# PLASTIC STATUS
# STEREO SWG

April 14 2011

Presented by A.B. Galvin

- PLASTIC
  - Recent Publications
  - Operations (M. Popecki)
    - Includes DPU software update
  - Selected Science Highlights
  - Data Status (L. Ellis)

# PLASTIC Publications 2010-2011


Bochsler et al., Diagnostics of Corotating Interaction Regions with the kinetic properties of iron ions as determined with STEREO/PLASTIC, Ann. Geophys., 28, 491-497, 2010.

Bochsler et al., Kinetic temperatures of iron ions in the solar wind observed with STEREO/PLASTIC, CP1216, Twelfth International Solar Wind Conference, ed. M. Maksimovic, K. Issautier, N. Meyer-Vernet, M. Moncuquet, and F. Pantellini, AIP 978-0-7354-0759-6/10, 257-260, 2010.

Davis et al., A comparison of space weather analysis techniques used to predict the arrival of the Earth-directed CME and its shockwave launched on 8 April 2010, Space Weather, 9, S01005, doi:10.1029/2010SW000620, 2011.

Drews et al., Observations of Interstellar Neon in the Helium Focusing Cone, J. Geophys. Res., 115, A10108, 9 pp., doi:10.1029/2010JA015585, 2010.

Farrugia et al., Multiple, Distant (40◦) in situ Observations of a Magnetic Cloud and a Corotating Interaction Region Complex, in press, JASTP, doi:10.1016/j.jastp.2010.09.011, 2011.

Galvin et al., Solar Wind Characteristics during the Current Solar Minimum (2007-2009) - STEREO PLASTIC Observations, SOHO-23: Understanding a Peculiar Solar Minimum ASP Conference Series, ed. Steven R. Cranmer, J. Todd Hoeksema, and John L. Kohl, Vol. 438, 275-278, 2010.

Galvin, Antoinette B., Solar Wind Observations from the STEREO Perspective (2007-2009), Chapter 11 in The Sun, the Solar Wind, and the Heliosphere, IAGA Special Sopron Book Series 4, ed. M.P. Miralles and J. Sanchez Almeida, Springer, pp 109-119, doi 10.1007/978-90-481-9787-3_11, 2011.

Gomez-Herrero et al., Multi-point observations of CIR-associated energetic particles during the 2008 solar minimum, CP1216, Twelfth International Solar Wind Conference, ed. M. Maksimovic, K. Issautier, N. Meyer-Vernet, M. Moncuquet, and F. Pantellini, AIP 978-0-7354-0759-6/10, 608-612, 2010.

Kistler et al., Escape of O+ Through the Distant Tail Plasma Sheet, Geophys. Res. Lett., 37, L21101, doi:10.1029/2010GR045075, 2010.
Lavraud et al., Statistics of counter-streaming solar wind suprathermal electrons at solar minimum: STEREO observations, Ann. Geophys., 28, 233–246, 2010.

# PLASTIC Publications 2010-2011


Moebius 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 Conference Proceedings, Vol 1302, p 37-43, doi:10.1063/1.3529987, 2010.

Moestl et al., STEREO and Wind observations of a fast ICME flank triggering a prolonged geomagnetic storm on 5-7 April 2010, Geophys. Res. Lett., 37, L24103, doi:10.1029/2010GL0450175, 2010.

Opitz et al., Solar wind bulk velocity throughout the inner heliosphere from multi-spacecraft measurements, Solar Physics, 264:377-382, DOI: 10.1007/s11207-010-9583-7, 2010.

Opitz et al., Temporal evolution of the solar wind electron core density at solar minimum by correlating the STEREO A and B SWEA measurements, Solar Physics, 266, 369, doi:10.1007/s11207-010-9613-5, 2010.

Rouillard et al., Intermittent release of transients in the slow solar wind: 2. In situ evidence, J. Geophys. Res., 115, A04104, 8 pp., doi:10.1029/2009JA014472, 2010.

Liu Y. C.-M. et al., Downstream structure and evolution of a simulated CME-driven sheath in the solar corona, Astronomy & Astrophysics, 2010.

Liu, Y. C.-M. et al., Proton Enhancement and Decreased O6+/H at the Heliospheric Current Sheet: Implication for the Origin of Slow Solar Wind, CP1216, Twelfth International Solar Wind Conference, ed. M. Maksimovic, K. Issautier, N. Meyer-Vernet, M. Moncuquet, and F. Pantellini, AIP 978-0-7354-0759-6/10, 363-366, 2010.

Simunac, K.D.C., A.B. Galvin, J. Barry, C. Farrugia, L.M. Kistler, H. Kucharek, M.A. Lee, Y.C.-M. Liu, E. Moebius, M.A. Popecki, Identifying the ends of high-speed streams near 1 AU with in situ data from STEREO/PLASTIC, CP1216, Twelfth International Solar Wind Conference, ed. M. Maksimovic, K. Issautier, N. Meyer-Vernet, M. Moncuquet, and F. Pantellini, AIP 978-0-7354-0759-6/10, 351-354, 2010.

Webb, D.F., D.A. Biesecker, N. Gopalswamy, O.C. St. Cry, J.M. Davila, C.J. Eyles, B.J. Thompson, K.D.C. Simunac and J.C. Johnston, Using STEREO-B as an L5 Space Weather Pathfinder Mission, Space Research Today, No. 178, p. 10 - 16, August 2010.

# PLASTIC Publications in Preparation (Spring 2011)

Moestl, Farrugia et al., Widely separated STEREO, Venus Express and near-Earth in in situ observations of geo-effective complex ejecta on August 2-4 2010

Simunac et al., Stream interface slope and the warp of the heliospheric current sheet

Simunac et al., The heliospheric plasma sheet observed in situ by 3 spacecraft over 4 solar rotations

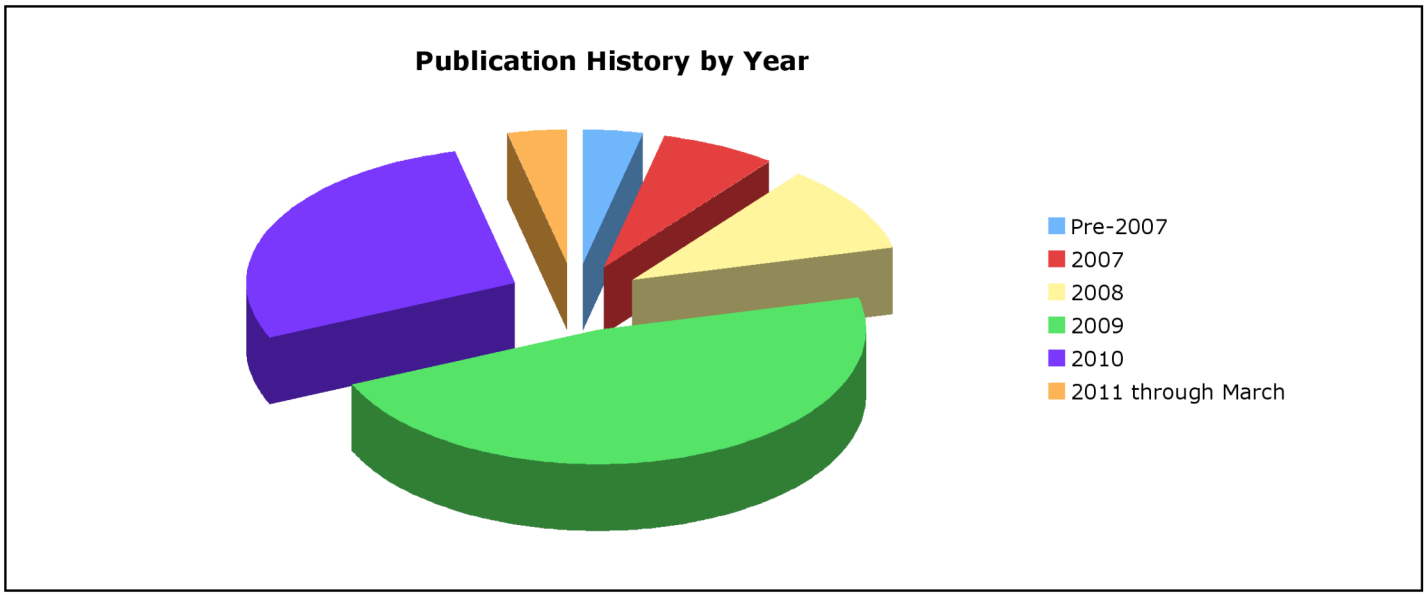
Miralles, Simunac, Galvin et al., Fast solar wind streams from the Sun to 1 AU during the recent solar minimum

Foullon, Simunac, Galvin, Farrugia et al., Plasmoid transient releases in the heliospheric current sheet with adjacent coronal hole boundary layer evolution

Farrugia and Moestl et al, two papers on the Aug 2010 ICME event

Webb, Farrugia et al., the January 12, 2010 ICME event

# PLASTIC Published Papers Overview




ALSO:

8 Dissertations/Theses
2 Honors Papers

There are two graduate students working on PLASTIC at UNH (third starts in summer) and one graduate student at CAU

# PLASTIC Talks/Posters Conferences 2010-2011

9th Annual International Astrophysics Conference (Pickup Ions Throughout the Heliosphere and Beyond) - March 2010
ISSI Workshop Suprathermal Tails - May 2010
Cospar, Bremen - June 2010
SHINE - July 2010
Wind/ACE/SOHO/STEREO Workshop, Maine 2010
AGU - Dec 2010
10th Annual International Astrophysics Conference (Physics of the Heliosphere) - March 2011
EGU - April 2011
Workshop II on Events of 1-4 August 2010, Graz - April 2011
Splinter Workshop on Events in January 2010, Graz - April 2011

Upcoming:
ISSI Workshop on Particle Acceleration in Cosmic Plasmas - May 2011
IUGG/IAGA - June-July 2011
Kiel Workshop - July 2011

# PLASTIC Operations Summary

March 2010 - April 2011

- **Anomalies**
  - *Restarts*
    - STA 4/15/10 Restarted the SSD electronics
      - transient high rates coincided with an upset of the SSD communication link.
    - STA 4/09/11 Re-initialized instrument
      - SEP event coincided with a reset of the instrument (HV goes down during reset)
    - STB 1/11/11 Restarted instrument
      - a current limit violation on the IMPACT DPU caused an autonomy shutdown of PLASTIC on 1/8/11
  - *Bit flips in the PLASTIC code section of the IMPACT/PLASTIC DPU memory*
    - STB 6/17/10 B RAM Checksum error
    - STB 10/26/10 B RAM Checksum error
    - STA 1/14/11 A RAM Checksum error

- **Maintenance activities**
  - STB 12/14/10 Changed trigger mode from 03 to 23 (now same as STA)
  - STA 2/16/10 Raised MCP voltage
  - STA 4/1/10 S-ch threshold switch adjustment on DPU and actel sides
  - STA 5/12/10 S-ch threshold switch adjustment on DPU and actel sides
  - STA 7/7/10 S-ch threshold switch adjustment on DPU and actel sides
  - STA 11/2/10 TAC threshold changed on non-ssd side
  - STA 12/14/10 Engineering mode data; preparation for an S-ch adjustment
  - STA 1/11/11 S-ch threshold switch adjustment on the DPU side, with eng mode data

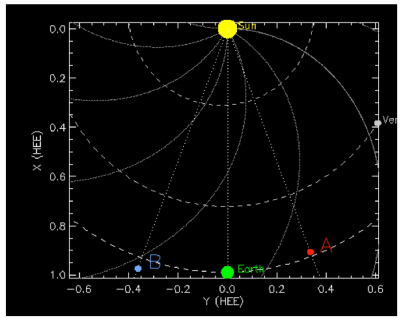
# DPU/PLASTIC Flight Software Development by Microtel and Testing by UNH

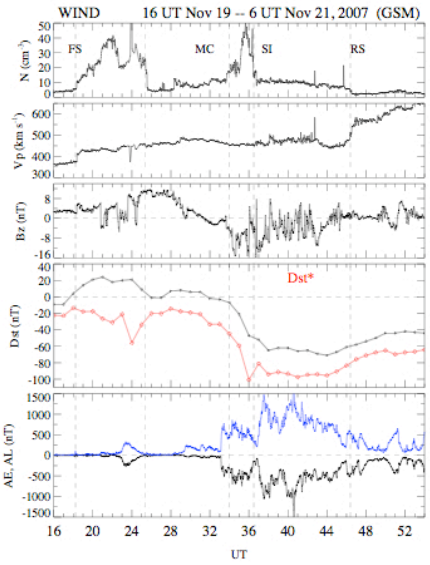
- DPU software changes are needed to accommodate low telemetry bit rates late in the mission.
- Changes allow:
  - Disabling of selectable ApIDs, and
  - Extension of heavy ion integration periods, up to 255 minutes (presently ≤ 10 minutes)
- Related changes:
  - Logic was added to detect and report *data overflow* in the heavy ion products and associated data within the PLASTIC Beacon Data (ApID 0x370)
  - Status bytes were added to the PLASTIC digital housekeeping packet (ApID 0x313) indicating *which* ApIDs have been disabled.
  - Software changes have been:
    - written by Microtel (W. Mocarsky)
    - tested at UNH with:
      - spare instrument / DPU / spacecraft emulator hardware (M. Popecki)
      - data processing and analysis software (L. Ellis)
- Final checks are taking place.

# Science Nuggets

# Multi-spacecraft Analysis of a 40$^{o}$ Magnetic Cloud

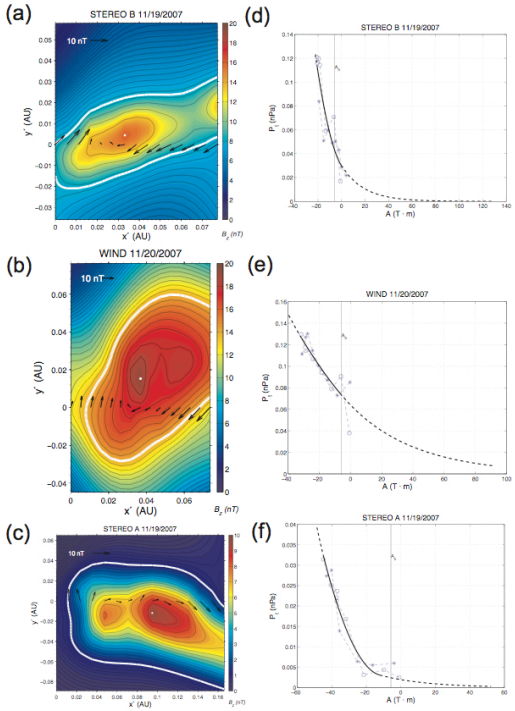
Farrugia et al., JASTP, doi:10.1016/j.jastp.2010.09.011, 2011



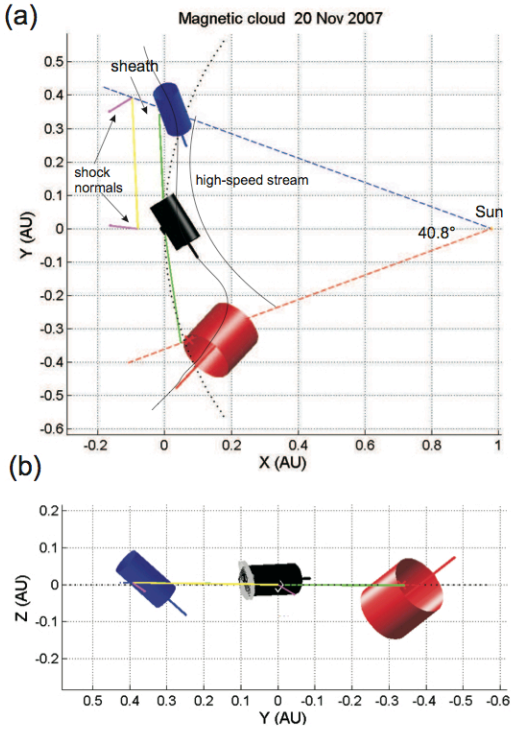




**Top: STB and STA orbit at time of event.**

**Bottom: Geomagnetic response to the event.**




**Magnetic field maps obtained from Grad-Shafranov reconstruction from solar east to west: STB, Wind, and STA**

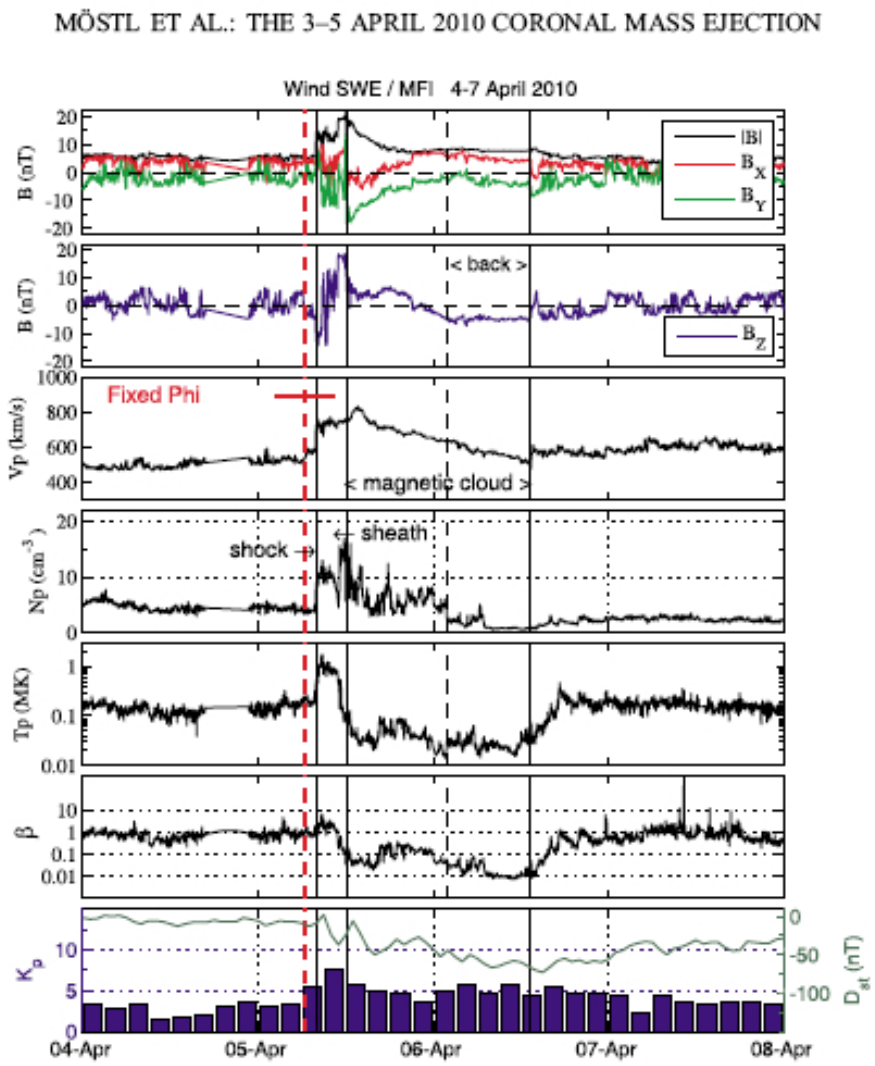



**Sketch of the magnetic cloud's global shape**

In-situ observations made by Wind and the STEREO probes (STA, STB) of a complex interaction between a corotating interaction region (CIR) and a magnetic cloud occurring near the heliospheric current sheet on November 19-21, 2007. This complex event resulted in a “double dip” storm at Earth.

# Fast ICME Observed by STEREO along the Sun-Earth Line, Leading to a Geoeffective Event

Moestl et al., GRL, doi:10.1029/2010GL045175, 2010




On April 5-7 2010, a moderate but prolonged geomagnetic storm was responsible for the loss of the Galaxy 15 satellite. (Minimum $D_{st}$ = -72 nT, maximum $K_p$ = $8^-$)

The ICME responsible for this storm is the first fast ICME (<V> = 650 km/s) observed by STEREO HI for the full Sun-Earth line. Note: up until this event, the Sun-Earth ICMEs have been slow, solar minimum events. This event was flare-associated (B7.4 flare at S25W03).

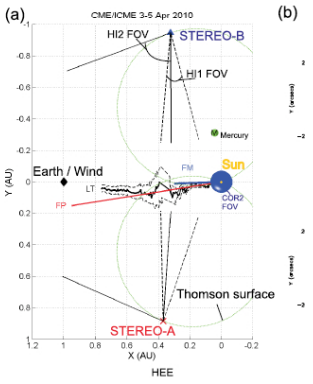
Single s/c in situ observations undersample an ICME's global structure. It is also unclear where the s/c intercepts the ICME with respect to its cross section. This makes interpretation and classification of ICMEs by a single s/c ambiguous, as it was with this event.

# Fast ICME Observed by STEREO along the Sun-Earth Line

Moestl et al., GRL, doi:10.1029/2010GL045175, 2010

By combining STEREO and Wind observations, this flare-associated ICME was continuously tracked along the Sun-Earth line, and the correlation of remote imaging and in-situ signatures established. It was determined that this was not (strictly speaking) a magnetic cloud event, but rather a magnetic cloud like (MCL), which includes not only a region of magnetic field rotation and decline, but also a "back region" where the magnetic field intensity is constant and not rotating. The combined STEREO-Wind analysis indicates that the Wind s/c crossed the MCL at the flank, where the ejecta was still driving a shock.

The short interval of negative $B_z$ in the sheath created the storm commencement. The negative $B_z$ in the "back region" was responsible for prolonging the storm growth phase, while an interval of negative $B_y$ in-between continued the ring current intensity.




**Spacecraft geometry during observations**

The observations emphasize the selection effect imposed by a particular s/c trajectory through an ICME. From the observations, a plausible explanation of the "back region" is that it is a purely geometrical effect - due to encountering the ICME on its flank, where the field is no longer helical. (Rather than due to reconnection, an earlier hypothesis).

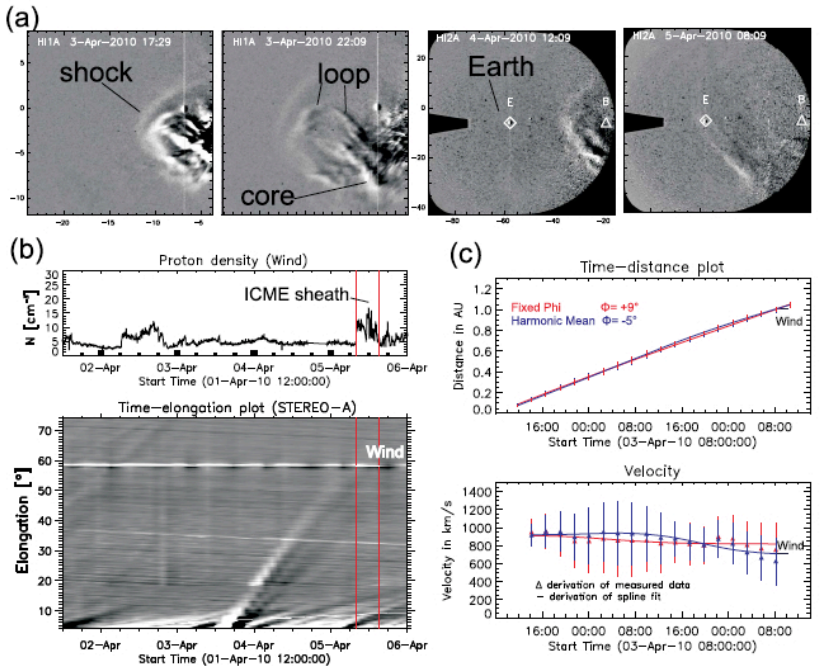
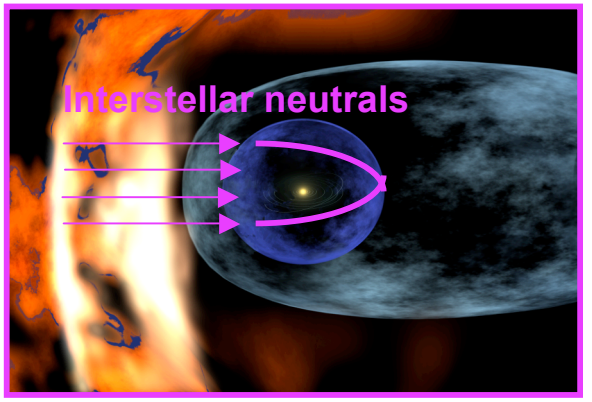



Figure 2. STEREO–A HI and Wind observations: (a) CME time evolution in HI1A (left two plots) and HI2A (right two plots). ICME features and the position of the Earth (E) and STEREO-B (B) are indicated. (b) Proton density measured by Wind and a HI1A / HI2A Jplot extracted along the ecliptic plane. Increased densities in the ICME sheath are delimited by vertical lines. (c) The (top) time–distance and (bottom0 time–velocity profiles of the CME up to 1 AU, using the Fixed–Φ (red) and Harmonic mean (blue) conversion methods, compared to Wind measurements of the shock arrival time and in situ plasma bulk velocity in the sheath.

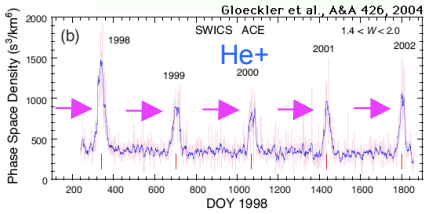
# STEREO Discovery of a Focusing Cone for Neon

Drews et al., Journal Geophysical Research, 115, A10108, doi:10.1029/2010JA015585

As the Sun plows its way through the Milky Way, interstellar neutral particles enter the heliosphere, where they feel the Sun's gravitational attraction and are focused by it into a cone which is located downwind of the Sun's motion through the interstellar medium.

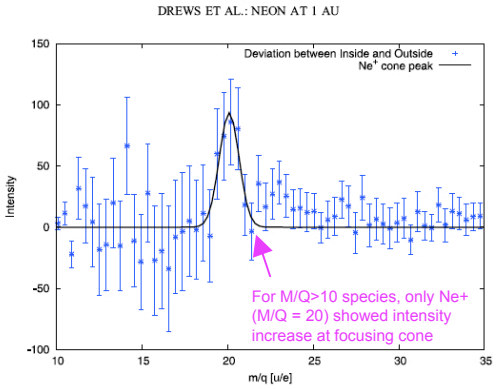


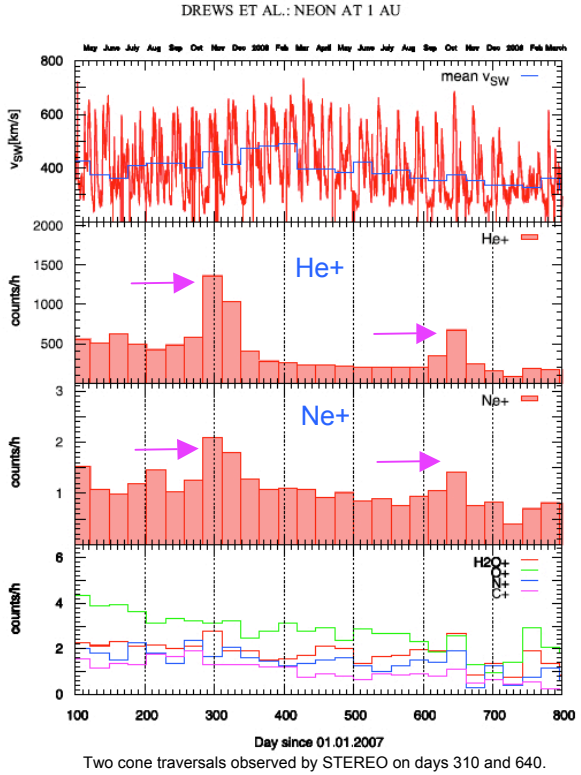

Such a focusing cone has been observed at 1 AU for years for interstellar Helium, but had never been found for any other species.




Yearly cone traversals observed by ACE for He+

With the large geometrical factor of the **STEREO PLASTIC** solar wind sensor, we are able to detect several species of pickup ions (He+, C+, N+, O+, water group, and Ne+) at hourly temporal resolution. With this data we have discovered a focusing cone at 1 AU for Neon. Of these species, only Helium and Neon showed a statistical deviation between inside and outside the cone, indicating the other species are likely of non-interstellar origin (e.g., inner source pickup ions).



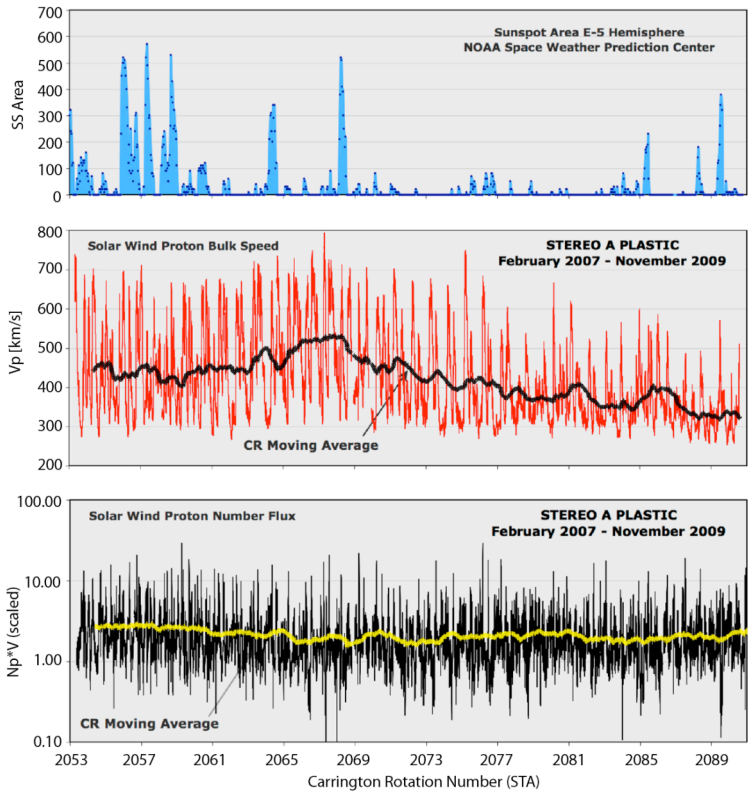



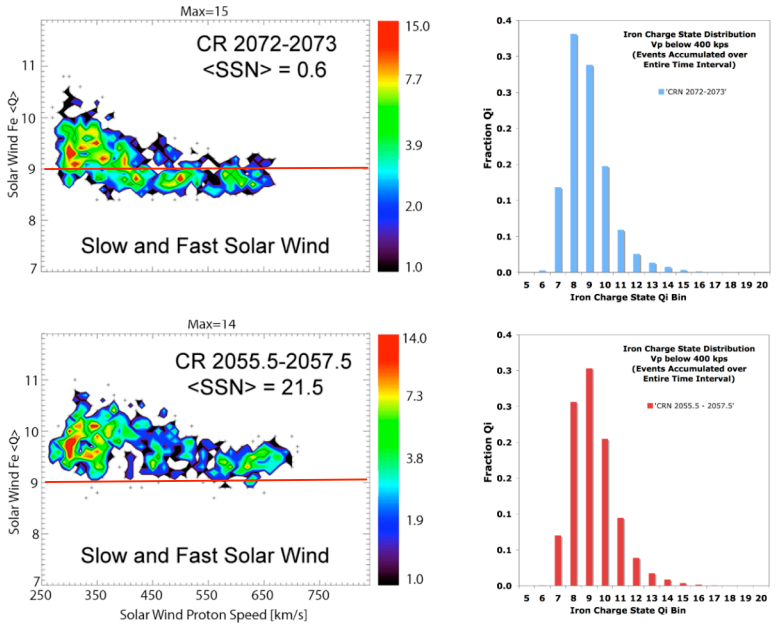

Two cone traversals observed by STEREO on days 310 and 640.
Data binned by 27 days

# “Warmer” Solar Wind during Higher Sunspot Activity

Galvin, Chapter 11 in “The Sun, the Solar Wind, and the Heliosphere, 2011

During the approach to the recent solar minimum (December 2008), recurrent coronal hole-associated fast solar wind and slow solar wind streams were observed during different levels of solar activity, as defined by the sunspot number.

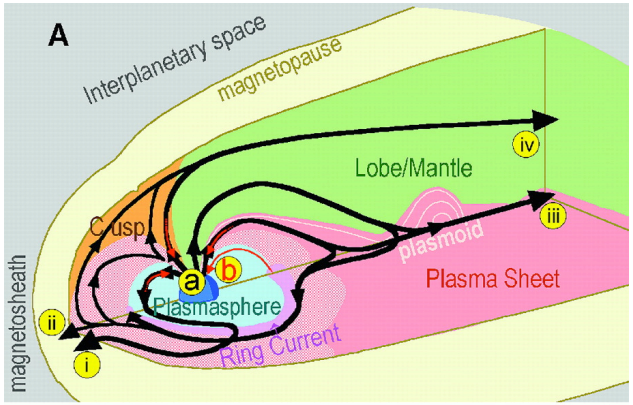


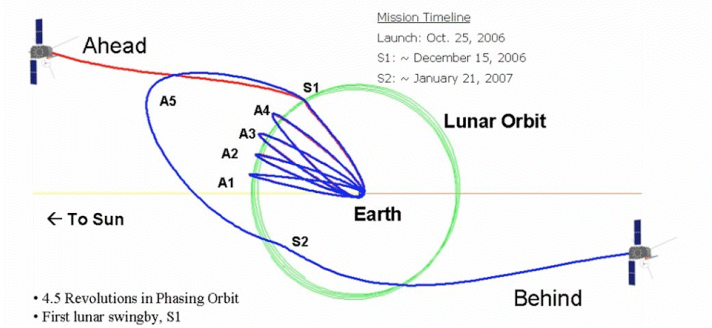

With STEREO PLASTIC, iron ionic charge states (hourly samples) were analyzed based on sunspot number. Transient events (ICMEs) were eliminated from the data set. There is a clear shift to higher charge states - indicating higher coronal temperatures - during the period of higher sunspot numbers. Different origins during different phases of the solar cycle may account for the shift seen in the slow solar wind, but the high speed solar wind in each case is from coronal holes.

# First Estimates of O+ Escape through the Distant Tail

Kistler et al., GRL, 37, L21101, doi:10.1029/2010GL045075, 2010




From Seki et al., 2001

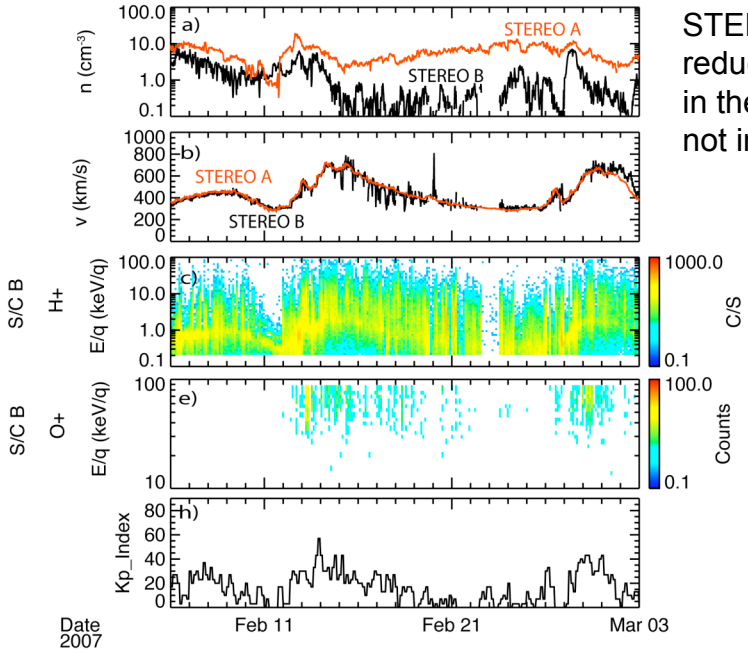



- The total quiet-time O+ outflow from the ionosphere is on the order of $1 \times 10^{25}$ ions/s
- The fraction of this O+ that eventually escapes is not known.
- 4 escape pathways have been identified:
  - escape of plasmaspheric ions out the front side
  - drift of plasma sheet and ring current ions out the front side
  - escape of cusp-origin ions through the lobe/mantle region
  - escape of ions tailward through the plasma sheet

The STEREO/Behind early-orbit deep tail pass allowed an estimate of the O+ escape through the distant tail plasma sheet to be made for the first time, using PLASTIC data.

# First Estimates of O+ Escape through the Plasmasheet

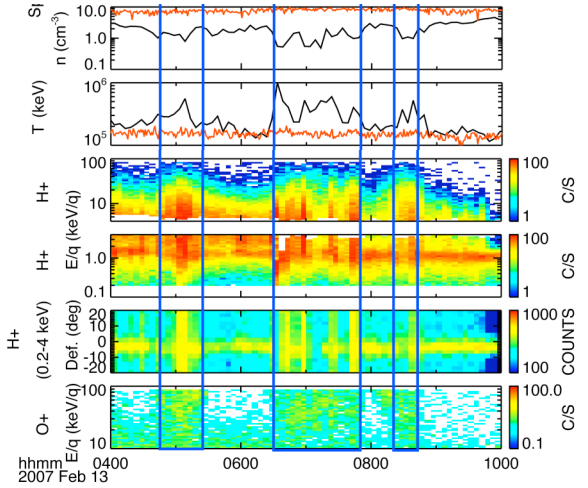
February 2007




STEREO/B density is reduced because it is in the magnetotail, not in the solar wind

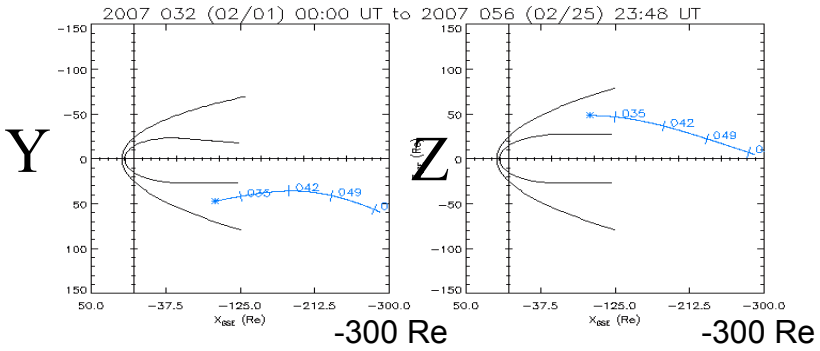
O+ and energetic H+ are observed during the tail period.

February 13, 2007,
200 Re downtail




Bursts of O+ are observed whenever the STB spacecraft moves from the magnetosheath into the plasma sheet.

STEREO/B Orbit in February 2007




## Results

- Even during quiet times, O+ is consistently observed flowing downtail in the distant (200-300 Re) plasma sheet.
- 10% of the total O+ ionospheric outflow is escaping through this path. This is the same order as the estimated loss through dayside transport.

Kistler et al.(2010), GRL, 37, L21101, doi:10.1029/2010GL045075

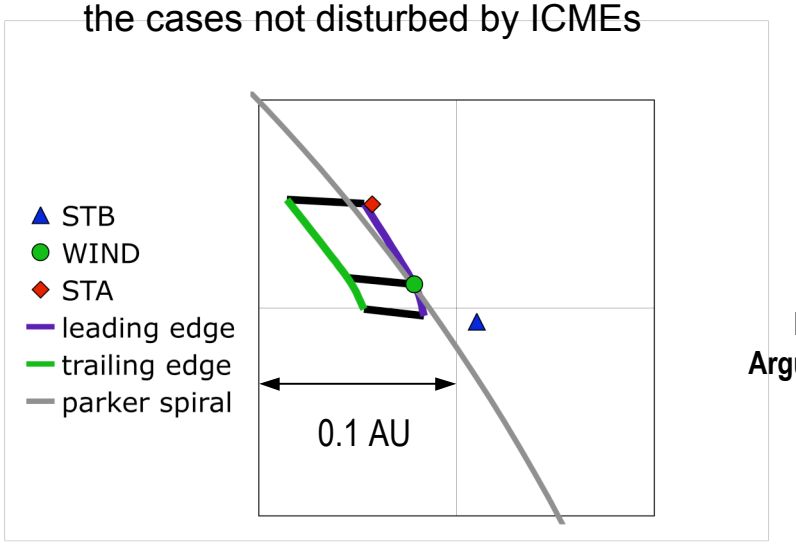
# The heliospheric plasma sheet observed in situ by 3 spacecraft over 4 solar rotations

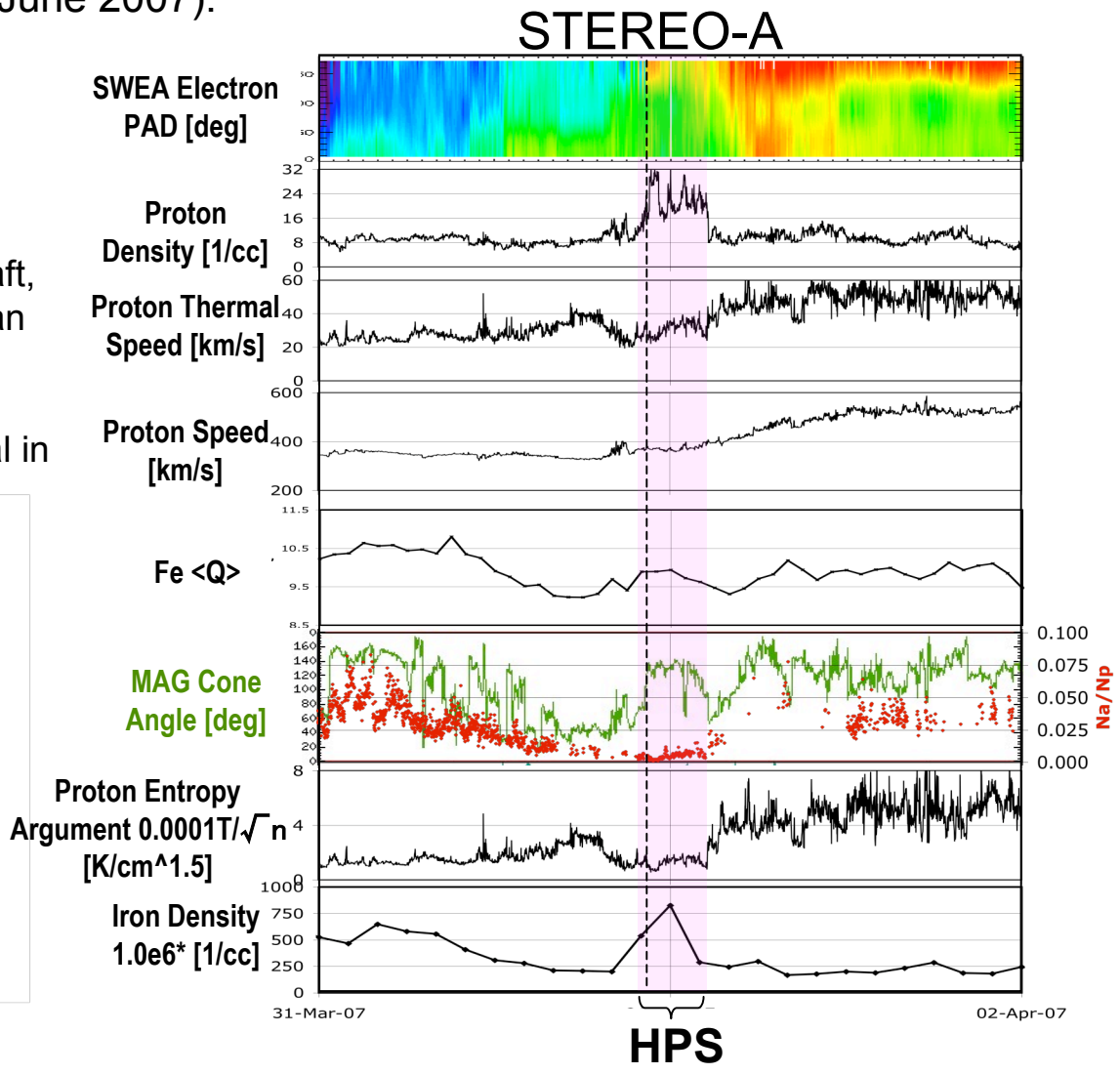
Simunac et al., in preparation

We present in situ observations of HPS crossings from STEREO-A, STEREO-B, and WIND over four solar rotations (late March through June 2007).

Our findings:

- enhancement of Fe <Q> and number density of iron ions at the HPS
- differences in the in situ proton parameters between the three spacecraft, despite temporal separations of less than one day
- the inferred geometry of the HPS is roughly parallel to the ideal Parker spiral in the cases not disturbed by ICMEs

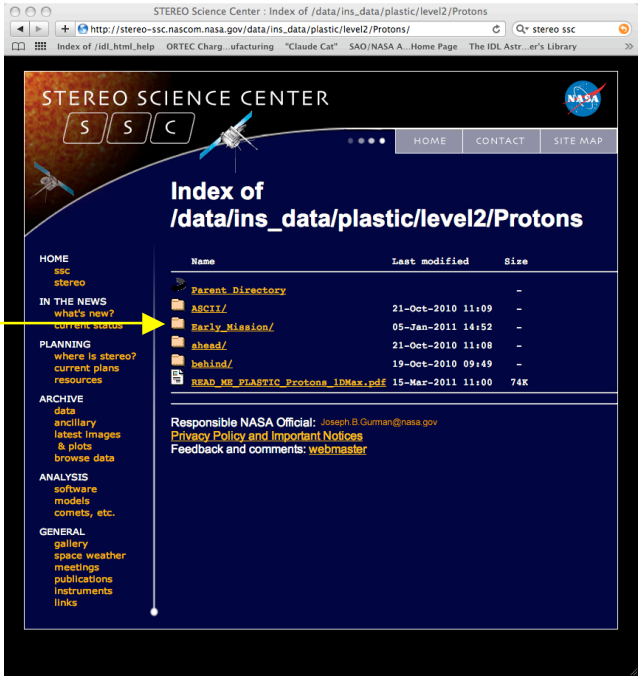


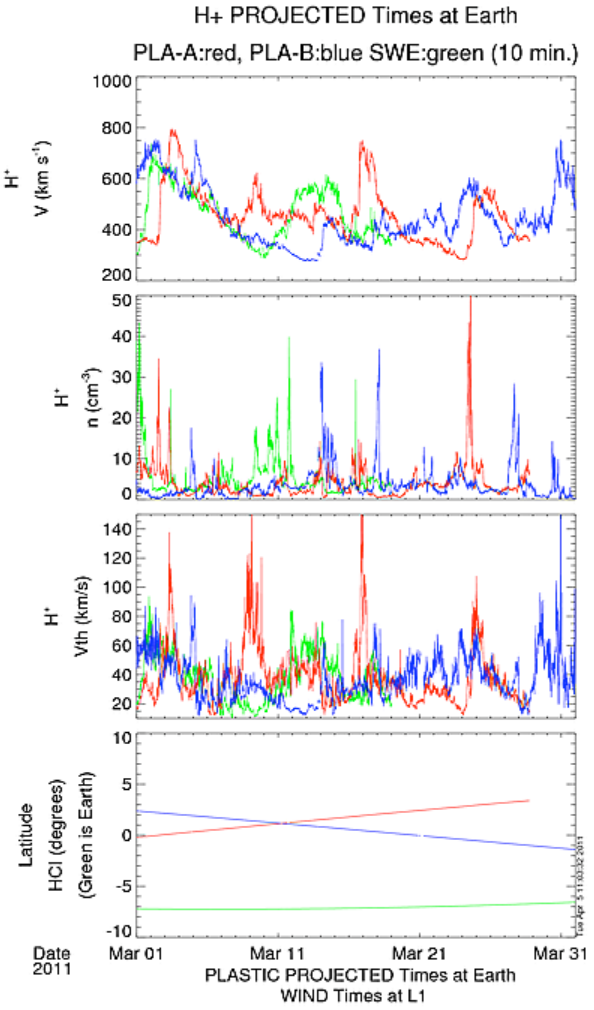
# Data and Browse Plots

Protons:  Added “Early Mission”, retrieving data prior to High Resolution Rate change.

Proton L2 data available through February 2011.



# Data and Browse Plots

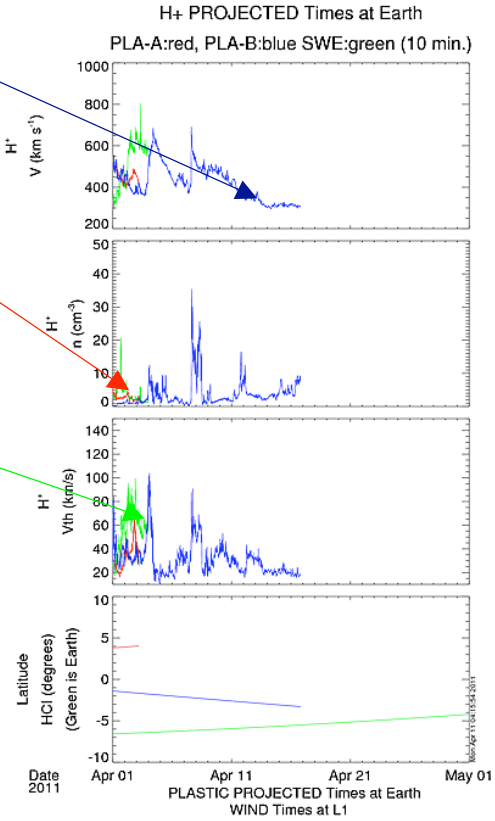



STB is projected into the “future”

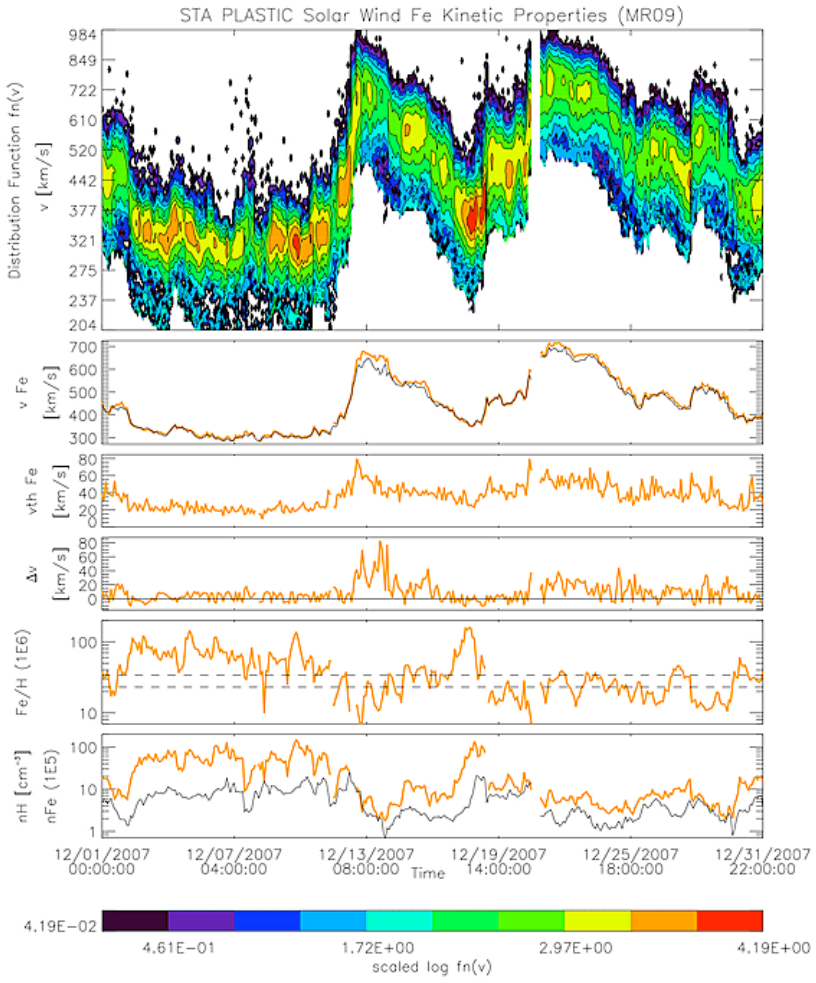
and STA into the “past”

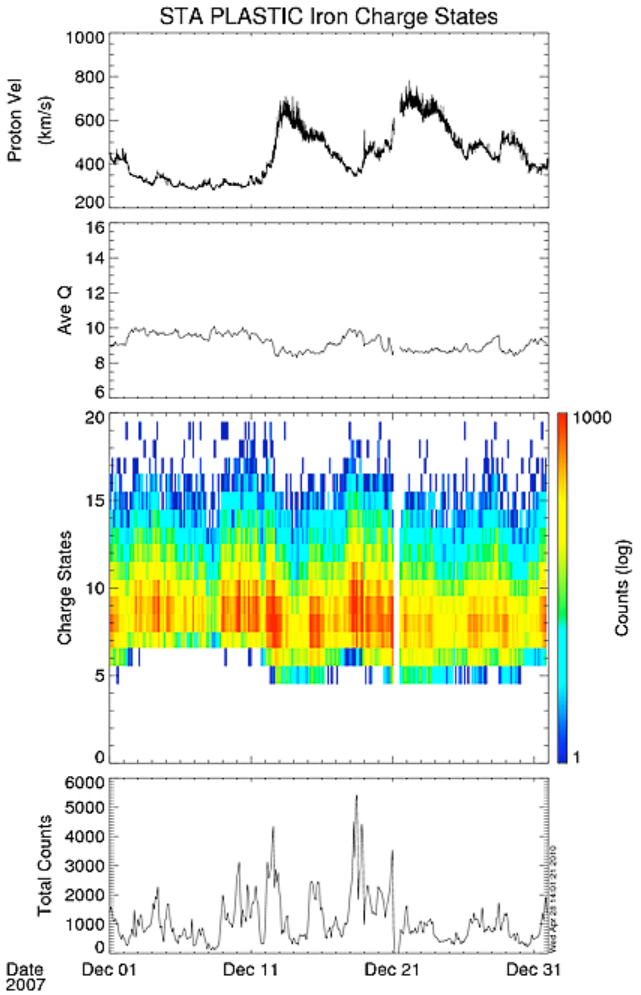
and compared against recent Wind SWE data.

Aids in evaluating temporal changes in solar wind profiles and aids the rocket launch community in determining usefulness of STB for predictions.



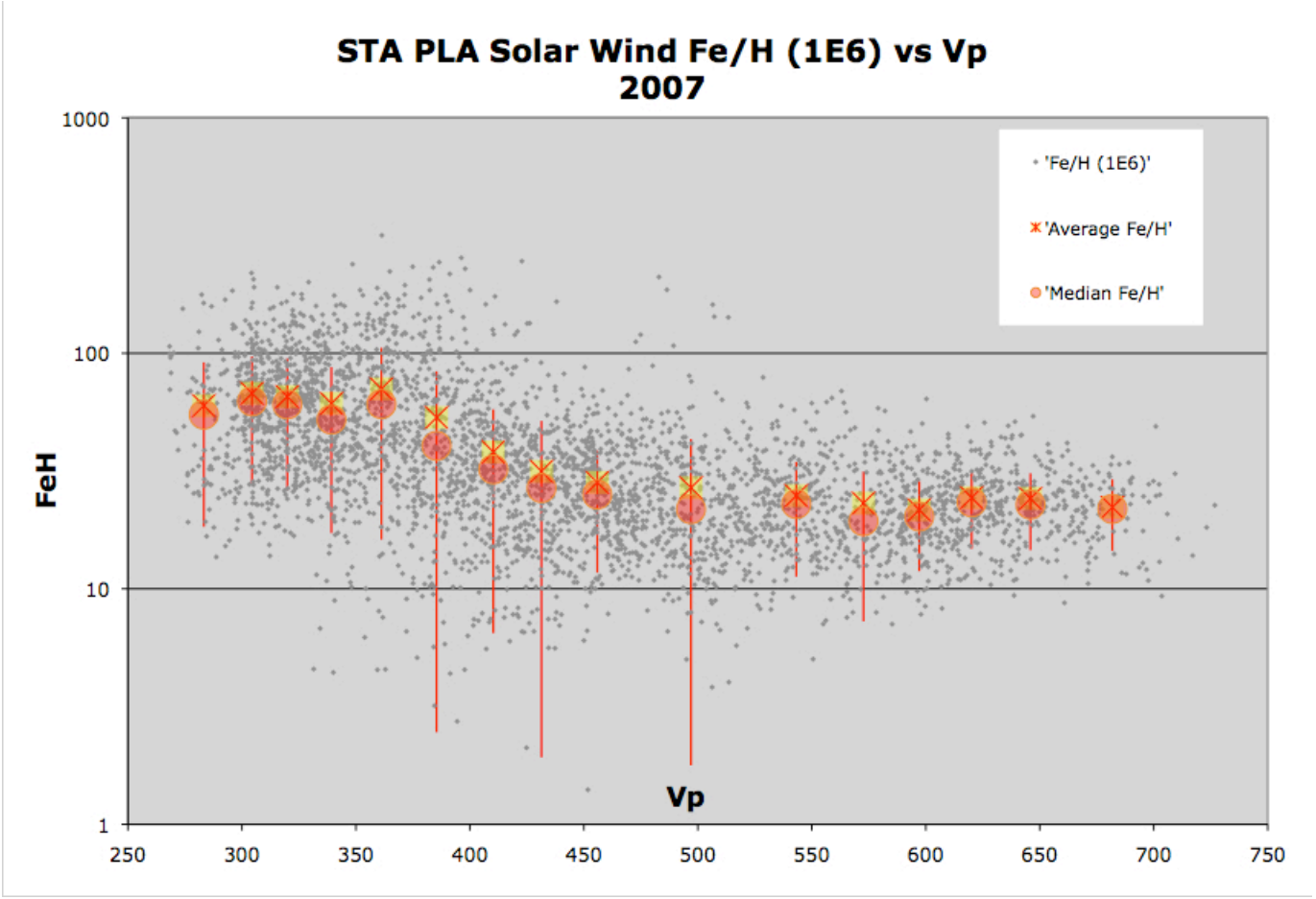
# Data and Browse Plots




Iron data processing in progress, through February 2011.

# Iron Abundances vs Solar Wind Speed



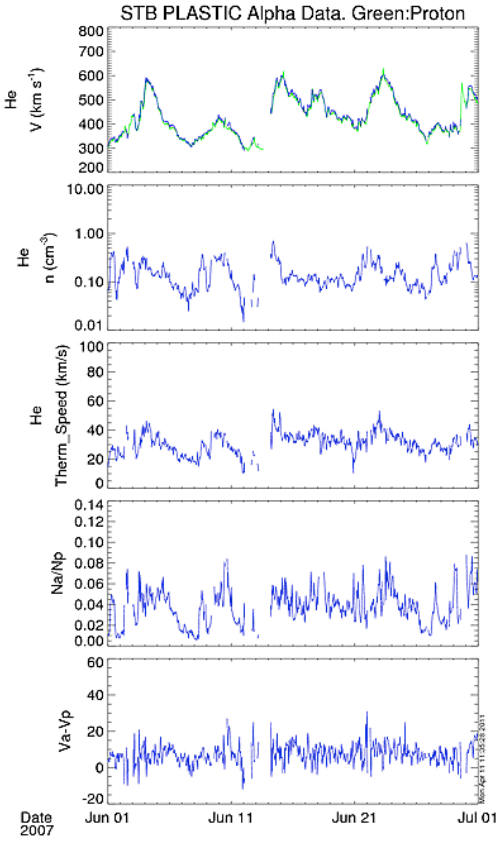
# Data and Browse Plots

Alphas:
Speed, thermal speed, density, density ratio, and speed differential

Currently processed as Level 2 data for Small Channel Aperture.

L2 data available through December 2010 (A) and June 2009 (B).

(STB Main Channel used after June 2009; data set under evaluation.)




Oxygen:
Speed, thermal speed, density.

Currently processed as Level 2 data for Main Channel Aperture.

L2 data available through December 2010 (A), in evaluation (B).

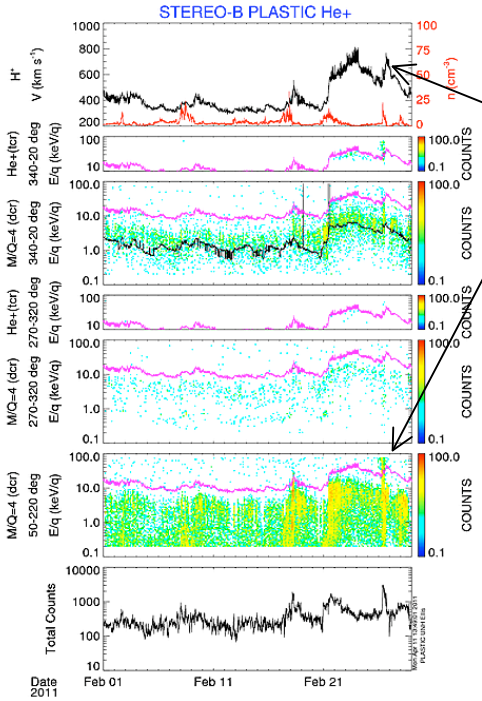
# Data and Browse Plots

He+:

Suprathermal pickup ions

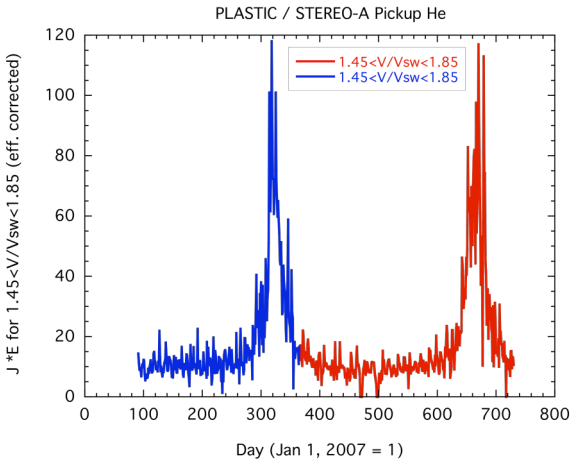
Level 3 STA data 2007-2009. Relative Fluxes in four V/Vsw ranges.

Data for 2010 in progress (B. Klecker).

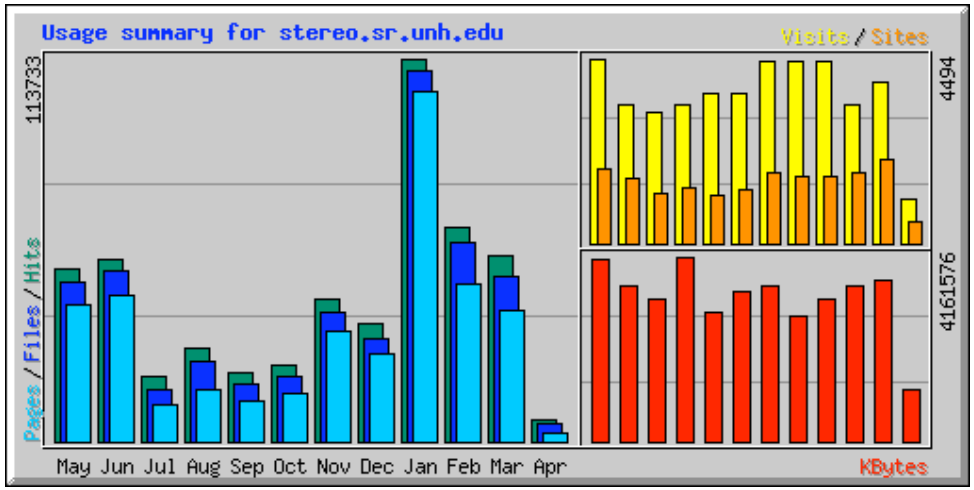


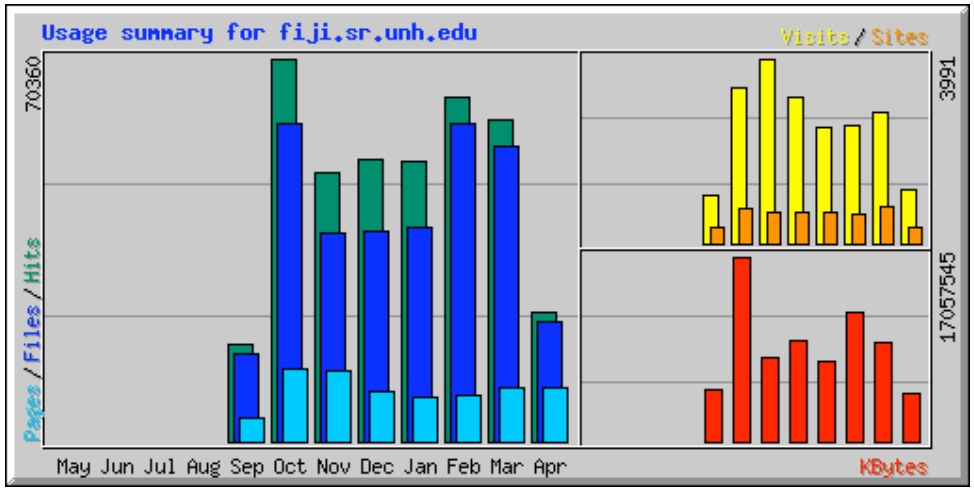

He+ acceleration at ICME period in Feb 2011

Cone traversals:



# Web Data Downloads (UNH only)




Two servers are involved at PLASTIC data center.

These are in addition to downloads from STEREO SSC archive.

Note: new OS installed Sept 2010, truncates history.