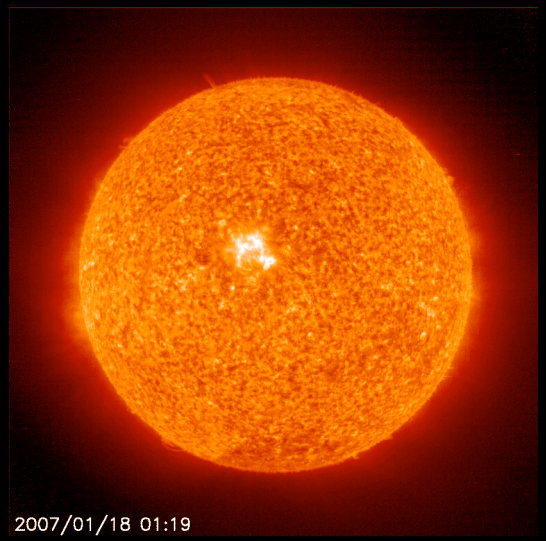
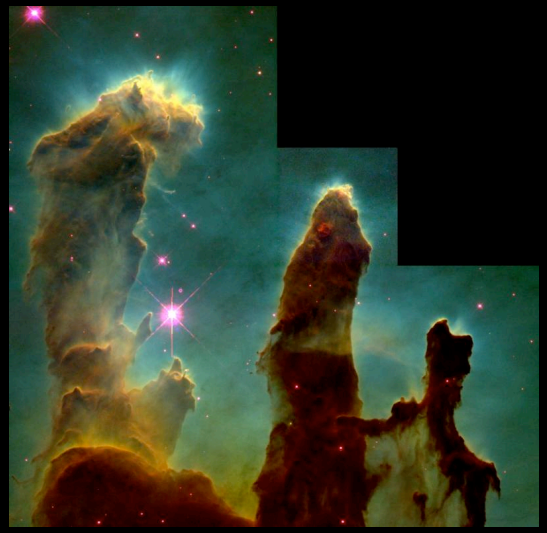
"Early Solar Wind Observations from the Plasma and Suprathermal Ion Composition (PLASTIC) Experiments on STEREO"

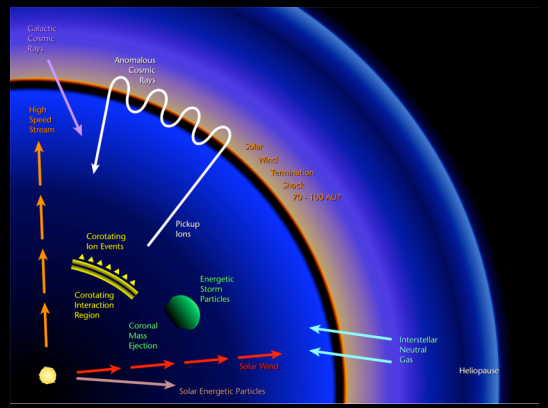
A. Galvin, L. Kistler, M. Popecki, C. Farrugia, E. Moebius, M. Lee, L. Ellis, K. Simunac, K. Singer, C. Russell, C. Walker, L. Blush, B. Klecker, R.F. Wimmer-Schweingruber, B. Thompson, P. Bochsler, P. Wurz, H. Daoudi, C. Giammanco, R. Karrer, A. Opitz, M. Koeten, A. Opitz, J.Luhmann, R. Howard, J. Wuelser,and M. Acuna

AGU May 2007 SH34-01



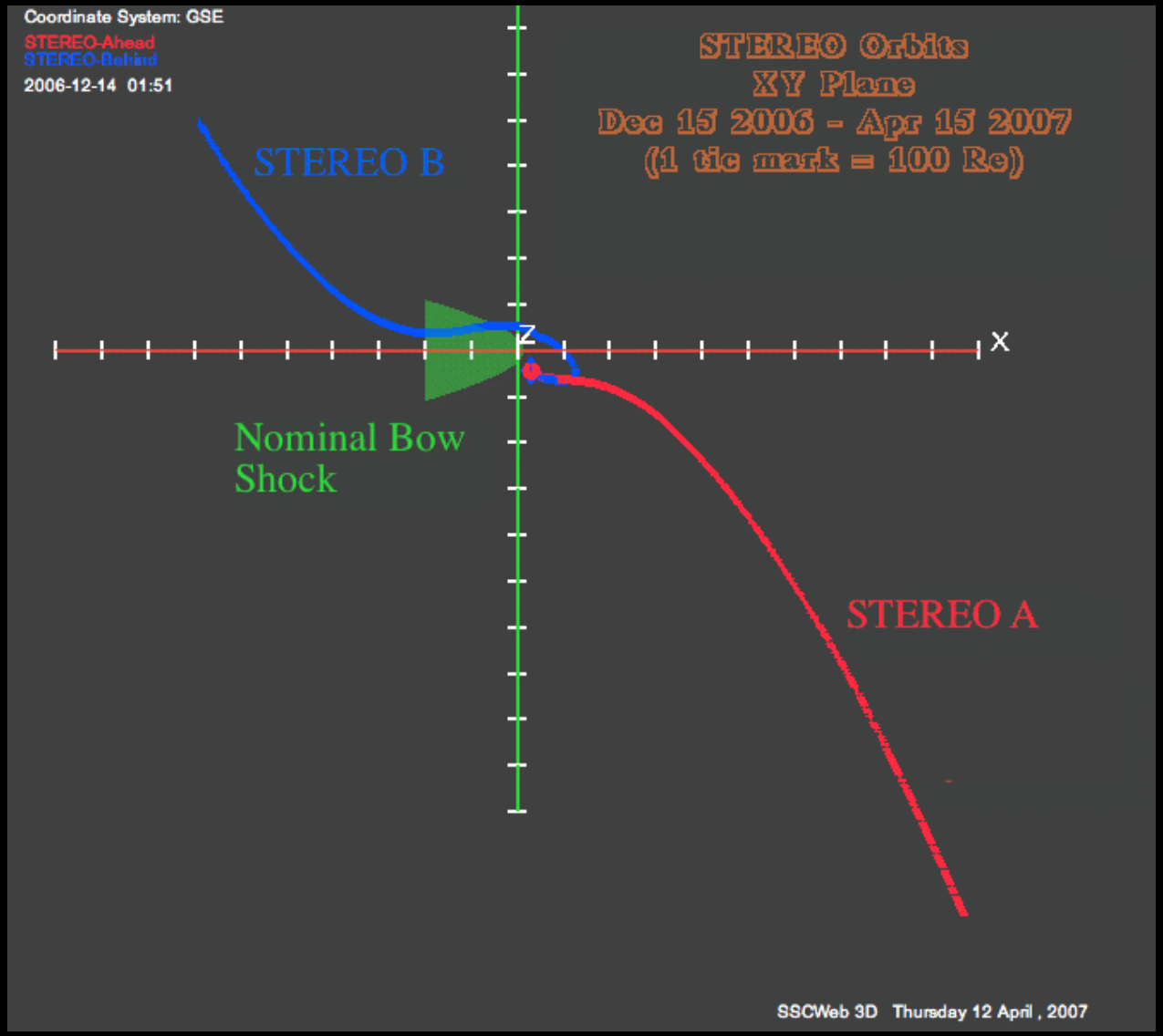


Heliospheric Diversity…



The data shown in the next three talks and tomorrow's poster represent at least four heliospheric particle populations with distinctly different origins:

Solar wind	**Origin: The Sun (coronal hole)**
Pickup ions (He+ ,< 40 keV/e)	**Origin: The Interstellar Medium**
Accelerated ions (H+,He+2, He+)	**Origin: Local - Interplanetary shock**
Magnetosphere (O+)	**Origin: Earth System**

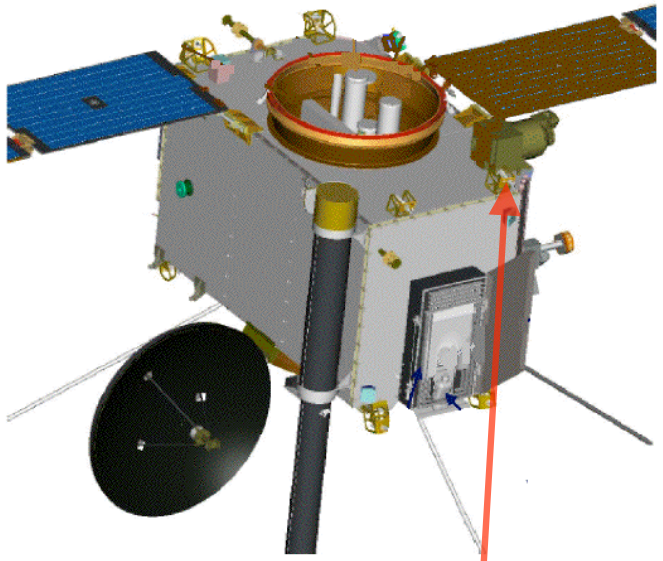


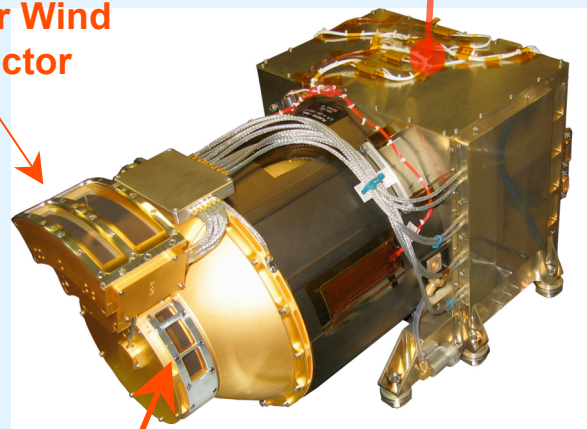
December 15 2006 - April 15 2007

- ***Solar Wind Sector* (SWS) Small (Proton) Channel** measures the distribution functions of **solar wind protons (H+)** and **alphas (He+2)**, providing proton density (*n*), speed (*Vsw*), kinetic temperature (*Tk*), and alpha to proton (He^{+2} / H+) ratios.

- ***Solar Wind Sector* (SWS) Main (Composition) Channel** measures the elemental composition, charge state distribution, kinetic temperature, and speed of the more abundant **solar wind heavy ions** (e.g., C, O, Mg, Si, and Fe).

- ***Wide-Angle Partition* (WAP)** measures distribution functions of **suprathermal ions**, including interplanetary shock-accelerated (IPS) particles associated with CME-related SEP events, recurrent particle events associated with Co-rotating Interaction Regions (CIRs), and heliospheric pickup ions.





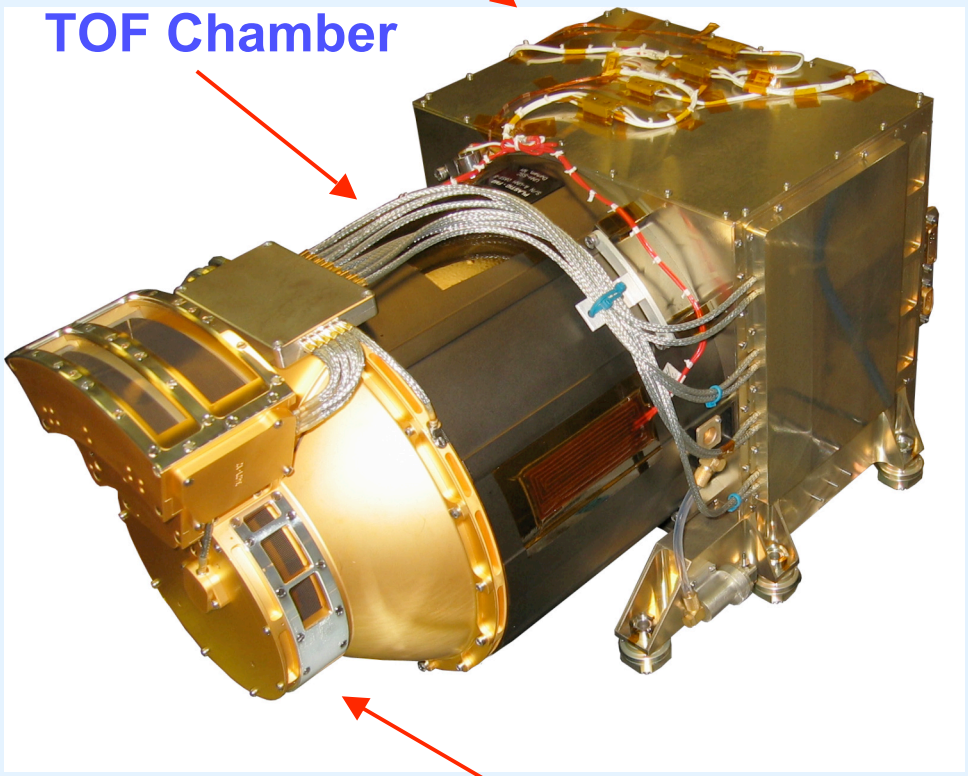
PLASTIC Early Mission Operations

- Commissioning of voltages (Electronics, Static Power Supplies -- PAC, MCP, SSD, and Static Mode -- ESA, DEFL) during Nov-Dec 2006
- Collection of full solar wind and suprathermal distribution (Sweeping Power Supplies -- ESA and DEFL) began mid-January 2007
  - Collection of full E/q distribution at 1 minute cycle rate from solar wind protons through suprathermal species (0.3-80 keV/e)

    PLASTIC-A January 18, 2007 at 21 UT

    PLASTIC-B January 19, 2007 at 23 UT
- During this time S/C-A was in the solar wind, S/C-B near Earth
- PLASTIC in-orbit tests and data evaluation
  - Verification, determination of instrument response, in-flight intercalibration
  - Refinement of instrument setting (optimizing detection efficiency, MCP 'scrubbing')
- Onboard moment calculations
  - Further refinement utilizing ground data ongoing

The PLAsma and SupraThermal Ion Composition (PLASTIC) Instrument



PLASTIC Flight Unit

Three structural elements comprise the instrument:

- **Entrance System**
- **Time-of-Flight (TOF) Chamber**
- **Electronics Box (EBox).**

PLASTIC Institutions:

UNH, U Bern, MPE, U Kiel, NASA/GSFC

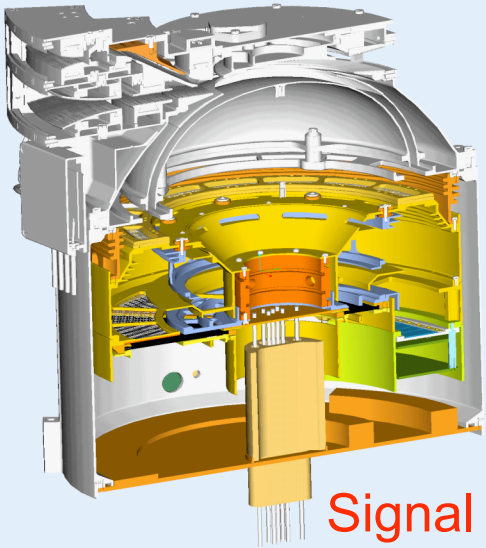
IDPU/LVC provided by UCB (IMPACT)

PLASTIC Measurement Principles & Detector Systems

The STEREO PLASTIC mass spectrometer is designed to provide composition (M, M/Q), energy spectra, and directional information for plasma and suprathermal ions in the energy range 0.3-80 keV/e.

Entrance System/ ESA

Time of Flight Chamber

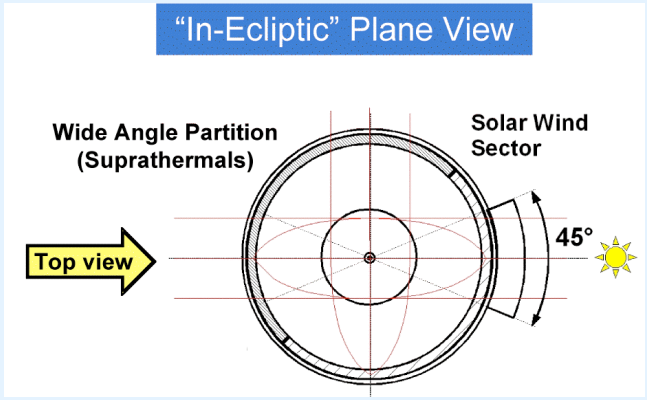


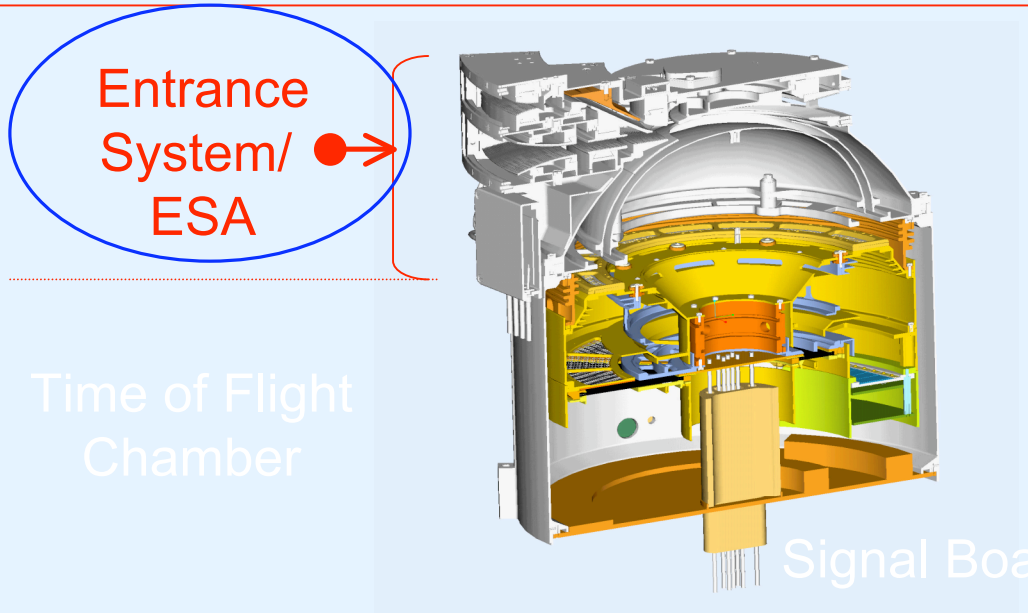
Signal Board

Subsystem Measurements

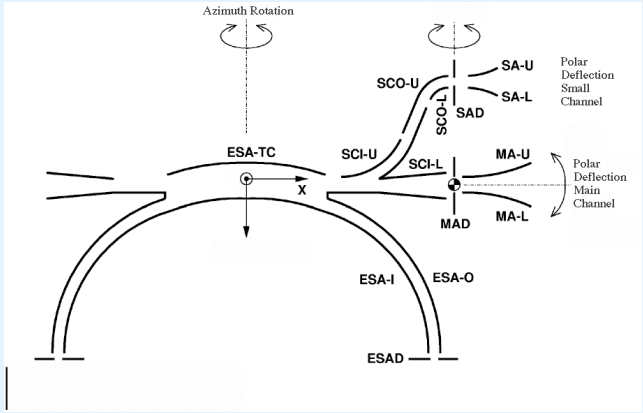
Entrance System		
	Deflectors	**Polar Angles**
	Geometrical Factors	**GFS, GFM, GFW**
	Electrostatic Analyzer	**E/q**
Time-of-Flight Chamber		
	C-foil, MCPs	**TOF**
	SSDs	***E***
Signal Board		
	TOF Anodes	**TOF**
	Position Anodes	**Azimuth Angles**

PLASTIC Measurement Principles & Detector Systems





Cross-section View

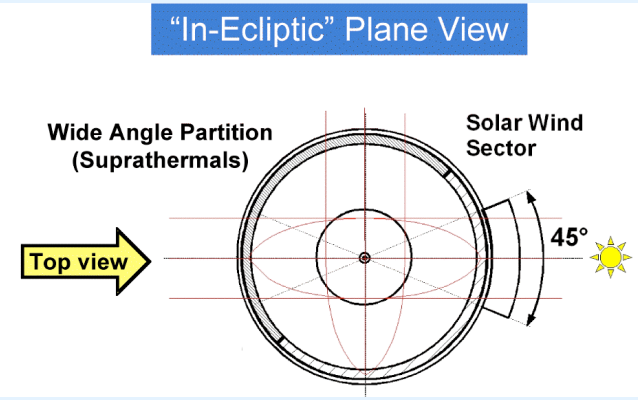


■ESA [Steps 0-127] selects ions from 80 keV/e down to 0.3 keV/e. Deflectors select angles within +/- 20° of the ecliptic (DEFL bins 0-31).

Subsystem Measurements

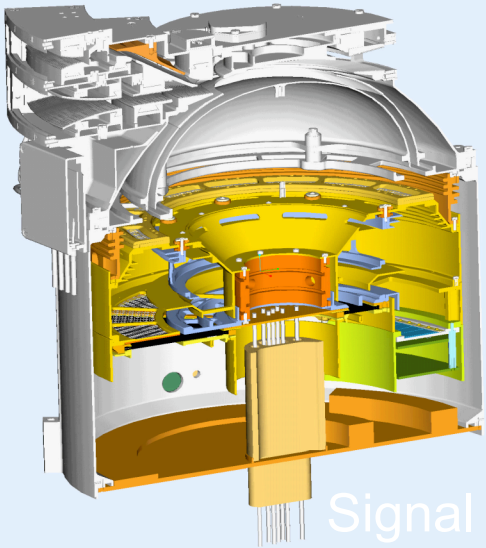
Entrance System	
Deflectors	Polar Angles
Geometrical Factors	GFS, GFM, GFW
Electrostatic Analyzer	E/q
Time-of-Flight Chamber	
C-foil, MCPs	TOF
SSDs	*E*
Signal Board	
TOF Anodes	TOF
Position Anodes	Azimuth Angles

PLASTIC Measurement Principles & Detector Systems



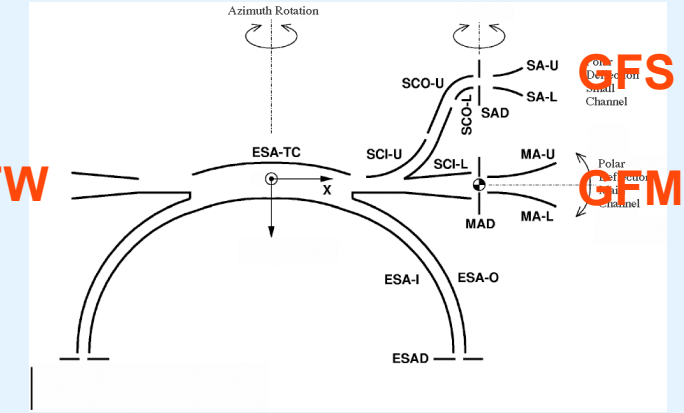
Entrance System/ ESA

Time of Flight Chamber



Signal Board

Cross-section View

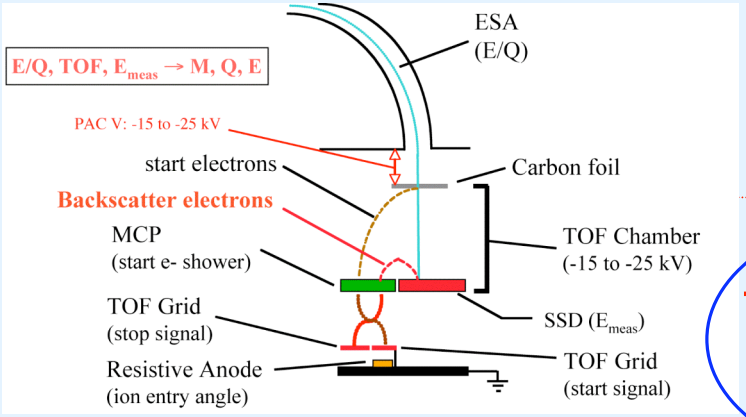


■Geometrical Factor Selection in the Solar Wind Sector is based on observed count rate.

Subsystem Measurements

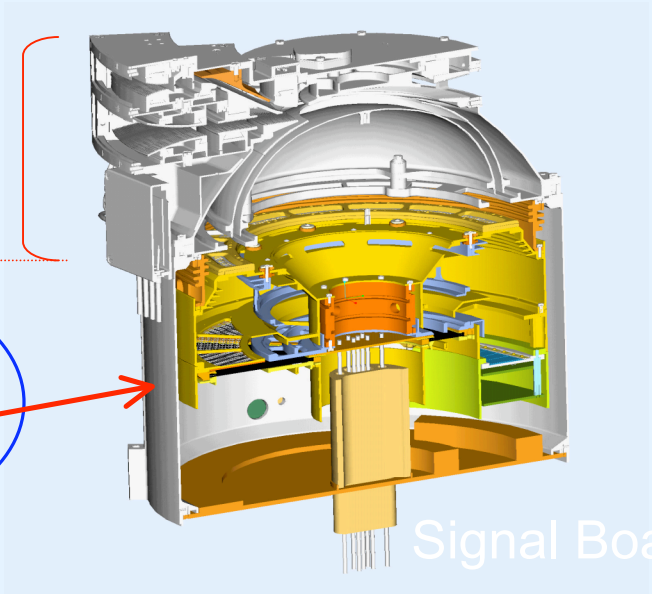
Entrance System	
Deflectors	**Polar Angles**
Geometrical Factors	**GFS, GFM, GFW**
Electrostatic Analyzer	**E/q**
Time-of-Flight Chamber	
C-foil, MCPs	**TOF**
SSDs	***E***
Signal Board	
TOF Anodes	**TOF**
Position Anodes	**Azimuth Angles**

PLASTIC Measurement Principles & Detector Systems



Entrance System/ ESA

Time of Flight Chamber



- Ions are accelerated by "post acceleration" PAC voltage - currently commanded at -20 kV.

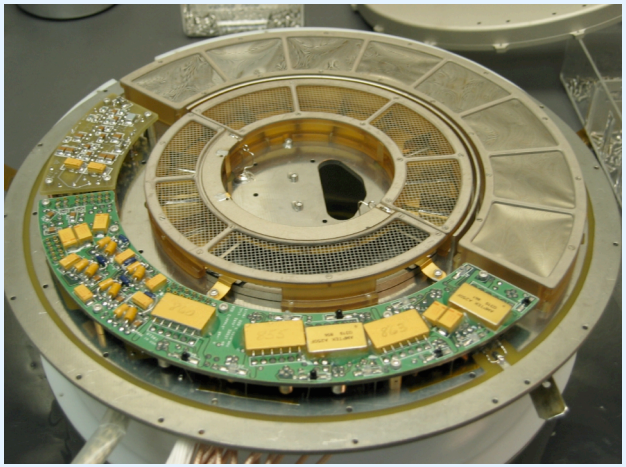
- Time of flight (TOF) is obtained from secondary electrons (SE) emitted from the carbon foil ('start') and from the surface of the SSD ('stop'). These electrons are electrostatically guided to the MCP.

- Solid State Detectors provide the measured residual energy (E).

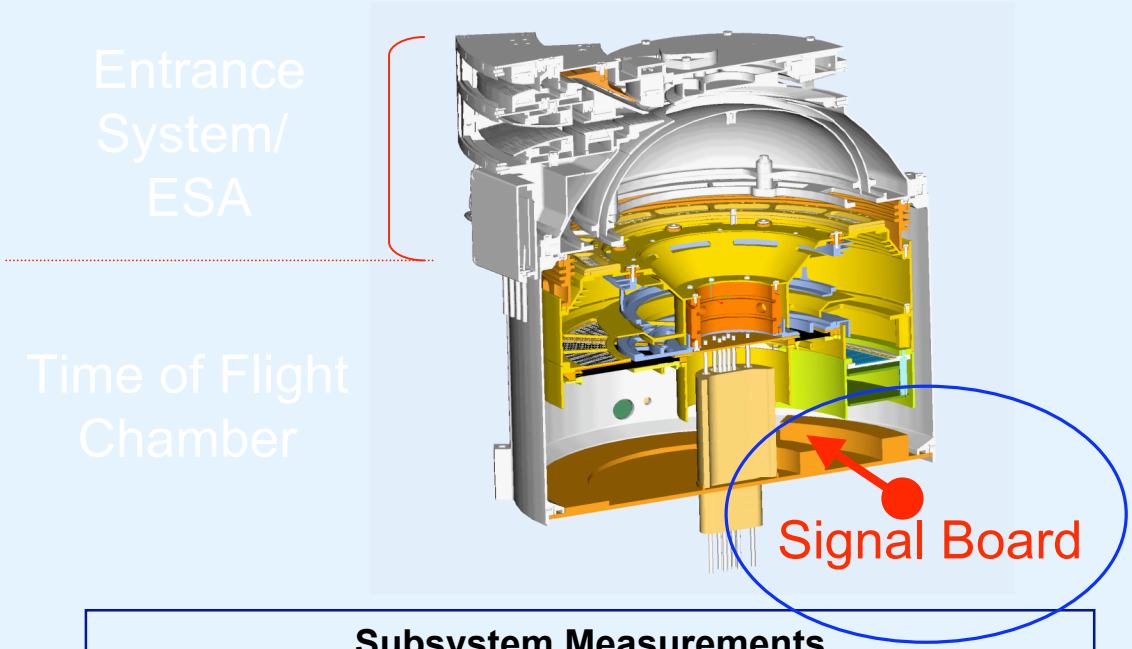
Subsystem Measurements

Entrance System		
	Deflectors	**Polar Angles**
	Geometrical Factors	**GFS, GFM, GFW**
	Electrostatic Analyzer	**E/q**
Time-of-Flight Chamber		
	C-foil, MCPs	**TOF**
	SSDs	***E***
Signal Board		
	TOF Anodes	**TOF**
	Position Anodes	**Azimuth Angles**

PLASTIC Measurement Principles & Detector Systems



- Signal Board has the Start and Stop Anodes for the MCPs.
- A Resistive Anode provides the azimuth direction for the Solar Wind Sector
- Coarser (22°) azimuth directional information in the Suprathermal "WAP" section is provided by discrete position anodes.

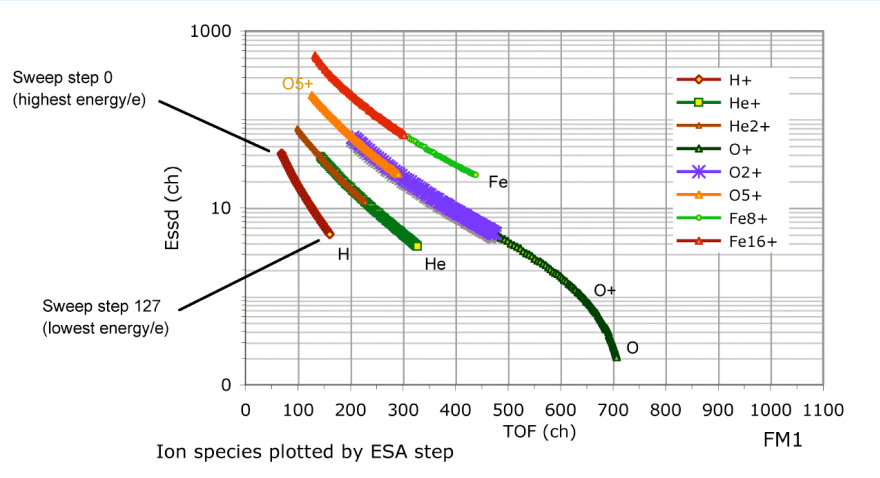


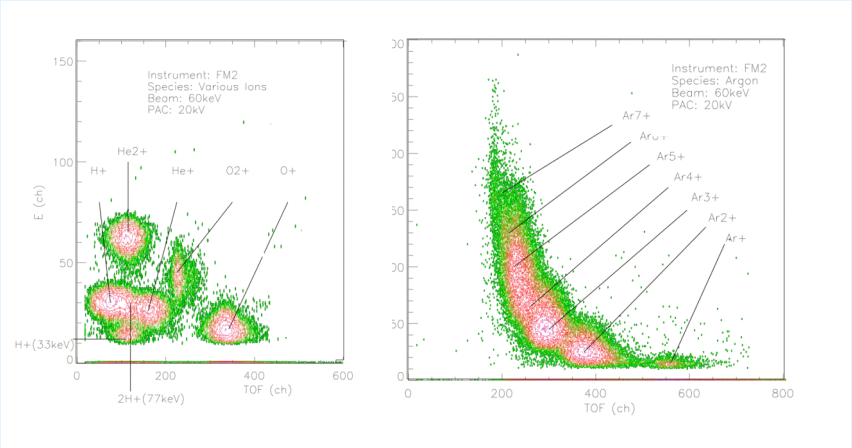
Subsystem Measurements

Entrance System		
	Deflectors	**Polar Angles**
	Geometrical Factors	**GFS, GFM, GFW**
	Electrostatic Analyzer	**E/q**
Time-of-Flight Chamber		
	C-foil, MCPs	**TOF**
	SSDs	***E***
Signal Board		
	TOF Anodes	**TOF**
	Position Anodes	**Azimuth Angles**

PLASTIC MASS SPECTROSCOPY
Composition as “E-TOF Tracks”

Each Element has its own track in Energy vs. Time-of-flight.



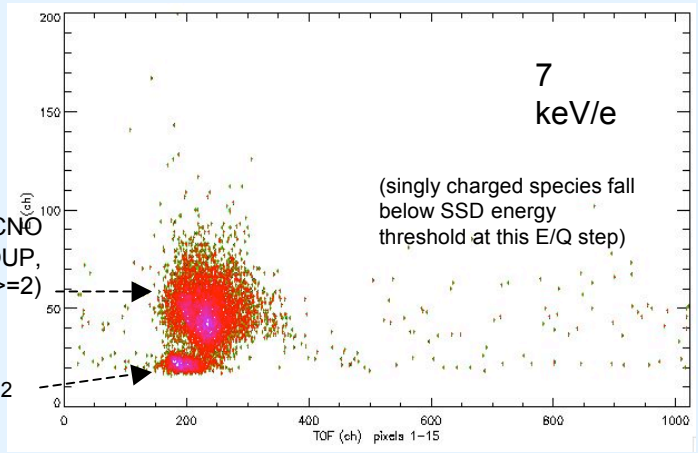


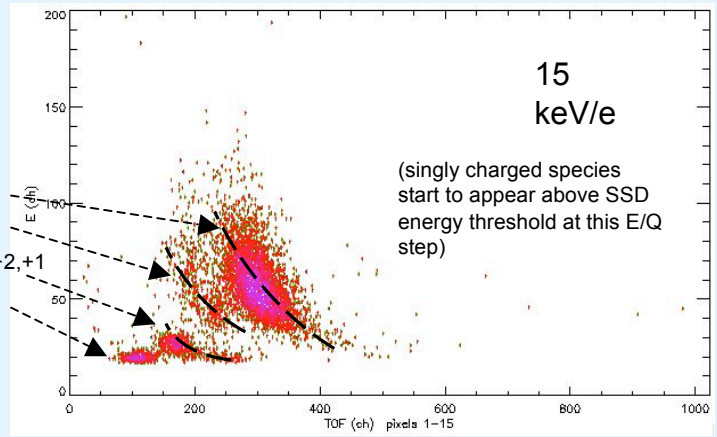
Prelaunch Energy vs. TOF calibration for PLASTIC-B taken at U Bern CASYMS Facility

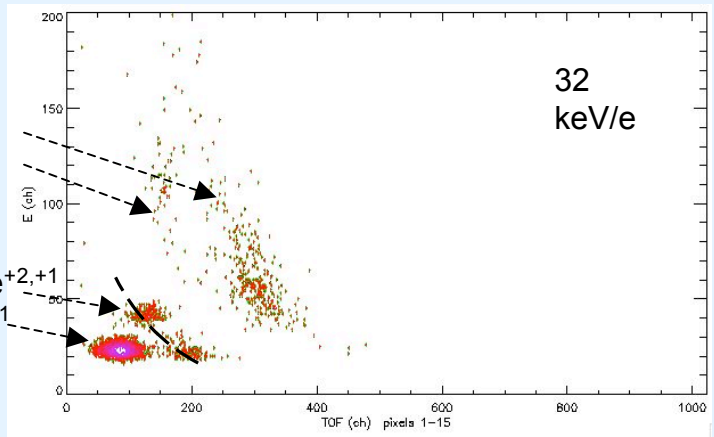
Position on track depends on incident Energy.

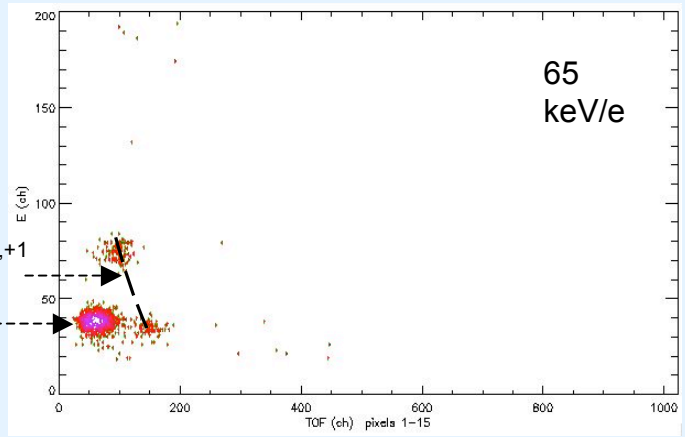
[Faster particles move to higher E and lower Time-of-flight.]

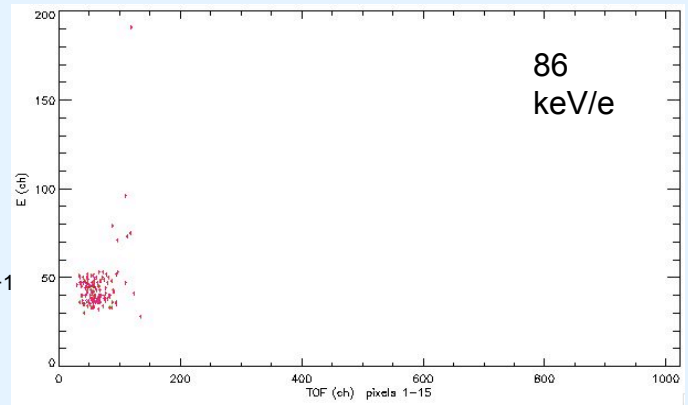
STEREO A PLASTIC
"First Light"
Dec 8, 2006
(Conditions: CH solar wind, SEP, ESP)
Energy vs Time-of-Flight
At Suprathermal Energies
(PAC at 17kV)

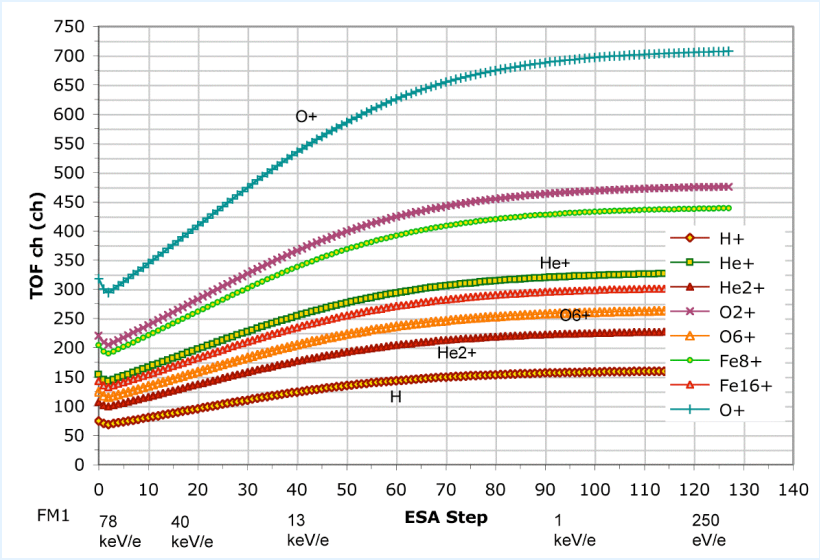








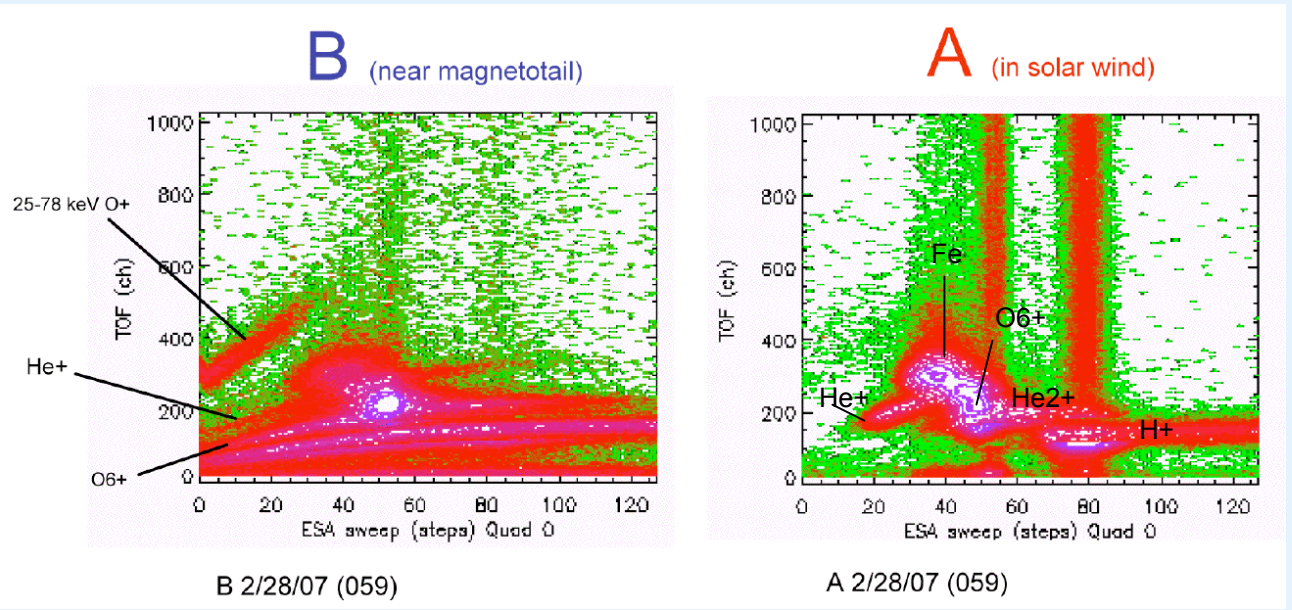




PLASTIC M/Q SPECTROSCOPY Composition as "TOF vs ESA Step" Tracks"

For suprathermals, species may be observed over a broad range of E/Q steps.

For solar wind, species travel together at about the same speed.

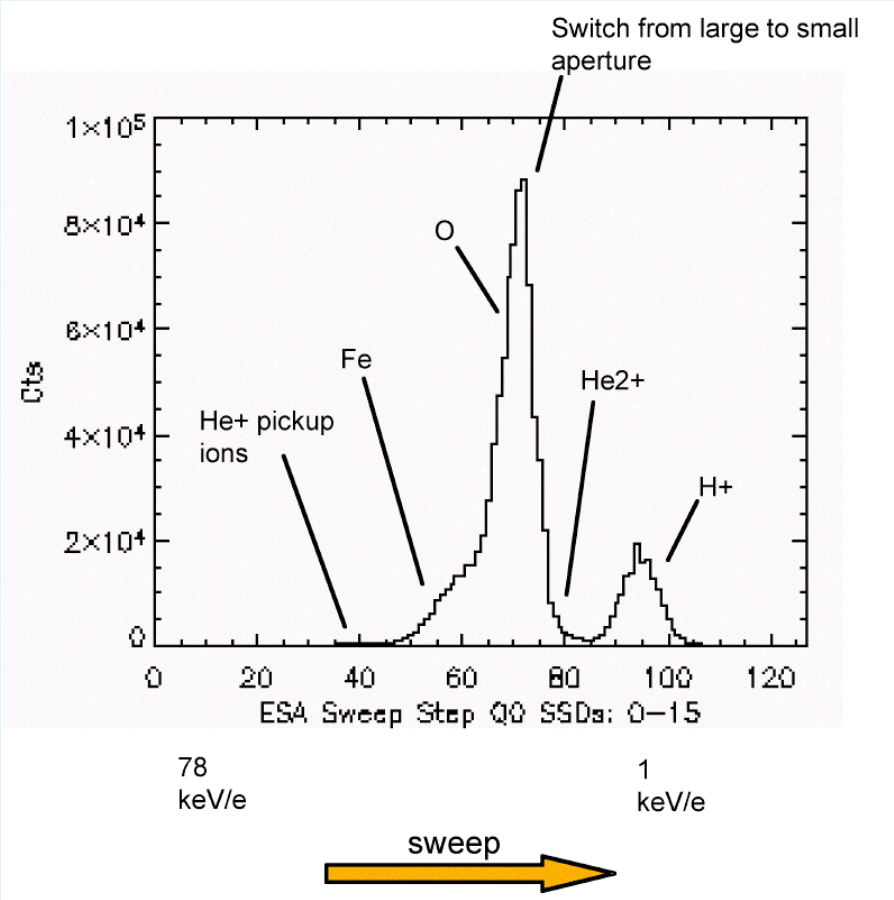


B 2/28/07 (059)

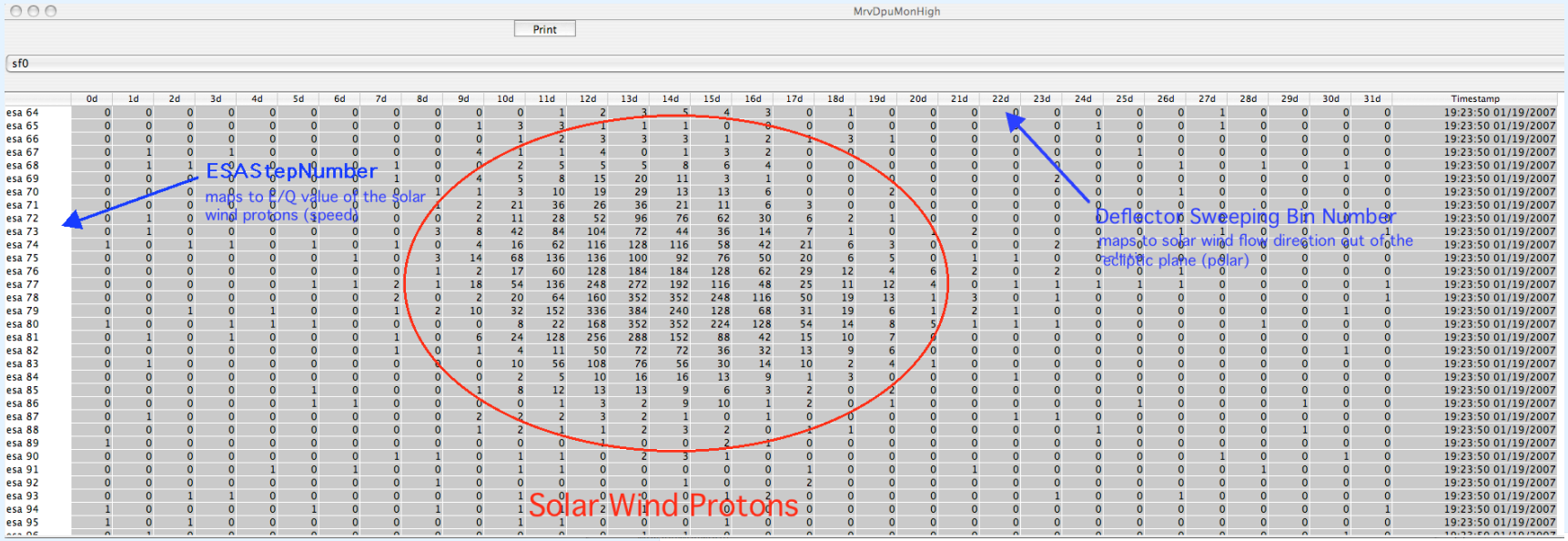
A 2/28/07 (059)

Typical Solar Wind Sector ESA Step Sweep: Main to Small Channel Transition

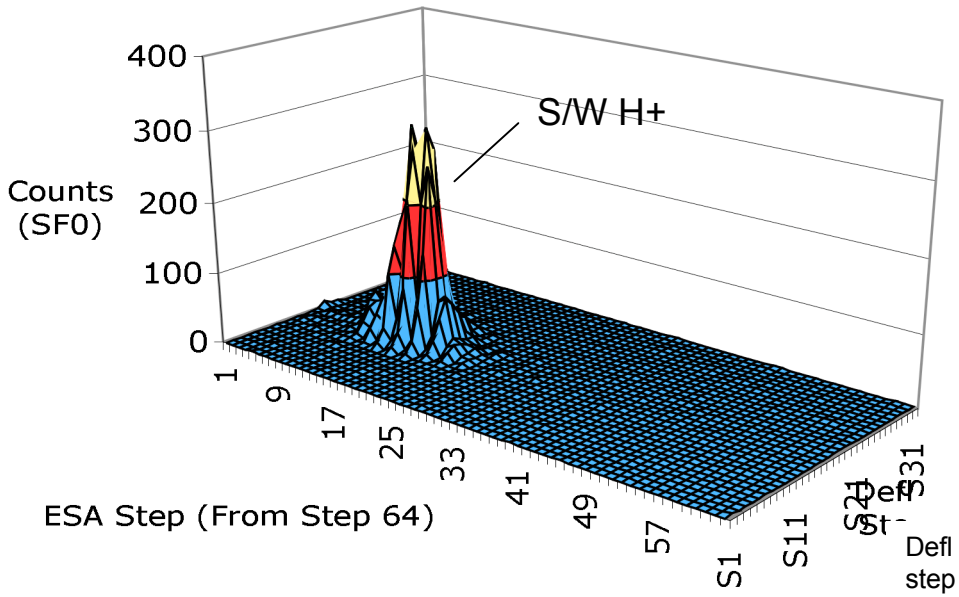
- Sweep starts at high E/Q
- He+ pickup ions are seen first.
- Solar wind ions typically move together at approximately the same speed, although heavy ions may be faster than H+.
- Solar wind ions begin to appear in sweep in order of E/Q ==> M/Q.
- PLASTIC switches from Main Channel to Small Channel to control the count rate when solar wind He^{2+} and H_+ enter.



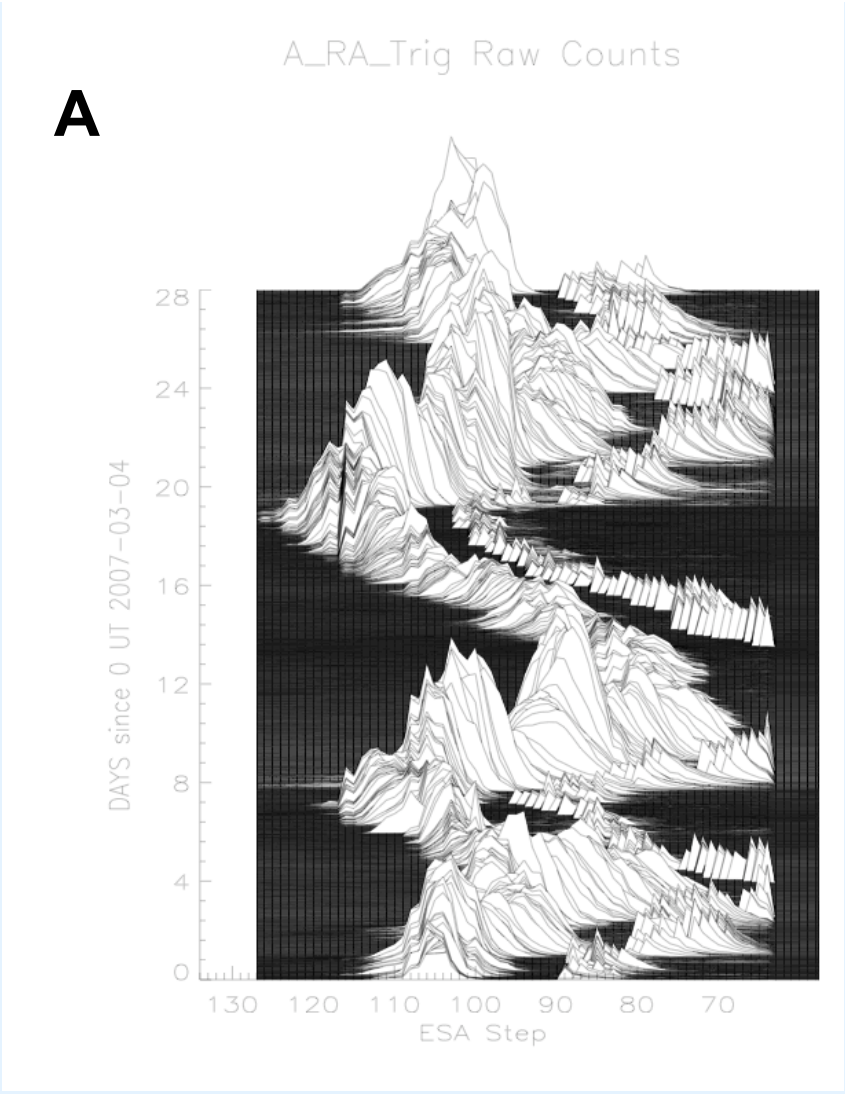
PLASTIC Solar Wind Protons in the "Small Channel"

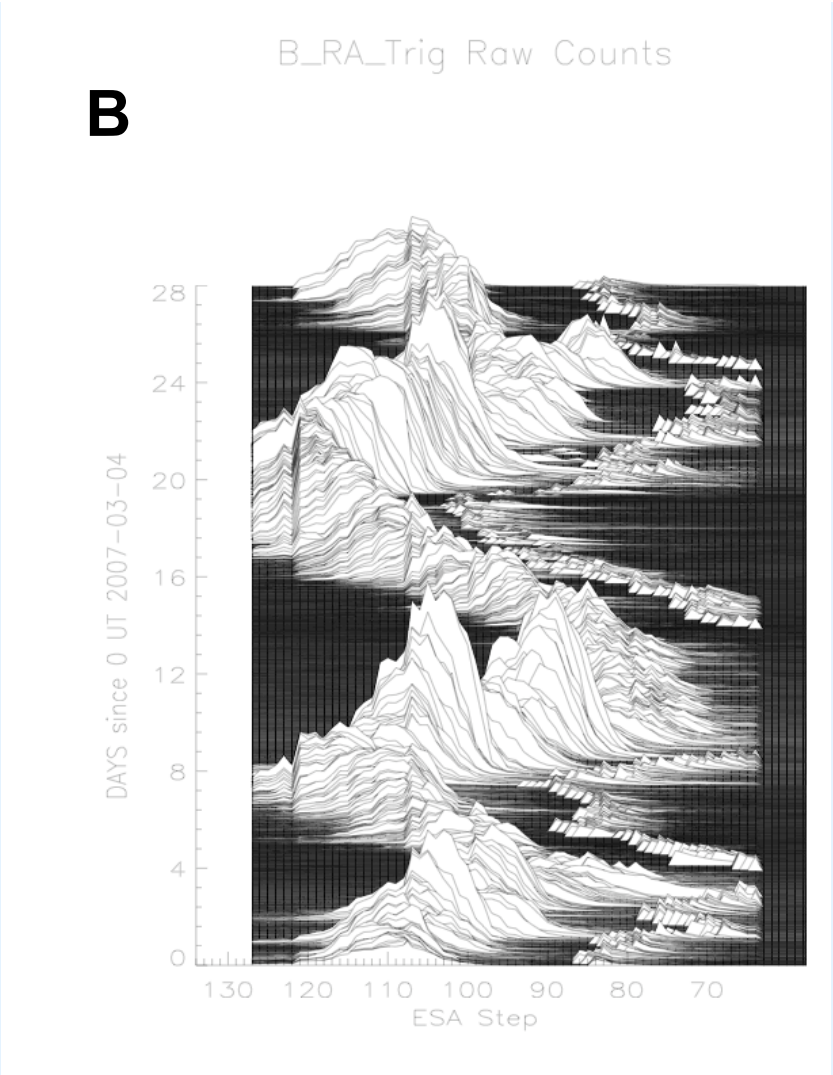


In this snapshot display, we observe the solar wind protons in a rate with one minute cadence which provides counts per ESA step vs Deflection Angle bin.



PLASTIC figures courtesy Katherine Singer and Mark Popecki. POCC displays by Lorna Ellis and Mike Vosbury.



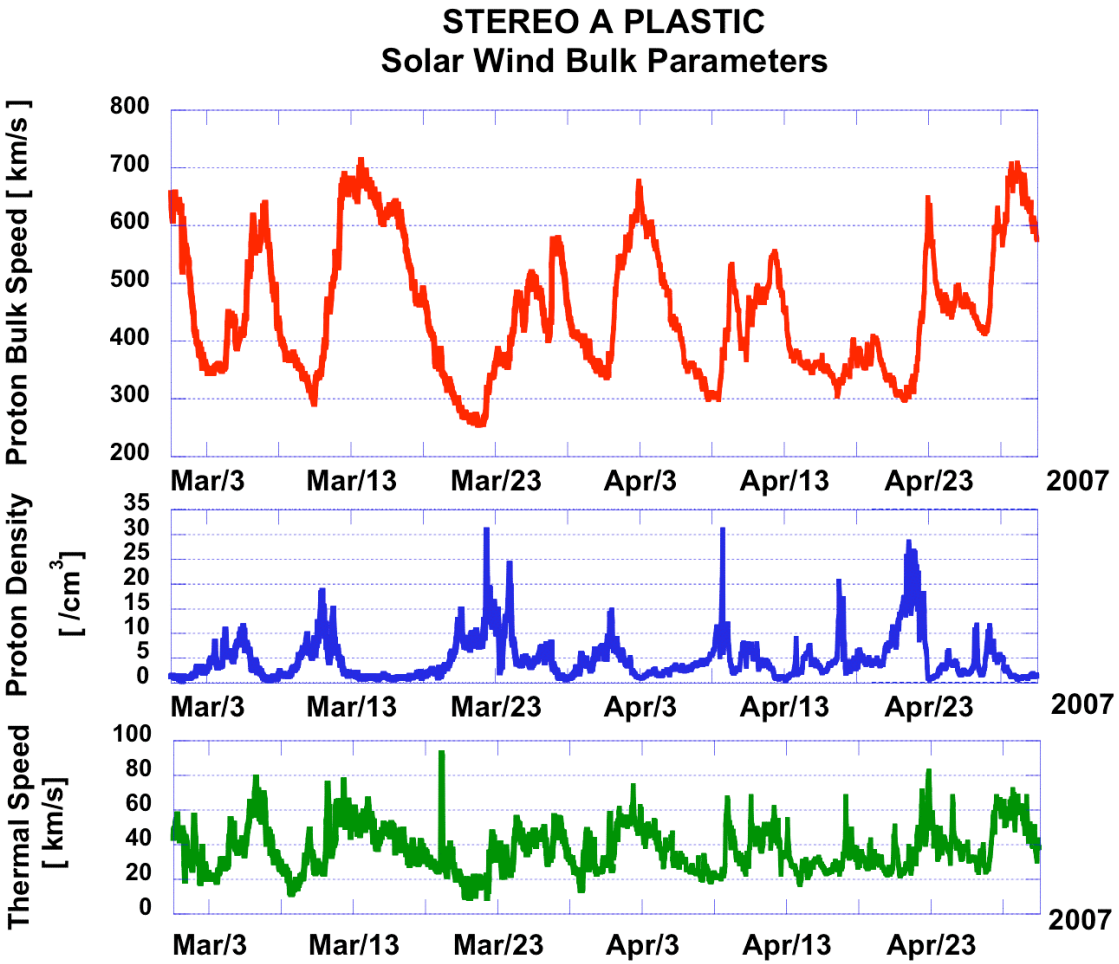


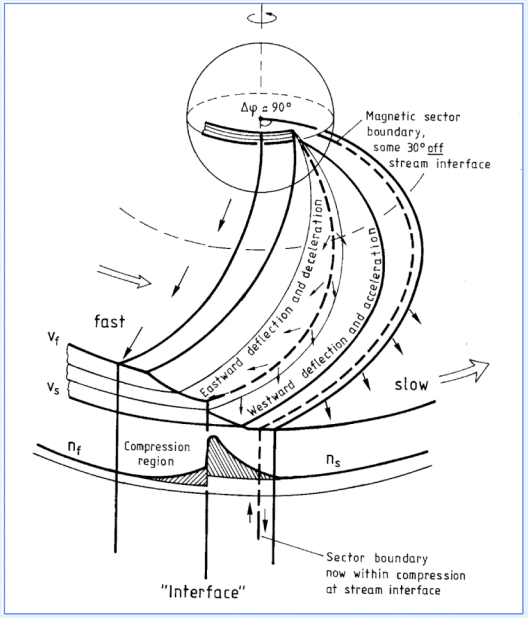
Solar Wind Protons - time series

Shown to the left is a time series taken by PLASTIC A of solar wind protons over Carrington Rotation 2054. Each horizontal trace is one minute of data, as shown in the previous slide. There are 1440 such ESA sweeps per day. On the right is the same period for PLASTIC B. STEREO B was still near-Earth.

Stack Plots courtesy K. Simunac

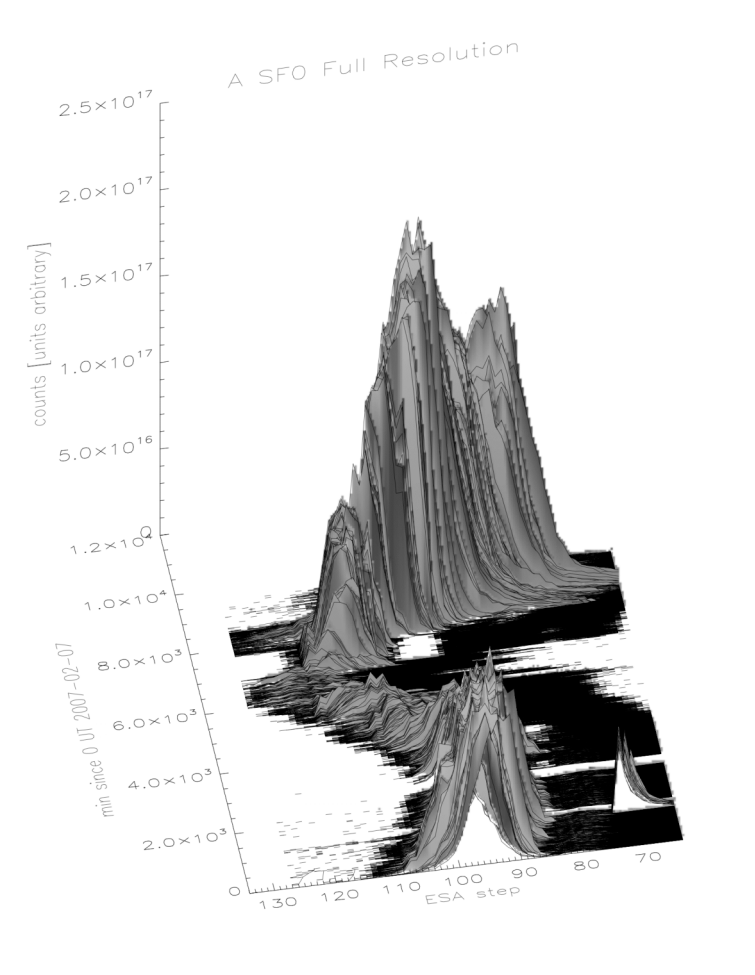
Solar Wind Proton Bulk Parameters

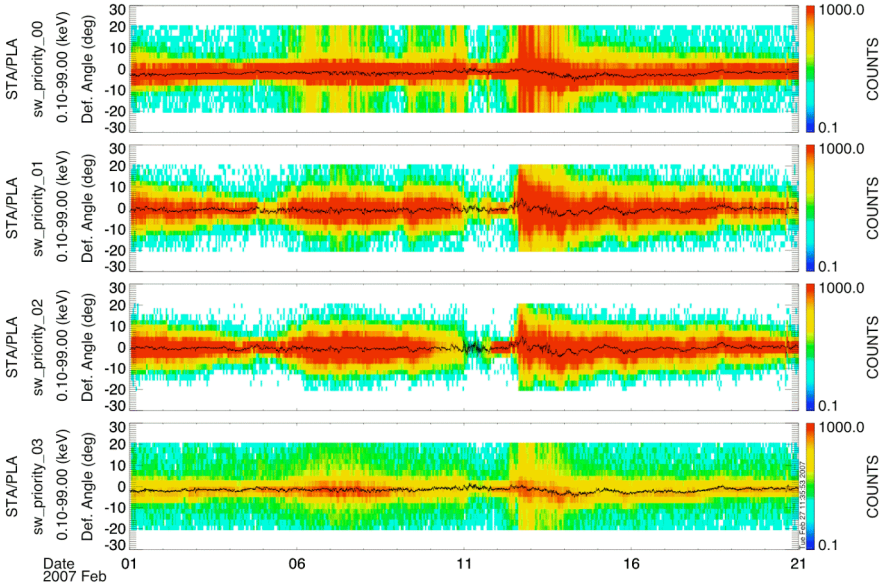


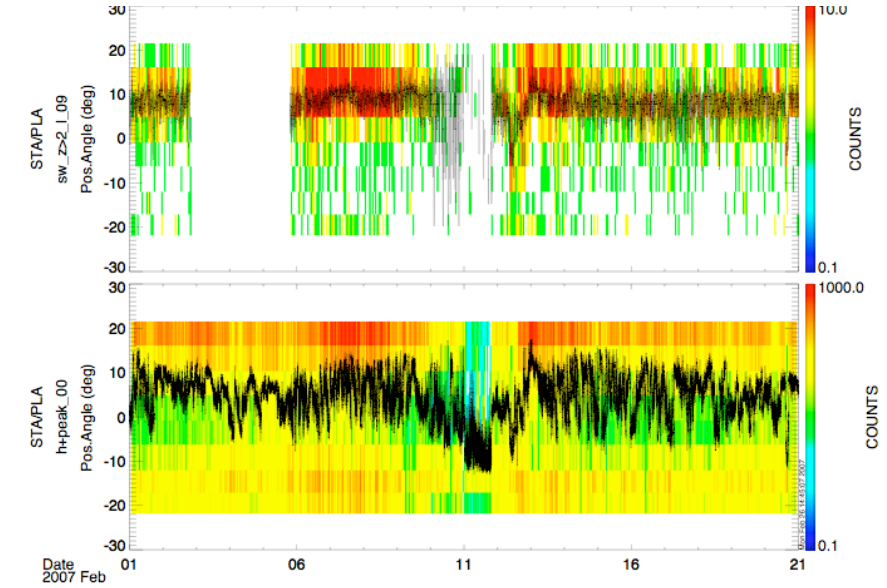


Signatures of recurrent high-slow speed stream interface (co-rotating interaction regions, or CIRs)

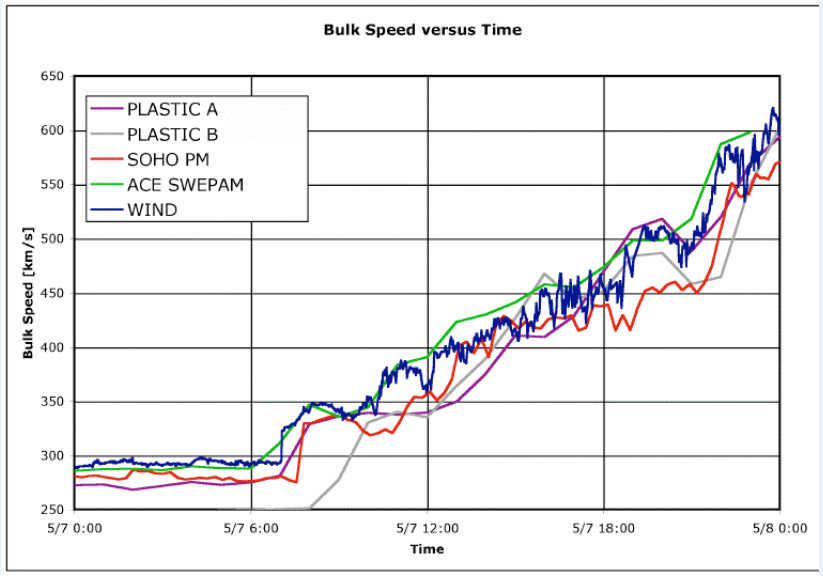
Solar Wind Flow Angles







CIR Compression Region

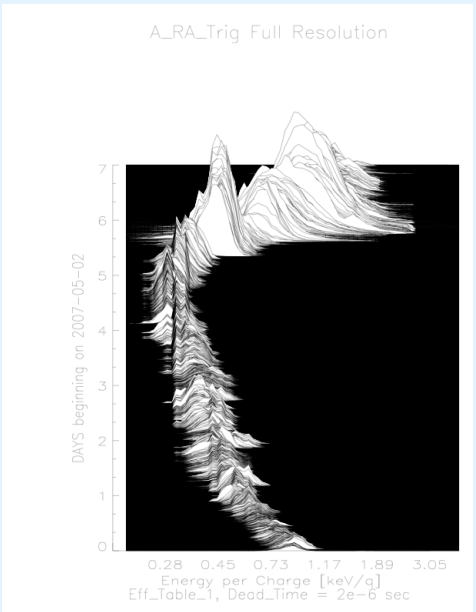


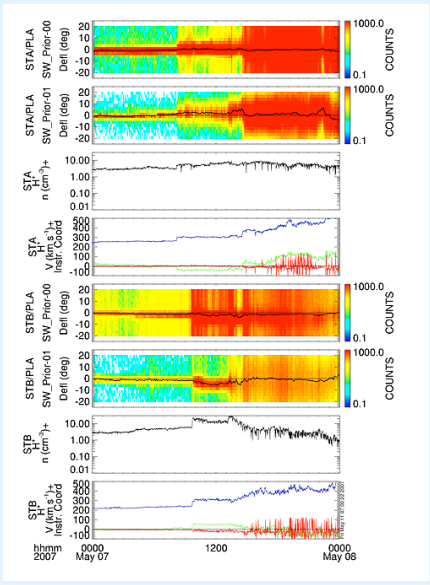
SOHO - P Bochsler PI

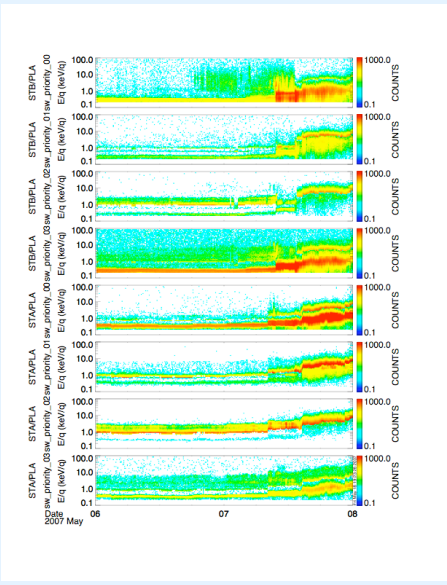
F. Ipavich PM Lead

ACE - D. McComas PI

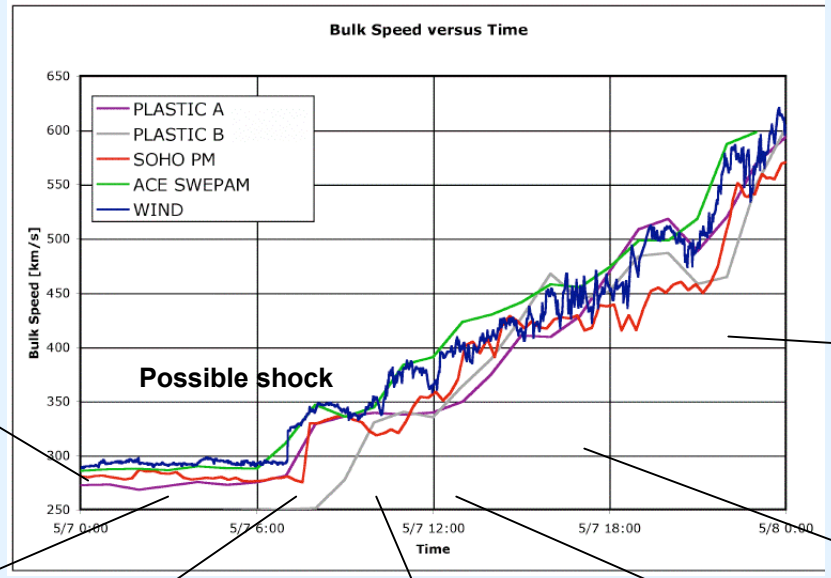
Wind - K. Ogilvie PI

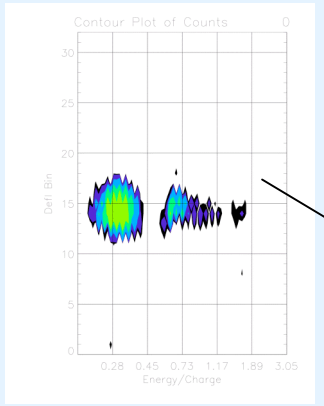


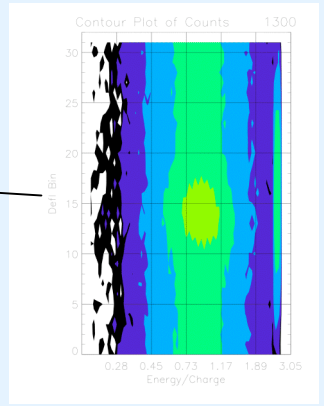


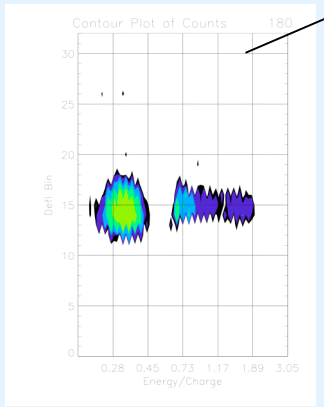


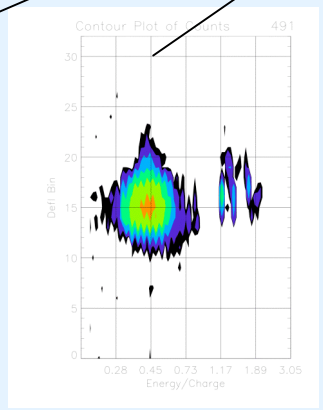
CIR Compression Region

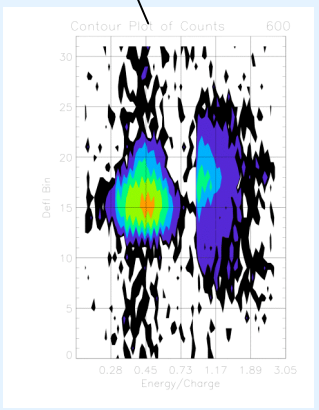


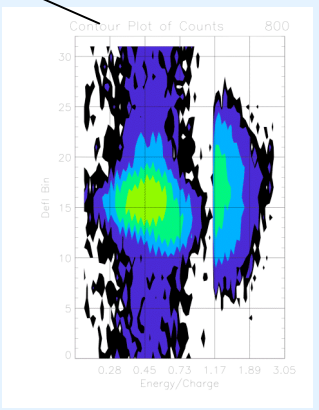


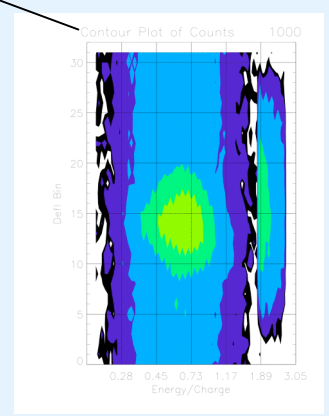










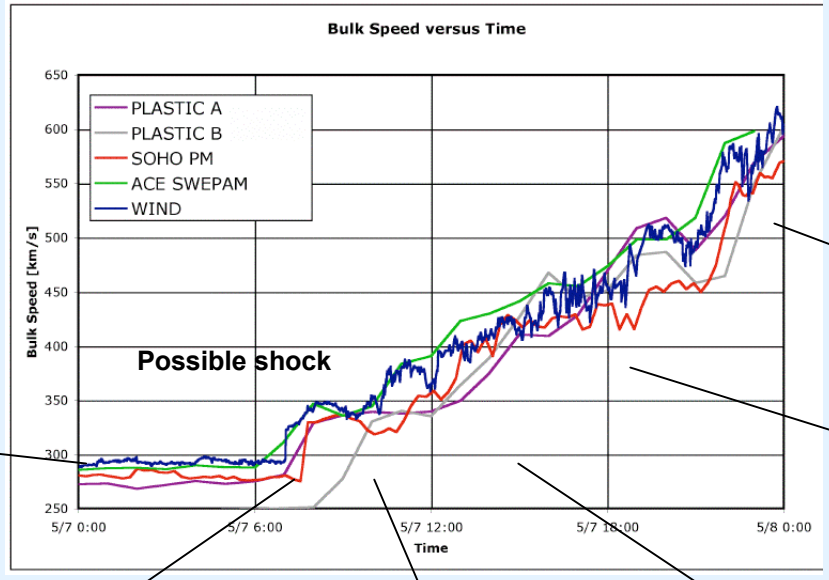


Deflection

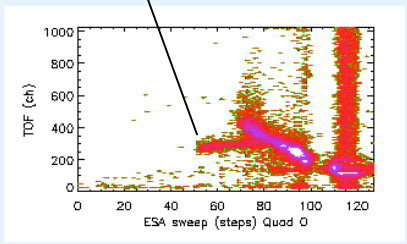
Energy per charge

Distribution Angle and E/Q

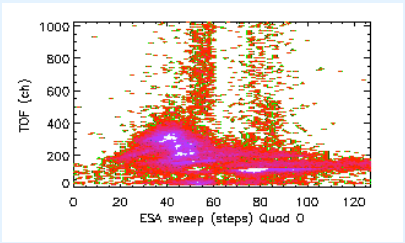
CIR Compression Region

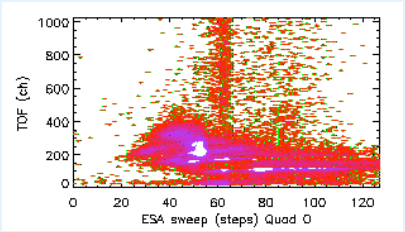


He+

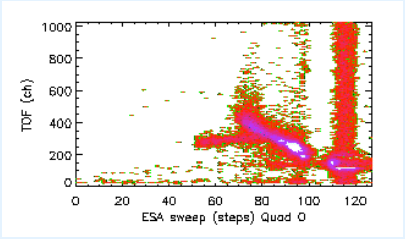


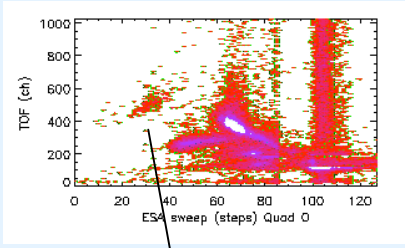
Possible shock

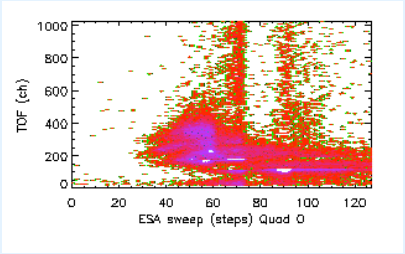




TOF







Energy per charge

O+

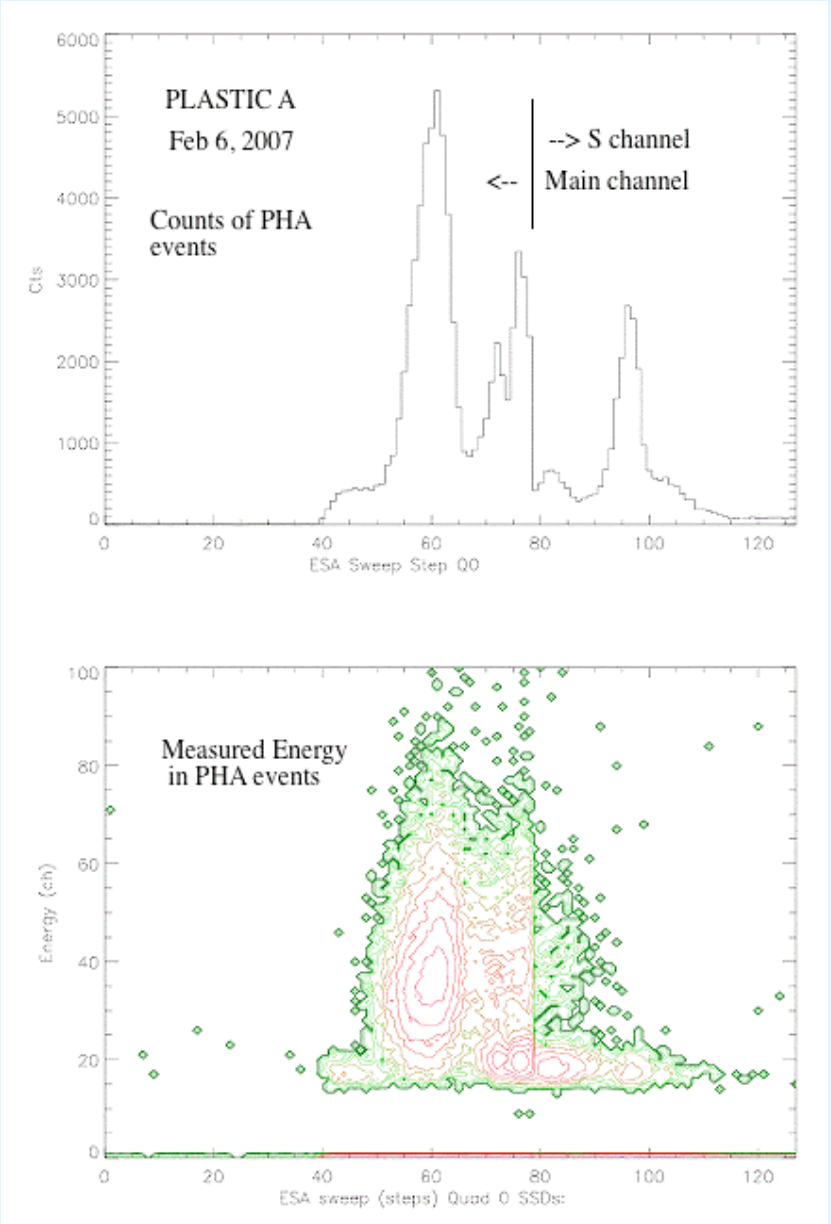
Composition

Solar Wind Minor Ions

In order to view the less abundant (0.1%) minor ions in the solar wind, the instrument incorporates two solar wind geometrical factors and also employs a prioritization scheme on the data accumulation.

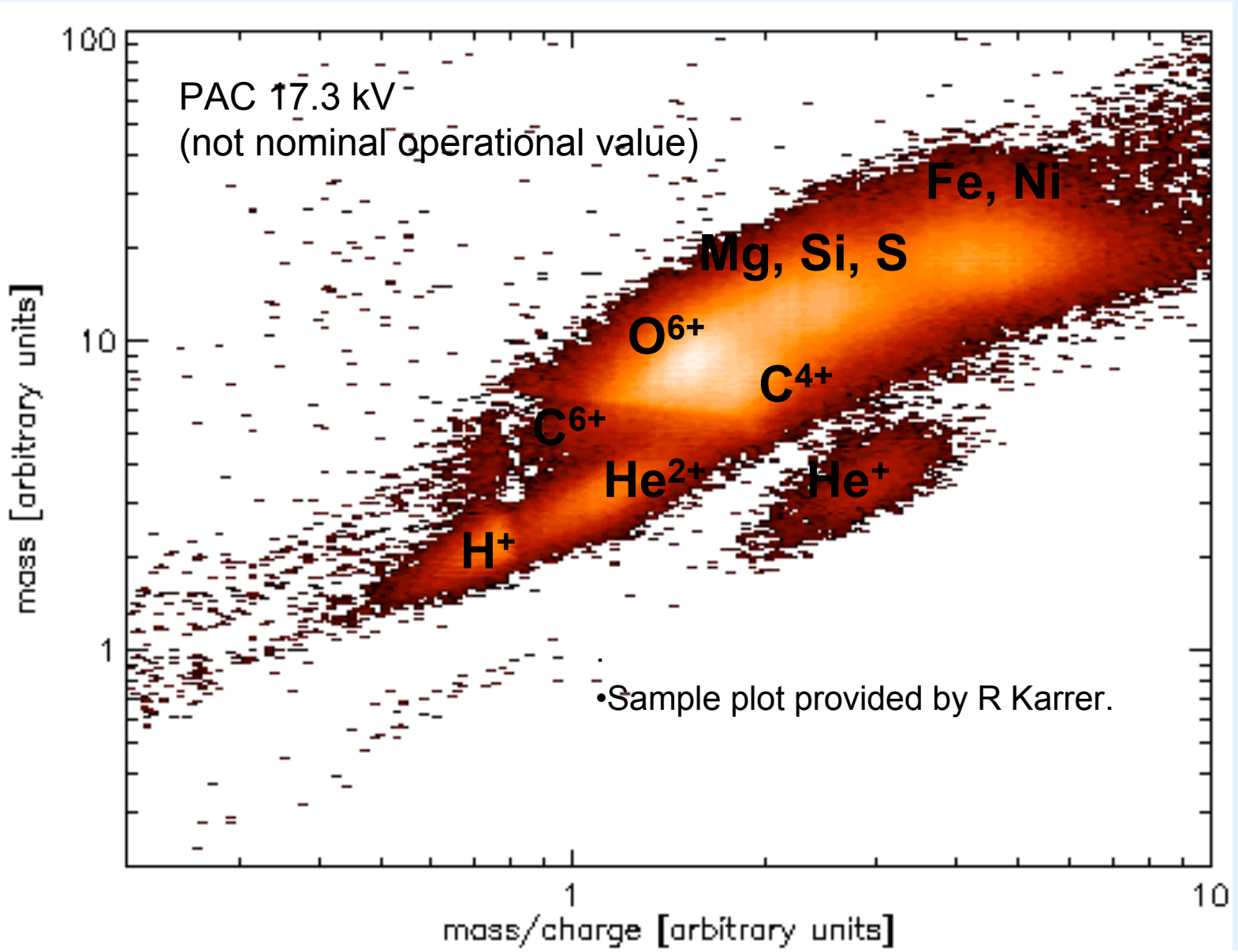
Shown here are composition data (called pulse height events) from two hours of accumulation, plotted against the E/Q parameter.

Some features (to the practiced eye) include the pickup ion He+, solar wind Fe, O, alphas and protons.



Plots courtesy Mark Popecki.

20 January 2007, 0-24, STEREO A

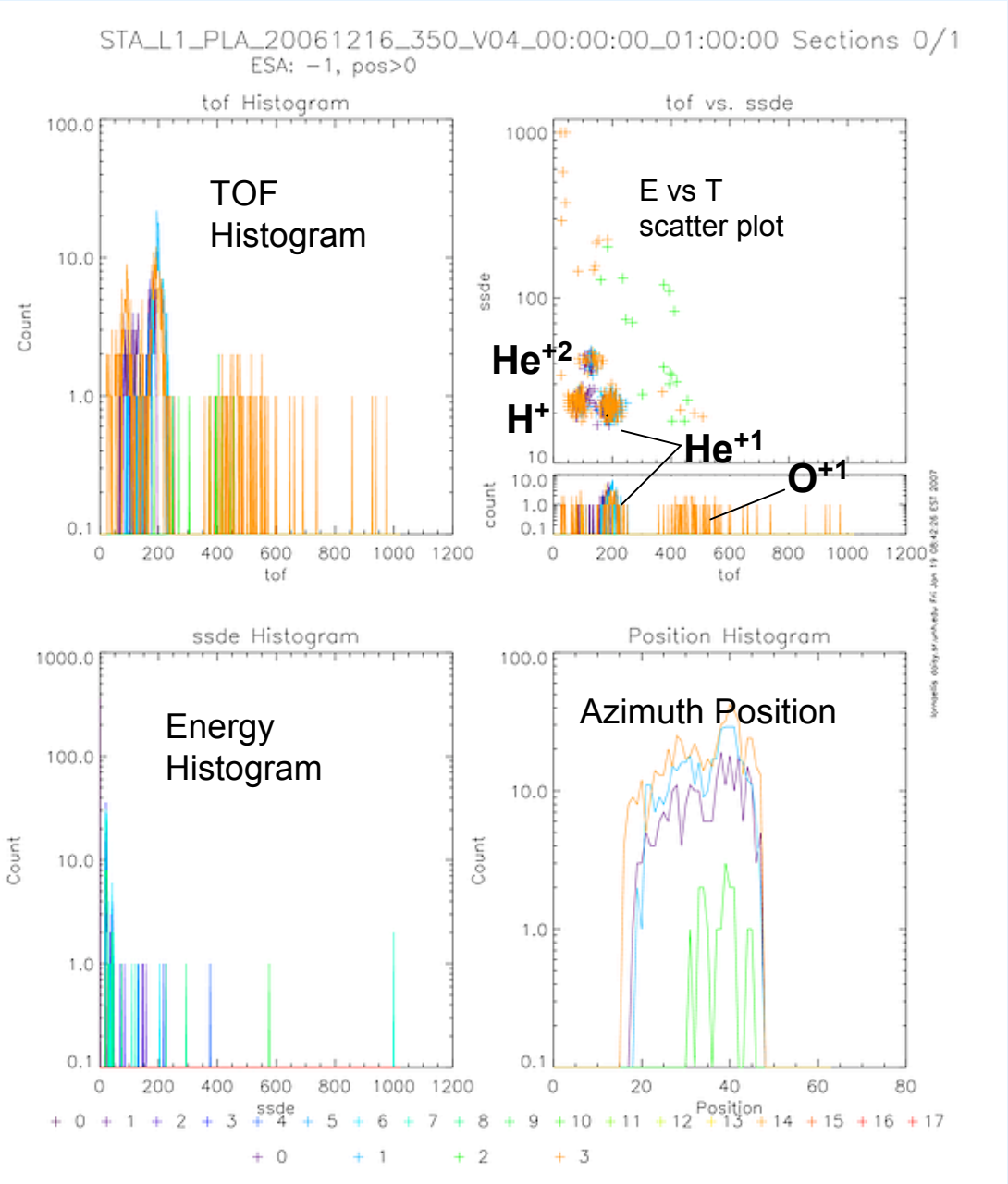


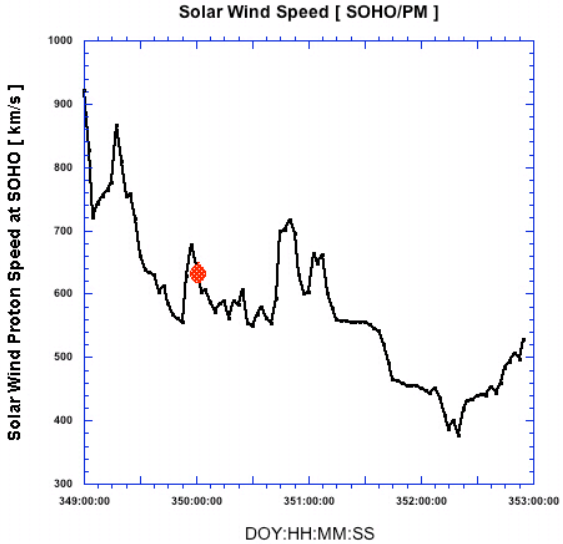
- Sample plot provided by R Karrer.

Suprathermal Temporal Variations

The next slides show ion composition from a fixed suprathermal energy -- 32 keV/e. Species types and intensity change over the two day period sampled.

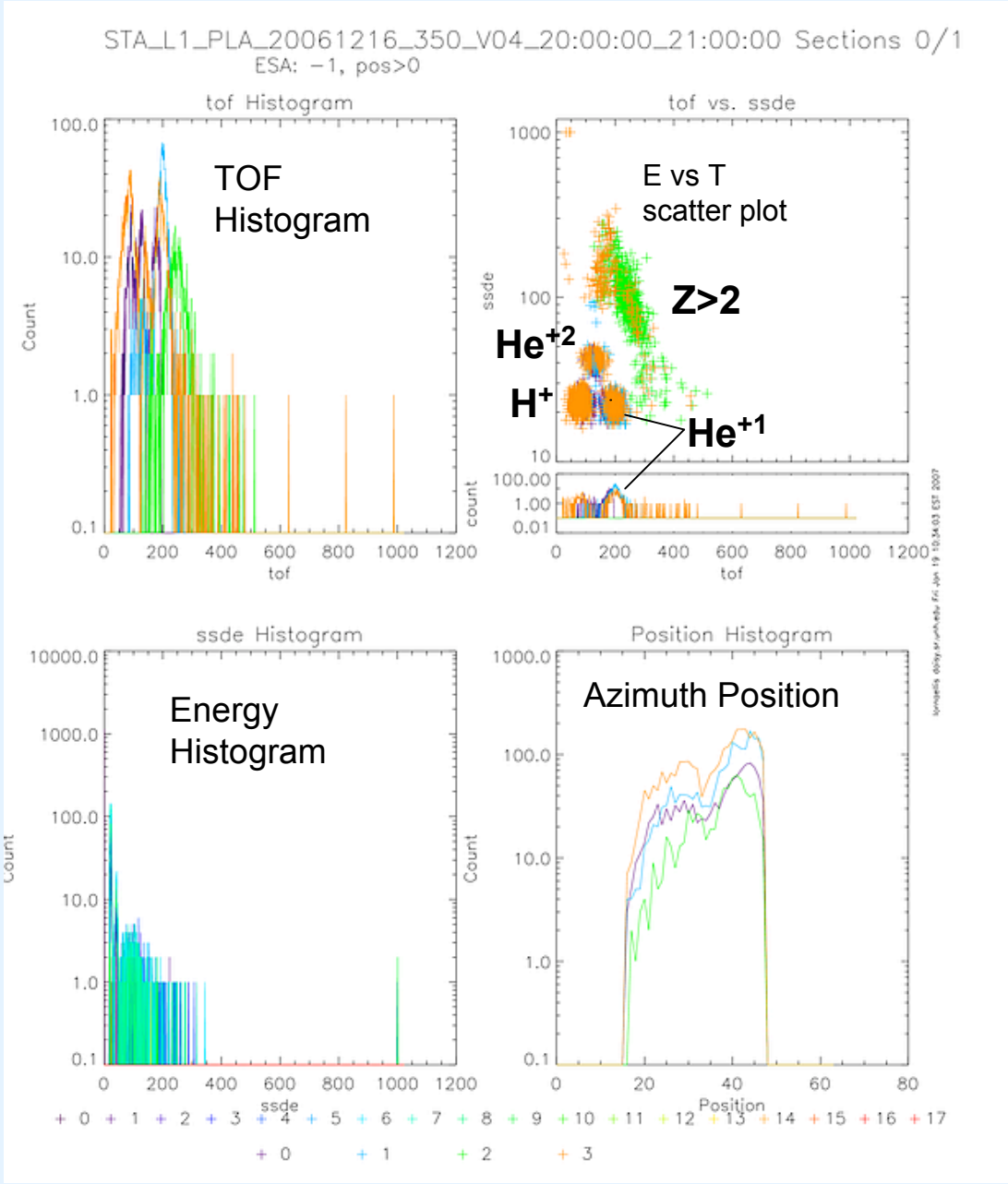
Note presence of Z>2 species during times of higher solar wind speeds, and overall decreased intensities as the solar wind speed declines at the end.

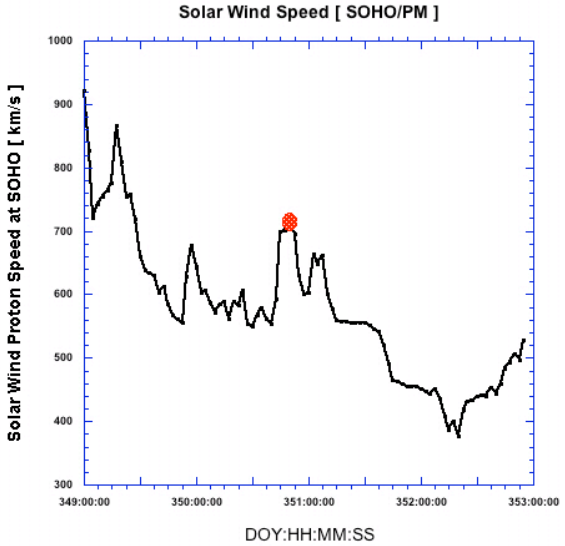




Above: Solar wind speed (SOHO/PM). Red dot corresponds to time of STEREO composition measurement shown on left.

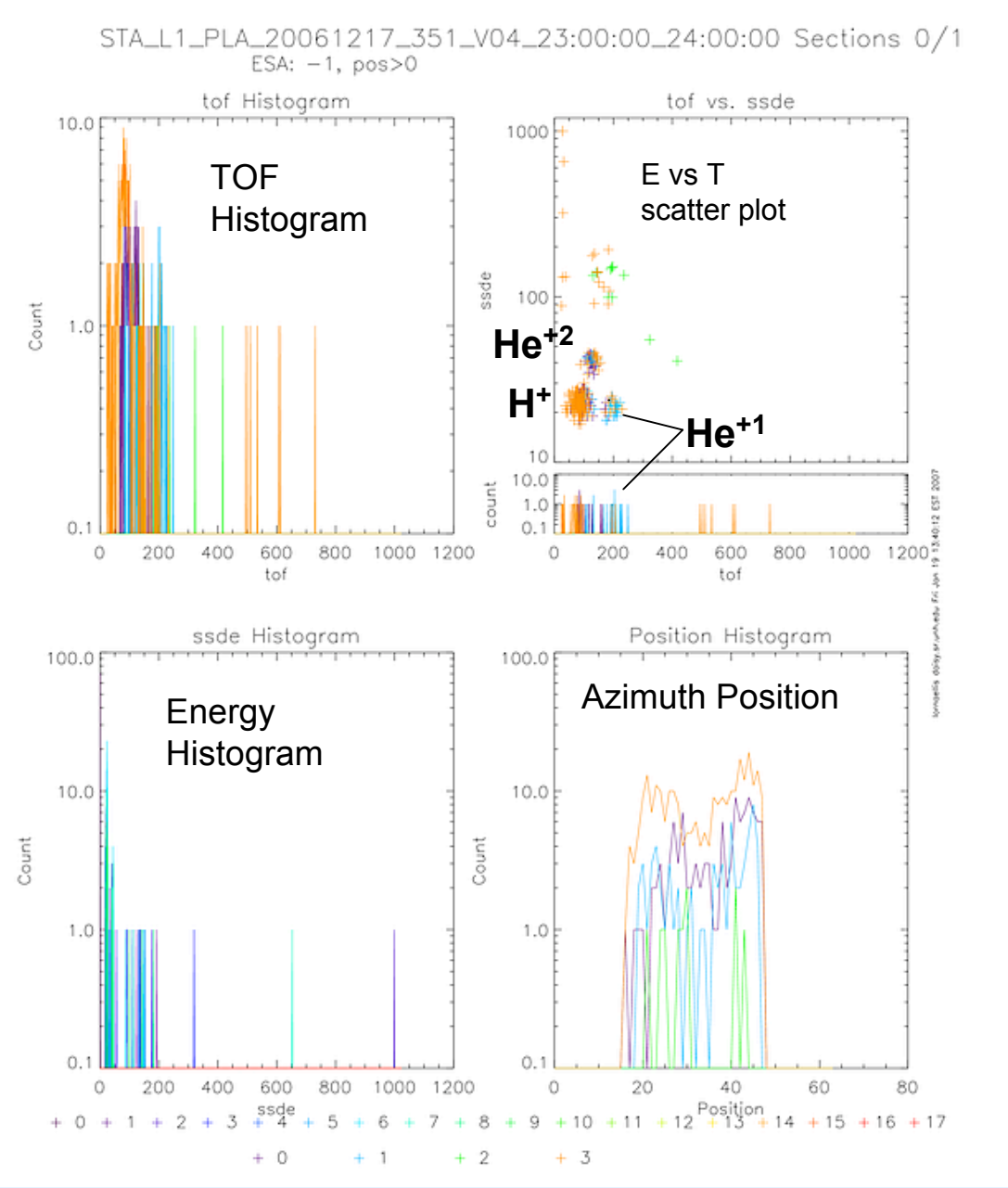
Left: Hour snapshot of STEREO A composition at fixed E/Q (32 keV/e).

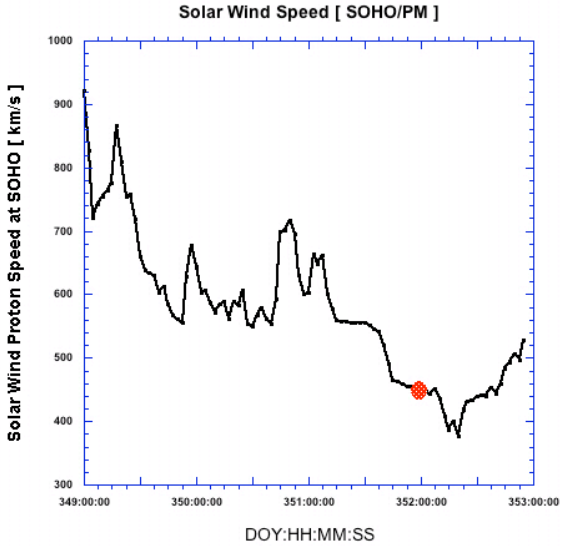




Above: Solar wind speed (SOHO/PM). Red dot corresponds to time of STEREO composition measurement shown on left.

Left: Hour snapshot of STEREO A composition at fixed E/Q (32 keV/e). Note presence of Z>2 species during time of higher solar wind speed.





Above: Solar wind speed (SOHO/PM). Red dot corresponds to time of STEREO composition measurement shown on left.

Left: Hour snapshot of STEREO A composition at fixed E/Q (32 keV/e). Note marked decrease in the suprathermal intensity at this lower solar wind speed.