

New Horizons Primary and Extended Mission in the Outer Solar System: Averaged Energetic Particle Flux Rates and Counts-per-Second from PEPSSI Observations

Summary

This dataset contains one-hour averaged energetic particle flux rate values and counts-per-second generated by the New Horizons Particles and Plasma science team from data taken by the Pluto Energetic Particle Spectrometer Science Investigation (PEPSSI) instrument. The data covers a time range from early 2012 through late 2020. Flux rates and sums are presented for each of the six instrument look directions. The time stamps (i.e. the 'Epoch' column) are at the midpoint of the averaging interval.

PEPSSI is a particle telescope and a time-of-flight (TOF) spectrometer that measures ions and electrons over a broad range of energies and angles. Particle composition and energy spectra are measured for H to Fe from ~ 30 keV to ~ 1 MeV (but not all species are uniquely separated) and for electrons from ~ 30 keV to 700 keV.

PEPSSI comprises a time-of-flight (TOF) section and a solid-state detector (SSD) array that measures particle energy. The combination of measured energy and TOF provides unique particle identification by mass and particle energy depending on the range: for protons from ~ 30 keV to ~ 1 MeV; for heavy (CNO) ions from ~ 80 keV to ~ 1 MeV. These measurements are called 'triples' within this dataset.

Lower-energy (>3 keV) ion fluxes are measured by TOF only, but without the SSD signal, providing velocity spectra at these energies as well. These measurements are called 'doubles' within this dataset.

Due to storage and bandwidth limitations, all event data cannot be stored or telemetered to the ground. Instead, a round-robin algorithm is used to save Energy, TOF, and timing data for select events.

The headers and contents for these higher level derived data products are described below.

Data File Types and Contents

Three of four detection types are provided in this dataset.

1. **Triples:** B-rates where both the total energy detected and the time of flight of the charged particle are known. Thus, the mass and energy of the particle can be determined.
2. **Doubles:** L-rates where only the time of flight of the charged particle is known. Since the distance of the measurement is also known, a velocity can be determined. The energy per unit mass, more commonly called the 'energy per nucleon', E/m , can also be determined through the following formulas:

$$E = \frac{mv^2}{2}$$

$$\frac{E}{m} = \frac{v^2}{2}$$

3. **Totals:** Total counts in each of the three detection modes. This is useful for determining overall charged particle activity at a given time.

Analysis of the fourth detection type, cosmic ray energy-only events, is not yet ready for public release.

For each measurement, calculated statistical uncertainties are provided.

The L and B fluxes include a complex correction for instrument efficiency variations related to turning the instrument off and on. See Kollman, et al. (2019) Appendix A.

Data has been removed if it was captured during times (a.k.a. “Bad Time Intervals” or “BTI”) when spacecraft operations make interpretation difficult (power on, power off, unusual telescope pointings, etc).

The data directory is divided into 3 directories: triples, doubles, and total counts.

```
total_counts:  pepssi_reduced_j_YYYY (csv and lbl)
doubles:      pepssi_reduced_lZZZ_YYYY_X (csv and lbl)
triples:      pepssi_reduced_bZZZ_YYYY_X (csv and lbl)
```

where:

YYYY is the year the measurements were taken

X is the segment number (a or b)

ZZZ is the units of the data (cps or flux)

The following acronyms embedded within the data filenames indicate five different types of analysis:

BCPS: 'Triples', counts-per-second.

BFLUX: 'Triples', c/s/ster/cm²/keV.

J: Total measured counts-per-second of the three event types, as indicated by parameter key values in the file headers:

J00: Cosmic Rays.

J01: Triples.
J02: Doubles.
LCPS: “Doubles”, counts-per-second.
LFLUX: “Doubles”, c/s/ster/cm²/keV.

Energy bounds for the L and B rate channels changed during 2014. Therefore, the set of channels is different before and after the energy bound changes. An “_a” has been appended to the filenames before the transition, and “_b” after.

Defining the various reduced data channels:

B<x>S<y> – a single instrument 'triple channel' with Energy Bin number x and Sector (i.e. Look Direction) y as defined in the documentation for L2 and L3 data

L<x>S<y> – a single instrument 'double channel' with Energy (determined from time of flight and an assumed species) Bin number x and Sector (i.e. Look Direction) y as defined in the documentation for L2 and L3 data

J00 – Total cosmic ray (energy only) events (originally conceived as an 'electron' measurement)

J01 – Total Triple (energy and time of flight) events, higher energy

J02 – Total Double (time of flight only) events, lower energy

There are several combined “Triples” channels, where the rate or flux is averaged over several individual channels:

ProtonAll, IonsAll, HeliumAll, CNOAll, HeavyAll – These products are averaged from the respective channels grouped by species (Ions is all Triple types, Heavy is anything not Proton, Helium, or CNO)

There are also some combined doubles channels as well:

LlonsAllAll, L01toL13OddAll, L07toL13All - These combined channels are All the Doubles channels, The Odd Doubles channels, and the Doubles channels 7 and above (the presence of an extra “ALL” string in these channel names was inadvertent and confusing and will be eliminated in future releases). Since the programming of how the Doubles channels were used changed throughout the mission, all three of these different groupings represent useful combinations during different mission phases.

For all of the above single and combined channels except the “J” rates, there are also combined channels averaged over all look directions indicated by the “SALL” string in the channel name.

Data File Headers

Each data file includes a five line header containing the following information:

Parameter Keys: A list of short, unique column identifiers.

Lower Bound: Where applicable, the lower energy bound of the passband for the channel represented by the column.

Upper Bound: Where applicable, the upper energy bound of the passband for the channel represented by the column.

Species: The particle species of the channel represented by the column. The species is used to calculate the flux/intensity for that column. For 'B' rates, the species is known or, for higher mass channels, it might be one of several possible species (for example, Oxygen for the CNO channels). For 'L' rates, the dominant component of the flux can only be guessed, and it is usually Hydrogen/Protons. L and B rates are described in more detail below.

Units: Physical units for reporting the rate or intensity.

[A Note About PDS4 Header Formats](#)

In the PDS3 and migrated PDS4 labels for these data, the **Parameter Keys**, **Species**, and **Units** header lines appear as separate header-type objects ("HEADER" in PDS3 and "<Header>" in PDS4). The **Lower Bound** and **Upper Bound** headers, however, were presented as a single delimited table with two rows, the first field of which was a string with the subsequent fields defined as real numbers for programmatic processing. An empty field is noted as meaning the boundaries are not applicable for the corresponding field in the main data table.

Unfortunately, an unresolvable conflict arose between the PDS DSV 1 standard used for delimited data tables and the data format requirements defined by the PDS4 Information Model when attempting to validate files that had blank values (that is, a string of blanks between the final field separator and the end-of-record marker) in the final **Lower/Upper Bound** field. The string of blanks resulted from the data preparer padding all the delimited records out to the same fixed record length value throughout the file, which did not present a problem in the PDS3 format in which the files were delivered.

To work around this PDS4 validation problem without having to undertake reformatting of the data files, the data type of all **Lower** and **Upper Bound** value fields has been changed from *ASCII_Real* to *ASCII_String*.

[References](#)

Kollmann, P., et al., 2019, Suprathermal Ions in the Outer Heliosphere, *The Astrophysical Journal* 876. doi:10.3847/1538-4357/ab125f