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Lunar Atmosphere and Dust Environment Explorer

(LADEE)

(LDEX PDS Software Interface Specification)

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(05/24/2013)

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This document is approved in accordance with LADEE Configuration Management Plan, C04.LADEE.CM, paragraph 3.6.1.1 Document Release Routing Approval Process.

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REVISION HISTORY			
Rev.	**Description of Change**	**Author(s)**	**Effective Date**
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RevB	This version incorporates the changes resulting from the pre-launch PDS review on 1/9/2013 including liens from that review.	David James Jamey Szalay	5/24/2013

CONFIGURATION MANAGEMENT PLAN

This document is an LADEE Project Configuration Management (CM)-controlled document. Changes to this document require prior approval of the LADEE Project Manager. Proposed changes shall be submitted to the LADEE CM office along with supportive material justifying the proposed change. Changes to this document will be made by complete revision.

Questions or comments concerning this document should be addressed to:

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ACRONYMS

ADC	Analog to Digital Converter
CCLDAS	Colorado Center for Lunar Dust and Atmospheric Studies
DAWG	Data and Archives Working Group
DMAP	Data Management and Archive Plan
DN	Data Number
EOM	End of (LADEE) Mission
ICD	Interface Control Document
LADEE	Lunar Atmosphere and Dust Environment Explorer
LASP	Laboratory for Atmospheric and Space Physics
LDEX	Lunar Dust Experiment
MCP	Microchannel Plate
OLAF	Online Archive Facility
PDS	Planetary Data System
SBN	Small Bodies Node
SIS	Software Interface Specification
SOC	Science Operation Center
SQL	Structured Query Language
TBD	To Be Determined

1. INTRODUCTION

1.1 Purpose and Scope

This document describes the format and the content of the Lunar Dust EXperiment (LDEX) products as archived in the Small Bodies Node in PDS. The data products stored in PDS are a subset of the holdings of the LDEX team database at the Laboratory for Atmospheric and Space Physics (LASP) in Boulder, CO.

This SIS is intended to provide enough information to enable users to read and understand the LDEX data products as stored in PDS. The users for whom this SIS is intended are software developers of the programs used in generating the LDEX products and scientists who will analyze the data, including those associated with the LADEE mission and those in the general lunar science community.

1.2 Contents

LDEX is an instrument on the LADEE spacecraft designed to study the lunar dust environment by measuring the physical properties of the particles impacting the instrument target during the mission. This Data Product SIS describes how the LDEX instrument acquires its data and how the data are processed. This document specifically discusses the high-level data subset, which is stored in PDS.

1.3 Applicable Documents and Constraints

1. Planetary Data System Standards Reference, JPL D-7669 part 2, version 4.0.6, October 8, 2012.
2. LADEE Project Data Management and Archive Plan, version 2.2, May, 2011.
3. LADEE LDEX PDS Interface Control Document, version 1.0 April, 24, 2012

1.4 Relationships with Other Interfaces

The LDEX data products are stored in multiple locations according to the LADEE Project Data Management and Archive Plan (DMAP). The copy at LASP, stored in an SQL (Structured Query Language) relational database for rapid instrument team access, will be used by the LDEX science team to retrieve and process data for delivery to PDS as described by the LADEE LDEX PDS Interface Control Document.

2. MANAGEMENT AND OVERSIGHT

Data will be produced by the LDEX science team for submission to PDS. Data delivered to PDS will be managed and verified according to the LADEE LDEX PDS Interface Control Document and the PDS Standards Reference.

3. DATA PRODUCT CHARACTERISTICS AND ENVIRONMENT

3.1 Instrument Overview

The Lunar Dust Experiment is an *in situ* instrument designed to characterize the dust exosphere by mapping the size and spatial distributions of dust grains in the lunar environment as a function of local time and the position of the Moon with respect to the magnetosphere of the Earth. LDEX will gauge the relative contributions of the two competing dust sources: a) ejecta production due to the continual bombardment of the Moon by interplanetary micrometeoroids [1], and b) lofting of small grains from the lunar surface due to plasma-induced near-surface electric fields [2].

LDEX is an impact ionization dust detector on the LADEE mission with a design based on the Heos 2 [3], Galileo and Ulysses [4], and Cassini [5] dust instruments. The LADEE spacecraft orbit is nearly circular at an altitude of 30-100 km above the lunar surface. For the ~1.67 km/s impact speeds expected on this orbit, the LDEX threshold for measuring individual dust grains is approximately $m = 9X10^{-16}$ kg (radius $r_g = 0.4$ μm for olivine grains) as determined by the olivine calibration measurements performed with the instrument. LDEX will also measure the collective current due to the impact of grains below the threshold for individual detection, enabling the search for a significant population of grains with $r_g \approx 0.1$ μm over the terminators, indicated by visual observations of Apollo astronauts [6].

3.1.1 Impact Ionization Detectors

The instrument operation principle is depicted in Figure 1. A dust particle impacts the hemispherical target and generates a plasma cloud. The -200 V bias applied on the ion focusing grid creates a radial electric field and separates the electrons and ions. The electrons are collected on the target and measured by a charge sensitive amplifier. The ions are detected by the microchannel plate (MCP) behind the focusing grid. The MCP anode is connected to current-to-voltage (I/V) amplifiers to measure the current pulse of the impact. An event with a signal amplitude above the user defined threshold on the MCP channel will trigger data collection for both the target and MCP waveforms. The impact charge is obtained both from the target and the MCP signals independently. The mass and size of the dust particle are calculated from the impact charge using laboratory calibration data. LDEX is able to detect individual impacts of particles with $r_g \geq 0.4$ μm.

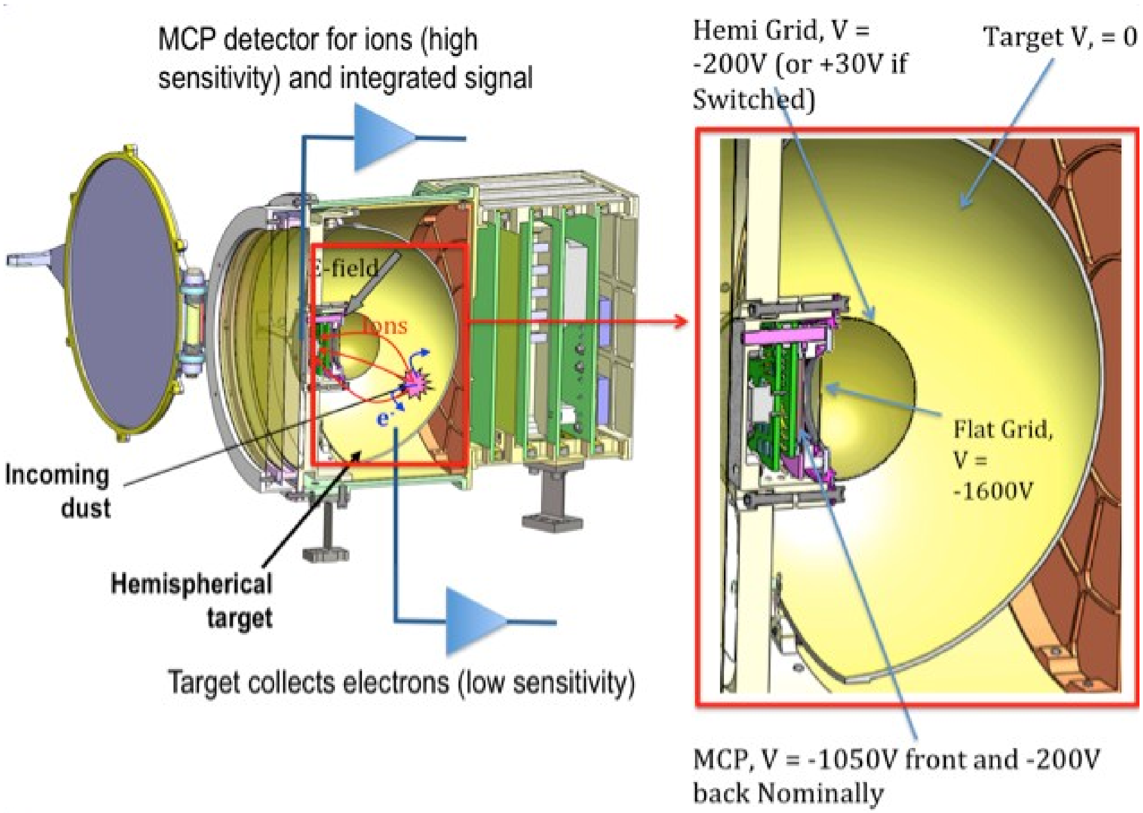

Figure 1: LDEX instrument and operating principle.

The cadence of storing valid waveforms is a selectable parameter. For those waveforms not kept, the signal amplitudes of the target and MCP are recorded. Each waveform consists of 50 points at 8 μs spacing with the trigger point nominally at 120 μs. Figure 2 shows a sample target and MCP waveform recorded during calibration.

The dead time of the instrument is defined as any time that the processing logic is busy and cannot detect new impacts. The dead time is approximately 1 millisecond for each valid and invalid impact. This total of valid and invalid impact count can be found in the primary housekeeping data.

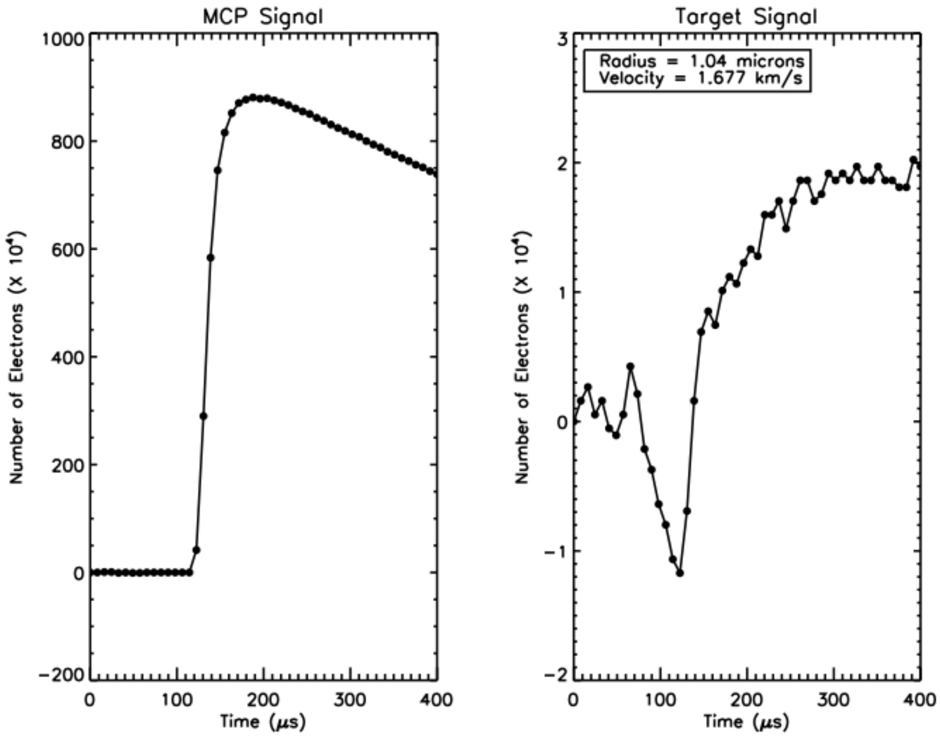

Figure 2: Sample MCP and Target waveforms from a 1.04 μm particle with a speed of 1.677 km/s. The dip in the target waveform from ~70 μs – 120 μs is due to the image charge created by the incoming particle.

3.1.2 Charge Integration Detector

Besides individual impact detection, LDEX can identify a large population of small ($r_g <$ 0.4 μm) dust grains with a separate mode of detection. LDEX integrates the MCP signal with a nominal cadence of 0.1 s to measure the cumulative charge collected from small dust impacts. The cumulative charge signal is expected to rise over the terminator region if a significant distribution of small particles is present.

The noise background (e.g. UV, energetic particles, etc.) is measured every 10 s and will be used to correct the measurements during data analysis. With 0.1 Hz frequency, the bias on the ion focusing grid is switched from -200 V to +30 V for a duration of 1 sec. The positive bias stops all dust impact generated ions and the MCP signal is solely due to background noise.

3.1.3 HV Screens

The LDEX instrument has three high voltage components in addition to the MCP. There is a solar wind screen nominally at -200V at the entrance of the instrument. This screen is between two additional grounded screens resulting in three screens at the entrance aperture. Each of these screens is 90% transmissive yielding a transmission of about 67% for these screens. There is a hemispherical shaped grid just in front of the MCP that the ions must pass through before reaching the MCP. This is nominally at -200V but can be switched to +30V to reject impact plasma ions and record the background signal. This is typically switched for 1 second every 10 seconds. Finally there is a flat grid just in front of the MCP at -1600V. This is used to focus the plasma-induced ions into the MCP.

3.1.4 Calibration

LDEX was constructed and tested at the Laboratory for Atmospheric and Space Physics (LASP), and was calibrated at the Colorado Center for Lunar Dust and Atmospheric Studies (CCLDAS) [7]. To calibrate the instrument, LDEX was bombarded by submicron dust particles in a velocity range of 1 - 40 km/s. Figure 2 shows the impact signal induced by a 1.04 μm particle at a speed of 1.677 km/s. The CCLDAS experiments confirmed that for a velocity of 1.67 km/s, $Q_I/m \approx 1.36$ C/kg, in agreement with expectations [3].

3.1.4.1 Single Event Detection

Before impact, if an incoming particle has sufficient charge, the target CSA measures the induced image charge on the target due to the approaching particle. The impact occurs at the sharp minimum followed by the collection of electrons from the impact plasma. The impact signal is first steep and then increases gradually. The steep part is due to the charge released by the primary impact, while the gradual part is due to the charge released by impacts of fragments of dust generated upon the primary impact. The MCP measures the current of the ions reaching the detector. The MCP and target channels use a CSA with the following conversion functions from voltage, V, to charge, q, which depends on the effective feedback capacitances:

$$Target : q_e = V_{tgt} * 4.2\text{E-}12$$
$$MCP : q_i = V_{mcp} * 6.2\text{E-}11.$$

Where q_e is the electron measurement and q_i is the ion measurement. For the MCP, this is the charge after the MCP gain, g_{mcp}, discussed below. Knowing that the plasma is quasi-neutral, the charges are related by:

$$|q_i| / g_{mcp} = |q_e| .$$

With the amplitude of the signals reported by LDEX, q, and the mass and velocity of the impactor reported by the accelerator, m and v respectively, a calibration curve for $m(q,v)$ can be established. This is done for both the MCP and Target signals. This calibration curve was measured over a range of temperatures, MCP bias voltages (nominally 850 V), and radial positions. Figure 3 shows the calibration curve at 20^{o} C, 850 volt MCP bias, and 2.54 cm radial position. For the nominal LDEX velocity of 1.67 km/s, the red line fit yields a mass calibration curve of:[1]

$$m_i = q_i * (2.88 \pm 0.3) \times 10^{-3} \text{ [kg]}$$

$$m_e = q_e * (0.736 \pm 0.075) \text{ [kg]}$$

[1] Pending final calibration analysis.

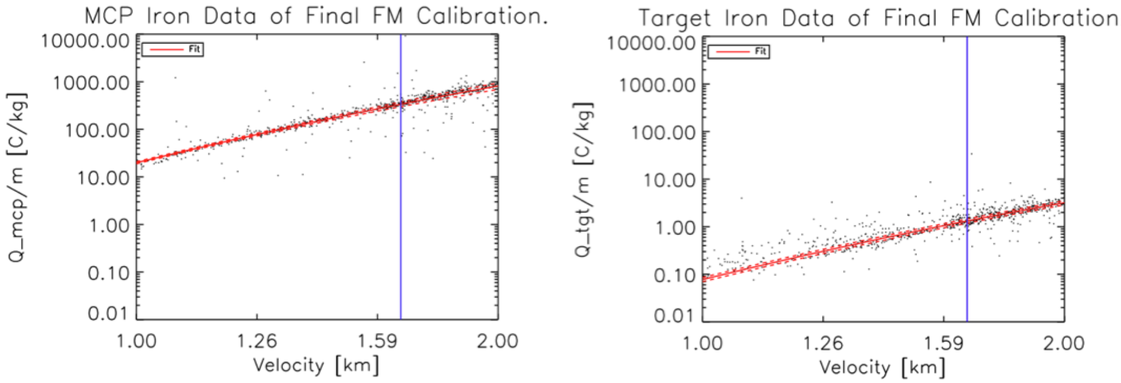

Figure 3: Data and fit for the LDEX iron data. These tests were at room temperature with an 850V MCP bias, and a position of 2.54 cm from the center of the target.

where m_i and m_e are the mass calculations from the ion and electron measurements respectively.

3.1.4.1.1 Temperature Effects

It was shown during testing that there is no measurable temperature dependence over the temperatures expected in orbit (-20 to +35 ^oC).

3.1.4.1.2 Radial Position Effects

The full radial dependence was mapped and showed a decrease in impacts with increasing radial distance. This is most likely due to the increasing impact angle with respect to normal given the hemispherical shape of the target, which leads to a decreasing impact charge as the radial impact distance increases. Taking into account that the cross sectional area increases with radial distance and the detection efficiency falls off slightly with radial distance, the position used for the calibration curve is 2.54 cm from the center of LDEX. Using this one distance, we account for particles that impact at other radial positions with an addition to the final uncertainty of the impact mass measurement.

3.1.4.1.3 MCP Gain v.s. MCP Bias Voltage

The bias voltage across the MCP affects the MCP gain and is a selectable parameter from 680 to 940 Volts. If the gain is changed in orbit, this will affect the calibration curve by adding a scale factor to the charge measured. Nominally, at 850 V, there is no scale factor. Note that this does not affect the charge generated by the target.

This gain of the MCP, g_{mcp}, as a function of the voltage across the MCP, ΔV, is equal to:

$$g_{mcp} = -21005.477 + 86.248555 * \Delta V - 0.1188874 * \Delta V^2 + 5.5170029e\text{-}05 * \Delta V^3.$$

This equation has been calibrated over the range of ΔV = 680 - 940 Volts (the range of possible LDEX MCP voltages). This gain is the ratio electrons out of the MCP to ions produced in the impact plasma. This gain takes into account such things as ions lost to imperfect focusing into the MCP, ion to electron conversion at the MCP, the transmission of the hemispherical and flat grids in front of the MCP, and the avalanche gain from the MCP itself. The electrons out of the MCP then pass through the electronics chain, which is not included in this equation.

3.1.4.2 Integration Channel

The integration calibration consists of determining the number of electrons detected at the MCP for each integration period before amplification, in order to measure the collective effect of many small grains incident on LDEX. This calibration requires converting the voltage measured across a capacitor in the integrator circuit every sample period into the total number of electrons stored in that capacitor. This number must then be multiplied by the appropriate factor to take MCP amplification into account and determine total number of ions originally incident on the MCP before amplification.

Once every 10 seconds for a duration of 1 second, the electric field is inverted such that all ions are rejected from the MCP. This will give a background for the integration measurement. This background is subtracted to give the true integrated ion signal due to dust impacts. Figure 4 shows a raw sample signal from this channel. The black crosses are the nominal signals due to all effects, including dust. Blue diamonds show the noise floor to be subtracted. The red x's show periods where voltage switching occurs and are removed in the processing routines. The signal for this sample data would be approximately (0.31-0.14) = 0.17 Volts.

The purpose of the integration channel is to measure the change in the flux of small particles. The calibrated data for this channel is reported as a current. To report as an integrated mass, the sizes of the particles need to be assumed. For this reason, and since the current is sufficient to accomplish the goal of the integrator, it was decided that these mass assumptions are better left to higher level data processing. The current for the integration channel, I_{impact}, can be determined by the equation:

$$I_{impact} = 6.211E\text{-}11 * V_{int}/(\Delta t * g_{mcp}),$$

where V_{int} is the voltage signal from the integrator, g_{mcp} is the gain of the MCP discussed above and Δt is the integration time. The constant 6.211E-11 is determined by the electronics of the integrator circuit. Note that for scientific analysis, the background (described above) also needs to be taken into consideration, and is not included in this equation. However, the same conversion equation holds for those background measurements.

It should be noted that the nominal baseline voltage (i.e. the zero signal voltage) of the integrator is a function of temperature. This voltage is:

$$V_{baseline} = 0.10908620 + 0.00044400417 * T + 2.5579423E\text{-}06 * T^2$$

Where T is temperature and $V_{baseline}$ is the voltage with no signal. This, however, gets subtracted out with the difference measurement of signal to background as both signal and background have this same effect.

3.1.4.3 Raw to Reduced Conversions

The data stored in PDS will be the reduced and calibrated data. The reduced data with physical units is produced from the raw data (DN) with polynomial conversions determined by the ADC. These conversions will be handled by the LDEX team and are shown in Table 1.

Table 1: Conversion from Raw to Reduced Data where applicable.

Item Name (See Appendix A)	Calibration Curve
Impact_Peak_MCP Impact_Peak_Target MCP_Signal Target_Signal Last_MCP_Signal Last_Tgt_Signal	V = .000076296273689993*DN
Integrator_Z_Lvl Integrator_S_Lvl Impact_Lvl Integrate_MCP_Sample	V = . 00004768372 *DN
HV_Adjust	V = -1049.72 - 9.5870*DN
Controller_Temp LVPS_Temp	T = -6.855E-12*DN^3 + 3.7054E-7*DN^2 - 9.5147E-3*DN + 111.5
P3_3V_Mon	V = 2.022E-4*DN
P5V_Mon M5V _Mon Grnd_V_Mon	V = 3.83E-4*DN
W_Screen_V_Mon MCP_Low_V_Mon MCP_High_V_Mon Flat_Grid_V_Mon Hemi_Grid_V_Mon	V = -DN*7.645-2
FED_Temp HVPS_Temp MCP_Temp	T = -3.0876E-29*DN^7 – 2.11E-24*DN^6 - 3.6499E-20*DN^5 +2.0062E-16*DN^4+6.5635E-12*DN^3 – 4.6992E-8*DN^2 – 2.0053E-3*DN + 25.003

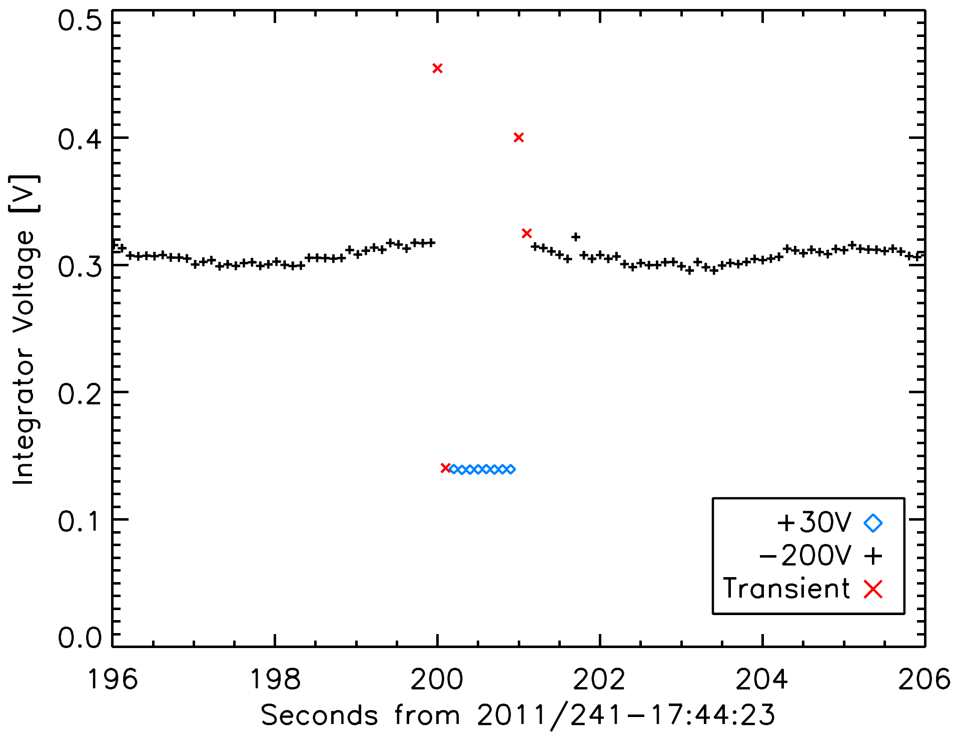

Figure 4: Sample integration channel data similar to that expected on orbit. The black crosses are nominal data. The blue diamonds show when a switched period occurs, rejecting all ions. The red x's are due to transient effects from switching.

3.2 Data Products

This document uses the LADEE data definitions for all products. These data have been reviewed and accepted by PDS to comply with anticipated PDS 4 standards. LDEX will deliver both raw and calibrated data to PDS as defined in the LADEE definitions table, Table 2, and delineated in Table 3.

Table 2: LADEE Data Processing Levels

Product	Product Description
Packet Data	Telemetry data stream as received at the ground station, with science and engineering data embedded.
Raw	Original data from an instrument. If compression, reformatting, packetization or other translation has been applied to facilitate data transmission or storage, those processes will be reversed so that the archived data are in a PDS approved archive format.
Reduced	Data that have been processed beyond the raw stage but which are not yet entirely independent of the instrument.
Calibrated	Data converted to physical units entirely independent of the instrument.
Derived	Results that have been distilled from one or more calibrated data products (for example, maps, gravity or magnetic fields, or ring particle size distributions). Supplementary data, such as calibration tables or tables of viewing geometry, used to interpret observational data should also be classified as derived data if not easily matched to one of the other three categories

3.2.1 LDEX Product Definitions

All LDEX products delivered to the PDS are in tabular format with space-delimited columns. These products are described in Table 3. Deliveries will be made to PDS in accordance with the schedule defined in the LADEE LDEX PDS Interface Control Document

Product Name	Description	Estimated File (B = Bytes)	Reduced or Calibrated
Impacts	Amplitudes of individual impacts	1GB	Reduced
Integrated	Samples of integrated voltages from MCP	2GB	Reduced
Wave	Waveforms of individual impacts	2GB	Reduced
Diagnostic	Secondary housekeeping telemetry	5MB	Calibrated
Primary Housekeeping	Primary housekeeping telemetry	1GB	Calibrated
Mass	Calibrated mass of each impact	2GB	Calibrated
Integrated Charge	Integrated charge from MCP	4GB	Calibrated

Table 3: Data Definitions For LDEX.

3.2.2 Data Product Detailed Description and Format

See Appendix A for the format and content description of the archived data products.

3.2.3 Data Products Generation

All data products and associated documentation will be generated by the LDEX team. The PDS SBN will assist in the definition and development of first delivery products and their associated PDS documentation, which will act as templates for subsequent updates. When new products are developed by the LDEX team, PDS SBN will likewise assist in the definition and development of those products and their associated PDS documentation in preparation for their initial delivery.

3.2.4 Data Validation

Data content validation will be performed by the LDEX science team prior to delivery to PDS. Data structure and format will be performed by the LDEX science team and the PDS data review team as described in Section 4.3.

4. ARCHIVE COLLECTION

4.1 Generation

The LDEX Data Product Archive Collection and its updates are produced by the LDEX Instrument Team in cooperation with the Small Bodies Node (SBN) of PDS. The Archive Collection will include data acquired during both the commissioning and science phases. The Small Bodies Node and LDEX will collaborate to design the PDS documentation files associated with the initial data delivery by the LDEX team. All data formats are based on the Planetary Data System standards as documented in the PDS Standards Reference.

4.2 Data Transfer

The LDEX team will submit data to PDS via the OnLine Archive Facility (OLAF). This submission tool is a product of the Small Bodies Node of PDS to help facilitate the exchange of data and will be maintained by SBN. The LDEX and SBN teams will work together in the submission via OLAF to ensure a product meeting the requirements of PDS.

4.3 Review and Revision

The Small Bodies Node is responsible for organizing the Peer Review of the LDEX data sets, according to PDS policy. The Peer Review Committee will include a small number of scientists, selected by SBN and from outside the LDEX Team, who have an interest in the anticipated data products. The Peer Review committee will also include LDEX Team members and Small Bodies Node representatives.

For LDEX there will be two such reviews. There will be a pre-launch review approximately 6 months from launch. This review will contain sample data and documentation in the format of the final archived data set. This sample data will be produced by the flight instrument pre-launch and will differ in the final data set only in specific values and size. Data format and archive method will be the equivalent.

There will be a final review within 6 weeks after the end of mission (EOM). This review will include all the data produced by LDEX from the beginning of the commissioning phase through the first 20 days of the science phase. Three months after EOM, LDEX will deliver the final data set for archive.

4.4 Data Volume Architecture

The complete set of LADEE LDEX data will be archived in PDS in a single bundle in the PDS4 standard. In the outline below, each .tab, .txt, and .pdf file is assumed to have an .xml label file with the same filename base, which is not mentioned in the outline. Other types of xml labels are mentioned explicitly. In all data product filenames below, multiple products for each product type are represented by a general filename with an X denoting the product timestamp.

Root Level of LDEX Bundle
bundle_1.xml - bundle label, including inventory for the bundle
checksum_manifest.txt - checksums for the bundle
readme_1.0.txt - bundle description
transfer_manifest.txt - manifest file listing all files in the bundle with their LIDs.

Context Collection – contains mission, spacecraft, instrument, and other context objects. These context objects refer to the full descriptions in the document collection.

/context
collection_1.0.tab - inventory of context collection
instrument_host_ladee_1.0.xml - LADEE spacecraft context object
instrument_ldex_1.0.xml - instrument context object

investigation_ladee_1.0.xml - LADEE mission context object
node_sbn_1.0.xml - SBN node context object

Calibrated Data Collection – contains all calibrated data products and their labels.

/data_calibrated
collection_1.0.tab - inventory of calibrated data collection
charge_X.tab - ontegrated charge tables
mass_X.tab - calibrated mass tables

Housekeeping Data Collection – contains all housekeeping products and their labels.

/data_housekeeping
collection_1.0.tab - inventory of housekeeping data collection
housekeeping_X.tab - primary housekeeping table
diagnostic_X.tab - secondary (diagnostic) housekeeping table

Reduced Data Collection – contains all reduced data products and their labels.

/data_reduced
collection_1.0.tab - inventory of reduced data collection
impact_X.tab - amplitudes of individual impacts
integrated_X.tab - samples of integrated voltages
wave_X.tab - waveforms of individual targets

Document Collection – contains documents relevant to the bundle and their labels. Note that the LDEX instrument description and the calibration description are contained in the LDEX SIS rather than in separate documents.

/document
collection_1.0.tab - inventory of document collection
LDEX Software Interface Specification (SIS) (ldex_pds_sis_reva.pdf)
LADEE Spacecraft Description (TBD)
LADEE Mission Description (ladee_pds_mission_rev1.pdf)/xml_schema

Schema Collection - contains the schemas used in the bundle

/xml_schema
collection_1.0.tab - inventory of schema collection
/products
catalog.xml - Lists PDS schemas and namespaces used in this bundle
catalog_label.xml - Label for catalog.xml
PDS4_OPS_0300a.sch – Main PDS schematron -- defines valid element values and other semantic constraints for PDS4

PDS4_OPS_0300a.xsd – Main PDS schema -- defines the element structure for PDS4
PDS4_OPS_0300a.xml – Label for main PDS schematron and schema

5. ARCHIVE RELEASE SCHEDULE

Figure 5 shows the delivery schedule in reference to the mission timeline. Three months from EOM, the final dataset with liens resolved will be delivered.

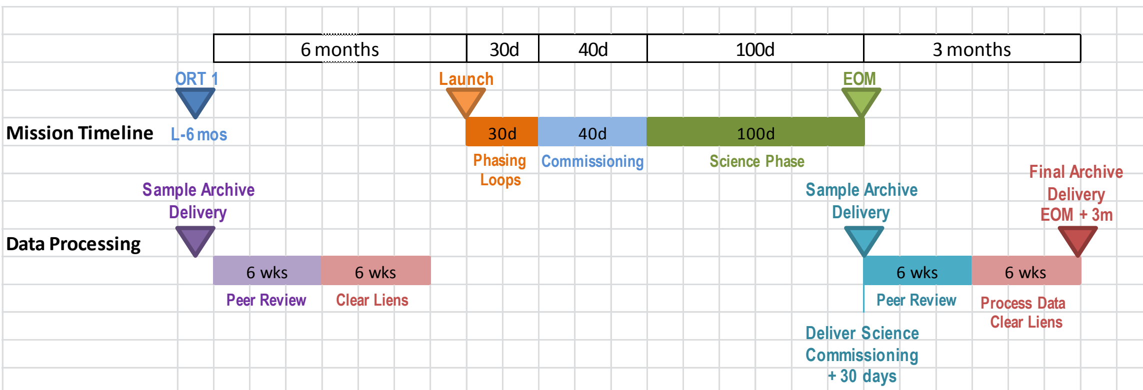

Figure 5: Data processing timeline against mission events and milestones.

6. COGNIZANT PERSONS

Table 4: Cognazant Persons for LDEX PDS Data

LDEX Team		
Principle Investigator, **Dr. Mihaly Horanyi**	Laboratory for Atmospheric and Space Physics University of Colorado 1234 Innovation Drive Boulder, CO 80303	303 492-6903 mihaly.horanyi@lasp.colorado.edu
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PDS Small Bodies Node		
PDS Small Bodies Node Archiving **Dr. Carol Neese**	Planetary Science Institute 1700 East Ft. Lowell, Suite 106 Tucson, AZ 85719-2395	520 382-0591 neese@psi.edu
PDS Engineering Node		
PDS LADEE Data Engineer	4800 Oak Grove Dr m.s. T1721	818 354-1259

Dr. Richard Chen	Pasadena, CA 91109	richard.l.chen@jpl.nasa.gov

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8. APPENDICES

8.1 LDEX Data Product Column Descriptions

This table contains the number of impacts recorded during a user selectable duration. It includes impacts recorded on both the target and MCP.

Table 5: LDEX Impact Data (Reduced)

#	Name	Start Byte	Format	Units	Description
1	Packet Time	1	A26		UTC Time (yyyy-mm-ddThh:mm:ss.ssssss)
2	Impact_Peak_MCP	28	F09.6	Volt	Peak value of MCP signal for impact (Volt) The Microchannel Plate (MCP) is sampled every 8 us. If the signal crosses a programmable threshold, an impact detection algorithm will be performed to determine if the event was caused by a dust impact. If the MCP signal meets the necessary conditions for a dust impact including rise time, peak duration, and sum to peak ratio, the peak amplitude of the MCP signal level will be stored.
3	Impact_Peak_Target	38	F09.6	Volt	Peak value of Target signal for impact (Volt). If the MCP signal has met the dust impact requirements described in the Impact Peak MCP description, the peak amplitude of the Target signal will be stored.
4	HV_Adjust	48	F5.1	Volt	MCP HV adjustment value (Volt)

The reduced integrated table contains the measurements recorded by the integrator for each period that the high voltage is turned on. The integration time is user selected and is nominally 100ms. The integrator is zeroed at the beginning of each sample.

Table 6: LDEX Integrated Table (Reduced)

#	Name	Start Byte	Format	Units	Description
1	Packet Time	1	A26		UTC Time (yyyy-mm-ddThh:mm:ss.ssssss)
2	Integrated_MCP_Sample	28	F09.6	Volt	Integrated dust samples (Volts). The Microchannel Plate (MCP) is sampled at a programmable rate with a default of 100 ms. This measurement takes two samples of the MCP each cycle to perform a correlated double sample. The first one is taken 1 ms after the start of the sample period to establish the zero level for the channel. The second one is taken after the programmed sample period has expired. The difference of the two is the measurement of the integrated low-level dust impinging on the instrument and is given in the Integrated Dust Samples.
3	Sample_Period	38	F5.3	Seconds	Period of samples (seconds). The sample period is a programmable period which can have a value of 0-255 seconds.
4	HV_Status	44	I1		0=High Voltage is off, 1=High Voltage is on.
5	Grid_Status	46	I1		0= Grid voltage is +30V, 1= Grid voltage is -200V. Switching the Grid voltage to +30V has the effect of any ions from the MCP, preventing dust impacts from registering on the MCP. Sampling when the Grid is switched is a way get a noise floor measurement for the electronics that can be used to correct the integrated dust measurement on the ground.

The wave packet stored by LDEX contains voltages from the MCP and target. When triggered (by rising above the threshold), the FPGA begins recording voltages from both the MCP and target in 8 microsecond intervals for 50 samples resulting in a 400 microsecond waveform. The two are recorded simultaneously. Because the instrument/spacecraft do not have the data volume to store all waveforms, the waveforms are stored at a specific cadence. The decimation factor (found in the diagnostic packet) determines this cadence that the full waveform is stored in the packet. A decimation factor of 1 means all waveforms are stored on a FIFO basis.

Table 7: LDEX Wave Table (Reduced)

#	Name	Start Byte	Format	Units	Description
1	Packet Time	1	A26		UTC Time (yyyy-mm-ddThh:mm:ss.ssssss)
2	MCP_Signal	28	F09.6	Volt	50 Samples of MCP Signal. The Microchannel Plate (MCP) is sampled every 8 us. If the signal crosses a programmable threshold, an impact detection algorithm will be performed to determine if the event was caused by a dust impact. If the MCP signal meets the necessary conditions for a dust impact including rise time, peak duration, and sum to peak ratio, then, 15 samples before the threshold crossing and 35 samples after the threshold crossing will be stored.
3	Target_Signal	528	F09.6	Volt	50 Samples of Target Signal. The hemispherical Target is sampled every 8 us. If the MCP signal meets the necessary dust impact requirements and 50 samples are stored as described in the MCP Signal description, 50 samples of the Target signal will also be stored.
4	Valid	1028	I1		0=invalid dust impact, 1=valid impact. If the MCP signal crosses the programmable threshold but fails the impact detection criteria, the event will be flagged as an invalid dust impact. Invalid dust impact waveforms will be stored at a programmable cadence.
5	HV_Adjust	1030	F5.1	Volt	MCP High Voltage adjustment value.
6	Noise_Status	1036	I1		1=Packet contains requested noise data. A test interface has been built into the software to allow for noise testing during instrument development and integration which will allow for 1000 samples the MCP and Target channels to be stored in 20 packets. These packets will be flagged as noise data.

This is the calibrated charge from the integrator channel of LDEX. This integrator collects cumulative charge from the MCP.

Table 8: LDEX Charge Table (Calibrated)

#	Name	Start Byte	Format	Units	Description
1	Time	1	A26		Time of integrated signal measurement in UTC.
2	Current	28	E9.3	Ampere	Integrated current collect by the MCP. Background noise has been subtracted from these measurements.
3	Int_Time	38	F4.2	Second	Duration of integration measurement.
4	Velocity	43	E9.3	km/s	Impacting velocity of incident dust grain assuming ballistic orbits.
5	Flags	53	I010		Spare data product to be used for qualifying flags where applicable.

This is the mass of each recorded event on the LDEX MCP.

Table 9: LDEX Mass Table (Calibrated)

#	Name	Start Byte	Format	Units	Description
1	Time	1	A26		Time of impact in UTC.
2	Mass	28	E8.2	kilogram	Calibrated mass of impacting dust grain. This is always derived from the MCP signal amplitude, unless the MCP signal saturates. In this case, it is derived from the target signal.
3	MCP_Charge	37	E9.3	Coulomb	Impact plasma charge from impact observed after gain of MCP.
4	Img_Charge	47	E7.1	Coulomb	Image charge from charged dust grain induced on the target.
5	Img_Velocity	55	E7.1	km/s	Speed of charged dust grain. Calculated using image charge signal waveform from target.
6	Mass_Threshold	63	E9.3	kilogram	Lowest mass of dust grain possible for LDEX to observe given current settings.
7	Velocity	73	E9.3	km/s	Impacting velocity of incident dust grain assuming ballistic orbits.
8	Flags	53	I010		Spare data product to be used for qualifying flags where applicable.

This is the LDEX data relating to diagnostic information from LDEX. This packet is stored only when commanded and contains telemetry related to the state of the instrument.

Table 10: LDEX Diagnostic Table (Secondary Housekeeping)

#	Name	Start Byte	Format	Units	Description
1	Packet Time	1	A26		Time the diagnostic information was packetized and sent to the spacecraft.
2	MCP_Low_V	28	E013.6	Volt	Commanded MCP low-side voltage.
3	HV_CLK_Delay	42	I03	40_nanosecond	Number of 40 ns periods to delay the HV clock.
4	Science_WO_HV	49	I02		Instrument is configured to output science regardless of HV enable state. Values: 0: Disabled, 1: Enabled
5	Hemi_Switch_Ena	49	I02		Hemispherical grid voltage switching enable status. Values: 0: False, 1: True
6	Hemi_Grid_HV_Ena	52	I02		Hemispherical grid HV enable status. Values: 0: False, 1: True
7	Grid_HV_Ena	55	I02		Flat grid HV enable status. Values: 0: False, 1: True
8	MCP_HV_Ena	58	I02		MCP HV (low and high side) enable status. Values: 0: False, 1: True
9	W_Screen_HV_Ena	61	I02		Solar wind screen HV enable status. Values: 0: False, 1: True
10	HK_Pkt_Rt	64	I03	Second	Primary housekeeping packet production interval.
11	Cover_Pulse	68	I05	millisecond	Aperture cover pulse width.
12	Impact_Lvl	74	E013.6		Impact threshold register.
13	Ssafing_Lvl	88	I05		Sun safing threshold register.
14	Impact_Min_Dt	94	E013.6	Second	Minimum time between threshold crossings for valid dust impact. MCP signal impact threshold crossings (rising and falling) that occur faster than this time are not counted as valid impacts for either waveform capture or individual impact detection. This is used to eliminate noise or non-dust impacts.
15	Decimation	108	I03		Waveform decimation register.
16	Arm_Timeout	112	I03	Second	Time before an 'arm' condition expires.
17	Firmware_Version				LDEX control FPGA firmware version number.

18	IP_Dust_Level	120	I05		Slope of MCP signal at which non-lunar dust is flagged. Interplanetary or interstellar dust will have higher impact speeds and will therefore generate MCP signals with steeper slopes. Any impacts detected with a slope at or above this level will be captured as waveforms regardless of the decimation value.
19	Integration_R_Tm	126	I03	millisecond	Integration reset time for collective dust particle impact signal.
20	Impact_Max_Dt	130	E013.6	Second	Maximum time between threshold crossings for valid dust impact. MCP signal impact threshold crossings (rising and falling) that occur faster than this time are not counted as valid impacts for either waveform capture or individual impact detection. This is used to eliminate noise or non-dust impacts.
21	Integration_S_Tm	144	I03	millisecond	Integration time for collective dust particle impact signal. This parameter is nominally 100 ms, but is adjustable in case pre-launch predictions of the dust environment are significantly different from actual conditions.
22	Impact_T_Ct	148	I03		Number of simulated impacts generated by the ‘init ldex impact_test’ command.
23	Impact_Max_P	152	I03	8_microsecond	Maximum time for MCP peak for valid dust impacts.
24	Impact_Min_R	156	I03		Minimum ratio between MCP sum and MCP peak for valid impacts. MCP waveforms that have a sum to peak ratio less than this value are not counted as valid impacts for either waveform capture or individual impact detection. This is used to eliminate noise or non-dust impacts.
25	Inv_Wf_Rt	160	I03	minute	Minimum period at which LDEX will transmit invalid impact waveform packets.

The primary housekeeping data contains telemetry recorded at a user selected interval, nominally around 10 seconds. This contains temperatures, voltages, and general information about the health and state of the instrument.

Table 11: LDEX Primary Housekeeping Table

#	Name	Start Byte	Format	Units	Description
1	Time	1	A26		Time the housekeeping information was packetized and sent to the spacecraft.
2	Controller_Temp	28	E013.6	Celsius	Controller board temperature.
3	P3_3V_Mon	42	E013.6	Volt	+3.3V supply voltage monitor.
4	M5V_Mon	56	E013.6	Volt	-5V supply voltage monitor.
5	P5V_Mon	70	E013.6	Volt	+5V supply voltage monitor.
6	FED_Temp	84	E013.6	Celsius	Front-end detector board temperature.
7	HVPS_Temp	98	E013.6	Celsius	High voltage power supply board temperature.
8	W_Screen_V_Mon	112	E013.6	Volt	Solar wind screen voltage monitor.
9	MCP_Temp	126	E013.6	Celsius	Micro-channel plate temperature.
10	LVPS_Temp	140	E013.6	Celsius	Low voltage power supply board temperature.
11	MCP_Low_V_Mon	154	E013.6	Volt	Micro-channel plate low side voltage monitor.
12	MCP_High_V_Mon	168	E013.6	Volt	Micro-channel plate high side voltage monitor.
13	Flat_Grid_V_Mon	182	E013.6	Volt	Flat MCP grid voltage monitor.
14	Hemi_Grid_V_Mon	196	E013.6	Volt	Hemispherical grid voltage moniror.
15	Grnd_V_Mon	210	E013.6	Volt	Analog ground voltage monitor (for reference).
16	Last_MCP_Signal	224	E013.6	Volt	Last sample of the MCP signal. The MCP is continually sampled so that integrated dust measurements can be made. This MCP signal is also used to detect if the sun is in the instrument field of view so that it can safe itself. The value here may or may not be part of an individual impact waveform packet. It is included in the primary housekeeping data as a means of tracking the MCP signal for troubleshooting the sun safing functionality.
17	Inv_Capture_Arm	238	I02		Indicates when waveform data will be captured for the next invalid impact. Values: 0: False 1: True
18	Time_Source	241	I02		Instrument time source. If LDEX gets out of sync with the spacecraft and can no longer process time value messages or is not getting the 1 Hz time sync pulse, it will go on internal time. When on internal time, the instrument clock will drift relative to the spacecraft clock. The LDEX internal timer rolls over at 0.999424 seconds, not exactly one second due to the use of a 20 MHz clock. Values: 0: External 1: Internal
19	Science_Enabled	244	I02		Enable/disable state of science data output Values: 0: False 1: True

20	Arm_Dis_Ssafing	247	I02		Arm state for sun safing disable command. Values: 0: Not Armed 1: Armed
21	Pkt_Sync_Loss	250	I02		Incoming (command/time value) CCSDS packet syncronization loss state. When this value is TRUE, the instrument will not be able to parse command packets. It is indicative of an interface issue between the spacecraft and instrument. Values: 0: False 1: True
22	Ssafing_Ena	253	I02		Enable/disable state for autonomous sun safing. Values: 0: Disabled 1: Enabled
23	Arm_Cover_Reject	256	I02		Set to TRUE if an arm cover command was received while high voltage is ON. This error flag is reset at POR or by command. Values: 0: False 1: True
24	HV_Ena_Reject	259	I02		Set if a high voltage enable command was received while the sun was in the FOV. This error flag is reset at POR or by command. Values: 0: False 1: True
25	Fire_WO_Arm	262	I02		Received 'fire' command without appropriate 'arm' command first. This error flag is reset at POR or by command. Values: 0: False 1: True
26	Cmd_Cksum_Error	265	I02		Received a command with an invalid checksum. This error flag is reset at POR or by command. Values 0: False 1: True
27	Cmd_Addr_Error	268	I02		Received a register read/write command with an invalid register address. This error flag is reset at POR or by command. Values: 0: False 1: True
28	Cmd_Opcode_Error	271	I02		Received a command with an invalid opcode. This error flag is reset at POR or by command. Values: 0: False 1: True
29	HV_State	274	I02		High voltage enable/disable state. Values: 0: Disabled 1: Enabled

30	Arm_Hv_Ena	277	I02		Arm state for high voltage enable command. Values: 0: Not armed 1: Armed
31	Arm_Opn_Cover	280	I02		Arm state for aperture cover command. Values: 0: Not armed 1: Armed
32	Pin_Puller_B	283	I02		Pin puller b-side fire status indicator. Values: 0: Not fired 1: Fired
33	Pin_Puller_A	286	I02		Pin puller a-side fire status indicator. Values: 0: Not fired 1: Fired
34	Sun_In_FOV	289	I02		Current sun in FOV indicator. Values: 0: False 1: True
35	Ssafing_Trip	292	I02		Flag indicating that sun safing was tripped. This error condition is latched and only cleared at POR or by command. Values: 0: False 1: True
36	Cmd_Fail_Ct	295	I05		Cumulative count of failed commands.
37	Cmd_Succ_Ct	301	I05		Cumulative count of successful commands.
38	Ssafing_Trip_Lvl	307	I05		MCP level that caused sun safing to trip.
39	Impact_Count	313	I010		Cumulative count of individually detected dust impacts since POR. Should match number of impacts recorded in dust impact packets.
40	Dropped_Bytes	324	I05		Cumulative count of incoming bytes dropped during out of sync condition.
41	MCP_DC_Offset	330	I05		Measured DC offset of MCP signal.
42	Last_Tgt_Signal	336	E013.6	Volt	Last sample of the hemispherical target signal. The hemispherical target is sampled at the primary housekeeping packet rate. The value here may or may not be part of an individual impact waveform packet. It is included in the primary housekeeping data as a means of tracking the signal for troubleshooting purposes.
43	Integrator_Z_Lvl	350	E013.6	Volt	Zero-level of integrated dust signal.
44	Integrator_S_Lvl	364	E013.6	Volt	Sample level of integrated dust signal.
45	Valid_Min_Dt_Flag	378	I02		Indicates if minimum pulse width requirement was met for the last impact event. Values: 0: False 1: True
46	Valid_Max_Dt_Flg	381	I02		Indicates if maximum pulse width requirement was met for the last impact event. Values 0: False 1: True

47	Valid_Max_P_Flg	384	I02		Indicates if peak time requirement was met for the last impact event. Values 0: False 1: True
48	Valid_Ratio_Flg	387	I02		Indicates if sum to peak ratio requirement was met for the last impact event. Values 0: False 1: True
49	Tgt_Wf_FIFO_Of	390	I02		Overflow indicator for hemispherical target waveform FIFO. Cleared at POR or by command. Values 0: False 1: True
50	MCP_Wf_FIFO_Of	393	I02		Overflow indicator for MCP waveform FIFO. Cleared at POR or by command. Values 0: False 1: True
51	Offset_FIFO_Of	396	I02		Overflow indicator for impact time offset FIFO. Cleared at POR or by command. Values 0: False 1: True
52	Time_FIFO_Of	399	I02		Overflow indicator for impact time stamp FIFO. Cleared at POR or by command. Values 0: False 1: True
53	Tgt_Imp_FIFO_Of	402	I02		Overflow indicator for hemispherical target impact FIFO. Cleared at POR or by command. Values 0: False 1: True
54	MCP_Imp_FIFO_Of	405	I02		Overflow indicator for MCP impact FIFO. Cleared at POR or by command. Values 0: False 1: True
55	Inv_Min_Dt	408	E013.6	Second	Value of minimum pulse width for last invalid impact.
56	Inv_Max_Dt	422	E013.6	Second	Value of maximum pulse width for last invalid impact.
57	Inv_Max_P	436	E013.6	Second	Value of peak time for last invalid impact.
58	Inv_Sum	450	I010		Integrated sum of 50 samples for last invalid impact.
59	Inv_Impact_Count	461	I05		Number of invalid impact events since last primary housekeeping packet.
60	Impact_Dead_Time	467	E013.6	Second	Accumulated dead time since last primary housekeeping packet. Includes time spent processing both valid and invalid impacts.
61	Valid_Min_Dt	481	E013.6	Second	Value of minimum pulse width for last valid impact.

62	Valid_Max_Dt	495	E013.6	Second	Value of maximum pulse width for last valid impact.
63	Valid_Max_P	509	E013.6	Second	Value of peak time for last valid impact.
64	Valid_Sum	523	I010		Integrated sum of 50 samples for last valid impact.
65	Inv_Peak	534	I05	Volt	Peak MCP amplitude for last invalid impact.
66	Valid_Peak	540	I05	Volt	Peak MCP amplitude for last valid impact.

8.2 XML Labels

8.2.1 Primary Housekeeping


```
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      <missing_constant>-9.999999E+09</missing_constant>
    </Special_Constants>
  </Field_Character>
  <Field_Character>
    <name>FLAT_GRID_V_MON</name>
    <field_number>13</field_number>
    <field_location unit="byte">182</field_location>
    <data_type>ASCII_Real</data_type>
    <field_length unit="byte">13</field_length>
    <field_format>E013.6</field_format>
    <unit>VOLT</unit>
    <description>Flat grid voltage monitor.</description>
    <Special_Constants>
      <missing_constant>-9.999999E+09</missing_constant>
    </Special_Constants>
  </Field_Character>
  <Field_Character>
    <name>HEMI_GRID_V_MON</name>
    <field_number>14</field_number>
    <field_location unit="byte">196</field_location>
    <data_type>ASCII_Real</data_type>
    <field_length unit="byte">13</field_length>
    <field_format>E013.6</field_format>
    <unit>VOLT</unit>
    <description>Hemispherical grid voltage monitor.</description>
    <Special_Constants>
      <missing_constant>-9.999999E+09</missing_constant>
    </Special_Constants>
  </Field_Character>
  <Field_Character>
    <name>GND_V_MON</name>
    <field_number>15</field_number>
    <field_location unit="byte">210</field_location>
    <data_type>ASCII_Real</data_type>
    <field_length unit="byte">13</field_length>
    <field_format>E013.6</field_format>
    <unit>VOLT</unit>
```

```xml
  <description>Analog ground voltage monitor (for
reference).</description>
  <Special_Constants>
    <missing_constant>-9.999999E+09</missing_constant>
  </Special_Constants>
</Field_Character>
<Field_Character>
  <name>LAST_MCP_SIGNAL</name>
  <field_number>16</field_number>
  <field_location unit="byte">224</field_location>
  <data_type>ASCII_Real</data_type>
  <field_length unit="byte">13</field_length>
  <field_format>E013.6</field_format>
  <unit>VOLT</unit>
  <description>Last sample of the MCP signal. The MCP
is continually sampled so that integrated dust measurements can be
made. This MCP signal is also used to detect if the sun is in the
instrument field of view so that it can safe itself. The value here
may or may not be part of an individual impact waveform packet. It is
included in the primary housekeeping data as a means of tracking the
MCP signal for troubleshooting the sun safing functionality.</description>
  <Special_Constants>
    <missing_constant>-9.999999E+09</missing_constant>
  </Special_Constants>
</Field_Character>
<Field_Character>
  <name>INV_CAPTURE_ARM</name>
  <field_number>17</field_number>
  <field_location unit="byte">238</field_location>
  <data_type>ASCII_Integer</data_type>
  <field_length unit="byte">2</field_length>
  <field_format>I02</field_format>
  <description>Indicates when waveform data will be
captured for the next invalid impact.
Values:
0: False
1: True</description>
  <Special_Constants>
    <missing_constant>-9</missing_constant>
  </Special_Constants>
</Field_Character>
<Field_Character>
  <name>TIME_SOURCE</name>
  <field_number>18</field_number>
  <field_location unit="byte">241</field_location>
  <data_type>ASCII_Integer</data_type>
  <field_length unit="byte">2</field_length>
  <field_format>I02</field_format>
  <description>Instrument time source. If LDEX gets out
of sync with the spacecraft and can no longer process time value
messages or is not getting the 1 Hz time sync pulse, it will go on
internal time. When on internal time, the instrument clock will drift
relative to the spacecraft clock. The LDEX internal timer rolls over
at 0.999424 seconds, not exactly one second due to the use of a 20 MHz
clock.
Values:
0: External
1: Internal</description>
  <Special_Constants>
    <missing_constant>-9</missing_constant>
  </Special_Constants>
</Field_Character>
<Field_Character>
  <name>SCIENCE_ENABLED</name>
  <field_number>19</field_number>
  <field_location unit="byte">244</field_location>
  <data_type>ASCII_Integer</data_type>
  <field_length unit="byte">2</field_length>
  <field_format>I02</field_format>
  <description>Enable/disable state of science data
```

```
output.
Values:
0: False
1: True</description>
  <Special_Constants>
    <missing_constant>-9</missing_constant>
  </Special_Constants>
</Field_Character>
<Field_Character>
  <name>ARM_DIS_SSAFING</name>
  <field_number>20</field_number>
  <field_location unit="byte">247</field_location>
  <data_type>ASCII_Integer</data_type>
  <field_length unit="byte">2</field_length>
  <field_format>I02</field_format>
  <description>Arm state for sun safing disable
command.
Values:
0: Not Armed
1: Armed</description>
  <Special_Constants>
    <missing_constant>-9</missing_constant>
  </Special_Constants>
</Field_Character>
<Field_Character>
  <name>PKT_SYNC_LOSS</name>
  <field_number>21</field_number>
  <field_location unit="byte">250</field_location>
  <data_type>ASCII_Integer</data_type>
  <field_length unit="byte">2</field_length>
  <field_format>I02</field_format>
  <description>Incoming (command/time value) CCSDS
packet syncronization loss state. When this value is TRUE, the
instrument will not be able to parse command packets. It is indicative
of an interface issue between the spacecraft and instrument.
Values:
0: False
1: True</description>
  <Special_Constants>
    <missing_constant>-9</missing_constant>
  </Special_Constants>
</Field_Character>
<Field_Character>
  <name>SSAFING_ENA</name>
  <field_number>22</field_number>
  <field_location unit="byte">253</field_location>
  <data_type>ASCII_Integer</data_type>
  <field_length unit="byte">2</field_length>
  <field_format>I02</field_format>
  <description>Enable/disable state for autonomous sun
safing.
Values:
0: Disabled
1: Enabled</description>
  <Special_Constants>
    <missing_constant>-9</missing_constant>
  </Special_Constants>
</Field_Character>
<Field_Character>
  <name>ARM_COVER_REJECT</name>
  <field_number>23</field_number>
  <field_location unit="byte">256</field_location>
  <data_type>ASCII_Integer</data_type>
  <field_length unit="byte">2</field_length>
  <field_format>I02</field_format>
  <description>Set to TRUE if an arm cover command was
received while high voltage is ON. This error flag is reset at POR or
by command.
Values:
0: False
```

```
1: True</description>
 <Special_Constants>
  <missing_constant>-9</missing_constant>
 </Special_Constants>
</Field_Character>
<Field_Character>
 <name>HV_ENA_REJECT</name>
 <field_number>24</field_number>
 <field_location unit="byte">259</field_location>
 <data_type>ASCII_Integer</data_type>
 <field_length unit="byte">2</field_length>
 <field_format>I02</field_format>
 <description>Set if a high voltage enable command was
received while the sun was in the FOV. This error flag is reset at POR
or by command.
Values:
0: False
1: True</description>
 <Special_Constants>
  <missing_constant>-9</missing_constant>
 </Special_Constants>
</Field_Character>
<Field_Character>
 <name>FIRE_WO_ARM</name>
 <field_number>25</field_number>
 <field_location unit="byte">262</field_location>
 <data_type>ASCII_Integer</data_type>
 <field_length unit="byte">2</field_length>
 <field_format>I02</field_format>
 <description>Received 'fire' command without
appropriate 'arm' command first. This error flag is reset at POR or by
command.
Values:
0: False
1: True</description>
 <Special_Constants>
  <missing_constant>-9</missing_constant>
 </Special_Constants>
</Field_Character>
<Field_Character>
 <name>CMD_CKSUM_ERROR</name>
 <field_number>26</field_number>
 <field_location unit="byte">265</field_location>
 <data_type>ASCII_Integer</data_type>
 <field_length unit="byte">2</field_length>
 <field_format>I02</field_format>
 <description>Received a command with an invalid
checksum. This error flag is reset at POR or by command.
Values:
0: False
1: True</description>
 <Special_Constants>
  <missing_constant>-9</missing_constant>
 </Special_Constants>
</Field_Character>
<Field_Character>
 <name>CMD_ADDR_ERROR</name>
 <field_number>27</field_number>
 <field_location unit="byte">268</field_location>
 <data_type>ASCII_Integer</data_type>
 <field_length unit="byte">2</field_length>
 <field_format>I02</field_format>
 <description>Received a register read/write command
with an invalid register address. This error flag is reset at POR or
by command.
Values:
0: False
1: True</description>
 <Special_Constants>
  <missing_constant>-9</missing_constant>
```

```
  </Special_Constants>
</Field_Character>
<Field_Character>
  <name>CMD_OPCODE_ERROR</name>
  <field_number>28</field_number>
  <field_location unit="byte">271</field_location>
  <data_type>ASCII_Integer</data_type>
  <field_length unit="byte">2</field_length>
  <field_format>I02</field_format>
  <description>Received a command with an invalid
opcode. This error flag is reset at POR or by command.
Values:
0: False
1: True</description>
  <Special_Constants>
    <missing_constant>-9</missing_constant>
  </Special_Constants>
</Field_Character>
<Field_Character>
  <name>HV_STATE</name>
  <field_number>29</field_number>
  <field_location unit="byte">274</field_location>
  <data_type>ASCII_Integer</data_type>
  <field_length unit="byte">2</field_length>
  <field_format>I02</field_format>
  <description>High voltage enable/disable state.
Values:
0: Disabled
1: Enabled</description>
  <Special_Constants>
    <missing_constant>-9</missing_constant>
  </Special_Constants>
</Field_Character>
<Field_Character>
  <name>ARM_HV_ENA</name>
  <field_number>30</field_number>
  <field_location unit="byte">277</field_location>
  <data_type>ASCII_Integer</data_type>
  <field_length unit="byte">2</field_length>
  <field_format>I02</field_format>
  <description>Arm state for high voltage enable
command.
Values:
0: Not armed
1: Armed</description>
  <Special_Constants>
    <missing_constant>-9</missing_constant>
  </Special_Constants>
</Field_Character>
<Field_Character>
  <name>ARM_OPN_COVER</name>
  <field_number>31</field_number>
  <field_location unit="byte">280</field_location>
  <data_type>ASCII_Integer</data_type>
  <field_length unit="byte">2</field_length>
  <field_format>I02</field_format>
  <description>Arm state for aperture cover open
command.
Values:
0: Not armed
1: Armed</description>
  <Special_Constants>
    <missing_constant>-9</missing_constant>
  </Special_Constants>
</Field_Character>
<Field_Character>
  <name>PIN_PULLER_B</name>
  <field_number>32</field_number>
  <field_location unit="byte">283</field_location>
  <data_type>ASCII_Integer</data_type>
```

```
  <field_length unit="byte">2</field_length>
  <field_format>I02</field_format>
  <description>Pin puller b-side fire status indicator.
Values:
0: Not fired
1: Fired</description>
  <Special_Constants>
    <missing_constant>-9</missing_constant>
  </Special_Constants>
</Field_Character>
<Field_Character>
  <name>PIN_PULLER_A</name>
  <field_number>33</field_number>
  <field_location unit="byte">286</field_location>
  <data_type>ASCII_Integer</data_type>
  <field_length unit="byte">2</field_length>
  <field_format>I02</field_format>
  <description>Pin puller a-side fire status indicator.
Values:
0: Not fired
1: Fired</description>
  <Special_Constants>
    <missing_constant>-9</missing_constant>
  </Special_Constants>
</Field_Character>
<Field_Character>
  <name>SUN_IN_FOV</name>
  <field_number>34</field_number>
  <field_location unit="byte">289</field_location>
  <data_type>ASCII_Integer</data_type>
  <field_length unit="byte">2</field_length>
  <field_format>I02</field_format>
  <description>Current sun in FOV indicator.
Values:
0: False
1: True</description>
  <Special_Constants>
    <missing_constant>-9</missing_constant>
  </Special_Constants>
</Field_Character>
<Field_Character>
  <name>SSAFING_TRIP</name>
  <field_number>35</field_number>
  <field_location unit="byte">292</field_location>
  <data_type>ASCII_Integer</data_type>
  <field_length unit="byte">2</field_length>
  <field_format>I02</field_format>
  <description>Flag indicating that sun safing was
tripped. This error condition is latched and only cleared at POR or by
command.
Values:
0: False
1: True</description>
  <Special_Constants>
    <missing_constant>-9</missing_constant>
  </Special_Constants>
</Field_Character>
<Field_Character>
  <name>CMD_FAIL_CT</name>
  <field_number>36</field_number>
  <field_location unit="byte">295</field_location>
  <data_type>ASCII_Integer</data_type>
  <field_length unit="byte">5</field_length>
  <field_format>I05</field_format>
  <description>Cumulative count of failed commands.</description>
  <Special_Constants>
    <missing_constant>-9999</missing_constant>
  </Special_Constants>
</Field_Character>
<Field_Character>
```

```
    &lt;name&gt;CMD_SUCC_CT&lt;/name&gt;
    &lt;field_number&gt;37&lt;/field_number&gt;
    &lt;field_location unit="byte"&gt;301&lt;/field_location&gt;
    &lt;data_type&gt;ASCII_Integer&lt;/data_type&gt;
    &lt;field_length unit="byte"&gt;5&lt;/field_length&gt;
    &lt;field_format&gt;I05&lt;/field_format&gt;
    &lt;description&gt;Cumulative count of successful
  commands.&lt;/description&gt;
    &lt;Special_Constants&gt;
      &lt;missing_constant&gt;-9999&lt;/missing_constant&gt;
    &lt;/Special_Constants&gt;
  &lt;/Field_Character&gt;
  &lt;Field_Character&gt;
    &lt;name&gt;SSAFING_TRIP_LVL&lt;/name&gt;
    &lt;field_number&gt;38&lt;/field_number&gt;
    &lt;field_location unit="byte"&gt;307&lt;/field_location&gt;
    &lt;data_type&gt;ASCII_Integer&lt;/data_type&gt;
    &lt;field_length unit="byte"&gt;5&lt;/field_length&gt;
    &lt;field_format&gt;I05&lt;/field_format&gt;
    &lt;description&gt;MCP level that caused sun safing to
  trip.&lt;/description&gt;
    &lt;Special_Constants&gt;
      &lt;missing_constant&gt;-9999&lt;/missing_constant&gt;
    &lt;/Special_Constants&gt;
  &lt;/Field_Character&gt;
  &lt;Field_Character&gt;
    &lt;name&gt;IMPACT_COUNT&lt;/name&gt;
    &lt;field_number&gt;39&lt;/field_number&gt;
    &lt;field_location unit="byte"&gt;313&lt;/field_location&gt;
    &lt;data_type&gt;ASCII_Integer&lt;/data_type&gt;
    &lt;field_length unit="byte"&gt;10&lt;/field_length&gt;
    &lt;field_format&gt;I010&lt;/field_format&gt;
    &lt;description&gt;Cumulative count of individually
  detected dust impacts since POR. Should match number of impacts
  recorded in dust impact packets.&lt;/description&gt;
    &lt;Special_Constants&gt;
      &lt;missing_constant&gt;-999999999&lt;/missing_constant&gt;
    &lt;/Special_Constants&gt;
  &lt;/Field_Character&gt;
  &lt;Field_Character&gt;
    &lt;name&gt;DROPPED_BYTES&lt;/name&gt;
    &lt;field_number&gt;40&lt;/field_number&gt;
    &lt;field_location unit="byte"&gt;324&lt;/field_location&gt;
    &lt;data_type&gt;ASCII_Integer&lt;/data_type&gt;
    &lt;field_length unit="byte"&gt;5&lt;/field_length&gt;
    &lt;field_format&gt;I05&lt;/field_format&gt;
    &lt;description&gt;Cumulative count of incoming bytes
  dropped during out of sync condition.&lt;/description&gt;
    &lt;Special_Constants&gt;
      &lt;missing_constant&gt;-9999&lt;/missing_constant&gt;
    &lt;/Special_Constants&gt;
  &lt;/Field_Character&gt;
  &lt;Field_Character&gt;
    &lt;name&gt;MCP_DC_OFFSET&lt;/name&gt;
    &lt;field_number&gt;41&lt;/field_number&gt;
    &lt;field_location unit="byte"&gt;330&lt;/field_location&gt;
    &lt;data_type&gt;ASCII_Integer&lt;/data_type&gt;
    &lt;field_length unit="byte"&gt;5&lt;/field_length&gt;
    &lt;field_format&gt;I05&lt;/field_format&gt;
    &lt;description&gt;Measured DC offset of MCP signal.&lt;/description&gt;
    &lt;Special_Constants&gt;
      &lt;missing_constant&gt;-9999&lt;/missing_constant&gt;
    &lt;/Special_Constants&gt;
  &lt;/Field_Character&gt;
  &lt;Field_Character&gt;
    &lt;name&gt;LAST_TGT_SIGNAL&lt;/name&gt;
    &lt;field_number&gt;42&lt;/field_number&gt;
    &lt;field_location unit="byte"&gt;336&lt;/field_location&gt;
    &lt;data_type&gt;ASCII_Real&lt;/data_type&gt;
    &lt;field_length unit="byte"&gt;13&lt;/field_length&gt;
```

```
  <field_format>E013.6</field_format>
  <unit>VOLT</unit>
  <description>Last sample of the hemispherical target
signal. The hemispherical target is sampled at the primary
housekeeping packet rate. The value here may or may not be part of an
individual impact waveform packet. It is included in the primary
housekeeping data as a means of tracking the signal for
troubleshooting purposes.</description>
  <Special_Constants>
    <missing_constant>-9.999999E+09</missing_constant>
  </Special_Constants>
</Field_Character>
<Field_Character>
  <name>INTEGRATOR_Z_LVL</name>
  <field_number>43</field_number>
  <field_location unit="byte">350</field_location>
  <data_type>ASCII_Real</data_type>
  <field_length unit="byte">13</field_length>
  <field_format>E013.6</field_format>
  <unit>VOLT</unit>
  <description>Zero-level of integrated dust signal.</description>
  <Special_Constants>
    <missing_constant>-9.999999E+09</missing_constant>
  </Special_Constants>
</Field_Character>
<Field_Character>
  <name>INTEGRATOR_S_LVL</name>
  <field_number>44</field_number>
  <field_location unit="byte">364</field_location>
  <data_type>ASCII_Real</data_type>
  <field_length unit="byte">13</field_length>
  <field_format>E013.6</field_format>
  <unit>VOLT</unit>
  <description>Sample level of integrated dust signal.</description>
  <Special_Constants>
    <missing_constant>-9.999999E+09</missing_constant>
  </Special_Constants>
</Field_Character>
<Field_Character>
  <name>VALID_MIN_DT_FLG</name>
  <field_number>45</field_number>
  <field_location unit="byte">378</field_location>
  <data_type>ASCII_Integer</data_type>
  <field_length unit="byte">2</field_length>
  <field_format>I02</field_format>
  <description>Indicates if minimum pulse width
requirement was met for the last impact event.
Values:
0: False
1: True</description>
  <Special_Constants>
    <missing_constant>-9</missing_constant>
  </Special_Constants>
</Field_Character>
<Field_Character>
  <name>VALID_MAX_DT_FLG</name>
  <field_number>46</field_number>
  <field_location unit="byte">381</field_location>
  <data_type>ASCII_Integer</data_type>
  <field_length unit="byte">2</field_length>
  <field_format>I02</field_format>
  <description>Indicates if maximum pulse width
requirement was met for the last impact event.
Values:
0: False
1: True</description>
  <Special_Constants>
    <missing_constant>-9</missing_constant>
  </Special_Constants>
</Field_Character>
```

```
<Field_Character>
  <name>VALID_MAX_P_FLG</name>
  <field_number>47</field_number>
  <field_location unit="byte">384</field_location>
  <data_type>ASCII_Integer</data_type>
  <field_length unit="byte">2</field_length>
  <field_format>I02</field_format>
  <description>Indicates if peak time requirement was
met for the last impact event.
Values:
0: False
1: True</description>
  <Special_Constants>
    <missing_constant>-9</missing_constant>
  </Special_Constants>
</Field_Character>
<Field_Character>
  <name>VALID_RATIO_FLG</name>
  <field_number>48</field_number>
  <field_location unit="byte">387</field_location>
  <data_type>ASCII_Integer</data_type>
  <field_length unit="byte">2</field_length>
  <field_format>I02</field_format>
  <description>Indicates if sum to peak ratio
requirement was met for the last impact event.
Values:
0: False
1: True</description>
  <Special_Constants>
    <missing_constant>-9</missing_constant>
  </Special_Constants>
</Field_Character>
<Field_Character>
  <name>TGT_WF_FIFO_OF</name>
  <field_number>49</field_number>
  <field_location unit="byte">390</field_location>
  <data_type>ASCII_Integer</data_type>
  <field_length unit="byte">2</field_length>
  <field_format>I02</field_format>
  <description>Overflow indicator for hemispherical
target waveform FIFO. Cleared at POR or by command.
Values:
0: False
1: True</description>
  <Special_Constants>
    <missing_constant>-9</missing_constant>
  </Special_Constants>
</Field_Character>
<Field_Character>
  <name>MCP_WF_FIFO_OF</name>
  <field_number>50</field_number>
  <field_location unit="byte">393</field_location>
  <data_type>ASCII_Integer</data_type>
  <field_length unit="byte">2</field_length>
  <field_format>I02</field_format>
  <description>Overflow indicator for MCP waveform
FIFO. Cleared at POR or by command.
Values:
0: False
1: True</description>
  <Special_Constants>
    <missing_constant>-9</missing_constant>
  </Special_Constants>
</Field_Character>
<Field_Character>
  <name>OFFSET_FIFO_OF</name>
  <field_number>51</field_number>
  <field_location unit="byte">396</field_location>
  <data_type>ASCII_Integer</data_type>
  <field_length unit="byte">2</field_length>
```

```
  <field_format>I02</field_format>
  <description>Overflow indicator for impact time
offset FIFO. Cleared at POR or by command.
Values:
0: False
1: True</description>
  <Special_Constants>
    <missing_constant>-9</missing_constant>
  </Special_Constants>
</Field_Character>
<Field_Character>
  <name>TIME_FIFO_OF</name>
  <field_number>52</field_number>
  <field_location unit="byte">399</field_location>
  <data_type>ASCII_Integer</data_type>
  <field_length unit="byte">2</field_length>
  <field_format>I02</field_format>
  <description>Overflow indicator for impact time stamp
FIFO. Cleared at POR or by command.
Values:
0: False
1: True</description>
  <Special_Constants>
    <missing_constant>-9</missing_constant>
  </Special_Constants>
</Field_Character>
<Field_Character>
  <name>TGT_IMP_FIFO_OF</name>
  <field_number>53</field_number>
  <field_location unit="byte">402</field_location>
  <data_type>ASCII_Integer</data_type>
  <field_length unit="byte">2</field_length>
  <field_format>I02</field_format>
  <description>Overflow indicator for hemispherical
target impact FIFO. Cleared at POR or by command.
Values:
0: False
1: True</description>
  <Special_Constants>
    <missing_constant>-9</missing_constant>
  </Special_Constants>
</Field_Character>
<Field_Character>
  <name>MCP_IMP_FIFO_OF</name>
  <field_number>54</field_number>
  <field_location unit="byte">405</field_location>
  <data_type>ASCII_Integer</data_type>
  <field_length unit="byte">2</field_length>
  <field_format>I02</field_format>
  <description>Overflow indicator for MCP impact FIFO.
Cleared at POR or by command.
Values:
0: False
1: True</description>
  <Special_Constants>
    <missing_constant>-9</missing_constant>
  </Special_Constants>
</Field_Character>
<Field_Character>
  <name>INV_MIN_DT</name>
  <field_number>55</field_number>
  <field_location unit="byte">408</field_location>
  <data_type>ASCII_Real</data_type>
  <field_length unit="byte">13</field_length>
  <field_format>E013.6</field_format>
  <unit>SECOND</unit>
  <description>Value of minimum pulse width for last
invalid impact.</description>
  <Special_Constants>
    <missing_constant>-9.999999E+09</missing_constant>
```

```
  </Special_Constants>
</Field_Character>
<Field_Character>
  <name>INV_MAX_DT</name>
  <field_number>56</field_number>
  <field_location unit="byte">422</field_location>
  <data_type>ASCII_Real</data_type>
  <field_length unit="byte">13</field_length>
  <field_format>E013.6</field_format>
  <unit>SECOND</unit>
  <description>Value of maximum pulse width for last
invalid impact.</description>
  <Special_Constants>
    <missing_constant>-9.999999E+09</missing_constant>
  </Special_Constants>
</Field_Character>
<Field_Character>
  <name>INV_MAX_P</name>
  <field_number>57</field_number>
  <field_location unit="byte">436</field_location>
  <data_type>ASCII_Real</data_type>
  <field_length unit="byte">13</field_length>
  <field_format>E013.6</field_format>
  <unit>SECOND</unit>
  <description>Value of peak time for last invalid
impact.</description>
  <Special_Constants>
    <missing_constant>-9.999999E+09</missing_constant>
  </Special_Constants>
</Field_Character>
<Field_Character>
  <name>INV_SUM</name>
  <field_number>58</field_number>
  <field_location unit="byte">450</field_location>
  <data_type>ASCII_Integer</data_type>
  <field_length unit="byte">10</field_length>
  <field_format>I010</field_format>
  <description>Integrated sum of 50 samples for last
invalid impact.</description>
  <Special_Constants>
    <missing_constant>-999999999</missing_constant>
  </Special_Constants>
</Field_Character>
<Field_Character>
  <name>INV_IMPACT_COUNT</name>
  <field_number>59</field_number>
  <field_location unit="byte">461</field_location>
  <data_type>ASCII_Integer</data_type>
  <field_length unit="byte">5</field_length>
  <field_format>I05</field_format>
  <description>Number of invalid impact events since
last primary housekeeping packet.</description>
  <Special_Constants>
    <missing_constant>-9999</missing_constant>
  </Special_Constants>
</Field_Character>
<Field_Character>
  <name>IMPACT_DEAD_TIME</name>
  <field_number>60</field_number>
  <field_location unit="byte">467</field_location>
  <data_type>ASCII_Real</data_type>
  <field_length unit="byte">13</field_length>
  <field_format>E013.6</field_format>
  <unit>SECOND</unit>
  <description>Accumulated dead time since last primary
housekeeping packet. Includes time spent processing both valid and
invalid impacts.</description>
  <Special_Constants>
    <missing_constant>-9.999999E+09</missing_constant>
  </Special_Constants>
```

```
</Field_Character>
<Field_Character>
  <name>VALID_MIN_DT</name>
  <field_number>61</field_number>
  <field_location unit="byte">481</field_location>
  <data_type>ASCII_Real</data_type>
  <field_length unit="byte">13</field_length>
  <field_format>E013.6</field_format>
  <unit>SECOND</unit>
  <description>Value of minimum pulse width for last
valid impact.</description>
  <Special_Constants>
    <missing_constant>-9.999999E+09</missing_constant>
  </Special_Constants>
</Field_Character>
<Field_Character>
  <name>VALID_MAX_DT</name>
  <field_number>62</field_number>
  <field_location unit="byte">495</field_location>
  <data_type>ASCII_Real</data_type>
  <field_length unit="byte">13</field_length>
  <field_format>E013.6</field_format>
  <unit>SECOND</unit>
  <description>Value of maximum pulse width for last
valid impact.</description>
  <Special_Constants>
    <missing_constant>-9.999999E+09</missing_constant>
  </Special_Constants>
</Field_Character>
<Field_Character>
  <name>VALID_MAX_P</name>
  <field_number>63</field_number>
  <field_location unit="byte">509</field_location>
  <data_type>ASCII_Real</data_type>
  <field_length unit="byte">13</field_length>
  <field_format>E013.6</field_format>
  <unit>SECOND</unit>
  <description>Value of peak time for last valid
impact.</description>
  <Special_Constants>
    <missing_constant>-9.999999E+09</missing_constant>
  </Special_Constants>
</Field_Character>
<Field_Character>
  <name>VALID_SUM</name>
  <field_number>64</field_number>
  <field_location unit="byte">523</field_location>
  <data_type>ASCII_Integer</data_type>
  <field_length unit="byte">10</field_length>
  <field_format>I010</field_format>
  <description>Integrated sum of 50 samples for last
valid impact.</description>
  <Special_Constants>
    <missing_constant>-999999999</missing_constant>
  </Special_Constants>
</Field_Character>
<Field_Character>
  <name>INV_PEAK</name>
  <field_number>65</field_number>
  <field_location unit="byte">534</field_location>
  <data_type>ASCII_Integer</data_type>
  <field_length unit="byte">5</field_length>
  <field_format>I05</field_format>
  <unit>VOLT</unit>
  <description>Peak MCP amplitude for last invalid
impact.</description>
  <Special_Constants>
    <missing_constant>-9999</missing_constant>
  </Special_Constants>
</Field_Character>
```

```
    <Field_Character>
     <name>VALID_PEAK</name>
     <field_number>66</field_number>
     <field_location unit="byte">540</field_location>
     <data_type>ASCII_Integer</data_type>
     <field_length unit="byte">5</field_length>
     <field_format>I05</field_format>
     <unit>VOLT</unit>
     <description>Peak MCP amplitude for last valid
    impact.</description>
     <Special_Constants>
      <missing_constant>-9999</missing_constant>
     </Special_Constants>
    </Field_Character>
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 </File_Area_Observational>
</Product_Observational>
```


8.2.2 Diagnostic (Secondary Housekeeping)


```
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<Product_Observational xmlns="http://pds.nasa.gov/pds4/pds/v03" xmlns:xsi="http://www.w3.org/2001/XMLSchema-
instance">
 <Identification_Area>
  <logical_identifier>urn:nasa:pds:ladee-
ldex:data_housekeeping:housekeeping_diagnostic_995241615_tab</logical_identifier>
  <version_id>1.0</version_id>
  <title>DIAGNOSTIC (SECONDARY HOUSEKEEPING)</title>
  <information_model_version>0.3.0.0.a</information_model_version>
  <product_class>Product_Observational</product_class>
 </Identification_Area>
 <Observation_Area>
  <Time_Coordinates>
   <start_date_time>2011-07-21T15:05:21</start_date_time>
   <stop_date_time>2011-07-21T21:29:28</stop_date_time>
  </Time_Coordinates>
  <Investigation_Area>
   <name>LADEE with LUNAR DUST EXPERIMENT</name>
   <type>Mission</type>
   <Internal_Reference>
    <lid_reference>urn:nasa:pds:ladee-ldex:context:investigation.LADEE</lid_reference>
    <reference_type>data_to_investigation</reference_type>
   </Internal_Reference>
  </Investigation_Area>
  <Observing_System>
   <Observing_System_Component>
    <name>Lunar Dust Experiment</name>
    <observing_system_component_type>Instrument</observing_system_component_type>
    <description>The LADEE Lunar Dust Experiment (LDEX) instrument description is included in the LADEE LDEX
Software Interface Specification (SIS) file 'ldex_pds_sis_reva.docx' in the document collection of the LADEE LDEX
bundle.</description>
   </Observing_System_Component>
   <Observing_System_Component>
    <name>Ladee</name>
    <observing_system_component_type>Spacecraft</observing_system_component_type>
    <description>The LADEE spacecraft description document is included in the file
'lad_pds_spacecraft_rev1.docx' in the document collection of the
LADEE LDEX bundle.</description>
   </Observing_System_Component>
  </Observing_System>
  <Target_Identification>
   <name>Dust</name>
   <type>Dust</type>
  </Target_Identification>
  <Target_Identification>
   <name>Moon</name>
   <type>Satellite</type>
  </Target_Identification>
```

```
</Observation_Area>
<File_Area_Observational>
 <File>
  <file_name>diagnostic_995241615.tab</file_name>
  <local_identifier>HOUSEKEEPING_DIAGNOSTIC_995241615_TAB</local_identifier>
  <creation_date_time>2013-03-01</creation_date_time>
  <file_size unit="byte">276340</file_size>
  <records>1685</records>
 </File>
 <Table_Character>
  <local_identifier>TABLE</local_identifier>
  <offset unit="byte">0</offset>
  <records>1685</records>
  <encoding_type>Character</encoding_type>
  <description>This is the LDEX data relating to
   diagnostic information from LDEX.  This packet is stored only when
   commanded and contains telemetry related to the state of the
   instrument.</description>
  <record_delimiter>carriage_return line_feed</record_delimiter>
  <Record_Character>
   <fields>25</fields>
   <record_length unit="byte">164</record_length>
   <Field_Character>
    <name>TIME</name>
    <field_number>1</field_number>
    <field_location unit="byte">1</field_location>
    <data_type>ASCII_Time</data_type>
    <field_length unit="byte">26</field_length>
    <field_format>A26</field_format>
    <description>Time the diagnostic information was
   packetized and sent to the spacecraft.</description>
   </Field_Character>
   <Field_Character>
    <name>MCP_LOW_V</name>
    <field_number>2</field_number>
    <field_location unit="byte">28</field_location>
    <data_type>ASCII_Real</data_type>
    <field_length unit="byte">13</field_length>
    <field_format>E013.6</field_format>
    <unit>VOLT</unit>
    <description>Commanded MCP low-side voltage.</description>
    <Special_Constants>
     <missing_constant>-9.999999E+09</missing_constant>
    </Special_Constants>
   </Field_Character>
   <Field_Character>
    <name>HV_CLK_DELAY</name>
    <field_number>3</field_number>
    <field_location unit="byte">42</field_location>
    <data_type>ASCII_Integer</data_type>
    <field_length unit="byte">3</field_length>
    <field_format>I03</field_format>
    <unit>40_NANOSECOND</unit>
    <description>Number of 40 ns periods to delay the HV
   clock.</description>
    <Special_Constants>
     <missing_constant>-99</missing_constant>
    </Special_Constants>
   </Field_Character>
   <Field_Character>
    <name>SCIENCE_WO_HV</name>
    <field_number>4</field_number>
    <field_location unit="byte">46</field_location>
    <data_type>ASCII_Integer</data_type>
    <field_length unit="byte">2</field_length>
    <field_format>I02</field_format>
    <description>Instrument is configured to output
   science regardless of HV enable state.
   Values:
   0: Disabled
```

1: Enabled</description>
<Special_Constants>
<missing_constant>-9</missing_constant>
</Special_Constants>
</Field_Character>
<Field_Character>
<name>HEMI_SWITCH_ENA</name>
<field_number>5</field_number>
<field_location unit="byte">49</field_location>
<data_type>ASCII_Integer</data_type>
<field_length unit="byte">2</field_length>
<field_format>I02</field_format>
<description>Hemispherical grid voltage switching
enable status.
Values:
0: False
1: True</description>
<Special_Constants>
<missing_constant>-9</missing_constant>
</Special_Constants>
</Field_Character>
<Field_Character>
<name>HEMI_GRID_HV_ENA</name>
<field_number>6</field_number>
<field_location unit="byte">52</field_location>
<data_type>ASCII_Integer</data_type>
<field_length unit="byte">2</field_length>
<field_format>I02</field_format>
<description>Hemispherical grid HV enable status.
Values:
0: False
1: True</description>
<Special_Constants>
<missing_constant>-9</missing_constant>
</Special_Constants>
</Field_Character>
<Field_Character>
<name>FLAT_GRID_HV_ENA</name>
<field_number>7</field_number>
<field_location unit="byte">55</field_location>
<data_type>ASCII_Integer</data_type>
<field_length unit="byte">2</field_length>
<field_format>I02</field_format>
<description>Flat grid HV enable status.
Values:
0: False
1: True</description>
<Special_Constants>
<missing_constant>-9</missing_constant>
</Special_Constants>
</Field_Character>
<Field_Character>
<name>MCP_HV_ENA</name>
<field_number>8</field_number>
<field_location unit="byte">58</field_location>
<data_type>ASCII_Integer</data_type>
<field_length unit="byte">2</field_length>
<field_format>I02</field_format>
<description>MCP HV (low and high side) enable
status.
Values:
0: False
1: True</description>
<Special_Constants>
<missing_constant>-9</missing_constant>
</Special_Constants>
</Field_Character>
<Field_Character>
<name>W_SCREEN_HV_ENA</name>
<field_number>9</field_number>

```
  <field_location unit="byte">61</field_location>
  <data_type>ASCII_Integer</data_type>
  <field_length unit="byte">2</field_length>
  <field_format>I02</field_format>
  <description>Solar wind screen HV enable status.
Values:
0: False
1: True</description>
  <Special_Constants>
    <missing_constant>-9</missing_constant>
  </Special_Constants>
</Field_Character>
<Field_Character>
  <name>HK_PKT_RT</name>
  <field_number>10</field_number>
  <field_location unit="byte">64</field_location>
  <data_type>ASCII_Integer</data_type>
  <field_length unit="byte">3</field_length>
  <field_format>I03</field_format>
  <unit>SECOND</unit>
  <description>Primary housekeeping packet production
interval.</description>
  <Special_Constants>
    <missing_constant>-99</missing_constant>
  </Special_Constants>
</Field_Character>
<Field_Character>
  <name>COVER_PULSE</name>
  <field_number>11</field_number>
  <field_location unit="byte">68</field_location>
  <data_type>ASCII_Integer</data_type>
  <field_length unit="byte">5</field_length>
  <field_format>I05</field_format>
  <unit>MILLISECOND</unit>
  <description>Aperture cover pulse width.</description>
  <Special_Constants>
    <missing_constant>-9999</missing_constant>
  </Special_Constants>
</Field_Character>
<Field_Character>
  <name>IMPACT_LVL</name>
  <field_number>12</field_number>
  <field_location unit="byte">74</field_location>
  <data_type>ASCII_Real</data_type>
  <field_length unit="byte">13</field_length>
  <field_format>E013.6</field_format>
  <description>Impact threshold register.</description>
  <Special_Constants>
    <missing_constant>-9.999999E+09</missing_constant>
  </Special_Constants>
</Field_Character>
<Field_Character>
  <name>SSAFING_LVL</name>
  <field_number>13</field_number>
  <field_location unit="byte">88</field_location>
  <data_type>ASCII_Integer</data_type>
  <field_length unit="byte">5</field_length>
  <field_format>I05</field_format>
  <description>Sun safing threshold register.</description>
  <Special_Constants>
    <missing_constant>-9999</missing_constant>
  </Special_Constants>
</Field_Character>
<Field_Character>
  <name>IMPACT_MIN_DT</name>
  <field_number>14</field_number>
  <field_location unit="byte">94</field_location>
  <data_type>ASCII_Real</data_type>
  <field_length unit="byte">13</field_length>
  <field_format>E013.6</field_format>
```

```
  <unit>SECOND</unit>
  <description>Minimum time between threshold crossings
for valid dust impact. MCP signal impact threshold crossings (rising
and falling) that occur faster than this time are not counted as valid
impacts for either waveform capture or individual impact detection.
This is used to eliminate noise or non-dust impacts.</description>
  <Special_Constants>
    <missing_constant>-9.999999E+09</missing_constant>
  </Special_Constants>
</Field_Character>
<Field_Character>
  <name>DECIMATION</name>
  <field_number>15</field_number>
  <field_location unit="byte">108</field_location>
  <data_type>ASCII_Integer</data_type>
  <field_length unit="byte">3</field_length>
  <field_format>I03</field_format>
  <description>Waveform decimation register.</description>
  <Special_Constants>
    <missing_constant>-99</missing_constant>
  </Special_Constants>
</Field_Character>
<Field_Character>
  <name>ARM_TIMEOUT</name>
  <field_number>16</field_number>
  <field_location unit="byte">112</field_location>
  <data_type>ASCII_Integer</data_type>
  <field_length unit="byte">3</field_length>
  <field_format>I03</field_format>
  <unit>SECOND</unit>
  <description>Time before an 'arm' condition expires.</description>
  <Special_Constants>
    <missing_constant>-99</missing_constant>
  </Special_Constants>
</Field_Character>
<Field_Character>
  <name>FIRMWARE_VERSION</name>
  <field_number>17</field_number>
  <field_location unit="byte">116</field_location>
  <data_type>ASCII_Integer</data_type>
  <field_length unit="byte">3</field_length>
  <field_format>I03</field_format>
  <description>LDEX control FPGA firmware version
number.</description>
  <Special_Constants>
    <missing_constant>-99</missing_constant>
  </Special_Constants>
</Field_Character>
<Field_Character>
  <name>IP_DUST_LEVEL</name>
  <field_number>18</field_number>
  <field_location unit="byte">120</field_location>
  <data_type>ASCII_Integer</data_type>
  <field_length unit="byte">5</field_length>
  <field_format>I05</field_format>
  <description>Slope of MCP signal at which non-lunar
dust is flagged. Interplanetary or interstellar dust will have higher
impact speeds and will therefore generate MCP signals with steeper
slopes. Any impacts detected with a slope at or above this level will
be captured as waveforms regardless of the decimation value.</description>
  <Special_Constants>
    <missing_constant>-9999</missing_constant>
  </Special_Constants>
</Field_Character>
<Field_Character>
  <name>INTEGRATION_R_TM</name>
  <field_number>19</field_number>
  <field_location unit="byte">126</field_location>
  <data_type>ASCII_Integer</data_type>
  <field_length unit="byte">3</field_length>
```

```
  <field_format>I03</field_format>
  <unit>MILLISECOND</unit>
  <description>Integration reset time for collective
dust particle impact signal.</description>
  <Special_Constants>
    <missing_constant>-99</missing_constant>
  </Special_Constants>
</Field_Character>
<Field_Character>
  <name>IMPACT_MAX_DT</name>
  <field_number>20</field_number>
  <field_location unit="byte">130</field_location>
  <data_type>ASCII_Real</data_type>
  <field_length unit="byte">13</field_length>
  <field_format>E013.6</field_format>
  <unit>SECOND</unit>
  <description>Maximum time between threshold crossings
for valid dust impact. MCP signal impact threshold crossings (rising
and falling) that occur slower than this time are not counted as valid
impacts for either waveform capture or individual impact detection.
This is used to eliminate noise or non-dust impacts.</description>
  <Special_Constants>
    <missing_constant>-9.999999E+09</missing_constant>
  </Special_Constants>
</Field_Character>
<Field_Character>
  <name>INTEGRATION_S_TM</name>
  <field_number>21</field_number>
  <field_location unit="byte">144</field_location>
  <data_type>ASCII_Integer</data_type>
  <field_length unit="byte">3</field_length>
  <field_format>I03</field_format>
  <unit>MILLISECOND</unit>
  <description>Integration time for collective dust
particle impact signal. This parameter is nominally 100 ms, but is
adjustable in case pre-launch predictions of the dust environment are
significantly different from actual conditions.</description>
  <Special_Constants>
    <missing_constant>-99</missing_constant>
  </Special_Constants>
</Field_Character>
<Field_Character>
  <name>IMPACT_T_CT</name>
  <field_number>22</field_number>
  <field_location unit="byte">148</field_location>
  <data_type>ASCII_Integer</data_type>
  <field_length unit="byte">3</field_length>
  <field_format>I03</field_format>
  <description>Number of simulated impacts generated by
the 'init ldex impact_test' command.</description>
  <Special_Constants>
    <missing_constant>-99</missing_constant>
  </Special_Constants>
</Field_Character>
<Field_Character>
  <name>IMPACT_MAX_P</name>
  <field_number>23</field_number>
  <field_location unit="byte">152</field_location>
  <data_type>ASCII_Integer</data_type>
  <field_length unit="byte">3</field_length>
  <field_format>I03</field_format>
  <unit>8_MICROSECOND</unit>
  <description>Maximum time for MCP peak for valid dust
impacts.</description>
  <Special_Constants>
    <missing_constant>-99</missing_constant>
  </Special_Constants>
</Field_Character>
<Field_Character>
  <name>IMPACT_MIN_R</name>
```

```
    <field_number>24</field_number>
    <field_location unit="byte">156</field_location>
    <data_type>ASCII_Integer</data_type>
    <field_length unit="byte">3</field_length>
    <field_format>I03</field_format>
    <description>Minimum ratio between MCP sum and MCP
   peak for valid impacts. MCP waveforms that have a sum to peak ratio
   less than this value are not counted as valid impacts for either
   waveform capture or individual impact detection. This is used to
   eliminate noise or non-dust impacts.</description>
    <Special_Constants>
      <missing_constant>-99</missing_constant>
    </Special_Constants>
   </Field_Character>
   <Field_Character>
    <name>INV_WF_RT</name>
    <field_number>25</field_number>
    <field_location unit="byte">160</field_location>
    <data_type>ASCII_Integer</data_type>
    <field_length unit="byte">3</field_length>
    <field_format>I03</field_format>
    <unit>MINUTE</unit>
    <description>Minimum period at which LDEX will
   transmit invalid impact waveform packets.</description>
    <Special_Constants>
      <missing_constant>-99</missing_constant>
    </Special_Constants>
   </Field_Character>
  </Record_Character>
 </Table_Character>
 </File_Area_Observational>
</Product_Observational>
```


8.2.3 Integrated


```
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<?xml-model href="http://pds.nasa.gov/pds4/pds/v03/PDS4_PDS_0300a.sch"?>
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instance">
 <Identification_Area>
  <logical_identifier>urn:nasa:pds:ladee-ldex:data_reduced:reduced_integrated_995241615_tab</logical_identifier>
  <version_id>1.0</version_id>
  <title>INTEGRATED</title>
  <information_model_version>0.3.0.0.a</information_model_version>
  <product_class>Product_Observational</product_class>
 </Identification_Area>
 <Observation_Area>
  <Time_Coordinates>
   <start_date_time>2011-07-21T15:20:12</start_date_time>
   <stop_date_time>2011-07-21T21:29:32</stop_date_time>
  </Time_Coordinates>
  <Investigation_Area>
   <name>LADEE with LUNAR DUST EXPERIMENT</name>
   <type>Mission</type>
   <Internal_Reference>
    <lid_reference>urn:nasa:pds:ladee-ldex:context:investigation.LADEE</lid_reference>
    <reference_type>data_to_investigation</reference_type>
   </Internal_Reference>
  </Investigation_Area>
  <Observing_System>
   <Observing_System_Component>
    <name>Lunar Dust Experiment</name>
    <observing_system_component_type>Instrument</observing_system_component_type>
    <description>The LADEE Lunar Dust Experiment (LDEX) instrument description is included in the LADEE LDEX
Software Interface Specification (SIS) file 'ldex_pds_sis_reva.docx' in the document collection of the LADEE LDEX
bundle.</description>
   </Observing_System_Component>
   <Observing_System_Component>
    <name>Ladee</name>
    <observing_system_component_type>Spacecraft</observing_system_component_type>
```

```
        <description>The LADEE spacecraft description document is included in the file
'lad_pds_spacecraft_rev1.docx' in the document collection of the
LADEE LDEX bundle.</description>
      </Observing_System_Component>
    </Observing_System>
    <Target_Identification>
      <name>Dust</name>
      <type>Dust</type>
    </Target_Identification>
    <Target_Identification>
      <name>Moon</name>
      <type>Satellite</type>
    </Target_Identification>
  </Observation_Area>
  <File_Area_Observational>
    <File>
      <file_name>integrated_995241615.tab</file_name>
      <local_identifier>REDUCED_INTEGRATED_995241615_TAB</local_identifier>
      <creation_date_time>2013-03-01</creation_date_time>
      <file_size unit="byte">3822000</file_size>
      <records>78000</records>
    </File>
    <Table_Character>
      <local_identifier>TABLE</local_identifier>
      <offset unit="byte">0</offset>
      <records>78000</records>
      <encoding_type>Character</encoding_type>
      <description>The raw integrated table contains the
        measurements recorded by the integrator for each period that the high
        voltage is turned on.  The integration time is user selected and is
        nominally 100ms.  The integrator is zeroed at the beginning of each
        sample.</description>
      <record_delimiter>carriage_return line_feed</record_delimiter>
      <Record_Character>
        <fields>5</fields>
        <record_length unit="byte">49</record_length>
        <Field_Character>
          <name>PACKET_TIME</name>
          <field_number>1</field_number>
          <field_location unit="byte">1</field_location>
          <data_type>ASCII_Time</data_type>
          <field_length unit="byte">26</field_length>
          <field_format>A26</field_format>
          <description>UTC Time (yyyy-mm-ddThh:mm:ss.ssssss)</description>
        </Field_Character>
        <Field_Character>
          <name>INTEGRATED_MCP_SAMPLE</name>
          <field_number>2</field_number>
          <field_location unit="byte">28</field_location>
          <data_type>ASCII_Real</data_type>
          <field_length unit="byte">9</field_length>
          <field_format>F09.6</field_format>
          <unit>VOLT</unit>
          <description>Integrated dust samples (Volts). The
        Microchannel Plate (MCP) is sampled at a programmable rate with a
        default of 100 ms. This measurement takes two samples of the MCP each
        cycle to perform a correlated double sample.  The first one is taken 1
        ms after the start of the sample period to establish the zero level
        for the channel.  The second one is taken after the programmed sample
        period has expired.  The difference of the two is the measurement of
        the integrated low-level dust impinging on the instrument and is given
        in the Integrated Dust Samples.</description>
        </Field_Character>
        <Field_Character>
          <name>SAMPLE_PERIOD</name>
          <field_number>3</field_number>
          <field_location unit="byte">38</field_location>
          <data_type>ASCII_Real</data_type>
          <field_length unit="byte">5</field_length>
          <field_format>F5.3</field_format>
```

```
        <unit>SECOND</unit>
        <description>Period of samples (seconds). The sample
      period is a programmable period which can have a value of 0-255
      seconds.</description>
      </Field_Character>
      <Field_Character>
        <name>HV_STATUS</name>
        <field_number>4</field_number>
        <field_location unit="byte">44</field_location>
        <data_type>ASCII_Integer</data_type>
        <field_length unit="byte">1</field_length>
        <field_format>I1</field_format>
        <description>0=High Voltage is off, 1=High Voltage is
      on.</description>
      </Field_Character>
      <Field_Character>
        <name>GRID_STATUS</name>
        <field_number>5</field_number>
        <field_location unit="byte">46</field_location>
        <data_type>ASCII_Integer</data_type>
        <field_length unit="byte">1</field_length>
        <field_format>I1</field_format>
        <description>0=Grid voltage is +30V, 1=Grid voltage
      is -200V. Switching the Grid voltage to +30V has the effect of any
      ions from the MCP, preventing dust impacts from registering on the
      MCP.  Sampling when the Grid is switched is a way get a noise floor
      measurement for the electronics that can be used to correct the
      integrated dust measurement on the ground.</description>
      </Field_Character>
    </Record_Character>
   </Table_Character>
  </File_Area_Observational>
</Product_Observational>
```


8.2.4 Impact


```
<?xml version="1.0" encoding="UTF-8"?>
<?xml-model href="http://pds.nasa.gov/pds4/pds/v03/PDS4_PDS_0300a.sch"?>
<Product_Observational xmlns="http://pds.nasa.gov/pds4/pds/v03" xmlns:xsi="http://www.w3.org/2001/XMLSchema-
instance">
  <Identification_Area>
    <logical_identifier>urn:nasa:pds:ladee-ldex:data_reduced:reduced_impact_995241615_tab</logical_identifier>
    <version_id>1.0</version_id>
    <title>IMPACTS</title>
    <information_model_version>0.3.0.0.a</information_model_version>
    <product_class>Product_Observational</product_class>
  </Identification_Area>
  <Observation_Area>
    <Time_Coordinates>
      <start_date_time>2011-07-21T15:21:06</start_date_time>
      <stop_date_time>2011-07-21T21:26:03</stop_date_time>
    </Time_Coordinates>
    <Investigation_Area>
      <name>LADEE with LUNAR DUST EXPERIMENT</name>
      <type>Mission</type>
      <Internal_Reference>
        <lid_reference>urn:nasa:pds:ladee-ldex:context:investigation.LADEE</lid_reference>
        <reference_type>data_to_investigation</reference_type>
      </Internal_Reference>
    </Investigation_Area>
    <Observing_System>
      <Observing_System_Component>
        <name>Lunar Dust Experiment</name>
        <observing_system_component_type>Instrument</observing_system_component_type>
        <description>The LADEE Lunar Dust Experiment (LDEX) instrument description is included in the LADEE LDEX
Software Interface Specification (SIS) file 'ldex_pds_sis_reva.docx' in the document collection of the LADEE LDEX
bundle.</description>
      </Observing_System_Component>
      <Observing_System_Component>
        <name>Ladee</name>
```

```
        <observing_system_component_type>Spacecraft</observing_system_component_type>
        <description>The LADEE spacecraft description document is included in the file
'lad_pds_spacecraft_rev1.docx' in the document collection of the
LADEE LDEX bundle.</description>
      </Observing_System_Component>
    </Observing_System>
    <Target_Identification>
      <name>Dust</name>
      <type>Dust</type>
    </Target_Identification>
    <Target_Identification>
      <name>Moon</name>
      <type>Satellite</type>
    </Target_Identification>
  </Observation_Area>
  <File_Area_Observational>
    <File>
      <file_name>impact_995241615.tab</file_name>
      <local_identifier>REDUCED_IMPACT_995241615_TAB</local_identifier>
      <creation_date_time>2013-02-28</creation_date_time>
      <file_size unit="byte">5115</file_size>
      <records>93</records>
    </File>
    <Table_Character>
      <local_identifier>TABLE</local_identifier>
      <offset unit="byte">0</offset>
      <records>93</records>
      <encoding_type>Character</encoding_type>
      <description>This table contains the number of
        impacts recorded during a user selectable duration.  It includes
        impacts recorded on both the target and MCP.</description>
      <record_delimiter>carriage_return line_feed</record_delimiter>
      <Record_Character>
        <fields>4</fields>
        <record_length unit="byte">55</record_length>
        <Field_Character>
          <name>PACKET_TIME</name>
          <field_number>1</field_number>
          <field_location unit="byte">1</field_location>
          <data_type>ASCII_Time</data_type>
          <field_length unit="byte">26</field_length>
          <field_format>A26</field_format>
          <description>UTC Time (yyyy-mm-ddThh:mm:ss.ssssss)</description>
        </Field_Character>
        <Field_Character>
          <name>IMPACT_PEAK_MCP</name>
          <field_number>2</field_number>
          <field_location unit="byte">28</field_location>
          <data_type>ASCII_Real</data_type>
          <field_length unit="byte">9</field_length>
          <field_format>F09.6</field_format>
          <unit>VOLT</unit>
          <description>Peak value of MCP signal for impact
        (Volts)  The Microchannel Plate (MCP) is sampled every 8 us. If the
        signal crosses a programmable threshold, an impact detection algorithm
        will be performed to determine if the event was caused by a dust
        impact. If the MCP signal meets the necessary conditions for a dust
        impact including rise time, peak duration and sum to peak ratio, the
        peak amplitude of the MCP signal level will be stored.</description>
        </Field_Character>
        <Field_Character>
          <name>IMPACT_PEAK_TARGET</name>
          <field_number>3</field_number>
          <field_location unit="byte">38</field_location>
          <data_type>ASCII_Real</data_type>
          <field_length unit="byte">9</field_length>
          <field_format>F09.6</field_format>
          <unit>VOLT</unit>
          <description>Peak value of Target signal for impact
        (Volts). If the MCP signal has met the dust impact requirements
```

```
        described in the Impact Peak MCP description, the peak amplitude of
        the Target signal will be stored.</description>
        </Field_Character>
        <Field_Character>
          <name>HV_ADJUST</name>
          <field_number>4</field_number>
          <field_location unit="byte">48</field_location>
          <data_type>ASCII_Real</data_type>
          <field_length unit="byte">5</field_length>
          <field_format>F5.1</field_format>
          <unit>VOLT</unit>
          <description>MCP HV adjustment value (Volts)</description>
        </Field_Character>
      </Record_Character>
    </Table_Character>
  </File_Area_Observational>
</Product_Observational>
```


8.2.5 Wave


```
<?xml version="1.0" encoding="UTF-8"?>
<?xml-model href="http://pds.nasa.gov/pds4/pds/v03/PDS4_PDS_0300a.sch"?>
<Product_Observational xmlns="http://pds.nasa.gov/pds4/pds/v03" xmlns:xsi="http://www.w3.org/2001/XMLSchema-
instance">
  <Identification_Area>
    <logical_identifier>urn:nasa:pds:ladee-ldex:data_reduced:reduced_wave_995241615_tab</logical_identifier>
    <version_id>1.0</version_id>
    <title>WAVE</title>
    <information_model_version>0.3.0.0.a</information_model_version>
    <product_class>Product_Observational</product_class>
  </Identification_Area>
  <Observation_Area>
    <Time_Coordinates>
      <start_date_time>2011-07-21T15:21:07</start_date_time>
      <stop_date_time>2011-07-21T21:26:04</stop_date_time>
    </Time_Coordinates>
    <Investigation_Area>
      <name>LADEE with LUNAR DUST EXPERIMENT</name>
      <type>Mission</type>
      <Internal_Reference>
        <lid_reference>urn:nasa:pds:ladee-ldex:context:investigation.LADEE</lid_reference>
        <reference_type>data_to_investigation</reference_type>
      </Internal_Reference>
    </Investigation_Area>
    <Observing_System>
      <Observing_System_Component>
        <name>Lunar Dust Experiment</name>
        <observing_system_component_type>Instrument</observing_system_component_type>
        <description>The LADEE Lunar Dust Experiment (LDEX) instrument description is included in the LADEE LDEX
Software Interface Specification (SIS) file 'ldex_pds_sis_reva.docx' in the document collection of the LADEE LDEX
bundle.</description>
      </Observing_System_Component>
      <Observing_System_Component>
        <name>Ladee</name>
        <observing_system_component_type>Spacecraft</observing_system_component_type>
        <description>The LADEE spacecraft description document is included in the file
'lad_pds_spacecraft_rev1.docx' in the document collection of the
LADEE LDEX bundle.</description>
      </Observing_System_Component>
    </Observing_System>
    <Target_Identification>
      <name>Dust</name>
      <type>Dust</type>
    </Target_Identification>
    <Target_Identification>
      <name>Moon</name>
      <type>Satellite</type>
    </Target_Identification>
  </Observation_Area>
  <File_Area_Observational>
```

```
<File>
  <file_name>wave_995241615.tab</file_name>
  <local_identifier>REDUCED_WAVE_995241615_TAB</local_identifier>
  <creation_date_time>2013-02-28</creation_date_time>
  <file_size unit="byte">96627</file_size>
  <records>93</records>
</File>
<Table_Character>
  <local_identifier>TABLE</local_identifier>
  <offset unit="byte">0</offset>
  <records>93</records>
  <encoding_type>Character</encoding_type>
  <description>The wave packet stored by LDEX contains
    voltages from the MCP and target.  When triggered (by rising above the
    threshold), the FPGA begins recording voltages from both the MCP and
    target in 8 microsecond intervals for 50 samples resulting in a 400
    microsecond waveform.  The two are recorded simultaneously.  Because
    the instrument/spacecraft do not have the data volume to store all
    waveforms, the waveforms are stored at a specific cadence.  The
    decimation factor (found in the diagnostic packet) determines this
    cadence that the full waveform is stored in the packet.  A decimation
    factor of 1 means all waveforms are stored on a FIFO basis.</description>
  <record_delimiter>carriage_return line_feed</record_delimiter>
  <Record_Character>
    <fields>6</fields>
    <record_length unit="byte">1039</record_length>
    <Field_Character>
      <name>PACKET_TIME</name>
      <field_number>1</field_number>
      <field_location unit="byte">1</field_location>
      <data_type>ASCII_Time</data_type>
      <field_length unit="byte">26</field_length>
      <field_format>A26</field_format>
      <description>UTC Time (yyyy-mm-ddThh:mm:ss.ssssss)</description>
    </Field_Character>
    <Group_Field_Character>
      <repetitions>50</repetitions>
      <fields>1</fields>
      <group_location unit="byte">28</group_location>
      <group_length unit="byte">10</group_length>
      <Field_Character>
        <name>MCP_SIGNAL</name>
        <field_number>2</field_number>
        <field_location unit="byte">28</field_location>
        <data_type>ASCII_Real</data_type>
        <field_length unit="byte">10</field_length>
        <field_format>1X,F09.6</field_format>
        <unit>VOLT</unit>
        <description>50 Samples of MCP Signal.  The
    Microchannel Plate (MCP) is sampled every 8 us. If the signal crosses
    a programmable threshold, an impact detection algorithm will be
    performed to determine the if the event was caused by a dust impact.
    If the MCP signal meets the necessary conditions for a dust impact
    including rise time, peak duration, and sum to peak ratio, then, 15
    samples before the threshold crossing and 35 samples after the
    threshold crossing will be stored.</description>
      </Field_Character>
    </Group_Field_Character>
    <Group_Field_Character>
      <repetitions>50</repetitions>
      <fields>1</fields>
      <group_location unit="byte">528</group_location>
      <group_length unit="byte">10</group_length>
      <Field_Character>
        <name>TARGET_SIGNAL</name>
        <field_number>3</field_number>
        <field_location unit="byte">528</field_location>
        <data_type>ASCII_Real</data_type>
        <field_length unit="byte">10</field_length>
        <field_format>1X,F09.6</field_format>
```

```xml
      <unit>VOLT</unit>
      <description>50 Samples of Target Signal. The
    hemispherical Target is sampled every 8 us.  If the MCP signal meets
    the necessary dust impact requirements and 50 samples are stored as
    described in the MCP Signal description, 50 samples of the Target
    signal will also be stored.</description>
     </Field_Character>
    </Group_Field_Character>
    <Field_Character>
     <name>VALID</name>
     <field_number>4</field_number>
     <field_location unit="byte">1028</field_location>
     <data_type>ASCII_Integer</data_type>
     <field_length unit="byte">1</field_length>
     <field_format>I1</field_format>
     <description>0=invalid dust impact, 1=valid impact.
    If the MCP signal crosses the programmable threshold but fails the
    impact detection criteria, the event will be flagged as an invalid
    dust impact. Invalid dust impact waveforms will be stored at a
    programmable cadence.</description>
    </Field_Character>
    <Field_Character>
     <name>HV_ADJUST</name>
     <field_number>5</field_number>
     <field_location unit="byte">1030</field_location>
     <data_type>ASCII_Real</data_type>
     <field_length unit="byte">5</field_length>
     <field_format>F5.1</field_format>
     <unit>VOLT</unit>
     <description>MCP High Voltage adjustment value.</description>
    </Field_Character>
    <Field_Character>
     <name>NOISE_STATUS</name>
     <field_number>6</field_number>
     <field_location unit="byte">1036</field_location>
     <data_type>ASCII_Integer</data_type>
     <field_length unit="byte">1</field_length>
     <field_format>I1</field_format>
     <description>1=Packet contains requested noise data.
    A test interface has been built into the software to allow for noise
    testing during instrument development and integration which will allow
    for 1000 samples the MCP and Target channels to be stored in 20
    packets. These packets will flagged as noise data.</description>
    </Field_Character>
   </Record_Character>
  </Table_Character>
 </File_Area_Observational>
</Product_Observational>
```


8.3 Charge


```xml
<?xml version="1.0" encoding="UTF-8"?>
<?xml-model href="http://pds.nasa.gov/pds4/pds/v03/PDS4_PDS_0300a.sch"?>
<Product_Observational xmlns="http://pds.nasa.gov/pds4/pds/v03" xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance">
 <Identification_Area>
  <logical_identifier>urn:nasa:pds:ladee-ldex:data_calibrated:calibrated_charge_1021593615_tab</logical_identifier>
  <version_id>1.0</version_id>
  <title>INTEGRATED CHARGE</title>
  <information_model_version>0.3.0.0.a</information_model_version>
  <product_class>Product_Observational</product_class>
 </Identification_Area>
 <Observation_Area>
  <Time_Coordinates>
   <start_date_time>2012-05-21T16:06:27</start_date_time>
   <stop_date_time>2012-05-21T16:07:13</stop_date_time>
  </Time_Coordinates>
  <Investigation_Area>
   <name>LADEE with LUNAR DUST EXPERIMENT</name>
   <type>Mission</type>
```

```
    <Internal_Reference>
      <lid_reference>urn:nasa:pds:ladee-ldex:context:investigation.LADEE</lid_reference>
      <reference_type>data_to_investigation</reference_type>
    </Internal_Reference>
  </Investigation_Area>
  <Observing_System>
    <Observing_System_Component>
      <name>Lunar Dust Experiment</name>
      <observing_system_component_type>Instrument</observing_system_component_type>
      <description>The LADEE Lunar Dust Experiment (LDEX) instrument description is included in the LADEE LDEX
Software Interface Specification (SIS) file 'ldex_pds_sis_reva.docx' in the document collection of the LADEE LDEX
bundle.</description>
    </Observing_System_Component>
    <Observing_System_Component>
      <name>Ladee</name>
      <observing_system_component_type>Spacecraft</observing_system_component_type>
      <description>The LADEE spacecraft description document is included in the file
'lad_pds_spacecraft_rev1.docx' in the document collection of the
LADEE LDEX bundle.</description>
    </Observing_System_Component>
  </Observing_System>
  <Target_Identification>
    <name>Dust</name>
    <type>Dust</type>
  </Target_Identification>
  <Target_Identification>
    <name>Moon</name>
    <type>Satellite</type>
  </Target_Identification>
 </Observation_Area>
 <File_Area_Observational>
  <File>
    <file_name>charge_1021593615.tab</file_name>
    <local_identifier>CALIBRATED_CHARGE_1021593615_TAB</local_identifier>
    <creation_date_time>2012-10-30</creation_date_time>
    <file_size unit="byte">28795</file_size>
    <records>443</records>
  </File>
  <Table_Character>
    <local_identifier>TABLE</local_identifier>
    <offset unit="byte">0</offset>
    <records>443</records>
    <encoding_type>Character</encoding_type>
    <description>This is the calibrated charge from the
      integrator channel of LDEX.  This integrator collects cumulative
      charge from the MCP.</description>
    <record_delimiter>carriage_return line_feed</record_delimiter>
    <Record_Character>
      <fields>5</fields>
      <record_length unit="byte">65</record_length>
      <Field_Character>
        <name>TIME</name>
        <field_number>1</field_number>
        <field_location unit="byte">1</field_location>
        <data_type>ASCII_Time</data_type>
        <field_length unit="byte">26</field_length>
        <field_format>A26</field_format>
        <description>Time of integrated signal measurement in
      UTC.</description>
      </Field_Character>
      <Field_Character>
        <name>CURRENT</name>
        <field_number>2</field_number>
        <field_location unit="byte">28</field_location>
        <data_type>ASCII_Real</data_type>
        <field_length unit="byte">9</field_length>
        <field_format>E9.3</field_format>
        <unit>AMPERE</unit>
        <description>Integrated current collect by the MCP.
      Background noise has been subtracted from these measurements.</description>
```

```
        </Field_Character>
        <Field_Character>
          <name>INT_TIME</name>
          <field_number>3</field_number>
          <field_location unit="byte">38</field_location>
          <data_type>ASCII_Real</data_type>
          <field_length unit="byte">4</field_length>
          <field_format>F4.2</field_format>
          <unit>SECOND</unit>
          <description>Duration of integration measurement.</description>
        </Field_Character>
        <Field_Character>
          <name>VELOCITY</name>
          <field_number>4</field_number>
          <field_location unit="byte">43</field_location>
          <data_type>ASCII_Real</data_type>
          <field_length unit="byte">9</field_length>
          <field_format>E9.3</field_format>
          <unit>KM/S</unit>
          <description>Impacting velocity of incident dust
        grain assuming ballistic orbits.</description>
        </Field_Character>
        <Field_Character>
          <name>FLAGS</name>
          <field_number>5</field_number>
          <field_location unit="byte">53</field_location>
          <data_type>ASCII_Integer</data_type>
          <field_length unit="byte">10</field_length>
          <field_format>I010</field_format>
          <description>Spare data product to be used for
        qualifying flags where applicable.</description>
        </Field_Character>
      </Record_Character>
    </Table_Character>
  </File_Area_Observational>
</Product_Observational>
```


8.3.1 Mass


```
<?xml version="1.0" encoding="UTF-8"?>
<?xml-model href="http://pds.nasa.gov/pds4/pds/v03/PDS4_PDS_0300a.sch"?>
<Product_Observational xmlns="http://pds.nasa.gov/pds4/pds/v03" xmlns:xsi="http://www.w3.org/2001/XMLSchema-
instance">
  <Identification_Area>
    <logical_identifier>urn:nasa:pds:ladee-ldex:data_calibrated:calibrated_mass_1021593615_tab</logical_identifier>
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        <observing_system_component_type>Instrument</observing_system_component_type>
        <description>The LADEE Lunar Dust Experiment (LDEX) instrument description is included in the LADEE LDEX
Software Interface Specification (SIS) file 'ldex_pds_sis_reva.docx' in the document collection of the LADEE LDEX
bundle.</description>
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      </Observing_System_Component>
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'lad_pds_spacecraft_rev1.docx' in the document collection of the
LADEE LDEX bundle.</description>
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      <type>Dust</type>
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      <file_size unit="byte">42085</file_size>
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      <description>This is the mass of each recorded event
        on the LDEX MCP.</description>
      <record_delimiter>carriage_return line_feed</record_delimiter>
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          <data_type>ASCII_Time</data_type>
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          <field_format>A26</field_format>
          <description>Time of impact in UTC.</description>
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        <Field_Character>
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          <field_location unit="byte">28</field_location>
          <data_type>ASCII_Real</data_type>
          <field_length unit="byte">8</field_length>
          <field_format>E8.2</field_format>
          <unit>KILOGRAM</unit>
          <description>Calibrated mass of impacting dust grain.
        This is always derived from the MCP signal amplitude, unless the MCP
        signal saturates.  In this case, it is derived from the target
        signal.</description>
        </Field_Character>
        <Field_Character>
          <name>MCP_CHARGE</name>
          <field_number>3</field_number>
          <field_location unit="byte">37</field_location>
          <data_type>ASCII_Real</data_type>
          <field_length unit="byte">9</field_length>
          <field_format>E9.3</field_format>
          <unit>COULOMB</unit>
          <description>Impact plasma charge from impact
        observed after gain of MCP.</description>
        </Field_Character>
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        <Field_Character>
          <name>IMG_CHARGE</name>
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          <unit>COULOMB</unit>
          <description>Image charge from charged dust grain
        induced on the target.</description>
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          <field_length unit="byte">7</field_length>
          <field_format>E7.1</field_format>
          <unit>KM/S</unit>
          <description>Speed of charged dust grain. Calculated
        using image charge signal waveform from target.</description>
          <Special_Constants>
            <missing_constant>0.0E+00</missing_constant>
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          <field_format>E9.3</field_format>
          <unit>KILOGRAM</unit>
          <description>Lowest mass of dust grain possible for
        LDEX to observe given current settings.</description>
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          <unit>KM/S</unit>
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        grain assuming ballistic orbits.</description>
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        qualifying flags where applicable.</description>
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</Product_Observational>
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