PLASTIC
Level 3 Data Document

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Modification History

Version	Date	Modifications
A	Oct.. 7, 2019	Original Version

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1. Overview of PLASTIC Instrument Operation

PLASTIC covers the full azimuthal range (ie. in the ecliptic plane) at all times, but needs to step through energies-per-charge and polar angles. The polar angle steps from +20 to – 20 degrees in 1.33 degree steps (32 steps). In normal mode, the ESA voltage is stepped in logarithmic increments in 128 steps. For each E/Q step, the ESA will sit at one voltage, while the deflector voltages sweep through their full set of values. Then the ESA voltage will continue to the next E/Q step in the cycle. Each deflection step takes 12.8 msec. The instrument sweeps across deflection steps first in one direction, and then in the opposite direction. Therefore, data is sent from the instrument to the DPU with deflection steps reversed on every odd ESA step. However, the DPU compensates for this reversal so that all science products including monitor rates (with the exception of the Memory Data – see section 3.5) arrive on the ground with the correct deflection steps. A full set of angles (32 steps, plus some overhead) takes 455.4 ms, and a full cycle will take 1 minute (128 ESA steps plus some overhead).

Because all solar wind ions flow with approximately the same speed, the E/q selection of the entrance system acts to separate solar wind ions by mass/q. Because the heavy ions are normally not fully ionized, their mass/q is normally larger than 2. Thus the heavy ions are observed at the higher E/q steps than H+, and to some extent, He++. Because there is a large difference in fluxes of H+, He++ and heavy ions, there are two entrance systems for the solar wind ions. One entrance has a large geometric factor, for the low abundance heavy ions, and one entrance has a small geometric factor for the H+ and possibly He++ ions. At the high E/q steps, when we are mainly measuring the heavy ions, we use the main, large geometric factor, aperture. At lower E/q steps, we need to switch to the "S-channel" ("small-aperture") low geometric factor aperture to measure the protons. The E/Q step at which to switch between the two entrance systems is determined by the DPU.

The PLASTIC instrument is functionally divided into two halves, one which has Solid State Detectors (SSD's) as well as MCP's, and one which just has MCP's. The length of the flight path is different for the two sides. There are two sets of time-of-flight electronics, one for each half.

2. Overview of Files

Most Level 3 data are stored in both ascii and CDF format. Event lists are an exception with are stored only in ascii.

3. Data Products

3.1 He+

3.1.1 He+ Phase Space Densities

STEREO pick up (He+) phase space densities (PSD) presented here are in the spacecraft frame of reference. The data sets provide 1hr and 24hr averages of He^+ phase space density as a function of V/Vsw in 51 velocity ranges, where V and Vsw are the particle speed and bulk speed of solar wind protons, respectively.

See https://stereo-ssc.nascom.nasa.gov/data/ins_data/plastic/level3/HePlus/HePlus_PSD/READ_ME_PLASTIC_HePlus_PSD.pdf for a full discussion of this data product.

3.1.2 He+ Relative Fluxes

STEREO pick up (He^+) data presented here are meant to provide an overview of the long-term behavior of He^+ pickup ions and are useful for the selection of interesting event periods.
The data set provides 24h averages of efficiency corrected He^+ counts per second in four ranges of V/V_{sw}. These values are proportional to the differential energy flux (J E) of pickup He^+.

As an example, the relative differential energy flux in the velocity range 1.85 > V/Vsw >1.44, i.e. just below the expected He^+ PUI cutoff at $V/V_{sw} = 2$, is shown for the time period 2007 to 2014 in Fig. 1 on page 4. The pronounced peaks in the relative differential energy flux show the transition of STEREO-A through the neutral helium focusing cone. (c.f. Möbius et al., 2010, AIP Conf. Proc. 1216, pp 363-366) and the information on PUI He^+ on the STEREO web pages at UNH (http://stereo.sr.unh.edu/data/PLASTIC_Resources/PickupIons_plots.htm).

See https://stereo-ssc.nascom.nasa.gov/data/ins_data/plastic/level3/HePlus/HePlus_flux/READ_ME_PLASTIC_HePlus_Fluxes.pdf for a full discussion of this data product.

3.1.3 He+ SW Frame Velocity Count Distributions

Preprocessing of raw STEREO-A PLASTIC SW sector data has been performed at the University of Kiel, Gemany to consolidate the measurements to a workable format. Pulse height analysis, described in Drews et al. (2010), is used to identify ion type and to measure the PUI velocity vector. The PLASTIC SW sector provides the unique capability to measure an incoming ion's incident angle in both the polar, θ (angle out of the ecliptic plane), and azimuthal, φ (angle in ecliptic to sun-spacecraft line) directions (Drews et al., 2015). The SW sector has a total azimuthal Field of View (FoV) of φ ± 22.5°, divided into 32 angular bins of width Δφ = 1.4°. In polar angle, the SW sector has a total FoV of θ ± 20.0° which is also divided into 32 bins, resulting in an angular resolution of Δθ = 1.3°.

The He^+ PUIs are identified in the raw ESA and ToF data through pulse height analysis (Drews et al., 2010), resulting in a measurement of the PUI speed (v_{He^+}) and incident angles (φ, θ), for each incident He^+. A scientific analysis of the pulse height analysis data is completed on a 5 minute time base, defining the time resolution. He^+ PUI, speeds are expressed in the SW frame by subtracting $\vec{v}_{SW}$ from the PLASTIC He^+ PUI measurements using their velocity vectors. The PUI speed in the solar wind frame, normalized to the local SW speed (w') is derived in Drews et al. (2012).

See https://stereo-ssc.nascom.nasa.gov/data/ins_data/plastic/level3/HePlus/HePlus_SW_VelCtDist/READ_ME_PLASTIC_HePlus_SW_VelCtDist.pdf for a full discussion of this data product and references.

3.2 He++ Phase Space Densities

Alpha particle (He^{2+}) phase space densities and total counts are provided in the spacecraft frame of reference as a function of w=V/Vsw, with particle speed V and solar wind speed Vsw. The phase space densities are computed from 10 minute averages of normalized counts and 10 min averages of the solar wind velocity for 51 bins (5% resolution) in the velocity range 8 > w > 0.66. Normalized counts are computed by summing over selected ranges in M/Q (double coincidences) and M/Q-M (triple coincidences), using the priority rates for normalization (s. a. Galvin et al., 2008). M and M/Q are the mass and mass per charge of the ions, respectively.

See https://stereo-ssc.nascom.nasa.gov/data/ins_data/plastic/level3/He2Pl_PSD/READ_ME_PLASTIC_He2Plus_PSD.pdf for a full discussion of this data product.

3.3 Alfvén Wave List

The table lists some Alfvén waves observed by the STEREO spacecraft from year 2007 to year 2014. They are identified while searching for small solar wind transients (STs).

STs were observed frequently in the solar wind (Yu et al., 2014, 2016). However, as pointed out by Marubashi et al. [2010] and Cartwright and Moldwin [2010], some solar wind Alfvénic structures can be mistaken for STs. For this reason, we need to identify Aflvénic structures. We classify as Aflvénic fluctuations those structures which satisfy the relation $\Delta V\# = \Delta\%\&$. Here '()

$\Delta V\#$ and $\Delta B\#$ represent the velocity and magnetic field perturbations perpendicular to the background field. The latter is obtained by smoothing. (RX, RY, RZ) are three correlation coefficients between $\Delta B\#$ and $\Delta A\# = \sqrt{\mu\text{-}\rho} * \Delta V\#$. We used CORRELATE function in IDL to get the three correlations between $\Delta B\#$ and $\Delta A\#$ (an example picture has been attached, see Figure 1).

We require all three correlations (RX, RY, RZ) to be greater than 0.5, or two greater than 0.6 and the other greater than 0.3, which is similar to the criterion in Cartwright and Moldwin [2008].

See https://stereo-ssc.nascom.nasa.gov/data/ins_data/plastic/level3/Alfven_Waves/READ_ME_PLASTIC_Alfven_Wave_List.pdf for a full discussion of this data product and references.

3.4 Small Transients List

The table lists some STs observed by the STEREO spacecraft from year 2007 to year 2014 (Yu et al., [2014], [2016]). They are identified by the following criteria.

1. The STs have durations between 0.5 and 12 hours.
2. Magnetic field strength is higher than the yearly average (> 1.3 times yearly average).
3. Low proton beta (less than 0.7 times yearly average) or low proton temperature (Tp/Texp < 0.7).
4. Low Alfvén Mach Number (less than 0.7 yearly average), or large rotations of magnetic field components (we used the minimum variance analysis on the magnetic field, Sonnerup and Cahill Jr. [1967], Sonnerup and Scheible [1998]; and we require that the intermediate-to-minimum eigenvalue ratio be > 5).
5. Checking the Aflvénic fluctuations.

We remove all three correlations (Rx, Ry, Rz) greater than 0.5, or two greater than 0.6 and the other greater than 0.3 from our list, which is similar to the criterion in Cartwright and Moldwin [2008].

See https://stereo-ssc.nascom.nasa.gov/data/ins_data/plastic/level3/Small_Transients/READ_ME_PLASTIC_Small_Transient_list.pdf for a full discussion of this data product and references.

3.5 Suprathermal Proton Event List

This data product contains a list of automatically identified suprathermal proton events measured on the Wide Angle Partition without a Solid State Detector (WAP non-SSD) portion of the STEREO/PLASTIC instrument. This list in conjunction with the IMPACT magnetic field information and PLASTIC solar wind data can aid a user in identifying energetic proton events related to Stream Interaction Regions (SIRs), shocks, upstream events, magnetospheric events, etc. For information on the WAP non-SSD portion of

PLASTIC see below. A thorough explanation of both PLASTIC and IMPACT can be found in [*Galvin* et al., 2008] and [*Luhmann et al.*, 2007], respectively.

See https://stereo-ssc.nascom.nasa.gov/data/ins_data/plastic/level3/Suprathermals/READ_ME_PLASTIC_Suprathermals.pdf for a full description of this data product and references.