPE                    =  TEXT

  INTERCHANGE_FORMAT             =  "ASCII"

  RECORDS                        =  4

  BYTES                          =  636

  DESCRIPTION                  = "The first 4 records of this
```

```
    file are the header section. The header contains column
    headings to improve usability."
END_OBJECT                    =  HEADER


OBJECT                        =  ASCII_TABLE
  COLUMNS                       =  18
  INTERCHANGE_FORMAT            =  ASCII
  ROW_BYTES                     =  159
  ROWS                          =  7956
  DESCRIPTION                    = "
    This table contains the Pulse Height Analysis (PHA) data collected by
    the MESSENGER Fast Imaging Plasma Spectrometer (FIPS).
    The complete column definitions are contained in an external file
    found in the LABEL directory of the archive volume. Energy per
    charge (E/q) tables referenced in SOURCE_PRODUCT_ID are located in
    the CALIBRATION directory of the archive volume. Additional details
    are contained in the CDR SIS document."
  ^STRUCTURE                    =  "FIPS_PHA_CDR.FMT"
END_OBJECT                    =  ASCII_TABLE

END
```

5.3.4.11 FIPS Scan PDS Label

The FIPS Scan CDR contains FIPS differential flux spectra at each Deflection System High Voltage (DSHV) step in a scan.

```
PDS_VERSION_ID                =  "PDS3"
```

```
/* ** FILE FORMAT ** */
FILE_RECORDS                   =  1163
RECORD_TYPE                    =  FIXED_LENGTH
RECORD_BYTES                   =  3573

/* ** GENERAL DATA DESCRIPTION PARAMETERS ** */
PRODUCT_ID                     =  "FIPS_R2008281CDR_V1"
PRODUCT_VERSION_ID             =  "V1"
PRODUCT_CREATION_TIME          =  2010-01-05T17:22:02
PRODUCT_TYPE                   =  "CDR"
STANDARD_DATA_PRODUCT_ID       =  "FIPS_SCAN_CDR"
SOFTWARE_NAME                  =  "mfips_decode_pha.pro"
SOFTWARE_VERSION_ID            =  "1.0"
INSTRUMENT_HOST_NAME           =  "MESSENGER"
INSTRUMENT_NAME                =  "FAST IMAGING PLASMA SPECTROMETER"
INSTRUMENT_ID                  =  "FIPS"
DATA_SET_ID                    =  "MESS-E/V/H/SW-EPPS-3-FIPS-CDR-V1.0"
DATA_SET_NAME                  =  "MESSENGER E/V/H/SW EPPS CALIBRATED FIPS CDR
V1.0"
SOURCE_PRODUCT_ID              =  {"FIPA_E2007210CDR_V1.TAB"}
MISSION_PHASE_NAME             =  "MERCURY 2 FLYBY"
TARGET_NAME                    =  "MERCURY"
START_TIME                     =  2008-281T00:01:33.000
STOP_TIME                      =  2008-282T00:00:51.000
SPACECRAFT_CLOCK_START_COUNT   =  "131825074.000"
SPACECRAFT_CLOCK_STOP_COUNT    =  "131911432.000"
^HEADER                        =  ("FIPS_R2008281CDR_V1.TAB", 1)
^ASCII_TABLE                   =  ("FIPS_R2008281CDR_V1.TAB", 6)
```

```
OBJECT                        =  HEADER
  HEADER_TYPE                   =  TEXT
  INTERCHANGE_FORMAT            =  "ASCII"
  RECORDS                       =  5
  BYTES                         =  17865
  DESCRIPTION                 = "The first 5 records of this
    file are the header section. The header contains column
    headings to improve usability."
END_OBJECT                    =  HEADER


OBJECT                        =  ASCII_TABLE
  COLUMNS                       =  9
  INTERCHANGE_FORMAT            =  ASCII
  ROW_BYTES                     =  3573
  ROWS                          =  1163
  DESCRIPTION                    = "
    This table contains the FIPS differential flux spectra gathered by the Fast Imaging
    Plasma Spectrometer (FIPS) accumulated over each separate observation.
    The complete column definitions are contained in an external file
    found in the LABEL directory of the archive volume. Energy per
    charge (E/q) tables referenced in SOURCE_PRODUCT_ID are located in
    the CALIBRATION directory of the archive volume. Additional details
    are contained in the CDR SIS document."
  ^STRUCTURE                    =  "FIPS_SCAN_CDR.FMT"
END_OBJECT                    =  ASCII_TABLE

END
```

5.3.4.12 FIPS High Resolution (Normalized) Proton Velocity Distribution (HRPVD) PDS Label

The FIPS HRPVD CDR contains a 32 x 32 high resolution normalized proton velocity distribution, integrated over a 10 scan sequence.

```
PDS_VERSION_ID                = "PDS3"

/* ** FILE FORMAT ** */
FILE_RECORDS                  = 129
RECORD_TYPE                   = FIXED_LENGTH
RECORD_BYTES                  = 12385

/* ** GENERAL DATA DESCRIPTION PARAMETERS ** */
PRODUCT_ID                    = "FIPS_V2008281CDR_V1"
PRODUCT_VERSION_ID            = "V1"
PRODUCT_CREATION_TIME         = 2010-01-05T17:21:06
PRODUCT_TYPE                  = "CDR"
STANDARD_DATA_PRODUCT_ID      = "FIPS_HIRES_P_V_CDR"
SOFTWARE_NAME                 = "mfips_decode_hrpvd.pro"
SOFTWARE_VERSION_ID           = "1.0"
INSTRUMENT_HOST_NAME          = "MESSENGER"
INSTRUMENT_NAME               = "FAST IMAGING PLASMA SPECTROMETER"
INSTRUMENT_ID                 = "FIPS"
DATA_SET_ID                   = "MESS-E/V/H/SW-EPPS-3-FIPS-CDR-V1.0"
DATA_SET_NAME                 = "MESSENGER E/V/H/SW EPPS CALIBRATED FIPS CDR
V1.0"
SOURCE_PRODUCT_ID             = {"FIPA_E2007210CDR_V1.TAB"}
MISSION_PHASE_NAME            = "MERCURY 2 FLYBY"
TARGET_NAME                   = "MERCURY"
```

```
START_TIME                     =  2008-281T00:09:21.000
STOP_TIME                      =  2008-281T23:55:17.000
SPACECRAFT_CLOCK_START_COUNT   =  "131825542.000"
SPACECRAFT_CLOCK_STOP_COUNT    =  "131911098.000"
^HEADER                        =  ("FIPS_V2008281CDR_V1.TAB", 1)
^ASCII_TABLE                   =  ("FIPS_V2008281CDR_V1.TAB", 6)

OBJECT                         =  HEADER
  HEADER_TYPE                    =  TEXT
  INTERCHANGE_FORMAT             =  "ASCII"
  RECORDS                        =  5
  BYTES                          =  61925
  DESCRIPTION                  = "The first 5 records of this
    file are the header section. The header contains column
    headings to improve usability."
END_OBJECT                     =  HEADER


OBJECT                         =  ASCII_TABLE
  COLUMNS                        =  40
  INTERCHANGE_FORMAT             =  ASCII
  ROW_BYTES                      =  12385
  ROWS                           =  129
  DESCRIPTION                     = "
    This table contains the high-resolution normalized proton velocity distributions
    gathered by the Fast Imaging Plasma Spectrometer (FIPS)collected over
    a 10-scan sequence. The complete column definitions are contained in
    an external file found in the LABEL directory of the archive volume.
    Energy per charge (E/q) tables referenced in SOURCE_PRODUCT_ID are
    located in the CALIBRATION directory of the archive volume. Additional
```

```
    details are contained in the CDR SIS document."
  ^STRUCTURE                   =  "FIPS_HRPVD_CDR.FMT"
END_OBJECT                   =  ASCII_TABLE

END
```

5.3.4.13 FIPS Energy Per Charge (E/q) Table PDS Label

The FIPS EQ ancillary data contains the energy per charge tables.

```
PDS_VERSION_ID               =  "PDS3"

/* ** FILE FORMAT ** */
FILE_RECORDS                 =  69
RECORD_TYPE                  =  FIXED_LENGTH
RECORD_BYTES                 =  264

/* ** GENERAL DATA DESCRIPTION PARAMETERS ** */
PRODUCT_ID                   =  "FIPA_E2004216CDR_V1"
PRODUCT_VERSION_ID           =  "V1"
PRODUCT_CREATION_TIME        =  2009-07-14T22:01:30
PRODUCT_TYPE                 =  "ANCILLARY_DATA"
STANDARD_DATA_PRODUCT_ID     =  "FIPS_E_PER_CHARGE"
INSTRUMENT_HOST_NAME         =  "MESSENGER"
INSTRUMENT_NAME              =  "FAST IMAGING PLASMA SPECTROMETER"
INSTRUMENT_ID                =  "FIPS"
DATA_SET_ID                  =  "MESS-E/V/H/SW-EPPS-3-FIPS-CDR-V1.0"
DATA_SET_NAME                =  "MESSENGER E/V/H/SW EPPS CALIBRATED FIPS CDR
V1.0"
```

```
^HEADER                        =  ("FIPA_E2004216CDR_V1.TAB",5)
^TABLE                         =  ("FIPA_E2004216CDR_V1.TAB",6)

OBJECT                    =  HEADER
  ^HEADER_TYPE              =  TEXT
  INTERCHANGE_FORMAT        =  "ASCII"
  RECORDS                   =  5
  BYTES                     =  1320
  DESCRIPTION                 = "The first 5 records of this
    file are the header section. The header contains column
    headings to improve usability."
END_OBJECT                =  HEADER

OBJECT                        =  TABLE
  COLUMNS                       =  33
  INTERCHANGE_FORMAT            =  ASCII
  ROW_BYTES                     =  264
  ROWS                          =  64
  DESCRIPTION                   = "
    This table contains the E/q value (keV/e), accumulation time (ms) and
    proton threshold (ns) as a function of E/q step number, for each of the
    8 stepping tables loaded into the instrument. The stepping table used
    at a particular time is given by the FIPS_SCANTYPE variable in the FIPS
    CDR data."
  ^STRUCTURE                    =  "FIPS_EQ.FMT"
END_OBJECT                    =  TABLE

END
```

5.3.4.14 FIPS Pixel Field of View Table PDS Label

The FIPS Pixel Field of View data lists the FOV pixels.

```
PDS_VERSION_ID                = "PDS3"

/* ** FILE FORMAT ** */
FILE_RECORDS                  = 931
RECORD_TYPE                   = FIXED_LENGTH
RECORD_BYTES                  = 88

/* ** GENERAL DATA DESCRIPTION PARAMETERS ** */
PRODUCT_ID                    = "FIPA_F2004216CDR_V1"
PRODUCT_VERSION_ID            = "01"
PRODUCT_CREATION_TIME         = 2014-06-04T10:00:00
PRODUCT_TYPE                  = ANCILLARY
STANDARD_DATA_PRODUCT_ID      = "FIPS_FOVPIXEL"
SOFTWARE_NAME                 = "mcpmapgen"
SOFTWARE_VERSION_ID           = "1.0"
INSTRUMENT_HOST_NAME          = "MESSENGER"
INSTRUMENT_NAME               = "ENERGETIC PARTICLE AND PLASMA SPECTROMETER"
INSTRUMENT_ID                 = "EPPS"
DATA_SET_ID                   = "MESS-E/V/H/SW-EPPS-3-FIPS-CDR-V1.0"
DATA_SET_NAME                 = "MESSENGER E/V/H/SW EPPS CALIBRATED FIPS CDR
V1.0"
START_TIME                    = 2004-08-03T00:00:00
STOP_TIME                     = 2008-08-17T23:59:59
^HEADER                       = ("FIPA_F2004216CDR_V1.TAB", 1)
```

```
^ASCII_TABLE                 =  ("FIPA_F2004216CDR_V1.TAB", 5)

OBJECT                       =  HEADER
  HEADER_TYPE                  =  TEXT
  INTERCHANGE_FORMAT           =  "ASCII"
  RECORDS                      =  4
  BYTES                        =  352
  DESCRIPTION                = "The first four records of this
    file are the header section. The header contains column
    headings to improve usability."
END_OBJECT                   =  HEADER



OBJECT                       =  ASCII_TABLE
  COLUMNS                      =  7
  INTERCHANGE_FORMAT           =  ASCII
  ROW_BYTES                    =  88
  ROWS                         =  927
  DESCRIPTION                   = "
This table contains normalizations for the FOV pixels."
  ^STRUCTURE                   =  "FIPS_FOVPIXEL.FMT"
END_OBJECT                   =  ASCII_TABLE

END
```

5.4 Standards Used in Generating Data Products

5.4.1 PDS Standards

The EPPS CDR data products are constructed according to the data object concepts developed by the PDS. By adopting the PDS format, the data products are consistent in content and organization with other planetary data collections. In the PDS standard, the CDR data file is grouped into objects with PDS labels describing the objects. Each CDR data product consists of two files:

- A data file containing an ASCII table object (the primary data), in fixed field format. ASCII table objects are in either comma separated value (CSV) format (EPS) or are whitespace delimited (FIPS). This makes the ASCII data extremely easy to read by many commercial off-the-shelf programs.

- A label file which serves as a high-level description of the parameters of which correspond to the data file. The label file contains a pointer to an external format file which details the structure of the table object in the data file.

5.4.2 Time Standards

One of the time fields in the FIPS table objects reference the Mission Elapsed Time (MET). This MET is the spacecraft time in integer seconds that is transmitted to MESSENGER subsystems by the Integrated Electronics Module (IEM). This is referred to by the MESSENGER project as Mission Elapsed Time (MET). MET = 0 is August 3, 2004, at 05:59:16 UTC (coordinated universal time), which is 1000 seconds prior to the MESSENGER launch. Relativistic effects and circumstances occurring during the mission would result in MET not being a true account of seconds since launch. Following a planned spacecraft clock reset in early 2013, partition numbers (1/, or 2/) were added to product labels to disambiguate MET seconds after the spacecraft clock reset (if partition number is not present, SPICE defaults to partition 1/). For this reason the MESSENGER spacecraft clock coefficients file is archived at the PDS Navigation and Ancillary Information Facility (NAIF) Node. This file is used in conjunction with the leapseconds kernel file in order to calculate the conversion between MET and UTC.

The conversion is easily done through the use of SPICE kernels and the CHRONOS Utility. CHRONOS is a utility included with the SPICE package that is distributed by the PDS NAIF node. The SPICE kernels are files that contain the information needed to perform the conversion. Two SPICE kernels are required. One is the Leapseconds Kernel (LSK) and the other is the MESSENGER Spacecraft Clock Kernel (SCLK). The SCLK file is used by CHRONOS to convert between spacecraft clock time and ephemeris time, while the LSK file is used to convert from ephemeris time to UTC time. The

CHRONOS utility is self-documenting and the SPICE package itself contains full documentation on each of the utilities (including CHRONOS) and how they are used.

EPPS CDR data is time-tagged with spacecraft event time (SCET) in the following UTC format: CCYY-DDDTHH:MM:SS.sss. This format represents a concatenation of the conventional date and time expressions with the two parts separated by the letter T:

CC - century (00-99)

YY - year (00-99)

DDD - day of year (001-366)

T - date/time separator

HH - hour (00-23)

MM - minute (00-59)

SS - second (00-59)

sss - fractions of second (000-999)

5.4.3 Coordinate Systems

There are two coordinate systems in use in the EPPS CDR data products: 1) the Mercury-centric Solar Orbital (MSO, defined in the MESSENGER SPICE Dynamic Frames Kernel) used for spacecraft position vectors; and 2) the FIPS Spherical coordinate system, used for FIPS incident angles since it represents natural coordinates for the sensor. The latter is a spherical version of the FIPS Cartesian coordinate system which is defined in the MESSENGER SPICE Frames Kernel FIPS Spherical coordinates consist of a radius (r), zenith angle (theta) and azimuthal angle (phi). The zenith angle is defined as the angle between the vector and the z axis in the FIPS Cartesian coordinate system. It ranges from 0 to 180 degrees. The azimuthal angle ranges from 0 to 360 degrees and is defined as the angle between the vector and the x axis in the FIPS Cartesian coordinate system. The radius is defined as usual as the magnitude of the FIPS Cartesian vector.

5.4.4 Data Storage Conventions

The data are organized following PDS standards and stored on hard disk at the MESSENGER SOC. The SOC transfers data to PDS using the delivery methods 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 EPPS CDR data archive volume set includes all data acquired during the MESSENGER mission. The archive validation procedure described in this section applies to data products generated during all post launch phases of the mission. To be clear, there is one and only one documentation volume and one and only one EPPS CDR data archive volume created over the whole mission. Release dates are stated in the schedule in [2]. Updates to the CDR data volume occurred according to the same schedule. Updates to the documentation volume occurred according to this schedule including updates to the calibration documentation at the discretion of the EPPS team.

PDS standards recommend that all data included in the formal archive be validated through a peer-review process. This process is designed to ensure that both the data and documentation are of sufficient quality to be useful to future generations of scientists. The process is presented as several steps, most of which occur in the PDS peer review. This peer review is conducted before any volumes are produced and released to PDS.

The peer review panel consists of members of the EPPS team, the PPI node of PDS, and at least one outside scientist actively working in the field of energetic particles research. The PDS personnel are responsible for validating that the volumes are fully compliant with PDS standards. The instrument team and outside reviewer(s) are responsible for verifying the content of the data set, the completeness of the documentation, and the usability of the data in its archive format.

The peer review validates the documentation and data archive volumes. First the panel reviews this document and verifies that the volumes and CDRs produced to this specification will be useful. The peer review also validates the EPPS CDR data in a two step process. The first step consists of reviewing a sample data set for compliance with the PDS standards. The sample data set is delivered and reviewed in conjunction with delivery and review of this SIS document. The second step is examination of the data to ensure usability and completeness. The PDS personnel are responsible for validating that the CDR data set is fully compliant with PDS standards. The instrument team and the outside science reviewer(s) are responsible for verifying the content of the data set, the completeness of the documentation, and the usability of the data in its archive format.

Any deficiencies in the archive data or documentation volumes are recorded as liens against the product by the review panel. The sample data set is created using software provided by APL and the University of Michigan. Once the sample data are validated, and all liens placed against the product or product generation software are resolved, the same software is used to generate subsequent data products in an automated fashion.

During automated production, the data file content is spot checked by members of the EPPS team. "Quick look" products generated by software provided by the EPPS team are produced routinely and examined by members of the team. In addition, the data are actively used by team members to perform their analysis. Any discrepancies in the data noted during these activities are investigated. If the discrepancy is a data error, the response depends on the source of the error. If the error is in the software producing the data product, the error is corrected and the data affected are reproduced, replacing the data file. If there is a correctable error in a data file, the file is replaced. If an error in a data file is uncorrectable, the error is described in the cumulative errata file included in the archive volume. The structure of data files and labels will be spot checked by the PPI node for compliance with PDS standards and this SIS.

6 Detailed Data Product Specification

6.1 Data Product Structure and Organization

The MESSENGER EPPS CDR data products are archived at the PDS PPI Node. The automated production and release of CDRs lends itself to the regular release schedule outlined in [2]. If errors are discovered the data are replaced with corrected CDRs on the next scheduled delivery date.

Calibration tables and calibration procedures are required to properly analyze CDRs. These ancillary data are archived at the PDS PPI Node as part of the EPPS documentation volume. The documentation volume is referenced by all EPPS data archive volumes. The documentation volume includes the EPPS EDR SIS,the EPPS CDR SIS, and the EPPS DDR SIS in addition to the calibration tables, calibration procedures, and other documents applicable to either data archive volume. A first release of the EPPS documentation volume accompanied the initial release of the EPPS EDR data archive. An update to the EPPS documentation volume accompanied the initial releases of the CDR and DDR data archives. After the initial releases of the CDR and DDR level documentation there were updates to the documentation volume to document data quality and as needed for product and calibration updates.

6.2 Handling Errors

The possibility exists that errors may be introduced into the archive even with validation procedures applied to the archive volumes. An ERRATA report file documents all discovered uncorrectable errors that may have occured during the mission. Correctable errors, such as revised CDRs or CDRs that were missing from a previous PDS delivery are provided at the next scheduled PDS delivery or at the final delivery date (schedule in [2]). PDS replaces the outdated files with the revised CDR files in the data directories of the archive volume. File revisions are also recorded in the data product label keywords PRODUCT_VERSION_ID and PRODUCT_CREATION_TIME, which can be used in addition to ERRATA.TXT to detect updates. The ERRATA report file is archived in the ROOT directory of the EPPS CDR data volume.

6.3 Data Format Description

Data are stored in ASCII table format. A detached PDS label file provides a detailed description of the structure of each table.

6.4 Label and Header Descriptions

The following are the keyword definitions for the detached PDS label file, which accompanies the instrument data file. The detached PDS label file has the same name as the data file it describes, except for the extension .LBL to distinguish it as a label file.

PDS_VERSION_ID

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

FILE_RECORDS

Indicates the number of physical file records, including both label records and data records.

RECORD_TYPE

Indicates the record format of a file. Note: In the PDS, when record_type is used in a detached label file it always describes its corresponding detached data file, not the label file itself. The use of record_type along with other file-related data elements is fully described in the PDS Standards Reference.

RECORD_BYTES

Indicates the number of bytes in a physical file record, including record terminators and separators. Note: In the PDS, the use of record_bytes, along with other file-related data elements is fully described in the Standards Reference.

PRODUCT_ID

Represents a permanent, unique identifier assigned to a data product by its producer.

PRODUCT_CREATION_TIME

Defines the UTC system format time when a product was created.

PRODUCT_VERSION_ID

Identifies the version of an individual product within a data set.

Example: 1.0, 2.0, 3.0.

Product_version_id is incremented if a given CDR has to be regenerated and sent to PDS to replace a previously submitted CDR.

PRODUCT_TYPE

Identifies the type or category of a product within a data set.

STANDARD_DATA_PRODUCT_ID

Used to link an EPPS CDR file to one of the 12 types of EPPS data products defined within the EPPS CDR SIS.

SOFTWARE_NAME

Identifies the data processing software used to convert from spacecraft telemetry into CDR products.

SOFTWARE_VERSION_ID

Indicates the version of the data processing software used to generate the CDR products from the EDRs.

MD5_CHECKSUM

Used to verify the successful electronic transfer of the CDR from the SOC to the PDS-PPI Node.

INSTRUMENT_HOST_NAME

The full name of the host on which an instrument is based. In this case it is the MESSENGER spacecraft.

INSTRUMENT_NAME

Provides the full name of the instrument.

INSTRUMENT_ID

Provides an abbreviated name or acronym which identifies an instrument.

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. There is only one data_set_id for the EPPS CDRs.

MISSION_PHASE_NAME

Provides the commonly used identifier of a mission phase.

TARGET_NAME

The target_name element identifies a target. The target may be a planet, satellite,ring,region, feature, asteroid or comet.

START_TIME

Provides the date and time of the beginning of an event or observation (whether it be a spacecraft, ground-based, or system event) in UTC system format.

STOP_TIME

Provides the date and time of the end of an observation or event (whether it be a spacecraft, ground-based, or system event) in UTC system format.

SPACECRAFT_CLOCK_START_COUNT

Provides the value of the spacecraft clock at the beginning of a time period of interest.

SPACECRAFT_CLOCK_STOP_COUNT

Provides the value of the spacecraft clock at the end of a time period of interest.

^TABLE

Pointer to the CDR file which contains the data in ASCII table format. The structure of the data file is defined in a referenced format file.

OBJECT

Specifies that the CDR is a PDS TABLE object. This object contains its own elements, which are defined below. NOTE: the end of the object definition is always marked with an END_OBJECT line.

COLUMNS

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

INTERCHANGE_FORMAT

This element specifies that the table is in ASCII format.

ROW_BYTES

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

ROWS

Identifies the number of rows (records) in the table.

^STRUCTURE

This is a pointer to the external file which provides the structure definition for the table object.

The following describes the keywords used to describe the PDS Table Object. These keywords are contained in the FORMAT (.FMT) files for each CDR data product.

COLUMN_NUMBER

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

NAME

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

BYTES

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

DATA_TYPE

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

START_BYTE

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

ITEMS

Defines the number of multiple, identical occurrences of a single object. Used mainly in columns containing spectral or histogram data.

ITEM_BYTES

The size in bytes of individual items in a column. ITEMS * ITEM_BYTES should equal the value in the BYTES column.

The format file contains the full text for describing each column of the table. See Appendices for a listing of each field in the individual format files.

6.5 File Naming Conventions

The file names developed for PDS data volumes are restricted to a maximum 36-character file name and a 3-character extension name with a period separating the file and extension names. Given this restriction the general form of the EPPS file name for CDRs is "EEEZ_XYYYYDDDAAA_V#.TAB" where:

```
EEE    instrument identifier: represents the EPPS instrument

             EPS, EPPS/EPS

             FIP, EPPS/FIPS

Z       specifies whether the packet contains data taken from the high,

       medium, or low priority science packet

             A, Ancillary Data (not from a packet)
```

H, High Priority

M, Medium Priority

L, Low Priority

N, Not Applicable

P, Raw or Proton PHA packet

S, data from Scan packet

The FSW6 upload removed the EPS PHA association with priority,

thus N indicates N/A association for EPS PHA CDRs

While FIPS PHA EDR data can extracted from several packet types, these data are combined in the CDR product.

X specifies whether data contains PHA events, spectra/counts, rates, velocity distributions, or energy per charge table data.

P, PHA events

S, Spectra

R, Rates (i.e. Rate spectra)

V, Velocity distributions

E, E/q table

F, Pixel Field Of View table

NOTE: The FSW6 upload had the effect of retiring several CDRs and adding new ones. In order to keep the EEEZ_XYYYYDDDAAA_V#.TAB file naming convention the Z and X characters are used in conjunction to identify the new CDRs.

The values of Z_X for each of the EPS and FIPS data products is shown below:

EPS High Priority Spectra: Z_X = "H_S"

EPS Medium Priority Spectra: Z_X = "M_S"

```
EPS PHA:                       Z_X = "N_P"

EPS High Resolution Spectra:   Z_X = "H_R"

EPS Low Resolution Spectra:    Z_X = "L_R"

EPS Summary Spectra:           Z_X = "S_S"

EPS Scan:                      Z_X = "S_R"

FIPS High Priority Spectra:    Z_X = "H_S"

FIPS Medium Priority Spectra:  Z_X = "M_S"

FIPS PHA:                      Z_X = "P_P"

FIPS Scan :                    Z_X = "S_R"

FIPS HRPVD CDR:                Z_X = "S_V"

FIPS E/q table:                Z_X = "A_E"
```

```
YYYY   four digit year

DDD    three digit day of year

AAA    specifies whether the data product is an EDR or CDR

V#     Version number. The initial version is "V1". The version number
       increments to "V2", "V3", etc for each successive version of the CDR
       product that is produced. A new version of the CDR product may be
       produced as a result of an error in the product or as a result of errors
       discovered in the product generation process.

TAB    the file extension is dependent on the file type

              .TAB, EPS and FIPS Instrument Data in ASCII table

              .LBL, Detached PDS label file
```

6.6 Archive Volume and File Size

Two archive volumes are created to archive both the EPPS CDR data and the documentation which is needed to analyze the CDRs. The first volume is the EPPS Documentation Volume, having volume ID MESSEPPS_DOC. This documentation volume contains products related to the EPPS EDR, CDR, and DDR data archives. The documentation volume contains the following products:

1. All required PDS catalog files for the EDR and CDR archives.
2. The EDR, CDR, and DDR SIS documents.
3. The EPPS calibration procedures document.
4. Calibration tables.
5. Other documents considered useful by the MESSENGER project or the EPPS team.

The second archive volume, designated as the EPPS Data Archive Volume and having volume ID MESSEPPS_CDR, will contain the CDR data and required files for conforming to PDS volume archive standards. This includes the index files, AAREADME.TXT file, etc. The final CDR data archive volume size for the mission is 1.5 TB.

6.7 Directory Structure and Contents for EPPS Documentation Volume

The following illustration shows the directory structure overview for the EPPS documentation volume.

```
                             <ROOT>
           ______________________|______________________
           |                |               |           |
     <CALIBRATION>     <DOCUMENT>      <CATALOG>    <INDEX>
                            |
               _____________|_____________
               |            |            |
           <EDR_SIS>    <CDR_SIS>    <DDR_SIS>
```

Figure 2 Documentation Volume Structure

6.7.1 Directory Contents

<ROOT> DIRECTORY

This is the top-level volume directory. The following are files contained in the root directory.

AAREADME.TXT - General information file. Provides users with an overview of the contents and organization of the associated volume, general instructions for its use, and contact information.

VOLDESC.CAT - PDS file containing the VOLUME object. This gives a high-level description of the contents of the volume. Information includes: production date, producer name and institution, volume ID, etc.

ERRATA.TXT - Text file for identifying and describing errors and/or anomalies found in the current volume, and possibly previous volumes of a set. Any known errors for the associated volume are documented in this file.

<CALIBRATION> DIRECTORY

This contains the calibration tables needed to analyze the EPPS CDR data. The calibration tables are in ASCII format. Format files for the calibration tables are also located here, as are the following files.

CALINFO.TXT – Brief description of the directory contents and naming conventions.

EPPS_*_EDR2CDR.PDF: Describes the procedure used to convert EDRs to CDRs for each instrument, (EPS or FIPS as indicated by the * text).

IMAGES: Directory containing image files used by the HTML version of the EPPS_*_EDR2CDR documents.

FIP*.TAB: The FIPS energy per charge and pixel field of view tables.

<CATALOG> DIRECTORY

This subdirectory contains the catalog object files for the entire volume. The following files are included in the catalog subdirectory.

CATINFO.TXT: Identifies and describes the function of each file in the catalog directory**.**

EPPS*DATASET.CAT: Describes the general content of the EDR data set for each instrument, as (indicated by the * text) and includes information about the duration of the mission and the person or group responsible for producing the data.

EPPS*DATASET_CDR.CAT: Describes the general content of the CDR data set for each instrument, (as indicated by the * text) and includes information about the duration of the mission and the person or group responsible for producing the data.

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

INSTHOST.CAT: Describes the MESSENGER spacecraft.

MISSION.CAT: Describes the scientific goals and objectives of the MESSENGER program. It also identifies key people and institutions.

PERSON.CAT: Lists and provides contact information for the people involved in the MESSENGER mission, including those involved with EPPS.

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

< DOCUMENT > Directory

This subdirectory contains the documentation that is needed in order to understand and analyze the EDR and CDR data volumes. The documents are separated into individual subdirectories according to the document type. The document types are not restricted to the four shown in the graphical depiction of the directory structure. There are as many document types as needed to categorize each document. The following file is included in the subdirectory.

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

< INDEX > Directory

This subdirectory contains the MD5.TAB file, which contains MD5 hash values for the volume.

MD5.TAB/.LBL: Contains the MD5 hash values and label information.

6.8 Directory Structure and Contents for EPPS Data Volume

```
                         <ROOT>
     ___________________________|___________________________
    |                       |                 |             |
 <DATA>               <GEOMETRY>           <INDEX>       <LABEL>
    |
____|______________________________________________________________________
|      |          |          |            |        |        |              |
|      |   <EPS_HI_SPECTRA>  | <EPS_MED_SPECTRA>   | <EPS_SUMMARY_SPECTRA> |
|      |                     |                     |                       |
```

```
  | <EPS_PHA>       <EPS_HIRES_SPECTRA>    <EPS_LORES_SPECTRA>   <EPS_SCAN_SPECTRA>
 _|_______________________________________________________________________
              |              |             |             |             |
   <FIPS_HI_SPECTRA>   <FIPS_MED_SPECTRA>  |   <FIPS_HIRES_PROTON_V>    |
                                           |                            |
                                      <FIPS_SCAN>                  <FIPS_PHA>
                                           |
                                           |
                                        <2008>
```

Figure 3 Data Volume Directory Structure

6.8.1 Directory Contents

<ROOT> Directory

This is the top-level directory of a volume. The following are files contained in the root directory.

AAREADME.TXT - General information file. Provides users with an overview of the contents and organization of the associated volume, general instructions for its use, and contact information.

VOLDESC.CAT - PDS file containing the VOLUME object. This gives a high-level description of the contents of the volume. Information includes: production date, producer name and institution, volume ID, etc.

ERRATA.TXT - Text file for identifying and describing errors and/or anomalies found in the current volume, and possibly previous volumes of a set. Any known errors for the associated volume are documented in this file. This includes revised CDRs meant to replace CDRs in a previous PDS delivery.

<DATA> Directory

This top level directory contains the CDR data products. Directly underneath the <DATA> directory are subdirectories corresponding to the nine standard data products (section 5.2). The directories are further subdivided into YEAR and MONTH directories.

<GEOMETRY> Directory

This subdirectory contains information about the files (e.g. SPICE kernels, etc) needed to describe the observation geometry for the data.

GEOMINFO.TXT : Identifies and describes the SPICE kernels that a user must have in order to determine observation geometry for the data. The SPICE kernel files are archived with the PDS NAIF node.

<INDEX> Directory

This subdirectory contains the indices for all data products on the volume. The following files are contained in the index subdirectory.

INDXINFO.TXT – Identifies and describes the function of each file in the index subdirectory. This includes a description of the structure and contents of each index table in the subdirectory AND usage notes.

INDEX.TAB - The CDR index file is organized as a table: there is one entry for each of the data files included in the EPPS data set; the columns contain parameters that describe the observation and instrument and spacecraft parameters. These parameters include state information, such as integration time, spacecraft clock count, time of observation, and instrument modes.

INDEX.LBL - Detached PDS label for INDEX.TAB. It contains the INDEX_TABLE object which identifies and describes the columns of the EPPS index table.

MD5.TAB - The MD5 checksum file that contains MD5 hash values for every file in the volume.

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

<LABEL> Directory

This subdirectory contains the "label fragments" (i.e., the *.FMT files) for all data products on the volume. These format files describe the table and data objects which store the data.

7 Archive Release Schedule to PDS

The MESSENGER EPPS data and volume archives were transferred from the SOC to the PDS PPI Node using the transfer process detailed in section 5.3.3. The SPICE kernels will be transferred to the NAIF node. The transfers took place according to the schedule in [2].

8 Appendices

8.1 EPSHIGH_CDR.FMT Table Columns

The following are the columns as defined by the EPSHIGH_CDR.FMT structure file. This file defines the ASCII table containing the EPS High Priority spectra data. Archive volume is optimized by defining the table structure once and providing a reference to it in the PDS label file. The columns are numbered according to their column order in the table. Data_Type refers to the PDS standards data type for a particular column in the table.

The FSW6 upload was done on 8/18/2008 and implemented on 8/19/2008. The software update retired the EPS High Priority Spectra packet. Thus there are no EPS Hi Spectra CDRs on or after 8/19/2008.

Table 19 EPSHIGH_CDR.FMT Columns

Length (bytes)	Data Type	Column Name	Summary (see full text for column description)
21	TIME	TIME	Spacecraft event time (UTC) for this data record.
23	ASCII Integer	ACCUM_TIME	The time period over which the rates were accumulated. (Seconds)
23	ASCII Real	RADIAL_DIST	The distance of the spacecraft from Mercury. (Mercury radii)
23	ASCII Real	MSO_LOCAL_TIME	The Mercury longitude of the spacecraft. (Fractional Hours)
23	ASCII Real	MSO_LATITUDE	The Mercury latitude of the spacecraft. (Degrees)
23	ASCII Real	MSGR_MSO_X	The X position of the spacecraft in the MSO frame. (Mercury radii)
23	ASCII Real	MSGR_MSO_Y	The Y position of the spacecraft in the MSO frame. (Mercury radii)
23	ASCII Real	MSGR_MSO_Z	The Z position of the spacecraft in the MSO frame. (Mercury radii)
23x8	ASCII Real	ION_S00_RATES	Ion count rate spectrum for ion direction 0, 8 energy bins. (counts/sec)
23x8	ASCII Real	ION_S00_RATES_UNC	Ion count rate spectrum uncertainty for ion direction 0, 8 energy bins. (counts/sec)
23x8	ASCII Real	ION_S01_RATES	Ion count rate spectrum for ion direction 1, 8 energy bins. (counts/sec)
23x8	ASCII Real	ION_S01_RATES_UNC	Ion count rate spectrum uncertainty for ion direction 1, 8

			energy bins. (counts/sec)
23x8	ASCII Real	ION_S02_RATES	Ion count rate spectrum for ion direction 2, 8 energy bins. (counts/sec)
23x8	ASCII Real	ION_S02_RATES_UNC	Ion count rate spectrum uncertainty for ion direction 2, 8 energy bins. (counts/sec)
23x8	ASCII Real	ION_S03_RATES	Ion count rate spectrum for ion direction 3, 8 energy bins. (counts/sec)
23x8	ASCII Real	ION_S03_RATES_UNC	Ion count rate spectrum uncertainty for ion direction 3, 8 energy bins. (counts/sec)
23x8	ASCII Real	ION_S04_RATES	Ion count rate spectrum for ion direction 4, 8 energy bins. (counts/sec)
23x8	ASCII Real	ION_S04_RATES_UNC	Ion count rate spectrum uncertainty for ion direction 4, 8 energy bins. (counts/sec)
23x8	ASCII Real	ION_S05_RATES	Ion count rate spectrum for ion direction 5, 8 energy bins. (counts/sec)
23x8	ASCII Real	ION_S05_RATES_UNC	Ion count rate spectrum uncertainty for ion direction 5, 8 energy bins. (counts/sec)
23x8	ASCII Real	ION_S00_FLUX	Ion count rate spectrum for ion direction 0, 8 energy bins. (1/cm^2 sr keV sec)
23x8	ASCII Real	ION_S00_FLUX_UNC	Ion count rate spectrum uncertainty for ion direction 0, 8 energy bins. (1/cm^2 sr keV sec)
23x8	ASCII Real	ION_S01_FLUX	Ion count rate spectrum for ion direction 1, 8 energy bins. (1/cm^2 sr keV sec)
23x8	ASCII Real	ION_S01_FLUX_UNC	Ion count rate spectrum uncertainty for ion direction 0, 8

			energy bins. (1/cm^2 sr keV sec)
23x8	ASCII Real	ION_S02_FLUX	Ion count rate spectrum for ion direction 0, 8 energy bins. (1/cm^2 sr keV sec)
23x8	ASCII Real	ION_S02_FLUX_UNC	Ion count rate spectrum uncertainty for ion direction 0, 8 energy bins. (1/cm^2 sr keV sec)
23x8	ASCII Real	ION_S03_FLUX	Ion count rate spectrum for ion direction 0, 8 energy bins. (1/cm^2 sr keV sec)
23x8	ASCII Real	ION_S03_FLUX_UNC	Ion count rate spectrum uncertainty for ion direction 0, 8 energy bins. (1/cm^2 sr keV sec)
23x8	ASCII Real	ION_S04_FLUX	Ion count rate spectrum for ion direction 0, 8 energy bins. (1/cm^2 sr keV sec)
23x8	ASCII Real	ION_S04_FLUX_UNC	Ion count rate spectrum uncertainty for ion direction 0, 8 energy bins. (1/cm^2 sr keV sec)
23x8	ASCII Real	ION_S05_FLUX	Ion count rate spectrum for ion direction 0, 8 energy bins. (1/cm^2 sr keV sec)
23x8	ASCII Real	ION_S05_FLUX_UNC	Ion count rate spectrum uncertainty for ion direction 0, 8 energy bins. (1/cm^2 sr keV sec)
23x8	ASCII Real	COARSE_E_S00_RATES	Coarse electron count rate spectrum for electron direction 0, 8 energy bins. (counts/sec)
23x8	ASCII Real	COARSE_E_S00_RATES_UNC	Coarse electron count rate spectrum uncertainty for electron direction 0, 8 energy bins. (counts/sec)
23x8	ASCII Real	COARSE_E_S01_RATES	Coarse electron count rate spectrum for electron direction 1, 8 energy bins. (counts/sec)

23x8	ASCII Real	COARSE_E_S01_RATES_UNC	Coarse electron count rate spectrum uncertainty for electron direction 1, 8 energy bins. (counts/sec)
23x8	ASCII Real	COARSE_E_S02_RATES	Coarse electron count rate spectrum for electron direction 2, 8 energy bins. (counts/sec)
23x8	ASCII Real	COARSE_E_S02_RATES_UNC	Coarse electron count rate spectrum uncertainty for electron direction 2, 8 energy bins. (counts/sec)
23x8	ASCII Real	COARSE_E_S03_RATES	Coarse electron count rate spectrum for electron direction 3, 8 energy bins. (counts/sec)
23x8	ASCII Real	COARSE_E_S03_RATES_UNC	Coarse electron count rate spectrum uncertainty for electron direction 3, 8 energy bins. (counts/sec)
23x8	ASCII Real	COARSE_E_S04_RATES	Coarse electron count rate spectrum for electron direction 4, 8 energy bins. (counts/sec)
23x8	ASCII Real	COARSE_E_S04_RATES_UNC	Coarse electron count rate spectrum uncertainty for electron direction 4, 8 energy bins. (counts/sec)
23x8	ASCII Real	COARSE_E_S05_RATES	Coarse electron count rate spectrum for electron direction 5, 8 energy bins. (counts/sec)
23x8	ASCII Real	COARSE_E_S05_RATES_UNC	Coarse electron count rate spectrum uncertainty for electron direction 5, 8 energy bins. (counts/sec)
23x8	ASCII Real	COARSE_E_S00_FLUX	Coarse electron flux spectrum for electron direction 0, 8 energy bins. (1/cm^2 sr keV sec)
23x8	ASCII Real	COARSE_E_S00_FLUX_UNC	Coarse electron flux spectrum uncertainty for electron direction 0, 8 energy bins. (1/cm^2 sr keV

			sec)
23x8	ASCII Real	COARSE_E_S01_FLUX	Coarse electron flux spectrum for electron direction 1, 8 energy bins. (1/cm^2 sr keV sec)
23x8	ASCII Real	COARSE_E_S01_FLUX_UNC	Coarse electron flux spectrum uncertainty for electron direction 0, 8 energy bins. (1/cm^2 sr keV sec)
23x8	ASCII Real	COARSE_E_S02_FLUX	Coarse electron flux spectrum for electron direction 0, 8 energy bins. (1/cm^2 sr keV sec)
23x8	ASCII Real	COARSE_E_S02_FLUX_UNC	Coarse electron flux spectrum uncertainty for electron direction 0, 8 energy bins. (1/cm^2 sr keV sec)
23x8	ASCII Real	COARSE_E_S03_FLUX	Coarse electron flux spectrum for electron direction 0, 8 energy bins. (1/cm^2 sr keV sec)
23x8	ASCII Real	COARSE_E_S03_FLUX_UNC	Coarse electron flux spectrum uncertainty for electron direction 0, 8 energy bins. (1/cm^2 sr keV sec)
23x8	ASCII Real	COARSE_E_S04_FLUX	Coarse electron flux spectrum for electron direction 0, 8 energy bins. (1/cm^2 sr keV sec)
23x8	ASCII Real	COARSE_E_S04_FLUX_UNC	Coarse electron flux spectrum uncertainty for electron direction 0, 8 energy bins. (1/cm^2 sr keV sec)
23x8	ASCII Real	COARSE_E_S05_FLUX	Coarse electron flux spectrum for electron direction 0, 8 energy bins. (1/cm^2 sr keV sec)
23x8	ASCII Real	COARSE_E_S05_FLUX_UNC	Coarse electron flux spectrum uncertainty for electron direction 0, 8 energy bins. (1/cm^2 sr keV sec)

23x12	ASCII Real	FAST_ENERGY_RATE	The 12 fast energy hardware count rates. (counts/sec)
23x12	ASCII Real	SHAPED_ENERGY_RATE	The 12 shaped energy hardware count rates. (counts/sec)
23	ASCII Real	E_EVENT_RATE	Electron event hardware count rate. (counts/sec)
23	ASCII Real	ION_EVENT_RATE	Ion event hardware count rate. (counts/sec)
23	ASCII Real	E_PROCESSED_RATE	Ion event hardware count rate. (counts/sec)
23	ASCII Real	ION_PROCESSED_RATE	Ion event hardware count rate. (counts/sec)
23	ASCII Real	PILEUP_E_DISCARD_RATE	Rate of electron events discarded due to pileup condition. (counts/sec)
23	ASCII Real	MULTIPLE_E_HITS_DISCARD_RATE	Rate of electron events discarded due to multiple hits. (counts/sec)
23	ASCII Real	PILEUP_ION_DISCARD_RATE	Rate of ion events discarded due to pileup condition. (counts/sec)
23	ASCII Real	MULTIPLE_ION_HITS_DISCARD_RATE	Rate of ion events discarded due to multiple hits. (counts/sec)
23x10	ASCII Real	FINE_E_S00B00_RATE	Ten sub-sampled electron count rates, super bin 0 from electron direction 0. (counts/sec)
23x10	ASCII Real	FINE_E_S00B00_RATE_UNC	Uncertainties for ten sub-sampled electron count rates, super bin 0 from electron direction 0. (counts/sec)
23x10	ASCII Real	FINE_E_S00B01_RATE	Ten sub-sampled electron count rates, super bin 1 from electron direction 0. (counts/sec)
23x10	ASCII Real	FINE_E_S00B01_RATE_UNC	Uncertainties for ten sub-sampled electron count rates, super bin 1 from electron direction 0. (counts/sec)

23x10	ASCII Real	FINE_E_S01B00_RATE	Ten sub-sampled electron count rates, super bin 0 from electron direction 1. (counts/sec)
23x10	ASCII Real	FINE_E_S01B00_RATE_UNC	Uncertainties for ten sub-sampled electron count rates, super bin 0 from electron direction 1. (counts/sec)
23x10	ASCII Real	FINE_E_S01B01_RATE	Ten sub-sampled electron count rates, super bin 1 from electron direction 1. (counts/sec)
23x10	ASCII Real	FINE_E_S01B01_RATE_UNC	Uncertainties for ten sub-sampled electron count rates, super bin 1 from electron direction 1. (counts/sec)
23x10	ASCII Real	FINE_E_S02B00_RATE	Ten sub-sampled electron count rates, super bin 0 from electron direction 2. (counts/sec)
23x10	ASCII Real	FINE_E_S02B00_RATE_UNC	Uncertainties for ten sub-sampled electron count rates, super bin 0 from electron direction 2. (counts/sec)
23x10	ASCII Real	FINE_E_S02B01_RATE	Ten sub-sampled electron count rates, super bin 1 from electron direction 2. (counts/sec)
23x10	ASCII Real	FINE_E_S02B01_RATE_UNC	Uncertainties for ten sub-sampled electron count rates, super bin 1 from electron direction 2. (counts/sec)
23x10	ASCII Real	FINE_E_S03B00_RATE	Ten sub-sampled electron count rates, super bin 0 from electron direction 3. (counts/sec)
23x10	ASCII Real	FINE_E_S03B00_RATE_UNC	Uncertainties for ten sub-sampled electron count rates, super bin 0 from electron direction 3. (counts/sec)
23x10	ASCII Real	FINE_E_S03B01_RATE	Ten sub-sampled electron count rates, super bin 1 from electron

			direction 3. (counts/sec)
23x10	ASCII Real	FINE_E_S03B01_RATE_UNC	Uncertainties for ten sub-sampled electron count rates, super bin 1 from electron direction 3. (counts/sec)
23x10	ASCII Real	FINE_E_S04B00_RATE	Ten sub-sampled electron count rates, super bin 0 from electron direction 4. (counts/sec)
23x10	ASCII Real	FINE_E_S04B00_RATE_UNC	Uncertainties for ten sub-sampled electron count rates, super bin 0 from electron direction 4. (counts/sec)
23x10	ASCII Real	FINE_E_S04B01_RATE	Ten sub-sampled electron count rates, super bin 1 from electron direction 4. (counts/sec)
23x10	ASCII Real	FINE_E_S04B01_RATE_UNC	Uncertainties for ten sub-sampled electron count rates, super bin 1 from electron direction 4. (counts/sec)
23x10	ASCII Real	FINE_E_S05B00_RATE	Ten sub-sampled electron count rates, super bin 0 from electron direction 5. (counts/sec)
23x10	ASCII Real	FINE_E_S05B00_RATE_UNC	Uncertainties for ten sub-sampled electron count rates, super bin 0 from electron direction 5. (counts/sec)
23x10	ASCII Real	FINE_E_S05B01_RATE	Ten sub-sampled electron count rates, super bin 1 from electron direction 5. (counts/sec)
23x10	ASCII Real	FINE_E_S05B01_RATE_UNC	Uncertainties for ten sub-sampled electron count rates, super bin 1 from electron direction 5. (counts/sec)
23x10	ASCII Real	FINE_E_S00B00_FLUX	Ten sub-sampled electron fluxes, super bin 0 from electron direction 0. (1/cm^s sr keV sec)

23x10	ASCII Real	FINE_E_S00B00_FLUX_UNC	Uncertainties for ten sub-sampled electron fluxes, super bin 0 from electron direction 0. (1/cm^s sr keV sec)
23x10	ASCII Real	FINE_E_S00B01_FLUX	Ten sub-sampled electron fluxes, super bin 1 from electron direction 0. (1/cm^s sr keV sec)
23x10	ASCII Real	FINE_E_S00B01_FLUX_UNC	Uncertainties for ten sub-sampled electron fluxes, super bin 1 from electron direction 0. (1/cm^s sr keV sec)
23x10	ASCII Real	FINE_E_S01B00_FLUX	Ten sub-sampled electron fluxes, super bin 0 from electron direction 1. (1/cm^s sr keV sec)
23x10	ASCII Real	FINE_E_S01B00_FLUX_UNC	Uncertainties for ten sub-sampled electron fluxes, super bin 0 from electron direction 1. (1/cm^s sr keV sec)
23x10	ASCII Real	FINE_E_S01B01_FLUX	Ten sub-sampled electron fluxes, super bin 1 from electron direction 1. (1/cm^s sr keV sec)
23x10	ASCII Real	FINE_E_S01B01_FLUX_UNC	Uncertainties for ten sub-sampled electron fluxes, super bin 1 from electron direction 1. (1/cm^s sr keV sec)
23x10	ASCII Real	FINE_E_S02B00_FLUX	Ten sub-sampled electron fluxes, super bin 0 from electron direction 2. (1/cm^s sr keV sec)
23x10	ASCII Real	FINE_E_S02B00_FLUX_UNC	Uncertainties for ten sub-sampled electron fluxes, super bin 0 from electron direction 2. (1/cm^s sr keV sec)
23x10	ASCII Real	FINE_E_S02B01_FLUX	Ten sub-sampled electron fluxes, super bin 1 from electron direction 2. (1/cm^s sr keV sec)
23x10	ASCII Real	FINE_E_S02B01_FLUX_UNC	Uncertainties for ten sub-sampled electron fluxes, super bin 1 from electron direction 2. (1/cm^s sr

			keV sec)
23x10	ASCII Real	FINE_E_S03B00_FLUX	Ten sub-sampled electron fluxes, super bin 0 from electron direction 3. (1/cm^s sr keV sec)
23x10	ASCII Real	FINE_E_S03B00_FLUX_UNC	Uncertainties for ten sub-sampled electron fluxes, super bin 0 from electron direction 3. (1/cm^s sr keV sec)
23x10	ASCII Real	FINE_E_S03B01_FLUX	Ten sub-sampled electron fluxes, super bin 1 from electron direction 3. (1/cm^s sr keV sec)
23x10	ASCII Real	FINE_E_S03B01_FLUX_UNC	Uncertainties for ten sub-sampled electron fluxes, super bin 1 from electron direction 3. (1/cm^s sr keV sec)
23x10	ASCII Real	FINE_E_S04B00_FLUX	Ten sub-sampled electron fluxes, super bin 0 from electron direction 4. (1/cm^s sr keV sec)
23x10	ASCII Real	FINE_E_S04B00_FLUX_UNC	Uncertainties for ten sub-sampled electron fluxes, super bin 0 from electron direction 4. (1/cm^s sr keV sec)
23x10	ASCII Real	FINE_E_S04B01_FLUX	Ten sub-sampled electron fluxes, super bin 1 from electron direction 4. (1/cm^s sr keV sec)
23x10	ASCII Real	FINE_E_S04B01_FLUX_UNC	Uncertainties for ten sub-sampled electron fluxes, super bin 1 from electron direction 4. (1/cm^s sr keV sec)
23x10	ASCII Real	FINE_E_S05B00_FLUX	Ten sub-sampled electron fluxes, super bin 0 from electron direction 5. (1/cm^s sr keV sec)
23x10	ASCII Real	FINE_E_S05B00_FLUX_UNC	Uncertainties for ten sub-sampled electron fluxes, super bin 0 from electron direction 5. (1/cm^s sr keV sec)

23x10	ASCII Real	FINE_E_S05B01_FLUX	Ten sub-sampled electron fluxes, super bin 1 from electron direction 5. (1/cm^s sr keV sec)
23x10	ASCII Real	FINE_E_S05B01_FLUX_UNC	Uncertainties for ten sub-sampled electron fluxes, super bin 1 from electron direction 5. (1/cm^s sr keV sec)

1. **TIME**

Spacecraft event time (UTC) for this data record.

2. **ACCUM_TIME**

The length of the accumulation interval for this data record.

3. **RADIAL_DIST**

The distance of the spacecraft from Mercury in the MSO frame, in units of Mercury radii..

4. **MSO_LOCAL_TIME**

The Mercury longitude of the spacecraft expressed in fractional hours.

5. **MSO_LATITUDE**

The Mercury latitude of the spacecraft in degrees.

6. **MSGR_MSO_X**

The X position of the spacecraft in the MSO frame, in units of Mercury radii.

7. **MSGR_MSO_Y**

The Y position of the spacecraft in the MSO frame, in units of Mercury radii.

8. MSGR_MSO_Z

The Z position of the spacecraft in the MSO frame, in units of Mercury radii.

9. ION_Sn_RATES

Ion rate (counts/second) histogram for ion direction n (SSD detector n*2+1), which is 1 of the 6 ion directions (0 through 5) that define the entire 160 degree field of view of the sensor for ions, and each representing about 27 degrees out of the entire field of view. Histogram contains the 8 bins shown in Table 3 and Table 5.

10. ION_Sn_RATES_UNC

Uncertainties for the ION_Sn_RATES.

11. ION_Sn_FLUX

Ion flux (1/cm^2 sr keV sec) histogram for ion direction n (SSD detector n*2+1), which is 1 of the 6 ion directions (0 through 5) that define the entire 160 degree field of view of the sensor for ions, and each representing about 27 degrees out of the entire field of view. Histogram contains the 8 bins shown in Table 3 and Table 5.

12. ION_Sn_FLUX_UNC

Uncertainties for the ION_Sn_FLUX.

13. COARSE_E_Sn_RATES

Electron rate (counts/second) histogram for electron direction n (SSD detector n*2), which is 1 of the 6 electron directions (0 through 5) that define the entire 160 degree field of view of the sensor for electrons, and each representing about 27 degrees out of the entire field of view. Histogram contains the 8 bins shown in Table 4 and Table 6.

14. COARSE_E_Sn_RATES_UNC

Uncertainties for the COARSE_E_Sn_RATES.

15. COARSE_E_Sn_FLUX

Electron flux (1/cm^2 sr keV sec) histogram for electron direction n (SSD detector n*2), which is 1 of the 6 ion directions (0 through 5) that define the entire 160 degree field of view of the sensor for ions, and each representing about 27 degrees out of the entire field of view. Histogram contains the 8 bins shown in Table 3 and Table 5.

16. COARSE_E_Sn_FLUX_UNC

Uncertainties for the COARSE_E_Sn_FLUX.

17. FAST_ENERGY_RATE

Fast energy hardware counter from one of 12 Solid State Detectors that define the 160 degree sensor field of view for both electrons and ions. All even-numbered SSDs are electrons and all odd channels are ions. This channel is the rate (counts/sec) of pulses whose amplitude is used to determine the energy of the particle that generated the pulse.

18. SHAPED_ENERGY_RATE

Shaped energy hardware counter from one of 12 Solid State Detectors that define the 160 degree sensor field of view for both electrons and ions. All even-numbered SSDs are electrons and all odd channels are ions. This channel is the rate (counts/sec) of pulses whose amplitude is used to determine the energy of the particle that generated the pulse.

19. E_EVENT_RATE

Hardware rate (counts/sec) for all classified Electron events registered in the fast processing electronics upstream from the Event Processing Computer. Because the Event Processing Computer can process at most about 5000 events, this counter allows the user to renormalize the processed output rates to retrieve true intensities.

20. ION_EVENT_RATE

Hardware rate (counts/sec) for all classified Ion events registered in the fast processing electronics upstream from the Event Processing Computer. Because the Event Processing Computer can process at most about 5000 events, this counter allows the user to renormalize the processed output rates to retrieve true intensities.

21. E_PROCESSED_RATE

Rate (counts/sec) of electron events processed by the Event Processing Computer during the accumulation interval.

22. ION_PROCESSED_RATE

Rate of high energy ion events processed by the Event Processing Computer during the accumulation interval.

23. PILEUP_E_DISCARD_RATE

Rate of electron events discarded by the Event Processing Computer due to pileup condition.

24. MULTIPLE_E_HITS_DISCARD_RATE

Rate of electron events discarded by the Event Processing Computer due to multiple electron hits.

25. PILEUP_ION_DISCARD_RATE

Rate of high energy ion events discarded by the Event Processing Computer due to pileup condition.

26. MULTIPLE_ION_DISCARD_RATE

Rate of high energy ion events discarded by the Event Processing Computer due to multiple ion hits.

27. FINE_E_S0nB0m_RATE

A series of 10 count rates (counts/sec) for "super bin m" for electron direction n (SSD detector 2*n), which is 1 of the 6 electron directions (numbered 0 through 5) that define the entire 160 degree field of view of the sensor, and each representing about 27 degrees out of the entire field of view. Each super bin is the accumulation of a subset of bin counts in one 1/10 *(ACCUM_TIME) subinterval. Super bin 0 is the sum of the energy bins 0-3 shown in Table 4 and Table 6. Super bin 1 is the sum of bins 4-7 shown in Table 4 and Table 6. Each super bin pair is measured once per subinterval for 10 subintervals, making a total of 20 items.

28. FINE_E_S0nB0m_RATE_UNC

Uncertainties for FINE_E_S0nB0m_RATE

29. FINE_E_S0nB0m_FLUX

A series of 10 count rates (1/cm^2 sr keV sec) for "super bin m" for electron direction n (SSD detector 2*n), which is 1 of the 6 electron directions (numbered 0 through 5) that define the entire 160 degree field of view of the sensor, and each representing about 27 degrees out of the entire field of view. Each super bin is the accumulation of a subset of bin counts in one 1/10*(ACCUM_TIME) subinterval. Super bin 0 is the sum of the energy bins 0-3 shown in Table 4 and Table 6. Super bin 1 is the sum of bins 4-7 shown in Table 4 and Table 6. Each super bin pair is measured once per subinterval for 10 subintervals, making a total of 20 items.

30. FINE_E_S0nB0m_FLUX_UNC

Uncertainties for FINE_E_S0nB0m_FLUX

8.2 EPSMED_CDR.FMT Table Columns

The following are the columns as defined by the EPSMED_CDR.FMT structure file. This file defines the ASCII table containing the EPS Medium Priority spectra data. Archive volume is optimized by defining the table structure once and providing a reference to it in the PDS label file. The columns are numbered according to their column order in the table. Data_Type refers to the PDS standards data type for a particular column in the table.

The FSW6 upload was done on 8/18/2008 and implemented on 8/19/2008. The software update retired the EPS Medium Priority Spectra packet. Thus there are no EPS Medium Priority CDRs on or after 8/19/2008.

Table 20 EPSMED_CDR.FMT Columns

Length (bytes)	Data Type	Column Name	Summary (see full text for column description)
21	TIME	TIME	Spacecraft event time (UTC) for this data record.
23	ASCII Integer	ACCUM_TIME	The time period over which the rates were accumulated. (Seconds)
23	ASCII Real	RADIAL_DIST	The distance of the spacecraft from Mercury. (Mercury radii)

23	ASCII Real	MSO_LOCAL_TIME	The Mercury longitude of the spacecraft. (Fractional Hours)
23	ASCII Real	MSO_LATITUDE	The Mercury latitude of the spacecraft. (Degrees)
23	ASCII Real	MSGR_MSO_X	The X position of the spacecraft in the MSO frame. (Mercury radii)
23	ASCII Real	MSGR_MSO_Y	The Y position of the spacecraft in the MSO frame. (Mercury radii)
23	ASCII Real	MSGR_MSO_Z	The Z position of the spacecraft in the MSO frame. (Mercury radii)
23x8	ASCII Real	ION_S00_RATES	Ion count rate spectrum for ion direction 0, 8 energy bins. (counts/sec)
23x8	ASCII Real	ION_S00_RATES_UNC	Ion count rate spectrum uncertainty for ion direction 0, 8 energy bins. (counts/sec)
23x8	ASCII Real	ION_S01_RATES	Ion count rate spectrum for ion direction 1, 8 energy bins. (counts/sec)
23x8	ASCII Real	ION_S01_RATES_UNC	Ion count rate spectrum uncertainty for ion direction 1, 8 energy bins. (counts/sec)
23x8	ASCII Real	ION_S02_RATES	Ion count rate spectrum for ion direction 2, 8 energy bins. (counts/sec)
23x8	ASCII Real	ION_S02_RATES_UNC	Ion count rate spectrum uncertainty for ion direction 2, 8 energy bins. (counts/sec)
23x8	ASCII Real	ION_S03_RATES	Ion count rate spectrum for ion direction 3, 8 energy bins. (counts/sec)
23x8	ASCII Real	ION_S03_RATES_UNC	Ion count rate spectrum uncertainty for ion direction 3, 8 energy bins. (counts/sec)
23x8	ASCII Real	ION_S04_RATES	Ion count rate spectrum for ion

			direction 4, 8 energy bins. (counts/sec)
23x8	ASCII Real	ION_S04_RATES_UNC	Ion count rate spectrum uncertainty for ion direction 4, 8 energy bins. (counts/sec)
23x8	ASCII Real	ION_S05_RATES	Ion count rate spectrum for ion direction 5, 8 energy bins. (counts/sec)
23x8	ASCII Real	ION_S05_RATES_UNC	Ion count rate spectrum uncertainty for ion direction 5, 8 energy bins. (counts/sec)
23x8	ASCII Real	ION_S00_FLUX	Ion count rate spectrum for ion direction 0, 8 energy bins. (1/cm^2 sr keV sec)
23x8	ASCII Real	ION_S00_FLUX_UNC	Ion count rate spectrum uncertainty for ion direction 0, 8 energy bins. (1/cm^2 sr keV sec)
23x8	ASCII Real	ION_S01_FLUX	Ion count rate spectrum for ion direction 1, 8 energy bins. (1/cm^2 sr keV sec)
23x8	ASCII Real	ION_S01_FLUX_UNC	Ion count rate spectrum uncertainty for ion direction 0, 8 energy bins. (1/cm^2 sr keV sec)
23x8	ASCII Real	ION_S02_FLUX	Ion count rate spectrum for ion direction 0, 8 energy bins. (1/cm^2 sr keV sec)
23x8	ASCII Real	ION_S02_FLUX_UNC	Ion count rate spectrum uncertainty for ion direction 0, 8 energy bins. (1/cm^2 sr keV sec)
23x8	ASCII Real	ION_S03_FLUX	Ion count rate spectrum for ion direction 0, 8 energy bins. (1/cm^2 sr keV sec)
23x8	ASCII Real	ION_S03_FLUX_UNC	Ion count rate spectrum uncertainty for ion direction 0, 8 energy bins. (1/cm^2 sr keV sec)

23x8	ASCII Real	ION_S04_FLUX	Ion count rate spectrum for ion direction 0, 8 energy bins. (1/cm^2 sr keV sec)
23x8	ASCII Real	ION_S04_FLUX_UNC	Ion count rate spectrum uncertainty for ion direction 0, 8 energy bins. (1/cm^2 sr keV sec)
23x8	ASCII Real	ION_S05_FLUX	Ion count rate spectrum for ion direction 0, 8 energy bins. (1/cm^2 sr keV sec)
23x8	ASCII Real	ION_S05_FLUX_UNC	Ion count rate spectrum uncertainty for ion direction 0, 8 energy bins. (1/cm^2 sr keV sec)
23x8	ASCII Real	COARSE_E_S00_RATES	Coarse electron count rate spectrum for electron direction 0, 8 energy bins. (counts/sec)
23x8	ASCII Real	COARSE_E_S00_RATES_UNC	Coarse electron count rate spectrum uncertainty for electron direction 0, 8 energy bins. (counts/sec)
23x8	ASCII Real	COARSE_E_S01_RATES	Coarse electron count rate spectrum for electron direction 1, 8 energy bins. (counts/sec)
23x8	ASCII Real	COARSE_E_S01_RATES_UNC	Coarse electron count rate spectrum uncertainty for electron direction 1, 8 energy bins. (counts/sec)
23x8	ASCII Real	COARSE_E_S02_RATES	Coarse electron count rate spectrum for electron direction 2, 8 energy bins. (counts/sec)
23x8	ASCII Real	COARSE_E_S02_RATES_UNC	Coarse electron count rate spectrum uncertainty for electron direction 2, 8 energy bins. (counts/sec)
23x8	ASCII Real	COARSE_E_S03_RATES	Coarse electron count rate spectrum for electron direction 3, 8 energy bins. (counts/sec)
23x8	ASCII Real	COARSE_E_S03_RATES_UNC	Coarse electron count rate spectrum uncertainty for electron direction 3, 8 energy bins. (counts/sec)

23x8	ASCII Real	COARSE_E_S04_RATES	Coarse electron count rate spectrum for electron direction 4, 8 energy bins. (counts/sec)
23x8	ASCII Real	COARSE_E_S04_RATES_UNC	Coarse electron count rate spectrum uncertainty for electron direction 4, 8 energy bins. (counts/sec)
23x8	ASCII Real	COARSE_E_S05_RATES	Coarse electron count rate spectrum for electron direction 5, 8 energy bins. (counts/sec)
23x8	ASCII Real	COARSE_E_S05_RATES_UNC	Coarse electron count rate spectrum uncertainty for electron direction 5, 8 energy bins. (counts/sec)
23x8	ASCII Real	COARSE_E_S00_FLUX	Coarse electron flux spectrum for electron direction 0, 8 energy bins. (1/cm^2 sr keV sec)
23x8	ASCII Real	COARSE_E_S00_FLUX_UNC	Coarse electron flux spectrum uncertainty for electron direction 0, 8 energy bins. (1/cm^2 sr keV sec)
23x8	ASCII Real	COARSE_E_S01_FLUX	Coarse electron flux spectrum for electron direction 1, 8 energy bins. (1/cm^2 sr keV sec)
23x8	ASCII Real	COARSE_E_S01_FLUX_UNC	Coarse electron flux spectrum uncertainty for electron direction 0, 8 energy bins. (1/cm^2 sr keV sec)
23x8	ASCII Real	COARSE_E_S02_FLUX	Coarse electron flux spectrum for electron direction 0, 8 energy bins. (1/cm^2 sr keV sec)
23x8	ASCII Real	COARSE_E_S02_FLUX_UNC	Coarse electron flux spectrum uncertainty for electron direction 0, 8 energy bins. (1/cm^2 sr keV sec)
23x8	ASCII Real	COARSE_E_S03_FLUX	Coarse electron flux spectrum for electron direction 0, 8 energy bins. (1/cm^2 sr keV sec)
23x8	ASCII Real	COARSE_E_S03_FLUX_UNC	Coarse electron flux spectrum uncertainty for electron direction 0, 8 energy bins. (1/cm^2 sr keV sec)

23x8	ASCII Real	COARSE_E_S04_FLUX	Coarse electron flux spectrum for electron direction 0, 8 energy bins. (1/cm^2 sr keV sec)
23x8	ASCII Real	COARSE_E_S04_FLUX_UNC	Coarse electron flux spectrum uncertainty for electron direction 0, 8 energy bins. (1/cm^2 sr keV sec)
23x8	ASCII Real	COARSE_E_S05_FLUX	Coarse electron flux spectrum for electron direction 0, 8 energy bins. (1/cm^2 sr keV sec)
23x8	ASCII Real	COARSE_E_S05_FLUX_UNC	Coarse electron flux spectrum uncertainty for electron direction 0, 8 energy bins. (1/cm^2 sr keV sec)
23x12	ASCII Real	SHAPED_ENERGY_RATE	The 12 shaped energy hardware count rates. (counts/sec)
23	ASCII Real	E_EVENT_RATE	Electron event hardware count rate. (counts/sec)
23	ASCII Real	ION_EVENT_RATE	Ion event hardware count rate. (counts/sec)
23	ASCII Real	E_PROCESSED_RATE	Ion event hardware count rate. (counts/sec)
23	ASCII Real	ION_PROCESSED_RATE	Ion event hardware count rate. (counts/sec)
23	ASCII Real	PILEUP_E_DISCARD_RATE	Rate of electron events discarded due to pileup condition. (counts/sec)
23	ASCII Real	MULTIPLE_E_HITS_DISCARD_RATE	Rate of electron events discarded due to multiple hits. (counts/sec)
23	ASCII Real	PILEUP_ION_DISCARD_RATE	Rate of ion events discarded due to pileup condition. (counts/sec)
23	ASCII Real	MULTIPLE_ION_HITS_DISCARD_RATE	Rate of ion events discarded due to multiple hits. (counts/sec)
23x10	ASCII Real	FINE_E_S00B00_RATE	Ten sub-sampled electron count rates, super bin 0 from electron direction 0. (counts/sec)
23x10	ASCII Real	FINE_E_S00B00_RATE_UNC	Uncertainties for ten sub-sampled electron count rates, super bin 0 from

			electron direction 0. (counts/sec)
23x10	ASCII Real	FINE_E_S00B01_RATE	Ten sub-sampled electron count rates, super bin 1 from electron direction 0. (counts/sec)
23x10	ASCII Real	FINE_E_S00B01_RATE_UNC	Uncertainties for ten sub-sampled electron count rates, super bin 1 from electron direction 0. (counts/sec)
23x10	ASCII Real	FINE_E_S01B00_RATE	Ten sub-sampled electron count rates, super bin 0 from electron direction 1. (counts/sec)
23x10	ASCII Real	FINE_E_S01B00_RATE_UNC	Uncertainties for ten sub-sampled electron count rates, super bin 0 from electron direction 1. (counts/sec)
23x10	ASCII Real	FINE_E_S01B01_RATE	Ten sub-sampled electron count rates, super bin 1 from electron direction 1. (counts/sec)
23x10	ASCII Real	FINE_E_S01B01_RATE_UNC	Uncertainties for ten sub-sampled electron count rates, super bin 1 from electron direction 1. (counts/sec)
23x10	ASCII Real	FINE_E_S02B00_RATE	Ten sub-sampled electron count rates, super bin 0 from electron direction 2. (counts/sec)
23x10	ASCII Real	FINE_E_S02B00_RATE_UNC	Uncertainties for ten sub-sampled electron count rates, super bin 0 from electron direction 2. (counts/sec)
23x10	ASCII Real	FINE_E_S02B01_RATE	Ten sub-sampled electron count rates, super bin 1 from electron direction 2. (counts/sec)
23x10	ASCII Real	FINE_E_S02B01_RATE_UNC	Uncertainties for ten sub-sampled electron count rates, super bin 1 from electron direction 2. (counts/sec)
23x10	ASCII Real	FINE_E_S03B00_RATE	Ten sub-sampled electron count rates, super bin 0 from electron direction 3. (counts/sec)
23x10	ASCII Real	FINE_E_S03B00_RATE_UNC	Uncertainties for ten sub-sampled electron count rates, super bin 0 from

			electron direction 3. (counts/sec)
23x10	ASCII Real	FINE_E_S03B01_RATE	Ten sub-sampled electron count rates, super bin 1 from electron direction 3. (counts/sec)
23x10	ASCII Real	FINE_E_S03B01_RATE_UNC	Uncertainties for ten sub-sampled electron count rates, super bin 1 from electron direction 3. (counts/sec)
23x10	ASCII Real	FINE_E_S04B00_RATE	Ten sub-sampled electron count rates, super bin 0 from electron direction 4. (counts/sec)
23x10	ASCII Real	FINE_E_S04B00_RATE_UNC	Uncertainties for ten sub-sampled electron count rates, super bin 0 from electron direction 4. (counts/sec)
23x10	ASCII Real	FINE_E_S04B01_RATE	Ten sub-sampled electron count rates, super bin 1 from electron direction 4. (counts/sec)
23x10	ASCII Real	FINE_E_S04B01_RATE_UNC	Uncertainties for ten sub-sampled electron count rates, super bin 1 from electron direction 4. (counts/sec)
23x10	ASCII Real	FINE_E_S05B00_RATE	Ten sub-sampled electron count rates, super bin 0 from electron direction 5. (counts/sec)
23x10	ASCII Real	FINE_E_S05B00_RATE_UNC	Uncertainties for ten sub-sampled electron count rates, super bin 0 from electron direction 5. (counts/sec)
23x10	ASCII Real	FINE_E_S05B01_RATE	Ten sub-sampled electron count rates, super bin 1 from electron direction 5. (counts/sec)
23x10	ASCII Real	FINE_E_S05B01_RATE_UNC	Uncertainties for ten sub-sampled electron count rates, super bin 1 from electron direction 5. (counts/sec)
23x10	ASCII Real	FINE_E_S00B00_FLUX	Ten sub-sampled electron fluxes, super bin 0 from electron direction 0. (1/cm^s sr keV sec)
23x10	ASCII Real	FINE_E_S00B00_FLUX_UNC	Uncertainties for ten sub-sampled electron fluxes, super bin 0 from

			electron direction 0. (1/cm^s sr keV sec)
23x10	ASCII Real	FINE_E_S00B01_FLUX	Ten sub-sampled electron fluxes, super bin 1 from electron direction 0. (1/cm^s sr keV sec)
23x10	ASCII Real	FINE_E_S00B01_FLUX_UNC	Uncertainties for ten sub-sampled electron fluxes, super bin 1 from electron direction 0. (1/cm^s sr keV sec)
23x10	ASCII Real	FINE_E_S01B00_FLUX	Ten sub-sampled electron fluxes, super bin 0 from electron direction 1. (1/cm^s sr keV sec)
23x10	ASCII Real	FINE_E_S01B00_FLUX_UNC	Uncertainties for ten sub-sampled electron fluxes, super bin 0 from electron direction 1. (1/cm^s sr keV sec)
23x10	ASCII Real	FINE_E_S01B01_FLUX	Ten sub-sampled electron fluxes, super bin 1 from electron direction 1. (1/cm^s sr keV sec)
23x10	ASCII Real	FINE_E_S01B01_FLUX_UNC	Uncertainties for ten sub-sampled electron fluxes, super bin 1 from electron direction 1. (1/cm^s sr keV sec)
23x10	ASCII Real	FINE_E_S02B00_FLUX	Ten sub-sampled electron fluxes, super bin 0 from electron direction 2. (1/cm^s sr keV sec)
23x10	ASCII Real	FINE_E_S02B00_FLUX_UNC	Uncertainties for ten sub-sampled electron fluxes, super bin 0 from electron direction 2. (1/cm^s sr keV sec)
23x10	ASCII Real	FINE_E_S02B01_FLUX	Ten sub-sampled electron fluxes, super bin 1 from electron direction 2. (1/cm^s sr keV sec)
23x10	ASCII Real	FINE_E_S02B01_FLUX_UNC	Uncertainties for ten sub-sampled electron fluxes, super bin 1 from electron direction 2. (1/cm^s sr keV sec)

23x10	ASCII Real	FINE_E_S03B00_FLUX	Ten sub-sampled electron fluxes, super bin 0 from electron direction 3. (1/cm^s sr keV sec)
23x10	ASCII Real	FINE_E_S03B00_FLUX_UNC	Uncertainties for ten sub-sampled electron fluxes, super bin 0 from electron direction 3. (1/cm^s sr keV sec)
23x10	ASCII Real	FINE_E_S03B01_FLUX	Ten sub-sampled electron fluxes, super bin 1 from electron direction 3. (1/cm^s sr keV sec)
23x10	ASCII Real	FINE_E_S03B01_FLUX_UNC	Uncertainties for ten sub-sampled electron fluxes, super bin 1 from electron direction 3. (1/cm^s sr keV sec)
23x10	ASCII Real	FINE_E_S04B00_FLUX	Ten sub-sampled electron fluxes, super bin 0 from electron direction 4. (1/cm^s sr keV sec)
23x10	ASCII Real	FINE_E_S04B00_FLUX_UNC	Uncertainties for ten sub-sampled electron fluxes, super bin 0 from electron direction 4. (1/cm^s sr keV sec)
23x10	ASCII Real	FINE_E_S04B01_FLUX	Ten sub-sampled electron fluxes, super bin 1 from electron direction 4. (1/cm^s sr keV sec)
23x10	ASCII Real	FINE_E_S04B01_FLUX_UNC	Uncertainties for ten sub-sampled electron fluxes, super bin 1 from electron direction 4. (1/cm^s sr keV sec)
23x10	ASCII Real	FINE_E_S05B00_FLUX	Ten sub-sampled electron fluxes, super bin 0 from electron direction 5. (1/cm^s sr keV sec)
23x10	ASCII Real	FINE_E_S05B00_FLUX_UNC	Uncertainties for ten sub-sampled electron fluxes, super bin 0 from electron direction 5. (1/cm^s sr keV sec)
23x10	ASCII Real	FINE_E_S05B01_FLUX	Ten sub-sampled electron fluxes, super bin 1 from electron direction 5.

			(1/cm^s sr keV sec)
23x10	ASCII Real	FINE_E_S05B01_FLUX_UNC	Uncertainties for ten sub-sampled electron fluxes, super bin 1 from electron direction 5. (1/cm^s sr keV sec)

1. **TIME**

Spacecraft event time (UTC) for this data record.

2. **ACCUM_TIME**

The length of the accumulation interval for this data record.

3. **RADIAL_DIST**

The distance of the spacecraft from Mercury in the MSO frame, in units of Mercury radii..

4. **MSO_LOCAL_TIME**

The Mercury longitude of the spacecraft expressed in fractional hours.

5. **MSO_LATITUDE**

The Mercury latitude of the spacecraft in degrees.

6. **MSGR_MSO_X**

The X position of the spacecraft in the MSO frame, in units of Mercury radii.

7. **MSGR_MSO_Y**

The Y position of the spacecraft in the MSO frame, in units of Mercury radii.

8. MSGR_MSO_Z

The Z position of the spacecraft in the MSO frame, in units of Mercury radii.

9. ION_Sn_RATES

Ion rate (counts/second) histogram for ion direction n (SSD detector n*2+1), which is 1 of the 6 ion directions (0 through 5) that define the entire 160 degree field of view of the sensor for ions, and each representing about 27 degrees out of the entire field of view. Histogram contains the 8 bins shown in Table 3 and Table 5.

10. ION_Sn_RATES_UNC

Uncertainties for the ION_Sn_RATES.

11. ION_Sn_FLUX

Ion flux (1/cm^2 sr keV sec) histogram for ion direction n (SSD detector n*2+1), which is 1 of the 6 ion directions (0 through 5) that define the entire 160 degree field of view of the sensor for ions, and each representing about 27 degrees out of the entire field of view. Histogram contains the 8 bins shown in Table 3 and Table 5.

12. ION_Sn_FLUX_UNC

Uncertainties for the ION_Sn_FLUX.

13. COARSE_E_Sn_RATES

Electron rate (counts/second) histogram for electron direction n (SSD detector n*2), which is 1 of the 6 electron directions (0 through 5) that define the entire 160 degree field of view of the sensor for electrons, and each representing about 27 degrees out of the entire field of view. Histogram contains the 8 bins shown in Table 4 and Table 6.

14. COARSE_E_Sn_RATES_UNC

Uncertainties for the COARSE_E_Sn_RATES.

15. COARSE_E_Sn_FLUX

Electron flux (1/cm^2 sr keV sec) histogram for electron direction n (SSD detector n*2), which is 1 of the 6 ion directions (0 through 5) that define the entire 160 degree field of view of the sensor for ions, and each representing about 27 degrees out of the entire field of view. Histogram contains the 8 bins shown in Table 4 and Table 6.

16. COARSE_E_Sn_FLUX_UNC

Uncertainties for the COARSE_E_Sn_FLUX.

17. SHAPED_ENERGY_RATE

Shaped energy hardware counter from one of 12 Solid State Detectors that define the 160 degree sensor field of view for both electrons and ions. All even-numbered SSDs are electrons and all odd channels are ions. This channel is the rate (counts/sec) of pulses whose amplitude is used to determine the energy of the particle that generated the pulse.

18. E_EVENT_RATE

Hardware rate (counts/sec) for all classified Electron events registered in the fast processing electronics upstream from the Event Processing Computer. Because the Event Processing Computer can process at most about 5000 events, this counter allows the user to renormalize the processed output rates to retrieve true intensities.

19. ION_EVENT_RATE

Hardware rate (counts/sec) for all classified Ion events registered in the fast processing electronics upstream from the Event Processing Computer. Because the Event Processing Computer can process at most about 5000 events, this counter allows the user to renormalize the processed output rates to retrieve true intensities.

20. E_PROCESSED_RATE

Rate (counts/sec) of electron events processed by the Event Processing Computer during the accumulation interval.

21. ION_PROCESSED_RATE

Rate of high energy ion events processed by the Event Processing Computer during the accumulation interval.

22. PILEUP_E_DISCARD_RATE

Rate of electron events discarded by the Event Processing Computer due to pileup condition.

23. MULTIPLE_E_HITS_DISCARD_RATE

Rate of electron events discarded by the Event Processing Computer due to multiple electron hits.

24. PILEUP_ION_DISCARD_RATE

Rate of high energy ion events discarded by the Event Processing Computer due to pileup condition.

25. MULTIPLE_ION_DISCARD_RATE

Rate of high energy ion events discarded by the Event Processing Computer due to multiple ion hits.

26. FINE_E_S0nB0m_RATE

A series of 10 count rates (counts/sec) for "super bin m" for electron direction n (SSD detector 2*n), which is 1 of the 6 electron directions (numbered 0 through 5) that define the entire 160 degree field of view of the sensor, and each representing about 27 degrees out of the entire field of view. Each super bin is the accumulation of a subset of bin counts in one 1/10*(ACCUM_TIME) subinterval. Super bin 0 is the sum of the energy bins 0-3 shown in Table 4 and Table 6. Super bin 1 is the sum of bins 4-7 shown in Table 4 and Table 6. Each super bin pair is measured once per subinterval for 10 subintervals, making a total of 20 items.

27. FINE_E_S0nB0m_RATE_UNC

Uncertainties for FINE_E_S0nB0m_RATE

28. FINE_E_S0nB0m_FLUX

A series of 10 count rates (1/cm^2 sr keV sec) for "super bin m" for electron direction n (SSD detector 2*n), which is 1 of the 6 electron directions (numbered 0 through 5) that define the entire 160 degree field of view of the sensor, and each representing about 27 degrees out of the entire field of view. Each super bin is the accumulation of a subset of bin counts in one 1/10*(ACCUM_TIME) subinterval. Super bin 0 is the sum of the energy bins 0-3 shown in Table 4 and Table 6. Super bin 1 is the sum of bins 4-7 shown in Table 4 and Table 6. Each super bin pair is measured once per subinterval for 10 subintervals, making a total of 20 items.

29. FINE_E_S0nB0m_FLUX_UNC

Uncertainties for FINE_E_S0nB0m_FLUX

8.3 EPS_PHA_CDR.FMT Table Columns

The following are the columns as defined by the EPS_PHA_CDR.FMT structure file. This file defines the ASCII table containing the EPS Pulse Height Analysis (PHA) event data. The FSW6 upload resulted in changing the EPS PHA data format. It was decided to merge the new format with the previously existing format rather than create an entirely new CDR.

Prior to FSW6 the EPS PHA data could be one of four types: Electron PHA event, Low Energy Ion PHA event, High Energy Ion PHA event, Diagnostic PHA event. After FSW6 there are no separate event types.

There are some common columns for the PHA formats pre and post FSW6, however other columns may be unique. Columns added as a result of FSW6 are INTEGRATION_TIME and ENERGY_BIN. The EPS PHA ASCII table contains all the possible columns that may be populated and includes a “Not Applicable” value when appropriate. Archive volume is optimized by defining the table structure once and providing a reference to it in the PDS label file. The columns are numbered according to their column order in the table. Data_Type refers to the PDS standards data type for a particular column in the table.

Table 21 EPS_PHA_CDR.FMT Columns

Length (bytes)	Data Type	Column Name	Summary (see full text for column description)
21	TIME	TIME	Spacecraft event time (UTC) for this data record.
23	ASCII Real	RADIAL_DIST	The distance of the spacecraft from Mercury. (Mercury radii)
23	ASCII Real	MSO_LOCAL_TIME	The Mercury longitude of the spacecraft. (Fractional Hours)

23	ASCII Real	MSO_LATITUDE	The Mercury latitude of the spacecraft. (Degrees)
23	ASCII Real	MSGR_MSO_X	The X position of the spacecraft in the MSO frame. (Mercury radii)
23	ASCII Real	MSGR_MSO_Y	The Y position of the spacecraft in the MSO frame. (Mercury radii)
23	ASCII Real	MSGR_MSO_Z	The Z position of the spacecraft in the MSO frame. (Mercury radii)
23	ASCII Real	RAW_ENERGY	The Energy of the particle event. (Peak – Baseline) (ADU, or Analog-to-Digital Units)
23	ASCII Real	ENERGY	The calibrated energy of the particle. (keV)
23	ASCII Real	ENERGY_PEAK	PHA value corresponding to the particle energy.
23	ASCII Real	ENERGY_BASELINE	Baseline against which the particle energy is measured.
1	ASCII Integer	ION_E_FLAG	Identifies event as either electron or ion. 0 – electron; 1 – ion.
23	ASCII Real	EPHEMERIS_TIME	Solar System Barycentric event time (TDB) in the J2000 system.
23	ASCII Real	FRACTIONAL_YEAR	UTC event time as a fractional year.
3	ASCII Integer	DAY_OF_YEAR	Event time: Day of Year. (1-366)
8	ASCII Integer	INTEGRATION_TIME	Integration/Accumulation time in seconds. (Unavailable, =0, before FSW6)
2	ASCII Integer	ENERGY_BIN	High resolution energy bin number computed by the flight software. (0-35; Unavailable, =99, before FSW6)
1	ASCII Integer	MULTIPLE_HITS	Flag indicating if more than one detector received a hit. (0 – 1)

1	ASCII Integer	CHANNEL_NUM	Indicates the high energy ion or electron channel. (0-5)
1	ASCII Integer	PRIORITY_GROUP	Priority group of the event (1-7) Only relevant prior to FSW6. (after FSW6 = 99)
23	ASCII Real	RATE_WEIGHT	Weight to normalize PHA events to rate channels. Only relevant prior to FSW6 (after FSW6, = 99)

1. **TIME**

Spacecraft event time (UTC) for this data record.

2. **RADIAL_DIST**

The distance of the spacecraft from Mercury in the MSO frame, in units of Mercury radii..

3. **MSO_LOCAL_TIME**

The Mercury longitude of the spacecraft expressed in fractional hours.

4. **MSO_LATITUDE**

The Mercury latitude of the spacecraft in degrees.

5. **MSGR_MSO_X**

The X position of the spacecraft in the MSO frame, in units of Mercury radii.

6. **MSGR_MSO_Y**

The Y position of the spacecraft in the MSO frame, in units of Mercury radii.

7. **MSGR_MSO_Z**

The Z position of the spacecraft in the MSO frame, in units of Mercury radii.

8. RAW_ENERGY

The raw PHA energy value of the event (Peak – Baseline) in uncalibrated Analog to Digital Units (ADUs).

9. ENERGY

Calibrated raw energy of the peak from the Pulse Height Analysis in keVs.

10. ENERGY_PEAK

Pulse Height Analysis (PHA) value corresponding to the particle energy in ADUs.

11. ENERGY_BASELINE

Pulse Height Analysis (PHA) value corresponding to the baseline against which the particle energy is measured in ADUs.

12. ION_E_FLAG

Identifies event as either ion or electron. 0 - electron, 1 – ion.

13. EPHEMERIS_TIME

Event time in seconds since 2000 at the Solar System Barycenter (J2000 TDB).

14. FRACTIONAL_YEAR

Event time in fractional years.

15. DAY_OF_YEAR

Day of the event.

16. INTEGRATION_TIME

Integration time in seconds. =0 (NA) for data created prior to FSW6.

17. ENERGY_BIN

High Resolution energy bin number computed by the flight software. =99 (NA) for data created prior to FSW6.

18. MULTIPLE_HITS

A flag that indicates that more than one detector received a hit. Value of 1 means multiple hits.

19. CHANNEL_NUM

Indicates the high energy ion or electron channel (0 through 5, indicating directionality within the 160 degree sensor field of view.

20. PRIORITY_GROUP

Priority group of this event for PHA event collection (see instrument description). Only used before FSW6.

21. RATE_WEIGHT

Calculated weight to normalize this event's significance to the particle rate counts in the EPS_MED_CDR spectral data. If you make a weighted histogram of these events using this weight, you should more closely approximate the actual spectrum; i.e. this should ameliorate the effects of the priority group sampling algorithm. Only used before FSW6.

8.4 EPS_HIRES_CDR.FMT Table Columns

The following are the columns as defined by the EPS_HIRES_CDR.FMT structure file. This file defines the ASCII table containing the EPS High Resolution Spectra data. Archive volume is optimized by defining the table structure once and providing a reference to it in the PDS label file. The columns are numbered according to their column order in the table. Data_Type refers to the PDS standards data type for a particular column in the table.

This is a new CDR created as a result of the FSW6 upload.

Table 22 EPS_HIRES_CDR.FMT Columns

Length (bytes)	Data Type	Column Name	Summary (see full text for column description)
21	TIME	TIME	Spacecraft event time (UTC) for this data record.
8	ASCII Integer	ACCUM_TIME	Integration/Accumulation time in seconds.
23	ASCII Real	RADIAL_DIST	The distance of the spacecraft from Mercury. (Mercury radii)
23	ASCII Real	MSO_LOCAL_TIME	The Mercury longitude of the spacecraft. (Fractional Hours)
23	ASCII Real	MSO_LATITUDE	The Mercury latitude of the spacecraft. (Degrees)
23	ASCII Real	MSGR_MSO_X	The X position of the spacecraft in the MSO frame. (Mercury radii)
23	ASCII Real	MSGR_MSO_Y	The Y position of the spacecraft in the MSO frame. (Mercury radii)
23	ASCII Real	MSGR_MSO_Z	The Z position of the spacecraft in the MSO frame. (Mercury radii)
23x36	ASCII Real	ION_S00_RATES	Ion count rate spectrum for ion direction 0, 36 energy bins. (counts/sec)
23x36	ASCII Real	ION_S00_RATES_UNC	Ion count rate spectrum uncertainty for ion direction 0, 36 energy bins. (counts/sec)
23x36	ASCII Real	ION_S01_RATES	Ion count rate spectrum for ion direction 1, 36 energy bins. (counts/sec)
23x36	ASCII Real	ION_S01_RATES_UNC	Ion count rate spectrum uncertainty for ion direction 1, 36 energy bins. (counts/sec)
23x36	ASCII Real	ION_S02_RATES	Ion count rate spectrum for ion direction 2, 36 energy bins. (counts/sec)
23x36	ASCII Real	ION_S02_RATES_UNC	Ion count rate spectrum uncertainty for ion direction 2, 36 energy bins. (counts/sec)
23x36	ASCII Real	ION_S03_RATES	Ion count rate spectrum for ion direction 3, 36 energy bins. (counts/sec)

23x36	ASCII Real	ION_S03_RATES_UNC	Ion count rate spectrum uncertainty for ion direction 3, 36 energy bins. (counts/sec)
23x36	ASCII Real	ION_S04_RATES	Ion count rate spectrum for ion direction 4, 36 energy bins. (counts/sec)
23x36	ASCII Real	ION_S04_RATES_UNC	Ion count rate spectrum uncertainty for ion direction 4, 36 energy bins. (counts/sec)
23x36	ASCII Real	ION_S05_RATES	Ion count rate spectrum for ion direction 5, 36 energy bins. (counts/sec)
23x36	ASCII Real	ION_S05_RATES_UNC	Ion count rate spectrum uncertainty for ion direction 5, 36 energy bins. (counts/sec)
23x34	ASCII Real	ION_S00_FLUX	Ion flux spectrum for ion direction 0, 34 energy bins. (1/cm^2 sr keV sec)
23x34	ASCII Real	ION_S00_FLUX_UNC	Ion flux spectrum uncertainty for ion direction 0, 34 energy bins. (1/cm^2 sr keV sec)
23x34	ASCII Real	ION_S01_FLUX	Ion flux spectrum for ion direction 1, 34 energy bins. (1/cm^2 sr keV sec)
23x34	ASCII Real	ION_S01_FLUX_UNC	Ion flux spectrum uncertainty for ion direction 0, 34 energy bins. (1/cm^2 sr keV sec)
23x34	ASCII Real	ION_S02_FLUX	Ion flux spectrum for ion direction 0, 34 energy bins. (1/cm^2 sr keV sec)
23x34	ASCII Real	ION_S02_FLUX_UNC	Ion flux spectrum uncertainty for ion direction 0, 34 energy bins. (1/cm^2 sr keV sec)
23x34	ASCII Real	ION_S03_FLUX	Ion flux spectrum for ion direction 0, 34 energy bins. (1/cm^2 sr keV sec)
23x34	ASCII Real	ION_S03_FLUX_UNC	Ion flux spectrum uncertainty for ion direction 0, 34 energy bins. (1/cm^2 sr keV sec)
23x34	ASCII Real	ION_S04_FLUX	Ion flux spectrum for ion direction 0, 34 energy bins. (1/cm^2 sr keV sec)
23x34	ASCII Real	ION_S04_FLUX_UNC	Ion flux spectrum uncertainty for ion direction 0, 34 energy bins. (1/cm^2 sr keV sec)
23x34	ASCII Real	ION_S05_FLUX	Ion flux spectrum for ion direction 0, 34 energy bins. (1/cm^2 sr keV sec)

23x34	ASCII Real	ION_S05_FLUX_UNC	Ion flux spectrum uncertainty for ion direction 0, 34 energy bins. (1/cm^2 sr keV sec)
23x36	ASCII Real	E_S00_RATES	Electron count rate spectrum for ion direction 0, 36 energy bins. (counts/sec)
23x36	ASCII Real	E_S00_RATES_UNC	Electron count rate spectrum uncertainty for ion direction 0, 36 energy bins. (counts/sec)
23x36	ASCII Real	E_S01_RATES	Electron count rate spectrum for ion direction 1, 36 energy bins. (counts/sec)
23x36	ASCII Real	E_S01_RATES_UNC	Electron count rate spectrum uncertainty for ion direction 1, 36 energy bins. (counts/sec)
23x36	ASCII Real	E_S02_RATES	Electron count rate spectrum for ion direction 2, 36 energy bins. (counts/sec)
23x36	ASCII Real	E_S02_RATES_UNC	Electron count rate spectrum uncertainty for ion direction 2, 36 energy bins. (counts/sec)
23x36	ASCII Real	E_S03_RATES	Electron count rate spectrum for ion direction 3, 36 energy bins. (counts/sec)
23x36	ASCII Real	E_S03_RATES_UNC	Electron count rate spectrum uncertainty for ion direction 3, 36 energy bins. (counts/sec)
23x36	ASCII Real	E_S04_RATES	Electron count rate spectrum for ion direction 4, 36 energy bins. (counts/sec)
23x36	ASCII Real	E_S04_RATES_UNC	Electron count rate spectrum uncertainty for ion direction 4, 36 energy bins. (counts/sec)
23x36	ASCII Real	E_S05_RATES	Electron count rate spectrum for ion direction 5, 36 energy bins. (counts/sec)
23x36	ASCII Real	E_S05_RATES_UNC	Electron count rate spectrum uncertainty for ion direction 5, 36 energy bins. (counts/sec)
23x34	ASCII Real	E_S00_FLUX	Electron flux spectrum for ion direction 0, 34 energy bins. (1/cm^2 sr keV sec)
23x34	ASCII Real	E_S00_FLUX_UNC	Electron flux spectrum uncertainty for ion direction 0, 34 energy bins. (1/cm^2 sr keV sec)
23x34	ASCII Real	E_S01_FLUX	Electron flux spectrum for ion direction 1, 34 energy bins. (1/cm^2 sr keV sec)

23x34	ASCII Real	E_S01_FLUX_UNC	Electron flux spectrum uncertainty for ion direction 0, 34 energy bins. (1/cm^2 sr keV sec)
23x34	ASCII Real	E_S02_FLUX	Electron flux spectrum for ion direction 0, 34 energy bins. (1/cm^2 sr keV sec)
23x34	ASCII Real	E_S02_FLUX_UNC	Electron flux spectrum uncertainty for ion direction 0, 34 energy bins. (1/cm^2 sr keV sec)
23x34	ASCII Real	E_S03_FLUX	Electron flux spectrum for ion direction 0, 34 energy bins. (1/cm^2 sr keV sec)
23x34	ASCII Real	E_S03_FLUX_UNC	Electron flux spectrum uncertainty for ion direction 0, 34 energy bins. (1/cm^2 sr keV sec)
23x34	ASCII Real	E_S04_FLUX	Electron flux spectrum for ion direction 0, 34 energy bins. (1/cm^2 sr keV sec)
23x34	ASCII Real	E_S04_FLUX_UNC	Electron flux spectrum uncertainty for ion direction 0, 34 energy bins. (1/cm^2 sr keV sec)
23x34	ASCII Real	E_S05_FLUX	Electron flux spectrum for ion direction 0, 34 energy bins. (1/cm^2 sr keV sec)
23x34	ASCII Real	E_S05_FLUX_UNC	Electron flux spectrum uncertainty for ion direction 0, 34 energy bins. (1/cm^2 sr keV sec)

1. TIME

Spacecraft event time (UTC) for this data record.

2. ACCUM_TIME

The length of the accumulation interval for this data record.

3. RADIAL_DIST

The distance of the spacecraft from Mercury in the MSO frame, in units of Mercury radii.

4. MSO_LOCAL_TIME

The Mercury longitude of the spacecraft expressed in fractional hours.

5. MSO_LATITUDE

The Mercury latitude of the spacecraft in degrees.

6. MSGR_MSO_X

The X position of the spacecraft in the MSO frame, in units of Mercury radii.

7. MSGR_MSO_Y

The Y position of the spacecraft in the MSO frame, in units of Mercury radii.

8. MSGR_MSO_Z

The Z position of the spacecraft in the MSO frame, in units of Mercury radii.

9. ION_Sn_RATES

Ion rate (counts/second) histogram for ion direction n (SSD detector n*2+1), which is 1 of the 6 ion directions (0 through 5) that define the entire 160 degree field of view of the sensor for ions, and each representing about 27 degrees out of the entire field of view. Histogram contains the 36 bins shown in Table 7.

10. ION_Sn_RATES_UNC

Uncertainties for the ION_Sn_RATES.

11. ION_Sn_FLUX

Ion flux ($1/cm^2$ sr keV sec) histogram for ion direction n (SSD detector n*2+1), which is 1 of the 6 ion directions (0 through 5) that define the entire 160 degree field of view of the sensor for ions, and each representing about 27 degrees out of the entire field of view. Histogram contains the 34 bins shown inTable 7 (the first and last bins are not doubly bounded, so they do not appear in this, flux-calibrated, spectrum).

12. ION_Sn_FLUX_UNC

Uncertainties for the ION_Sn_FLUX,

13. E_Sn_RATES

Electron rate (counts/second) histogram for electron direction n (SSD detector n*2), which is 1 of the 6 electron directions (0 through 5) that define the entire 160 degree field of view of the sensor for electrons, and each representing about 27 degrees out of the entire field of view. Histogram contains the 36 bins shown in Table 8.

14. E_Sn_RATES_UNC

Uncertainties for the COARSE_E_Sn_RATES.

15. E_Sn_FLUX

Electron flux (1/cm^2 sr keV sec) histogram for electron direction n (SSD detector n*2), which is 1 of the 6 ion directions (0 through 5) that define the entire 160 degree field of view of the sensor for ions, and each representing about 27 degrees out of the entire field of view. Histogram contains the 34 bins shown in Table 8 (the first and last bins are not doubly bounded, so they do not appear in this, flux-calibrated, spectrum).

16. E_Sn_FLUX_UNC

Uncertainties for the E_Sn_FLUX.

8.5 EPS_LORES_CDR.FMT Table Columns

The following are the columns as defined by the EPS_LORES_CDR.FMT structure file. This file defines the ASCII table containing the EPS Low Resolution Spectra data. Archive volume is optimized by defining the table structure once and providing a reference to it in the PDS label file. The columns are numbered according to their column order in the table. Data_Type refers to the PDS standards data type for a particular column in the table.

This is a new CDR created as a result of the FSW6 upload.

Table 23 EPS_LORES_CDR.FMT Columns

Length(bytes)	Data Type	Column Name	Summary (see full text for column description)
21	TIME	TIME	Spacecraft event time (UTC) for this data record.
8	ASCII Integer	ACCUM_TIME	Integration/Accumulation time in seconds.
23	ASCII Real	RADIAL_DIST	The distance of the spacecraft from Mercury. (Mercury radii)
23	ASCII Real	MSO_LOCAL_TIME	The Mercury longitude of the spacecraft. (Fractional Hours)
23	ASCII Real	MSO_LATITUDE	The Mercury latitude of the spacecraft. (Degrees)
23	ASCII Real	MSGR_MSO_X	The X position of the spacecraft in the MSO frame. (Mercury radii)
23	ASCII Real	MSGR_MSO_Y	The Y position of the spacecraft in the MSO frame. (Mercury radii)
23	ASCII Real	MSGR_MSO_Z	The Z position of the spacecraft in the MSO frame. (Mercury radii)
23x12	ASCII Real	ION_S00_RATES	Ion count rate spectrum for ion direction 0, 12 energy bins. (counts/sec)
23x12	ASCII Real	ION_S00_RATES_UNC	Ion count rate spectrum uncertainty for ion direction 0, 12 energy bins. (counts/sec)
23x12	ASCII Real	ION_S01_RATES	Ion count rate spectrum for ion direction 1, 12 energy bins. (counts/sec)
23x12	ASCII Real	ION_S01_RATES_UNC	Ion count rate spectrum uncertainty for ion direction 1, 12 energy bins. (counts/sec)
23x12	ASCII Real	ION_S02_RATES	Ion count rate spectrum for ion direction 2, 12 energy bins. (counts/sec)

23x12	ASCII Real	ION_S02_RATES_UNC	Ion count rate spectrum uncertainty for ion direction 2, 12 energy bins. (counts/sec)
23x12	ASCII Real	ION_S03_RATES	Ion count rate spectrum for ion direction 3, 12 energy bins. (counts/sec)
23x12	ASCII Real	ION_S03_RATES_UNC	Ion count rate spectrum uncertainty for ion direction 3, 12 energy bins. (counts/sec)
23x12	ASCII Real	ION_S04_RATES	Ion count rate spectrum for ion direction 4, 12 energy bins. (counts/sec)
23x12	ASCII Real	ION_S04_RATES_UNC	Ion count rate spectrum uncertainty for ion direction 4, 12 energy bins. (counts/sec)
23x12	ASCII Real	ION_S05_RATES	Ion count rate spectrum for ion direction 5, 12 energy bins. (counts/sec)
23x12	ASCII Real	ION_S05_RATES_UNC	Ion count rate spectrum uncertainty for ion direction 5, 12 energy bins. (counts/sec)
23x10	ASCII Real	ION_S00_FLUX	Ion flux spectrum for ion direction 0, 10 energy bins. (1/cm^2 sr keV sec)
23x10	ASCII Real	ION_S00_FLUX_UNC	Ion flux spectrum uncertainty for ion direction 0, 10 energy bins. (1/cm^2 sr keV sec)
23x10	ASCII Real	ION_S01_FLUX	Ion flux spectrum for ion direction 1, 10 energy bins. (1/cm^2 sr keV sec)
23x10	ASCII Real	ION_S01_FLUX_UNC	Ion flux spectrum uncertainty for ion direction 0, 10 energy bins. (1/cm^2 sr keV sec)
23x10	ASCII Real	ION_S02_FLUX	Ion flux spectrum for ion direction 0, 10 energy bins. (1/cm^2 sr keV sec)
23x10	ASCII Real	ION_S02_FLUX_UNC	Ion flux spectrum uncertainty for ion direction 0, 10 energy bins. (1/cm^2 sr keV sec)
23x10	ASCII Real	ION_S03_FLUX	Ion flux spectrum for ion direction 0, 10 energy bins. (1/cm^2 sr keV sec)
23x10	ASCII Real	ION_S03_FLUX_UNC	Ion flux spectrum uncertainty for ion direction 0, 10 energy bins. (1/cm^2 sr keV sec)
23x10	ASCII Real	ION_S04_FLUX	Ion flux spectrum for ion direction 0, 10 energy bins. (1/cm^2 sr keV sec)

23x10	ASCII Real	ION_S04_FLUX_UNC	Ion flux spectrum uncertainty for ion direction 0, 10 energy bins. (1/cm^2 sr keV sec)
23x10	ASCII Real	ION_S05_FLUX	Ion flux spectrum for ion direction 0, 10 energy bins. (1/cm^2 sr keV sec)
23x10	ASCII Real	ION_S05_FLUX_UNC	Ion flux spectrum uncertainty for ion direction 0, 10 energy bins. (1/cm^2 sr keV sec)
23x12	ASCII Real	E_S00_RATES	Electron count rate spectrum for ion direction 0, 12 energy bins. (counts/sec)
23x12	ASCII Real	E_S00_RATES_UNC	Electron count rate spectrum uncertainty for ion direction 0, 12 energy bins. (counts/sec)
23x12	ASCII Real	E_S01_RATES	Electron count rate spectrum for ion direction 1, 12 energy bins. (counts/sec)
23x12	ASCII Real	E_S01_RATES_UNC	Electron count rate spectrum uncertainty for ion direction 1, 12 energy bins. (counts/sec)
23x12	ASCII Real	E_S02_RATES	Electron count rate spectrum for ion direction 2, 12 energy bins. (counts/sec)
23x12	ASCII Real	E_S02_RATES_UNC	Electron count rate spectrum uncertainty for ion direction 2, 12 energy bins. (counts/sec)
23x12	ASCII Real	E_S03_RATES	Electron count rate spectrum for ion direction 3, 12 energy bins. (counts/sec)
23x12	ASCII Real	E_S03_RATES_UNC	Electron count rate spectrum uncertainty for ion direction 3, 12 energy bins. (counts/sec)
23x12	ASCII Real	E_S04_RATES	Electron count rate spectrum for ion direction 4, 12 energy bins. (counts/sec)
23x12	ASCII Real	E_S04_RATES_UNC	Electron count rate spectrum uncertainty for ion direction 4, 12 energy bins. (counts/sec)
23x12	ASCII Real	E_S05_RATES	Electron count rate spectrum for ion direction 5, 12 energy bins. (counts/sec)
23x12	ASCII Real	E_S05_RATES_UNC	Electron count rate spectrum uncertainty for ion direction 5, 12 energy bins. (counts/sec)
23x10	ASCII Real	E_S00_FLUX	Electron flux spectrum for ion direction 0, 10 energy bins. (1/cm^2 sr keV sec)

23x10	ASCII Real	E_S00_FLUX_UNC	Electron flux spectrum uncertainty for ion direction 0, 10 energy bins. (1/cm^2 sr keV sec)
23x10	ASCII Real	E_S01_FLUX	Electron flux spectrum for ion direction 1, 10 energy bins. (1/cm^2 sr keV sec)
23x10	ASCII Real	E_S01_FLUX_UNC	Electron flux spectrum uncertainty for ion direction 0, 10 energy bins. (1/cm^2 sr keV sec)
23x10	ASCII Real	E_S02_FLUX	Electron flux spectrum for ion direction 0, 10 energy bins. (1/cm^2 sr keV sec)
23x10	ASCII Real	E_S02_FLUX_UNC	Electron flux spectrum uncertainty for ion direction 0, 10 energy bins. (1/cm^2 sr keV sec)
23x10	ASCII Real	E_S03_FLUX	Electron flux spectrum for ion direction 0, 10 energy bins. (1/cm^2 sr keV sec)
23x10	ASCII Real	E_S03_FLUX_UNC	Electron flux spectrum uncertainty for ion direction 0, 10 energy bins. (1/cm^2 sr keV sec)
23x10	ASCII Real	E_S04_FLUX	Electron flux spectrum for ion direction 0, 10 energy bins. (1/cm^2 sr keV sec)
23x10	ASCII Real	E_S04_FLUX_UNC	Electron flux spectrum uncertainty for ion direction 0, 10 energy bins. (1/cm^2 sr keV sec)
23x10	ASCII Real	E_S05_FLUX	Electron flux spectrum for ion direction 0, 10 energy bins. (1/cm^2 sr keV sec)
23x10	ASCII Real	E_S05_FLUX_UNC	Electron flux spectrum uncertainty for ion direction 0, 10 energy bins. (1/cm^2 sr keV sec)
23x12	ASCII Real	FAST_ENERGY_RATE	The 12 fast energy hardware count rates. (counts/sec)
23x12	ASCII Real	SHAPED_ENERGY_RATE	The 12 shaped energy hardware count rates. (counts/sec)
23	ASCII Real	ION_EVENT_RATE	Ion event hardware count rate. (counts/sec)
23	ASCII Real	E_EVENT_RATE	Electron event hardware count rate. (counts/sec)
23	ASCII Real	ION_PROCESSED_RATE	Ion event hardware count rate. (counts/sec)
23	ASCII Real	E_PROCESSED_RATE	Ion event hardware count rate. (counts/sec)
23	ASCII Real	PILEUP_ION_RATE	Rate of ion events discarded due to pileup condition. (counts/sec)

23	ASCII Real	PILEUP_E_RATE	Rate of electron events discarded due to pileup condition. (counts/sec)
23	ASCII Real	REJECTED_ION_RATE	Rate of ion events rejected due to negative energy. (counts/sec)
23	ASCII Real	REJECTED_E_RATE	Rate of electron events rejected due to negative energy. (counts/sec)
23	ASCII Real	MULTIPLE_HITS_RATE	Rate of events discarded due to multiple hits. (counts/sec)

1. **TIME**

Spacecraft event time (UTC) for this data record.

2. **ACCUM_TIME**

The length of the accumulation interval for this data record.

3. **RADIAL_DIST**

The distance of the spacecraft from Mercury in the MSO frame, in units of Mercury radii..

4. **MSO_LOCAL_TIME**

The Mercury longitude of the spacecraft expressed in fractional hours.

5. **MSO_LATITUDE**

The Mercury latitude of the spacecraft in degrees.

6. **MSGR_MSO_X**

The X position of the spacecraft in the MSO frame, in units of Mercury radii.

7. **MSGR_MSO_Y**

The Y position of the spacecraft in the MSO frame, in units of Mercury radii.

8. MSGR_MSO_Z

The Z position of the spacecraft in the MSO frame, in units of Mercury radii.

9. ION_Sn_RATES

Ion rate (counts/second) histogram for ion direction n (SSD detector n*2+1), which is 1 of the 6 ion directions (0 through 5) that define the entire 160 degree field of view of the sensor for ions, and each representing about 27 degrees out of the entire field of view. Histogram contains the 12 bins shown in Table 9.

10. ION_Sn_RATES_UNC

Uncertainties for the ION_Sn_RATES.

11. ION_Sn_FLUX

Ion flux (1/cm^2 sr keV sec) histogram for ion direction n (SSD detector n*2+1), which is 1 of the 6 ion directions (0 through 5) that define the entire 160 degree field of view of the sensor for ions, and each representing about 27 degrees out of the entire field of view. Histogram contains the 10 bins shown in Table 9 (the first and last bins are not doubly bounded, so they do not appear in this, flux-calibrated, spectrum).

12. ION_Sn_FLUX_UNC

Uncertainties for the ION_Sn_FLUX.

13. E_Sn_RATES

Electron rate (counts/second) histogram for electron direction n (SSD detector n*2), which is 1 of the 6 electron directions (0 through 5) that define the entire 160 degree field of view of the sensor for electrons, and each representing about 27 degrees out of the entire field of view. Histogram contains the 12 bins shown in Table 10.

14. E_Sn_RATES_UNC

Uncertainties for the COARSE_E_Sn_RATES.

15. E_Sn_FLUX

Electron flux (1/cm^2 sr keV sec) histogram for electron direction n (SSD detector n*2), which is 1 of the 6 ion directions (0 through 5) that define the entire 160 degree field of view of the sensor for ions, and each representing about 27 degrees out of the entire field of view. Histogram contains the 10 bins shown in Table 10 (the first and last bins are not doubly bounded, so they do not appear in this, flux-calibrated, spectrum).

16. E_Sn_FLUX_UNC

Uncertainties for the E_Sn_FLUX.

17. FAST_ENERGY_RATE

Counts the firing rate of a discriminator when an analog signal exceeds a settable threshold. The discriminator is connected to the output of the pole-zero shaping circuit. There are 12 values, one for each SSD.

18. SHAPED_ENERGY_RATE

Counts the firing of a discriminator when an analog signal exceeds a settable threshold. The discriminator is connected to the output of the 3 pole Gaussian shaping circuit. There are 12 values, one for each SSD.

19. ION_EVENT_RATE

Hardware rate (counts/sec) for all classified Ion events registered in the fast processing electronics upstream from the Event Processing Computer. Because the Event Processing Computer can process at most about 5000 events, this counter allows the user to renormalize the processed output rates to retrieve true intensities.

20. E_EVENT_RATE

Hardware rate (counts/sec) for all classified Electron events registered in the fast processing electronics upstream from the Event Processing Computer. Because the Event Processing Computer can process at most about 5000 events, this counter allows the user to renormalize the processed output rates to retrieve true intensities.

21. ION_PROCESSED_RATE

Rate of ion events processed by the Event Processing Computer during the accumulation interval

22. **E_PROCESSED_RATE**

Rate (counts/sec) of electron events processed by the Event Processing Computer during the accumulation interval.

23. **PILEUP_ION_RATE**

Rate of ion events discarded by the Event Processing Computer due to pileup condition.

24. **PILEUP_E_RATE**

Rate of electron events discarded by the Event Processing Computer due to pileup condition.

25. **REJECTED_ION_RATE**

Rate of ions rejected due to negative energy.

26. **REJECTED_E_RATE**

Rate of electrons rejected due to negative energy.

27. **MULTIPLE_HIT_RATE**

Ion or electron events rejected due to multiple hits.

8.6 EPS_SUM_CDR.FMT Table Columns

The columns defined by the EPS_SUM_CDR.FMT structure file are identical to those defined by the EPS_LORES_CDR.FMT file. The EPS Summary data contains the same data columns as EPS LoRes data, but sampled at the (lower) EPS HiRes rate. This serves the dual purpose of facilitating comparisons between HiRes and LoRes data and providing a low bandwidth data type which can be used for quick look verification during spacecraft operations. Refer to Section 8.5 for a description of the EPS_SUM_CDR.FMT columns.

This is a new CDR created as a result of the FSW6 upload.

8.7 EPS_SCAN_CDR.FMT Table Columns

New in FSW6 is the Scan data. In scan mode, EPS varies the energy thresholds integrating hardware rates at each threshold setting (defined in tables). The thresholds are changed three times, then the base thresholds are restored. A scan is defined as four threshold settings: three offsets and one nominal. At each threshold step, a subset of the hardware rate counters are accumulated for 1/4 second. The Scan mode gives EPS the ability to lower its electronics threshold by temporary suspending the processor operation.

Scan rates are reported in two forms. Simple rates or fluxes represent the counts (or calibrated flux) above the threshold values as shown in Table 11 and Table 12. Delta rates or fluxes represent the counts (or calibrated flux) obtained by subtracting counts in “adjacent” scans so that the resulting value mimics a double bounded energy bin.

Table 24 EPS_SCAN_CDR.FMT Columns

Length (bytes)	**Data Type**	**Field Name**	**Summary (see full text for column description)**
21	TIME	TIME	Spacecraft event time (UTC) for this data record.
8	ASCII Integer	ACCUM_TIME	Integration/Accumulation time in seconds.
23	ASCII Real	RADIAL_DIST	The distance of the spacecraft from Mercury. (Mercury radii)
23	ASCII Real	MSO_LOCAL_TIME	The Mercury longitude of the spacecraft. (Fractional Hours)
23	ASCII Real	MSO_LATITUDE	The Mercury latitude of the spacecraft. (Degrees)
23	ASCII Real	MSGR_MSO_X	The X position of the spacecraft in the MSO frame. (Mercury radii)

23	ASCII Real	MSGR_MSO_Y	The Y position of the spacecraft in the MSO frame. (Mercury radii)
23	ASCII Real	MSGR_MSO_Z	The Z position of the spacecraft in the MSO frame. (Mercury radii)
23x12	ASCII Real	FAST_DELTA_RATES_OFFSET_A	Fast-mode delta rate. One for each SSD. (counts/second)
23x12	ASCII Real	FAST_DELTA_RATES_UNC_OFFSET_A	Fast-mode delta rate uncertainty. One for each SSD. (counts/second)
23x12	ASCII Real	FAST_DELTA_FLUXES_OFFSET_A	Fast-mode delta flux. One for each SSD. (1/cm^2 sr keV sec)
23x12	ASCII Real	FAST_DELTA_FLUXES_UNC_OFFSET_A	Fast-mode delta flux uncertainty. One for each SSD. (1/cm^2 sr keV sec)
23x12	ASCII Real	SHAPED_DELTA_RATES_OFFSET_A	Shaped-mode delta rate. One for each SSD. (counts/second)
23x12	ASCII Real	SHAPED_DELTA_RATES_UNC_OFFSET_A	Shaped-mode delta rate uncertainty. One for each SSD. (counts/second)
23x12	ASCII Real	SHAPED_DELTA_FLUXES_OFFSET_A	Shaped-mode delta flux. One for each SSD. (1/cm^2 sr keV sec)
23x12	ASCII Real	SHAPED_DELTA_FLUXES_UNC_OFFSET_A	Shaped -mode delta flux uncertainty. One for each SSD. (1/cm^2 sr keV sec)
23x12	ASCII Real	FAST_SCAN_RATES_OFFSET_A	Fast-mode count delta rate. One for each SSD. (counts/second)
23x12	ASCII Real	FAST_SCAN_RATES_UNC_OFFSET_A	Fast-mode count delta rate uncertainty. One for each SSD. (counts/second)
23x12	ASCII Real	SHAPED_SCAN_RATES_OFFSET_A	Fast-mode count scan rate. One for each SSD. (counts/second)
23x12	ASCII Real	SHAPED_SCAN_RATES_UNC_OFFSET_A	Fast-mode count scan rate uncertainty. One for each SSD.

			(counts/second)
23x12	ASCII Real	FAST_DELTA_RATES_OFFSET_B	Fast-mode delta rate. One for each SSD. (counts/second)
23x12	ASCII Real	FAST_DELTA_RATES_UNC_OFFSET_B	Fast-mode delta rate uncertainty. One for each SSD. (counts/second)
23x12	ASCII Real	FAST_DELTA_FLUXES_OFFSET_B	Fast-mode delta flux. One for each SSD. (1/cm^2 sr keV sec)
23x12	ASCII Real	FAST_DELTA_FLUXES_UNC_OFFSET_B	Fast-mode delta flux uncertainty. One for each SSD. (1/cm^2 sr keV sec)
23x12	ASCII Real	SHAPED_DELTA_RATES_OFFSET_B	Shaped-mode delta rate. One for each SSD. (counts/second)
23x12	ASCII Real	SHAPED_DELTA_RATES_UNC_OFFSET_B	Shaped-mode delta rate uncertainty. One for each SSD. (counts/second)
23x12	ASCII Real	SHAPED_DELTA_FLUXES_OFFSET_B	Shaped-mode delta flux. One for each SSD. (1/cm^2 sr keV sec)
23x12	ASCII Real	SHAPED_DELTA_FLUXES_UNC_OFFSET_B	Shaped -mode delta flux uncertainty. One for each SSD. (1/cm^2 sr keV sec)
23x12	ASCII Real	FAST_SCAN_RATES_OFFSET_B	Fast-mode count delta rate. One for each SSD. (counts/second)
23x12	ASCII Real	FAST_SCAN_RATES_UNC_OFFSET_B	Fast-mode count delta rate uncertainty. One for each SSD. (counts/second)
23x12	ASCII Real	SHAPED_SCAN_RATES_OFFSET_B	Fast-mode count scan rate. One for each SSD. (counts/second)
23x12	ASCII Real	SHAPED_SCAN_RATES_UNC_OFFSET_B	Fast-mode count scan rate uncertainty. One for each SSD. (counts/second)
23x12	ASCII Real	FAST_DELTA_RATES_OFFSET_C	Fast-mode delta rate. One for each SSD. (counts/second)
23x12	ASCII Real	FAST_DELTA_RATES_UNC_OFFSET_C	Fast-mode delta rate uncertainty. One for each SSD.

			(counts/second)
23x12	ASCII Real	FAST_DELTA_FLUXES_OFFSET_C	Fast-mode delta flux. One for each SSD. (1/cm^2 sr keV sec)
23x12	ASCII Real	FAST_DELTA_FLUXES_UNC_OFFSET_C	Fast-mode delta flux uncertainty. One for each SSD. (1/cm^2 sr keV sec)
23x12	ASCII Real	SHAPED_DELTA_RATES_OFFSET_C	Shaped-mode delta rate. One for each SSD. (counts/second)
23x12	ASCII Real	SHAPED_DELTA_RATES_UNC_OFFSET_C	Shaped-mode delta rate uncertainty. One for each SSD. (counts/second)
23x12	ASCII Real	SHAPED_DELTA_FLUXES_OFFSET_C	Shaped-mode delta flux. One for each SSD. (1/cm^2 sr keV sec)
23x12	ASCII Real	SHAPED_DELTA_FLUXES_UNC_OFFSET_C	Shaped -mode delta flux uncertainty. One for each SSD. (1/cm^2 sr keV sec)
23x12	ASCII Real	FAST_SCAN_RATES_OFFSET_C	Fast-mode count delta rate. One for each SSD. (counts/second)
23x12	ASCII Real	FAST_SCAN_RATES_UNC_OFFSET_C	Fast-mode count delta rate uncertainty. One for each SSD. (counts/second)
23x12	ASCII Real	SHAPED_SCAN_RATES_OFFSET_C	Fast-mode count scan rate. One for each SSD. (counts/second)
23x12	ASCII Real	SHAPED_SCAN_RATES_UNC_OFFSET_C	Fast-mode count scan rate uncertainty. One for each SSD. (counts/second)
23x12	ASCII Real	FAST_DELTA_RATES_OFFSET_D	Fast-mode delta rate. One for each SSD. (counts/second)
23x12	ASCII Real	FAST_DELTA_RATES_UNC_OFFSET_D	Fast-mode delta rate uncertainty. One for each SSD. (counts/second)
23x12	ASCII Real	FAST_DELTA_FLUXES_OFFSET_D	Fast-mode delta flux. One for each SSD. (1/cm^2 sr keV sec)
23x12	ASCII Real	FAST_DELTA_FLUXES_UNC_OFFSET_D	Fast-mode delta flux uncertainty. One for each SSD. (1/cm^2 sr

			keV sec)
23x12	ASCII Real	SHAPED_DELTA_RATES_OFFSET_D	Shaped-mode delta rate. One for each SSD. (counts/second)
23x12	ASCII Real	SHAPED_DELTA_RATES_UNC_OFFSET_D	Shaped-mode delta rate uncertainty. One for each SSD. (counts/second)
23x12	ASCII Real	SHAPED_DELTA_FLUXES_OFFSET_D	Shaped-mode delta flux. One for each SSD. (1/cm^2 sr keV sec)
23x12	ASCII Real	SHAPED_DELTA_FLUXES_UNC_OFFSET_D	Shaped -mode delta flux uncertainty. One for each SSD. (1/cm^2 sr keV sec)
23x12	ASCII Real	FAST_SCAN_RATES_OFFSET_D	Fast-mode count delta rate. One for each SSD. (counts/second)
23x12	ASCII Real	FAST_SCAN_RATES_UNC_OFFSET_D	Fast-mode count delta rate uncertainty. One for each SSD. (counts/second)
23x12	ASCII Real	SHAPED_SCAN_RATES_OFFSET_D	Fast-mode count scan rate. One for each SSD. (counts/second)
23x12	ASCII Real	SHAPED_SCAN_RATES_UNC_OFFSET_D	Fast-mode count scan rate uncertainty. One for each SSD. (counts/second)

1. TIME

Spacecraft event time (UTC) for this data record.

2. ACCUM_TIME

The length of the accumulation interval for this data record.

3. RADIAL_DIST

The distance of the spacecraft from Mercury in the MSO frame, in units of Mercury radii..

4. **MSO_LOCAL_TIME**

The Mercury longitude of the spacecraft expressed in fractional hours.

5. **MSO_LATITUDE**

The Mercury latitude of the spacecraft in degrees.

6. **MSGR_MSO_X**

The X position of the spacecraft in the MSO frame, in units of Mercury radii.

7. **MSGR_MSO_Y**

The Y position of the spacecraft in the MSO frame, in units of Mercury radii.

8. **MSGR_MSO_Z**

The Z position of the spacecraft in the MSO frame, in units of Mercury radii.

9. **FAST_DELTA_RATES_OFFSET_n**

Count rate of the firing of a discriminator when an analog signal exceeds a settable threshold, for offset n threshold, where n is one of A, B, C, or D. The discriminator is connected to the output of the pole-zero shaping circuit. Reported as a "delta" value.

10. **FAST_DELTA_RATES_UNC_OFFSET_n**

Uncertainties for the FAST_DELTA_RATES, for offset n threshold, where n is one of A, B, C, or D.

11. **FAST_DELTA_FLUXES_OFFSET_n**

Calibrated flux of the delta value of the firing rate of a discriminator when an analog signal exceeds a settable threshold, for offset n threshold, where n is one of A, B, C, or D. The discriminator is connected to the output of the pole-zero shaping circuit.

12. FAST_DELTA_FLUXES_UNC_OFFSET_n

Uncertainties for the FAST_DELTA_FLUXES, for offset n threshold, where n is one of A, B, C, or D.

13. SHAPED_DELTA_RATES_OFFSET_n

Count rate of the firing of a discriminator when an analog signal exceeds a settable threshold, for offset n threshold, where n is one of A, B, C, or D. The discriminator is connected to the output of the 3 pole Gaussian shaping circuit. Reported as a “delta” value.

14. SHAPED_DELTA_RATES_UNC_OFFSET_n

Uncertainties for the SHAPED_DELTA_RATES.

15. SHAPED_DELTA_FLUXES_OFFSET_n

Calibrated flux of the delta value of the firing rate of a discriminator when an analog signal exceeds a settable threshold, for offset n threshold, where n is one of A, B, C, or D. The discriminator is connected to the output of the 3 pole Gaussian shaping circuit.

16. SHAPED_DELTA_FLUXES_UNC_OFFSET_n

Uncertainties for the SHAPED_DELTA_FLUXES, for offset n threshold, where n is one of A, B, C, or D.

17. FAST_SCAN_RATES_OFFSET_n

Count rate of the firing of a discriminator when an analog signal exceeds a settable threshold, for offset n threshold, where n is one of A, B, C, or D. The discriminator is connected to the output of the pole-zero shaping circuit.

18. FAST_SCAN_RATES_UNC_OFFSET_n

Uncertainties for the FAST_SCAN_RATES, for offset n threshold, where n is one of A, B, C, or D.

19. SHAPED_SCAN_RATES_OFFSET_n

Count rate of the firing of a discriminator when an analog signal exceeds a settable threshold, for offset n threshold, where n is one of A, B, C, or D. The discriminator is connected to the output of the 3 pole Gaussian shaping circuit.

20. SHAPED_SCAN_RATES_UNC_OFFSET_n

Uncertainties for the SHAPED_SCAN_RATES, for offset n threshold, where n is one of A, B, C, or D.

8.8 FIPS_HI_CDR.FMT Table Columns

The following are the columns as defined by the FIPS_HI_CDR.FMT structure file. This file defines the ASCII table containing the FIPS High Priority data. Archive volume is optimized by defining the table structure once and providing a reference to it in the PDS label file. The columns are numbered according to their column order in the table. Data_Type refers to the PDS standards data type for a particular column in the table.

A FIPS flight software upload was implemented on 9/6/2007. The FIPS_SCANTYPE and STOP_FLUX columns were introduced as a result. The values for these columns are not meant to be valid prior to 9/6/2007.

Table 25 FIPS_HI_CDR.FMT Columns

Length (bytes)	Data Type	Field Name	Summary (see full text for column description)
16	ASCII Real	MET	Mission Elapsed Time in seconds.
21	TIME	TIME	UTC time string.
7	ASCII Integer	DATA_QUALITY	Data quality flag.
4	ASCII Integer	FIPS_SCANTYPE	Indicates FIPS Scan mode.
10 X 64	ASCII Real	PROTON_V_DIST0	64 element array of normalized proton velocity distribution values.
10 X 64	ASCII Real	START_FLUX	64 element array of start particle differential flux.

10 X 64	ASCII Real	STOP_FLUX	64 element array of stop particle differential flux.
10 X 64	ASCII Real	VALID_EVT_FLUX	64 element array of valid event particle differential flux.
10 X 64	ASCII Real	PROTON_FLUX	64 element array of proton particle differential flux.
10 X 64	ASCII Real	EVT_PROC_FLUX	64 element array of event processed particle differential flux.

1. MET

Mission elapsed time in seconds at the end of the accumulation.

2. TIME

Spacecraft event time (UTC) for this data record.

3. DATA_QUALITY

Data quality flag, taking on values of 0 (bad) and 1 (good).

4. FIPS_SCANTYPE

Indicates the FIPS Scan Mode. Tables referenced here are one of the eight E/q stepping tables loaded into the instrument. See the EPPS CDR SIS in the EPPS Document Archive Volume for details. =0 Normal Scan, =1 High Temp Scan, =2 Burst Scan, =3 Test Scan, =4 Table 4, =5 Table 5, =6 Table 6, =7 Table 7.

5. PROTON_V_DIST0

A 64-element normalized proton velocity distribution function based on the proton events detected during the first 64-step voltage scan of each 10-scan sequence.

6. START_FLUX

The start particle differential flux, in counts per (keV/e) per sec per cm**2 per sr. Sampled at each of the 64 steps in the 1st scan of a 10-scan sequence.

7. STOP_FLUX

The stop particle differential flux, in counts per (keV/e) per sec per cm**2 per sr. Sampled at each of the 64 steps in the 1st scan of a 10-scan sequence.

8. VALID_EVT_FLUX

The valid event particle differential flux, in counts per (keV/e) per sec per cm**2 per sr. Sampled at each of the 64 steps in the 1st scan of a 10-scan sequence.

9. PROTON_FLUX

The proton particle differential flux, in counts per (keV/e) per sec per cm**2 per sr. Sampled at each of the 64 steps in scan 10 of a 10-scan sequence.

10. EVT_PROC_FLUX

The events processed particle differential flux, in counts per (keV/e) per sec per cm**2 per sr. Sampled at each of the 64 steps in scan 10 of a 10-scan sequence.

8.9 FIPS_MED_CDR.FMT Table Columns

The following are the columns as defined by the FIPS_MED_CDR.FMT structure file. This file defines the ASCII table containing the FIPS Medium Priority spectra data. Archive volume is optimized by defining the table structure once and providing a reference to it in the PDS label file. The columns are numbered according to their column order in the table. Data_Type refers to the PDS standards data type for a particular column in the table.

A FIPS flight software upload was implemented on 9/6/2007. The FIPS_SCANTYPE and STOP_FLUX columns were introduced as a result. The values for these columns are not meant to be valid prior to 9/6/2007.

The FSW6 upload was done on 8/18/2008 and implemented on 8/19/2008. The software update retired the FIPS Medium Priority Spectra packet. Thus there are no FIPS Medium Priority CDRs on or after 8/19/2008.

Table 26 FIPS_MED_CDR.FMT Columns

Length (bytes)	Data Type	Field Name	Summary (see full text for column description)
16	ASCII Real	MET	Mission Elapsed Time in seconds.
21	TIME	TIME	UTC time string.
7	ASCII Integer	DATA_QUALITY	Data quality flag.
4	ASCII Integer	FIPS_SCANTYPE	Indicates FIPS Scan mode.
10 X 64	ASCII Real	PROTON_V_DIST210	64 element array of Normalized proton velocity distribution values.
10 X 64	ASCII Real	START_FLUX	64 element array of start differential flux.
10 X 64	ASCII Real	STOP_FLUX	64 element array of stop differential flux.
10 X 64	ASCII Real	VALID_EVT_FLUX	64 element array of valid event differential flux.
10 X 64	ASCII Real	PROTON_FLUX	64 element array of proton differential flux.
10 X 64	ASCII Real	EVT_PROC_FLUX	64 element array of events processed differential flux.

1. MET

Mission elapsed time in seconds at the end of the accumulation.

2. TIME

Spacecraft event time (UTC) for this data record.

3. DATA_QUALITY

Data quality flag, taking on values of 0 (bad) and 1 (good).

4. FIPS_SCANTYPE

Indicates the FIPS Scan Mode. Tables referenced here are one of the eight E/q stepping tables loaded into the instrument. See the EPPS CDR SIS in the EPPS Document Archive Volume for details. =0 Normal Scan, =1 High Temp Scan, =2 Burst Scan, =3 Test Scan, =4 Table 4, =5 Table 5, =6 Table 6, =7 Table 7.

5. **PROTON_V_DIST210**

A 64-element normalized proton velocity distribution accumulated over each of scans 2-10 in the 10 scan sequence, expressed as a unit-less probability..

6. **START_FLUX**

Start differential flux, in counts per (keV/e) per sec per cm**2 per sr.

7. **STOP_FLUX**

Stop differential flux, in counts per (keV/e) per sec per cm**2 per sr.

8. **VALID_EVT_FLUX**

Valid event differential flux, in counts per (keV/e) per sec per cm**2 per sr.

9. **PROTON_FLUX**

Proton differential flux, in counts per (keV/e) per sec per cm**2 per sr.

10. **EVT_PROC_FLUX**

Events processed differential flux, in counts per (keV/e) per sec per cm**2 per sr.

8.10 FIPS_PHA_CDR.FMT Table Columns

The following are the columns as defined by the FIPS_PHA_CDR.FMT structure file. This file defines the ASCII table containing the FIPS Pulse Height Analysis (PHA) event data. Archive volume is optimized by defining the table structure once and providing a reference to it in the PDS label file. The columns are numbered according to their column order in the table. Data_Type refers to the PDS standards data type for a particular column in the table.

A FIPS flight software upload was implemented on 9/6/2007. The FIPS_SCANTYPE column was introduced as a result. The value for this column is not meant to be valid prior to 9/6/2007.

In addition, another flight software upload (FSW7) was done on 8/18/2009. As a result, the PRIORITY_DECIMATION column meaning is different before FSW7. See the description for details.

Table 27 FIPS_PHA_CDR.FMT Columns

Length (bytes)	**Data Type**	**Field Name**	**Summary (see full text for column description)**
16	ASCII Real	MET	Mission Elapsed Time in seconds.
21	TIME	TIME	UTC time string.
8	ASCII Integer	DATA_QUALITY	Data quality flag.
8	ASCII Integer	FIPS_SCANTYPE	Indicates FIPS Scan mode.
7	ASCII Integer	PRIORITY_DECIMATION	PHA priority ID (pre-FSW7); proton hardware decimation level (post-FSW7).
4	ASCII Integer	STEP_NUM	E/q step number.
6	ASCII Real	ENERGY_PER_CHARGE	E/q value.
4	ASCII Integer	X	Calculated value for FIPS event.
4	ASCII Integer	Y	Calculated value for FIPS event.
7	ASCII Real	ZENITH_ANGLE	Incident zenith angle for particle.
7	ASCII Real	AZIMUTHAL_ANGLE	Incident azimuthal angle for particle.
5	ASCII Integer	TIME_OF_FLIGHT	Time of flight.
5	ASCII Integer	TIME_OF_FLIGHT_NS	Time of flight in nanoseconds.
6	ASCII Integer	WEDGE	Wedge number.
6	ASCII Integer	STRIP	Strip number.
6	ASCII Integer	ZIGZAG	Zigzag number.
10	ASCII Real	MASS_PER_CHARGE	Estimated mass per charge for particle.
10	ASCII Real	WEIGHT	Weight for particle.

1. **MET**

Mission elapsed time in seconds at the end of the accumulation.

2. **TIME**

Spacecraft event time (UTC) for this data record.

3. **DATA_QUALITY**

Data quality flag, taking on values of 0 (bad) and 1 (good).

4. **FIPS_SCANTYPE**

Indicates the FIPS Scan Mode and particle type. Tables referenced here are one of the eight E/q stepping tables loaded into the instrument. See the EPPS CDR SIS for details. =0 Normal Scan Heavy Ion, =1 High Temp Scan Heavy Ion, =2 Burst Scan Heavy Ion, =3 Test Scan Heavy Ion, =4 Table 4 Heavy Ion, =5 Table 5 Heavy Ion, =6 Table 6 Heavy Ion, =7 Table 7 Heavy Ion, =8 Normal Scan Proton, =9 High Temp Scan Proton, =10 Burst Scan Proton, =11 Test Scan Proton, =12 Table 4 Proton, =13 Table 5 Proton, =14 Table 6 Proton, =15 Table 7 Proton.

5. **PRIORITY_DECIMATION**

Prior to FSW7 this column records the priority level of the PHA data. 0 = High Priority, 1 = Medium priority, 2 = Low priority. After FSW7 this column records the proton hardware decimation level for

proton PHAs or =99 for Heavy Ion PHAs.

6. **STEP_NUM**

E/q Step Number (0-63) at which particle was measured.

7. **ENERGY_PER_CHARGE**

E/q value in keV/e corresponding to step number at which particle was measured.

8. **X**

In FSW4, FSW5, and FSW7, X is computed as

[128*(w+(w-z)/5)/sum],

and in FSW6, X is computed as

[96*(s+(s-z)/5)/sum]

where

w = wedge - wedge_offset

s = strip - strip_offset

z = 14*(zigzag - zigzag_offset)/10

sum = w+s+z.

A value of -9999 means X is N/A.

9. Y

In FSW4, FSW5, and FSW7, Y is computed as

[128*(s+(s-z)/5)/sum],

and in FSW6, Y is computed as

[100*(s+2*(s-z)/11)/sum]

where

w = wedge - wedge_offset

s = strip - strip_offset

z = 14*(zigzag-zigzag_offset)/10

sum = w+s+z.

A value of -9999 means Y is N/A.

10. ZENITH_ANGLE

Incident zenith angle for particle in degrees.

11. AZIMUTHAL_ANGLE

Incident azimuthal angle for particle in degrees.

12. TIME_OF_FLIGHT

Time of flight in digital channels.

13. TIME_OF_FLIGHT_NS

Time of flight in nanoseconds.

14. WEDGE

Wedge number. A value of -9999 means WEDGE is N/A.

15. STRIP

Strip number. A value of -9999 means STRIP is N/A.

16. ZIGZAG

Zigzag number. A value of -9999 means ZIGZAG is N/A.

17. MASS_PER_CHARGE

Estimated mass per charge (m/q) for particle.

18. WEIGHT

Weight for particle, includes instrument-related factors such as efficiency and angle dependence.

8.11 FIPS_SCAN_CDR.FMT Table Columns

The following are the columns as defined by the FIPS_SCAN_CDR.FMT structure file. This file defines the ASCII table containing the FIPS Scan data. Archive volume is optimized by defining the table structure once and providing a reference to it in the PDS label file. The columns are numbered according to their column order in the table. Data_Type refers to the PDS standards data type for a particular column in the table.

Available only after the FSW6 upload..

Table 28 FIPS_SCAN_CDR.FMT Columns

Length (bytes)	Data Type	Field Name	Summary (see full text for column description)
16	ASCII Real	MET	Mission Elapsed Time in seconds.
21	TIME	TIME	UTC time string.
7	ASCII Integer	DATA_QUALITY	Data quality flag.
4	ASCII Integer	FIPS_SCANTYPE	Indicates FIPS Scan mode.
10 X 64	ASCII Real	START_FLUX	Start differential flux.
10 X 64	ASCII Real	STOP_FLUX	Stop differential flux.
10 X 64	ASCII Real	VALID_EVT_FLUX	Valid event differential flux.
10 X 64	ASCII Real	PROTON_FLUX	Proton differential flux.
10 X 64	ASCII Real	EVT_PROC_FLUX	Events processed differential flux.

1. MET

Mission elapsed time in seconds at the end of the accumulation.

2. TIME

Spacecraft event time (UTC) for this data record.

3. DATA_QUALITY

Data quality flag, taking on values of 0 (bad) and 1 (good).

4. FIPS_SCANTYPE

Indicates the FIPS Scan Mode. Tables referenced here are one of the eight E/q stepping tables loaded into the instrument. See the EPPS CDR SIS in the EPPS Document Archive Volume for details. =0 Normal Scan, =1 High Temp Scan, =2 Burst Scan, =3 Test Scan, =4 Table 4, =5 Table 5, =6 Table 6, =7 Table 7.

5. **START_FLUX**

Start differential flux sampled at each E/q step in the scan, in counts per (keV/e) per sec per cm**2 per sr.

6. **STOP_FLUX**

Stop differential flux sampled at each E/q step in the scan, in counts per (keV/e) per sec per cm**2 per sr.

7. **VALID_EVT_FLUX**

Valid event differential flux sampled at each E/q step in the scan, in counts per (keV/e) per sec per cm**2 per sr.

8. **PROTON_FLUX**

Proton rate counter differential flux sampled at each E/q step in the scan, in counts per (keV/e) per sec per cm**2 per sr.

9. **EVT_PROC_FLUX**

Events processed differential flux sampled at each E/q step in the scan, in counts per (keV/e) per sec per cm**2 per sr.

8.12 FIPS_HRPVD_CDR.FMT Table Columns

The following are the columns as defined by the FIPS_HRPVD_CDR.FMT structure file. This file defines the ASCII table containing the Hi-resolution normalized proton velocity distributions. Archive volume is optimized by defining the table structure once and providing a reference to it in the PDS label file. The columns are numbered according to their column order in the table. Data_Type refers to the PDS standards data type for a particular column in the table.

Available only after the FSW6 upload.

Table 29 FIPS_HRPVD_CDR.FMT Columns

Length (bytes)	Data Type	Field Name	Summary (see full text for column description)
16	ASCII Real	MET	Mission Elapsed Time in seconds.

21	TIME	TIME	UTC time string.
7	ASCII Integer	DATA_QUALITY	Data quality flag.
4	ASCII Integer	FIPS_SCANTYPE	Indicates FIPS Scan mode.
11 X 32	ASCII Real	PROTONV_L00	Line 0 of a 32X32 hi-res proton vel distribution, integrated over 10 scan seq
11 X 32	ASCII Real	PROTONV_L01	Line 1 of a 32X32 hi-res proton vel distribution, integrated over 10 scan seq
11 X 32	ASCII Real	PROTONV_L02	Line 2 of a 32X32 hi-res proton vel distribution, integrated over 10 scan seq
11 X 32	ASCII Real	PROTONV_L03	Line 3 of a 32X32 hi-res proton vel distribution, integrated over 10 scan seq
11 X 32	ASCII Real	PROTONV_L04	Line 4 of a 32X32 hi-res proton vel distribution, integrated over 10 scan seq
11 X 32	ASCII Real	PROTONV_L05	Line 5 of a 32X32 hi-res proton vel distribution, integrated over 10 scan seq
11 X 32	ASCII Real	PROTONV_L06	Line 6 of a 32X32 hi-res proton vel distribution, integrated over 10 scan seq
11 X 32	ASCII Real	PROTONV_L07	Line 7 of a 32X32 hi-res proton vel distribution, integrated over 10 scan seq
11 X 32	ASCII Real	PROTONV_L08	Line 8 of a 32X32 hi-res proton vel distribution, integrated over 10 scan seq
11 X 32	ASCII Real	PROTONV_L09	Line 9 of a 32X32 hi-res proton vel distribution, integrated over 10 scan seq
11 X 32	ASCII Real	PROTONV_L10	Line 10 of a 32X32 hi-res proton vel distribution, integrated over 10 scan

			seq
11 X 32	ASCII Real	PROTONV_L11	Line 11 of a 32X32 hi-res proton vel distribution, integrated over 10 scan seq
11 X 32	ASCII Real	PROTONV_L12	Line 12 of a 32X32 hi-res proton vel distribution, integrated over 10 scan seq
11 X 32	ASCII Real	PROTONV_L13	Line 13 of a 32X32 hi-res proton vel distribution, integrated over 10 scan seq
11 X 32	ASCII Real	PROTONV_L14	Line 14 of a 32X32 hi-res proton vel distribution, integrated over 10 scan seq
11 X 32	ASCII Real	PROTONV_L15	Line 15 of a 32X32 hi-res proton vel distribution, integrated over 10 scan seq
11 X 32	ASCII Real	PROTONV_L16	Line 16 of a 32X32 hi-res proton vel distribution, integrated over 10 scan seq
11 X 32	ASCII Real	PROTONV_L17	Line 17 of a 32X32 hi-res proton vel distribution, integrated over 10 scan seq
11 X 32	ASCII Real	PROTONV_L18	Line 18 of a 32X32 hi-res proton vel distribution, integrated over 10 scan seq
11 X 32	ASCII Real	PROTONV_L19	Line 19 of a 32X32 hi-res proton vel distribution, integrated over 10 scan seq
11 X 32	ASCII Real	PROTONV_L20	Line 20 of a 32X32 hi-res proton vel distribution, integrated over 10 scan seq
11 X 32	ASCII Real	PROTONV_L21	Line 21 of a 32X32 hi-res proton vel distribution, integrated over 10 scan seq
11 X 32	ASCII Real	PROTONV_L22	Line 22 of a 32X32 hi-res proton vel distribution, integrated over 10 scan

			seq
11 X 32	ASCII Real	PROTONV_L23	Line 23 of a 32X32 hi-res proton vel distribution, integrated over 10 scan seq
11 X 32	ASCII Real	PROTONV_L24	Line 24 of a 32X32 hi-res proton vel distribution, integrated over 10 scan seq
11 X 32	ASCII Real	PROTONV_L25	Line 25 of a 32X32 hi-res proton vel distribution, integrated over 10 scan seq
11 X 32	ASCII Real	PROTONV_L26	Line 26 of a 32X32 hi-res proton vel distribution, integrated over 10 scan seq
11 X 32	ASCII Real	PROTONV_L27	Line 27 of a 32X32 hi-res proton vel distribution, integrated over 10 scan seq
11 X 32	ASCII Real	PROTONV_L28	Line 28 of a 32X32 hi-res proton vel distribution, integrated over 10 scan seq
11 X 32	ASCII Real	PROTONV_L29	Line 29 of a 32X32 hi-res proton vel distribution, integrated over 10 scan seq
11 X 32	ASCII Real	PROTONV_L30	Line 30 of a 32X32 hi-res proton vel distribution, integrated over 10 scan seq
11 X 32	ASCII Real	PROTONV_L31	Line 31 of a 32X32 hi-res proton vel distribution, integrated over 10 scan seq
10	ASCII Real	PROTON_L	Probability of protons in left edge of the 32X32 window.
10	ASCII Real	PROTON_R	Probability of protons in right edge of the 32X32 window.
10	ASCII Real	PROTON_BOT	Probability of protons in bottom edge of the 32X32 window.
10	ASCII Real	PROTON_TOP	Probability of protons in top edge of

the 32X32 window.

1. **MET**

Mission elapsed time in seconds at the end of the accumulation.

2. **TIME**

Spacecraft event time (UTC) for this data record.

3. **DATA_QUALITY**

Data quality flag, taking on values of 0 (bad) and 1 (good).

4. **FIPS_SCANTYPE**

Indicates the FIPS Scan Mode. Tables referenced here are one of the eight E/q stepping tables loaded into the instrument. See the EPPS CDR SIS in the EPPS Document Archive Volume for details. =0 Normal Scan, =1 High Temp Scan, =2 Burst Scan, =3 Test Scan, =4 Table 4, =5 Table 5, =6 Table 6, =7 Table 7.

5. **PROTONV_L00**

Line 0 of a 32x32 high-resolution normalized proton velocity distribution, integrated over a 10-scan sequence, expressed as a unit-less probability..

6. **PROTONV_L01**

Line 1 of a 32x32 high-resolution normalized proton velocity distribution, integrated over a 10-scan sequence, expressed as a unit-less probability..

7. **PROTONV_L02**

Line 2 of a 32x32 high-resolution normalized proton velocity distribution, integrated over a 10-scan sequence, expressed as a unit-less probability..

8. **PROTONV_L03**

Line 3 of a 32x32 high-resolution normalized proton velocity distribution, integrated over a 10-scan sequence, expressed as a unit-less probability..

9. PROTONV_L04

Line 4 of a 32x32 high-resolution normalized proton velocity distribution, integrated over a 10-scan sequence, expressed as a unit-less probability..

10. PROTONV_L05

Line 5 of a 32x32 high-resolution normalized proton velocity distribution, integrated over a 10-scan sequence, expressed as a unit-less probability..

11. PROTONV_L06

Line 6 of a 32x32 high-resolution normalized proton velocity distribution, integrated over a 10-scan sequence, expressed as a unit-less probability..

12. PROTONV_L07

Line 7 of a 32x32 high-resolution normalized proton velocity distribution, integrated over a 10-scan sequence, expressed as a unit-less probability..

13. PROTONV_L08

Line 8 of a 32x32 high-resolution normalized proton velocity distribution, integrated over a 10-scan sequence, expressed as a unit-less probability..

14. PROTONV_L09

Line 9 of a 32x32 high-resolution normalized proton velocity distribution, integrated over a 10-scan sequence, expressed as a unit-less probability..

15. PROTONV_L10

Line 10 of a 32x32 high-resolution normalized proton velocity distribution, integrated over a 10-scan sequence, expressed as a unit-less probability..

16. PROTONV_L11

Line 11 of a 32x32 high-resolution normalized proton velocity distribution, integrated over a 10-scan sequence, expressed as a unit-less probability..

17. PROTONV_L12

Line 12 of a 32x32 high-resolution normalized proton velocity distribution, integrated over a 10-scan sequence, expressed as a unit-less probability..

18. PROTONV_L13

Line 13 of a 32x32 high-resolution normalized proton velocity distribution, integrated over a 10-scan sequence, expressed as a unit-less probability..

19. PROTONV_L14

Line 14 of a 32x32 high-resolution normalized proton velocity distribution, integrated over a 10-scan sequence, expressed as a unit-less probability..

20. PROTONV_L15

Line 15 of a 32x32 high-resolution normalized proton velocity distribution, integrated over a 10-scan sequence, expressed as a unit-less probability..

21. PROTONV_L16

Line 16 of a 32x32 high-resolution normalized proton velocity distribution, integrated over a 10-scan sequence, expressed as a unit-less probability..

22. PROTONV_L17

Line 17 of a 32x32 high-resolution normalized proton velocity distribution, integrated over a 10-scan sequence, expressed as a unit-less probability..

23. PROTONV_L18

Line 18 of a 32x32 high-resolution normalized proton velocity distribution, integrated over a 10-scan sequence, expressed as a unit-less probability..

24. PROTONV_L19

Line 19 of a 32x32 high-resolution normalized proton velocity distribution, integrated over a 10-scan sequence, expressed as a unit-less probability..

25. PROTONV_L20

Line 20 of a 32x32 high-resolution normalized proton velocity distribution, integrated over a 10-scan sequence, expressed as a unit-less probability..

26. PROTONV_L21

Line 21 of a 32x32 high-resolution normalized proton velocity distribution, integrated over a 10-scan sequence, expressed as a unit-less probability..

27. PROTONV_L22

Line 22 of a 32x32 high-resolution normalized proton velocity distribution, integrated over a 10-scan sequence, expressed as a unit-less probability..

28. PROTONV_L23

Line 23 of a 32x32 high-resolution normalized proton velocity distribution, integrated over a 10-scan sequence, expressed as a unit-less probability..

29. PROTONV_L24

Line 24 of a 32x32 high-resolution normalized proton velocity distribution, integrated over a 10-scan sequence, expressed as a unit-less probability..

30. PROTONV_L25

Line 25 of a 32x32 high-resolution normalized proton velocity distribution, integrated over a 10-scan sequence, expressed as a unit-less probability..

31. PROTONV_L26

Line 26 of a 32x32 high-resolution normalized proton velocity distribution, integrated over a 10-scan sequence, expressed as a unit-less probability..

32. PROTONV_L27

Line 27 of a 32x32 high-resolution normalized proton velocity distribution, integrated over a 10-scan sequence, expressed as a unit-less probability..

33. PROTONV_L28

Line 28 of a 32x32 high-resolution normalized proton velocity distribution, integrated over a 10-scan sequence, expressed as a unit-less probability..

34. PROTONV_L29

Line 29 of a 32x32 high-resolution normalized proton velocity distribution, integrated over a 10-scan sequence, expressed as a unit-less probability..

35. PROTONV_L30

Line 30 of a 32x32 high-resolution normalized proton velocity distribution, integrated over a 10-scan sequence, expressed as a unit-less probability..

36. PROTONV_L31

Line 31 of a 32x32 high-resolution normalized proton velocity distribution, integrated over a 10-scan sequence, expressed as a unit-less probability..

37. PROTON_L

Probability of protons off the left edge of the 32x32 window.

38. PROTON_R

Probabilty of protons off the right edge of the 32x32 window.

39. PROTON_BOT

Probability of protons off the bottom edge of the 32x32 window.

40. PROTON_TOP

Probabilty of protons off the top edge of the 32x32 window.

8.13 FIPS_EQ.FMT Table Columns

The following are the columns as defined by the FIPS_EQ.FMT structure file. This file defines the ASCII table containing the FIPS energy per charge ancillary data. Archive volume is optimized by defining the table structure once and providing a reference to it in the PDS label file. The columns are numbered according to their column order in the table. Data_Type refers to the PDS standards data type for a particular column in the table.

Table 30 FIPS_SCAN_CDR.FMT Columns

Length (bytes)	Data Type	Field Name	Summary (see full text for column description)
6	ASCII Integer	STEP	Position in electrostatic analyzer voltage stepping sequence.

6	ASCII Real	EQ_TABLE_0	E/q in keV/e of measurement.
6	ASCII Integer	DSHV_TABLE_0	Index of E/q value in flight software DSHV Index Table, the table of possible DSHV (E/q) values that can be specified in a given stepping table. Useful for grouping E/q values in natural bins. Range 0..63.
7	ASCII Integer	ACCUM_TIME_0	Accumulation time for measurement in milliseconds.
9	ASCII Real	H_THRESH_TABLE_0	Proton threshold in nanoseconds. Events with TOF < threshold are classified as protons, and treated differently than heavy ions.
6	ASCII Real	EQ_TABLE_1	E/q in keV/e of measurement.
6	ASCII Integer	DSHV_TABLE_1	Index of E/q value in flight software DSHV Index Table, the table of possible DSHV (E/q) values that can be specified in a given stepping table. Useful for grouping E/q values in natural bins. Range 0..63.
7	ASCII Integer	ACCUM_TIME_1	Accumulation time for measurement in milliseconds.
9	ASCII Real	H_THRESH_TABLE_1	Proton threshold in nanoseconds. Events with TOF < threshold are classified as protons, and treated differently than heavy ions.
6	ASCII Real	EQ_TABLE_2	E/q in keV/e of measurement.
6	ASCII Integer	DSHV_TABLE_2	Index of E/q value in flight software DSHV Index Table, the table of possible DSHV (E/q) values that can be specified in a given stepping table. Useful for grouping E/q values in natural bins. Range 0..63.
7	ASCII Integer	ACCUM_TIME_2	Accumulation time for measurement in milliseconds.
9	ASCII Real	H_THRESH_TABLE_2	Proton threshold in nanoseconds. Events with TOF < threshold are classified as protons, and treated differently than heavy ions.

6	ASCII Real	EQ_TABLE_3	E/q in keV/e of measurement.
6	ASCII Integer	DSHV_TABLE_3	Index of E/q value in flight software DSHV Index Table, the table of possible DSHV (E/q) values that can be specified in a given stepping table. Useful for grouping E/q values in natural bins. Range 0..63.
7	ASCII Integer	ACCUM_TIME_3	Accumulation time for measurement in milliseconds.
9	ASCII Real	H_THRESH_TABLE_3	Proton threshold in nanoseconds. Events with TOF < threshold are classified as protons, and treated differently than heavy ions.
6	ASCII Real	EQ_TABLE_4	E/q in keV/e of measurement.
6	ASCII Integer	DSHV_TABLE_4	Index of E/q value in flight software DSHV Index Table, the table of possible DSHV (E/q) values that can be specified in a given stepping table. Useful for grouping E/q values in natural bins. Range 0..63.
7	ASCII Integer	ACCUM_TIME_4	Accumulation time for measurement in milliseconds.
9	ASCII Real	H_THRESH_TABLE_4	Proton threshold in nanoseconds. Events with TOF < threshold are classified as protons, and treated differently than heavy ions.
6	ASCII Real	EQ_TABLE_5	E/q in keV/e of measurement.
6	ASCII Integer	DSHV_TABLE_5	Index of E/q value in flight software DSHV Index Table, the table of possible DSHV (E/q) values that can be specified in a given stepping table. Useful for grouping E/q values in natural bins. Range 0..63.
7	ASCII Integer	ACCUM_TIME_5	Accumulation time for measurement in milliseconds.
9	ASCII Real	H_THRESH_TABLE_5	Proton threshold in nanoseconds. Events with TOF < threshold are classified as protons, and treated differently than heavy ions.

6	ASCII Real	EQ_TABLE_6	E/q in keV/e of measurement.
6	ASCII Integer	DSHV_TABLE_6	Index of E/q value in flight software DSHV Index Table, the table of possible DSHV (E/q) values that can be specified in a given stepping table. Useful for grouping E/q values in natural bins. Range 0..63.
7	ASCII Integer	ACCUM_TIME_6	Accumulation time for measurement in milliseconds.
9	ASCII Real	H_THRESH_TABLE_6	Proton threshold in nanoseconds. Events with TOF < threshold are classified as protons, and treated differently than heavy ions.
6	ASCII Real	EQ_TABLE_7	E/q in keV/e of measurement.
6	ASCII Integer	DSHV_TABLE_7	Index of E/q value in flight software DSHV Index Table, the table of possible DSHV (E/q) values that can be specified in a given stepping table. Useful for grouping E/q values in natural bins. Range 0..63.
7	ASCII Integer	ACCUM_TIME_7	Accumulation time for measurement in milliseconds.
9	ASCII Real	H_THRESH_TABLE_7	Proton threshold in nanoseconds. Events with TOF < threshold are classified as protons, and treated differently than heavy ions.

1. STEP

Position in electrostatic analyzer voltage stepping sequence.

2. EQ_TABLE_n

E/q in keV/e of measurement.

3. DSHV_TABLE__n

Index of E/q value in flight software DSHV Index Table, the table of possible DSHV (E/q) values that can be specified in a given stepping table. Useful for grouping E/q values in natural bins. Range 0..63.

4. **ACCUM_TIME_n**

Accumulation time for measurement in milliseconds.

5. **H_THRESH_TABLE_n**

Start flux sampled at each E/q step in the scan, in counts per (keV/e) per sec per cm**2 per sr.

8.14 FIPS_FOVPIXEL.FMT Table Columns

The following are the columns as defined by the FIPS_FOV Pixel_CDR.FMT structure file. This file defines the ASCII table containing the FIPS FOV Pixel normalizations. The archive volume is optimized by defining the table structure once and providing a reference to it in the PDS label file. The columns are numbered according to their column order in the table. Data Type refers to the PDS standards data type for a particular column in the table.

The INDEX field values are unique for a given day and may be used to match data in this file to that in the two FIPS CDR files for the same day. This fact is used to avoid data duplication: Universal Time (UTC) and MESSENGER positions are given only this file.

Table 31 FIPS_FOVPIXEL.FMT Columns

Length (bytes)	Data Type	Field Name	Summary (see full text for column description)
9	ASCII Integer	X	X-coordinate in FIPS FOV.
8	ASCII Real	Y	Y-coordinate in FIPS FOV.

16	ASCII Real	V_POLAR	Polar angle of the corresponding XY pixel. Values range 15-75. Zero is aligned with the FIPS boresight vector
54	ASCII Real	V_AZIMUTH	Azimuthal angle of the corresponding XY pixel. Values range 0-359. Zero is aligned with the X axis in FIPS Cartesian coordinates.
16	ASCII Real	PIXEL_SOLID_ANG	The solid angle viewing area of the corresponding XY pixel.
16	ASCII Real	PIXEL_EFF	Relative efficiency of the corresponding XY pixel. Value is normalized by the average of efficiencies across all visible pixels. The average of these values across all pixels on the MCP is 1.
16	ASCII Integer	QUAL	Pixel quality flag. 0 - Good pixel; 1 - SC body obstructed pixel.

8.15 SPICE Kernel Files Used in MESSENGER Data Products

The following SPICE kernel files are 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.

***.bsp**:

MESSENGER spacecraft ephemeris file. Also known as the Planetary Spacecraft Ephemeris Kernel (SPK) file.

*.**bc:**

MESSENGER spacecraft orientation file. Also known as the Attitude C-Kernel (CK) file.

***.tf:**

MESSENGER reference frame file. Also known as the Frames Kernel. Contains the MESSENGER spacecraft, science instrument, and communications antennae frame definitions.

***.ti:**

MESSENGER instrument kernel (I-kernel). Contains references to mounting alignment, operation modes, and timing as well as internal and field of view geometry for the EPPS.

***.tsc:**

MESSENGER spacecraft clock coefficients file. Also known as the Spacecraft Clock Kernel (SCLK) file.

***.tpc:**

Planetary constants file. Also known as the Planetary Constants Kernel (PcK) file.

***.tls:**

NAIF leapseconds kernel file. Used in conjunction with the SCLK kernel to convert between Universal Time Coordinated (UTC) and MESSENGER Mission Elapsed Time (MET). Also called the Leap Seconds Kernel (LSK) file.

8.16 CODMAC/NASA Definition of Processing Levels

CODMAC/NASA Definition of processing levels for science data sets

CODMAC Level	Proc. Type	Data Processing Level Description
1	Raw Data	Telemetry data stream as received at the ground station, with science and engineering data embedded. Corresponds to NASA packet data.
2	Edited Data	Instrument science data (e.g. raw voltages, counts) at full resolution, time ordered, with duplicates and transmission errors removed. Referred to in the MESSENGER program as 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 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

CODMAC Level	Proc. Type	Data Processing Level Description
		some cases these also qualify as derived data products (DDRs). Corresponds to NASA Level 1A.
4	Resampled data	Irreversibly transformed (e.g. resampled, remapped, calibrated) values of the instrument measurements (e.g. radiances, magnetic field strength). Referred to in the MESSENGER program as either derived data products (DDPs) or derived analysis products (DAPs). Corresponds to NASA Level 1B.
5	Derived Data	Derived results such as maps, reports, graphics, etc. Corresponds to NASA Levels 2 through 5
6	Ancillary Data	Non-Science data needed to generate calibrated or resampled data sets. Consists of instrument gains, offsets; pointing information for scan platforms, etc.
7	Corrective Data	Other science data needed to interpret space-borne data sets. May include ground based data observations such as soil type or ocean buoy measurements of wind drift.
8	User Description	Description of why the data were required, any peculiarities associated with the data sets, and enough documentation to allow secondary user to extract information from the data.

The above is based on the national research council committee on data management and computation (CODMAC) data levels.

8.17 MESSENGER Glossary and Acronym List

ACT Applied Coherent Technology Corporation

ADU Analog-to-Digital Units

AMU Atomic Mass Unit

APL The Johns Hopkins university Applied Physics Laboratory

ASCII American Standard Code for Information Interchange

CDR Calibrated Data Record

CK Attitude C-Kernel (SPICE)

CODMAC Committee on Data Management and Computation

DAP Derived Analysis Products

DDP Derived Data Products

DSHV Deflection System High Voltage

EDR Experiment Data Records

EPPS Energetic Particle and Plasma Spectrometer

EPS Energetic Particle Spectrometer

ESA Electrostatic Analyzer

FIFO First In, First out. An electronic component that stores and retrieves information following a first-in-first-out discipline.

FIPS Fast Imaging Plasma Spectrometer

FOV Field-of-View

FSW Flight Software

FTP File Transfer protocol

GEANT4 GEometry ANd Tracking software toolkit

GF Geometric Factor

I2C Inter-Integrated Circuit

JPL Jet Propulsion Laboratory

IEM Integrated Electronic Module

LSB Least Significant Bit

LSK Leapseconds Kernel (SPICE)

MCP Micro-channel Plate

MESSENGER MErcury Surface, Space ENvironment, GEochemistry, and Ranging

MET Mission Elapsed Time

MIDL Mission Independent Data Layer

MSO Mercury-centric Solar Orbital

NAIF Navigation and Ancillary Information Facility

NASA National Aeronautics and Space Administration

PCK Planetary Constant Kernel (SPICE)

PDS Planetary Data System

PHA Pulse Height Analysis

PPI Planetary Plasma Interactions PDS Node

RDR Reduced Data Record

SCLK Space Clock Kernel (SPICE)

SOC Science Operations Center

SPICE Spacecraft, Planet, Instrument, C-matrix Events, refers to the kernel files and NAIF software used to generate viewing geometry.

SPK Spacecraft and Planets Kernel (SPICE)

SSD Solid-State Detector

SSR Space Sciences Review

TOF Time of Flight

UTC Coordinated Universal Time