README for Singly-Charged Helium (He^{+}) SW Frame Velocity Count Distributions From STEREO-A PLASTIC

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1 Data Usage

This data set is released in conjunction with the publication of Bower et al. (2019), to satisfy AGU's fair use data policy. Funding for this data release was provided by the SR&T Grant (NNX16AF79G) and the Heliophysics Grand Challenge (80NSSC17K000) at the University of New Hampshire and under DLR-Grant 50 OC 1103 at the Universität Kiel. CJF funded by NASA STEREO Quadrature grant.

This data set presents STEREO-A pickup-ion (PUI) He^{+} velocity distributions defined at a 5 min time resolution in the solar wind (SW) frame of reference. The velocity distributions are defined as a function of $|\vec{v'}_{He^{+}}|/|v_{sw}$ in 69 velocity bins, where $\vec{v'}_{He^{+}}$ is the PUI speed in the SW frame and v_{sw} is the SW speed.

This data set is not efficiency corrected, which has been shown to cause an increased relative count rate in the suprathermal tail region. Observation using this data set should be limited to the core PUI distribution.

If used in presentation or publications we strongly suggest contacting J.S. Bower to ensure you are working with the latest release.

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For reporting purposes, we request bibliography information for any publication, etc., using these data. Please send information on the use of this data to the PLASTIC PI:

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If you have questions regarding the data availability, please contact the PLASTIC Data System Manager:

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2 Computation of SW Frame He^+ 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 $\phi \pm 22.5°$, divided into 32 angular bins of width $\Delta\phi = 1.4°$. In polar angle, the SW sector has a total FoV of $\theta \pm 20.0°$ which is also divided into 32 bins, resulting in an angular resolution of $\Delta\theta = 1.3°$.

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):

$$w' = \frac{|\vec{v}_{sw} - \vec{v}_{He+}|}{v_{sw}} = \sqrt{w^2 - 2 * w * \cos(\phi)\cos(\theta) + 1} \tag{1}$$

3 File Format

3.1 Naming Convention

The file names have the following format:

`STx_L3_PLA_HePlus_SW_VelCtDist_5min_20XX_VXX.txt`

Where:

"STx" is given as "STA" or "STB" for STEREO A and STEREO B, respectively.

"L3" indicates Level 3 data in the STEREO PLASTIC convention.

"PLA" indicates Plasma and Suprathermal Ion Composition (PLASTIC) Investigation.

"HePlus" indicates singly ionized helium (He^+) as determined by PLASTIC.

"SW" indicates the counts are in the SW frame of reference.

"VelCtDist" indicates that this data set is made up of count distributions as opposed to phase space densities.

"5min" indicates the time averaging interval of 5mins.

"20XX" represents the year.

"VXX" represents the version number.

3.2 File Header

The 1 file header line describes each of the columns in the data set. Columns 1-9 are described below, columns 9-77 of the header give the center bin speed, in w', for the He^+ velocity count distributions.

3.3 Data Structure

PUI speeds in the SW frame, and SW parameters, measured by PLASTIC and IMPACT, have been consolidated and averaged to meet PUI measurement cadence. All individual PUI counts are binned in w' to produce an easily manipulatable VDF for every measurement period. This results in a consolidated data set comprised of averaged SW parameter measurements and He^+ count distributions determined at a 5min time resolution, spanning STEREO-A's operation from 2007-2013. Additional years are available to add to the consolidated data set, and are undergoing preprocessing. The data are organized in 77 columns with :

Column

1. time: (in days from 2007)
2. lon: Spacecraft longitude (in Ecliptic longitude defined from the Sun-Earth line at the spring equinox)
3. vsw: solar wind speed proton speed $[km/s]$
4. n: solar wind number density $[p/cm^3]$
5. b: Interplanetary Magnetic field (IMF) strength $[nT]$
6. theta: IMF angle out of the ecliptic [°]. Defined between[0,180]
7. phi: IMF angle out of the ecliptic [°]. Defined between [-180,180]
8. cone_ang: IMF cone angle [°] (described below). Defined between [0,180].
9. - 77. PUI velocity count density measured in w', binned in 69 sectors in the range $[.5 < w' < 1.5]$. The center bin speed is defined on row 1 (the header).

The proton bulk parameters (vsw, and n) are derived from a PLASTIC detector rate, using a 1D Maxwellian fit and are corrected for background and dead time. Up to date proton bulk parameters can be found through the STEREO website:

- http://stereo-ssc.nascom.nasa.gov/data/ins_data/plastic/level2/Protons/

3.4 IMF Angles

The IMF angles (theta,phi,cone_ang) are all defined from the radial sun spacecraft line. The magnetic field cone angle is defined as the total angle between the IMF vector ($\vec{B}$) and the sun spacecraft line, and simply calculated using the IMF component angles theta (θ_B) and phi (ϕ_B).

$$\Phi_{cone} = \arccos(\cos(|\phi_B|)\cos(\pi/2 - \theta_B)) \tag{2}$$

The cone angle is useful in identifying times when the PUI torus is visible in the PLASTIC SW sector. The torus distribution forms perpendicular to the IMF, and as such is visible to PLASTIC when the IMF is quasi-perpendicular to the sun spacecraft line, $70° < \Phi_{cone} < 110°$. During these times, PUIs that have been freshly injected into the torus dominate the shape of the count distribution, which results in a reduction of the impact of SW compressions and accelleration (Taut et al., 2018; Bower et al., 2019). The impact of this selection criteria is shown below in Figure 1.

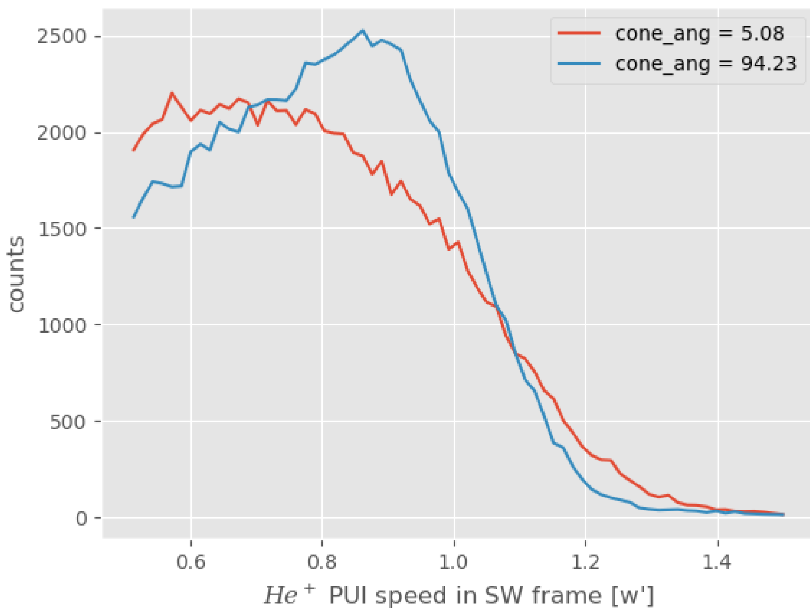

Figure 1: PUI count distribution for a parallel IMF orientation (red) and a qusi-perpendicular orientation (blue). When the IMF is quasi perpendicular the PUI count distribution is less processed by the SW, having a steeper cutoff and reduced suprathermal tail.

4 SW Frame PUI Measurements

As an example, we provide two plots generated from this data set. Figure 2 shows the velocity count distributions accumulated in one day bins spanning the range of the data set (2007-2013). Here one can see that the PUI cutoff speed varies yearly with the spacecraft orbit. This effect is driven by a change in the radial neutral injection speed, brought about by gravitational deflection of the Interstellar neutrals (ISN) around the SUN (Möbius et al., 1999).

Figure 3 shows daily averages of the PUI counts between 2007-2013. The peaks here are associated with the spacecraft passing through the ISN focusing cone. Additionally, because this data set has not been efficiency corrected, the overall PUI count rate decreases through the PLASIC operational time. In effect this means that measurements from the first years of operation will be weighted more heavily for any super-posed epoch analysis. An effort to provide an efficiency corrected data set will be made in the near future.

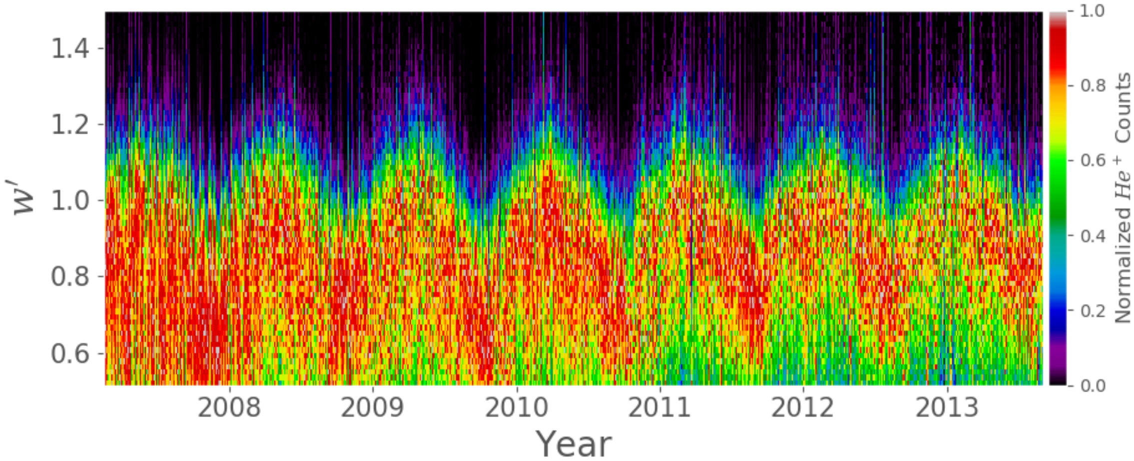

Figure 2: PUI velocity count distributions accumulated in one day bins between 2007 and 2013. Here, one can see the sinusoidal like fluctuations of the PUI cutoff speed (driven by changes in the PUI injection speed) as STEREO-A orbits the sun.

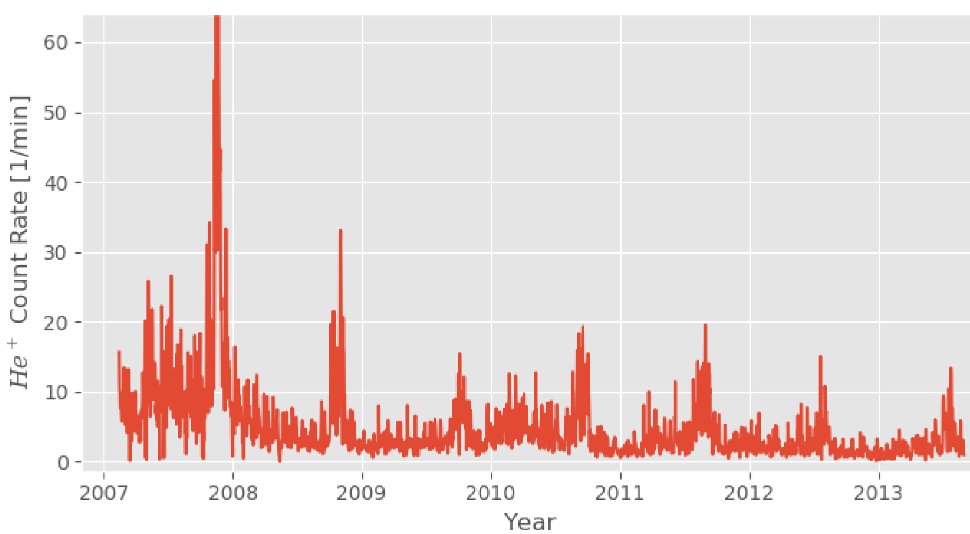

Figure 3: One day averages of STEREO-A PLASTIC He^+ PUI counts in the velocity range $.5 < w' < 1.5$ from 2007 to 2013. Peaks in the count rate are associated with STEREO passing through the ISN focusing cone.

References

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