STEREO SECCHI and S/WAVES Observations of Spacecraft Debris Caused by Micron-Size Interplanetary Dust Impacts

O. C. St. Cyr, M.L. Kaiser, N. Meyer-Vernet, R.A. Howard, R.A. Harrison, S.D. Bale, W.T. Thompson, K. Goetz, D. Wang,and S. Crothers

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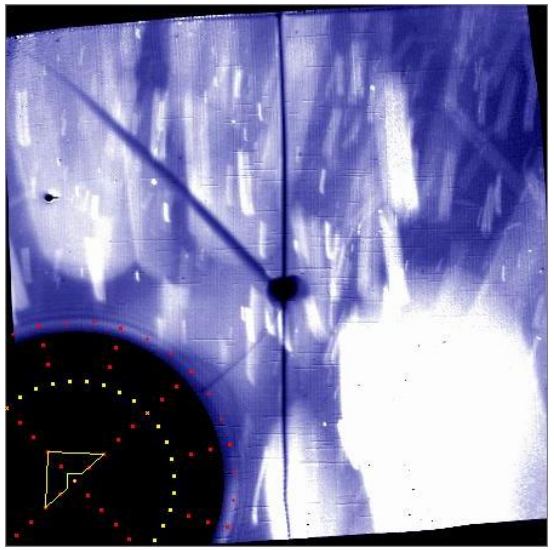
Coronagraphs are sensitive to faint intensities and have detected debris in the past

Skylab ATM S052

[water dumps]

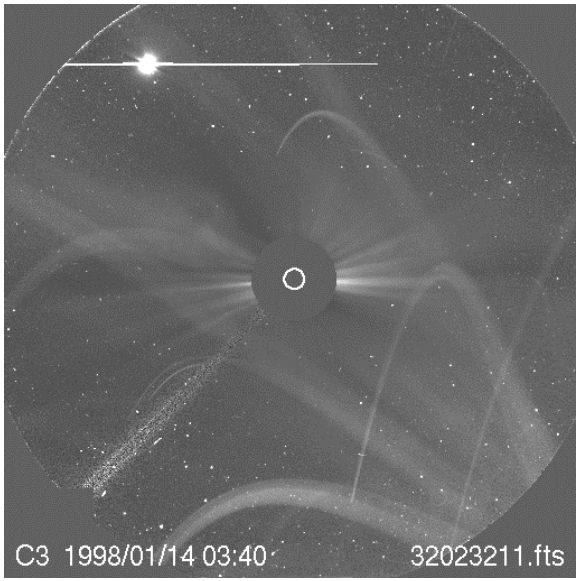


SMM C/P

[believed to be paint]

SOHO LASCO

[believed to be MLI]



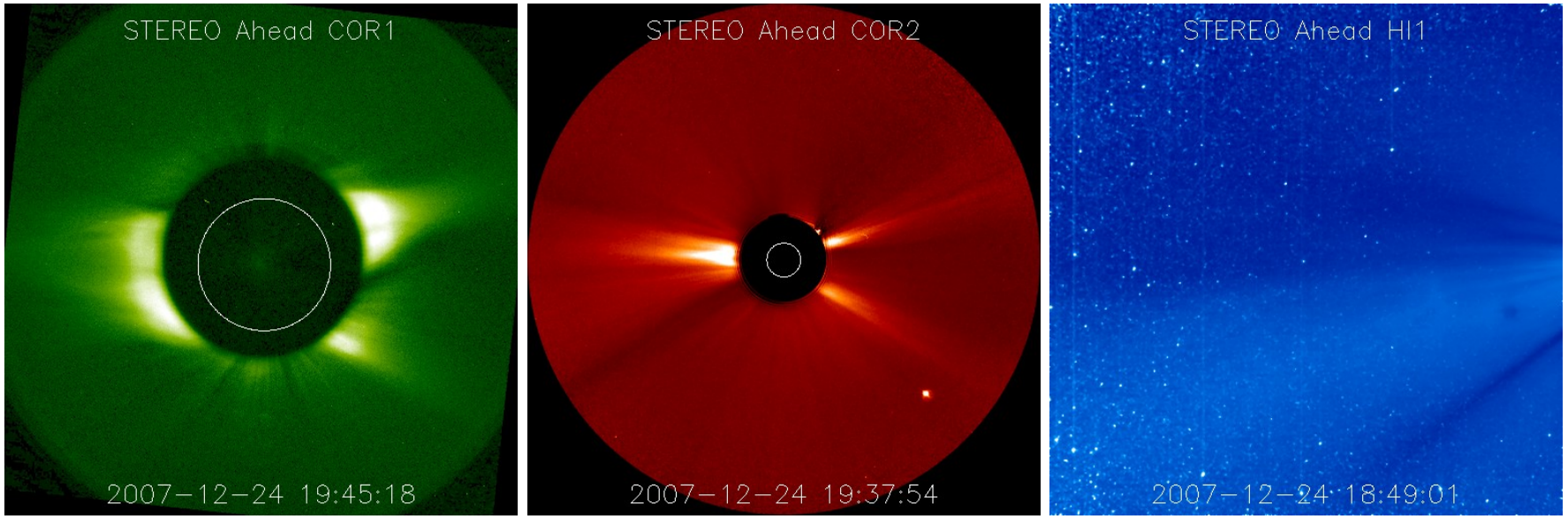
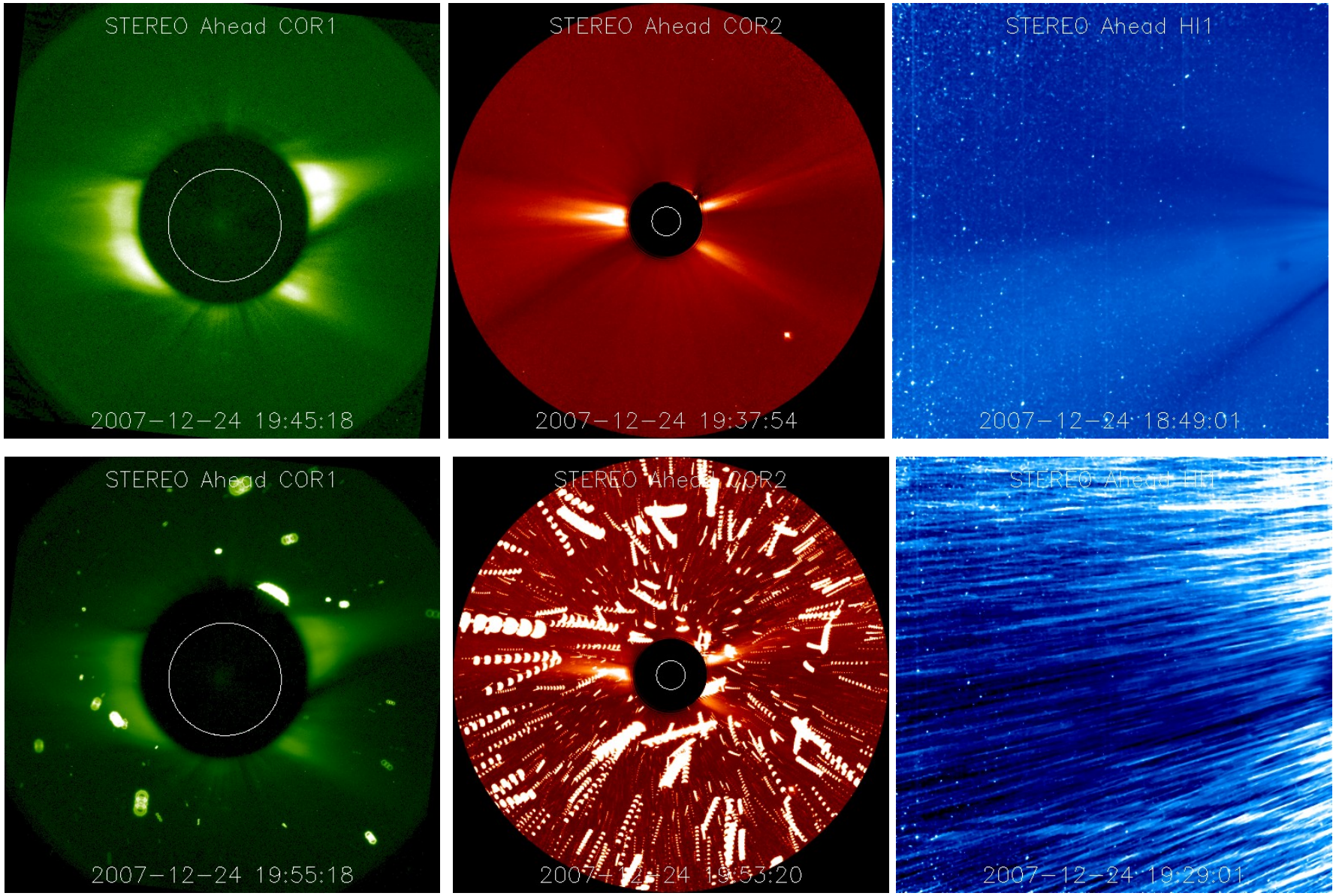


Figure 1: STEREO-A images from COR1, COR2, and HI1 immediately before (top panel) and during (bottom panel) the debris storm on 2007-12-24. Times of each image are shown, and the degradation to the scientific quality is evident.



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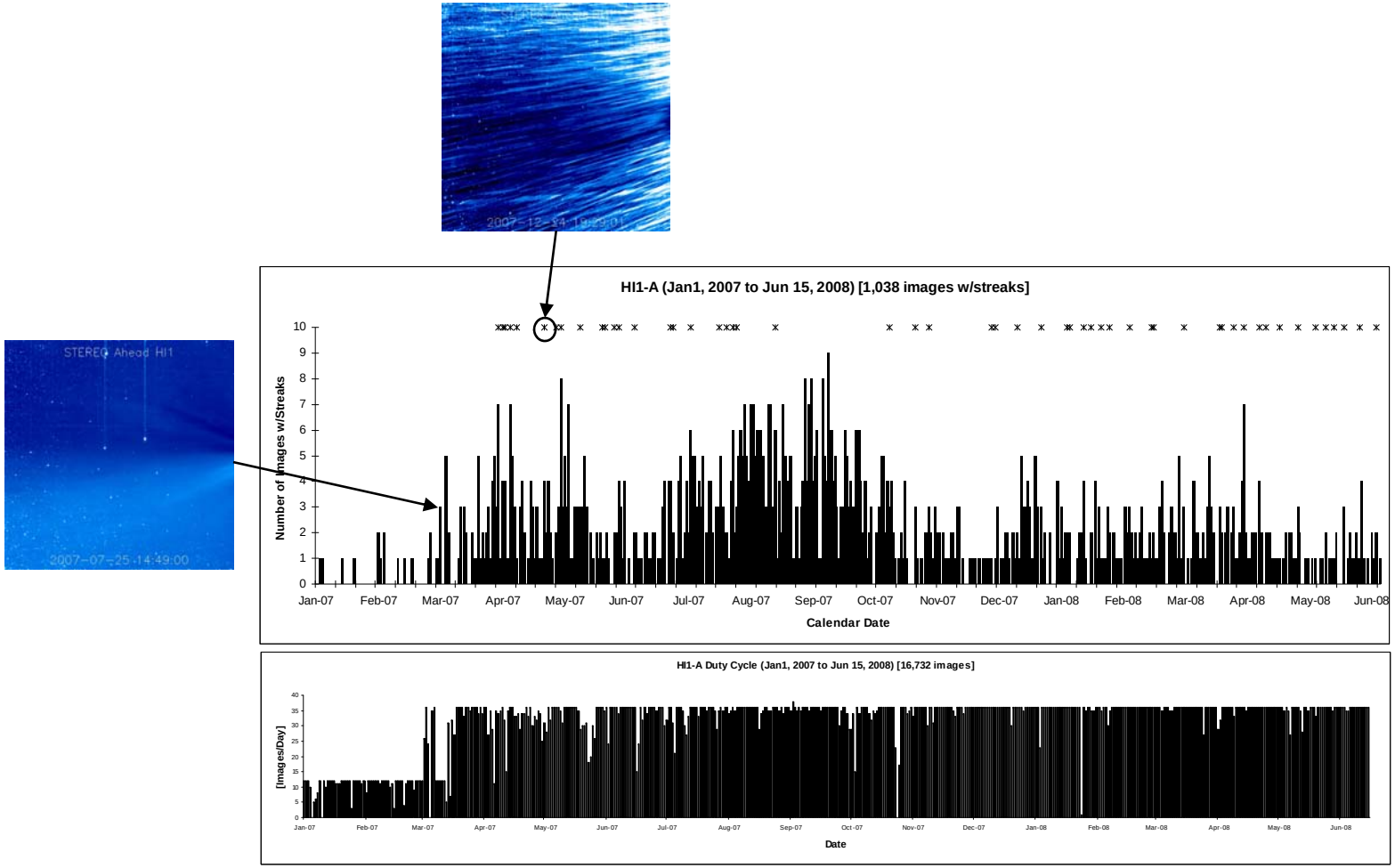


Figure 2a: Histograms of HI1-A duty cycle and debris detection from 01-Jan-2007 through 15-Jun-2008. A nominal duty cycle for this instrument is to return 36 images per day, which it has through most of this period. The asterisks denote days when "storms" have been detected (see Figure 1).

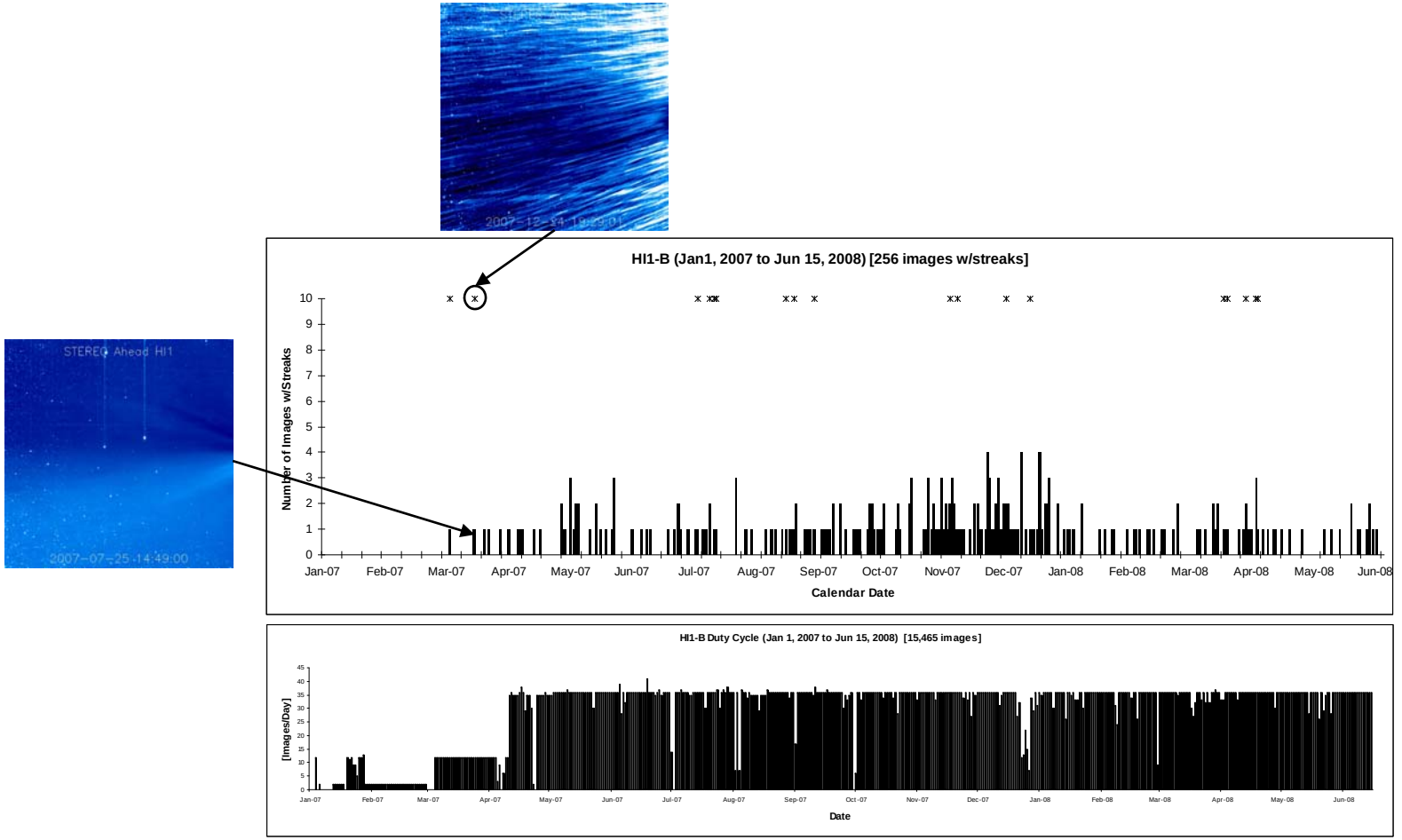


Figure 2b: Same histograms for HI1-B.

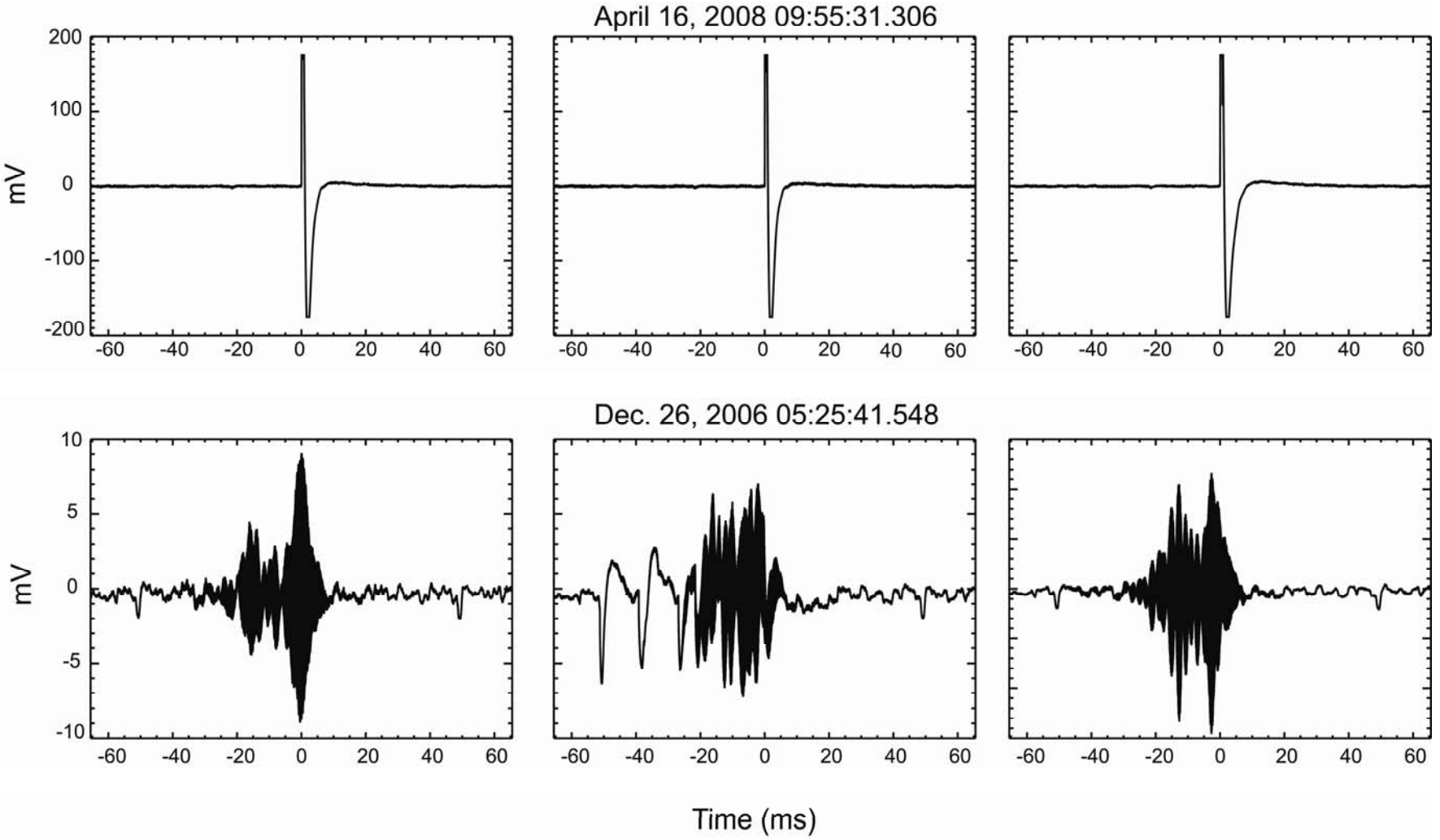


Figure 3. Top panels show an example of an impulse-like event recorded by all three electric antennas connected to the S/WAVES TDS instrument on the Ahead spacecraft. TDS samples the voltages on all three antennas 125,000 times per second. This particular event occurs during the same one minute interval as one of the HI1 debris storms. The TDS event is characterized by a brief rise to maximum intensity (saturation) followed by a large excursion in the opposite direction. The total duration of the event and others like it is typically 5-10 milliseconds. The bottom panels show a typical *in situ* Langmuir wave event recorded by the TDS. Langmuir wave and other *in situ* solar wind events rarely, if ever, saturate the TDS and are always much longer in duration than the impulse-like events. Note the different scale for the vertical axes between top and bottom panels.

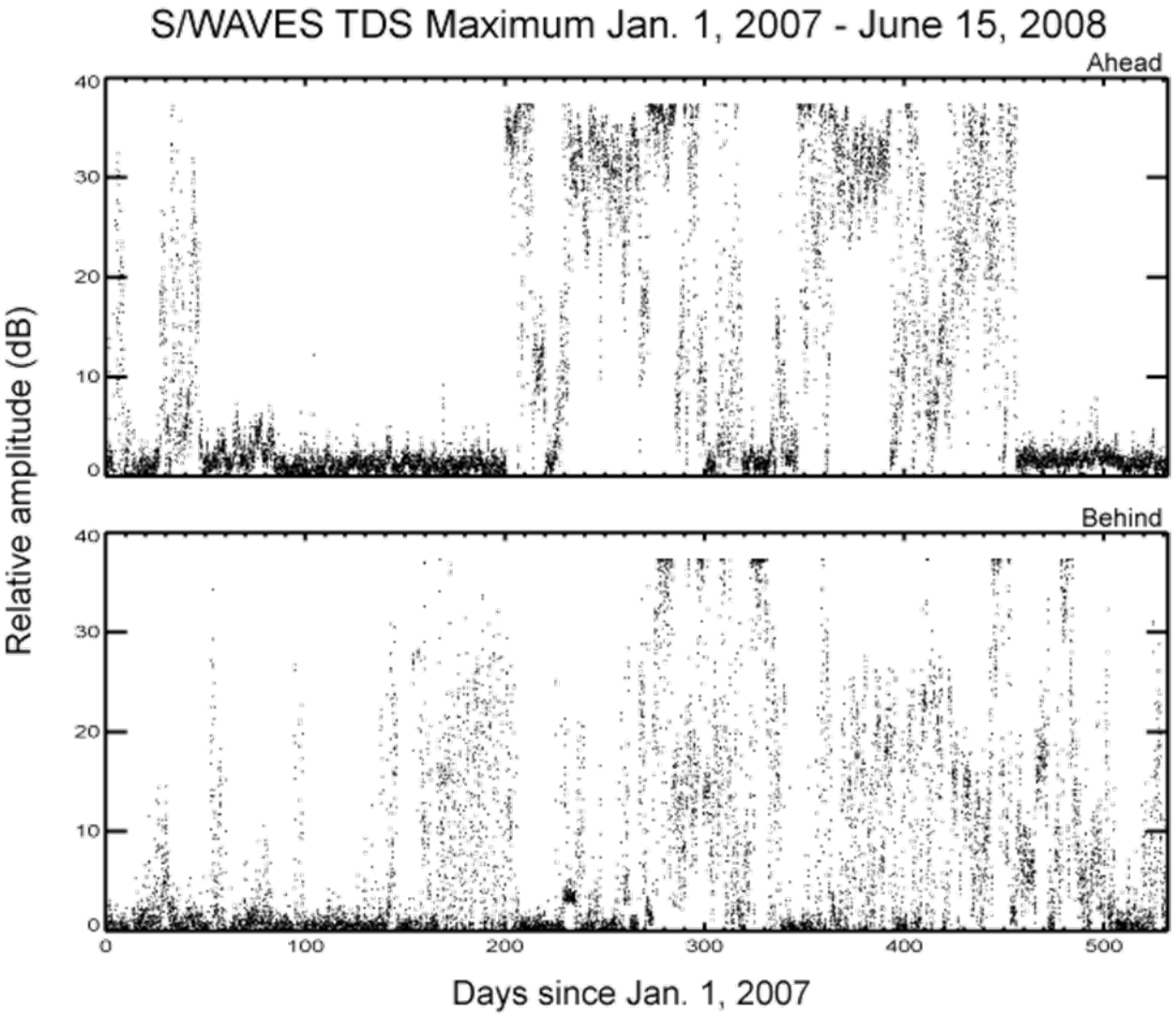
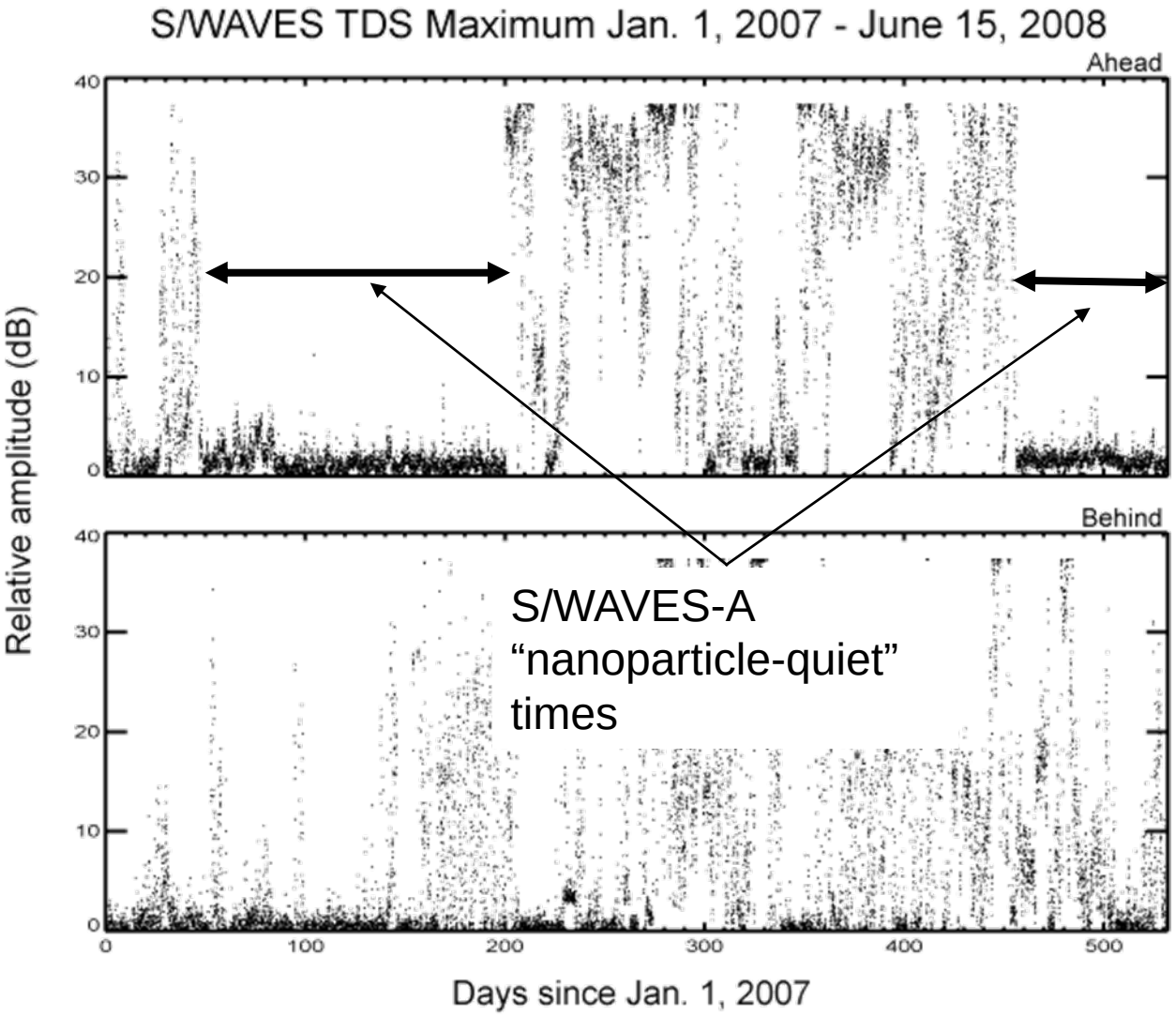


Figure 4. The average hourly maximum excursion (absolute value) of S/WAVES TDS events like those shown in figure 3 for the Ahead (top panel) and Behind (bottom panel) spacecraft for the interval of study, January 1, 2007 to June 15, 2008.



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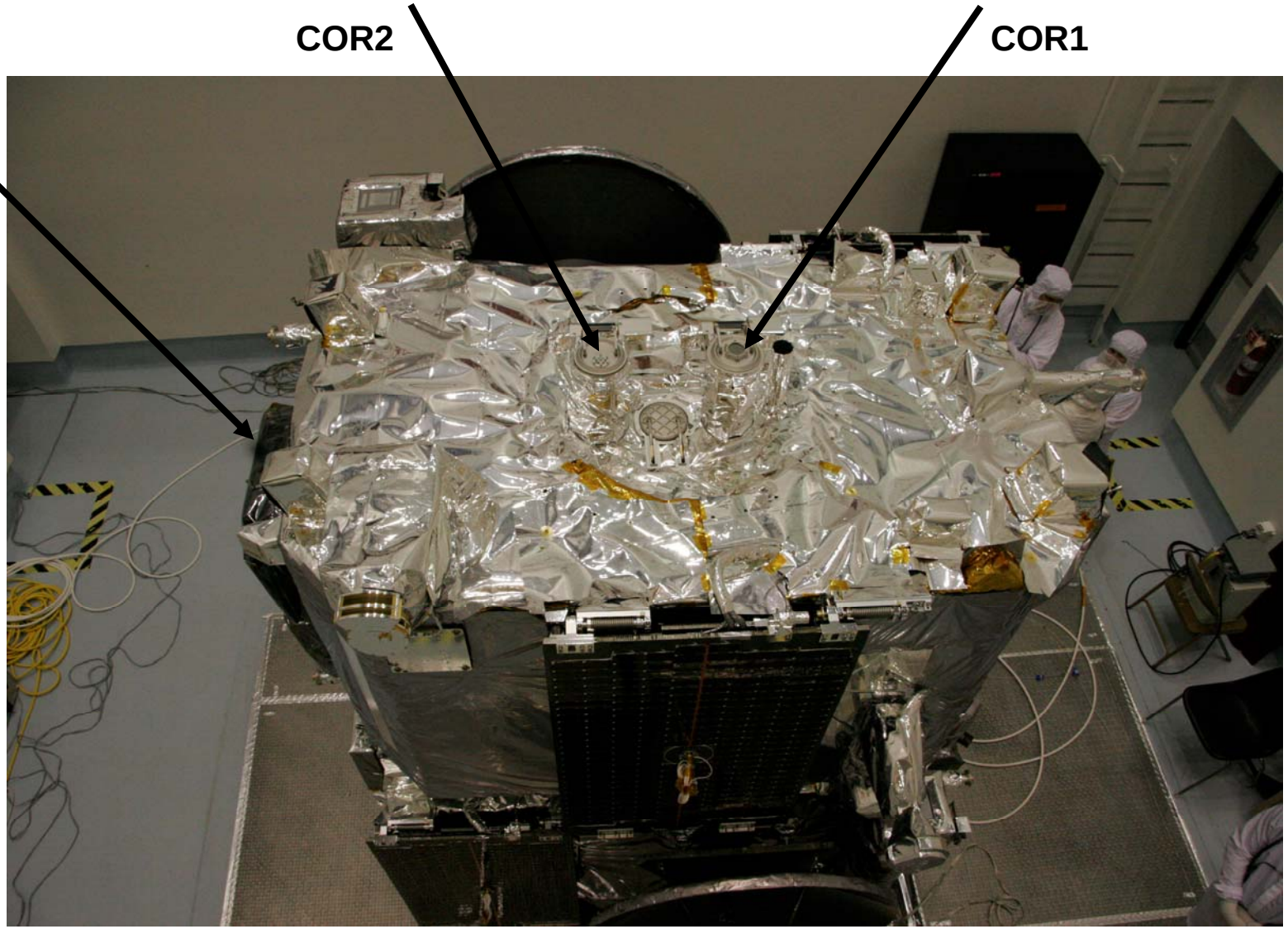
	HI1 Storms	HI1 CR Counter Avg Duration	In COR1 Images	In COR2 Images	In HI2 Image	HI2 CR counter	HI2 CR Counter Avg Duration		HI1 Events During S/WAVES Quiet Times	S/WAVES Event
HI1-A	68	7.8 m	24 (35%)	47 (69%)	6 (9%)	50 (74%)	9.9 m		34	32 (94%)
HI1-B	17	7.6 m	2 (12%)	4 (24%)	2 (12%)	13 (76%)	7.3 m		17	16 (94%)

Table 2. These are the cross-instrument statistics for the HI1 debris storms (defined as a single image containing 10 or more streaks) for the period 01-Jan-2007 through 15-June-2008. Statistics for and the length of time the debris was seen in the HI1 and HI2 cosmic ray removal counter (CR counter) are also shown.

STEREO-A



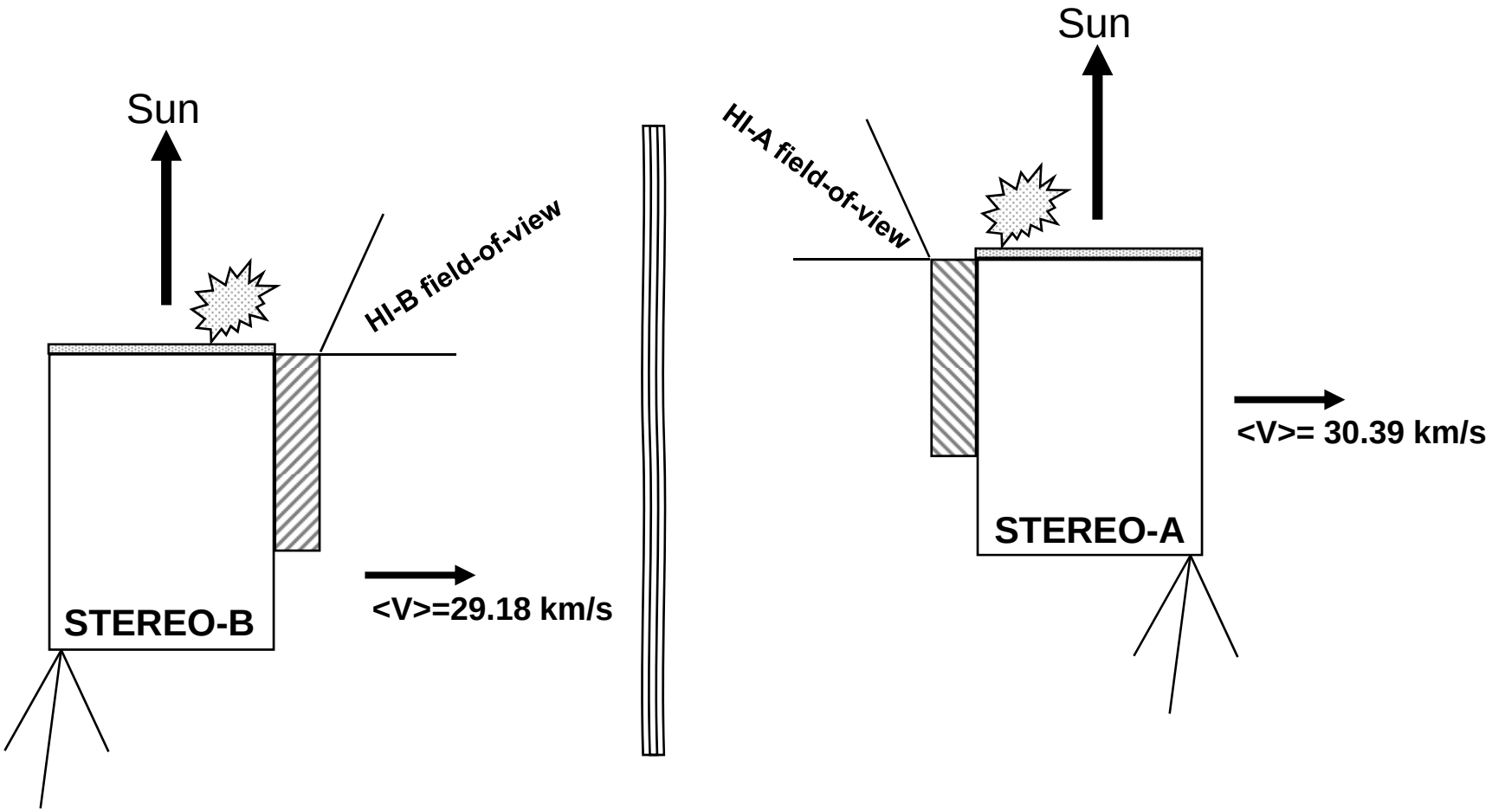
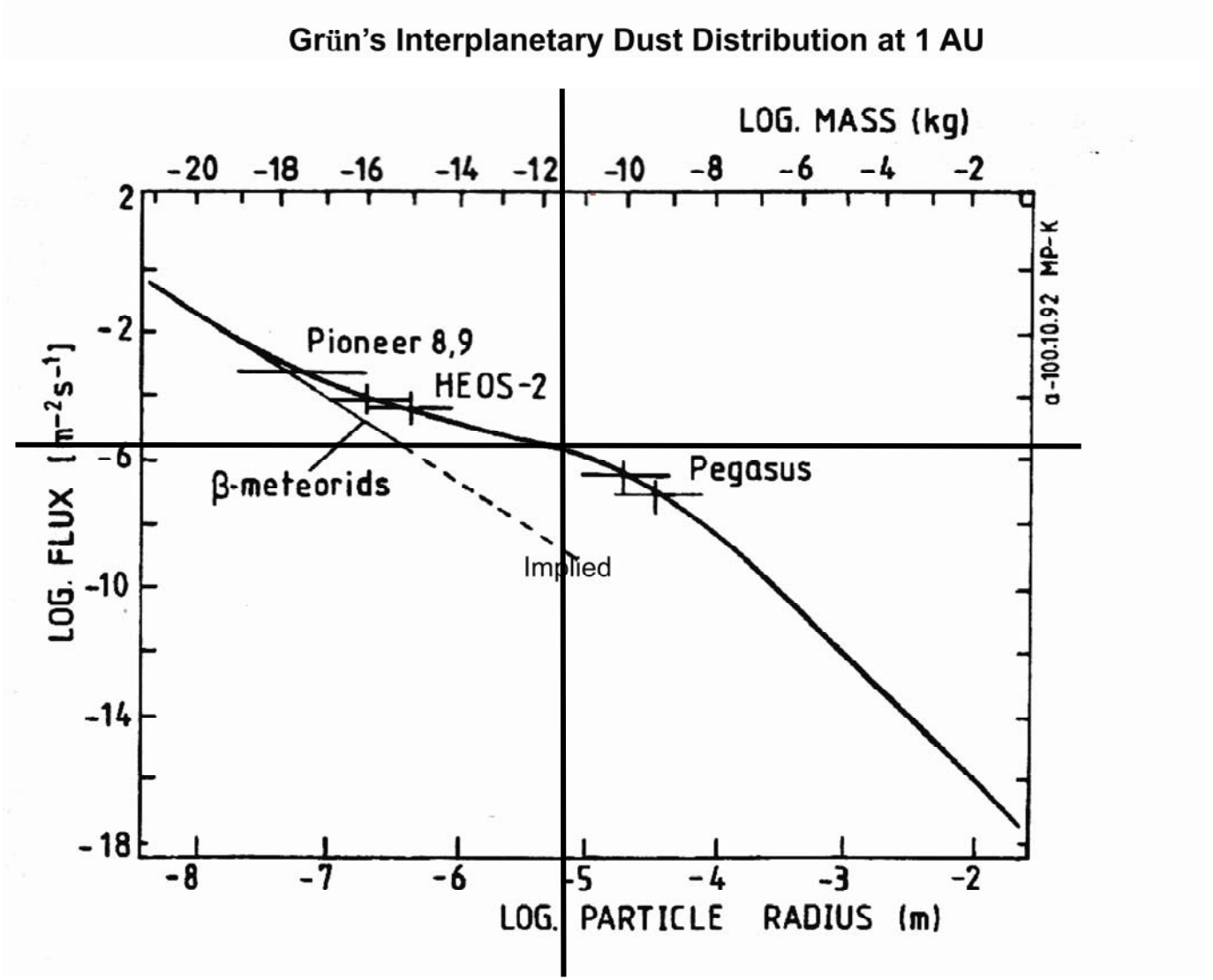


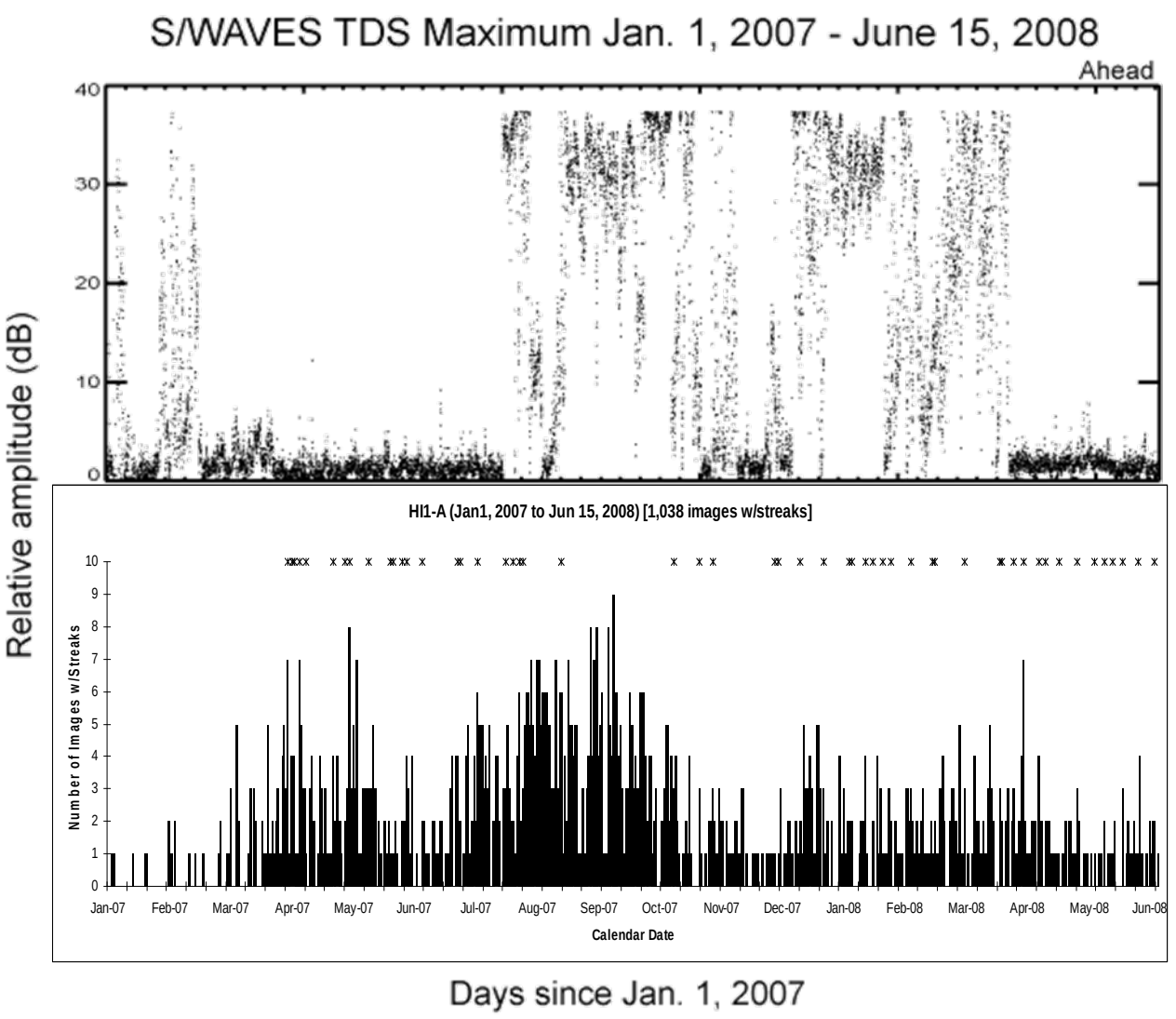
Figure 5. The orientation of STEREO-A and –B, showing the relative location of the SECCHI HI imagers (cross-hatched rectangle) with respect to the spacecraft motion (*i.e.*, ram direction). The HI fields-of-view and the location of the three S/WAVES antennae on each spacecraft are depicted schematically. A stylized "explosion" of particles is shown coming off the sunward face of each spacecraft, which is covered with an ITO-coated silver teflon thermal blanket. The spacecraft orbital motion puts the particle debris cloud into [away from] the HI-A [-B] field of view.

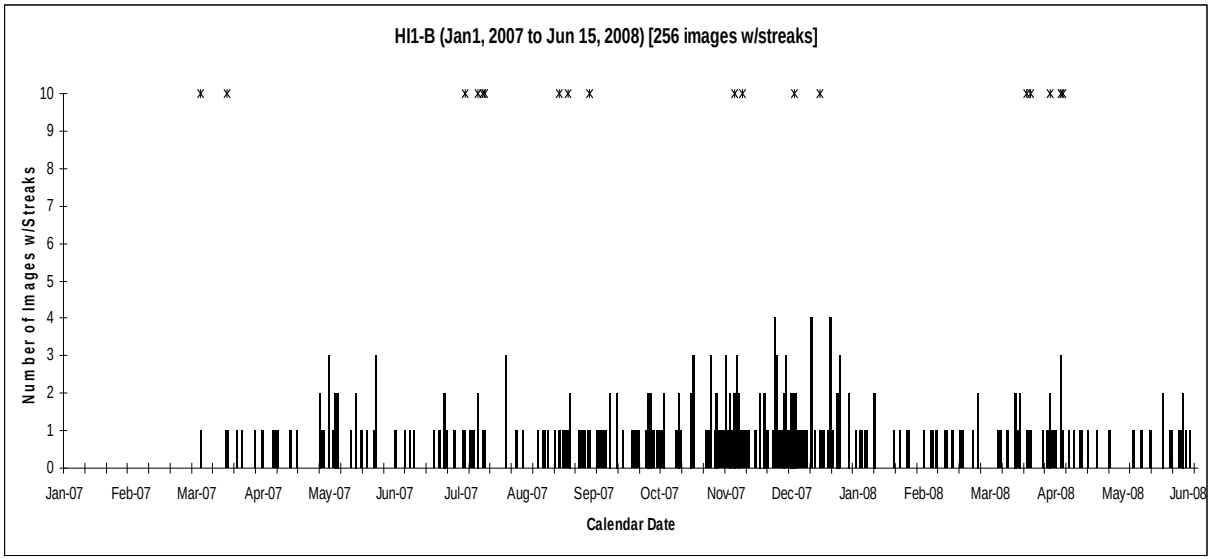
Using the HI1-A statistics, there were 16,732 images, each representing 30 minute accumulations – thus 3.012 x 10^7 seconds of observation (out of the nearly 18 months, yields a 62% duty cycle). If we assume that the Sunward face of STEREO is ~1 m^2 and the 68 debris storms represent interplanetary dust strikes on that face

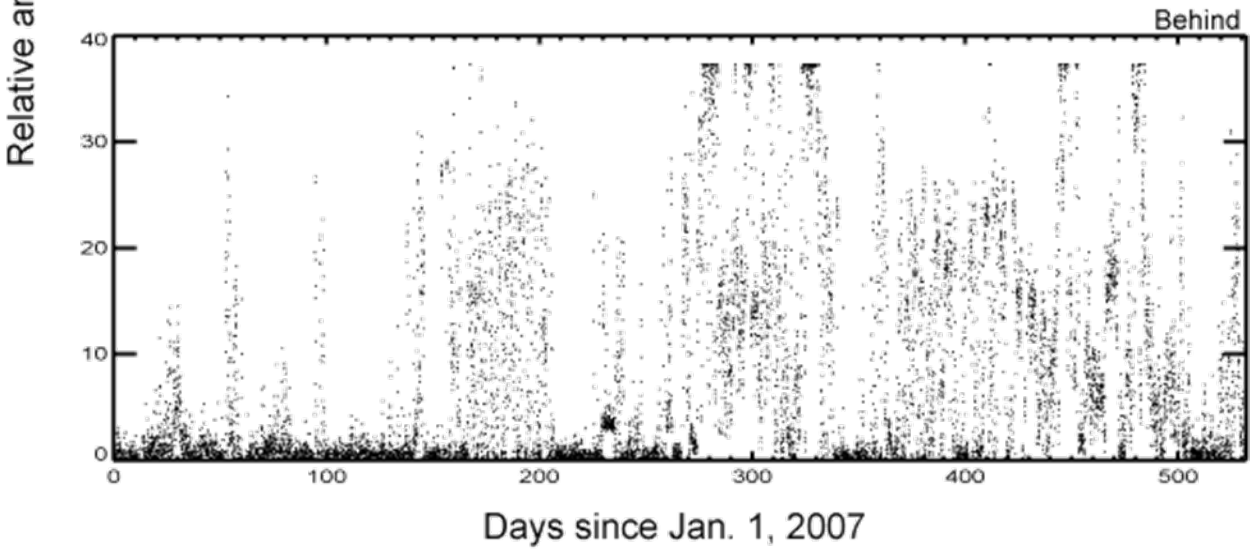


Conclusions

- Engineering Result
  - Coronagraph builders have YA learned an old lesson!
- Science Result
  - S/WAVES and SECCHI appear to detect micron-size dust impacts on the spacecraft routinely in four instruments
    - Impacts appear visually as debris in HI1
    - Also seen in HI1 and HI2 cosmic ray scrubbing counters
    - Coincident with a saturated TDS spike in S/WAVES TDS
    - Sometimes appear in visually as debris COR1 and COR2
  - A is about 4x worse than B → geometry


S/WAVES TDS Maximum Jan. 1, 2007 - June 15, 2008
Ahead
Relative amplitude (dB)
40
30
20
10
0
HI1-A (Jan1, 2007 to Jun 15, 2008) [1,038 images w/streaks]
Number of Images w/Streaks
10
9
8
7
6
5
4
3
2
1
0
Jan-07
Feb-07
Mar-07
Apr-07
May-07
Jun-07
Jul-07
Aug-07
Sep-07
Oct-07
Nov-07
Dec-07
Jan-08
Feb-08
Mar-08
Apr-08
May-08
Jun-08
Calendar Date
Days since Jan. 1, 2007


HI1-B (Jan1, 2007 to Jun 15, 2008) [256 images w/streaks]
Number of Images w/Streaks
0
1
2
3
4
5
6
7
8
9
10
Jan-07
Feb-07
Mar-07
Apr-07
May-07
Jun-07
Jul-07
Aug-07
Sep-07
Oct-07
Nov-07
Dec-07
Jan-08
Feb-08
Mar-08
Apr-08
May-08
Jun-08
Calendar Date


Behind
Relative amplitude (dB)
0
10
20
30
40
0
100
200
300
400
500
Days since Jan. 1, 2007