# README FOR SINGLY-CHARGED HELIUM ($HE^+$) PHASE SPACE DENSITIES FROM PLASTIC / STEREO

Last update: November 6, 2017

## 1. Data Usage

Data provided by the PLASTIC team at the University of New Hampshire is under NASA grants NNX15AU01G and 80NSSC17K0556.

Helium ($He^+$) data provided here is courtesy of B. Klecker, L. Ellis, and A. B. Galvin.

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.

These data are delivered to the public domain on a regular basis. Efforts are made to include the latest known calibration and background determinations, however, these are expected to undergo revision. We therefore suggest that users regularly return to this page, and make sure to get the most recent revision.

If used in presentations or publications:

We strongly suggest that Dr. A. B. Galvin (toni.galvin@unh.edu) and Dr. B. Klecker (berndt.klecker@mpe.mpg.de) be contacted to ensure that you are working with the latest release.

Please acknowledge STEREO PLASTIC Investigation (A.B. Galvin, PI), and NASA Grants NNX15AU01G and 80NSSC17K0556.
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:

Dr. A.B. Galvin
toni.galvin@unh.edu

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

Lorna Ellis
lorna.ellis@unh.edu

## 2. Computation of Singly-charged Helium ($He^+$) Phase Space Densities

$He^+$ (PUI) 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.

The phase space density F_Vsw is computed from

$$F\_Vsw\ [s^3/km^6] = CTS / eff * K1 * K2 * 1 / (E/M)^2, \quad (1)$$

- CTS are the normalized counts per second
- eff is the efficiency of PLASTIC for $He^+$ (energy and time dependent, derived from in-flight calibration)
- K1 is a constant, determined by the PLASTIC geometry and energy resolution (= 317)
- K2 is a constant, determined by cross-calibration with ACE / SWICS in 2007 (=1.09, s. paragraph 5)
- E/M is the energy per nucleon of the particle in units of keV/nucleon

## 3. File Format

### 3.1 Naming convention

The file names have the following format:

STx_L3_PLA_HePlus_F_Vsw_XXhr_YYYY_Vzz.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.

"XXhr", indicates the time averaging interval of 01 or 24 hours (*)

"YYYY" represents Year

“Vzz” represents the version number

(*) Note: For higher time resolutions (minimum: 10 minutes) please contact the PI.

### 3.2 File Header

The 3 file header lines provide information on the spacecraft, production date, software version number, in-flight calibration file name and column headers.

### 3.3 Data

The files with 01hr and 24hr averages provide the data for 1 year. The data are organized in 113 columns, with

Column

| | |
|---|---|
| 1 | year |
| 2 | month |
| 3 | day of month |
| 4 | day of year |
| 5 | hour (start time of time bin) |
| 6 | min (start time of time bin) |
| 7 | day of year (decimal) |
| 8 | maximum # of instrument cycles in time bin |
| 9 | solar wind proton speed (km/s) |
| 10 | solar wind proton thermal speed [km/s] |
| 11 | solar wind proton density [$p/cm^3$] |
| 12 | phase space density [$s^3/km^6$], for mean V/Vsw= 7.80, s. a. column header |
| 13 | total counts for this V/Vsw bin |
| 14-113 | same as 12-13 for other V/Vsw bins |

The proton bulk parameters $V_{sw}$, $V_{therm}$ and Density ($N_p$) are derived from a 1D Maxwellian fit to a single detector rate (no coincidence required), and are corrected for background and dead time. The software version number used to derive the proton bulk parameters is shown in the file header (Version V06 and later). The most recent update of the proton bulk parameters can be found on the following STEREO website:

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

**Note of caution:** At low V/Vsw (starting around 1.2 - 1.4, and certainly below 1), the fluxes are subject to background that needs to be evaluated on a case by case basis. Note also that for high solar wind speed, the measurement range in V/Vsw is limited, for example for $He^+$ to V/Vsw < 3 for Vsw < 650 km/s (see Fig. 1 below).

## 4. Measurement range (V/Vsw) for $He^+$ PUI

Figure 1 shows the range of maximum and minimum V/Vsw values for ESA step 2 (maximum energy 81 keV/q), and ESA step 91 (minimum energy 1.17 keV/q), selected for processing $He^+$. The maximum value of V/Vsw for $He^{2+}$ is shown for comparison.

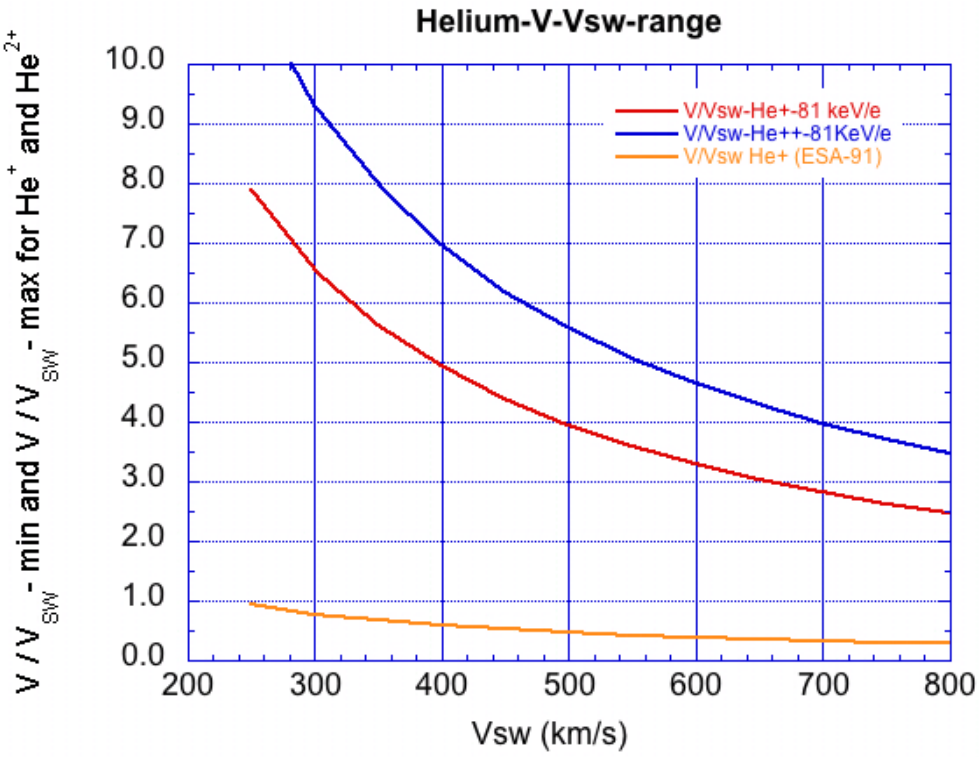


Fig. 1 V/Vsw range for $He^+$ and $He^{2+}$ as a function of maximum energy (81 keV/e) and minimum energy (ESA step 91, 1.17 keV/q) selected for processing $He^+$.

## 5. Comparison of STEREO PLASTIC PUI Spectra with ACE / SWICS

The in-flight calibration for PLASTIC / STEREO-A can be checked by a comparison with PUI data from ACE during times when both spacecraft are in the upwind region, i.e. when the $He^+$ PUI intensities can be expected to be similar. In June 2007, both ACE and STEREO-A are in the upwind direction of the interstellar neutral flow with a separation distance of only 8.5° in ecliptic longitude. The $He^+$ PUI spectra for June 2007 of ACE/SWICS (courtesy G. Gloeckler, s. a. ACE Science Center, http://www.srl.caltech.edu/ACE/ASC/DATA/level3/swics/He_plus.html, and Möbius, et al., 2010) and STEREO-A/PLASTIC show a very good overall agreement (Fig. 2). For the PLASTIC PUI spectrum shown in Fig. 2 an energy- and time-independent intercalibration factor of 1.09 was applied (constant K2 in equation (1) on page 2).

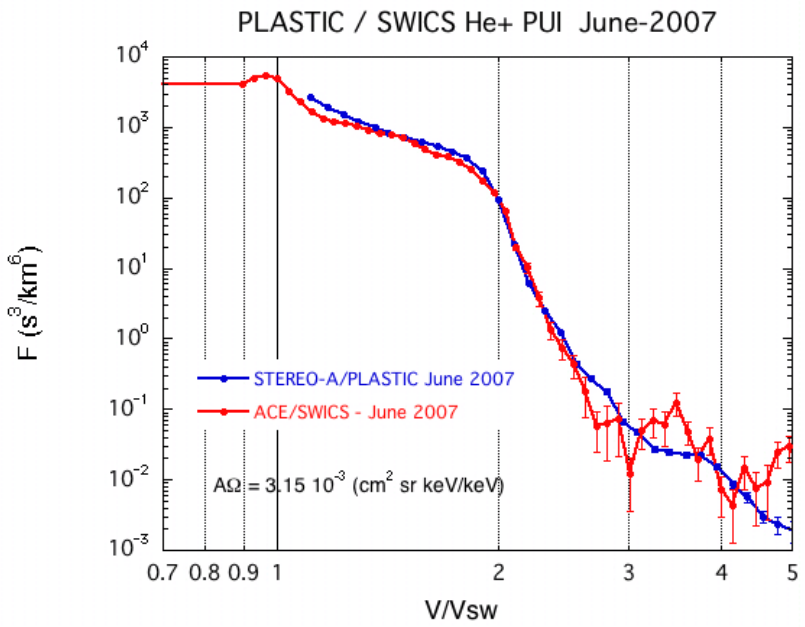


Fig. 2: One month average He+ PUI spectra as observed in June 2007 on ACE and STEREO-A

In June 2008 the separation distance between ACE and STEREO-A is significantly larger (~30° in ecliptic longitude). However, the energy spectra in the plateau region of PUI intensities agree also very well (Fig. 3). At higher energies, in particular above the cut-off energy of 2 x V/Vsw, larger differences of the spectra due to local differences of the interplanetary conditions, resulting in differences in the acceleration, can be expected.

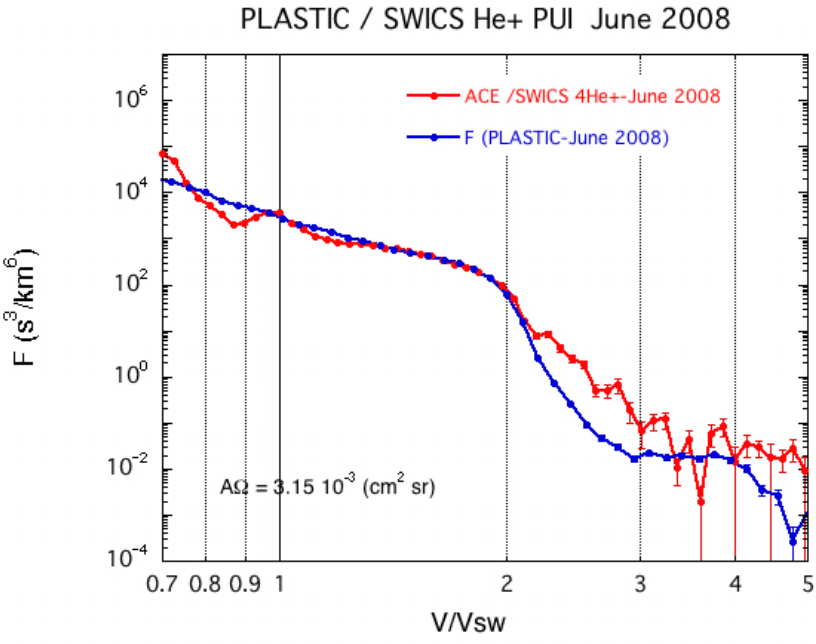


Fig. 3: One month average $He^+$ PUI spectra as observed in June 2008 on ACE and STEREO-A

## 6. Long-term PUI Measurements

Figure 4 shows daily averages of efficiency corrected counts/s for the years 2007 to 2017. The vertical lines indicate the expected time of the passage through the neutral helium focusing cone in the downwind direction. The relative constant average fluxes in the upwind direction suggest a very stable performance of the sensor.

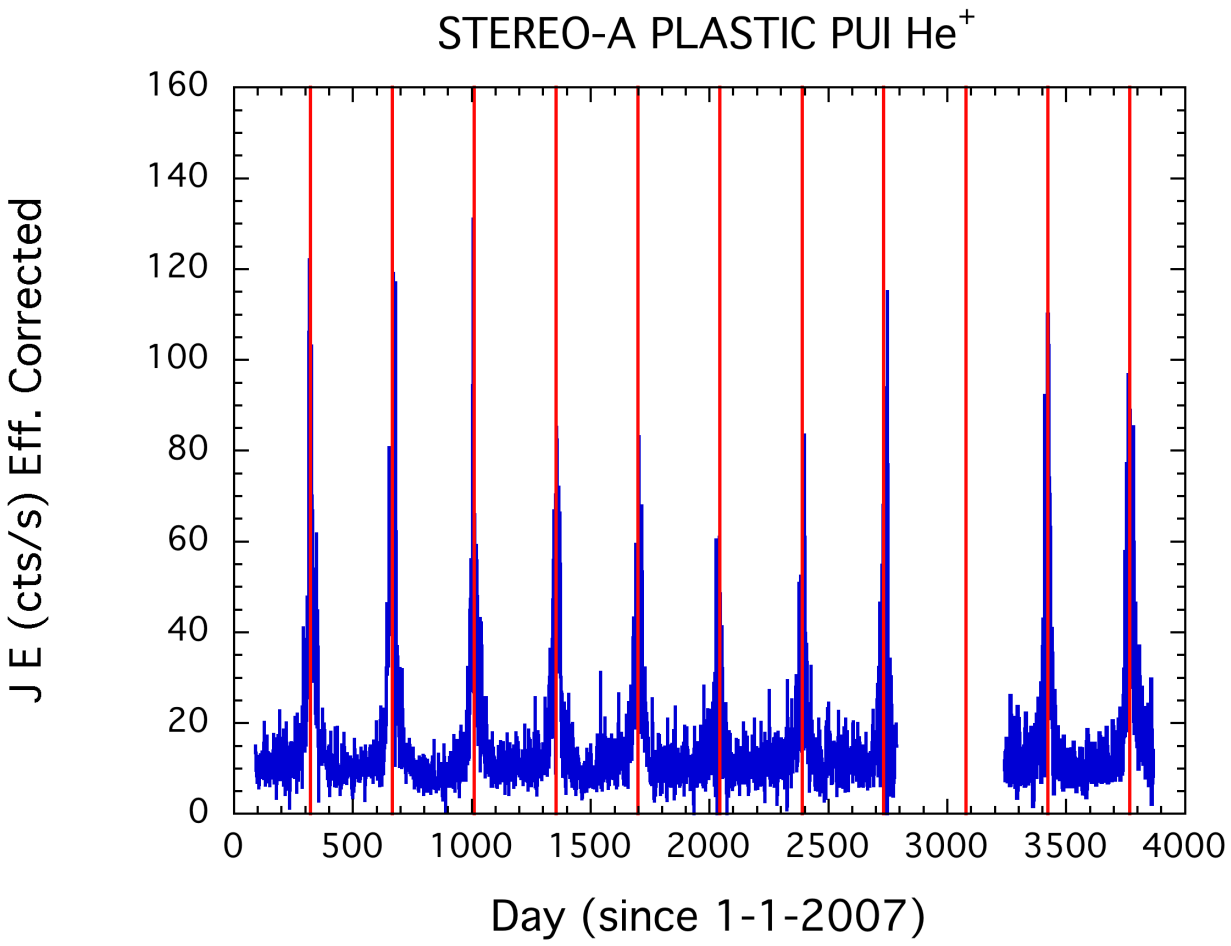


Fig. 4: One day averages of relative differential energy flux in the velocity range 1.85>V/Vsw>1.44 for the years 2007 to 2017 as measured with PLASTIC onboard STEREO-A. The extended data gaps in 2014 and 2015 are due to the solar conjunction.

## 6. Data Access

Starting in July 2015, calibrated PUI $He^+$ data (phase space density), averaged over 1hr and 24hr, will be available on the STEREO Science Center:

http://stereo-ssc.nascom.nasa.gov/data/ins_data/plastic/level3/HePlus/

For higher time resolution (minimum 10 min), please contact the PI.

**Data Coverage:**

**Table 1 – Data coverage**

The data coverage for the years 2007 to 2017 is provided in Table 1. The extended data gaps in 2014 and 2015 are due to the solar conjunction. The data for August to December 2017 will be provided with the next update.

| Year | Start | | Stop | | Comment |
|---|---|---|---|---|---|
| | Month | Day of Month | Month | Day of Month | |
| **2007** | **04** | **01** | **12** | **31** | Full operation |
| **2008** | **01** | **01** | **12** | **31** | |
| **2009** | **01** | **01** | **12** | **31** | |
| **2010** | **01** | **01** | **12** | **31** | |
| **2011** | **01** | **01** | **12** | **31** | |
| **2012** | **01** | **01** | **12** | **31** | |
| **2013** | **01** | **01** | **12** | **31** | |
| **2014** | **01** | **01** | **08** | **18** | Solar Conjunction |
| **2015** | **11** | **17** | **12** | **31** | Solar Conjunction |
| **2016** | **01** | **01** | **12** | **31** | |
| **2017** | **01** | **01** | **07** | **31** | |
| | | | | | |

**References**

Galvin, A. B, et al.: The Plasma and Suprathermal Ion Composition (PLASTIC) Investigation on the STEREO Observatories, Space Science Rev. 136, 437-486, 2008.

Möbius, E., et al., He Pickup Ions in the Inner Heliosphere - Diagnostics of the Local Interstellar Gas and of Interplanetary Conditions, In: Pickup Ions Throughout the Heliosphere and Beyond: Proceedings of the 9th Annual International Astrophysics Conference, AIP Conf. Proc. 1302, pp 37-43, 2010.