Data Introduction: New Horizons Spacecraft, PEPSSI Instrument

This is an abbreviated guide to the main elelements of this [instrument] 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 read the documentation referenced by or provided in this data set.

PEPSSI science goals: 1) determine the escape rate of Pluto's atmosphere; 2) measure the interaction of the solar wind with Pluto's ionosphere; 3) determine the source and nature of energetic particles found near Pluto.

Instrument: PEPSSI (Pluto Energetic Particles Spectrometer Science Investigation) is a compact particle telescope with a time-of-flight (TOF) section and a solid-state detector (SSD) array with twelve detectors arranged in a 12° x 160° swath in six 25°-wide angular sectors and 2° between sectors, with one TOF start anode and two SSDs per sector. Sectors 0,2,5 each have one ion detector and one electron detector; sectors 1,3,4 each have two ion detectors. PEPSSI measures ions and electrons over a broad range of energies and pitch angles. Particle composition and energy spectra are measured for H to Fe from ~ 30 keV to ~1 MeV and for electrons from ~30 keV to 700 keV.

Operations and *measurements*: 1) A mechanical collimator defines the acceptance angles for incoming ions and electrons, directing them to one of the six sectors. 2) PEPSSI measures the ion ***TOF*** using secondary electrons generated as the ion passes through entrance and exit foils; entrance foil secondary electrons hit the sector's start anode flagging the TOF start and ***identifying the sector*** and therefore the incoming ion direction; exit foil electrons hit the stop anode flagging TOF stop. 3) PEPSSI measures the ***total ion energy***, above a threshold, when ions hit the SSD array. Energies below the SSD thresholds may be measured via secondary electron pulse height on a micro-channel plate (MCP) above the TOF anodes, which provides a coarse indication of low-energy particle mass.

Event data, selection, accumulation and classification: (N.B. this section is greatly simplified to keep this introduction within a set page limit; refer to data set documentation for a more complete understanding.) Each event generates TOF and/or energy on-board measurements in Analog-to-Digital Units (ADUs) i.e. raw data counts; ADU values are log-compressed with 5 bits each of mantissa and exponent. For events with a TOF detection, there is the sector(s) of the start anode(s) (N.B. multiple start anodes may detect secondary electrons from an event). For events with energy detection only, there is the sector (0-5 for ion SSDs) or electron SSD (0-2). Due to bandwidth limitations, all (Pulse Height Analysis; PHA) data for all events are not stored; instead, PHA data for only a subset of events are chosen, according to a round-robin priority scheme, and stored on-board. Further, the timestamps of individual events are not recorded, rather all events over an interval (typically 10s to 600s) are passed from the instrument to spacecraft storage as a group, with a single timestamp for the start of the group interval. PHA data are separated into three event types: High-Energy Ion (also High-Ion or Triple) events where both TOF and energy detections were measured; Electron events where only electron SSD detections were measured; Low-Energy Ion (also Low-Ion, Double or TOF-Only) events where only TOF detections were measured. Finally, although full PHA data for all events are not recorded, all events are classified by event type, sector, and [TOF+energy] Rate Box, and a count (rate) of each classification is recorded over each time interval. The classifications are represented by 6 character strings, with one character for event type (B = Hi-Ion; L = Low-Ion; R = Electron); a two-digit rate box (00-18; see the 19 colored regions in the figure to the right); and an S (Sector) followed by a two-digit sector designator (00-05 for Hi-Ion events; 00-02 for Electron events). For example: a rate labeled B02S04 represents a particle arriving from the sector 3 direction (Start Anode 4; N.B. anode and detector numbering are reversed), which deposited energy between 94 and 169 ADUs (see orange region 2 in the figure) onto one of the SSDs. There are additional classifications (HK for housekeeping; C for software counters, etc.); refer to the data set documentation for more detail.

Finding the Data: Archival data are stored in directories with names of the form ***yyyymmdd_kkk*** where ***yyyy***, ***mm***, and ***dd*** are the year, month, and day on which data taking started and ***kkk*** is the 6-digit mission elapsed time (MET) prefix. Data filenames have the form ***pep_mmm_0xaaa_nnn.fit***, where ***mmm*** is the 10-digit spacecraft clock time suffix, ***aaa*** is the telemetry application identifier (ApID), ***nnn*** is the processing level identifier. An additional version number suffix, ***_v,*** follows the processing level in some data sets.

```
0xaaa = 0x691 (High Priority); 0x692 (Medium); 0x693 (Low, < 501 PHA); 0x694 (Low, > 500 PHA)
        0x695 (Diag "       ); 0x696 (Diag "); 0x697 (Diag "         ); 0x698 (Diag "         )
  nnn = eng (raw data); sci (calibrated)
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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_pepssi_...***). 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_pepssi_*.lbl***) for more detail.

Reading the data: Each file typically contains data from one day (86,400s) of observations. All data files are in FITS format and are readable with standard FITS viewers and software libraries. All FITS files have records with 2880 bytes. Refer to the NASA FITS Support Office (currently http://fits.gsfc.nasa.gov/) for FITS standard details. All sections in FITS files start on 2880-byte boundaries and are padded to a 2880-byte boundary with spaces or nulls. A detached PDS label file named ***pep_mmm_0xaaa_nnn_v.lbl*** accompanies each FITS data file and describes its structure; a selectively edited example label fragment for a raw data file is shown below. The black section describes the entire file as comprising 262 2880-byte records. The red section has pointers locating five sections in the file: three headers and two tables; tables contain data; FITS HEADERs describe the data sections and contain ancillary information, but are generally redundant with information in the PDS label (not shown here).

```
PDS_VERSION_ID          = PDS3
RECORD_BYTES            = 2880
FILE_RECORDS            = 262
^HEADER = "PEP_0299310715_0X691_ENG.FIT"
^EXTENSION_N1_HEADER = ("PEP_0299310715_0X691_ENG.FIT", 8)
^EXTENSION_N1_TABLE = ("PEP_0299310715_0X691_ENG.FIT", 26)
^EXTENSION_PHA_ELECTRON_HEADER = ("PEP_0299310715_0X691_ENG.FIT", 213)
```