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SUPPORTING INFORMATION FOR “DIFFERENT TYPES OF ION POPULATIONS
UPSTREAM OF THE 8 OCTOBER 2013 INTERPLANETARY SHOCK”

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1. CONTENTS

This file contains information on how the combined ion omni directional spectra and three dimensional particle distribution functions were obtained from the data from the ESA and SST instruments and an explanation on their operational modes. We also show the sensitivities (one count levels) of both instruments and compare them with the observations.

2. ESA AND SST OPERATIONAL MODES

The ARTEMIS ESA and SST instruments were in magnetospheric Fast Survey Mode until $\sim 19:29$ UT. After that they were in magnetospheric Slow Survey Mode. While each ESA and SST sample is always collected over one spacecraft spin period (~ 4 seconds), during the two modes, there are differences in the angular, energy, and temporal resolutions of various downlinked data products.

During Fast Survey, we have three-dimensional ESA “full mode” ion distributions (88 angles, 32 energies) available every 32 spins (~ 2.1 minutes) and “reduced mode” ion distributions (50 angles, 24 energies) available for every spin. SST “full mode” ion distributions (64 angles, 16 energies) are also available for every spin.

During Slow Survey mode, ESA “full mode” ion distributions are available every 128 spins (~ 9 minutes), and “reduced/omni-directional” distributions (1 angle, 32 energies) are available every spin. SST “full mode” ion distributions are available every 64 spins (~ 4.3 minutes) and “reduced/omni-directional” distributions (1 angle, 16 energies) are available for every spin.

The mode change may sometimes result in a minor data loss of some products. Note also that some ground calibrations are only possible for the higher angular resolution data products.

3. COMBINED OMNI-DIRECTIONAL ION SPECTRA AND THREE-DIMENSIONAL ION DISTRIBUTIONS

The high time-resolution omni-directional ion spectra shown in Figure 2 of this study were constructed in the following way. During the early part of the interval, when the spacecraft were in Fast Survey mode, we have plotted the spectra of ESA reduced mode distributions and SST full mode distributions in the same panel (no interpolation, as evidenced by the small white horizontal gap).

During the later part of the interval, when the spacecraft were in Slow Survey mode, we have plotted the ESA and SST reduced/omni-directional distributions in the same panel (no interpolation). There were minor losses of the reduced/omni-directional data products during the mode change, which manifest as the white gaps in Figure 2 panels a and d.

To make the ion distribution slices shown in Figure 3, we have combined the ESA and SST full mode (highest energy and angular resolution) measurements using 3D interpolation. (Note that the cadence at which these measurements are available depends on which Survey mode the instruments were in, as described above.) This type of combined distributions have recently been used in several ARTEMIS/THEMIS studies of different plasma regions (see e.g. [Dorfman et al. 2017](#); [Hietala et al. 2015, 2017](#); [Runov et al. 2015](#)). We first removed the bins that were at or below the one-count-level from the measurements. We then combined the (cleaned-up) ESA and SST measurements by interpolating in 3D across the energy gap (at 25 keV) between the instruments. The lowest SST energy channels (<35 keV) on P2 were excluded from the interpolation due to degradation effects. Note that the distribution slices only show the features that are still above the one-count-level after the observed (and cleaned-up) distribution has been interpolated into the slice plane.

4. SENSITIVITIES OF THE ESA AND SST INSTRUMENTS

Figure 1 shows two one-dimensional spectra from ARTEMIS P1 spacecraft (a) obtained at 20:13:49-20:13:53 UT and from P2 spacecraft (b) observed at 20:13:56-20:14:01 UT on 8 October 2013. The red and blue diamonds show measurements of the ESA and SST instruments, respectively. The red dashed lines and blue dash-dotted lines represent one-count levels of the ESA and SST, respectively.

We see that, on average, the sensitivity of the ESA instruments does not permit the detection of the suprathermal ions with energies between 2 keV and 20 keV for the IP shock studied here. Similarly, the SST instrument does not observe ions with energies above 200 keV.

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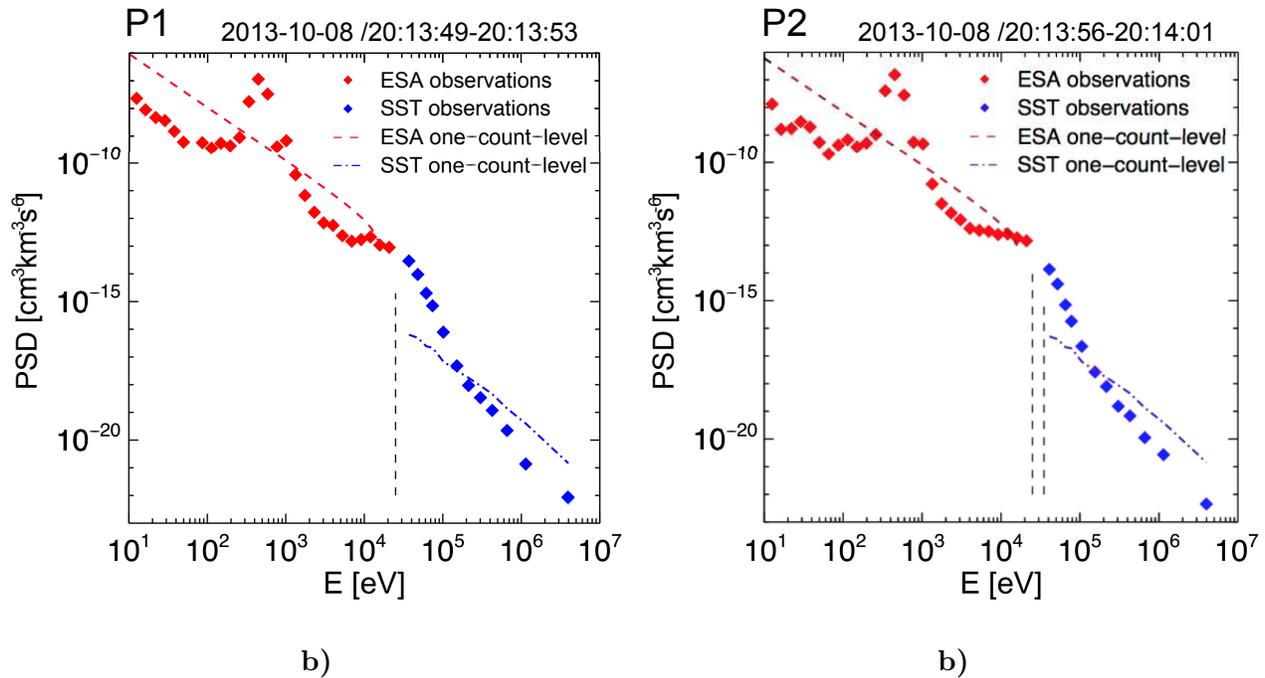


Figure 1. 1D spectra obtained by ARTEMIS P1 spacecraft (a) at 20:13:49-20:13:53 UT and by P2 spacecraft (b) at 20:13:56-20:14:01 UT on 8 October 2013. Red and blue diamonds represent ESA and SST data, respectively. The red dashed lines represent the one-count level of the ESA instrument and the blue dash-dotted lines show the one-count level of the SST instrument. Vertical dashed black lines delimit ESA data from SST data.

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