Data Introduction: New Horizons Spacecraft, Venetia-Burney Student Dust Counter (SDC) Instrument

This is an abbreviated guide to the main elements of this SDC data set to provide an overview and a quick path to viewing the data. Many details and subtleties regarding these data have been excluded here for the sake of brevity and clarity; those who plan to perform scientific analysis on these data must first read the documentation referenced by or provided in this data set.

Science Goals

SDC has 3 main goals: to map the dust density distribution in the Solar System; to understand dust particle size distribution and how it varies; and to determine the rate that the Kuiper Belt produces dust.

Instrument

The instrument consists of the detector panel, front-end analog electronics, digital interface electronics, and an intraharness which connects the detector panel which is mounted on the outside ram direction of the spacecraft to the electronics box inside the spacecraft. The detector panel consists of 12 active detectors mounted on the top and 2 background detectors on the underside. The total active top surface area is about 0.1 m^2. Each detector corresponds to a channel in the instrument electronics. The detectors are made from polyvinylidine flouride (PVDF) film, a pyroelectric material which turns the impact crater caused by a dust particle hit into a depolarization signal. This signal is then picked up by the highly sensitive analog electronics and transmitted to the software in the instrument for processing and storage until the next time the data can be transferred to the spacecraft SSR. The two background detectors measure the background noise environment caused from spacecraft thruster firings and other sources.

The depolarization signals are measured in charge (Q) produced. Note that SDC reports charge in number of electrons. Even though this is not strictly charge, the number of electrons will from here on be referred to as the charge. The charge from an impacting particle depends on the particle's mass and velocity. Because the unit of the raw data is data number (DN), a calibration curve from data number to charge (DN=>Q) is needed. This curve is a function of electronics box temperature and detector channel. For SDC, this curve was produced pre-flight and is checked during the mission with internal calibration procedures.

Detectors correspond to channels 0 - 13. Channels 6 and 13 are the 2 background detectors. Note that Channel 11 failed before launch and the data from it should be ignored. For all higher level data products the channel IDs are incremented by 1 and become 1 - 14.

Operations

SDC was designed to take advantage of the quiet state of the spacecraft during non-encounter mission phases, especially hibernation. Various active spacecraft operations cause mechanical shocks that are picked up by the detectors and register as science events, particularly during 3-axis and active spin spacecraft modes. If the thruster-induced science events are frequent, the autonomy system turns off that channel until it is reset. Thresholds are set for each channel that determine when the autonomy is triggered. During Cruise, thresholds were set to a nominal level appropriate for a hibernating spacecraft when not many activities were occurring. During the Pluto Encounter, thresholds were set higher as of a few months prior to the encounter so that the active operations of the spacecraft would not turn off the channels. The channels were also often frequently reset in commanding in case they had been triggered. The duration of the off and on times for each channel must be considered in making any calculation of average dust detection event rates.

The stimulus calibration activity is known to generate false positive science events. Data from this activity exhibits cross-talk and should be excluded from science analysis. This data set includes a PDS TABLE, DOCUMENT/SDC_STIM_Vnnnn.TAB, that lists time periods when stimulus calibrations were active (sporadically during Launch and Jupiter mission phases, and about half an hour per year during Annual CheckOuts (ACO) in the Pluto Cruise mission phase).

SDC records four parameters for each dust particle: measured charge; timestamp; count; and channel (detector number). The measured charge of an event in its raw form is a 16-bit unsigned integer value in the range 65535-0; note that this SDC raw integer value decreases with increasing event charge in physical units (equivalent electrons).

Finding the Data Directory- and file-names: ***data/YYYYMMDD_METMET/sdc_metmetmetm_0xaaa_ttt.sfx***

The data are all stored as file pairs of one detached PDS label and one FITS file per exposure. The directory and file names are delimited by underscores and slashes as demonstrated above: ***YYYYMMDD*** is year, month and day-of-month; ***METMET*** is the first six digits of the ten-digit MET clock (Mission Event Time; ~spacecraft seconds since launch); ***sdc*** is the prefix for SDC data; ***metmetmetm*** is the full ten-digit MET of the image; ***0xaaa*** is the Application (Process) Identifier (ApID) for the telemetry data packet type; ***ttt*** is either ***eng*** or ***sci*** for EDR or RDR data; ***sfx*** is ***fit*** or ***lbl*** for the FITS or PDS label file.

Searching for Data

There is a brief summary of the types of observations in the data set catalog (catalog/dataset.cat). There is also a table of the sequences in the data set documentation (document/seq_sdc_...). Each row in that table provides 1) a sequence ID that matches NEW_HORIZONS:SEQUENCE_ID keywords in data product PDS labels, 2) a time, in UTC & SCLK, just before all observations of that sequence, 3) a brief prose description of the observations. Refer to the sequence table label (document/seq_sdc_*.lbl) for more detail.

Raw data files

Raw data are unprocessed telemetry. All levels of data are recorded in FITS format. The SDC team uses an IDL FITS reader that is part of the Goddard IDL library, specifically mrdfits.pro. If this is used, please note that a "/unsigned" flag must be given as the data are all unsigned integers.

The raw data FITS file consists of housekeeping and science data. Some of these data are not used in the calibration process to produce the calibrated data. It is stated in the PDS label files which telemetry points are and are not used by the calibration process.

The data in the FITS file are stored as a binary table extension, with five tables: DATA, HOUSEKEEPING_SDC, HOUSEKEEPING_0X004, HOUSEKEEPING_0X00D, HOUSEKEEPING_0X00A, THRUSTERS.

The DATA table has columns of Copy Number (not used in calibration), Channel ID (detectors 0-13), Zero Fill (not used in calibration), Threshold (threshold setting - note DN scale is reversed, where 65535 is a small event and 0 is a very large event - the threshold value is the maximum magnitude for accepted science hits - hits above the threshold, ie those with smaller signals but higher DN values, are rejected in the instrument), Magnitude (size of a hit in DN - note DN scale is reversed here too, where 65535 is the smallest event), and Time Stamp (time of the hit in Mission Elapsed Time or MET).

The HOUSEKEEPING tables record various temperatures, voltages, and currents for SDC. Details are listed in the ICD. The THRUSTERS table has two columns giving the METs of all thruster fires and whether one of the thrusters fired.

Calibrated data files

The data calibration is a three-step process: the telemetry is stored as raw DN; each DN representing the size of a hit is converted into charge; each charge is converted into mass via the ground calibration results and an assumed particle velocity. Each event is converted to a mass regardless of whether or not it is believed to be noise.

The charge calibration file contains the calibration values described above as a matrix of floating point values with dimension (4 X 14 X 3 X 19) representing values for the 4 box temperatures (Tbox), the 14 channels, and the 3 types of calibration values (9th order polynomial fit coefficients for Q, DNavg & SIG). DNavg and SIG are the average DN and its standard deviation, respectively, at each charge pulse amplitude, box temperature, and channel. The coefficients are the 9th order fit for each box temperature and channel. The fourth index is dependent on the third index of the 3 types of calibration values. More details are in the ICD.

The calibrated FITS file consists of science data expressed in units of number of electrons and quality flags for the PVDF detectors. The quality flags signal whether or not any of the housekeeping values were out of the standard operating range when the hit occurred. The quality flags also tell whether or not the data was extrapolated or interpolated from the pre-flight calibration curve.

Reading the Data

Various tools are available to read these data. In the IDL environment, the READPDS.PRO package from PDS-SBN can read the data using the PDS label to access the accompanying FITS file. To use the FITS file directly, the NASA FITS Office has utilities and libraries in multiple languages and environments (from C to R and beyond). Refer to the documentation provided and referenced at those web sites for support.