Data Introduction: New Horizons Spacecraft, Solar Wind Around Pluto (SWAP) Instrument

This is an abbreviated guide to the main elements of this SWAP 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

The Solar Wind Analyzer around Pluto (SWAP) instrument measures charged particles from the solar wind near Pluto to determine whether Pluto has a magnetosphere and how fast its atmosphere is escaping.

Instrument

Solar Wind Around Pluto (SWAP) instrument is designed to measure the properties of solar wind ions for the New Horizons mission to Pluto. The SWAP instrument is an electrostatic instrument. The SWAP electro-optics control the energy band pass of ions entering the instrument. The electro-optics have three parts: the Retarding Potential Analyzer (RPA), the Electrostatic Analyzer (ESA), and the deflector (DFL). The RPA consists of four grids with the inner two having a positive voltage, which repels ions with energies less than the corresponding potential energy (qV). The Electrostatic Analyzer has two parts, which are concentrically spaced, an inner dome and an outer spherical shell (at ground). For any given settings of the RPA and ESA voltages, only ions with a limited range (bandpass) of energies pass through the ESA to reach the detector. The deflector is used to adjust the field of view.

SWAP ESA and RPA voltages are used together to select the E/q (energy per charge) passband. When the RPA is off, the passband is determined solely by the ESA voltage, which provides an 8.5% FWHM resolution. At increasing RPA voltages for a given ESA voltage, the passband is cutoff in a variable shark-fin shape, allowing roughly two decades decreased sensitivity. Finally, differentiating adjacent RPA/ESA voltage combinations, or deconvolving multiple combinations, provides high-resolution differential measurements of the incident beam's flux as a function of energy. Differences in the ion energy as small as 1-2 eV are distinguishable at typical solar wind energies of ~1000 eV which is a resolution on the order of 0.1%.

The SWAP instrument is mounted on the $-Z_{SC}$ side of the spacecraft and the normal to the center of the aperture is aligned with $+Y_{SC}$.

Operations

SWAP data are affected by spacecraft attitude and thruster firings. Values for those parameters concurrent with each observation, along with housekeeping information, are included in the observation's data file.

SWAP counts events which represent the interactions between the SWAP electro-optics and solar wind particles. The energy of any detected event is determined by the energy bandpass in effect at the time of that event, which in turn is determined by the ESA and RPA settings (voltages). SWAP sweeps its energy bandpass over the instrument's energy range, sorts events into energy and time bins, and returns either real-time science or summary data based on those events.

Indirectly through calibration, the SWAP instrument measures the bulk properties of the solar wind (speed, density or flux, temperature). Analysis of changes in these parameters during Pluto encounter provides an indication of the nature of any atmospheric particles that are escaping Pluto.The deflector is used to adjust the field-of-view (FOV). If the solar wind, which is highly collimated (spanning only a few degrees), enters at the bottom of the RPA, the voltage on the deflector could be set so that only ions that are not part of the solar wind beam enter the instrument, allowing pickup ions, which occur over a wide range of angles, to be studied.

Operating the deflector affects the energy of the ions that can enter the ESA. The RPA voltage is adjusted to compensate such that the same energy ions enter the ESA as did prior to the deflector voltage change. The deflector voltage can be automatically varied based on the commanded angle. The voltage settings for the ESA, RPA, deflector, and the amount the RPA should be adjusted to compensate for the deflector setting are all specified using lookup tables, which allow many instrument operation changes to be made by uploading new tables without having to make any software changes.

The SWAP instrument has two kinds of voltage scans (also called sweeps): coarse and fine. The sweeps are performed in pairs. The two possible pair options are either two back-to-back coarse scans or a coarse scan followed by a fine scan. The voltage settings are predefined with onboard voltage tables. In coarse scans large voltage steps are taken with the ESA and RPA holding the ratio of the two voltages fixed. In the fine scans the RPA and ESA are held at a constant ratio, but take smaller steps. The voltage tables allow varying the ratio between the RPA and ESA voltages, but typically this ratio is held constant as much as possible. Onboard there is one ESA table with 1024 steps and 4 RPA tables with 1024 steps each. For a given sweep we use the ESA table and one of the RPA tables.

Real-time science packets can occur at a rate as high as 1 Hz where each packet contains a set of counts, voltages, etc. Observations for 2 energy steps are stored in one packet. One observation occurs in the 1st half second and a 2nd observation occurs in the 2nd half second. The 1st and 2nd half second measurements correspond to two different steps in a given sweep. Each step consists of an RPA and ESA voltage pairing, and 64 such pairs complete either a coarse-coarse scan or a coarse-fine scan. In a coarse-coarse scan two 64 step (32 packets) coarse scans are done back to back. In a coarse-fine scan a 64 step (32 packets) coarse scan and then a 64 step (32 packets) fine is performed. Both a complete coarse-coarse, and a coarse-fine scan have 64 packets. There is a parameter called SWAP_RT.sec64_ST, which is included in every real-time science packet and has the value 1 at the start of a pair of scans (a set of 64 packets) and is zero otherwise. We use this parameter to ensure that a 64 second cycle (pair of scans) is not split across a day.

Finding the Data: Directory- and file-names: ***data/YYYYMMDD_METMET/swa_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); ***swa*** is the prefix for SWAP 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, respectively.

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_swap_...). 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_swap_*.lbl) for more detail.

Reading the data

There are six types of SWAP science and engineering data: real-time science (ApID 0x584), summary (0x585), histogram (0x586), housekeeping, messages, and memory dump.

Raw data files

There are separate files for summary, histogram, and real-time data. Corresponding housekeeping data are placed in each file. Note that not all kinds of packets will be generated every day. For example, during commissioning there may only be housekeeping and memory dump packets, and during cruise there will be housekeeping, summary, and histogram packets. All the packet types have a CHKSUM parameter. This parameter is calculated onboard and is also calculated on the ground to check the data. For the real-time science data (0x584) there are black and white images of the coincidence spectrogram array where the y-axis is energy bin number and the x-axis is time bin number.

Housekeeping packets are included as extensions in the raw (Level 2) files. Housekeeping time tags are compared to the time tags in the three types of science packets to ensure that each of the three raw (level 2) files includes all the housekeeping data required for processing. Since the summary and histogram packets are assembled over an extended interval, the beginning and ending times of the measurements (included in the summary and histogram packets) are used to determine the correct housekeeping measurements.

The SWAP raw data are arranged in a binary table such that the columns are instrument parameters and measurements, and rows are measurement times. The histogram counts and the number of samples in each bin are stored as image extensions. The zeroth extension contains only the primary header, the first extension holds the real-time data, the second extension holds the housekeeping data, and the third extension holds the thruster data. A complete histogram observation consists of one histogram type 1 packet and 63 histogram type 2 packets. A complete set of real-time science measurements consists of a full 64-second cycle. Please see the ICD, section 14.5, for a full description of the conversion from raw to calibrated data files.