DAWN'S GAMMA RAY AND NEUTRON DETECTOR (GRAND)

VESTA BUNDLE DESCRIPTION

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CONTENTS

WHAT'S IN THE VESTA BUNDLE?

The Vesta bundle contains raw, calibrated, and derived data products for Dawn's encounter with main belt asteroid (4) Vesta from May 2011 through August 2012 (see [1] for timeline). See the Operations Summary in this report for a description of instrument operations and performance during Vesta encounter. The data are accompanied by supporting documents and browse files, which provide a graphical overview. For further information on the GRaND archive and instrument, see [2-4]. The Vesta bundle includes the following collections.

DATA RAW COLLECTION

The Dawn GRaND Raw Collection for Vesta encounter includes gamma ray and neutron counting data and histograms. These are an intermediate data product derived from spacecraft science and housekeeping telemetry using reversible process. All higher order data products included in the bundle were derived from the raw data. The data are grouped into directories by date range. These contain GRaND housekeeping (HK), gamma-ray

(GAMMA), and neutron (NEUTRON) counting data and histograms. A detailed description of the format and contents of the raw data is provided by [3].

DATA CALIBRATED COLLECTION

The Dawn GRaND calibrated data collection contains corrected, time-series pulse height spectra in energy units for the bismuth germanate (BGO) scintillator subsystem. Peak areas extracted from the spectra and subjected to geometry and cosmic-ray corrections can be used to determine the concentration of elements within Vesta's regolith. The data reduction and calibration procedures are described by [5].

The collection also contains spacecraft ephemeris, pointing, and geometry (EPG) information for every science data recorded during Vesta encounter. This information can be related to raw and calibrated spectra and counts using the unique SCLK identifier that accompanies each record. The EPG data file also contains estimates of live time needed to determine counting rates, and the corrected triples count rate, which is a proxy for the flux of galactic cosmic rays. The information contained in the file and methods to determine live time and geometry corrections is described by [6]. Shape files used in the derivation of geometry corrections are provided in the Ancillary bundle (urn:nasa:pds:dawn-grand-ancillary).

DATA DERIVED COLLECTION

The Dawn GRaND data derived collection contains maps of counting data and elemental concentrations determined by the Dawn Science Team. The maps are rectangular projections (cylindrical and/or quasi-equal-area pixels), described in the label accompanying each file. The following products are included:

- HYDROGEN/GRD_HYDROGEN_MAP - Vesta hydrogen abundance map

This is a global map of the distribution of hydrogen (micrograms/gram) on Vesta. A smoothed, 0.5 deg cylindrical map is provided. See [7] for methods and scientific interpretation.

- ABSORPTION/GRD_NEUTRON_ABSORPTION_MAP - Vesta neutron absorption map

Global map of the thermal neutron absorption cross section of Vesta's regolith. The data are presented as a unitless compositional parameter along with 1-sigma uncertainties. Expressions to convert the data to absorption units are provided in the catalog file. The thermal neutron absorption cross section depends primarily on the concentration of Fe, Ca, Al, Ti. The absorption data is sensitive to petrology (e.g. the percentage of eucritic material in howardite). See [8] for a description of the methods and scientific interpretation of the data.

- IRON/GRD_IRON_UNCORRECTED_COUNTS_MAP - Vesta Fe gamma-ray uncorrected counts map

This is a global map of the intensity (counts/s) of the 7.6 MeV gamma ray produced by neutron capture with Fe. An additional correction for variations in neutron number density is needed in order to derive a quantity that is proportional to the concentration of Fe (see the corrected map below). Methods are described by [9].

- IRON/GRD_IRON_CORRECTED_COUNTS_MAP - Vesta Fe gamma-ray corrected counts map

This is a global map of the intensity (counts/s) of the 7.6 MeV gamma ray produced by neutron capture with Fe. All corrections have been applied such that the intensity is proportional to Fe concentration. An expression to convert counting rate to Fe concentration (wt.%) is provided in the label accompanying the data file. See [9] for methods and scientific interpretation.

- FAST_NEUTRON/GRD_FAST_NEUTRON_RESIDUAL_MAP - Vesta fast neutron residual map

This global map of fast neutron residual counting rates is sensitive to variations in the concentration of elements other than hydrogen. The methods used to make the map and an analysis of the sensitivity of the fast residuals to atomic mass is presented by [10].

- HEGR/GRD_HEGR_COUNTS_MAP - Vesta High Energy Gamma-Ray Counts Map

A global map of the high energy gamma ray (HEGR) continuum measured by GRaND's bismuth germanate scintillator is sensitive to the atomic mass and atomic number of Vesta's regolith. Methods and scientific interpretation of the data are described by [11].

COORDINATE SYSTEM

For Vesta, the derived data were analyzed and mapped in the Claudia coordinate system, in which the prime meridian passes close to a small crater named Claudia. In this coordinate system, the prominent Marcia crater is located at 190E longitude. Maps published by the Dawn Geochemistry Working Group are presented in the Claudia coordinate system [7-11].

Consistent with IAU guidelines, maps of GRaND data in this bundle are presented in the 'Claudia Double Prime' (CDP) coordinate system. CDP has the same pole position as Claudia such that latitudes are the same; however, the prime meridian of CDP is shifted by 210 degrees from that of the Claudia system, passing 20 degrees to the east of Marcia crater [12].

All the maps use rectangular pixels with east longitudes within -180 to 180 degrees in the Claudia system. For archiving, the longitudes were converted to CDP as follows:

1. longitude_CDP = longitude_Claudia - 210 degrees.
2. If longitude_CDP is less than -180 degrees, add 360 degrees.

For example, if longitude_Claudia = -170 (the location of Marcia crater), then longitude_CDP = -20.

Similarly, longitudes in the CDP system can be converted to Claudia as follows:

1. longitude_Claudia = longitude_CDP + 210.
2. If longitude_Claudia is greater than 180 degrees, subtract 360 degrees.

Thus, the pixel longitude boundaries, tabulated in this archive in the CDP system, can easily be converted back to the Claudia system, in which the data were analyzed, by the user when desired. To further facilitate comparison between the PDS archived maps and those published in the literature, a 'side-by-side' display of each map in the Claudia and CDP systems is included in the accompanying browse file (see BROWSE directory).

For further clarification, we note that map pixels in the Claudia system always have MIN_LON < MAX_LON; however, when transformed into the CDP system, not all pixels will meet this condition. For example, in some quasi-equal area maps, the polar pixels have MIN_LON = -180 and MAX_LON = 180 in the Claudia coordinate system. These pixels span 360 degrees in longitude. When transformed to the CDP coordinate system, these pixels have MIN_LON = -30 and MAX_LON = -30, such that MIN_LON = MAX_LON. In addition, for some maps, a portion of the pixels will have MIN_LON > MAX_LON when transformed into the CDP system. To avoid confusion, we included the width of each pixel in longitude as DELTA_LON. For example, for the aforementioned polar pixels, DELTA_LON = 360.

MISCELLANEOUS COLLECTION

The miscellaneous collection contains the binary stereolithography file CERES_SPC181019_0512_PLT_1.00.stl. This is the shape model that was used to derive solid angles reported in the ephemeris, pointing, and geometry (EPG) file found in the calibrated collection. The STL format is open source and is fully described in the accompanying label. See [6] for a description of the methods.

BROWSE COLLECTION

The browse collection contains graphical presentations of the data found in the raw, calibrated and derived collections. For each raw directory (GRD-L1A-Y1M1D1-Y2M2D2_YCMCDC),[3] an accompanying browse file provides statistics (records and gaps), instrument settings, strip charts of selected parameters, and pulse-height spectra. The browse files accompanying the calibrated collection include a graphical mission timeline and BGO pulse height spectra by mission phase. The browse files accompanying the calibrated collection provide a graphical presentation of each of the map products.

DOCUMENT COLLECTION

The document collection contains the bundle description (this document). The BGO calibrated data processing and ephemeris, pointing and geometry documents [5,6] are also included as secondary members of the collection.

OPERATIONS SUMMARY

During Vesta encounter, the Dawn spacecraft entered safe mode six times: on 27-Jun-2011 (VSA), 21-Sep-2011 (VSH), 4-Dec-2011 (VTL), 14-Jan-2012 (VSL), 21-Feb-2012 (VSL), and 8-Aug-2012 (VTC). GRaND was not powered back on following the last safe mode entry. Recovery of GRaND was delayed due to anomalous conditions for the 21-Sep-2011 and 14-Jan-2012 events. Recovery for the latter event required resetting the communications link between GRaND and the spacecraft; however, GRaND was found in an anomalous state following recovery from the 21-Sep-2011 event, which is described here.

GRaND was powered on and configured for science data acquisition on 22-Sep-2011. It was discovered that following entry into NORMAL mode and prior to application of high voltage, the BGO counting rate was about 80 hertz, with a sharp peak around channel 100. During normal operations, no counts would have been observed at this stage. At nominal high voltage settings, the BGO pulse height spectrum was found to be noisy and the spectrum was shifted and distorted (see EDRs in the 110922-110928 directory). The behavior was stable, and the instrument was allowed to operate at nominal high voltages for about a week while the anomaly was investigated.

On 28-Sep-2011, GRaND was commanded into STANDBY mode, with all HV supplies off and the low voltage supplies enabled.

The anomaly review panel concluded that it would do no harm to GRaND to cycle power; however, the panel also suggested that GRaND remained powered off for a few days in case the anomaly was caused by a damaged component, which might recover with power removed. The instrument was powered off on 30-Sep-2011 and powered on and configured on 4-Oct-2012. The instrument was found to be nominal upon entry into NORMAL mode with the ±5V supply and high voltage supply enabled. Given the absence of the 80-Hz noise, the decision was made to ramp up the high voltages for the BGO scintillator. This was carried out on 5-Oct-2012, and the spectrum was found to be nominal. The high voltages for the remaining scintillators were ramped up the same day; however, the high voltages for the CZT were not ramped up until 11-Oct-2011. The system was fully configured and restored to nominal operations on 12-Oct-2011.

Although the root cause has not been identified, it was determined that the abrupt removal of power from GRaND upon entry into safe mode was not likely have caused catastrophic damage to analog components. The analog or digital circuitry appears to have an anomalous state that can be entered upon application of power. Thus, the problem was mitigated by monitoring the event counter on entry into NORMAL mode. If anomalous counts are observed, the instrument can be power cycled. This operational measure was effectively implemented during the recovery from the 21-Feb-2011 safing.

The BGO anomaly and recovery affects raw data in directories with the following date ranges:

110922-110928
111004-111006
111006-111011
111011-111016

For completeness, data corrupted (e.g. due to transmission errors) are not excluded from the dataset; however, instances of corrupt data are rare, restricted to the 120225-120303 directory (VSL), primarily on two days during Vesta encounter: 29-Feb-2012 and 1-Mar-2012. User's should be cautious when processing data in this directory. See [3] for a general description of issues impacting data quality.

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