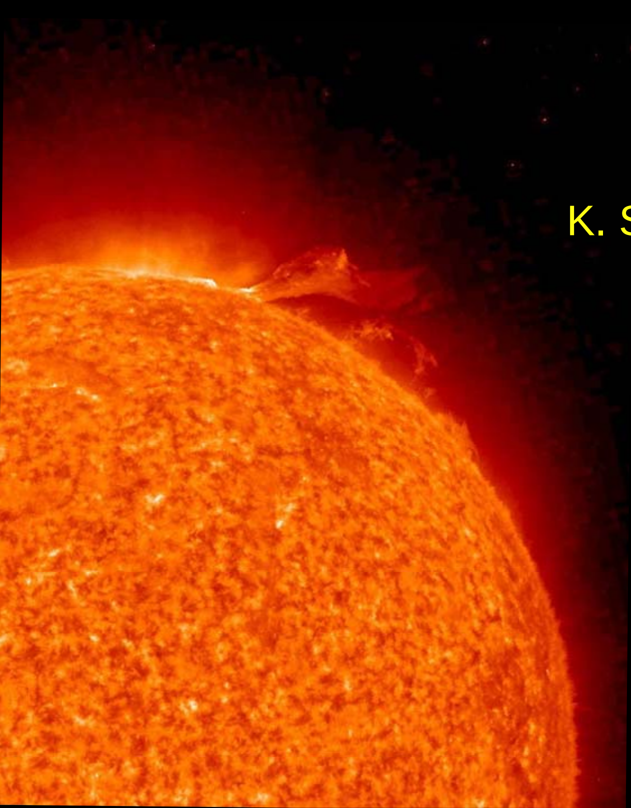
STEREO PLASTIC Composition at Solar Wind Interfaces

Toni Galvin (UNH)

K. Simunac (Protons), A. Gustafson (Programs), Lorna Ellis (Data, Programs), M. Popecki (Calib), K. Singer (Calib), R. Karrer (Calib), the PLASTIC Team, and E. Huttunen (Flux Rope)

STEREO PLASTIC Institutions:
UNH, U Bern, MPE, U Kiel, NASA/GSFC
IDPU/LVC provided by UCB (IMPACT)



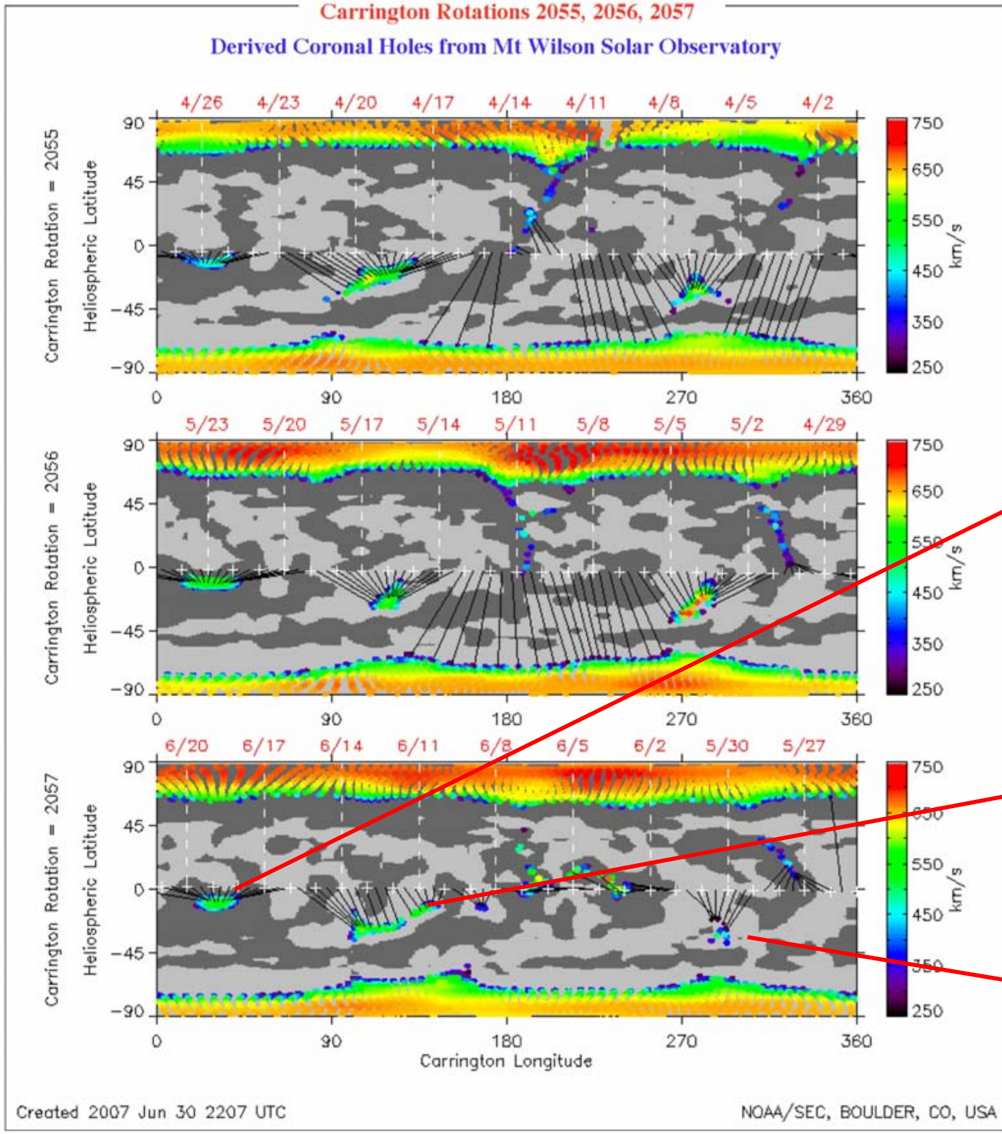
The Sun in EUV courtesy STEREO/SECCHI/NRL

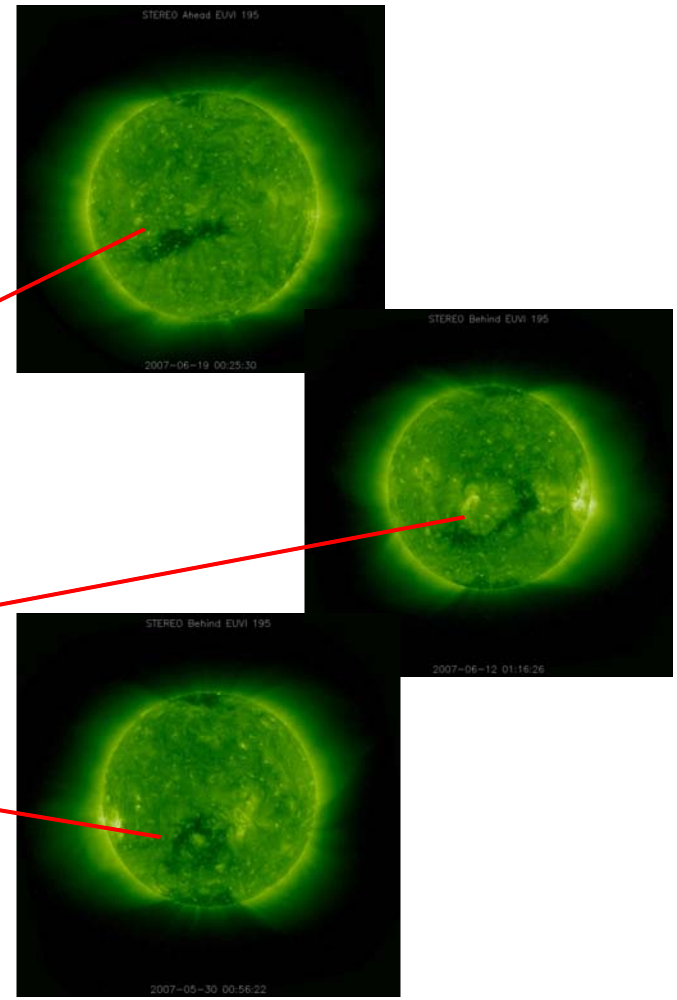
Solar Wind Composition

- As a tool in identifying solar sources and types of solar wind (coronal hole-associated high speed streams, ICMEs, slow solar wind)

- As a tool in identifying boundaries in large scale structures

Solar sources for the high speed solar wind - long lived polar and equatorial coronal holes - observed by SECCHI EUVI (B).





Solar sources for slow solar wind is an area of discussion -- likely multiple sources, including small transients.

Solar wind M/Q composition as a tool in identifying flow types

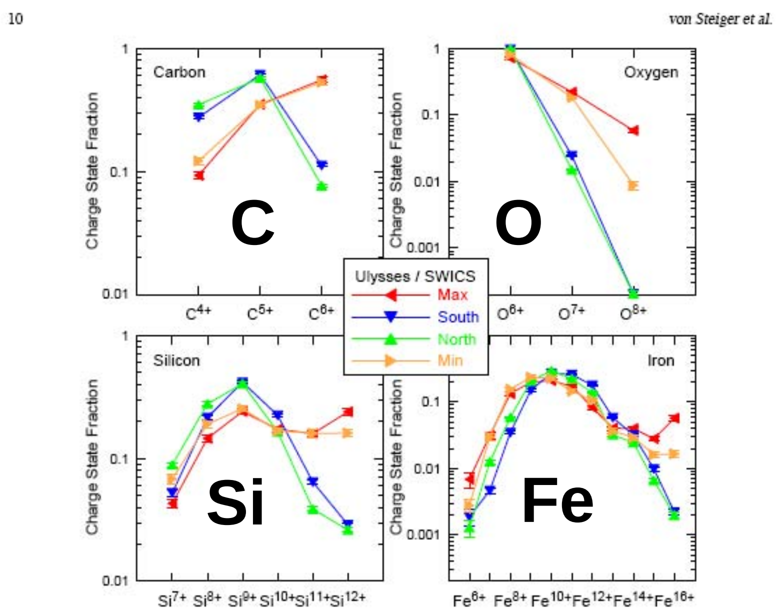
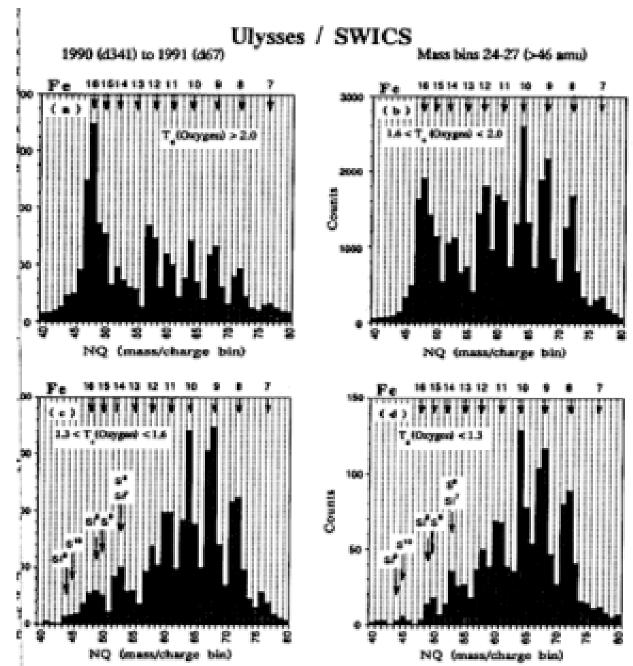


Plate 5. Average charge state spectra of C, O, Si, and Fe from Ulysses/SWICS, obtained during the four ~300-day periods defined in Plate 1. As in Plate 4, data points denote averages of the daily values, but here the bars indicate the errors of the mean values.



Charge state distributions for Fe ions in each of the four oxygen temperature categories.

Fe

M/Q distributions for fast vs. slow solar wind, von Steiger et al. 2000

300-day accumulations each trace

Fe M/Q distributions for different types of solar wind, Ipavich et al. 1992

3-month interval

Solar wind M/Q composition as a tool in identifying flow types and solar sources

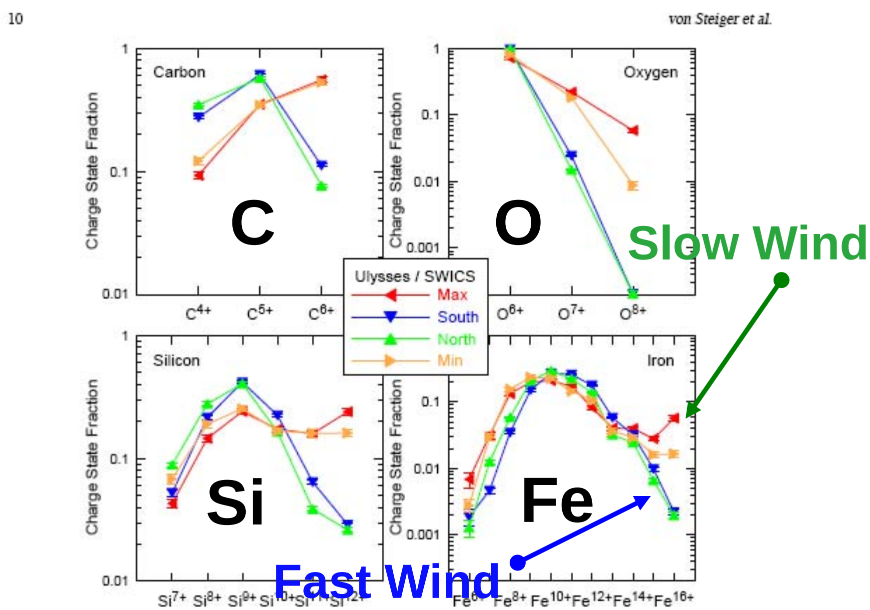
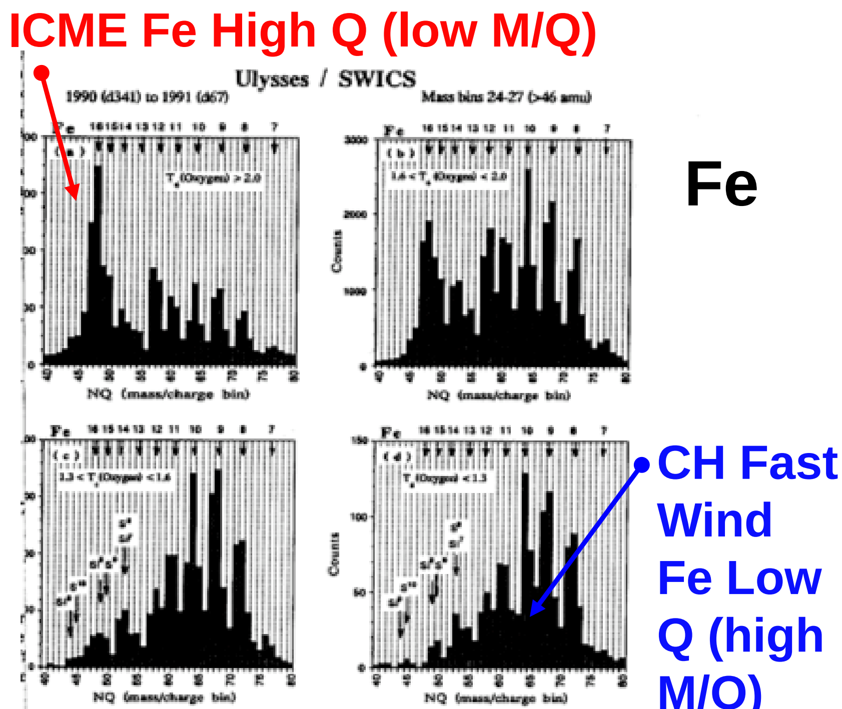


Plate 5. Average charge state spectra of C, O, Si, and Fe from Ulysses/SWICS, obtained during the four ~300-day periods defined in Plate 1. As in Plate 4, data points denote averages of the daily values, but here the bars indicate the errors of the mean values.



Charge state distributions for Fe ions in each of the four oxygen temperature categories.

M/Q distributions for fast vs. slow solar wind, von Steiger et al. 2000

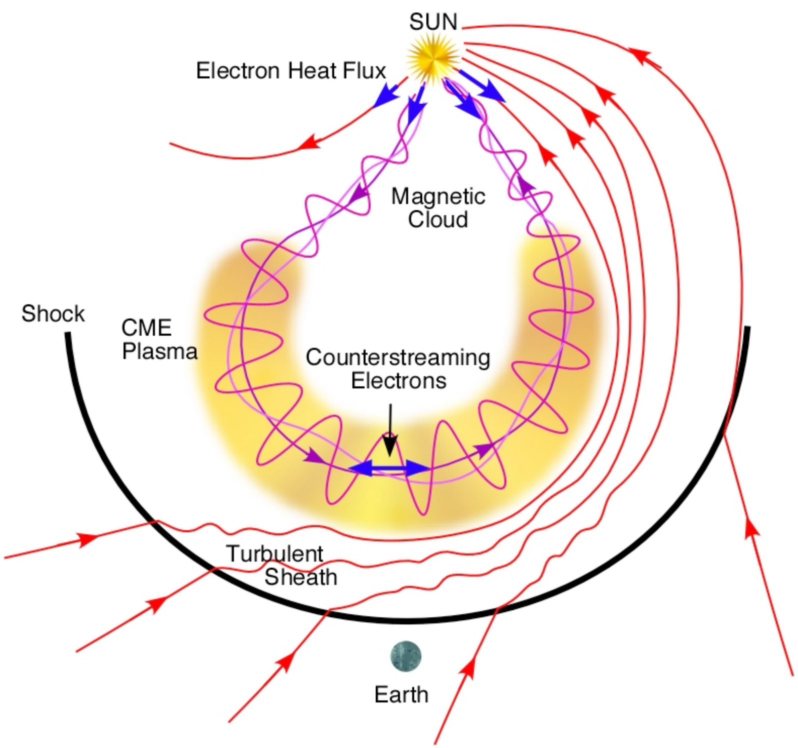
300-day accumulations each trace

Fe M/Q distributions for different types of solar wind, Ipavich et al. 1992

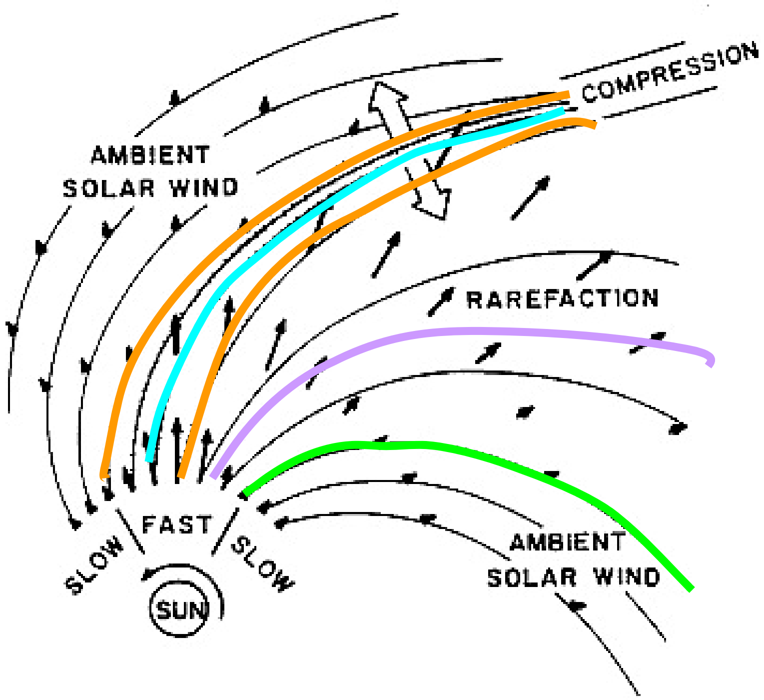
3-month interval

Solar Wind Interfaces

Ambient-ICME-
Ambient Interfaces



Slow-Fast-Slow Interfaces in corotating structures



Pizzo, V., *J. Geophys. Res.*, 83, 5563–5572 (1978).

Solar wind composition as a tool in identifying interfaces between different solar wind flows

Balogh et al.

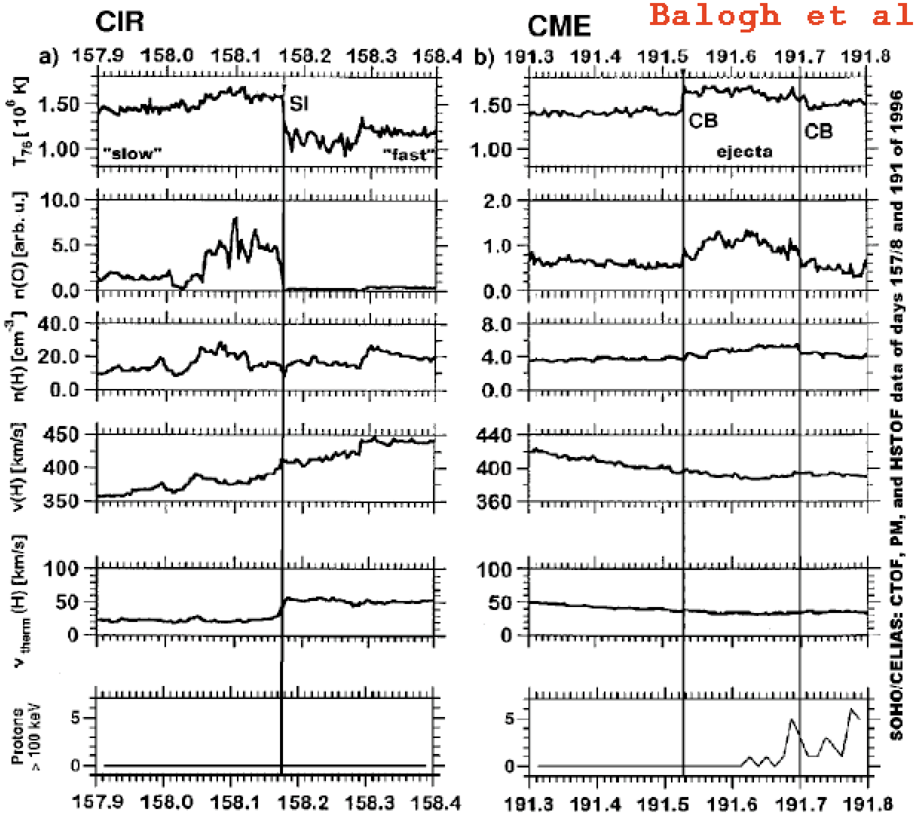


Figure 12. Left panel: Typical stream interface (SI) in a CIR at 1 AU (upper five data panels from Hefti, 1997). The interaction of the intermediate-speed stream with the low-speed solar wind causes a compression of the hydrogen and oxygen density. The kinetic temperature remains low in the compression region and increases in the intermediate stream within approximately 20 min. The sharpest separation between the two regimes is possible using T_f (O^{7+}/O^{6+}) (topmost panel). This parameter drops by 0.3 MK within a short time interval of 10 min. There is only a gradual transition within hours from low-speed solar wind with a proton bulk velocity of 350 km/s to intermediate-speed solar wind at 450 km/s. *Right panel:* Identification of compositional boundaries (CB) between slow solar wind and CME-related solar wind. The clearest signatures are given by the oxygen freeze-in charge states, density enhancements of protons and oxygen are also detected. The kinematic signatures alone would

Wimmer et al. 1997

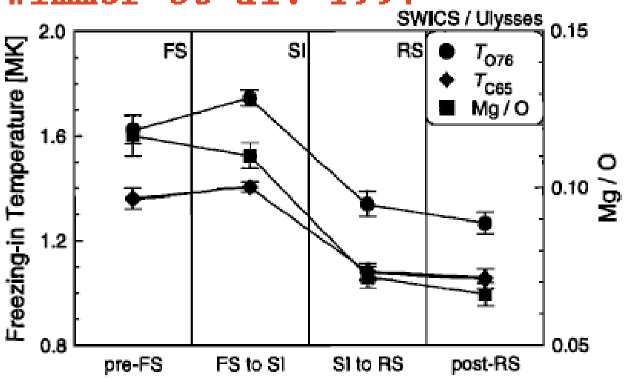


Figure 8. Summary plot of the compositional changes observed in CIRs: C and O freezing-in temperatures and the Mg/O abundance ratio. All CIRs were divided into 4 domains (2 days before the forward shock, forward shock to SI, SI to reverse shock, and 2 days following the reverse shock). Averages were obtained over the 15 CIRs for each of the three parameters. The error bars indicate the 1-σ error of the mean. It is obvious that the drops in freezing-in temperatures (by ~ 25%) and in the Mg/O ratio (by ~ 35%) occur at the SI, whereas no significant changes can be seen at the shocks. Note that the x axis is not strictly a time axis, as the forward shock-SI and SI-reverse shock times may vary.

Many studies on composition at Slow/Fast interface. Fewer studies on Fast/Slow interface (Burton et al.1999)

Composition with STEREO PLASTIC

NOTE: work in progress
results subject to revision !

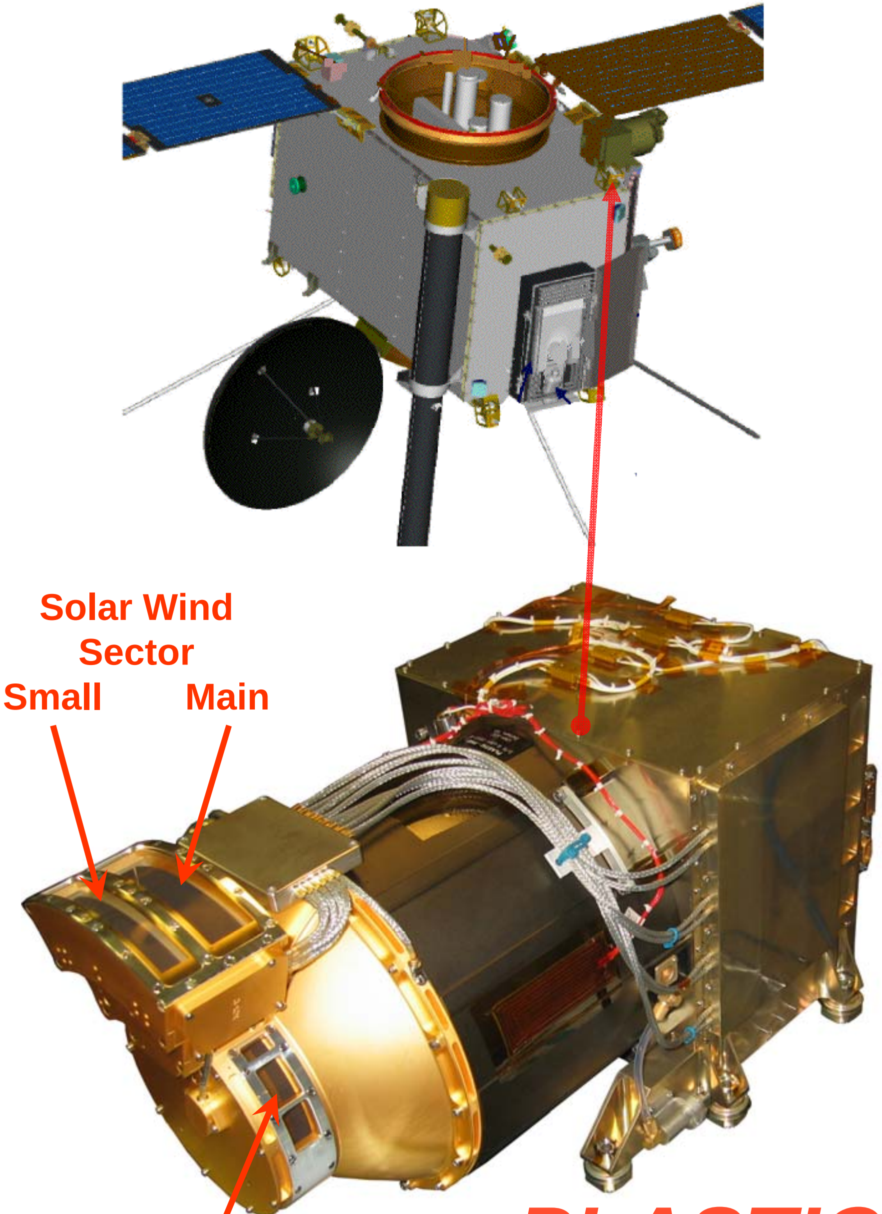
PLASMA AND SUPRATHERMAL ION COMPOSTION INSTRUMENT

- ***Solar Wind Sector* (SWS) Small (Proton) Channel**

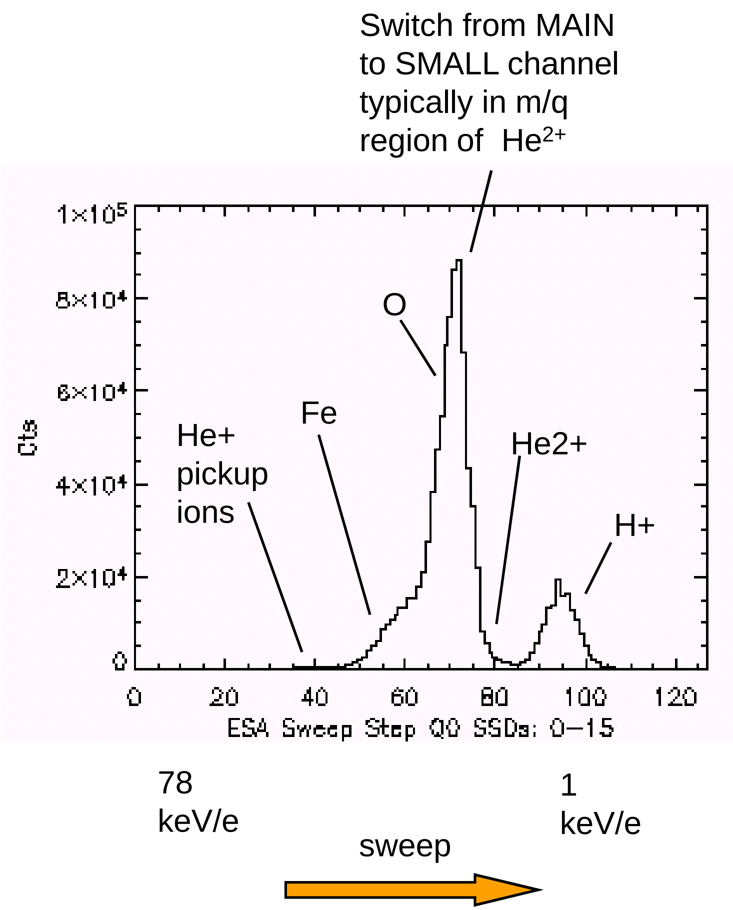
  measures the distribution functions of **solar wind protons (H+)** and **alphas (He^{+2}), and can include M/Q ~ 2, such as O^{+8}, C^{+6}**.

- ***Solar Wind Sector* (SWS) Main (Composition) Channel**

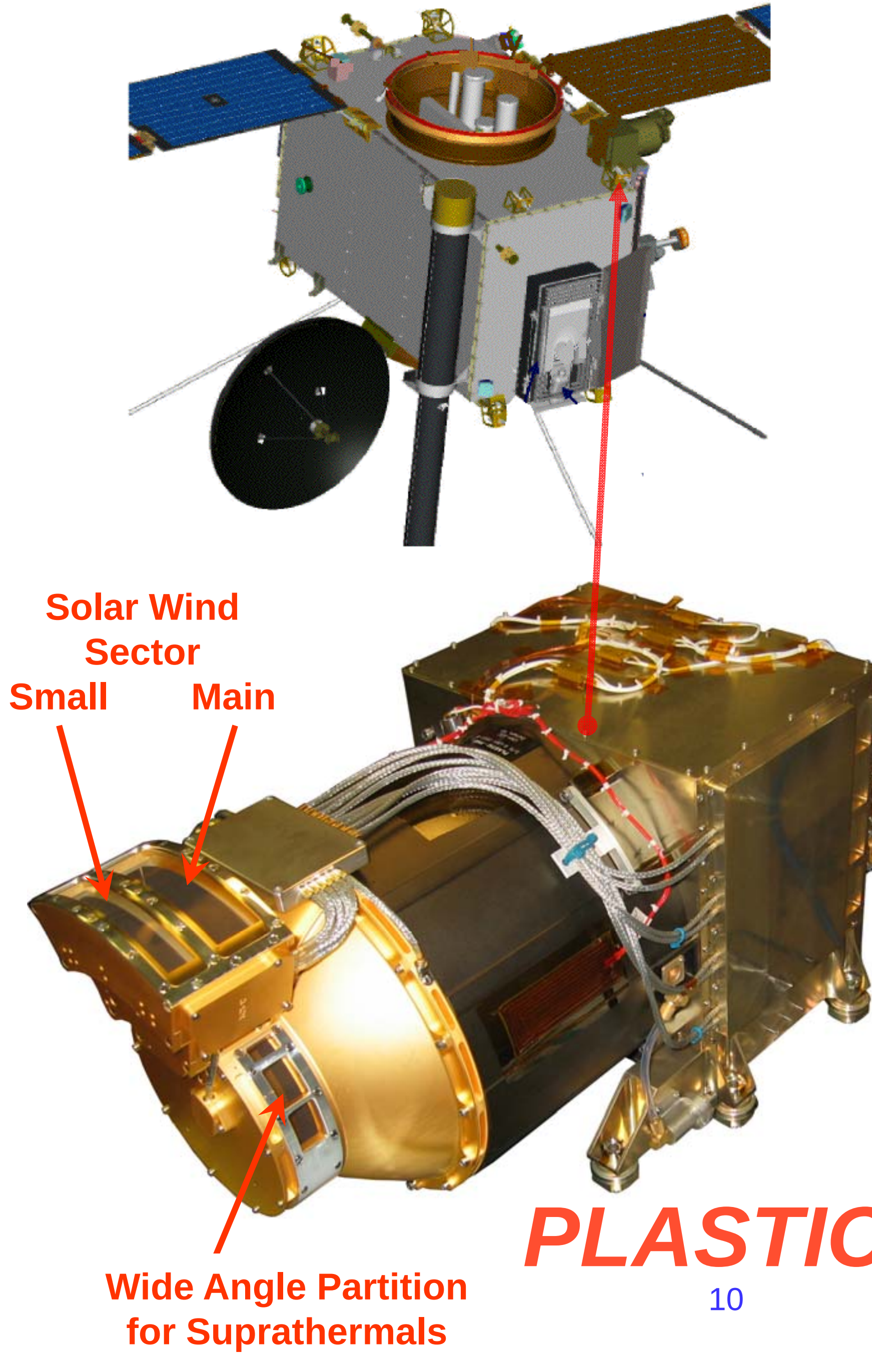
  measures the more abundant **solar wind heavy ions** (e.g., C, O, Mg, Si, and Fe).



PLASMA AND SUPRATHERMAL ION COMPOSTION INSTRUMENT



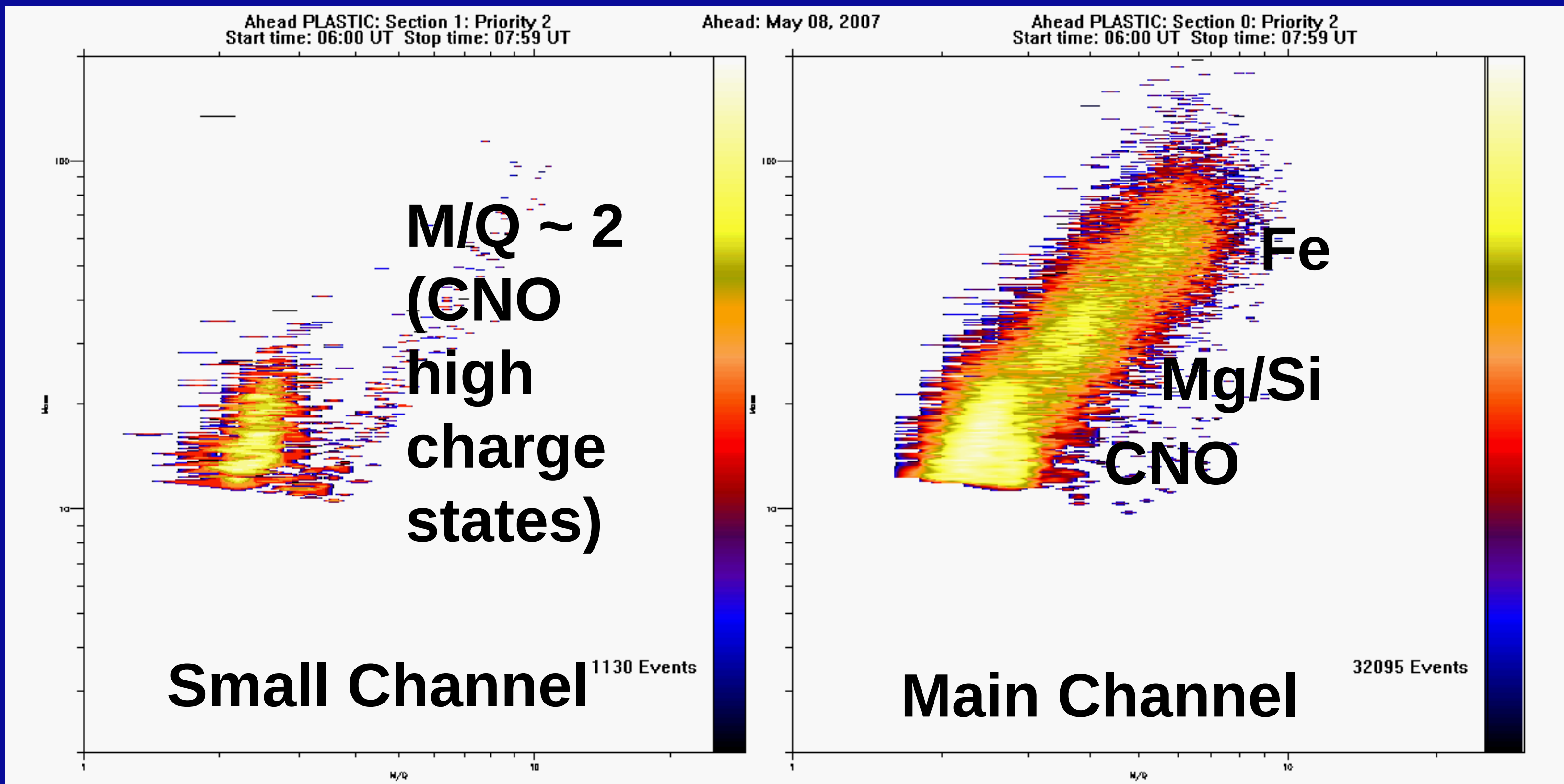
ESA EQ STEPPING



PLASTIC

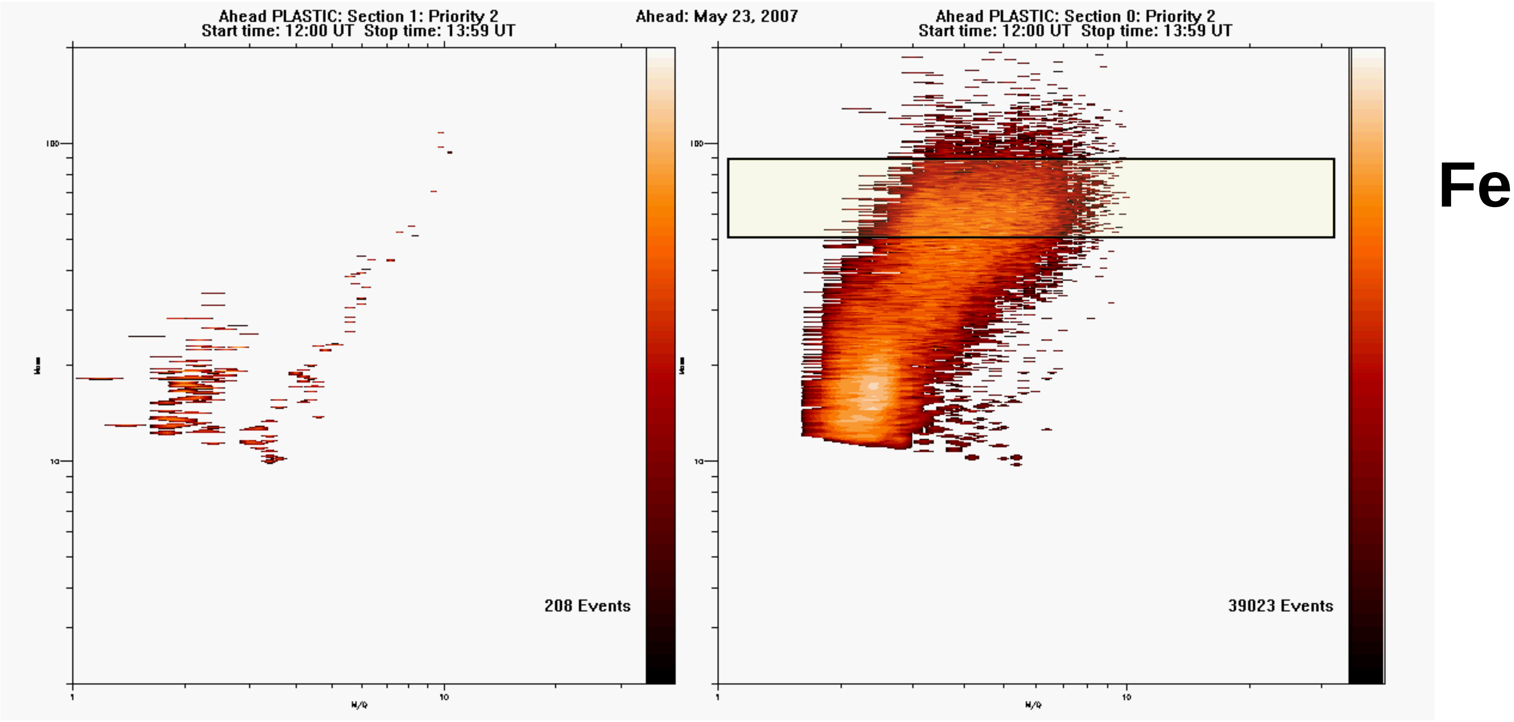
Solar Wind Sector
PRIORITY 2 Composition

Relative Mass



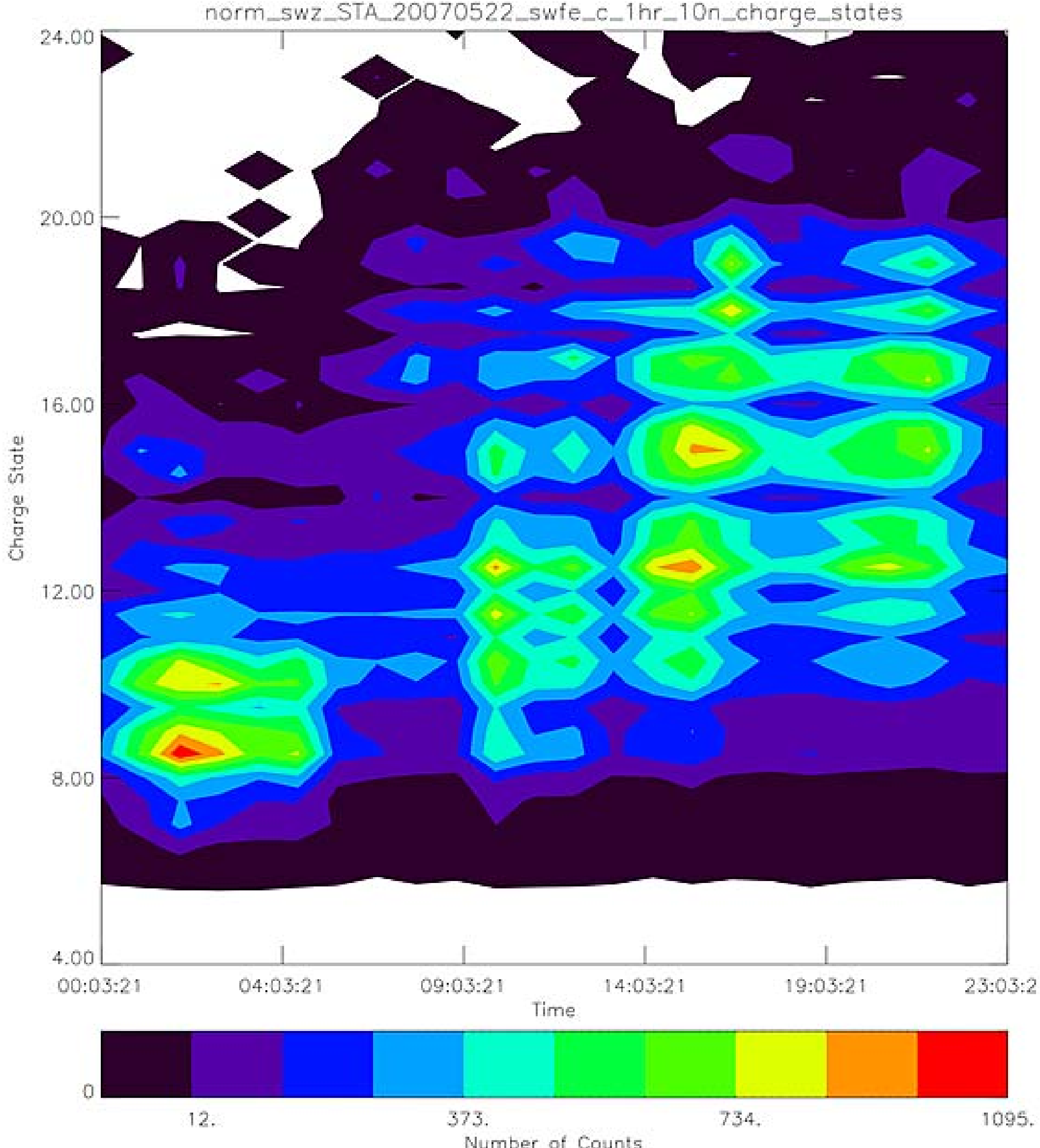
Relative M/Q

Relative M/Q



For Charge State Distributions - take a slice in "Mass" around the iron, and look at charge states over 1 hr accumulations

Fe Charge States



>16

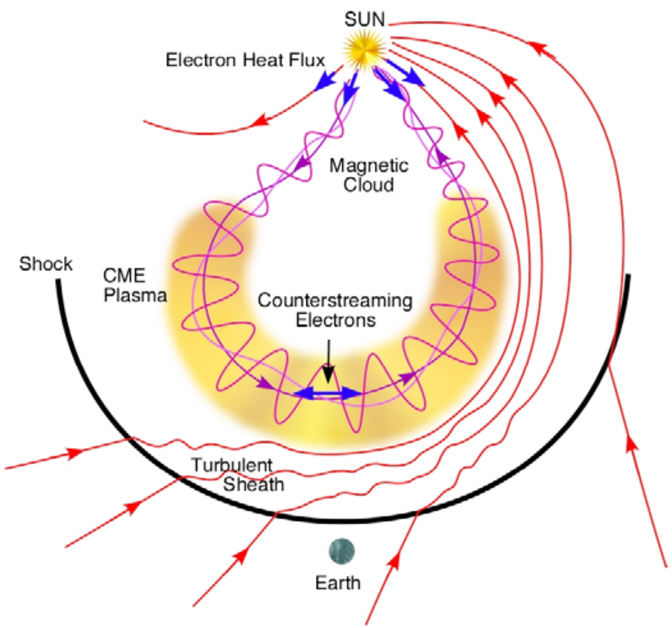
Hour of Day (1hr bins)

ICME Case Study

STEREO A

May 22-23 2007

Ambient-ICME-Ambient Interfaces



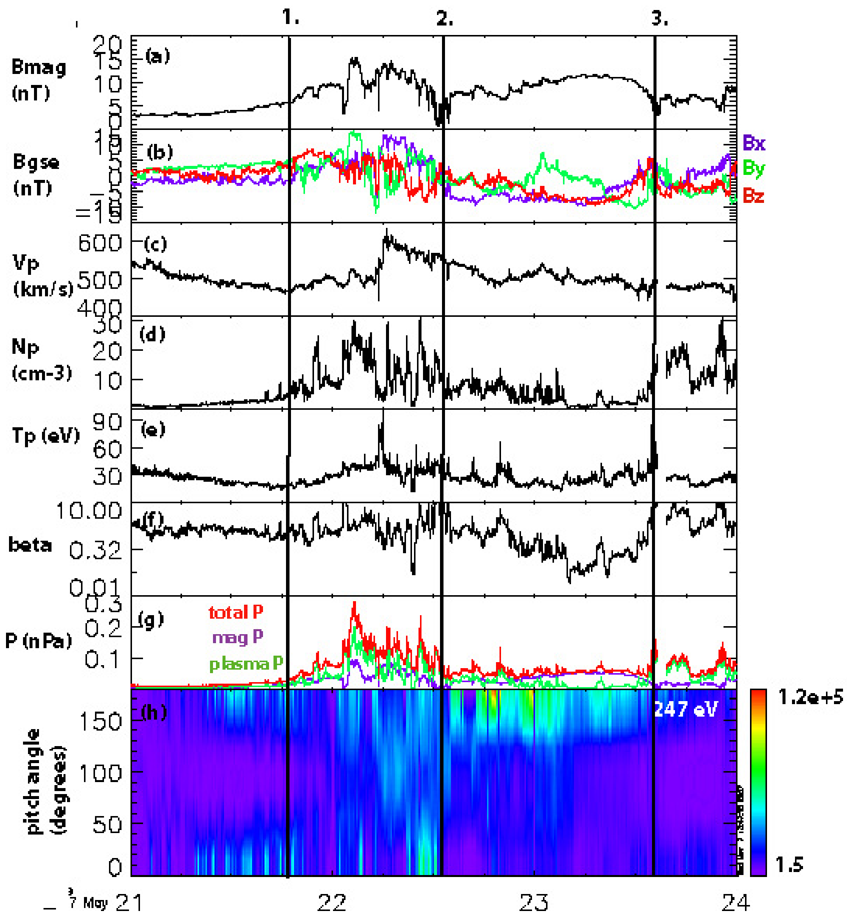
ICME Signatures in the Solar Wind

Important note: Not all signatures are seen all the time…

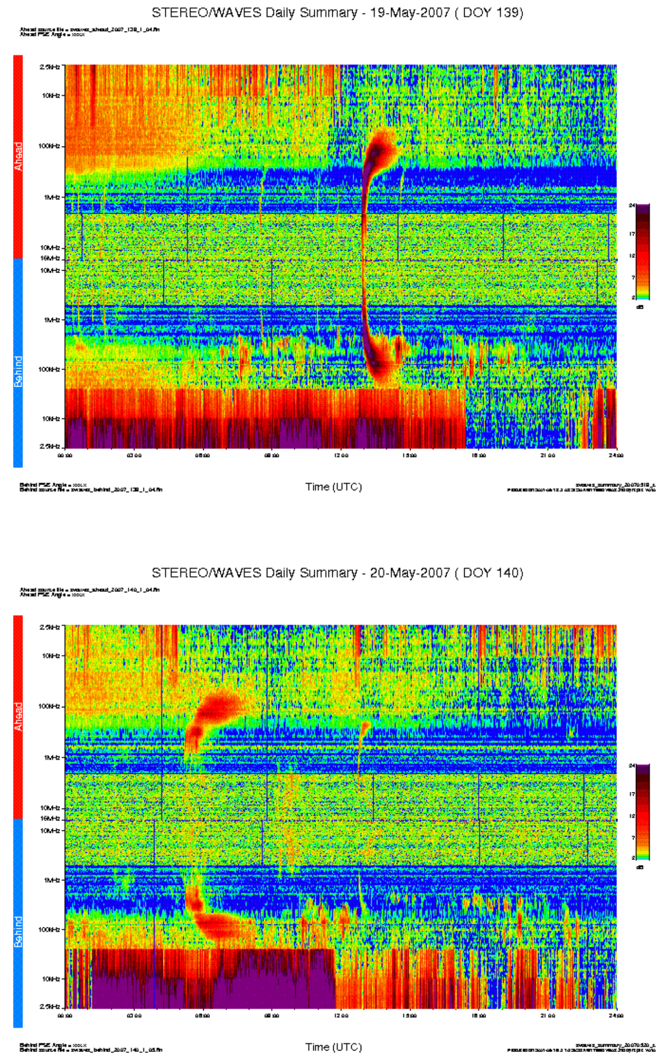
•Shock, other discontinuities
•Counterstreaming suprathermal electrons (along the B field)
•Counterstreaming suprathermal protons (along the B field)
•Change in SEP intensity at discontinuity
•He/H enhanced
•Anomalous ion charge states (He+, Fe>16)
•Mass or FIP dependencies on elemental composition
•Low proton and electron kinetic temperatures
•Low plasma beta (gas pressure / field pressure)
•Strong B field
•Low B variance
•Field rotation (flux rope)

Magnetic Clouds are a particular subset of ICMEs with distinct characteristics from the above list … strong magnetic field with a smooth and coherent rotation, low beta plasma with depressed kinetic temperatures

May 22-23 2007 - Flux Rope Case Study

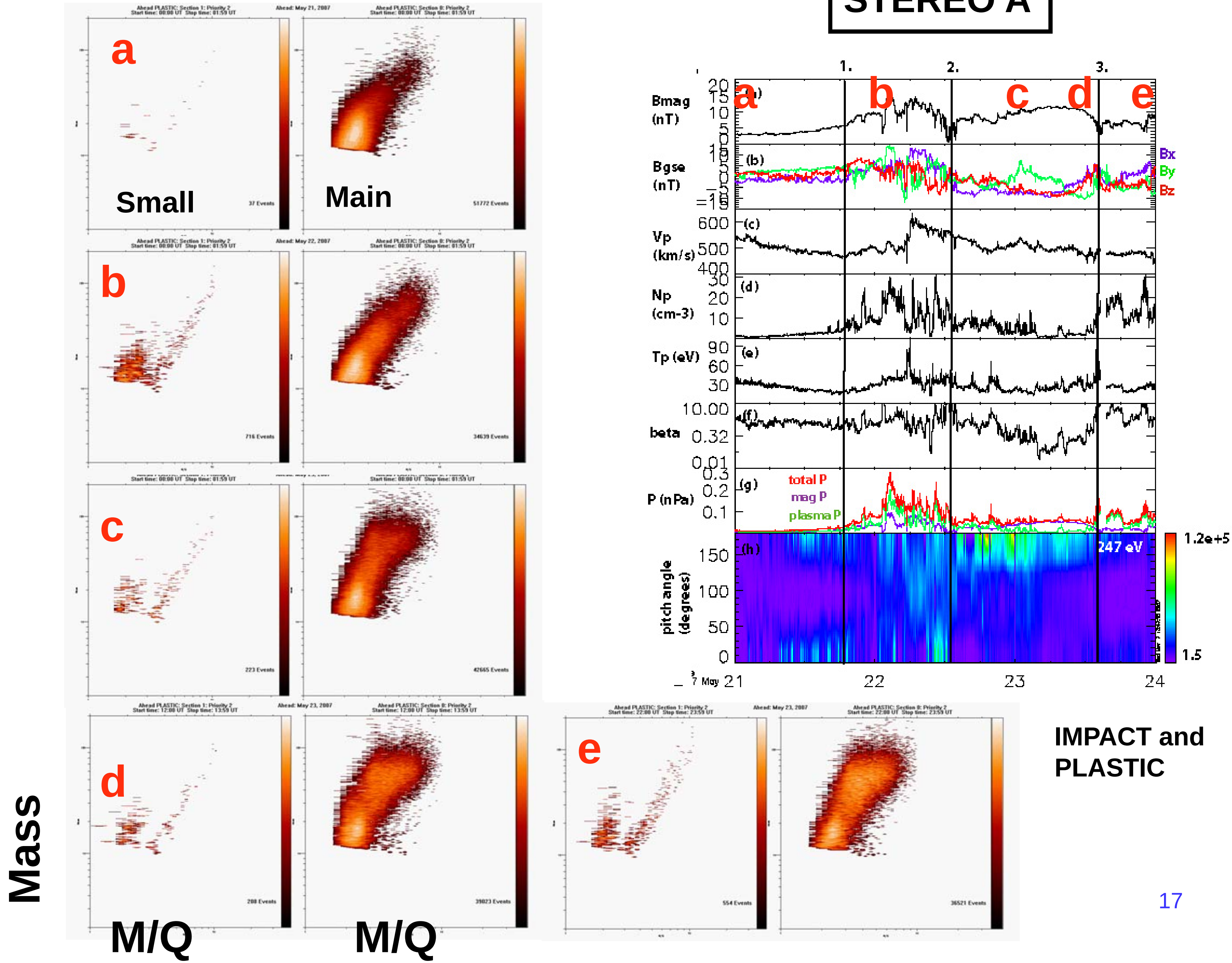


IMPACT SWEA/MAG
PLASTIC protons
(Plot from E. Huttunen)



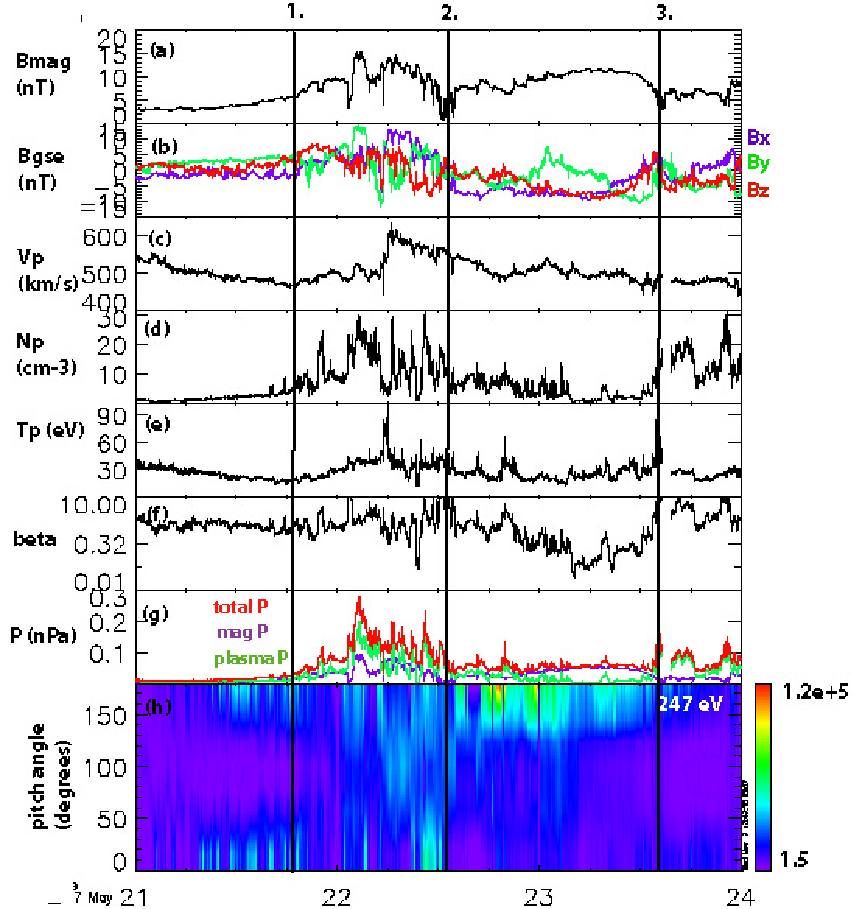
Top: SWAVES May 19 2007
Bottom: SWAVES May 20 2007

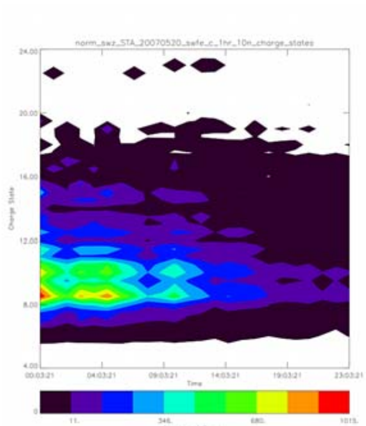
STEREO A



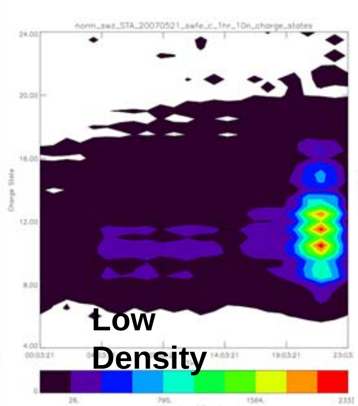
IMPACT and PLASTIC

Highest Fe Charge State signature between lines 2 - 3. Still somewhat elevated after line 3 to end of day.

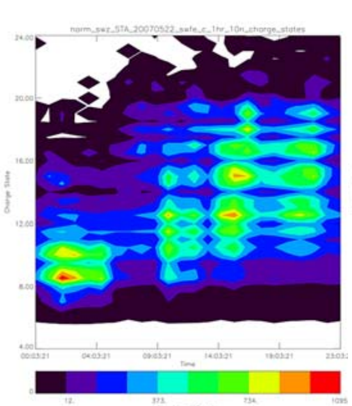




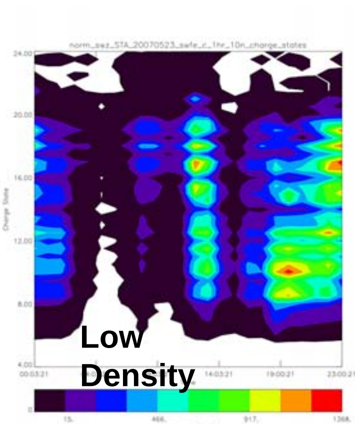
May 20



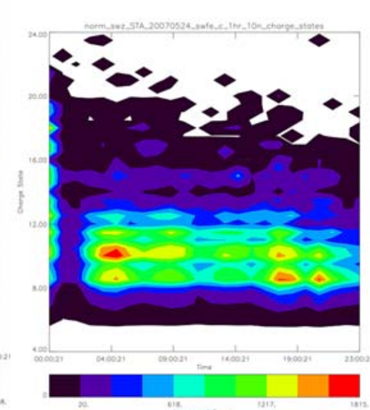
May 21



May 22

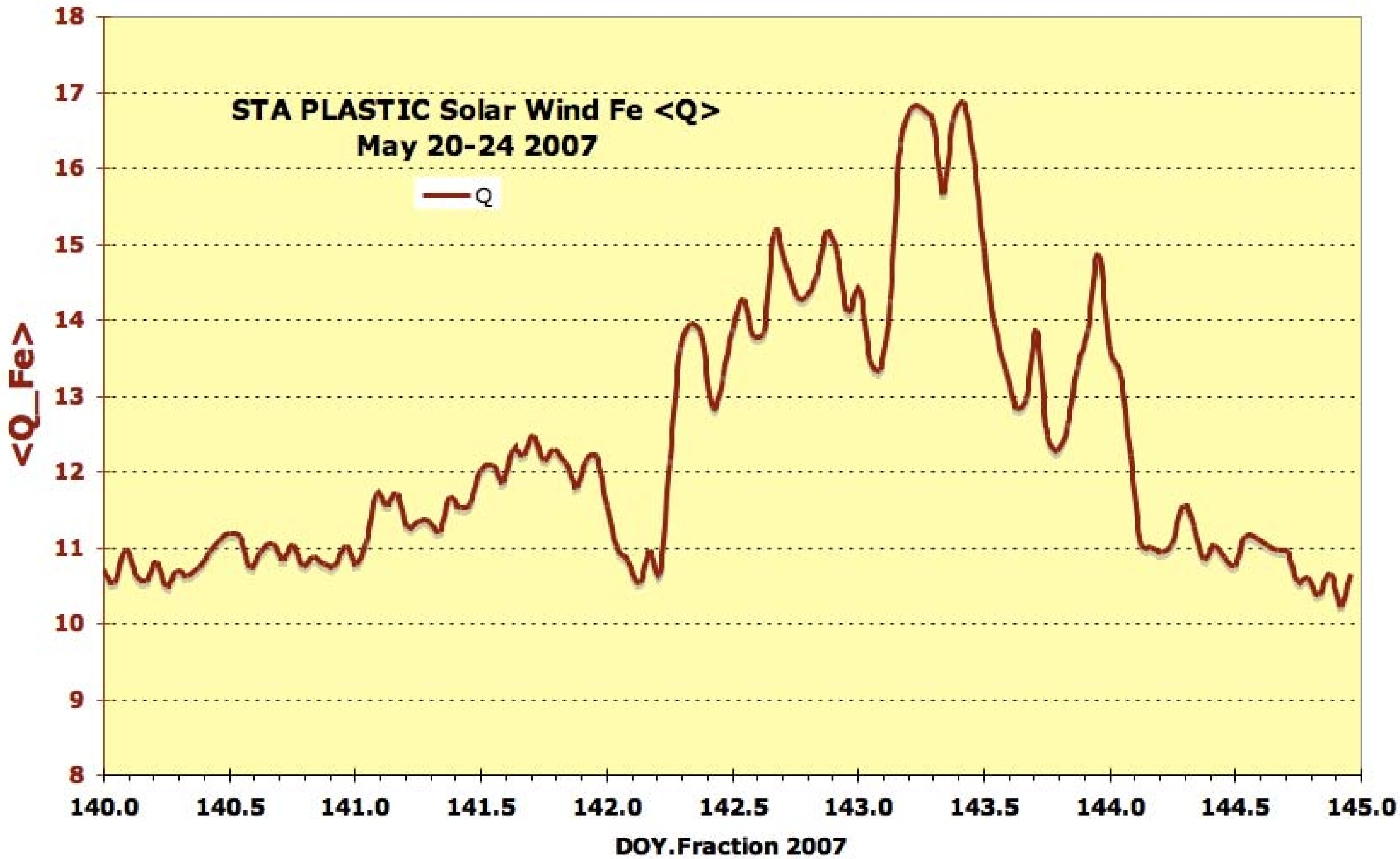


May 23



May 24

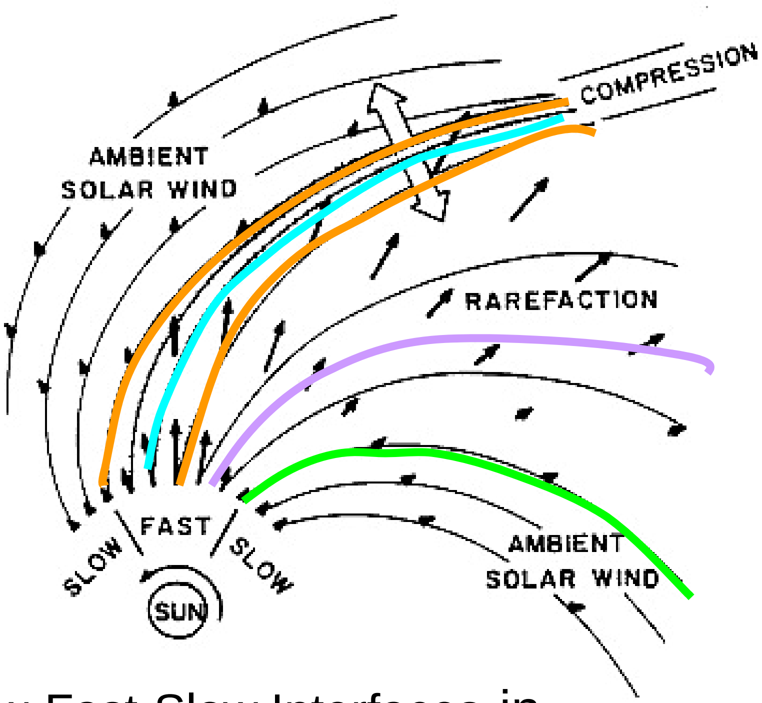
•He/H enhanced
•Anomalous ion charge states (He+, Fe>16)
•Mass or FIP dependencies on elemental composition
•Low proton and electron kinetic temperatures



Slow-Fast-Slow Case Study

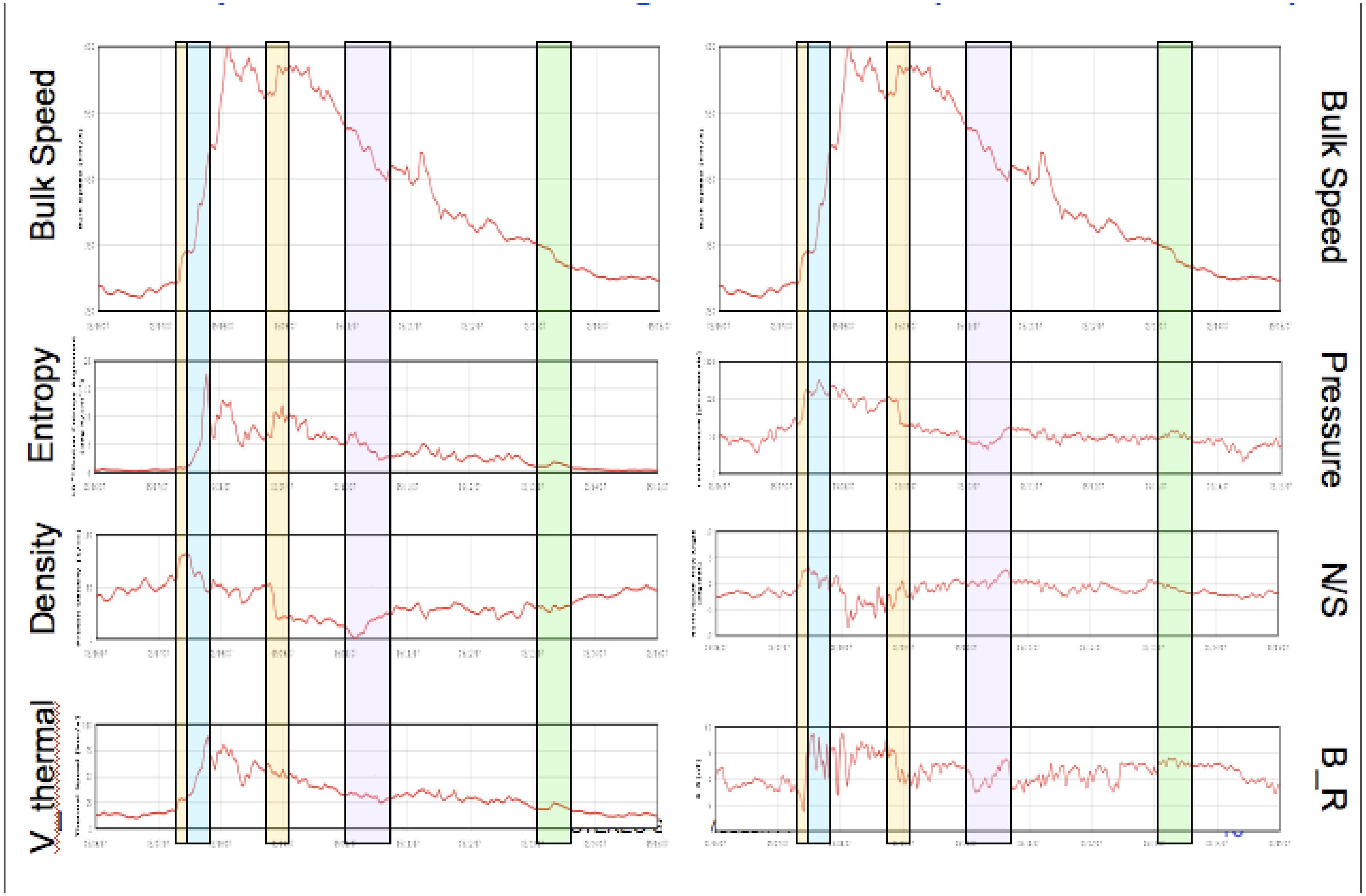
STEREO A

May 06-15 2007



Slow-Fast-Slow Interfaces in corotating structures

Solar Wind Interfaces (Slow-Fast-Slow) perspective from STEREO PLASTIC proton and IMPACT magnetic field data May 6 - 14 2007 (from Simunac et al. this meeting)



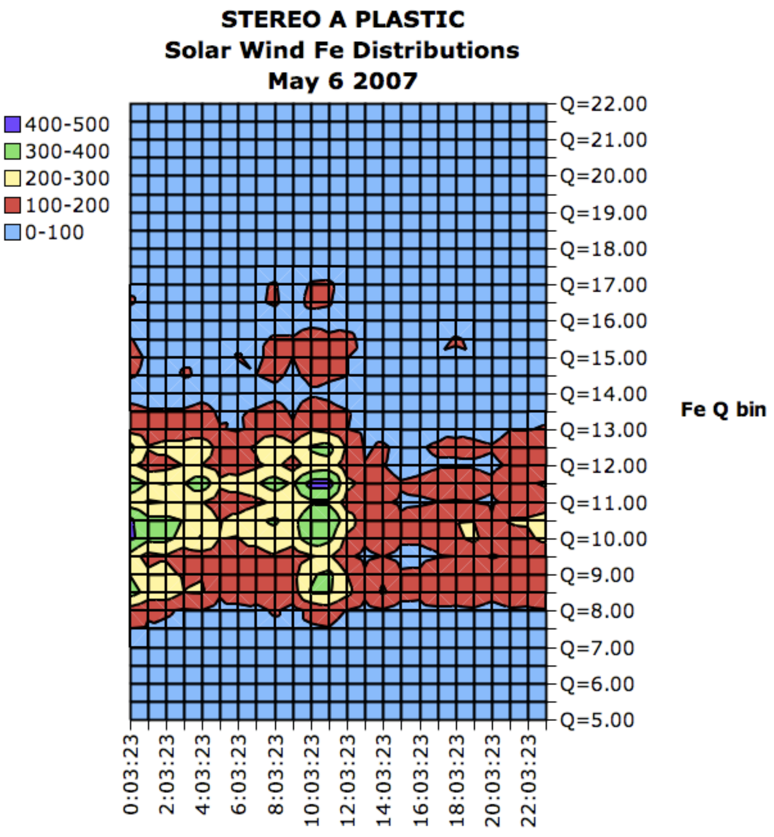
Perspective from Solar Wind Fe charge states:

Example:

1 Day

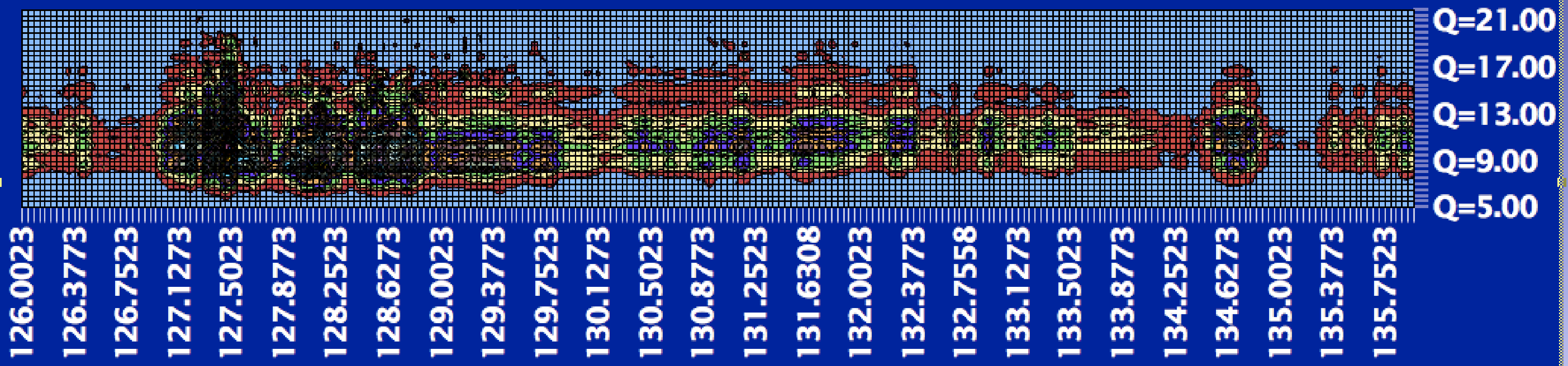
Fe Ionic Charge Q bins
vs.
Time bins (1hr)

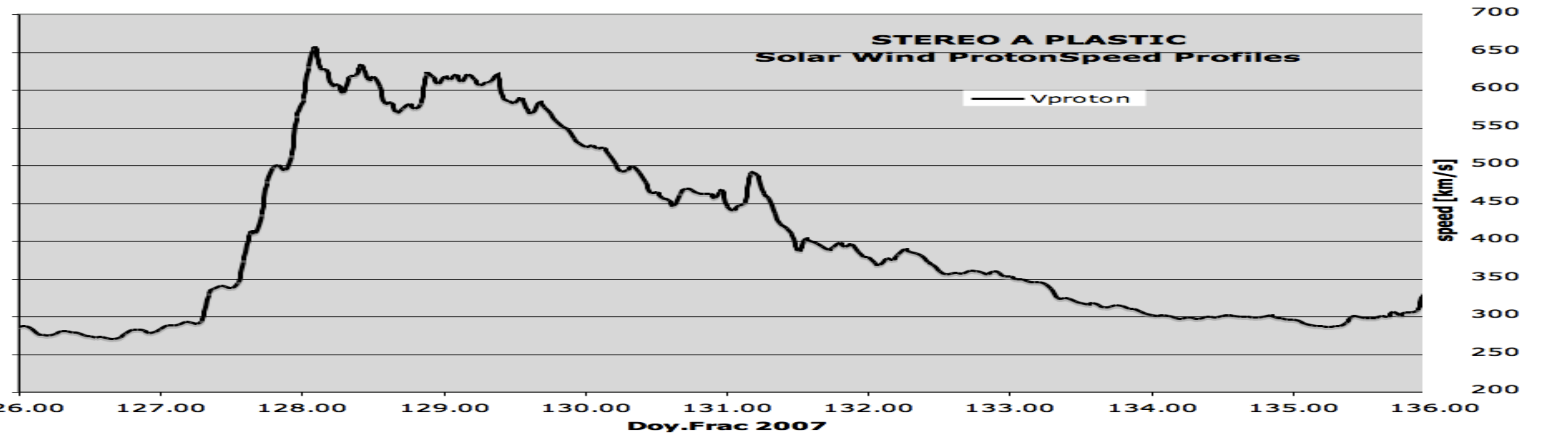
But for slow/fast/slow interfaces want several days overview ….



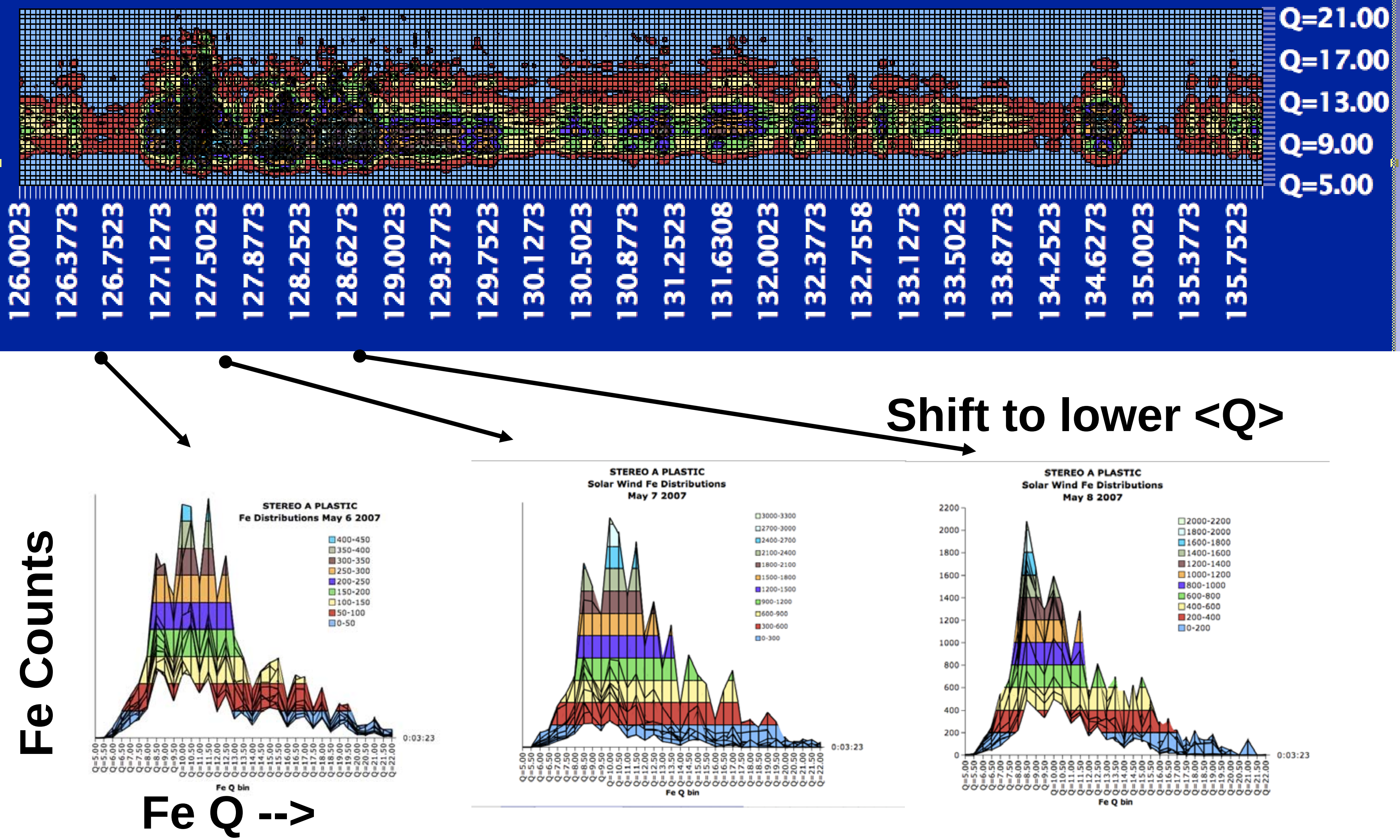
Same format as before, but switched from IDL to Excel

Solar Wind Iron Charge States
STEREO A PLASTIC May 6-15 2007

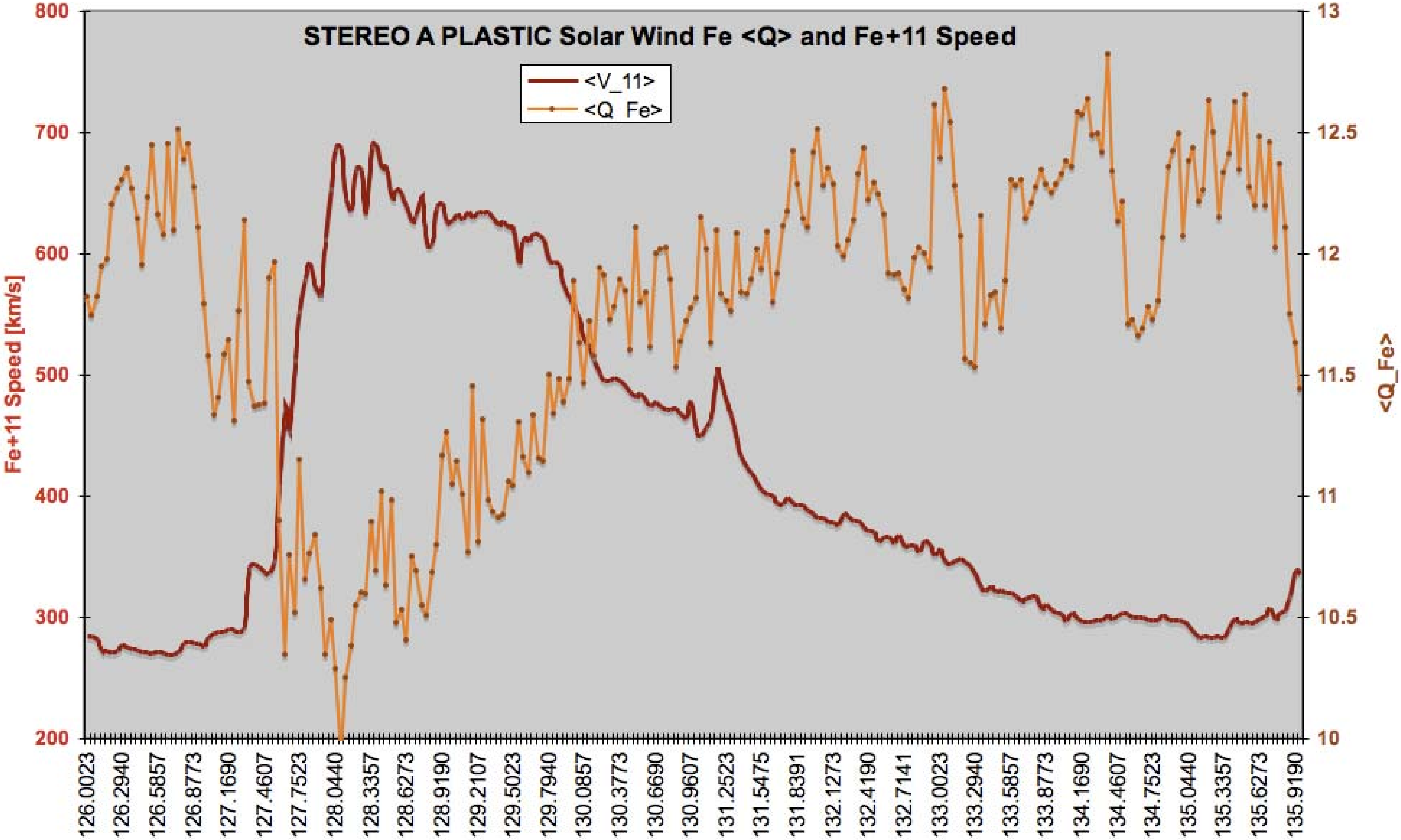




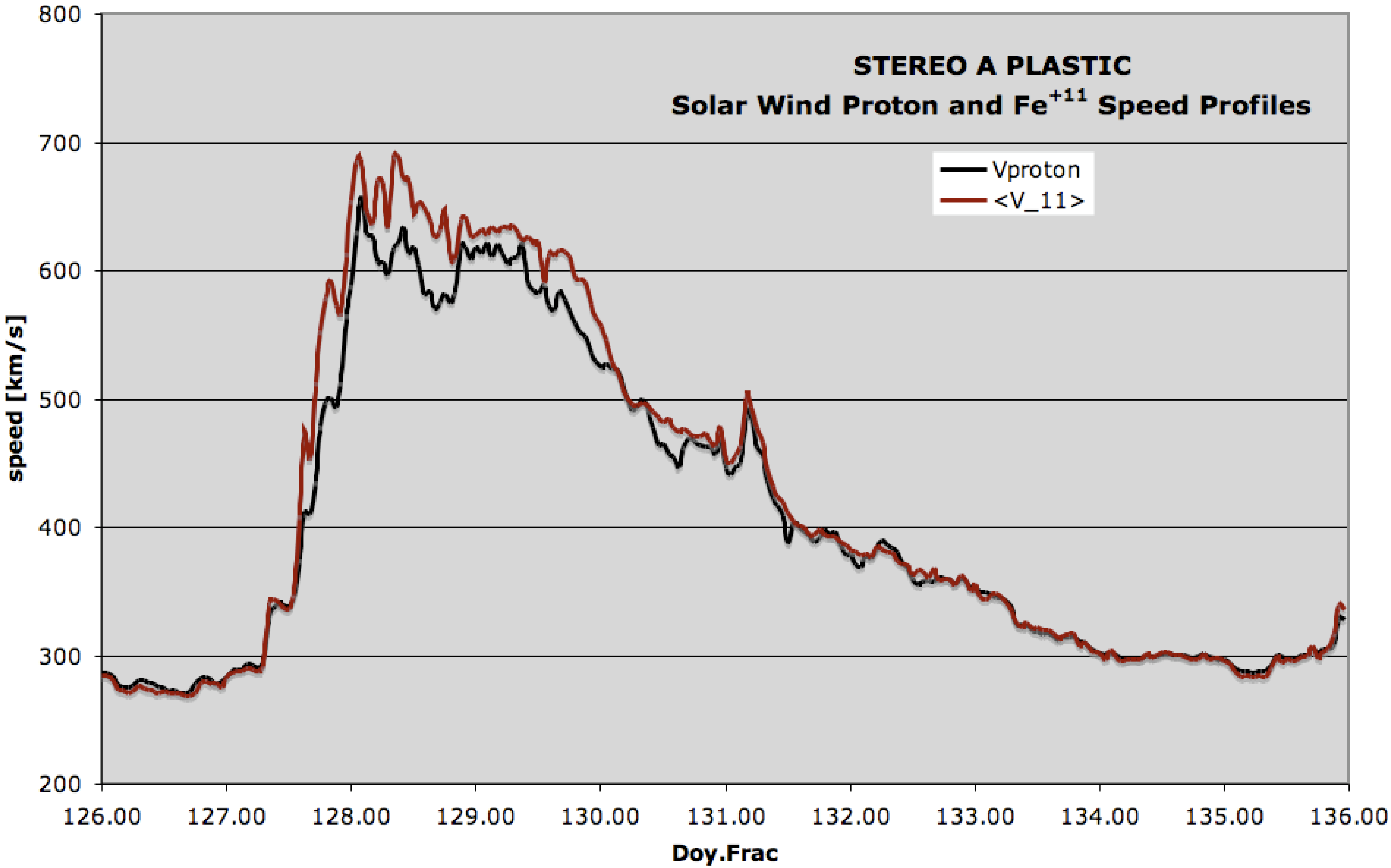
Solar Wind Iron Charge States
STEREO A PLASTIC May 6-15 2007

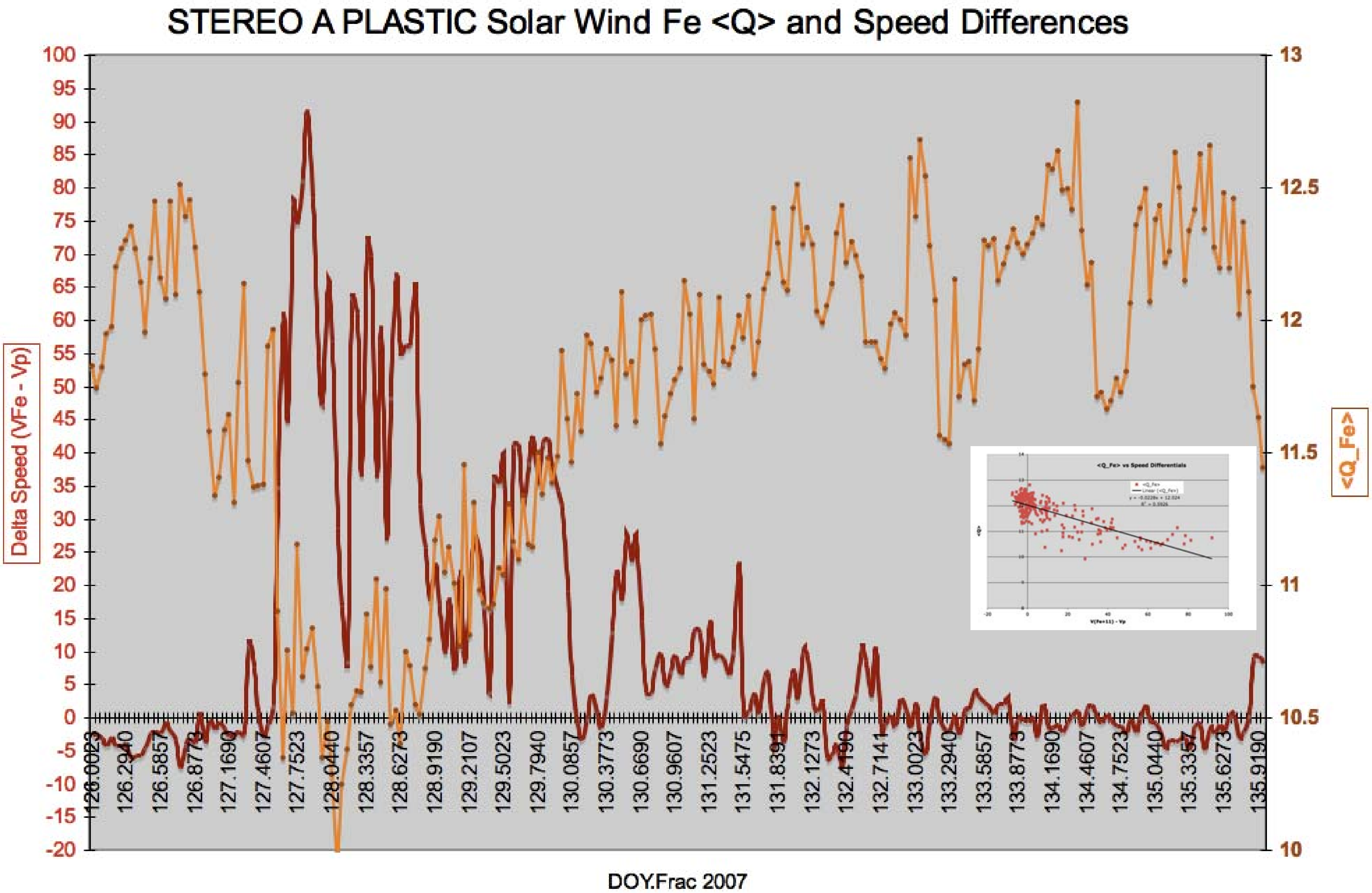


Average <Q_Fe> and Fe^{+11} Speeds



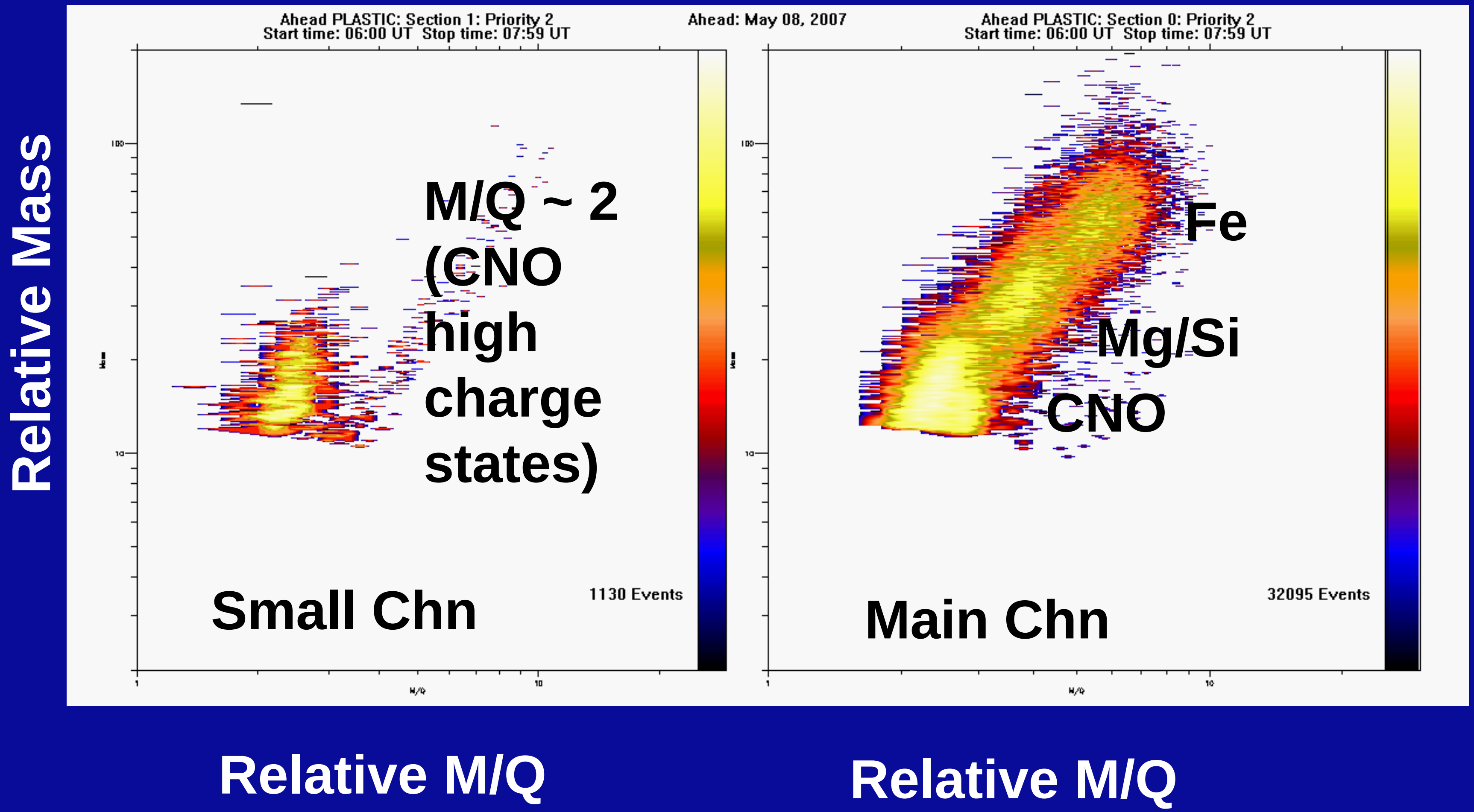
Proton and Fe^{+11} Speeds



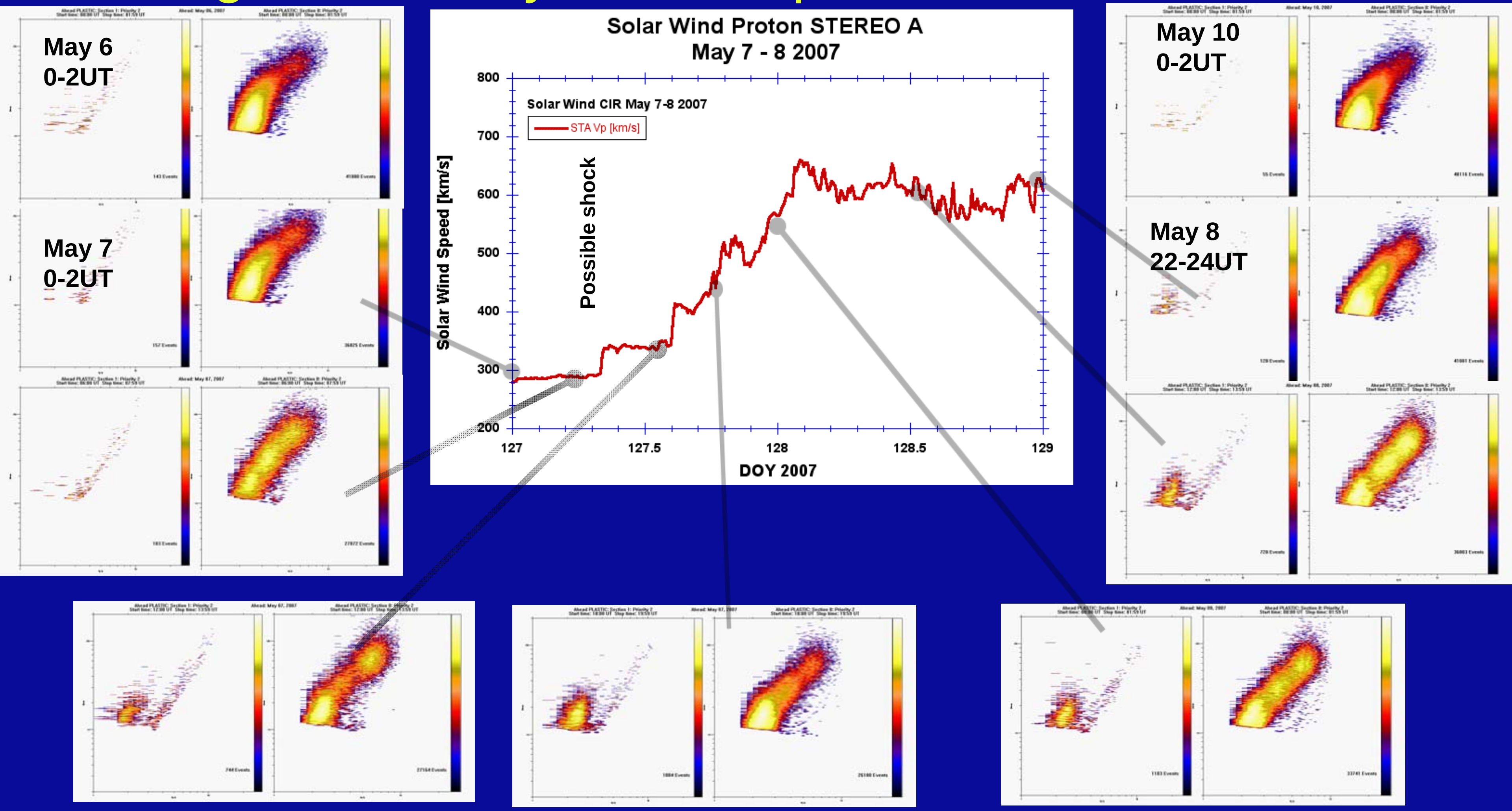


STEREO A PLASTIC Solar Wind Fe <Q> and Speed Differences
Delta Speed (VFe - Vp)
100
95
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0
-5
-10
-15
-20
<Q_Fe>
13
12.5
12
11.5
11
10.5
10
126.0023
126.2940
126.5857
126.8773
127.1690
127.4607
127.7523
128.0440
128.3357
128.6273
128.9190
129.2107
129.5023
129.7940
130.0857
130.3773
130.6690
130.9607
131.2523
131.5475
131.8391
132.1273
132.4190
132.7141
133.0023
133.2940
133.5857
133.8773
134.1690
134.4607
134.7523
135.0440
135.3357
135.6273
135.9190
DOY.Frac 2007
<Q_Fe> vs Speed Differentials

Solar Wind Sector
PRIORITY 2 Composition



Interface from Slow to Fast - Changes in Heavy Ion Composition Abundances

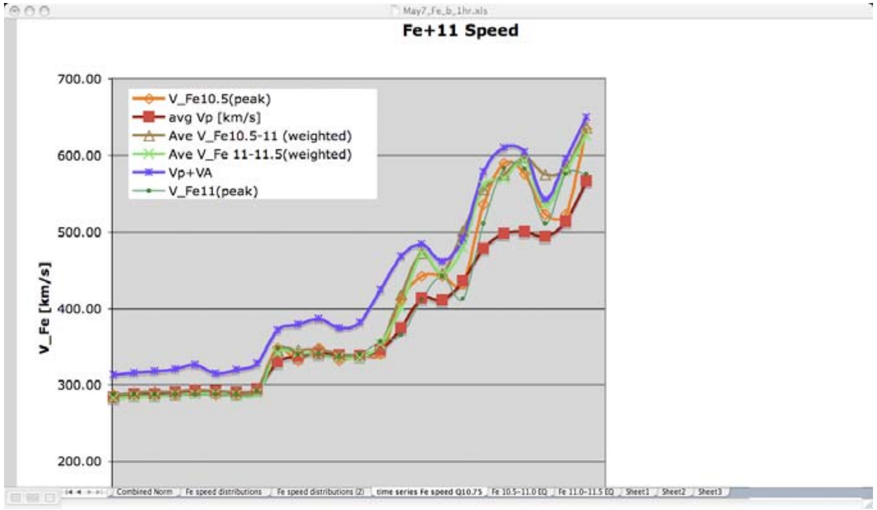


Two Hour Snap Shots

SWS Heavy Ions “PR2”

Work in Progress!

- Still working on calibration factors for fine-tuning charge identifications ("fractional charge states"), and for possible systematic (E/Q calibration) affects on heavy ion speeds.



- Need to cross check Delta Speeds with Alfven Speeds