New Horizons SWAP Instrument Overview

This document is an overview of the New Horizons' Solar Wind Around Pluto (SWAP) instrument. The SWAP description was originally adapted from the New Horizons website, Weaver et al. (2008), and McComas et al. (2008). During migration to PDS4, this current copy was adapted from the PDS3 SWAP instrument catalog file, providing light edits to the text, format, and flow.

Instrument Overview

Specifications

NAME:	SWAP (Solar Wind Around Pluto)
DESCRIPTION:	Low energy plasma instrument
PRINCIPAL INVESTIGATOR:	Dave McComas, SwRI (Southwest Research Institute)
ENERGY RANGE:	30 eV - 7.7 keV
FIELD OF VIEW:	270 deg x 10 deg (Note 1)
ANGULAR RESOLUTION:	Not Applicable
ENERGY RESOLUTION:	1eV (<2keV); 9% (>2 keV)

Note 1: deflection angles up to +15 deg additional

Description

Solar Wind Around Pluto (SWAP) instrument is designed to measure the properties of solar wind ions for the New Horizons mission. 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.

SWAPs ESA and RPA voltages are used together to select the E/q (energy) 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%.

See Weaver et al. (2008) and McComas et al. (2008) for further details of this instrument and its capabilities.

Scientific Objective

The Solar Wind Around Pluto (SWAP) instrument will measure charged particles from the solar wind near a solar system body to determine whether the body has a magnetosphere and how fast its atmosphere is escaping.

Calibration

See the SWAP calibration document and Section 4 of McComas et al. (2008).

Operational Considerations

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.

The SWAP experiment detects atmospheric escape from solar system bodies as a change in the solar wind caused by the interaction of the atmosphere with the solar wind. In certain scenarios, a factor of 10 variation in the solar wind may occur over a period of days. It is therefore critical to measure the solar wind for several solar rotations in order to characterize the most likely external solar wind properties during the actual encounter period.

Detectors & Electronics

See the instrument description and specifications above.

Operational Modes

The SWAP instrument uses six modes: OFF; BOOT; Low-Voltage Engineering (LVENG); Low-Voltage Science (LVSCI); High-Voltage Engineering (HVENG); High-Voltage Science (HVSCI). For a description of these modes see Tables IV & V in McComas et al. (2008).

Science Data Collection

Science data are collected in the HVENG and HVSCI modes. HVENG was used extensively during commissioning for initial High-Voltage (HV) ramp-up. HVSCI is the primary SWAP science mode. In HVSCI, the optical power supply voltages are stepped every 0.5 seconds. During each 0.5-second period at a single pair of RPA/EPA voltage settings, approximately 100 milliseconds are allowed for the optical power supply settling time and 390 milliseconds are allocated to counting events. An overall cadence comprising 128 0.5-second steps defines the 64-second science-acquisition frames and hence all science activities.

Two methods of sweeping during each 64 second period, called the coarse-fine and coarse-coarse sweeps, are user selectable. A typical coarse-fine sweep comprises a 32-second coarse sweep which covers the entire energy range with 64 logarithmically-spaced optical power supply voltages, followed by a 32-second (also 64 0.5-second steps) fine sweep. A coarse-coarse sweep comprises two 32-second coarse sweeps performed in one 64-second period.

For both sweep types, the optical power supply voltages are set from one of several user-selectable tables. For the coarse-fine sweep, the peak value of the event counter during the coarse sweep is located to set the center voltages of the fine sweep so that a finer resolution sweep around that peak response can be performed.

The following graphics describe very roughly what happens during a typical coarse-fine sweep; more detailed plots are available in the documents referred to earlier. In all three graphics, the abscissa is time covering one 64-second coarse-fine sweep. The legend inside each plot gives a description, the range, and the units of the ordinate.

In the first 32 seconds on the left of the plots, the ESA and RPA voltages go rapidly through a large range in a coarse sweep that covers the entire energy range of the instrument. At around ten to fifteen seconds into that coarse sweep, there is a rise in count rate indicated by the peak. Based on the timing and voltages corresponding to that peak, the SWAP instrument sets the ESA and RPA voltages and changes them more slowly through the fine sweep during the second 32 seconds on the right of the plots, and there is a peak observed at much higher resolution during that time.

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                                                            *                |
          Output Count rate (0-600Hz)                      * *               |
                                                          *   *              |
                                                         *     *             |
                                                         *      *            |
                                                        *       *            |
                                                        *        *           |
             *                                         *         *           |
            * *                                        *          *          |
           *   *                                     **            *         |
_**********_____*************************************______________********__|
0s                                 32s                                     64s
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_____________________________________________________________________________
                                                                             |
*                                                                            |
*          Input ESA Voltage (0-4000V)                                       |
 *                                                                           |
  *                                                                          |
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     **                                                                      |
       ***                                                                   |
          ****                        ______________                         |
              *****                  *              --------------____________|
                   ******           *                                        |
_________________________*********___________________________________________|
0s                                 32s                                     64s
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______________________________________________________________________________
                                                                              |
******                                                                        |
     *      Input RPA Voltage (0-2000V)                                       |
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      *                                                                       |
       *                                                                      |
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         **                          *     ------_______                      |
            **                       *                  ------______          |
              ***                   *                               ------___|
                 *******            *                                         |
________________________***********___________________________________________|
0s                                32s                                       64s
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One result of this is that there will be gaps in the apparent energy resolution when the data from coarse and fine sweeps are compared against each other.

Measured Parameters

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), and analysis of changes in these parameters during a body encounter will provide an indication of the nature of any atmospheric particles that are escaping a body.

See McComas et al. (2008) for more details.

Note on Reading the Data and Extensions

Summary plots cover ranges from 1 day to 1 year of data. Some of the summary plots do not contain any data, or such a limited amount that it is hard to see. The main purpose of the summary plots is to get a quick look at the data available, so it is normal when some of these plots appear to be blank.

For the histogram data (0x586) extension zero is an array of 2048 values containing the number of samples in the normalized histograms. Extension 1 holds the total count rates in bins normalized according to the peak location found in the fine scans. Starting in 2008, the histogram data files were changed such that the last 64 bins of extension 1 contain the total count rates for each of the coarse scan energy steps. In extension 0 the number of samples for these last 64 elements is zero. The other bins remain as they were prior to this change. To obtain the number of samples in the totals for the last 64 bins you need to use the parameter SMPLCNT in the primary header (header for extension 0).

Please note that this is not applicable to Level 5 derived data.

References

McComas, D., F. Allegrini, F. Bagenal, P. Casey, P. Delamere, D. Demkee, G. Dunn, H. Elliott, J. Hanley, K. Johnson, J. Langle, G. Miller, S. Pope, M. Reno, B. Rodriguez, N. Schwadron, P. Valek, and S. Weidner, The Solar Wind Around Pluto (SWAP) Instrument Aboard New Horizons, Space Science Review, Vol. 140, 261-313, 2008. https://doi.org/10.1007/s11214-007-9205-3 (preprint provided in the PDS with LID urn:nasa:pds:nh_documents:swap:swap_ssr)

Weaver, H.A., W.C. Gibson, M.B. Tapley, L.A. Young, and S.A. Stern, Overview of the New Horizons Science Payload, Space Sci. Rev., Vol. 140, 75-91, 2008. https://doi.org/10.1007/s11214-008-9376-6

Further Reading

SWAP Calibration document, urn:nasa:pds:nh_documents:swap:swap_cal, NASA Planetary Data System.