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Final Report
Restoration and Archiving of Data
From the Plasma Composition Experiment
on the International Sun-Earth Explorer One (ISEE 1)
Grant NAGW-4496

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The objective of this project has been to complete the archiving of energetic (10 eV/e - 18 keV/e) ion composition data from the Lockheed Plasma Composition Experiment on the International Sun-Earth Explorer One (ISEE 1) satellite, using a particular data format that had previously been approved by NASA and the NSSDC. That same format, a combination of ion velocity moments and differential flux spectra, had been used in 1991 to archive, at the NSSDC, the first 28 months (the "Prime" period of ISEE investigations) of data from the Lockheed instrument under NASA Contract NAS5-33047.

With the completion of this project, the almost 4 1/2-year time span of these unique data is now covered by a very compact set, approximately 1 gigabyte in total, of electronic files with physical quantities, all in ASCII. The files are organized by data type and time of data acquisition, in Universal Time, and named according to year and day of year. Each calendar day has five separate files (five types of data), the lengths of which vary from day to day, depending on the instrument mode of operation. The data format and file structure are described in detail in appendices 1 and 2. The physical medium consists of high-density (6250 cpi) 9-track magnetic tapes, complemented by a set of hard-copy line plots of certain plasma parameters. In this case there are five tapes, to be added to the six previous ones from 1991, and 25 booklets of plots, one per month, to be added to the previous 28. The tapes, including an extra standard-density (1600 cpi) tape with electronic versions of the Data User's Guide and self-guiding VAX/VMS command files, and the hardcopy plots are being boxed for shipment to the NSSDC.



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Appendices:

1. Data User's Guide (30 pages)
2. Sample Printouts of Data Files (12 pages)
3. Sample Plots of Certain Plasma Parameters (2 pages)
4. VAX/VMS Command Files for Magnetic Tape Operations (13 pages)
5. Sample Magnetic Tape Directory Listing (1 page)

Appendix 1

Data User's Guide

(30 pages)

ISEE-1 ION COMPOSITION DATA (10 eV/e to 16 keV/e);
A GUIDE TO READING THE ED-, MD-, MC-, MS-, AND EX-FILES

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PREFACE

The data and data formats described herein have been generated in cooperation with several people at the Lockheed Martin Advanced Technology Center, formerly the Lockheed Research and Development Division, in particular with R. D. Sharp, E. G. Shelley, W. K. Peterson, D. L. Carr, and W. E. Francis. The archiving of these data was supported by NASA Contract NAS5-33047 and Grant NAGW-4496.

The magnetic fields included here are based on ISEE-1 magnetometer data made available by C. T. Russell of the Institute for Geophysics and Planetary Physics at the University of California, Los Angeles, California. The processing and editing of the magnetometer data are the sole responsibility of the author.

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1. INTRODUCTION

The ISEE-1 spacecraft (along with the ISEE-2) was launched on October 22, 1977, into an orbit with apogee at almost 23 RE (geocentric), perigee at about 300 km altitude, an inclination of 29 deg, and an orbital period of 57 hours. It was placed in a spinning mode with the axis nearly perpendicular to the solar ecliptic plane and with a period of approximately 3 seconds. It reentered almost 10 years later, on September 26, 1987.

The Lockheed Plasma Composition Experiment flown on ISEE-1 is one of a family of instruments using the same type of ion optics and covering nearly the same range of energies (0 eV/e to about 17 keV/e) which have also been flown on GEOS 1 and 2, Dynamics Explorer One, and AMPTE CCE [Shelley et al., IEEE Trans. Geosci. Electron., GE-16, 266, 1978]. The Principal Investigator of the ISEE-1 experiment during its development and during its several years of operation in orbit was R. D. Sharp. In the later phase of data analysis this role was transferred to O. W. Lennartsson. For a review of the first few years of data analysis see Sharp et al. in *Energetic Ion Composition in the Earth's Magnetosphere*, edited by R. G. Johnson, TERRAPUB, Tokyo, 231, 1983.

The ISEE-1 instrument consists of two nearly identical mass spectrometers with the respective fields of view centered 5 deg above and 5 deg below the spin plane, that is about 5 deg above and below the solar ecliptic plane. Each field of view is 10 deg wide along the spin plane, and 10 to 50 deg wide transverse to this plane, being the widest at the low energy end and gradually decreasing to 10 deg with increasing energy. All data used for this archiving were obtained with one spectrometer, the one viewing below the spin plane. Information on the instantaneous pitch angles is provided by the ISEE-1 Fluxgate Magnetometer [Russell, IEEE Trans. Geosci. Electron., GE-16, 239, 1978].

Each spectrometer consists of an electrostatic analyzer to select energy per charge, followed by a combined electrostatic and magnetic analyzer to select mass per charge. Both analyzer sections have particle detectors, so at each energy setting the experiment provides both the total ion flux and the partial flux at a selected mass per charge. The detector in the energy analyzer is offset from the center path of ions and corresponds to a view direction that is slightly different from the nominal mass spectrometer field of view, being more nearly within the spin plane. To be more specific, the two detectors have about the same size fields of view at all energies, but the "energy detector" central view direction varies, being some 15 deg away from the spin plane on the opposite side of the "mass detector" view direction at near-zero energies, and gradually approaching the spin plane with increasing energy.

Each combination of energy and mass is maintained for at least 1/16 sec in high telemetry bit rate and 1/4 sec in low (normal) bit rate. Different combinations are stepped through in a cyclic fashion according to various patterns controlled by a random access memory which is programmable from the ground. Some patterns, or "modes", may require only a couple of minutes per cycle, others may take 15 to 20 minutes.

The mass selections usually include one that blocks all ions from reaching the second detector, which is a modified Johnston electron multiplier, allowing intermittent measurements of the noise associated with penetrating radiation (mostly MeV electrons and associated bremsstrahlung). These measurements are later used to correct the count rates of mass analyzed ions. The background count rate in the first detector, which is a so called spiraltron, is generally negligible and is not corrected for.

The maximum energy range is 0 eV/e (or spacecraft potential) to 17.9 keV/e, divided into 32 contiguous channels, but the lowest channel, from 0 eV/e to about 100 eV/e, is normally limited to energies above 10 eV/e by an RPA (retarding potential analyzer) in the entrance. That same RPA is used to provide "cold plasma" data from 0 to 100 eV/e (retarding within the lowest channel) during part of some measurement cycles. Because of measurement uncertainties associated with spacecraft charging and plasma convection, the "cold plasma" data have not been included here. The lowest "hot plasma" channel, the one covering 10 eV/e to 100 eV/e, has been used only sparingly for those same reasons.

All velocity moments, with one exception (see below), use 100 eV/e as the lower energy limit. As far as moments are concerned, the highest energy channel (above 16 keV/e) has not been used either, because of a slight variation over time of the mass peak locations in that channel. The energy range of moments is therefore generally 100 eV/e to (about) 16 keV/e, unless further limited by a particular instrument energy/mass scan mode (see below).

The mass range is from below 1 amu/e to about 150 amu/e, divided into 64 channels, but the most common scan cycles only sample 4 to 5 channels, corresponding to the principal ions, plus a background channel (below 1 amu/e).

2. ARCHIVAL DATA FORMAT

These archival data are a combination of ion data, magnetic field data, and s/c ephemeris, generally sorted by instrument energy/mass scan cycle and placed in five kinds of ASCII files, called the ED-, MD-, MC-, MS-, and EX-files, respectively. There is one set of these files for each day of data, and the date is part of the file names, represented by the last two digits of the year, followed by three digits for the day of the year, as for example ED78057.DAT, etc. The format and content of each kind of file are described in detail in following sections.

The ion data are a combination of velocity moments, calculated two different ways (using two different sets of assumptions about symmetry in velocity space), and energy and mass spectra. The velocity moments are calculated both from the total ion count rates in the energy analyzer, assuming that all counts are due to H⁺ ions (and using one set of symmetry assumptions), and from the partial count rates at M/Q = 1, 2, 4, and 16 in the mass analyzer, assuming those counts to be due to the four principal magnetospheric ions H⁺, He⁺⁺, He⁺, and O⁺, respectively (and using both sets of symmetry assumptions). The "total ion" moments are listed in the ED-file, the partial (mass analyzed) moments are listed in the MD-file.

The energy spectra are based on mass analyzed counts only, and are listed in the MC-file for the same four principal ions (same four M/Q values), plus a fifth ion, namely the O⁺⁺ (M/Q= 8). The five energy spectra are a compacted representation of the raw count rates at each energy (spin-averaged and maximum).

The mass spectra (when produced) show the accumulated raw counts (and number of samples) in each of the 64 mass channels in four energy ranges. These are listed in the MS-file.

The magnetic field data (time averaged) are listed in all of the ED-, MD-, MC-, and MS-files. In addition, the magnetic field measurements have been used in

conjunction with the ion data to determine pitch angles and ion plasma beta.

The s/c ephemeris is also listed with the ion data in the ED-, MD-, MC-, and MS-files, but an extra set of half-hour interval parameters are listed in the EX-file. That file contains only ephemeris, and has been used to label certain data plots. These plots are available in hardcopy (see end of this document for description).

3. TIME COVERAGE

These data have been produced to cover the entire 4.4-year lifetime of the Lockheed ISEE-1 instrument, from launch on October 22, 1977, through March 20 of 1982. The coverage is continuous with the following exceptions:

- a. The initial two weeks were devoted to extensive in-flight testing and calibration of the experiment. The resulting data have not been used for this archiving, so the beginning date is day 312 of 1977.
- b. The instrument was normally turned off for 1.5 to 2 hours at perigee, occasionally longer (primarily to avoid the inner radiation belts).
- c. Extended periods of "cold plasma" measurements (a few tens of hours all together). No such measurements are included here, but they were normally carried out as brief (few minutes) interruptions of longer energy/mass scan cycles and do not normally show up as data gaps.
- d. Solar wind measurements in the so called "sun-synchronous" mode. In this mode data were taken at an increased rate in a narrow spin angle sector around the sun direction, and no data were taken at other angles, in order to maintain the same average data rate per spin. These data have been judged too cumbersome to treat within the particular format of this archiving. The resulting data gaps are numerous and extensive, sometimes leaving an entire day blank.
- e. Gaps in the data transmission/reception or poor quality reception. These are usually of modest duration (few hours) but fairly common.

4. NUMERICAL ACCURACY

The absolute calibration of the instrument is believed to have been accurate to better than 30% in the early phase of in-flight operations. This estimate is based mostly on pre-flight tests in the laboratory, but also on extensive early in-flight confirmation of the location and shape of major peaks in M/Q spectra. As discussed below (in connection with the MC-file), the first 28 months of mass analyzed data have been derived from counts acquired at the higher of two detector triggering levels, in order to minimize the effect of background. This triggering level has become progressively less sensitive over the years, but it has been monitored, and the count rates, through February (actually through March 1) of 1980, have been adjusted accordingly, before being used in the moment calculations. These adjustments are believed to have maintained the absolute calibration accuracy to within about 30% to 35% during high (normal) sensitivity operations. Data taken after February of 1980 are based on the lower triggering level, which is believed to have remained fairly constant over time. Except for the somewhat higher background in these later data, the absolute accuracy is expected to be comparable to that of the earlier data.

4.1 Normal High Sensitivity Mode

These estimates assume ideal conditions, however, which means that the differential flux of any ion species is isotropic within the field of view of each sampling, constant in energy over the width of each energy channel, and constant in time during each sampling. Any or all of these conditions may be violated in a real situation, and the resulting error may be significantly greater than 35%. To take an extreme example: if a phase space density is inferred from the count rate in the lowest energy channel, from between 10 eV/e and slightly beyond 100 eV/e, that count rate is divided by 40 eV/e (the weighted center energy). If in fact the ions all have energies near the lower or upper edges of this channel, then the phase space density will be either four times too small or almost three times too large. Errors of a similar magnitude may occur when the ion flux has an extremely narrow angular distribution, or when it varies rapidly in time. The energy distribution is of less concern at higher energies (smaller ΔE over E), but the potential error in phase space density due to narrow angular distributions can be large at any energy, especially in low (normal) bit rate, where the instrument sweeps through 30 deg of spin angle during a sampling (1/4 sec).

Summing (weighted) phase space densities into moments does reduce the relative measuring errors, but to infer complete three-dimensional moments from these data requires assumptions about that part of the unit sphere which is not being sampled. The potential new errors are impossible to calculate, of course, but they can be minimized by making realistic assumptions. The moments listed in the MD-file have been calculated two ways, using two entirely different sets of assumptions (see file description), each set being optimal in some part of the ISEE-1 environment. As can be seen from the listed numbers, the two ways of calculating number densities, for example, produce nearly the same result much of the time, at least in the magnetosphere. If the respective set of assumptions is correct, then the moment calculations are intrinsically accurate to within a few percent.

4.2 Low Sensitivity Mode

If operated normally, the particle counters will saturate when exposed to the high directional flux of H^+ in the magnetosheath and solar wind. Even the He^{++} may cause saturation in these regions of space. To avoid this and to increase the dynamical range of the data, the instrument was designed to have a second commandable detector function that would reduce the sensitivity by about two orders of magnitude. This is accomplished in one case by turning off one of two power supplies (in the mass analyzer) and by shifting the power to another detector in the other case (in the energy analyzer). For the most part, this sensitivity change is programmed to occur automatically when the count rate exceeds a certain threshold, and to be deactivated at the start of the next group of commands, that is typically within 8 sec in low bit rate and within 2 sec in high. New commands are activated at intervals that are multiples of 32 samplings, called "octaves", usually at every such octave. Normally the instrument maintains the same mass channel for one or more whole octaves at a time as well.

In theory this dual sensitivity function is simple enough, but it has several practical problems, especially when it is set to be automatic. The change to low sensitivity takes a finite known time (close to one second), but the telemetry bit stream does not allow the exact starting time to be shown, only the af-

ected octave is flagged. Instead the time of change must be estimated from the sequence of count rates, which is hampered by rapid strong variations in the ion flux. In automatic operation it is also reset to normal in an automatic fashion (takes negligible time), so the change to low sensitivity may be repeated as often as every octave (or every other octave in high bit rate).

During the computer processing of these archival data, the transitions from high to low sensitivity have been treated as data dropouts, for simplicity, and only counts taken at least 1.5 seconds (1/2 spin) beyond the estimated start of each transition have been included, after multiplication by a constant scaling factor representing the end state (no such multiplication in the MS-file). This method avoids having the transient count rates multiplied by the wrong variable scaling factor, due to uncertainties in the exact timing, but it creates a systematic undersampling of the ion flux near its maximum and on one side of this maximum. The situation is further aggravated by the fact that these automatic sensitivity changes tend to occur where the ion fluxes have the strongest anisotropies and the narrowest energy distributions.

In view of these difficulties, all data obtained in low sensitivity mode should be treated with suspicion. They show the gross and qualitative plasma properties very well, but the tabulated numbers may be substantially wrong. If it is important to establish absolute values, it is worth comparing these numbers with archived data from some of the other particle instruments on the ISEE-1 and -2. The data most often obtained in this mode are those in the ED-file and the H+ data in the MD-, MC-, and MS-files. Sometimes the He++ data are also affected. All data obtained this way are clearly flagged (see file descriptions).

5. KNOWN ERRORS

All data, including the magnetic field data, have been screened very rigorously with respect to potential problems in the telemetry transmission and reception. Any time the telemetry quality flags suggest a potential problem, all data that could possibly be affected have been discarded without further investigation. In addition, every ion count rate and every magnetic field reading have been examined for clearly "unrealistic" values, that is unrealistically large values under given circumstances (given region of space). Such values have been discarded on an individual basis (sample by sample).

5.1 Ion Data

The remaining errors, as far as they are known, are rather few and normally obvious from the wider context, especially when the various files are intercompared. One group of known errors consists of a few isolated "bursts of counts" in the MS-file (mass spectra) at M/Q values where no significant ions are to be expected. Being outside of the nominal mass peaks, these false counts are not included in the MC- and MD-files. Another group of suspected errors consists of a few isolated "bursts of ions" having strangely repetitive count rate and angle of motion, as evident in the MC-file.

Another known but subtle error may occur in the lowest energy channel (< 100 eV/e) in mass analyzed H+ data, at very low count rates. This error is most likely caused by scattered sunlight. Specifically, when the instrument aperture is pointing very nearly sunward, the energy analyzer is set for $E/Q < 100$ eV/e, and the mass analyzer is set for $M/Q = 1$, a very weak signal may arise from what is believed to be ions produced internal to the instrument preacceleration re-

gion by photoionization of residual gas, giving the impression of a weak anti-sunward flow of H⁺ ions. No systematic investigation has yet been undertaken to quantify this problem, but the effect is probably only of concern in the tail lobes, where natural H⁺ counts may be extremely low [Sharp et al., J. Geophys. Res., 86, p. 4639, 1981]. This is one of the reasons why the lowest energy channel is treated separately in the moment calculations (see below).

5.2 Magnetic Field Data

These have more errors in them, unfortunately, but that is offset by the fact that expertly processed values can be obtained from other archival files supplied by the Principal Investigator for the ISEE-1 Fluxgate Magnetometer (C. T. Russell; NSSDC identification No. 77-102A-04; see also newly released data on the World Wide Web, at <http://www-ssc.igpp.ucla.edu/forms/isee/>). There are two main types of errors occurring here, one brief error often present at the gain changes (at most once or twice per orbit) due to a misalignment of the gain flag and the actual data on the tape, and another less common but longer lasting error that may appear in connection with certain offset corrections (related to the antenna flip status). These errors are more fully explained in the descriptions of the ED- and MD-files, along with methods to recognize the errors (see also description of hardcopy plots at the end of this document). Errors in the magnetic field only affect part of the ion data, namely the beta value and the moments that are based on pitch-angle binning (the second method used in the MD-file).

6. THE ED-FILE

This file contains data from a particle counter called the "energy detector", or "ED", which intersects the ions after energy analysis but before mass analysis. The count rates have been converted to certain velocity moments assuming that all counts are due to protons. These moments are thus not directly comparable to any of the moments in the MD-files, unless the protons are indeed the dominant species. Even in that case, there may often be significant differences between the ED and MD proton moments, because the ED and MD particle counters respond to ions with slightly different external angles of motion (see above), and the two sets of count rates are usually averaged over different times.

Since the ED count rates are independent of the mass channel selection, and the energy channels are normally scanned at a higher rate than are the mass channels, it is usually possible to obtain several consecutive sets of ED moments during each complete instrument scan cycle. This advantage has been utilized whenever possible, and the ED averaging intervals are more or less independent of the phase of the instrument cycle. The criterion most commonly used for defining the ED intervals is to have a "sufficiently dense" coverage in energy and spin phase angle. This criterion varies with different types of energy and mass scan patterns, but typically amounts to having at least every other energy channel sampled in each of 12 spin angle sectors (30 deg wide sectors). The missing matrix points are filled in by interpolation between adjacent points before the moments are calculated.

The criterion for ending each ED averaging interval is modified when the instrument is in low sensitivity mode (usually set by automatic triggering at extreme count rates) and, at the same time, the count rates show strong (10-fold or stronger) spin phase modulation. At such times the ED intervals are made equal to the instrument scan cycle. This situation occurs most often in the solar

wind. The purpose is to suppress artificial oscillations in the moments caused (in some modes) by spin phase dependent energy samplings. The modification has not been applied uniformly throughout the entire data set, however, so there are periods of "strange" and non-physical modulations in the ED moments, especially in the densities. At any rate, all data taken in low sensitivity mode should be treated with care; they are not intended to represent accurate quantitative measurements, but they have been included to complete the gross qualitative picture and to provide continuity between times of normal magnetospheric data. All low sensitivity data are flagged as such (see below).

Unlike the MD data, the ED data have not been corrected for background counts due to penetrating radiation (not measured), but they are known to be much less affected by that problem than are the MD data (different kinds of detectors). The ED data also differ from the MD data in that no standard deviations are calculated from the combination of counts (a saving in CPU time and output volume). If necessary, approximate upper limits on the ED standard deviations can be estimated from the corresponding standard deviations in the MD-file (the MD data have additional variance associated with background correction).

6.1 File Format

The ED-file has been written by a formatted sequential FORTRAN WRITE:

```
WRITE (9,210) IYYDDD, IUTSEC, BXED, BYED, BZED, BTED, ITHETB, IPHIB,  
*EDDNS, EDEMN, EDVEL, IEDANG, ACSEC, XCSEC, ENRG1, ENRG2, RX, RY, RZ  
  
210 FORMAT(2I6, 4F8.1, I4, I5, 3(1PE10.2), I5, 2(0PF8.2), 2F5.1, 3F6.1)
```

The variable names represent the following quantities:

IYYDDD is the year (two digits) and day of year (three digits).

IUTSEC is the universal time in seconds at the midpoint of the averaging interval. The nominal length of each interval is defined by the distance between adjacent midpoints, but the actual length may vary somewhat because of time gaps (noise) in the data (see ACSEC below).

BXED, BYED, BZED, and BTED are the GSE components and absolute value, respectively, of the measured magnetic field, each averaged over the ED interval (for data quality check, see next section). The unit is "nanotesla" ("nT"), or equivalently, "gamma".

ITHETB and IPHIB are, respectively, the magnetic field elevation and longitude angles in GSE coordinates. ITHETB ranges from -90 deg (southward) to +90 deg (northward), IPHIB from -180 deg (antisunward) to +180 deg (antisunward), with 0 deg being sunward and 90 deg duskward. These angles have been calculated from the time averaged field components, and are rounded to the nearest integer.

EDDNS is the ion number density in "/cm³" (assuming protons) contained in the nominal energy range from 100 eV to about 16 keV (see also next section).

EDEMN is the "thermal" ion energy in "keV", that is the mean energy (0.1 - 16 keV) minus the energy associated with the common drift motion.

EDVEL is the common drift speed in "km/sec" in a plane parallel to the s/c

spin plane, that is approximately in the solar ecliptic plane.

IEDANG is the longitudinal direction angle of that same drift, with 0 deg being sunward, and 90 deg duskward (-180 deg to +180 deg).

ACSEC is the number of seconds of data included in the moments. This number is normally at least 6% smaller than the length of the averaging interval, since neither the lowest nor the highest energy channels are included (may be further reduced by data gaps).

XCSEC is the number of seconds during the averaging interval when the ED detector was in low sensitivity mode. This number is almost always zero in the magnetosphere, but usually nonzero in the magnetosheath and solar wind. If nonzero, it implies that at least some of the count rates have been multiplied by a crude scaling factor (= 130) to compensate for the reduced sensitivity.

ENRG1 and ENRG2 are, respectively, the lower and upper energy limits used in the moment calculations, in units of "keV". These are normally 0.1 and 16.1, but may be modified in some modes (cf. comments on energies above).

RX, RY, and RZ are the GSM coordinates of the s/c (at midpoint of interval) in units of "earth radii". On the rare occasions when the GSM coordinates are unavailable (due to faulty ephemeris tape) the GSE coordinates are used instead (available on raw data tape). Those occasions are flagged in the EX-file (also flagged in the MC-, MD- and MS-files).

6.2 Further Explanations of Certain Variables.

The magnetic field values provided here may to some extent duplicate what is now available at the NSSDC (Prof. C. T. Russell; NSSDC identification number 77-102A-04) and on the World Wide Web (<http://www-ssc.igpp.ucla.edu/forms/isee/>) but are not intended to supplant those. The values derived here may not have been adequately screened against telemetry noise or adjusted for instrument anomalies, so it is recommended that the PI provided data be consulted whenever there is doubt about accuracy. There are two types of errors known to occur here:

- a. When the magnetometer is commanded to low gain on the inbound leg of the s/c orbit, usually between $R = 8 R_e$ and $= 5 R_e$, the corresponding flag may show up slightly too late on the raw data tape, resulting in a brief underrepresentation of the field by a factor of 32. This may last for about a minute or less (part of one major frame) and affects a single ED interval. This error ought to be fairly obvious in the ED data, and therefore traceable in the MD data as well (by comparing the times). The corresponding mismatch at high gain command on the outbound leg, that is a sudden 32-fold increase of the field, is usually discovered as "unreal" and corrected.
- b. Part of the computing procedure to decipher the raw telemetry data is to infer, indirectly, the current magnetometer antenna flip status from the uncorrected field values themselves (pertains to the s/c Y and Z coordinates). This part fails occasionally, which in turn makes the remaining procedure unable to correct the field readings for magnetometer offset, resulting in anomalous modulations of the GSE components. Early in the mission, when the offset is fairly small, these modulations cause the

sum $BXED^{**2} + BYED^{**2} + BZED^{**2}$ to be much smaller than the square of the time-averaged absolute field strength $BTED^{**2}$. Later in the mission, when magnetometer drift has created a larger offset, this sum may settle at a rather large artificial value, of order 100 nT. In either case, it is recommended that the two measures of field strength be compared routinely, and that other magnetic field data be consulted if those two differ by more than a few percent. This problem usually only occurs in regions of weak magnetic field, mostly in the solar wind, where it is easily recognized by the aforementioned sum being nearly constant, with no evidence of diamagnetic influence by the ion pressure (see below). An additional (or alternative) check can be made using certain MD data (see below).

The velocity moments have been calculated from a 32 energy channel (covering the entire range from 10 eV to about 18 keV) by 12 spin angle sector (30 deg each) matrix of time-averaged count rates in the following steps:

- I. A phase space density is assigned to each matrix point, using the local count rate when available, or interpolating between adjacent count rates if the point has not been sampled. The bottom and top energy channels are included in the interpolation procedure, when necessary, but not in the integration (summation) over energy.
- II. Within each energy channel the phase space densities are weighted by cosines or sines of the spin angle (center of sector) and summed over angle to form two orthogonal projections. These projections are in turn weighted by energy and by an energy bandwidth (see below) and summed over energy channels, forming two orthogonal components, approximately the GSE X and Y components, of a vector that is proportional to number flow density. Both components are then divided by a total (scalar) sum of phase space densities weighted by the energy bandwidth and by the square root of the energy, that is by a sum proportional to number density, to form (approximate) X and Y drift velocity components, and an angle IEDANG.
- III. A spherical coordinate system is envisioned with its polar axis along the drift velocity vector, that is in the GSE X-Y plane. It is now assumed that the phase space density has azimuthal symmetry in this coordinate system (rotational symmetry around drift velocity vector). The number density, drift speed (but not angle), and mean energy are recalculated by summing over solid angle and energy in this system. The solid angle weighting factors in this case are zones on a unit sphere, each defined at the intersection with the GSE X-Y plane by the boundaries of a 30 deg spin angle sector, or by one boundary and the drift velocity vector. These zones are partially overlapping, and summing over 12 spin angle sectors (typically = 14 zones) means covering the unit sphere twice, so a factor 1/2 is applied to each sum. The drift speed (EDVEL) and mean energy (EDEMN) are obtained by dividing flow density and energy density, respectively, by the number density (EDDNS). The mean energy is converted to "thermal" energy by subtracting the equivalent drift energy.

If the drift speed in step II is less than 14 km/sec (less than 1 eV energy), the coordinate system is instead aligned with the X-Y projection of the magnetic field, that is with the angle IPHIB, provided the elevation angle ITHETB is between -45 and +45 deg. If the latter is not the case, and if the drift speed is below 14 km/sec, the coordinate system is aligned with the s/c spin axis, and

the phase space densities are treated as isotropic. Only density and mean energy are recalculated in these two cases.

The summation over energy treats each energy channel, except the second one (first channel not included), as a point measurement at the center energy, and takes the energy bandwidth to be the distance between adjacent channels in the trapezoidal fashion. At the second channel an extra term is added to extend the integral from the center energy downward to about 0.1 keV, assuming the flux to be a constant. This addition brings the mathematical energy range in better agreement with the instrumental range of acceptance.

The variable ACSEC is a sum of elementary time segments associated with each commanded setting of the power supplies controlling energy and mass channels. These elementary times are 1/4 sec during low bit rate operation (about 80% of the time) and 1/16 sec during high bit rate operation. These times include the resetting of the power supplies, however, and are slightly longer than the times associated with particle counting. For simplicity, the particle counting is interrupted for about 12% of the elementary time segments in both low and high bit rate operation to allow for resetting. The ACSEC therefore exceeds the actual particle counting time by about 14% in both cases.

7. THE MD-FILE

This file contains data from a particle counter called the "mass detector", or "MD", which receives the ions after both energy and mass analysis. Count rates of the four principal magnetospheric ion species, the H⁺, He⁺⁺, He⁺, and O⁺, have been sorted by 32 energy channels (10 eV/e to 18 keV/e), 12 spin angle sectors (30 deg each) and 9 pitch-angle ranges (20 deg each) and averaged over each complete energy/mass scan cycle of the instrument. At the end of each cycle the averaged count rates have been converted to certain velocity moments using two different assumptions: the velocity distributions have rotational symmetry around either (A) the bulk flow vector or (B) the local magnetic field direction (see below). Note: the ion labels are applied to certain M/Q values (the instrument does not measure mass per se) and may be inappropriate in the magnetosheath and solar wind, especially at M/Q= 4 (He⁺).

The energy/mass scan cycles vary in length from a few minutes to about 20 min or more, depending on the instrument mode of operation. Each cycle may cover only a few mass channels and a reduced energy range, or it may cover the full energy range at each of 64 mass channels (load mode). The most common modes in the magnetosphere provide for multiple energy scans at each of 5 to 7 mass channels (including a background channel at M/Q < 1), where each energy scan may sample a different subset of the 32 energy channels (e.g. every fourth channel in four interleaving scans), and each energy channel is maintained for about four seconds (1.3 s/c spin cycles). In addition, each cycle may contain a few scans through all 64 mass channels at a few energies, as well as one or two brief scans through the RPA voltages in the lowest energy channel (cold plasma measurements not included here). In order to simplify tabulation of moments, no distinction is made here between different phases of a given cycle. That is, all moments are treated as averages over the same cycle, although different ions were in fact sampled at different phases (the same ion often more than once per cycle).

All MD moments have been corrected for background counts due to penetrating radiation (mostly MeV electrons and associated bremsstrahlung). This has been done by subtracting an average background, that is the average sampled during

a given energy/mass scan cycle, from the average ion count rates in each energy and angle bin. As a consequence, normally non-negative moments such as number density may end up negative, when the count rate of a given ion is very close to background levels, and the count rate in the background channel happens to be on the high side due to normal statistical or temporal fluctuations. This is to be expected, and negative values ought to be included in any statistical averaging of number densities from these files, in order not to bias the result.

All MD moments have a standard deviation assigned to them. This one accounts for purely statistical uncertainties, those associated with Poisson counting statistics. In all cases but one, the tabulated value is an integer number between 0 and 999, which represents the ratio in percent (%) between the standard deviation and the absolute value of the moment itself, rounded downward (values greater than 999 assumed irrelevant). The one exception is the bulk flow angle (drift direction angle) in the GSE X-Y plane (spin plane), where the standard deviation is expressed as an angle between 0 and 360 deg, rounded to the nearest integer.

The variance (square of standard deviation) of a given moment, or a given combination of moments (as in bulk velocity and mean energy), has been calculated in a customary fashion by taking the partial derivative with respect to the count rate in each energy and angle bin included in the moment (in both numerator and denominator, where applicable), squaring the derivative, multiplying it with the variance of the associated count rate, and adding such terms over all bins. If the same count rate is used twice, in order to replace a missing sample in an adjacent bin (see below), its contribution to the variance is adjusted so as to reflect the reduced number of independent samplings. All standard deviations, except the one assigned to bulk flow angle (see below), include a contribution from the variance of the background measurement. The reason for the exception is that the background measurement, although subtracted from all other count rates, is a scalar (single number) that cancels out from the calculation of flow angle.

For various reasons, the data may be statistically insufficient to allow a given moment (or combination of moments) to be calculated. If the number density has been calculated to be a negative number (background measurement too high), for example, it makes no sense to even attempt to calculate a mean energy. And if only a few energy channels have been sampled (due to noisy data), it makes no sense to calculate any of the moments, since the output format presumes a certain degree of consistency. Whenever a moment calculation fails, the corresponding standard deviation is set equal to -1.

7.1 File Format

The MD-file has been written in groups of five lines (records), using formatted sequential FORTRAN WRITE statements as follows:

The first of five lines is a title line:

```
WRITE (8, 230) IYYDDD, JSTART, JSTOP, RX, RY, RZ, RT, DZ, IMLAT, TLOCL,  
*BXMD, BYMD, BZMD, BTMD, BETA, IDBETA, BCTR, MDTCR,  
*ENEMAX, IRATE, RSEY, RSEZ
```

```
230 FORMAT (I6, 2I5, 5F6.1, I4, F5.1, 4F8.1, 1PE10.2, I3, 1PE10.2, I3,  
*0PF5.1, I2, 2F6.1)
```

The variable names represent the following quantities:

IYYDDD is the year (two digits) and day of year (three digits).

JSTART is the universal time in minutes at the beginning of the averaging interval, that is the time of the first good data in that interval. This is normally at the start of an energy/mass scan cycle, unless some initial data in that cycle are bad.

JSTOP is the universal time in minutes at the end of the averaging interval, that is the time of the last good data in that interval. This is normally at the end of an energy/mass scan cycle, unless the last data in that cycle are bad.

RX, RY, RZ, and RT are, respectively, the GSM X, Y, Z, and radial distance at the midpoint of the averaging interval, all in units of "earth radii" ("Re"). RY and RZ are set to 999. if GSM coordinates not available (RX same in GSE).

DZ is the distance in "earth radii" (at midpoint) from the nominal neutral sheet in the geotail according to Fairfield and Ness [J.Geophys. Res., 75, 7032, 1970]. This is only displayed for GSM X < -11 Re, otherwise set to 999. If no GSM coordinates available, it is set to 0.

IMLAT is the geomagnetic latitude in degrees (at midpoint), rounded to the nearest integer. This is set to 0, if no ephemeris tape available.

TLOCL is the geographic local time in hours and 1/10 hours (at midpoint). This is set to 0.0, if no ephemeris tape available.

BXMD, BYMD, BZMD, and BTMD are the GSE components and absolute value, respectively, of the measured magnetic field, each averaged over the whole MD interval (for data quality check, see next section). The unit is "nanotesla" ("nT"), or equivalently, "gamma".

BETA and IDBETA are a simplified representation of the ion plasma beta and its standard deviation (% of absolute value). Its definition is explained in the next section.

BCTR is the average background count rate in counts/sec.

MDTCR is a flag showing which of two detector pulse height triggering levels has been used (= 2 in data from before March 2 of 1980, = 1 afterwards).

ENEMAX is the maximum energy sampled, in units of "keV/e", or equal to 16.1, whichever is smaller (16.1 is maximum in moments). Even if it is listed as 16.1 (typical) the moments of some ion species may sometimes be limited to lower energies, depending on the energy/mass scan mode (see next section).

IRATE is a flag showing which of two data accumulation (and telemetry transmission) rates has been used. The low or normal rate (80% of the time) is shown by IRATE = 1, the high rate by IRATE = 4. Note: low rate means four (4) samplings/sec, high rate means sixteen (16) samplings/sec.

RSEY and RSEZ are the GSE Y and Z (at midpoint of averaging interval) in units of "earth radii".

The next four lines list, respectively, the moments for H⁺ (K= 1), He⁺⁺ (K= 2), He⁺ (K= 3), and O⁺ (K= 4) (that is actually for M/Q= 1, 2, 4, and 16):

```
DO 270 K=1,4
```

```
WRITE(8,240)DNS5, ID0, DNS8, ID1, EMN8, ID2,  
*VDRFT, ID3, IDRFT, ID4,  
*BGD, ID6, ACSEC, XCSEC,  
*IPAMIN, IPAMAX, DENS8, ID7, EPER8, ID8, EPAR8, ID9
```

```
240 FORMAT(4(1PE10.2, I3), I5, I4, 1PE10.2, I3, 0PF7.2, 0PF6.2,  
*I4, I4, 1PE10.2, I3, 2(1PE9.2, I3))
```

```
270 CONTINUE
```

The variable names represent the following quantities:

DNS5 and ID0 are the number density in "/cm³" and standard deviation (% of absolute value) of ions with energies between 10 eV/e and about 100 eV/e, that is of ions in the lowest energy channel (with RPA voltage fixed at 10 V).

DNS8 and ID1 are the number density in "/cm³" and standard deviation (% of absolute value) of ions with energies between about 100 eV/e and 16 keV/e (normally).

EMN8 and ID2 are the mean energy in "keV" and standard deviation (%) of ions in the nominal energy range from 100 eV/e to 16 keV/e. Note: this is total energy, including bulk motion, and it is in units of "keV", not "keV/e".

VDRFT and ID3 are the common (among those ions) drift speed (bulk flow speed) in "km/sec" and standard deviation (%) of ions in that same energy range (100 eV/e - 16 keV/e). This drift speed is in the s/c spin plane, that is approximately in the GSE X-Y plane.

IDRFT and ID4 are the longitudinal direction angle of that same drift and its standard deviation, both in "degrees". IDRFT = 0 is sunward and = 90 is duskward (-180 deg to +180 deg). ID4 is between 0 and 360 deg.

These moments, from DNS5 through IDRFT, assume that the velocity distribution has rotational symmetry around the drift (flow) vector (in the GSE X-Y plane).

BGD and ID6 are the equivalent isotropic density in "/cm³", over the 100 eV/e to 16 keV/e range, and standard deviation (%) corresponding to the measured average background count rate. That is, BGD is equal to the total background correction of DNS8 (a number already subtracted from DNS8). The ID6, when expressed in absolute terms, is part of ID1.

ACSEC is the number of seconds of data included in the moments for that ion species. This number is normally a small fraction of the length of the averaging interval (energy/mass scan cycle).

XCSEC is the number of seconds during the averaging interval when the MD detector was in low sensitivity mode and, at the same time, was sampling that particular ion species. This number is almost always zero in the magne-

tosphere, but usually nonzero for H+ in the magnetosheath and solar wind. In the latter cases it is often nonzero for He++ ions as well. If it is not zero, it implies that at least some of the count rates of that ion species have been multiplied by a crude scaling factor (= 65 for MDTCR = 2) to compensate for the reduced sensitivity.

IPAMIN and IPAMAX are the minimum and maximum pitch angles in "degrees" sampled for those ions, rounded to the nearest integer. Note: if the magnetic field is properly measured and corrected for magnetometer offsets, then the sum of these angles, IPAMIN + IPAMAX, should range between about 170 deg and 190 deg.

DENS8 and ID7 are the number density in "/cm³" and standard deviation (% of absolute value) of ions in the 100 eV/e - 16 keV/e range, assuming that the velocity distribution has rotational symmetry around the local magnetic field vector (see next section for further explanations).

EPER8 and ID8 are the mean perpendicular energy (perpendicular to magnetic field; two degrees of freedom) in "keV" and standard deviation (%) of ions in the 100 eV/e - 16 keV/e range, assuming that same kind of symmetry.

EPAR8 and ID9 are the mean parallel energy (parallel to magnetic field; one degree of freedom) in "keV" and standard deviation (%) of ions in the 100 eV/e - 16 keV/e range, assuming that same kind of symmetry.

7.2 Further Explanations of Certain Variables.

The magnetic field values provided here may to some extent duplicate what is now available at the NSSDC (Prof. C. T. Russell; NSSDC identification number 77-102A-04) and on the World Wide Web (<http://www-ssc.igpp.ucla.edu/forms/isee/>) but are not intended to supplant those. The values derived here may not have been adequately screened against telemetry noise or adjusted for instrument anomalies, so it is recommended that the PI provided data be consulted whenever there is doubt about accuracy. There are two types of errors known to occur here:

- a. When the magnetometer is commanded to low gain on the inbound leg of the s/c orbit, usually between $R = 8 R_e$ and $= 5 R_e$, the corresponding flag may show up slightly too late on the raw data tape, resulting in a brief underrepresentation of the field by a factor of 32. This may last for about a minute or less (part of one major frame) and affects a single MD interval. This error ought to be fairly obvious in the ED data, and therefore traceable in the MD data as well (by comparing the times). The corresponding mismatch at high gain command on the outbound leg, that is a sudden 32-fold increase of the field, is usually discovered as "unreal" and corrected.
- b. Part of the computing procedure to decipher the raw telemetry data is to infer, indirectly, the current magnetometer antenna flip status from the uncorrected field values themselves (pertains to the s/c Y and Z coordinates). This part fails occasionally, which in turn makes the remaining procedure unable to correct the field readings for magnetometer offset, resulting in anomalous modulations of the GSE components. Early in the mission, when the offset is fairly small, these modulations cause the sum $BXMD^{**2} + BYMD^{**2} + BZMD^{**2}$ to be much smaller than the square of the

time-averaged absolute field strength BTMD**2. Later in the mission, when magnetometer drift has created a larger offset, this sum may settle at a rather large artificial value, of order 100 nT. In either case, it is recommended that the two measures of field strength be compared routinely, and that other magnetic field data be consulted if those two differ by more than a few percent. This problem usually only occurs in regions of weak magnetic field, mostly in the solar wind, where it is easily recognized by the aforementioned sum being nearly constant, with no evidence of diamagnetic influence by the ion pressure (see below). An additional (or alternative) check can be made by summing IPAMIN and IPAMAX. If that sum is several degrees smaller than 170 deg or several degrees larger than 190 deg, then the magnetic field should be in doubt.

The velocity moments have been calculated two ways, A and B, using either of two energy-angle matrices. Both matrices consist of 32 energy channels (covering the entire range from 10 eV/e to about 18 keV/e), but one has 12 spin angle sectors (30 deg each) and no pitch angles, the other has 9 pitch-angle sectors (20 deg each) and no spin angles. In method A, using 12 spin angle sectors, the calculations consist of the following steps:

- A.I A phase space density and a corresponding standard deviation are assigned to each matrix point that has been sampled, using the local average count rate, minus an average background count rate, and the number of samplings. No interpolations are made at this stage.
- A.II Within each energy channel that has been sampled (usually all have), except the bottom and top ones, the phase space densities are weighted by cosines or sines of the spin angle (center of sector) and summed over angle to form two orthogonal projections. At this stage the phase space densities are interpolated in angle, if some angular bins have no samples. These projections are in turn weighted by energy and by an energy bandwidth (see below) and summed over energy channels, forming two orthogonal components, approximately the GSE X and Y components, of a vector that is proportional to number flow density. Both components are then divided by a total (scalar) sum of phase space densities weighted by the energy bandwidth and by the square root of the energy, that is by a sum proportional to number density, to form (approximate) X and Y drift velocity components, and a drift angle IDRFT. Similar summations are carried out with the variances (square of standard deviations), using the corresponding partial derivatives (squared) as weights, to derive the standard deviation of the drift angle (ID4).
- A.III A spherical coordinate system is envisioned with its polar axis along the drift velocity vector, that is in the GSE X-Y plane. It is now assumed that the phase space density has azimuthal symmetry in this coordinate system (rotational symmetry around drift velocity vector). The number density, flow density (but not angle), and energy density are recalculated by summing over solid angle and energy in this system. The solid angle weighting factors in this case are zones on a unit sphere, each defined at the intersection with the GSE X-Y plane by the boundaries of a 30 deg spin angle sector, or by one boundary and the drift velocity vector. These zones are partially overlapping, and summing over 12 spin angle sectors (typically = 14 zones) means covering the unit sphere twice, so a factor 1/2 is applied to each sum. The drift speed (VDRFT) and mean energy (EMN8) are obtained by dividing

flow density and energy density, respectively, by the number density (DNS8). No drift energy is subtracted from this mean energy. The corresponding standard deviations (ID3, ID2, and ID1) are derived from similar sums of variances, using partial derivatives as weights.

- A.IV The partial number density of ions in the bottom energy channel (DNS5) and the corresponding standard deviation (ID0) are also calculated in this coordinate system, although in this case the energy "sum" has a single term covering the channel width (10 eV/e to about 100 eV/e).

If the drift speed in step A.II corresponds to less than 1 eV (less than 14 km/sec for H+, less than 4 km/s for O+, etc.), then the coordinate system is instead aligned with the X-Y projection of the magnetic field (calculated from BXMD and BYMD), provided the field elevation angle (including BZMD) is between -45 and +45 deg. If the latter is not the case, and if the drift speed is below minimum, the coordinate system is aligned with the s/c spin axis, and the phase space densities are treated as isotropic. Only density and mean energy are recalculated in these two cases.

In method B, using 9 pitch-angle ranges (0.0 - 19.9, 20.0 - 39.9, etc.), the steps are as follows:

- B.I A phase space density and a corresponding standard deviation are assigned to each matrix point that has been sampled, using the local average count rate, minus an average background count rate, and the number of samplings.
- B.II If only part of the pitch-angle range has been sampled, which is often the case (indicated by IPAMIN and IPAMAX), then the empty angular bins near 0 deg and 180 deg are assigned the same phase space density as the nearest sampled bin (closer to 90 deg) at the same energy.
- B.III A spherical coordinate system is envisioned with its polar axis along the magnetic field vector (arbitrary direction). It is now assumed that the phase space density has azimuthal symmetry in this coordinate system (rotational symmetry around magnetic field vector), which is to say that the phase space densities in the 9 pitch-angle bins represent the entire unit sphere. The number density and the parallel (axial) and perpendicular energy densities are calculated by summing over solid angle and energy in this system. When summing over solid angle, the parallel and perpendicular energies are represented by, respectively, the cosine square and the sine square of the pitch angle at the center of each bin. The solid angle weighting factors in this case are 9 contiguous zones on a unit sphere, each defined by the boundaries of a 20 deg pitch-angle sector. The two mean energies (EPAR8 and EPER8) are obtained by dividing the respective energy densities by the number density (DNS8). The corresponding standard deviations (ID9, ID8, and ID7) are derived from similar sums of variances, using partial derivatives as weights. Only the standard energy range (0.1 - 16 keV/e) is included here.

EPER8 and EPAR8 should have a ratio of 2:1 if the velocity distribution is isotropic (or if the count rates have been extrapolated from a single bin at 90 deg pitch angle), since EPER8 represents two degrees of freedom and EPAR8 only one. Due to rounding-off errors in the summation over angle, however, the isotropic ratio is not exactly 2, but about 1.969. More specifically, if statistical and

instrumental errors are neglected, EPER8 is very nearly exact (about 0.02% too small), but EPAR8 is about 1.55% too large. Naturally, neither energy will be very meaningful if the magnetic field is in error (see above).

The "ion plasma beta" listed in the title line, BETA, is actually calculated with method A. The ion pressure used here is equal to 2/3 (two degrees of freedom) of the sum of "thermal" energy densities of the four ion species, that is total energy densities minus the energy densities associated with the respective drift speed, as calculated assuming symmetry around the respective drift velocity vector. This pressure has been divided by a magnetic pressure based on BTMD. An alternative and more formally correct value may be calculated using the "gyrotropic" density DENS8 and perpendicular energy EPER8, although those quantities do not account for bulk flow (drift). In case the magnetic field is suspect, and other field measurements are available, the beta can only be recalculated with method A (using DNS8, EMN8, and VDREFT for each ion).

The summation over energy treats each energy channel, except the first and second ones, as a point measurement at the center energy, and takes the energy bandwidth to be the distance between adjacent sampled channels in the trapezoidal fashion, ignoring intermediate channels with no samples. At the second channel an extra term is added to extend the standard energy integral from the center of the channel downward to about 0.1 keV, assuming the flux to be a constant. This addition brings the mathematical energy range into better agreement with the instrumental range of acceptance. At the first energy channel, which is treated separately, the energy summation has only one term that includes the channel width (10 eV/e - 100 eV/e) as a factor (only DNS5 and ID0 calculated).

Since the summations are done after the completion of an energy/mass scan cycle, the energy channels have normally been sampled in a contiguous fashion, but the summation procedures are set up to accept gaps of as many as four channels (due to noisy data), before declaring the data insufficient.

Depending on the scan mode, the lowest and highest energy channels sampled may vary, and are sometimes different for different ions. The summation procedure uses the actual lower and upper channels, so the moments of different ions may on occasion cover different energy ranges. There are no flags to separate ions in that regard in the MD-file (insufficient space), but the actual energy coverage is shown for each ion in the MC-file (see below). See also the explanation of ENEMAX above.

The variable ACSEC is a sum of elementary time segments associated with each commanded setting of the power supplies controlling energy and mass channels. These elementary times are 1/4 sec during low bit rate operation (about 80% of the time) and 1/16 sec during high bit rate operation. These times include the resetting of the power supplies, however, and are slightly longer than the times associated with particle counting. For simplicity, the particle counting is interrupted for about 12% of the elementary time segments in both low and high bit rate operation to allow for resetting. The ACSEC therefore exceeds the actual particle counting time by about 14% in both cases.

8. THE MC-FILE

This file is essentially an abbreviated listing of the count rates that have been converted to velocity moments in the MD-file. All relevant energy channels are represented, but the spin angle bins have been replaced, in each separate energy channel, by the peak count, the time of the peak (in seconds), the spin

angle of the peak (angle of motion of ions), a measure of the angular width of the ion flux, and the spin-averaged count rate with standard deviation. No pitch-angle information is listed, but the approximate pitch angle at the peak count can be derived from the spin angle and the magnetic field orientation.

Count rates are listed for five ion species, that is for the same four species included in the MD-file: H+, He⁺⁺, He+, and O+ (actually for M/Q= 1, 2, 4, and 16), and, in addition, for doubly charged oxygen: O⁺⁺ (M/Q= 8). The listing for O⁺⁺ is usually incomplete (contains fill) because it has only been measured over part of the energy range, or it has not been measured at all, depending on the energy/mass scan mode. It is common to limit the measurement of the O⁺⁺ to the lowest 24 energy channels (to energies below about 10 keV/e), to avoid contamination by the more abundant O+, whose M/Q response function partially overlaps with that of the O⁺⁺ at the highest energies.

Usually the MC-file displays count rates from all 32 energy channels, but if the energy/mass scan cycle is limited to a lower portion of the energy range (as may be the case when the instrument has been commanded for solar wind or magnetosheath observations), then the MC-file is also limited to lower energies. In such cases, it is not uncommon to have a different energy coverage for different ions, but the MC-file lists the same number of channels (same number of lines) for all five ion species, displaying dummy fill where data are missing. The fill consists of -1 or -1.00.

Note: The MC-file is the only documentation of the actual energy ranges used in the MD-file, in case different ions have been measured over different energy ranges. The MD moment calculations will extend across missing intermediate energies, up to four contiguous missing channels (see above), but they will not extrapolate below or above the end channels, and they will not extend above 16 keV/e (or below 100 eV/e in most cases). The actual ranges can be deduced from the MC-file by the lowest and highest channels (lines) that have data (rather than fill). Usually the only places where the energy sweep is shortened and made different for different ions are in the solar wind and in the magnetosheath, as predicted from average magnetosphere configurations.

In order to simplify the file format, all averaged counts are treated as representing the whole energy/mass scan cycle, even though different ions were in fact sampled at different phases of the cycle (the same ion often more than once). However, the time labels on the peak counts do refer to the respective times of sampling, rounded downward to the whole second.

All MC counts and count rates are raw data, except when the instrument has been operating in low sensitivity mode. In that case the peak count and some counts included in the spin-averaged rate have been multiplied by a crude scaling factor (= 65) to compensate for the reduced sensitivity. Such counts are flagged accordingly (see below). None of the counts or count rates has been corrected for background counts due to penetrating radiation (mostly MeV electrons and associated bremsstrahlung). However, the average background count rate measured during each energy/mass scan cycle is listed as average counts per sample, along with the sampling rate, which is expressed in number of samples per second here.

The MC counts and count rates may be converted to differential fluxes or phase space densities using the instrument parameters listed in a separate section below.

8.1 File Format

The MC-file has been written in groups of up to 34 lines (up to 33 records), using formatted sequential FORTRAN WRITE statements as follows:

The first line in each group has a single character indicating the format of the counts (1 or 2), the second line is a title line that also indicates how many lines (energy channels) are to follow in the current group:

```
WRITE(11,243) IFORMT, IYYDDD, JSTART, JSTOP, RX, RY, RZ, RT, RSEY, RSEZ,  
*DZ, IMLAT, TLOCL, BXMD, BYMD, BZMD, BTMD, BETA, IDBETA, BGND, IDBGND,  
*MAXES0, NSPLPS
```

```
243 FORMAT(I2/3I6, 7F6.1, I4, F5.1, 4F8.1, 1PE10.2, I3, 1PE9.2, I3, 2I3)
```

The variable names represent the following quantities:

IFORMT is the format flag for the counts, showing either of two formats. The standard format (IFORMT = 1) lists the averaged count rates in floating point with two decimal places, the other one (IFORMT = 2) rounds them to the nearest integer in order to allow more positions for the peak counts (always integers) on the same line.

IYYDDD is the year (two digits) and day of year (three digits).

JSTART is the universal time in seconds (not minutes) at the beginning of the averaging interval, that is the time of the first good data in that interval. This is normally at the start of an energy/mass scan cycle, unless some initial data in that cycle are bad.

JSTOP is the universal time in seconds (not minutes) at the end of the averaging interval, that is the time of the last good data in that interval. This is normally at the end of an energy/mass scan cycle, unless the last data in that cycle are bad.

RX, RY, RZ, and RT are, respectively, the GSM X, Y, Z, and radial distance at the midpoint of the averaging interval, all in units of "earth radii" ("Re"). RY and RZ are set to 999. if GSM coordinates not available (RX same in GSE).

RSEY and RSEZ are the GSE Y and Z (at midpoint of averaging interval) in units of "earth radii".

DZ is the distance in "earth radii" (at midpoint) from the nominal neutral sheet in the geotail according to Fairfield and Ness [J.Geophys. Res., 75, 7032, 1970]. This is only displayed for GSM X < -11 Re, otherwise set to 999. If no GSM coordinates available, it is set to 0.

IMLAT is the geomagnetic latitude in degrees (at midpoint), rounded to the nearest integer. This is set to 0, if no ephemeris tape available.

TLOCL is the geographic local time in hours and 1/10 hours (at midpoint). This is set to 0.0, if no ephemeris tape available.

BXMD, BYMD, BZMD, and BTMD are the GSE components and absolute value, respectively, of the measured magnetic field, each averaged over the whole interval (for data quality check, see description of MD-file). The unit

is "nanotesla" ("nT"), or equivalently, "gamma".

BETA and IDBETA are a simplified representation of the ion plasma beta and its standard deviation (% of absolute value). Its definition is explained in the description of the MD-file.

BGND and IDBGND are the average background count rate in counts per sample (not per second) and standard deviation (%).

MAXES0 is the number of lines to follow in the current group (usually = 32, sometimes less). Each line represents one energy channel, always starting with the lowest channel (10 eV/e - 100 eV/e), whether or not that channel was sampled, and running through the channels contiguously. MAXES0 is the number of the highest energy channel sampled at any phase of the energy/mass scan cycle.

NSPLPS is the number of samples per second taken during the current energy/mass scan cycle, either 4 (low bit rate) or 16 (high bit rate).

The next $N = \text{MAXES0}$ lines list counting data in N contiguous energy channels, starting at the bottom channel ($I=1$), for H^+ ($J=1$), He^{++} ($J=2$), He^+ ($J=3$), O^+ ($J=4$), and O^{++} ($J=5$) ($M/Q=1, 2, 4, 16, \text{ and } 8$):

```
DO 248 I=1,MAXES0

  IF (IFORMT.EQ.1) THEN
    WRITE (11,246)
    *(ACTR(J), IDCTR(J), IPCTR(J), IUTPC(J), IPDEG(J), IWDEG(J), J=1,5)

246  FORMAT(X,F7.2,I3,I4,I5,I4,I4,4(F7.2,I3,I3,I5,I4,I4))

  ELSE
    WRITE (11,247)
    *(IACTR(J), IDCTR(J), IPCTR(J), IUTPC(J), IPDEG(J), IWDEG(J), J=1,5)

247  FORMAT(X,I5,I3,I6,I5,I4,I4,4(I5,I3,I5,I5,I4,I4))

  ENDIF
248  CONTINUE
```

The variable names represent the following quantities:

ACTR is the average (spin-averaged) count rate in floating point representation ($\text{IFORMT} = 1$), that is the average number of counts per sample (4 or 16 samples per second).

IACTR is an integer approximation of ACTR, that is ACTR rounded to the nearest integer. This format ($\text{IFORMT} = 2$) is used when some ion (usually H^+) at some energy (usually around one keV) has a value of ACTR that would cause the standard format to overflow (IACTR is capped in the rare event that it would also overflow). This same integer representation is used for all ions at all energies, regardless of where the overflow would have occurred. This condition is usually associated with a change of instrument operation to low sensitivity mode, so the largest IACTR values usually contain counts that have been "corrected", that is multiplied by a scaling factor (= 65), and are flagged accordingly (by IDCTR).

IDCTR is normally the Poisson standard deviation of ACTR (or IACTR), expressed in percent and rounded downward to an integer value. That is, IDCTR represents the ratio (in %) between the square root of the sum of counts and the sum of counts (sum = ACTR * No of samples). In case the instrument has been in low sensitivity mode at any time while a particular ACTR (or IACTR) was being averaged, the IDCTR is instead used as a flag and set equal to -9. In that case ACTR (or IACTR) contains "corrected" counts and should be treated with some care.

IPCTR is the maximum number of counts during any single sample (about 1/4:th or 1/16:th of a second) of a given ion at a given energy. If IDCTR = -9, then IPCTR probably contains a "correction factor" (= 65).

IUTPC is the (approximate) time of maximum count rate (IPCTR), expressed as integer number of seconds after the beginning of the current averaging interval. That is, the universal time in seconds is = JSTART + IUTPC.

IPDEG is the angle of motion in the s/c spin plane of those ions that cause the maximum count rate. The angle refers to the midpoint of the sampling interval (and the midpoint of the instrument field of view), and is rounded to the nearest integer. During each sampling interval the instrument sweeps (spins) through about 30 deg of angle in low bit rate (4 samplings/sec), and about 7.5 deg in high bit rate (16 samplings/sec).

IWDEG is a measure of the angular width (nearest integer) of the ion flux distribution around the maximum. It is a sum of two angles, one being the closest spin angle from IPDEG with a count rate less than 1/3 of IPCTR, the other being the most distant spin angle from IPDEG with a count rate at least 1/3 of IPCTR. That is, IWDEG is a crude measure of the full width at 1/3 of maximum. It is measured after IUTPC if more than 1/2 s/c spin remains, otherwise set to -1. If IPCTR is more than 3 times greater than any subsequent counts, IWDEG is set to 30 deg in low bit rate and 8 deg in high bit rate (or -1 if too close to end of interval).

8.2 Relevant Instrument Parameters.

To convert counts per sample, or CTS, to counts per second, or CTRATE, use

$$\text{CTRATE} = \text{CTS} * \text{RATE} / 0.21865$$

where RATE = 1.0 in low bit rate, and RATE = 4.0 in high bit rate.

However, the count rates in the MC-file are raw counts and may need to be adjusted for detector degradation (including peak counts and background), depending on which pulse height triggering level was being used. Count rates from before March 2 of 1980 have been obtained at the higher of two levels in the MD particle detector, at the MDTCR = 2 level. The lower level, MDTCR = 1, used afterwards, provides a more nearly one to one detection level, that is one count for every ion entering the detector, but it also admits more false counts due to penetrating radiation than does the higher level. The reason for using the MDTCR = 2 level is to minimize the background. The lower sensitivity to ions is not a problem in itself as long as it is well known, since the count rate can be adjusted accordingly, but it has slowly declined over time, making it necessary to do periodic in-flight calibrations. These have consisted of inter-comparing the count rates at the MDTCR = 1 and = 2 levels, which are both part

of the instrument output, during times of extremely low background. Fortunately, the MDTCR = 1 level has shown no degradation, and can be used as a standard reference. The following table shows the results of these intercomparisons in the lowest and highest energy channels for the four principal ions (date refers to beginning of month). The intercomparisons for O++ (ION= 5) have been less extensive but suggest that the O+ (ION= 4) ratios can be used for the O++ as well.

c Ratios of MDTCR= 2 count rate to MDTCR= 1 count rate in flight;

c

c in lowest energy channel:

DATA CMD01/

c launch -	Jan 78,	Jul 78,	Jan 79,	Jul 79,	Jan 80,	Jul 80
c ION= 1						
*	.90,	.81,	.60,	.48,	.36,	.24,
c ION= 2						
*	.95,	.90,	.80,	.70,	.60,	.50,
c ION= 3						
*	.95,	.85,	.70,	.60,	.50,	.40,
c ION= 4						
*	.95,	.89,	.75,	.65,	.55,	.45/

c

c in highest energy channel:

DATA CMD32/

c launch -	Jan 78,	Jul 78,	Jan 79,	Jul 79,	Jan 80,	Jul 80
c ION= 1						
*	.94,	.93,	.82,	.72,	.61,	.50,
c ION= 2						
*	.97,	.95,	.90,	.85,	.80,	.75,
c ION= 3						
*	.97,	.95,	.90,	.85,	.80,	.75,
c ION= 4						
*	.97,	.95,	.90,	.85,	.80,	.75/

Intercomparisons have been made at many energies, and it appears that the ratios vary about linearly with energy channel number (1 through 32). That relation has been used when converting count rates to velocity moments in the MD-file, that is, the ratios have been interpolated linearly in energy channel number. They have also been interpolated linearly in time between the dates above. For dates beyond February of 1980 this scheme has been abandoned, and MDTCR = 1 counts have been used exclusively. Given count rates from before March 2, 1980, these are thus to be adjusted by

$$\text{CTRATE} = \text{CTRATE} / \text{CMD}(\text{IE}, \text{date}, \text{ION})$$

where IE is the energy channel No, and CMD(...) is obtained by linear interpolation in IE and date between the CMD01 and CMD32 in the table. For ION= 5 (O++) use the same numbers as for ION= 4 (O+).

There is actually one more adjustment that can be made to improve the one to one relationship between counts and ions in the MC-file. This one does not depend on the MDTCR level, but it depends somewhat on the energy/mass scan mode. To have exactly one count for every ion entering the MD detector, on average, requires that the power supplies controlling the M/Q separation be tuned exactly to the peak response for a given ion at every energy. This is impractical, but

in all scan modes, except the so called "load mode", the single mass channel chosen to represent a given ion will have let that ion through at about 90% of peak response, or higher. In the "load mode", however, every mass channel has been sampled, and all counts at a response of 40% or higher have been used (for the five ions listed). The average response for those counts ranges between 70% and 90% of the peak, varying somewhat randomly from one energy channel to the next, but is mostly 80% to 85%.

Therefore, if the counts have been obtained in "load mode" it may be worth adjusting the time averaged counts (ACTR and IACTR) by another factor of about 1.2 (average over energy). The peak count rates (IPCTR) cannot be adjusted for this effect at this stage, since the mass channel No. is not listed. The "load mode" can be recognized from the MS-file (see below). By contrast, all counts used when calculating moments for the MD-file were adjusted for off-peak response on a sample by sample basis (after first summing over the mass peak in load mode).

Once adjusted, the count rates in the MC-file can be converted to differential flux "FLUX" and phase space density "F" with the following subroutine.

```

SUBROUTINE AFLUX( ION, CTRATE, IE, FLUX, F )
c**** Input:  ION= 1 (H+), 2 (He++), 3 (He+), 4 (O+), or 5 (O++)
c****          CTRATE= counts per second (floating point), and
c****          IE= 1, 2, 3, ....., 32 (energy channel)
c****
c**** Output: "FLUX" in units of "/cm2/sec/ster/keV"
c****          "F" in units of "sec3/km6".
c****
      DIMENSION AM(5),Q(5) ! ion mass and charge units
      DATA AM/1.,4.,4.,16.,16./, Q/1.,2.,1.,1.,2./
c**** instrument energies (center of channels):
      DIMENSION ENERGY(32) ! "keV/e"
      DATA ENERGY/
*   .040, .212, .410, .628, .851, 1.095, 1.353, 1.633,
*   1.929, 2.244, 2.580, 2.934, 3.317, 3.718, 4.146, 4.599,
*   5.080, 5.592, 6.132, 6.713, 7.333, 7.998, 8.701, 9.446,
*   10.235, 11.076, 11.969, 12.917, 13.927, 14.999, 16.144, 17.364/
c**** instrument geometric factors, including delta-E:
      DIMENSION G(32,5) ! "1.0E-4 cm2 keV"
      DATA G/
c**** ION= 1:
*   3.60,6.00,6.00,6.00,6.01,6.01,6.01,6.01,6.01,6.01,6.02,6.02,6.02,
*   6.48,6.94,7.40,7.85,8.31,8.77,9.23,9.69,10.3,10.9,11.5,12.1,12.8,
*   13.4,14.0,14.6,15.2,15.8,16.4,
c**** ION= 2:
*   4.50,7.37,7.20,7.04,6.87,6.70,6.54,6.37,6.21,6.04,5.87,5.71,5.54,
*   5.85,6.17,6.48,6.80,7.11,7.43,7.74,8.06,8.39,8.71,9.04,9.37,9.69,
*   10.0,10.4,10.8,11.2,11.6,12.0,
c**** ION= 3:
*   7.20,11.9,11.3,10.7,10.0,9.41,8.79,8.16,7.54,6.92,6.30,5.67,5.05,
*   5.37,5.69,6.01,6.32,6.64,6.96,7.28,7.60,7.99,8.38,8.77,9.16,9.54,
*   9.93,10.3,10.7,11.1,11.5,11.9,
c**** ION= 4:
*   3.10,5.28,5.23,5.17,5.12,5.07,5.01,4.96,4.91,4.86,4.80,4.75,4.70,
*   4.85,4.99,5.14,5.29,5.44,5.59,5.73,5.88,6.26,6.63,7.02,7.42,7.82,
*   8.23,8.61,9.02,9.42,9.82,10.2,
c**** ION= 5:

```

```

* 4.71,7.83,7.55,7.28,7.01,6.74,6.47,6.19,5.92,5.65,5.38,5.10,4.83,
* 5.05,5.26,5.47,5.69,5.90,6.12,6.33,6.54,6.92,7.30,7.68,8.06,8.52,
* 8.96,9.34,9.72,10.2,10.6,11.0/
c**** normalize:
GDE= G(IE, ION)*1.0E-4
c**** differential flux:
FLUX= CTRATE/GDE/Q(ION) ! "/cm2/s/sr/keV"
c**** phase space density:
F= 0.5449208*FLUX*AM(ION)*AM(ION)/Q(ION)/ENERGY(IE) ! "s3/km6"
RETURN
END

```

The energy channel widths (in keV/e) and the angular fields of view in each energy channel are inherent in the geometric factors listed in this subroutine (G-delta-E), but it may be of interest to know them separately:

The external energy bandwidth is defined by the internal energy resolution of the instrument, which is about a constant 5% at all energies, but the external bandwidth is not a constant fraction of energy, because the ions are pre-accelerated by about 3.0 kV before they enter energy analysis (energy selection). To obtain the absolute energy bandwidth to incoming ions, add 3.0 keV/e to the center energies listed in the subroutine, except the lowest energy, and take 5% of the sum. The lowest energy channel is different, due to the applied RPA voltage, and extends approximately between 10 eV/e and 100 eV/e (more precisely to about 110 eV/e).

As mentioned, the center of the instrument field of view (the one used here) points 5 deg below the spin plane, that is about 5 deg below the GSE X-Y plane (ion velocity vector pointing 5 deg above). In this plane the width is about 10 deg. In the perpendicular (GSE Z) direction it varies with energy (due to the pre-acceleration), from about 45 deg at 10 eV/e to 10 deg at 18 keV/e. To be more specific, if the center energies of the 32 energy channels are used as reference, the corresponding 32 angular widths are as follows (full width at 25% of max; in deg):

```

40.0, 30.0, 26.0, 22.5, 20.0, 18.0, 16.5, 15.5,
15.0, 14.0, 13.5, 13.0, 13.0, 12.5, 12.5, 12.0,
12.0, 11.5, 11.5, 11.0, 11.0, 11.0, 11.0, 10.5,
10.5, 10.5, 10.5, 10.5, 10.5, 10.0, 10.0, 10.0

```

9. THE MS-FILE

This file contains complete mass spectra in four energy ranges, provided the instrument energy/mass scan included complete mass scans at some energies (not always the case). The counts in this file are also from the MD detector, but they are normally not the same counts as those listed in the MC-file, which went into moment calculations for the MD-file. It is only in the mode called "load mode" that the same raw counts have been used in all three files with MD data. This particular mode (hardwired) consists of one complete 32-step energy scan in each successive mass channel over the complete 64 mass-channel range (four such scan cycles have been used to define a full cycle in high bit rate here). This scan mode is used infrequently, and can be recognized by the fact that the number of samplings in the MS-file (see below) add up to cover the entire averaging interval (entire scan cycle). In all other scan modes the mass spectra are obtained as separate and small parts of each energy/mass scan cycle, and are only

used to provide data for the MS-file here. For simplicity, the same beginning and ending times are listed here as are listed in the MD-file, even if the mass spectra were obtained for brief intervals well inside those times.

The four mass spectra are listed in four vertical columns, with each line representing one mass channel, beginning with channel No. 1 at the top and ending with No. 64 at the bottom. Each column represents one energy range, with the energy increasing from left to right:

Leftmost energy range: channel No. 1 (about 10 eV/e - 100 eV/e).

Second to the right: channels No. 2 - 5 (about 100 eV/e - 1 keV/e)

Third to the right: channels No. 6 - 12 (about 1 keV/e - 3 keV/e)

Fourth to the right: channels No. 13 - 31 (about 3 keV/e - 16 keV/e)

The counts in each mass channel (on each line) are a sum of counts from all energy channels sampled within each energy range. Along with the sum of counts is the number of samples.

The MS-counts are pure raw counts; no "corrective" factor has been applied when the instrument has been operating in low sensitivity mode. However, each column has a flag above it showing how many of the samples in that column were taken in low sensitivity mode (without specifying mass channel). No background counts have been subtracted either.

Within each mass spectrum (each column) certain mass peaks may be found more often than others. The following is a listing of expected mass channel No. (1 through 64) at peak count rate for certain important M/Q:

M/Q= 16.00 about 16 to 17
= 8.00 about 21 to 22
= 4.00 about 29 to 30
= 2.66 about 35 to 36
= 2.00 about 40 to 41
= 1.50 about 45 to 46
= 1.00 about 55 to 56

9.1 File Format

The MS-file has been written in groups of 68 lines (65 records), using formatted sequential FORTRAN WRITE statements as follows:

The first line in each group is blank, the second and third make up a title, and the fourth lists (above each mass spectrum) the No. of samples taken in low sensitivity mode:

```
WRITE(12,255)  
*IYYDDD,JSTART,JSTOP,RX,RY,RZ,RT,RSEY,RSEZ,DZ,IMLAT,TLOCL,
```

*BXMD, BYMD, BZMD, BTMD, BETA, IDBETA, BGND, IDBGND, MAXEMS, NSPLPS,
*(IMSLOW(I), I=1, 4)

255 FORMAT (X/I6, 2I5, 7F6.1, I4, F5.1/X, 4F8.1, 1PE10.2, I3, 1PE9.2, I3, 2I3/
*X, 4I13)

The variable names represent the following quantities:

IYYDDD is the year (two digits) and day of year (three digits).

JSTART is the universal time in minutes at the beginning of the averaging interval, that is the time of the first good data in that interval. This is normally at the start of an energy/mass scan cycle, unless some initial data in that cycle are bad.

JSTOP is the universal time in minutes at the end of the averaging interval, that is the time of the last good data in that interval. This is normally at the end of an energy/mass scan cycle, unless the last data in that cycle are bad.

RX, RY, RZ, and RT are, respectively, the GSM X, Y, Z, and radial distance at the midpoint of the averaging interval, all in units of "earth radii" ("Re"). RY and RZ are set to 999. if GSM coordinates not available (RX same in GSE).

RSEY and RSEZ are the GSE Y and Z (at midpoint of averaging interval) in units of "earth radii".

DZ is the distance in "earth radii" (at midpoint) from the nominal neutral sheet in the geotail according to Fairfield and Ness [J.Geophys. Res., 75, 7032, 1970]. This is only displayed for GSM X < -11 Re, otherwise set to 999. If no GSM coordinates available, it is set to 0.

IMLAT is the geomagnetic latitude in degrees (at midpoint), rounded to the nearest integer. This is set to 0, if no ephemeris tape available.

TLOCL is the geographic local time in hours and 1/10 hours (at midpoint). This is set to 0.0, if no ephemeris tape available.

BXMD, BYMD, BZMD, and BTMD are the GSE components and absolute value, respectively, of the measured magnetic field, each averaged over the whole interval (for data quality check, see description of MD-file). The unit is "nanotesla" ("nT"), or equivalently, "gamma".

BETA and IDBETA are a simplified representation of the ion plasma beta and its standard deviation (% of absolute value). Its definition is explained in the description of the MD-file.

BGND and IDBGND are the average background count rate in counts per sample (not per second) and standard deviation (%).

MAXEMS is the number of the highest energy channel included in the mass spectra (31 or lower).

NSPLPS is the number of samples per second taken during the current energy/mass scan cycle, either 4 (low bit rate) or 16 (high bit rate).

IMSLOW is the total number of samples taken in low sensitivity mode while gathering the mass spectrum below it (regardless of mass channel).

The next 64 lines, one for each mass channel, list the accumulated number of counts (sums) in each of four energy ranges (explained above), along with the corresponding number of samples:

```
DO 258 J=1,64

WRITE(12,257)((ISUM04(I),ISPL04(I)),I=1,4)

257 FORMAT(X,4(I9,I4))

258 CONTINUE
```

The variable names represent the following quantities:

ISUM04 is the accumulated number of counts within energy range I, regardless of instrument look angle.

ISPL04 is the corresponding number of samples (4 per seconds in low bit rate, 16 per seconds in high; cf. NSPLPS)

10. THE EX-FILE

This file contains auxiliary ISEE-1 ephemeris that may be used for labeling plots of data from the other files (see comments on existing plots at the end of this data user's guide). It is derived from separate ISEE ephemeris tapes which have a more complete set of coordinates, all listed once per minute. This file has a subset of the ephemeris, and it only lists this set every 30 minutes. If the ephemeris tape is unavailable (unreadable), it substitutes the GSE coordinates from the instrument data telemetry tape for the corresponding ephemeris coordinates, choosing these to be as closely as possible on the half hour, and fills the remaining positions with dummy numbers.

10.1 File Format

The EX-file always has 49 lines (records) which have been written with a formatted sequential FORTRAN WRITE as follows:

```
MMMM=0
DO 38 I=1,49
36 WRITE(7,37)IYYDDD,MMMM,RX,RY,RZ,RT,DZ,IMLAT,TLOCL,RSEY,RSEZ,RL

37 FORMAT(I6,I5,5F6.1,I4,F5.1,2X,3F6.1)

38 MMMM=MMMM+30
```

The variable names represent the following quantities:

IYYDDD is the year (two digits) and day of year (three digits).

MMMM is the universal time in minutes.

RX, RY, RZ, and RT are the GSM X, Y, Z, and radial distance, respectively, all in units of "earth radii" ("Re"). RY and RZ are set to 999. if GSM coordinates not available (RX same in GSE).

DZ is the (calculated) distance in "earth radii" from the nominal neutral sheet in the geotail according to Fairfield and Ness [J.Geophys. Res., 75, 7032, 1970]. This is only displayed for GSM X < -11 Re, otherwise set to 999. If no GSM coordinates available, it is set to 0.

IMLAT is the geomagnetic latitude in degrees, rounded to the nearest integer. This is set to 0, if no ephemeris tape available.

TLOCL is the geographic local time in hours and 1/10 hours. This is set to 0, if no ephemeris tape available.

RSEY and RSEZ are the GSE Y and Z in "earth radii" (may have values even when no ephemeris tape available; same with RX and RT).

RL is McIlwain's L value. This is only defined in the inner magnetosphere, otherwise set to 0. (also when no ephemeris tape available).

11. GRAPHIC REPRESENTATION

A subset of the data in the ED- and MD-files is available in graphical form in a series of booklets, one booklet for each month of data. There are two pages of graphs for each day, each page covering 12 hours of universal time. Each page consists of a vertical stack of 7 panels. These panels show the following data items:

Panel 1 (top) shows the "total" ion density from the ED-file (EDDNS) and the partial densities of He⁺⁺, He⁺, and O⁺ from the MD-file (DNS8). Note: the labels He⁺ and O⁺ may not be appropriate in the magnetosheath and solar wind, where heavier ions in high charge states may dominate weak count rates near those M/Q values, especially near M/Q= 4.

Panel 2 shows the He⁺⁺/H⁺ density ratio from the MD-file (DNS8[He⁺⁺]/DNS8[H⁺]). This panel and the top one are the only ones with MD-data, the ones below all have data from the ED-file only.

Panel 3 shows the ion "thermal" energy from the ED-file (EDEMN).

Panel 4 shows the "thermal" energy density from the ED-file multiplied by 2/3 (EDDNS*EDEMN*2./3.) along with the magnetic pressure and field strength based on the ED-averages. Note: the magnetic pressure and field strength are based, respectively, on the sum and the square root of BXED**2 + BYED**2 + BZED**2 (not on BTED) in order to show more clearly those (rare) times when the magnetic field is flawed. When the problem is the one related to the wrong antenna flip status, the magnetic pressure typically stays nearly constant, showing no evidence of the diamagnetic effect of the ions (total pressure is not preserved). This constant value is small in the early data, while the magnetometer offset is still small, but increases over time, due to increasing offset. The brief (one data point) error in the magnetic field gain factor on many inbound (and a few outbound) passes is also clearly seen in this panel (errors discussed in connection with the ED- and MD-files above).

Panel 5 shows the ion drift speed (in GSE X-Y plane) from the ED-file (EDVEL).

Panel 6 shows the magnetic field elevation angle (relative to GSE X-Y plane) from the ED-file (ITHETB). Note: when the magnetic field is in error, because of the antenna flip status being misinterpreted, this angle typically stays close to either plus or minus 90 degrees.

Panel 7 (bottom) shows the ion drift angle (IEDANG) and magnetic longitude angle (IPHIB) in the GSE X-Y plane from the ED-file.

Below the bottom panel are the UT and assorted ephemeris. When ephemeris tape has not been available (very rare) only the geocentric distance (R) will show.

Appendix 2

Sample Printouts of Data Files

(12 pages)

A1. Magnetosphere /Geomagnetically Quiet Day
(Low O⁺/H⁺ density ratio)

78064 2 18 -12.2 -11.3 -0.8 16.6 0.5 5 3.1 0.8 5.7 6.3 9.1 1.28E+01 0 9.22E-01 2 16.1 1 -9.8 5.6
1.10E-01 5 1.57E+00 2 1.17E+00 0 8.25E+00 22 42 13 4.19E-03 11 124.00 0.00 24 146 1.58E+00 0 1.46E+00 0 7.17E-01 0
8.07E-04 65 5.66E-02 2 6.72E+00 2 1.56E+01 40 -19 19 3.94E-03 11 124.00 0.00 39 137 5.52E-02 1 4.39E+00 2 2.39E+00 2
0.00E+00 -1 7.86E-03 12 3.03E+00 18 5.29E+01 42 -41 23 5.11E-03 11 124.00 0.00 23 151 7.77E-03 10 2.26E+00 14 9.36E-01 17
3.85E-03 74 1.85E-02 14 5.79E+00 11 4.81E+00260 21 76 1.45E-02 11 124.00 0.00 24 147 1.82E-02 13 3.94E+00 12 2.08E+00 9
78064 18 33 -12.0 -11.2 -0.8 16.4 0.6 5 3.1 7.1 12.2 4.7 15.1 3.46E+00 0 9.10E-01 2 16.1 1 -9.8 5.5
3.18E-01 4 1.73E+00 0 1.43E+00 0 2.90E+01 4 12 2 4.13E-03 11 124.00 0.00 7 165 1.65E+00 0 8.98E-01 0 5.25E-01 0
5.03E-04 97 6.60E-02 2 5.14E+00 2 1.15E+01 46 -20 20 3.89E-03 11 124.00 0.00 6 165 6.48E-02 2 3.38E+00 3 1.71E+00 2
1.50E-03 35 5.78E-03 16 2.32E+00 33 2.92E+01 97 -126 95 5.04E-03 11 124.00 0.00 8 165 5.90E-03 15 1.55E+00 36 5.82E-01 45
2.13E-03129 2.97E-02 9 3.92E+00 10 2.34E+01 36 66 16 1.43E-02 11 124.00 0.00 4 165 2.69E-02 10 2.32E+00 13 1.54E+00 9
78064 33 49 -11.8 -11.1 -0.8 16.2 0.7 6 3.1 4.9 10.4 4.5 12.6 5.37E+00 0 8.87E-01 2 16.1 1 -9.7 5.4
2.02E-01 4 1.67E+00 0 1.67E+00 0 1.34E+01 9 -15 4 4.03E-03 11 123.75 0.00 8 161 1.59E+00 0 1.07E+00 0 6.04E-01 0
0.00E+00 -1 6.03E-02 2 5.52E+00 2 1.63E+01 35 -19 16 3.79E-03 11 124.00 0.00 11 161 5.79E-02 2 3.52E+00 3 2.05E+00 2
5.32E-04 70 5.45E-03 16 1.61E+00 56 4.55E+01 63 -112 31 4.91E-03 11 124.00 0.00 8 162 5.57E-03 15 1.22E+00 51 7.02E-01 39
-1.13E-03156 1.20E-02 21 5.08E+00 17 -1.00E+00 -1 0 -1 1.40E-02 11 124.00 0.00 5 166 1.36E-02 17 4.38E+00 13 1.26E+00 19
78064 56 65 -11.5 -11.0 -0.8 16.0 0.9 6 3.1 6.4 12.1 4.1 14.3 4.10E+00 1 7.62E-01 2 16.1 1 -9.7 5.3
0.00E+00 -1 1.75E+00 0 1.53E+00 0 1.44E+01 12 102 7 2.86E-03 17 60.00 0.00 8 161 1.70E+00 0 9.30E-01 0 5.78E-01 0
0.00E+00 -1 6.23E-02 3 5.80E+00 3 3.16E+01 27 119 20 3.22E-03 17 60.00 0.00 11 160 5.97E-02 3 3.78E+00 3 1.99E+00 2
0.00E+00 -1 5.71E-03 21 2.29E+00 37 -1.00E+00 -1 0 -1 4.22E-03 17 68.00 0.00 11 161 5.62E-03 20 1.64E+00 35 9.21E-01 29
3.68E-03 73 2.21E-02 13 4.58E+00 11 2.28E+01 47 -145 29 1.20E-02 17 124.00 0.00 11 162 2.32E-02 12 3.75E+00 10 1.26E+00 11
78064 65 80 -11.4 -10.9 -0.7 15.8 1.0 7 3.1 2.2 8.7 7.6 13.2 4.70E+00 0 9.57E-01 2 16.1 1 -9.6 5.2
2.87E-01 3 1.67E+00 0 1.58E+00 0 1.40E+01 9 43 5 4.35E-03 11 124.00 0.00 10 158 1.68E+00 0 1.03E+00 0 5.35E-01 0
1.01E-03 63 5.84E-02 2 4.92E+00 3 2.37E+01 25 -62 24 4.10E-03 11 124.00 0.00 5 164 6.04E-02 2 3.35E+00 3 1.65E+00 2
2.66E-03 26 4.78E-03 19 1.69E+00 62 4.53E+01 73 -144 181 5.30E-03 11 124.00 0.00 19 155 5.40E-03 15 1.40E+00 40 4.19E-01 69
8.46E-03 45 1.99E-02 14 4.78E+00 12 1.01E+01121 -148 116 1.51E-02 11 124.00 0.00 19 152 1.99E-02 11 3.16E+00 10 1.83E+00 9
78064 80 96 -11.2 -10.9 -0.7 15.6 1.1 7 3.2 -0.2 5.8 5.6 8.4 1.20E+01 0 8.28E-01 2 16.1 1 -9.6 5.1
2.27E-01 4 1.84E+00 0 1.47E+00 0 1.18E+01 10 -23 5 3.76E-03 11 124.00 0.00 28 144 1.86E+00 0 9.71E-01 0 4.81E-01 0
1.15E-03 50 6.23E-02 2 5.17E+00 2 1.14E+01 50 65 28 3.55E-03 11 124.00 0.00 29 142 6.15E-02 2 3.37E+00 2 1.79E+00 2
1.23E-03 48 8.08E-03 12 1.56E+00 37 2.42E+01 80 149 77 4.59E-03 11 124.00 0.00 28 144 7.62E-03 11 1.43E+00 32 5.20E-01 35
6.98E-03 47 2.50E-02 11 4.41E+00 11 1.39E+01 68 34 23 1.31E-02 11 124.00 0.00 19 153 2.15E-02 11 3.10E+00 12 1.73E+00 8
78064 96 111 -11.0 -10.8 -0.6 15.4 999.0 8 3.2 -2.0 5.6 7.5 10.5 7.78E+00 0 7.35E-01 2 16.1 1 -9.5 5.0
3.47E-01 3 1.76E+00 0 1.55E+00 0 1.58E+01 8 34 6 3.34E-03 12 124.00 0.00 21 148 1.76E+00 0 1.01E+00 0 5.40E-01 0
1.06E-03 55 6.25E-02 2 5.02E+00 2 6.27E+00 91 80 29 3.15E-03 12 124.00 0.00 21 150 6.17E-02 2 3.28E+00 2 1.80E+00 2
8.55E-04 50 6.20E-03 14 2.71E+00 25 1.04E+01240 165 87 4.08E-03 12 124.00 0.00 32 138 5.77E-03 12 1.82E+00 23 6.84E-01 30
-3.84E-04439 2.43E-02 10 5.07E+00 9 2.27E+01 44 3 25 1.16E-02 12 124.00 0.00 33 141 2.48E-02 8 3.34E+00 7 1.43E+00 8
78064 111 127 -10.7 -10.7 -0.6 15.1 999.0 8 3.2 -0.1 8.5 7.7 12.5 5.41E+00 0 8.05E-01 2 16.1 1 -9.5 4.9
2.32E-01 4 1.57E+00 0 1.68E+00 0 2.00E+01 6 11 3 3.66E-03 12 124.00 0.00 17 152 1.54E+00 0 1.11E+00 0 5.88E-01 0
1.13E-03 53 6.36E-02 2 5.68E+00 2 1.89E+01 31 4 15 3.45E-03 12 124.00 0.00 21 151 6.00E-02 2 3.91E+00 2 1.86E+00 2
1.74E-03 37 7.14E-03 13 3.59E+00 15 1.26E+01180 58 159 4.46E-03 12 124.00 0.00 19 151 7.73E-03 11 2.49E+00 14 6.94E-01 25
6.06E-03 59 2.65E-02 10 4.32E+00 11 2.65E+01 33 -63 28 1.27E-02 12 114.50 0.00 24 148 2.58E-02 9 3.03E+00 11 1.28E+00 11
78064 127 142 -10.5 -10.6 -0.5 14.9 999.0 9 3.2 -0.1 7.4 7.6 10.8 7.43E+00 0 7.47E-01 2 16.1 1 -9.4 4.9
2.81E-01 3 1.68E+00 0 1.65E+00 0 1.38E+01 12 28 7 3.39E-03 12 124.00 0.00 26 144 1.69E+00 0 1.07E+00 0 5.78E-01 0
2.04E-03 35 6.56E-02 2 5.69E+00 2 2.12E+01 27 121 32 3.20E-03 12 124.00 0.00 26 144 6.41E-02 1 3.84E+00 2 1.98E+00 2
2.35E-03 31 8.16E-03 11 2.72E+00 18 3.17E+01 65 240 25 4.14E-03 12 124.00 0.00 25 144 7.90E-03 9 1.98E+00 15 8.10E-01 18
4.56E-03 72 1.61E-02 15 5.46E+00 12 3.58E+01 40 -60 20 1.18E-02 12 124.00 0.00 26 144 1.72E-02 12 3.99E+00 10 1.53E+00 10
78064 142 158 -10.3 -10.5 -0.5 14.7 999.0 9 3.3 2.1 8.8 5.3 10.8 8.58E+00 0 8.75E-01 2 16.1 1 -9.3 4.7
1.62E-01 4 1.88E+00 0 1.73E+00 0 1.33E+01 11 -116 7 3.98E-03 11 124.00 0.00 19 151 1.86E+00 0 1.17E+00 0 5.62E-01 0

1	78064	158	1093	-12.2	-11.3	-0.8	16.6	-9.8	5.6	0.5	5	3.1	0.8	5.7	6.3	9.1	1.28E+01	0.2	0.02E-01	11	32	4					
	21.19	5	42	189	185	360	0.56 33	2	255	352	360	1	381	184	360	0.44 37	2	509	252	360	0.31 44	1	448	238	360		
	99.63	2	133	580	50	360	2.81 14	6	645	158	207	3	773	257	207	0.44 37	3	903	113	360	0.31 44	2	446	21	360		
	62.50	3	75	194	328	360	2.50 15	5	257	288	266	3	384	268	157	0.13 70	2	515	243	30	0.25 50	1	452	342	360		
	101.00	2	123	584	164	360	3.63 13	6	649	243	360	3	777	10	182	0.88 26	4	907	286	360	0.13 70	1	440	1	360		
	167.50	1	189	184	253	360	4.56 11	7	248	302	360	2	376	11	360	0.31 44	2	504	79	360	0.38 40	1	456	66	360		
	139.25	2	165	578	173	360	5.00 11	9	642	193	360	4	771	350	54	0.56 33	2	896	4	360	0.13 70	1	439	242	360		
	111.13	2	141	199	200	360	4.94 11	8	260	283	360	4	388	22	69	0.25 50	1	517	90	360	0.25 50	1	460	268	360		
	97.00	2	115	590	155	360	5.31 10	10	652	297	266	4	780	336	123	0.56 33	1	908	345	360	0.44 37	2	433	222	360		
	76.31	2	95	180	140	360	4.69 11	8	245	277	296	3	375	223	207	0.25 50	1	500	266	360	0.25 50	1	464	293	360		
	78.94	2	99	572	153	360	3.31 13	7	637	350	182	3	767	237	94	0.31 44	2	894	127	360	0.06100	1	431	15	360		
	62.06	3	79	204	72	360	3.69 13	8	264	7	187	3	393	165	360	0.31 44	1	520	85	360	0.06100	1	470	343	360		
	71.94	2	83	595	327	360	3.00 14	7	659	17	360	2	784	31	182	0.44 37	2	913	247	360	0.25 50	1	425	24	360		
	74.38	2	99	176	85	360	3.38 13	6	242	253	296	2	369	232	360	0.69 30	2	498	89	360	0.13 70	1	473	279	360		
	70.56	2	99	571	5	360	3.56 13	6	632	29	296	1	761	246	360	0.44 37	1	888	107	360	0.25 50	2	421	271	148		
	75.88	2	87	205	279	360	3.63 13	7	270	28	266	2	397	308	360	0.19 57	1	524	229	360	0.06100	1	477	62	360		
	80.56	2	95	597	234	360	3.56 13	10	663	101	207	1	788	174	360	0.38 40	2	919	238	360	0.25 50	1	416	9	360		
	78.88	2	99	175	297	360	3.88 12	8	237	50	266	2	364	330	157	0.31 44	1	492	98	360	0.13 70	1	840	242	360		
	70.38	2	87	567	340	360	4.38 11	8	631	271	360	0	756	14	360	0.50 35	2	887	78	360	0.13 70	1	836	158	360		
	62.75	3	79	211	240	360	3.19 14	9	273	324	153	2	400	274	182	0.31 44	1	528	12	360	0.38 40	2	845	84	360		
	45.25	3	75	601	348	360	3.19 14	7	666	96	207	2	792	317	182	0.56 33	2	922	203	360	0.25 50	1	832	14	360		
	40.63	3	58	170	94	360	2.50 15	5	232	207	360	2	360	276	360	0.63 31	1	488	256	360	0.19 57	1	848	50	360		
	26.00	4	38	562	19	360	2.25 16	6	627	187	94	1	752	231	360	0.88 26	3	880	329	360	0.25 50	1	828	261	360		
	19.31	5	24	213	88	360	2.50 15	6	279	344	123	0	405	146	360	0.50 35	2	532	96	69	0.19 57	1	852	223	360		
	12.81	6	22	607	8	360	1.19 22	4	668	62	182	1	796	12	360	0.94 25	3	924	139	148	0.19 57	2	824	117	157		
	8.81	8	14	167	40	360	1.13 23	3	229	242	296	2	359	158	360	0.63 31	2	484	172	360	0.19 57	1	856	307	360		
	8.13	8	11	558	266	360	0.94 25	3	623	103	360	0	750	23	360	0.50 35	2	876	156	157	0.31 44	3	821	181	207		
	5.44	10	10	216	142	193	0.50 35	2	281	221	207	0	409	319	360	0.69 30	3	539	205	360	0.25 50	1	860	61	360		
	5.75	10	9	612	270	360	0.69 30	2	677	48	360	0	804	298	360	0.50 35	2	935	2	-1	0.06100	1	816	279	360		
	3.44	13	6	160	350	360	0.38 40	2	225	98	360	0	355	44	360	0.31 44	1	480	117	360	0.31 44	1	864	145	360		
	2.25	16	7	611	92	94	0.13 70	1	674	353	360	0	800	185	360	0.56 33	4	929	312	118	0.31 44	1	812	107	360		
	2.00	17	4	220	197	178	0.31 44	1	285	335	360	0	415	280	360	0.44 37	1	540	324	360	0.19 57	1	868	318	360		
	1.18	19	3	554	211	266	0.22 44	1	10	196	360	0	7	201	360	0.36 24	2	810	289	360	0.28 44	1	744	3	360		
1	78064	1093	2029	-12.0	-11.2	-0.8	16.4	-9.8	5.5	0.6	5	3.1	7.1	12.2	4.7	15.1	3.46E+00	0	1.99E-01	11	32	4					
	51.75	3	213	191	272	178	0.38 40	1	253	55	360	1	384	89	360	0.38 40	2	508	103	94	0.25 50	1	449	257	360		
	278.50	1	345	581	20	360	6.88	9	11	648	64	360	4	772	19	182	0.56 33	2	901	206	237	0.06100	1	445	84	360	
	72.94	2	99	194	268	360	2.63 15	6	259	46	237	0	387	55	360	0.44 37	2	514	35	360	0.25 50	2	454	99	360		
	148.75	2	221	587	40	360	10.44	7	19	651	59	360	5	779	69	123	0.25 50	2	906	349	153	0.31 44	2	443	266	360	
	177.75	1	265	186	40	360	4.19	12	9	251	178	326	2	378	69	360	0.50 35	2	505	49	360	0.13 70	1	457	154	360	
	137.25	2	237	578	24	360	8.81	8	14	641	14	326	2	771	231	360	0.88 26	3	899	299	118	0.19 57	1	438	335	360	
	121.25	2	141	197	263	360	4.38	11	10	260	223	153	2	392	287	360	1.19	22	4	517	30	148	0.19 57	1	461	179	360
	89.69	2	221	590	65	266	6.50	9	11	652	207	242	0	375	153	178	1.19	22	4	910	103	153	0.25 50	1	434	221	360
	85.38	2	141	183	45	360	4.94	11	10	245	217	246	0	375	103	360	1.31	21	13	502	53	45	0.06100	1	466	140	360
	59.69	3	119	575	29	360	5.19	10	11	638	349	360	2	764	151	182	1.13	23	3	896	274	262	0.06100	1	429	19	360
	70.56	2	87	203	254	360	4.00	12	8	267	273	296	2	395	341	360	0.63	31	3	520	84	178	0.31 44	2	470	194	148

78064	2	18	-12.2	-11.3	-0.8	16.6	-9.8	5.6	0.5	5	3.1
0.8		5.7		6.3	9.1	1.28E+01	0	2.02E-01	11	25	4
	0			0							
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0	1	0	4	2	2	0	2				
0	1	2	4	0	2	0	2				
3	1	0	4	0	2	0	2				
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8	1	36	4	16	2	25	2				
24	1	422	4	166	2	75	2				
38	1	860	4	292	2	113	2				
26	1	442	4	155	2	93	2				
5	1	37	4	18	2	36	2				
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78064	0	-12.3	-11.3	-0.8	16.8	0.4	4	3.1	-9.8	5.6	0.0
78064	30	-12.0	-11.2	-0.8	16.4	0.6	5	3.1	-9.8	5.5	0.0
78064	60	-11.6	-11.0	-0.8	16.0	0.9	6	3.1	-9.7	5.3	0.0
78064	90	-11.2	-10.8	-0.7	15.6	1.1	7	3.2	-9.6	5.1	0.0
78064	120	-10.7	-10.7	-0.6	15.1	999.0	8	3.2	-9.5	4.9	0.0
78064	150	-10.3	-10.5	-0.5	14.7	999.0	9	3.3	-9.3	4.8	0.0
78064	180	-9.8	-10.3	-0.3	14.2	999.0	10	3.3	-9.2	4.6	0.0
78064	210	-9.3	-10.0	-0.2	13.7	999.0	11	3.4	-9.1	4.3	0.0
78064	240	-8.9	-9.8	0.0	13.2	999.0	12	3.4	-8.9	4.1	0.0
78064	270	-8.3	-9.5	0.1	12.7	999.0	12	3.5	-8.7	3.9	0.0
78064	300	-7.8	-9.2	0.2	12.1	999.0	13	3.5	-8.5	3.7	0.0
78064	330	-7.3	-8.9	0.3	11.5	999.0	13	3.6	-8.3	3.4	0.0
78064	360	-6.7	-8.6	0.4	10.9	999.0	13	3.7	-8.0	3.2	0.0
78064	390	-6.1	-8.2	0.5	10.2	999.0	12	3.8	-7.7	2.9	0.0
78064	420	-5.4	-7.8	0.5	9.5	999.0	12	3.9	-7.4	2.6	0.0
78064	450	-4.8	-7.4	0.5	8.8	999.0	11	4.0	-7.0	2.3	0.0
78064	480	-4.1	-6.9	0.4	8.0	999.0	10	4.1	-6.6	2.0	0.0
78064	510	-3.3	-6.3	0.3	7.2	999.0	8	4.3	-6.1	1.7	7.7
78064	540	-2.5	-5.7	0.1	6.2	999.0	6	4.5	-5.5	1.3	6.6
78064	570	-1.7	-4.9	0.0	5.2	999.0	3	4.8	-4.9	0.9	5.4
78064	600	-0.8	-4.0	-0.3	4.1	999.0	-2	5.3	-4.0	0.5	4.2
78064	630	0.2	-2.8	-0.5	2.8	999.0	-10	6.3	-2.8	0.1	3.0
78064	660	1.0	-0.9	-0.5	1.5	999.0	-26	9.5	-1.0	-0.4	2.0
78064	690	0.1	1.5	0.2	1.5	999.0	7	17.8	1.5	-0.1	1.4
78064	720	-1.7	2.1	1.0	2.9	999.0	23	20.8	2.2	0.6	3.4
78064	750	-3.1	2.1	1.7	4.1	999.0	25	22.1	2.4	1.2	5.1
78064	780	-4.3	2.0	2.2	5.2	999.0	24	22.8	2.4	1.7	6.6
78064	810	-5.4	1.8	2.6	6.2	999.0	23	23.2	2.3	2.1	8.0
78064	840	-6.3	1.5	3.0	7.2	999.0	22	23.5	2.2	2.5	9.4
78064	870	-7.2	1.2	3.4	8.0	999.0	21	23.8	2.0	2.9	11.0
78064	900	-8.0	0.8	3.6	8.8	999.0	20	24.0	1.9	3.2	0.0
78064	930	-8.7	0.4	3.9	9.5	999.0	19	0.1	1.7	3.6	0.0
78064	960	-9.4	0.0	4.1	10.2	999.0	18	0.3	1.5	3.8	0.0
78064	990	-10.0	-0.4	4.3	10.9	999.0	17	0.4	1.2	4.1	0.0
78064	1020	-10.6	-0.8	4.4	11.5	999.0	17	0.5	1.0	4.4	0.0
78064	1050	-11.2	-1.2	4.5	12.1	3.5	16	0.6	0.8	4.6	0.0
78064	1080	-11.7	-1.6	4.6	12.7	3.6	16	0.6	0.6	4.9	0.0
78064	1110	-12.2	-2.0	4.7	13.2	3.8	16	0.7	0.4	5.1	0.0
78064	1140	-12.7	-2.5	4.7	13.7	3.9	16	0.8	0.1	5.3	0.0
78064	1170	-13.1	-2.8	4.7	14.2	4.1	16	0.9	-0.1	5.5	0.0
78064	1200	-13.6	-3.2	4.7	14.7	4.3	17	0.9	-0.3	5.7	0.0
78064	1230	-14.0	-3.6	4.6	15.1	4.5	17	1.0	-0.5	5.8	0.0
78064	1260	-14.3	-3.9	4.6	15.6	4.7	18	1.0	-0.8	6.0	0.0
78064	1290	-14.7	-4.2	4.6	16.0	4.9	19	1.1	-1.0	6.2	0.0
78064	1320	-15.1	-4.6	4.6	16.4	5.2	19	1.1	-1.2	6.3	0.0
78064	1350	-15.4	-4.8	4.5	16.8	5.4	20	1.2	-1.4	6.5	0.0
78064	1380	-15.7	-5.1	4.5	17.1	5.7	21	1.2	-1.6	6.6	0.0
78064	1410	-16.0	-5.3	4.5	17.5	6.0	23	1.2	-1.8	6.8	0.0
78064	1440	-16.4	-5.6	4.6	17.9	6.3	24	1.3	-2.1	6.9	0.0

A2. Magnetosphere /Geomagnetically Disturbed Day

(High O⁺/H⁺ density ratio)

78124	123	48.6	23.8	-11.4	55.4	-12	26	1.60E-01	5.05E+00	1.91E+02	8	132.00	0.00	0.1	16.1	-10.7	0.1	2.8
78124	256	42.7	29.7	-13.7	53.9	-15	35	2.20E-01	4.69E+00	1.12E+02	6	116.00	0.00	0.1	16.1	-10.7	0.1	2.8
78124	350	39.3	32.7	-10.3	52.2	-11	40	3.28E-01	3.58E+00	9.24E+01	-16	60.00	0.00	0.1	16.1	-10.7	0.0	2.8
78124	418	40.3	32.6	-9.8	52.8	-11	39	2.53E-01	4.94E+00	6.24E+01	-13	56.00	0.00	0.1	16.1	-10.6	0.0	2.8
78124	544	40.5	31.6	-6.9	51.9	-8	38	2.09E-01	4.94E+00	4.29E+01	24	154.00	0.00	0.1	16.1	-10.6	0.0	2.8
78124	671	39.7	30.0	-9.3	50.6	-11	37	1.60E-01	5.68E+00	1.10E+02	27	64.00	0.00	0.1	16.1	-10.6	0.0	2.7
78124	757	34.4	28.0	-8.3	45.2	-11	39	2.34E-01	4.19E+00	1.29E+02	34	96.00	0.00	0.1	16.1	-10.5	0.0	2.7
78124	844	33.8	26.7	-10.1	44.3	-13	38	2.12E-01	4.51E+00	5.37E+01	18	66.00	0.00	0.1	16.1	-10.5	0.0	2.7
78124	933	37.1	25.8	-11.7	46.7	-15	35	1.85E-01	4.12E+00	1.12E+02	18	96.00	0.00	0.1	16.1	-10.5	0.0	2.7
78124	1047	40.1	25.3	-11.8	48.9	-14	32	1.80E-01	5.13E+00	1.36E+02	19	116.00	0.00	0.1	16.1	-10.4	0.0	2.7
78124	1141	45.7	23.7	-9.0	52.3	-10	27	2.09E-01	4.74E+00	8.66E+01	21	60.00	0.00	0.1	16.1	-10.4	0.0	2.7
78124	1209	47.2	22.7	-7.3	53.0	-8	26	2.12E-01	4.74E+00	1.85E+02	17	56.00	0.00	0.1	16.1	-10.4	0.0	2.6
78124	1305	52.3	23.4	-9.3	58.1	-9	24	3.33E-01	4.18E+00	1.78E+02	-1	116.00	0.00	0.1	16.1	-10.4	0.0	2.6
78124	1427	61.9	19.7	-10.4	65.9	-9	18	4.00E-01	4.13E+00	1.65E+02	-25	116.00	0.00	0.1	16.1	-10.3	-0.1	2.6
78124	1544	58.1	19.9	-16.6	63.7	-15	19	3.06E-01	3.95E+00	2.07E+02	-5	102.00	0.00	0.1	16.1	-10.3	-0.1	2.5
78124	1636	53.6	17.0	-17.6	59.0	-17	18	3.18E-01	4.38E+00	1.24E+02	-8	66.00	0.00	0.1	16.1	-10.3	-0.1	2.5
78124	1725	55.6	17.7	-18.5	61.3	-18	18	2.97E-01	4.50E+00	1.45E+02	-7	96.00	0.00	0.1	16.1	-10.2	-0.1	2.5
78124	1839	61.4	15.9	-17.5	65.9	-15	15	5.55E-01	3.24E+00	4.09E+01	-70	116.00	0.00	0.1	16.1	-10.2	-0.1	2.5
78124	1933	66.1	18.2	-11.0	69.4	-9	15	3.09E-01	4.66E+00	6.20E+01	6	60.00	0.00	0.1	16.1	-10.2	-0.1	2.5
78124	2001	59.7	17.4	-7.3	62.6	-7	16	3.14E-01	4.09E+00	1.87E+02	21	56.00	0.00	0.1	16.1	-10.1	-0.1	2.5
78124	2097	65.7	13.4	-5.2	67.3	-4	11	3.29E-01	3.75E+00	5.83E+01	-7	116.00	0.00	0.1	16.1	-10.1	-0.1	2.5
78124	2219	67.6	11.0	-5.0	68.8	-4	9	2.86E-01	3.67E+00	6.66E+01	-14	116.00	0.00	0.1	16.1	-10.1	-0.1	2.4
78124	2336	63.3	9.3	-2.8	64.1	-3	8	3.16E-01	3.83E+00	2.69E+01	-11	102.00	0.00	0.1	16.1	-10.1	-0.1	2.4
78124	2428	54.2	10.7	-0.5	55.3	-1	11	5.90E-01	3.93E+00	1.48E+01	-57	66.00	0.00	0.1	16.1	-10.0	-0.1	2.4
78124	2517	47.4	10.9	0.0	48.7	0	13	3.66E-01	4.36E+00	3.61E+01	-132	96.00	0.00	0.1	16.1	-10.0	-0.1	2.4
78124	2630	54.8	5.6	-2.6	55.3	-3	6	4.68E-01	4.35E+00	9.85E+01	-61	104.00	0.00	0.1	16.1	-9.9	-0.2	2.3
78124	2724	61.9	3.2	-3.7	62.1	-3	3	6.74E-01	5.63E+00	4.72E+01	-71	60.00	0.00	0.1	16.1	-9.9	-0.2	2.3
78124	2792	62.2	3.5	-5.0	62.6	-5	3	5.17E-01	4.41E+00	4.09E+01	-78	56.00	0.00	0.1	16.1	-9.9	-0.2	2.3
78124	2888	60.6	4.8	-6.0	61.2	-6	5	2.93E-01	4.37E+00	1.65E+02	-11	116.00	0.00	0.1	16.1	-9.8	-0.2	2.3
78124	3010	57.5	2.8	-8.9	58.4	-9	3	3.12E-01	4.71E+00	1.67E+02	-13	116.00	0.00	0.1	16.1	-9.8	-0.2	2.3
78124	3127	57.9	1.3	-9.1	58.7	-9	1	2.68E-01	5.11E+00	1.61E+02	-6	102.00	0.00	0.1	16.1	-9.8	-0.2	2.2
78124	3219	59.6	1.4	-9.6	60.4	-9	1	2.80E-01	5.17E+00	6.58E+01	-9	66.00	0.00	0.1	16.1	-9.7	-0.2	2.2
78124	3308	61.3	3.7	-10.7	62.4	-10	3	2.66E-01	5.72E+00	1.22E+02	-19	96.00	0.00	0.1	16.1	-9.7	-0.2	2.2
78124	3422	61.0	3.6	-10.8	62.0	-10	3	3.29E-01	5.21E+00	1.22E+02	-16	116.00	0.00	0.1	16.1	-9.6	-0.2	2.1
78124	3516	61.8	5.9	-12.4	63.3	-11	5	3.35E-01	5.81E+00	6.19E+01	-18	60.00	0.00	0.1	16.1	-9.6	-0.2	2.1
78124	3605	63.8	7.0	-12.0	65.4	-11	6	4.13E-01	5.02E+00	3.00E+01	-44	82.00	0.00	0.1	16.1	-9.6	-0.2	2.1
78124	3701	67.6	8.4	-12.8	69.3	-11	7	4.02E-01	5.17E+00	3.75E+01	-61	74.00	0.00	0.1	16.1	-9.5	-0.3	2.1
78124	3802	69.5	11.8	-17.6	72.7	-14	10	2.90E-01	4.63E+00	7.01E+01	-65	116.00	0.00	0.1	16.1	-9.5	-0.3	2.1
78124	3919	70.8	10.8	-20.3	74.5	-16	9	1.88E-01	4.60E+00	5.79E+01	-47	102.00	0.00	0.1	16.1	-9.5	-0.3	2.1
78124	4012	69.5	12.3	-19.2	73.1	-15	10	1.80E-01	4.64E+00	9.54E+00	-82	65.81	0.00	0.1	16.1	-9.4	-0.3	2.0
78124	4101	71.0	10.6	-18.5	74.2	-14	9	1.37E-01	5.29E+00	2.62E+01	-38	94.00	0.00	0.1	16.1	-9.4	-0.3	2.0
78124	4214	68.9	10.4	-16.4	71.6	-13	9	1.65E-01	4.37E+00	6.44E+01	-108	116.00	0.00	0.1	16.1	-9.4	-0.3	2.0
78124	4308	67.4	10.9	-14.9	69.9	-12	9	1.86E-01	4.48E+00	1.44E+01	-138	60.00	0.00	0.1	16.1	-9.3	-0.3	2.0
78124	4376	66.2	9.9	-13.8	68.4	-12	8	1.80E-01	4.49E+00	5.23E+01	-158	56.00	0.00	0.1	16.1	-9.3	-0.3	1.9
78124	4472	67.2	9.1	-12.1	68.9	-10	8	1.65E-01	4.50E+00	1.11E+01	-167	116.00	0.00	0.1	16.1	-9.3	-0.3	1.9
78124	4594	67.2	3.6	-9.0	68.0	-8	3	2.29E-01	3.71E+00	8.97E+01	-97	116.00	0.00	0.1	16.1	-9.2	-0.3	1.9
78124	4728	71.6	5.4	-7.9	74.0	-6	4	9.49E-02	5.25E+00	1.70E+02	-173	116.00	0.00	0.1	16.1	-9.2	-0.4	1.9

78124	0	13	-10.6	0.0	2.8	11.0	999.0	4	23.7	41.5	29.1	-9.9	51.9	2.82E-01	1	4.62E-01	2	16.1	4	1.4	2.4	
	0.00E+00	-1	1.41E-01	1	3.86E+00	1	5.71E+01	10	242	3	1.38E-03	16	120.00	0.00	10	1.06E-01	1	1.90E+00	2	2.14E+00	1	
	-8.06E-05348	8.65E-04	62	2.10E+01	43	1.31E+02	172	-1	60	2.00E-03	16	120.00	0.00	11	179	4.81E-04	104	0.00E+00	-1	1.18E+01	62	
	3.57E-04	84	7.30E-03	10	5.45E+00	9	2.92E+01	83	-133	10	2.62E-03	16	120.00	0.00	15	176	6.86E-03	10	3.07E+00	14	2.73E+00	6
	3.64E-03	60	4.17E-01	1	5.40E+00	1	2.60E+01	7	-70	6	7.39E-03	16	120.00	0.00	15	175	2.37E-01	1	2.79E+00	2	2.98E+00	1
78124	13	26	-10.4	0.0	2.6	10.7	999.0	4	23.8	48.4	23.0	-11.3	55.3	2.48E-01	1	6.40E-01	2	16.1	4	1.2	2.3	
	0.00E+00	-1	1.63E-01	1	4.33E+00	1	6.23E+01	7	-121	3	1.91E-03	13	120.00	0.00	11	178	1.29E-01	1	2.07E+00	2	2.24E+00	1
	3.28E-04129	4.21E-04135	0.00E+00	-1	1.00E+00	-1	0	0	-1	2.77E-03	13	120.00	0.00	12	178	-2.35E-05999	0.00E+00	-1	0.00E+00	-1	0.00E+00	-1
	2.61E-04120	6.52E-03	12	4.63E+00	11	7.32E+01	50	-146	12	3.62E-03	13	120.00	0.00	14	176	7.91E-03	10	1.41E+00	25	3.01E+00	7	
	2.46E-03100	4.89E-01	1	4.44E+00	1	4.49E+01	3	-17	1	1.02E-02	13	120.00	0.00	11	179	4.91E-01	1	1.80E+00	2	2.09E+00	1	
78124	26	40	-10.1	-0.1	2.5	10.4	999.0	4	23.8	62.1	14.4	-10.1	65.0	1.83E-01	1	7.23E-01	2	16.1	4	1.1	2.2	
	0.00E+00	-1	2.03E-01	1	3.89E+00	1	3.62E+01	12	-133	4	2.16E-03	12	120.00	0.00	7	179	1.55E-01	1	1.76E+00	2	2.07E+00	1
	-2.92E-04100	2.99E-04196	1.32E+01140	-1.00E+00	-1	0	0	0	-1	3.13E-03	12	120.00	0.00	7	180	5.97E-04	96	6.60E+00	91	0.00E+00	-1	
	-2.59E-04	98	2.10E-02	5	3.64E+00	6	1.10E+01	90	-104	73	4.09E-03	12	120.00	0.00	9	180	1.07E-02	8	1.52E+00	18	2.17E+00	6
	6.70E-04310	5.16E-01	1	3.94E+00	1	1.04E+01	16	45	5	1.16E-02	12	120.00	0.00	6	179	3.94E-01	1	1.66E+00	2	2.13E+00	1	
78124	40	53	-9.9	-0.2	2.3	10.1	999.0	4	23.9	56.8	5.1	-5.0	57.5	2.54E-01	1	5.21E-01	2	16.1	4	0.9	2.1	
	0.00E+00	-1	1.81E-01	1	3.64E+00	1	2.84E+01	17	-12	4	1.56E-03	15	120.00	0.00	2	180	1.51E-01	1	1.47E+00	2	2.15E+00	1
	-5.88E-05461	9.00E+00	-1	0.00E+00	-1	1.00E+00	-1	0	0	-1	2.26E-03	15	120.00	0.00	4	180	0.00E+00	-1	0.00E+00	-1	0.00E+00	-1
	0.00E+00	-1	1.13E-02	8	3.54E+00	10	3.61E+01	50	-11	8	2.95E-03	15	104.00	0.00	6	179	1.11E-02	8	1.25E+00	21	2.30E+00	6
	6.63E-03	49	4.76E-01	1	5.25E+00	1	4.30E+01	5	-19	1	8.34E-03	15	120.00	0.00	6	180	4.29E-01	1	2.45E+00	2	3.07E+00	1
78124	53	66	-9.6	-0.2	2.1	9.8	999.0	4	23.9	64.9	7.1	-13.8	66.9	1.77E-01	1	5.21E-01	2	16.1	4	0.7	2.0	
	0.00E+00	-1	2.67E-01	0	4.76E+00	1	2.49E+01	12	-101	12	1.56E-03	15	120.00	0.00	14	176	1.61E-01	1	2.27E+00	1	2.46E+00	1
	0.00E+00	-1	-2.17E-05999	0.00E+00	-1	-1.00E+00	-1	0	0	-1	2.26E-03	15	120.00	0.00	14	176	0.00E+00	-1	0.00E+00	-1	0.00E+00	-1
	2.36E-04126	1.23E-02	7	4.09E+00	8	2.11E+01	78	-59	26	2.95E-03	15	120.00	0.00	14	176	9.12E-03	8	2.58E+00	11	1.81E+00	8	
	2.36E-03	90	3.73E-01	2	4.44E+00	2	1.99E+01	8	-88	7	8.31E-03	15	104.00	0.00	14	176	2.70E-01	2	3.00E+00	2	2.03E+00	2
78124	66	79	-9.3	-0.3	1.9	9.5	999.0	4	24.0	68.9	8.3	-13.4	71.0	5.72E-02	2	4.86E-01	2	16.1	4	0.6	1.9	
	0.00E+00	-1	8.72E-02	1	4.30E+00	1	2.86E+01	22	-158	10	1.45E-03	15	120.00	0.00	14	176	8.53E-02	1	2.52E+00	2	1.79E+00	1
	2.81E-04146	4.11E-05999	0.00E+00	-1	1.00E+00	-1	0	0	-1	2.11E-03	15	120.00	0.00	14	176	-2.98E-05999	0.00E+00	-1	0.00E+00	-1	0.00E+00	-1
	4.32E-04	94	4.54E-03	16	2.32E+00	33	6.06E+01	51	-151	16	2.75E-03	15	120.00	0.00	8	179	4.49E-03	16	1.41E+00	44	1.29E+00	21
	3.21E-03	71	2.05E-01	2	3.87E+00	2	8.00E+01	3	-166	1	7.77E-03	15	104.00	0.00	9	180	2.03E-01	2	2.23E+00	2	1.77E+00	2
78124	79	92	-9.0	-0.4	1.8	9.2	999.0	4	24.0	43.6	15.5	10.5	54.9	8.09E-02	3	7.70E-01	2	16.1	4	0.4	1.8	
	0.00E+00	-1	6.10E-02	1	6.17E+00	2	1.18E+02	7	-130	4	2.30E-03	12	120.00	0.00	8	180	5.57E-02	1	4.29E+00	2	1.94E+00	2
	-1.38E-04231	1.03E-03	59	1.38E+01	38	2.72E+02	73	-21	29	3.34E-03	12	120.00	0.00	12	178	1.37E-03	42	7.28E+00	32	1.51E+00	82	
	-2.67E-04	95	2.65E-03	31	6.96E+00	20	4.61E+01	150	-108	38	4.36E-03	12	120.00	0.00	1	178	2.99E-03	24	5.41E+00	15	2.63E+00	16
	7.35E-03	53	7.39E-02	4	6.87E+00	3	5.22E-01999	-248	19	1.23E-02	12	120.00	0.00	0	178	7.58E-02	3	4.48E+00	3	2.60E+00	3	
78124	92	106	-8.7	-0.5	1.6	8.9	999.0	3	0.0	10.1	14.2	33.2	37.8	2.54E-01	2	2.18E+00	2	16.1	4	0.3	1.7	
	0.00E+00	-1	9.76E-02	1	5.61E+00	1	2.10E+01	31	-128	21	6.52E-03	7	120.00	0.00	44	127	9.89E-02	1	3.68E+00	1	1.80E+00	1
	-3.84E-04140	2.01E-03	49	1.30E+01	36	1.88E+02	65	-86	44	9.45E-03	7	120.00	0.00	44	125	2.55E-03	31	7.41E+00	20	4.25E+00	18	
	9.46E-04	69	2.18E-03	59	8.79E+00	37	3.96E+02	50	47	31	1.24E-02	7	120.00	0.00	46	124	2.31E-03	45	4.63E+00	24	2.55E+00	21
	9.26E-03	43	9.06E-02	4	8.55E+00	3	2.48E+01	24	24	7	3.49E-02	7	120.00	0.00	46	126	1.22E-01	3	4.35E+00	2	2.36E+00	2
78124	106	119	-8.4	-0.6	1.4	8.5	999.0	3	0.1	16.2	11.6	28.9	35.4	3.56E-01	2	2.22E+00	2	16.1	4	0.1	1.5	
	0.00E+00	-1	8.78E-02	1	4.90E+00	2	8.50E+01	7	-1	5	6.63E-03	7	117.75	0.00	45	125	8.82E-02	1	3.22E+00	1	1.68E+00	1
	0.00E+00	-1	5.45E-04194	2.32E+01147	1.34E+02285	-167	57	9.58E-03	7	104.00	0.00	46	125	0.00E+00	-1	0.00E+00	-1	0.00E+00	-1	0.00E+00	-1	
	3.67E-04146	3.77E-03	35	2.90E+00	59	1.17E+02	61	42	34	1.26E-02	7	117.75	0.00	44	127	3.82E-03	30	1.75E+00	58	1.84E+00	22	
	4.79E-03	72	1.96E-01	3	6.22E+00	2	1.94E+01	16	12	10	3.54E-02	7	103.75	0.00	42	128	2.02E-01	2	3.86E+00	2	2.14E+00	2
78124	119	122	-8.2	-0.6	1.3	8.3	999.0	3	0.1	23.9	12.3	34.1	43.5	5.61E-02	6	3.17E+00	2	16.1	4	0.0	1.5	
	0.00E+00	-1	8.11E-02	2	5.08E+00	2	6.52E+00155	-171	26	9.46E-03	10	50.00	0.00	43	128	8.70E-02	2	3.25E+00	1	1.79E+00	1	

1	78124	30	821	-10.6	0.0	2.8	11.0	1.4	2.4	999.0	4	23.7	41.5	29.1	-9.9	51.9	2.82E-01	1	2.53E-02	16	32	16								
	0.86	13	10	71	175	11	0.02100	1	132	204	360	0.09	40	1	254	254	360	0.11	37	3	378	181	76	0.05	57	1	320	184	360	
	10.05	3	64	448	225	190	0.05	57	1	512	197	360	0.08	44	1	634	343	360	0.88	13	7	759	29	145	0.06	50	1	318	315	360
	3.91	6	23	74	215	360	0.02100	1	137	106	360	0.13	35	2	260	326	360	0.03	70	1	384	186	360	0.05	57	2	327	256	360	
	4.92	5	75	454	223	185	0.02100	1	516	347	360	0.11	37	4	639	223	8	1.42	10	9	764	231	155	0.09	40	1	312	2	360	
	1.66	9	9	65	207	360	0.02100	1	129	238	360	0.25	24	2	250	222	360	0.25	24	3	375	230	360	0.06	50	1	328	29	360	
	4.63	5	95	445	222	11	0.00999	0	509	305	360	0.22	26	4	630	222	8	1.48	10	9	753	38	158	0.02100	1	308	241	360		
	1.30	10	8	77	210	181	0.05	57	1	140	71	360	0.14	33	2	622	203	180	0.44	18	12	387	248	360	0.02100	1	335	212	360	
	2.80	7	22	457	225	192	0.05	57	1	518	209	360	0.06	50	2	642	196	360	2.52	7	15	766	34	170	0.02100	1	305	164	360	
	2.06	8	11	63	15	178	0.03	70	1	123	196	360	0.14	33	2	247	227	360	1.38	10	18	373	16	20	0.06	50	1	336	234	360
	2.72	7	16	442	227	192	0.03	70	1	502	160	360	0.09	40	1	626	28	360	2.08	8	16	750	50	175	0.05	57	1	300	344	360
	2.33	8	14	83	208	197	0.03	70	1	142	37	360	0.14	33	2	267	67	360	0.77	14	7	392	24	182	0.02100	1	343	35	360	
	3.14	7	15	463	230	192	0.09	57	1	522	330	360	0.05	57	1	647	38	360	1.22	11	11	770	221	20	0.06	50	1	297	349	360
	2.00	8	8	56	207	192	0.02100	1	121	48	360	0.09	40	2	244	232	360	0.86	13	5	366	223	155	0.08	44	1	344	168	360	
	3.36	6	18	436	230	185	0.02100	1	500	275	360	0.11	37	2	623	40	360	1.02	12	5	746	230	360	0.05	57	1	293	243	360	
	2.38	8	12	85	18	180	0.00999	0	150	167	360	0.11	37	2	272	240	360	0.95	12	8	396	241	141	0.00999	0	350	54	360		
	2.48	7	11	465	26	197	-1.00	-1	-1	-1	-1	0.13	35	2	653	28	360	1.13	11	10	776	234	37	0.06	50	1	289	78	360	
	2.59	7	15	54	22	360	0.05	57	1	114	255	360	0.08	44	1	238	219	360	1.13	11	12	363	220	360	0.05	57	1	700	207	360
	1.84	9	11	433	227	192	0.02100	1	496	199	360	0.31	22	3	621	215	37	0.63	15	8	743	228	360	0.03	70	1	697	227	360	
	2.20	8	9	91	16	215	0.03	70	1	150	256	360	0.14	33	4	275	228	8	3.47	6	42	399	221	26	0.05	57	1	704	276	360
	3.66	6	16	468	36	200	-1.00	-1	-1	-1	-1	0.17	30	3	655	213	360	1.41	10	7	778	44	182	0.06	50	2	695	5	360	
	3.17	7	16	48	24	192	0.05	57	1	110	134	360	0.14	33	1	234	83	360	2.28	8	17	360	225	192	0.03	70	1	708	52	360
	3.20	6	15	428	32	360	0.02100	1	493	204	360	0.09	40	2	615	224	360	1.31	10	8	741	28	293	0.08	44	1	688	175	360	
	3.44	6	18	92	208	171	0.02100	1	157	298	360	0.20	27	1	278	223	360	1.28	11	5	403	357	190	0.06	50	1	712	225	360	
	2.72	7	10	474	33	207	-1.00	-1	-1	-1	-1	0.06	50	1	658	201	360	1.23	11	6	785	197	219	0.00999	0	687	138	360		
	1.86	9	9	45	7	200	0.00999	0	110	112	360	0.11	37	1	231	44	360	1.44	10	8	355	0	160	0.03	70	1	716	249	360	
	2.19	8	11	425	37	185	0.03	70	1	488	288	360	0.16	31	2	613	288	360	1.31	10	11	735	38	185	0.08	44	1	680	36	360
	2.30	9	12	98	191	207	0.11	37	1	158	123	360	0.03	70	2	284	228	8	1.39	10	5	407	22	182	0.09	40	2	723	35	360
	3.50	9	11	481	201	185	-1.00	-1	-1	-1	-1	0.22	37	2	667	231	360	1.19	16	4	790	39	-1	0.30	22	3	677	26	155	
	2.14	8	9	43	197	200	0.06	50	1	103	356	360	0.09	40	1	226	216	360	0.61	16	3	352	328	200	0.33	21	3	726	30	178
	2.14	8	8	477	36	207	-1.00	-1	-1	-1	-1	0.16	31	2	662	28	360	1.30	10	6	787	15	212	0.52	17	9	674	46	19	
	1.88	12	5	100	53	197	0.09	57	1	162	207	360	0.09	57	1	286	105	360	0.66	21	3	410	354	185	0.84	19	8	729	40	89
	2.29	7	10	420	202	187	0.04	57	1	482	245	360	0.00999	0	2	316	360	1.01	8	16	671	36	13	0.42	18	4	608	42	168	
1	78124	821	1613	-10.4	0.0	2.6	10.7	1.2	2.3	999.0	4	23.8	48.4	23.0	-11.3	55.3	2.48E-01	1	3.50E-02	13	32	16								
	2.81	7	13	70	179	185	0.08	44	1	130	134	360	0.08	44	1	255	76	360	0.09	40	1	379	114	360	0.02100	1	322	110	360	
	8.84	4	28	450	246	197	0.06	50	1	511	179	360	0.20	27	5	636	231	11	3.09	7	25	758	318	360	0.00999	0	320	292	360	
	3.77	6	46	73	226	30	0.06	50	1	134	262	360	0.20	27	2	259	234	360	0.38	20	2	383	161	360	0.08	44	1	324	60	360
	5.06	5	34	455	14	207	0.00999	0	518	332	360	0.27	24	2	642	222	360	2.89	7	26	764	309	67	0.08	44	1	312	102	360	
	1.67	9	9	67	221	81	0.02100	1	130	97	360	0.17	30	2	254	16	360	1.30	10	7	377	222	44	0.06	50	1	329	248	360	
	3.77	6	23	447	214	37	0.02100	1	508	250	360	0.13	35	2	633	221	360	7.17	4	60	755	0	126	0.06	50	1	308	341	360	
	2.69	7	20	79	224	10	0.03	70	1	139	53	360	0.16	31	2	265	209	360	0.63	15	7	388	3	178	0.00999	0	336	26	360	
	3.64	6	16	459	209	52	0.05	57	1	520	142	360	0.16	31	1	642	288	360	4.58	5	38	767	348	126	0.05	57	1	306	97	360
	2.52	7	14	61	216	182	0.03	70	1	122	274	360	0.14	33	1	246	201	360	0.58	16	4	372	335	163	0.00999	0	340	140	360	
	3.19	7	22	444	211	197	0.03	70	1	504	63	360	0.17	30	2	628	357	360	6.47	4	50	752	5	141	0.08	44	2	303	20	360
	2.13	8	9	83	226	192	0.06	50	1	143	166	360	0.20	27	2	269	44	360	1.14	11	9	391	13	360	0.05	57	1	341	273	360

78124	0	-10.8	0.1	2.9	11.1	999.0	4	23.7	1.4	2.5	0.0
78124	30	-10.2	-0.1	2.5	10.5	999.0	4	23.8	1.1	2.2	0.0
78124	60	-9.6	-0.2	2.1	9.8	999.0	4	23.9	0.7	2.0	0.0
78124	90	-8.9	-0.4	1.7	9.1	999.0	3	0.0	0.4	1.7	0.0
78124	120	-8.2	-0.6	1.3	8.3	999.0	3	0.1	0.0	1.5	0.0
78124	150	-7.4	-0.8	0.9	7.5	999.0	2	0.3	-0.3	1.2	0.0
78124	180	-6.5	-1.0	0.6	6.6	999.0	0	0.5	-0.7	0.9	7.2
78124	210	-5.5	-1.2	0.2	5.7	999.0	-3	0.8	-1.1	0.6	6.0
78124	240	-4.4	-1.4	-0.2	4.6	999.0	-7	1.2	-1.4	0.2	4.9
78124	270	-3.0	-1.5	-0.6	3.4	999.0	-13	1.9	-1.6	-0.1	3.8
78124	300	-1.2	-1.4	-0.8	2.1	999.0	-27	3.7	-1.6	-0.4	2.8
78124	330	0.9	-0.4	-0.5	1.1	999.0	-20	10.7	-0.5	-0.4	1.2
78124	360	1.3	1.6	0.9	2.2	999.0	26	15.8	1.8	0.5	2.7
78124	390	0.7	3.0	1.8	3.6	999.0	32	17.8	3.3	1.2	4.9
78124	420	0.1	4.0	2.5	4.7	999.0	31	18.7	4.4	1.7	6.7
78124	450	-0.6	4.9	3.0	5.8	999.0	30	19.2	5.3	2.2	8.1
78124	480	-1.2	5.7	3.4	6.7	999.0	29	19.6	6.1	2.6	9.5
78124	510	-1.8	6.3	3.8	7.6	999.0	27	19.9	6.8	3.0	10.9
78124	540	-2.4	6.9	4.1	8.4	999.0	25	20.1	7.4	3.3	12.4
78124	570	-3.0	7.5	4.4	9.2	999.0	23	20.3	7.9	3.6	0.0
78124	600	-3.6	8.0	4.7	9.9	999.0	22	20.4	8.4	3.9	0.0
78124	630	-4.1	8.4	4.9	10.6	999.0	20	20.5	8.8	4.2	0.0
78124	660	-4.6	8.8	5.2	11.2	999.0	19	20.6	9.2	4.4	0.0
78124	690	-5.1	9.1	5.5	11.8	999.0	18	20.7	9.6	4.6	0.0
78124	720	-5.6	9.4	5.8	12.4	999.0	17	20.8	9.9	4.9	0.0
78124	750	-6.1	9.6	6.2	12.9	999.0	16	20.9	10.2	5.1	0.0
78124	780	-6.6	9.8	6.5	13.5	999.0	15	21.0	10.5	5.3	0.0
78124	810	-7.0	9.9	6.9	14.0	999.0	14	21.0	10.8	5.4	0.0
78124	840	-7.4	10.0	7.3	14.4	999.0	14	21.1	11.0	5.6	0.0
78124	870	-7.9	10.0	7.8	14.9	999.0	14	21.1	11.3	5.8	0.0
78124	900	-8.3	10.0	8.2	15.3	999.0	14	21.2	11.5	5.9	0.0
78124	930	-8.7	9.9	8.7	15.8	999.0	14	21.2	11.7	6.1	0.0
78124	960	-9.1	9.8	9.2	16.2	999.0	14	21.3	11.9	6.2	0.0
78124	990	-9.4	9.6	9.6	16.6	999.0	14	21.3	12.0	6.3	0.0
78124	1020	-9.8	9.4	10.1	16.9	999.0	15	21.4	12.2	6.5	0.0
78124	1050	-10.2	9.2	10.5	17.3	999.0	16	21.4	12.3	6.6	0.0
78124	1080	-10.5	9.0	10.9	17.6	999.0	16	21.4	12.5	6.7	0.0
78124	1110	-10.8	8.8	11.3	17.9	999.0	17	21.5	12.6	6.8	0.0
78124	1140	-11.2	8.6	11.6	18.3	7.8	18	21.5	12.7	6.9	0.0
78124	1170	-11.5	8.4	11.9	18.6	8.2	19	21.5	12.8	7.0	0.0
78124	1200	-11.8	8.2	12.2	18.8	8.6	21	21.6	12.9	7.1	0.0
78124	1230	-12.1	8.0	12.4	19.1	9.0	22	21.6	13.0	7.2	0.0
78124	1260	-12.4	7.9	12.6	19.4	9.4	23	21.6	13.0	7.2	0.0
78124	1290	-12.7	7.8	12.8	19.6	9.8	24	21.7	13.1	7.3	0.0
78124	1320	-12.9	7.8	12.9	19.9	10.1	25	21.7	13.2	7.4	0.0
78124	1350	-13.2	7.8	13.0	20.1	10.4	26	21.7	13.2	7.4	0.0
78124	1380	-13.5	7.9	13.0	20.3	10.7	27	21.7	13.3	7.5	0.0
78124	1410	-13.7	8.0	13.0	20.5	11.0	28	21.8	13.3	7.6	0.0
78124	1440	-14.0	8.1	13.0	20.8	11.2	29	21.8	13.3	7.6	0.0

Appendix 3

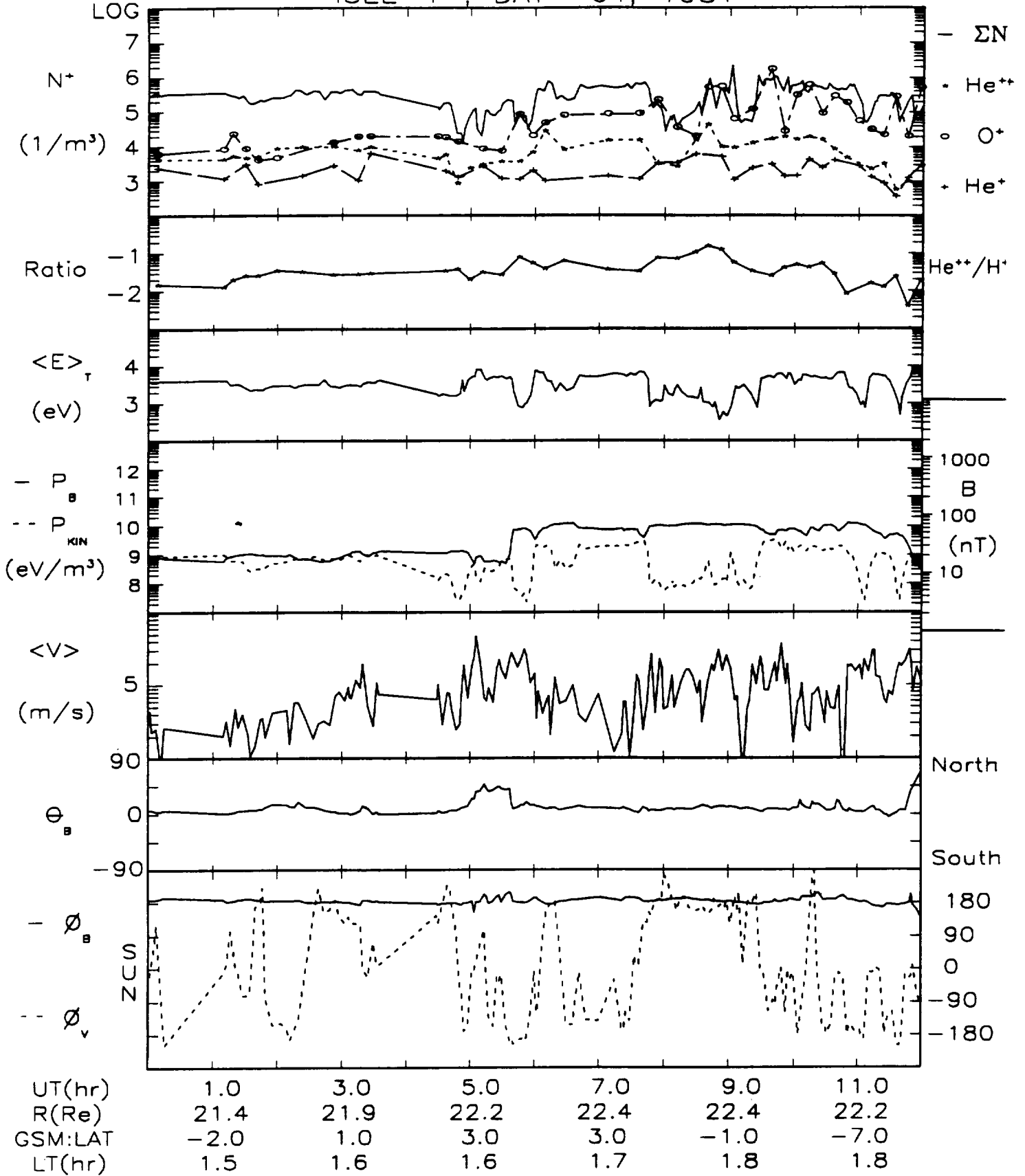
Sample Plots of Certain Plasma Parameters

(2 pages)

0.1-16 keV/e IONS

16-AUG-95,08:56:02

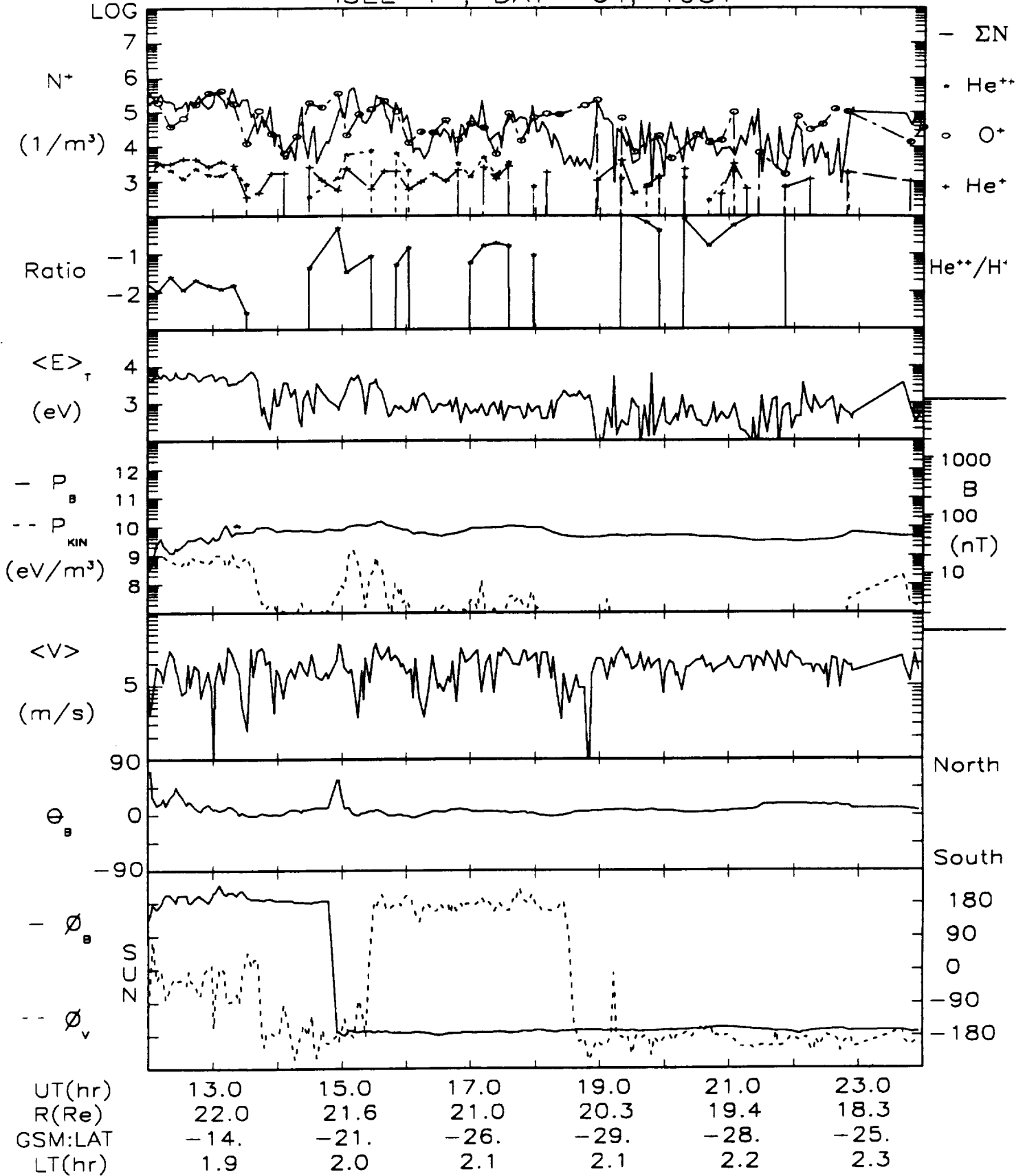
ISEE-1, DAY 64, 1981



0.1-16 keV/e IONS

16-AUG-95,08:56:02

ISEE-1, DAY 64, 1981



Appendix 4

**VAX/VMS Command Files
for Magnetic Tape Operations**
(13 pages)

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$!***** LOCKHEED PLASMA COMPOSITION EXPERIMENT ON ISEE-1 *****
$!          ***** COPY_ISEEMS.COM *****
$!
$! Interactive command file for copying data from archival tapes (label: ISEEMS)
$!          using the VAX/VMS Backup Utility
$!
$!          by O. W. Lennartsson
$!          Lockheed Martin Missiles & Space
$!          Advanced Technology Center
$!          Dept. H1-11, Bldg. 255
$!          3251 Hanover Street
$!          Palo Alto, CA 94304
$!
$! Telephone (650) 424-3259
$!
$! Developed under NASA Contract NAS5-33047 and NASA Grant NAGW-4496
$!
$! Operating system used: VAX/VMS version V5.5
$!
$! To execute this file, simply enter @COPY_ISEEMS, if the file resides in the
$! same directory used for the data files, otherwise specify directory name in
$! the command: @directory_nameCOPY_ISEEMS (your default directory should be the
$! one used for data files).
$!*****
$WRITE SYS$OUTPUT " "
$DEFAULT_DIR = F$LOGICAL("SYS$DISK")+F$DIRECTORY()
$WRITE SYS$OUTPUT_"Your default directory is: ",''DEFAULT_DIR'
$WRITE SYS$OUTPUT "Is this where you want the files?"
$WRITE SYS$OUTPUT "If not, Ctrl/Y, reset default and reenter command."
$WRITE SYS$OUTPUT " "
$INQUIRE DUM "If directory OK, then press return"
$SET NOON
$WRITE SYS$OUTPUT " "
$INQUIRE NAME "Which tape drive? (enter name of device)"
$DRIVE= F$STRING(NAME)
$ALLOCATE 'DRIVE' TAPE
$IF $SEVERITY .EQ. 1 THEN GOTO DRIVE_OK
$WRITE SYS$OUTPUT "EXIT"
$WRITE SYS$OUTPUT "Reenter command if trying another drive."
$SET ON
$EXIT
$DRIVE_OK:
$SET ON
$WRITE SYS$OUTPUT " "
$WRITE SYS$OUTPUT "Mount tape on ''F$LOGICAL("TAPE")'' "
$WRITE SYS$OUTPUT " "
$INQUIRE DUM "When tape mounted and on line (!), then press return"
$MOUNT/FOREIGN/DENSITY=6250 TAPE
$WRITE SYS$OUTPUT " "
$WRITE SYS$OUTPUT -
  "If you only want to copy the Data User's Guide, enter Y (yes) here,"
$INQUIRE GUIDE -
  "otherwise press return again"
$IF GUIDE THEN SET NOON
$IF GUIDE THEN GOTO ONLY_GUIDE
$WRITE SYS$OUTPUT " "
$WRITE SYS$OUTPUT "Data files are copied by date, starting with the ",-

```

```

"first date entered,"
$WRITE SYS$OUTPUT "and ending with the second date (inclusive) ",-
"-assuming one and the same year."
$WRITE SYS$OUTPUT "If data run into second year, reenter a new set ",-
"of dates for that second year."
$WRITE SYS$OUTPUT -
  "It is OK to copy one single day also, that is second date = first date."
$IRWND=0
$NYOLD=0
$NEW_YEAR:
$WRITE SYS$OUTPUT " "
$INQUIRE P2 "What YEAR? (two digits)"
$LENGTH_OF_YEAR:
$LP2=F$LENGTH(P2)
$IF(LP2.EQ.2) THEN GOTO CHECK_YEAR
$INQUIRE P2 "Enter two digits for the year: 77 through 82"
$GOTO LENGTH_OF_YEAR
$WRONG_YEAR:
$INQUIRE P2 "Enter either of 77, 78, 79, 80, 81, or 82"
$CHECK_YEAR:
$NY=F$INTEGER(F$EXTRACT(0,2,P2))
$IF(NY.LT.77.OR.NY.GT.82) THEN GOTO WRONG_YEAR
$IF(NY.EQ.NYOLD) THEN GOTO YEAR_OK
$IF(NY.LT.NYOLD) THEN GOTO WRONG_ORDER_YEARS
$MNDAY=999
$MXDAY=0
$YEAR_OK:
$IRWRS=0
$WRITE SYS$OUTPUT " "
$INQUIRE P3 "First DAY to be copied? (one to three digits)"
$LP3=F$LENGTH(P3)
$IF(LP3.GT.3) THEN GOTO YEAR_OK
$IF(LP3.EQ.2) THEN P3:= "0''P3'"
$IF(LP3.EQ.1) THEN P3:= "00''P3'"
$ND=F$INTEGER(F$EXTRACT(0,3,P3))
$IF(NY.EQ.80) .AND. (ND.LT.1.OR.ND.GT.366) .OR. -
  (NY.NE.80) .AND. (ND.LT.1.OR.ND.GT.365) THEN GOTO YEAR_OK
$IF(ND.LE.MXDAY) THEN IRWRS=1
$IF(IRWRS.EQ.1) THEN GOTO OVERLAP1
$NO_OVERLAP1:
$ISTART=ND
$YEAR_STILL_OK:
$WRITE SYS$OUTPUT " "
$INQUIRE P3 "Last DAY to be copied? (in that same segment)"
$LP3=F$LENGTH(P3)
$IF(LP3.GT.3) THEN GOTO YEAR_STILL_OK
$IF(LP3.EQ.2) THEN P3:= "0''P3'"
$IF(LP3.EQ.1) THEN P3:= "00''P3'"
$ND=F$INTEGER(F$EXTRACT(0,3,P3))
$IF(NY.EQ.80) .AND. (ND.LT.1.OR.ND.GT.366) .OR. -
  (NY.NE.80) .AND. (ND.LT.1.OR.ND.GT.365) THEN GOTO YEAR_STILL_OK
$IF(ND.LT.ISTART) THEN GOTO WRONG_ORDER_DAYS
$IF(ND.GE.MNDAY) .AND. (IRWRS.EQ.1) THEN GOTO OVERLAP2
$NO_OVERLAP2:
$IRWRS=0
$ISTOP=ND
$IDAY=ISTART

```

```

$SET NOON
$BACKUP_TO_DISK:
$IF (IDAY.LT.MNDAY) THEN MNDAY=IDAY
$IF (IDAY.GT.MXDAY) THEN MXDAY=IDAY
$IF (IDAY.LE.9) THEN YYDDD= F$STRING(NY) + "00" + F$STRING(IDAY)
$IF (IDAY.GT.9) .AND. (IDAY.LE.99) THEN -
  YYDDD= F$STRING(NY) + "0" + F$STRING(IDAY)
$IF (IDAY.GT.99) THEN YYDDD= F$STRING(NY) + F$STRING(IDAY)
$IF (IDAY.EQ.ISTART) THEN YYDDD1=YYDDD
$IF (IRWND.EQ.0) THEN BACKUP/LOG TAPE:'YYDDD'.BCK 'DEFAULT_DIR'
$IF (IRWND.EQ.1) THEN BACKUP/REWIND/LOG TAPE:'YYDDD'.BCK 'DEFAULT_DIR'
$IRWND=0
$IDAY=IDAY+1
$IF (IDAY.LE.ISTOP) THEN GOTO BACKUP_TO_DISK
$NYOLD=NY
$WRITE SYSS$OUTPUT " "
$IF (ISTOP.EQ.ISTART) THEN WRITE SYSS$OUTPUT -
  "Last segment copied: a single day ", 'YYDDD'
$IF (ISTOP.GT.ISTART) THEN WRITE SYSS$OUTPUT -
  "Last segment copied: days ", 'YYDDD1'," through ", 'YYDDD'
$WRITE SYSS$OUTPUT " "
$INQUIRE MORE -
  "Are there more data files to be copied from this tape? [Y/N]"
$IF MORE THEN GOTO NEW_YEAR
$WRITE SYSS$OUTPUT " "
$INQUIRE GUIDE -
  "Do you want to copy the User's Guide? (last file on the tape) [Y/N]"
$ONLY_GUIDE:
$IF GUIDE THEN -
  BACKUP/LOG TAPE:GUIDE.BCK 'DEFAULT_DIR'
$IF $SEVERITY .EQ. 1 THEN GOTO REMOVE_TAPE
$DIR 'DEFAULT_DIR'GUIDE.
$IF $SEVERITY .EQ. 1 THEN GOTO REMOVE_TAPE
$IF GUIDE THEN WRITE SYSS$OUTPUT " "
$IF GUIDE THEN WRITE SYSS$OUTPUT "Tape already at end, must be rewound."
$IF GUIDE THEN -
  BACKUP/REWIND/LOG TAPE:GUIDE.BCK 'DEFAULT_DIR'
$GOTO REMOVE_TAPE
$WRONG_ORDER_DAYS:
$WRITE SYSS$OUTPUT " "
$WRITE SYSS$OUTPUT "First and last days in wrong order!"
$INQUIRE REDO "Want to reenter dates? [Y/N]"
$IF REDO THEN GOTO NEW_YEAR
$GOTO REMOVE_TAPE
$WRONG_ORDER_YEARS:
$WRITE SYSS$OUTPUT " "
$WRITE SYSS$OUTPUT "Going backwards in years (rewinding tape)?"
$INQUIRE SURE "Is this really the year you want? [Y/N]"
$IF SURE THEN IRWND=1
$IF SURE THEN NYOLD=0
$IF SURE THEN MNDAY=999
$IF SURE THEN MXDAY=0
$IF SURE THEN GOTO YEAR_OK
$INQUIRE REDO "Want to correct year? [Y/N]"
$IF REDO THEN GOTO NEW_YEAR
$GOTO REMOVE_TAPE
$OVERLAP1:

```

```

$WRITE SYSS$OUTPUT " "
$WRITE SYSS$OUTPUT "Caution:"
$IF(ND.LT.MXDAY) THEN WRITE SYSS$OUTPUT -
  "First day precedes days already copied!"
$IF(ND.EQ.MXDAY) THEN WRITE SYSS$OUTPUT -
  "First day has already been copied once!"
$!IF(ND.EQ.MXDAY) THEN GOTO NEW_YEAR
$WRITE SYSS$OUTPUT "Tape will have to be rewound."
$WRITE SYSS$OUTPUT " "
$INQUIRE SURE "Is that what you want? [Y/N]"
$IF SURE THEN IRWND=1
$IF SURE THEN GOTO NO_OVERLAP1
$INQUIRE REDO "Want to correct dates? [Y/N]"
$IF REDO THEN GOTO NEW_YEAR
$GOTO REMOVE_TAPE
$OVERLAP2:
$WRITE SYSS$OUTPUT " "
$WRITE SYSS$OUTPUT "Caution:"
$IF(ND.GT.MNDAY) THEN WRITE SYSS$OUTPUT -
  "Check your Last day entry!"
$IF(ND.EQ.MNDAY) THEN WRITE SYSS$OUTPUT -
  "Last day has already been copied once!"
$!IF(ND.EQ.MNDAY) THEN GOTO YEAR_STILL_OK
$WRITE SYSS$OUTPUT " "
$INQUIRE SURE "Are you satisfied with your dates? [Y/N]"
$IF SURE THEN GOTO NO_OVERLAP2
$INQUIRE REDO "Want to reenter both dates? [Y/N]"
$IF REDO THEN GOTO NEW_YEAR
$INQUIRE REDO "Want to reenter last day? [Y/N]"
$IF REDO THEN GOTO YEAR_STILL_OK
$REMOVE_TAPE:
$SET ON
$DISMOUNT 'DRIVE'
$DEALLOCATE 'DRIVE'
$WRITE SYSS$OUTPUT " "
$WRITE SYSS$OUTPUT "EXIT"
$WRITE SYSS$OUTPUT "That's the end of this run."
$WRITE SYSS$OUTPUT -
  "Tape is dismounted and 'F$LOGICAL("TAPE")' is deallocated."
$EXIT

```

```

$!***** LOCKHEED PLASMA COMPOSITION EXPERIMENT ON ISEE-1 *****
$!          ***** USER_TAPE.COM *****
$!
$! Interactive command file for copying ISEEMS data files from disk to a new
$!          magnetic tape using the VAX/VMS Copy Utility
$!
$!          by O. W. Lennartsson
$!          Lockheed Martin Missiles & Space
$!          Advanced Technology Center
$!          Dept. H1-11, Bldg. 255
$!          3251 Hanover Street
$!          Palo Alto, CA 94304
$!
$! Telephone (650) 424-3259
$!
$! Developed under NASA Contract NAS5-33047 and NASA Grant NAGW-4496
$!
$! Operating system used: VAX/VMS version V5.5
$!
$! To execute this file, simply enter @USER_TAPE, if the file resides in the
$! same directory used for the data files, otherwise specify directory name in
$! the command: @directory_nameUSER_TAPE (your default directory should be the
$! one used for data files). The new tape will be labeled IONS and will be
$! written at a density of 1600 bpi.
$!*****
$WRITE SYS$OUTPUT " "
$DEFAULT_DIR = F$LOGICAL("SYS$DISK")+F$DIRECTORY()
$WRITE SYS$OUTPUT "Your default directory is: ','DEFAULT_DIR'"
$WRITE SYS$OUTPUT "Is this where the ISEEMS files are?"
$WRITE SYS$OUTPUT "If not, Ctrl/Y, reset default and reenter command."
$WRITE SYS$OUTPUT " "
$INQUIRE DUM "If directory OK, then press return"
$SET NOON
$WRITE SYS$OUTPUT " "
$INQUIRE NAME "Which tape drive? (enter name of device)"
$DRIVE= F$STRING(NAME)
$ALLOCATE 'DRIVE' TAPE
$IF $SEVERITY .EQ. 1 THEN GOTO DRIVE_OK
$WRITE SYS$OUTPUT "EXIT"
$WRITE SYS$OUTPUT "Reenter command if trying another drive."
$SET ON
$EXIT
$DRIVE_OK:
$SET ON
$WRITE SYS$OUTPUT " "
$WRITE SYS$OUTPUT "Mount tape on ''F$LOGICAL('TAPE')'"
$WRITE SYS$OUTPUT " "
$WRITE SYS$OUTPUT "Make sure tape is on line."
$WRITE SYS$OUTPUT " "
$INQUIRE INIZLD -
  "Has tape already been initialized at 1600 bpi and labeled IONS? [Y/N]"
$IF INIZLD THEN GOTO INITIALIZED
$INITIALIZE/OVERRIDE=EXPIRATION/DENS=1600/PROT=(G:RW,W:RW) -
  'DRIVE' IONS
$INITIALIZED:
$MOUNT/DENSITY=1600 'DRIVE' IONS TAPE
$WRITE SYS$OUTPUT " "

```

```

$INQUIRE GUIDE -
  "Do you want to copy the Data User's Guide at this point? [Y/N]"
$IF .NOT. GUIDE THEN GOTO DATA_NEXT
$SET NOON
$COPY/LOG 'DEFAULT_DIR'GUIDE. TAPE
$IF $SEVERITY .EQ. 1 THEN GOTO DATA_FILES
$WRITE SYS$OUTPUT " "
$INQUIRE DATA "Do you want to copy data files anyway? [Y/N]"
$IF .NOT. DATA THEN GOTO TAPEDIR_LIS
$SET ON
$GOTO DATA_NEXT
$DATA_FILES:
$WRITE SYS$OUTPUT " "
$INQUIRE DATA "And you also want to copy data files? [Y/N]"
$IF .NOT. DATA THEN GOTO TAPEDIR_LIS
$SET ON
$DATA_NEXT:
$WRITE SYS$OUTPUT " "
$WRITE SYS$OUTPUT "Data files are copied by date, starting with the ",-
  "first date entered,"
$WRITE SYS$OUTPUT "and ending with the second date (inclusive) ",-
  "-assuming one and the same year."
$WRITE SYS$OUTPUT "If data run into second year, reenter a new set ",-
  "of dates for that second year."
$WRITE SYS$OUTPUT " "
$WRITE SYS$OUTPUT -
  "If you are copying one single day, then make last date = first date."
$NYOLD=0
$NEW_YEAR:
$WRITE SYS$OUTPUT " "
$INQUIRE P2 "What YEAR? (two digits)"
$LENGTH_OF_YEAR:
$LP2=F$LENGTH(P2)
$IF (LP2.EQ.2) THEN GOTO CHECK_YEAR
$INQUIRE P2 "Enter two digits for the year: 77 through 82"
$GOTO LENGTH_OF_YEAR
$WRONG_YEAR:
$INQUIRE P2 "Enter either of 77, 78, 79, 80, 81, or 82"
$CHECK_YEAR:
$NY=F$INTEGER(F$EXTRACT(0,2,P2))
$IF (NY.LT.77.OR.NY.GT.82) THEN GOTO WRONG_YEAR
$IF (NY.EQ.NYOLD) THEN GOTO YEAR_OK
$YY= F$STRING(NY)
$DIR/OUTPUT=DRECTRY.TMP 'DEFAULT_DIR'EX'YY'*.DAT
$IF $SEVERITY .EQ. 1 THEN GOTO YEAR_POSSIBLE
$DELETE DRECTRY.TMP;*
$WRITE SYS$OUTPUT " "
$WRITE SYS$OUTPUT "No files found from year ", 'YY', "!"
$INQUIRE REDO "Want to reenter year? [Y/N]"
$IF REDO THEN GOTO NEW_YEAR
$GOTO REMOVE_TAPE
$YEAR_POSSIBLE:
$DELETE DRECTRY.TMP;*
$IF (NY.LT.NYOLD) THEN GOTO WRONG_ORDER_YEARS
$MNDAY=999
$MXDAY=0
$YEAR_OK:

```

```

$IRWRS=0
$WRITE SYS$OUTPUT " "
$INQUIRE P3 "First DAY to be copied? (one to three digits)"
$LP3=F$LENGTH(P3)
$IF(LP3.GT.3) THEN GOTO YEAR_OK
$IF(LP3.EQ.2) THEN P3:= "0''P3'"
$IF(LP3.EQ.1) THEN P3:= "00''P3'"
$ND=F$INTEGER(F$EXTRACT(0,3,P3))
$IF(NY.EQ.80) .AND. (ND.LT.1.OR.ND.GT.366) .OR. -
(NY.NE.80) .AND. (ND.LT.1.OR.ND.GT.365) THEN GOTO YEAR_OK
$IF(ND.LE.MXDAY) THEN IRWRS=1
$IF(IRWRS.EQ.1) THEN GOTO OVERLAP1
$NO_OVERLAP1:
$YDDD= F$EXTRACT(0,2,P2) + F$EXTRACT(0,3,P3)
$DIR/OUTPUT=DRECTRY.TMP 'DEFAULT_DIR'*'YDDD'.DAT
$IF $SEVERITY .EQ. 1 THEN GOTO GOOD_START
$DELETE DRECTRY.TMP;*
$WRITE SYS$OUTPUT " "
$WRITE SYS$OUTPUT "No files found with date ','YDDD','!"
$INQUIRE REDO "Want to reenter dates? [Y/N]"
$IF REDO THEN GOTO NEW_YEAR
$GOTO REMOVE_TAPE
$GOOD_START:
$DELETE DRECTRY.TMP;*
$ISTART=ND
$WRITE SYS$OUTPUT " "
$WRITE SYS$OUTPUT_-
  "If it is doubtful that all days will fit on this tape,"
$WRITE SYS$OUTPUT "then try successive pairs of first and last days,"
$WRITE SYS$OUTPUT "and put remaining days on a new tape."
$WRITE SYS$OUTPUT -
  "(It is OK to copy one day at a time, that is last day = first day.)"
$YEAR_STILL_OK:
$WRITE SYS$OUTPUT " "
$INQUIRE P3 "Last DAY to be copied? (in that same segment)"
$LP3=F$LENGTH(P3)
$IF(LP3.GT.3) THEN GOTO YEAR_STILL_OK
$IF(LP3.EQ.2) THEN P3:= "0''P3'"
$IF(LP3.EQ.1) THEN P3:= "00''P3'"
$ND=F$INTEGER(F$EXTRACT(0,3,P3))
$IF(NY.EQ.80) .AND. (ND.LT.1.OR.ND.GT.366) .OR. -
(NY.NE.80) .AND. (ND.LT.1.OR.ND.GT.365) THEN GOTO YEAR_STILL_OK
$IF(ND.LT.ISTART) THEN GOTO WRONG_ORDER_DAYS
$IF(ND.GE.MNDAY) .AND. (IRWRS.EQ.1) THEN GOTO OVERLAP2
$NO_OVERLAP2:
$IRWRS=0
$IF(ND.EQ.ISTART) THEN GOTO SINGLE_DAY
$YDDD= F$EXTRACT(0,2,P2) + F$EXTRACT(0,3,P3)
$DIR/OUTPUT=DRECTRY.TMP 'DEFAULT_DIR'*'YDDD'.DAT
$IF $SEVERITY .EQ. 1 THEN GOTO GOOD_STOP
$DELETE DRECTRY.TMP;*
$WRITE SYS$OUTPUT " "
$WRITE SYS$OUTPUT "No files found with date ','YDDD','!"
$INQUIRE REDO "Want to reenter both dates? [Y/N]"
$IF REDO THEN GOTO NEW_YEAR
$INQUIRE REDO "Want to reenter last day? [Y/N]"
$IF REDO THEN GOTO YEAR_STILL_OK

```



```

$GOTO REMOVE_TAPE
$GOOD_STOP:
$DELETE DRECTRY.TMP;*
$$SINGLE_DAY:
$ISTOP=ND
$IDAY=ISTART
$SET NOON
$COPY_TO_TAPE:
$IF (IDAY.LT.MNDAY) THEN MNDAY=IDAY
$IF (IDAY.GT.MXDAY) THEN MXDAY=IDAY
$IF (IDAY.LE.9) THEN YYDDD= F$STRING(NY) + "00" + F$STRING(IDAY)
$IF (IDAY.GT.9) .AND. (IDAY.LE.99) THEN -
  YYDDD= F$STRING(NY) + "0" + F$STRING(IDAY)
$IF (IDAY.GT.99) THEN YYDDD= F$STRING(NY) + F$STRING(IDAY)
$IF (IDAY.EQ.ISTART) THEN YYDDD1=YYDDD
$COPY/LOG 'DEFAULT_DIR'*'YYDDD'.DAT TAPE
$IDAY=IDAY+1
$IF (IDAY.LE.ISTOP) THEN GOTO COPY_TO_TAPE
$NYOLD=NY
$WRITE SYS$OUTPUT " "
$IF (ISTOP.EQ.ISTART) THEN WRITE SYS$OUTPUT -
  "Last segment copied: a single day ", 'YYDDD'
$IF (ISTOP.GT.ISTART) THEN WRITE SYS$OUTPUT -
  "Last segment copied: days ", 'YYDDD1'," through ", 'YYDDD'
$WRITE SYS$OUTPUT " "
$INQUIRE MORE -
  "Are there more data files to be copied to this tape? [Y/N]"
$IF MORE THEN GOTO NEW_YEAR
$WRITE SYS$OUTPUT " "
$INQUIRE GUIDE -
  "Do you want to add the Data User's Guide at the end? [Y/N]"
$IF GUIDE THEN -
  COPY/LOG 'DEFAULT_DIR'GUIDE. TAPE
$TAPEDIR_LIS:
$WRITE SYS$OUTPUT " "
$INQUIRE LISTING "Do you want a tape directory file (TAPEDIR.LIS)? [Y/N]"
$IF .NOT. LISTING THEN GOTO REMOVE_TAPE
$DIR/SIZE/DATE/OUTPUT='DEFAULT_DIR'TAPEDIR.LIS TAPE
$SET PROT=(G:RWED,W:RWED) TAPEDIR.LIS
$GOTO REMOVE_TAPE
$WRONG_ORDER_DAYS:
$WRITE SYS$OUTPUT " "
$WRITE SYS$OUTPUT "First and last days in wrong order!"
$INQUIRE REDO "Want to reenter dates? [Y/N]"
$IF REDO THEN GOTO NEW_YEAR
$GOTO REMOVE_TAPE
$WRONG_ORDER_YEARS:
$WRITE SYS$OUTPUT " "
$WRITE SYS$OUTPUT "Going backwards in years?"
$INQUIRE SURE "Is this really the year you want? [Y/N]"
$IF SURE THEN NYOLD=0
$IF SURE THEN MNDAY=999
$IF SURE THEN MXDAY=0
$IF SURE THEN GOTO YEAR_OK
$INQUIRE REDO "Want to correct year? [Y/N]"
$IF REDO THEN GOTO NEW_YEAR
$GOTO REMOVE_TAPE

```

```

$OVERLAP1:
$WRITE SYS$OUTPUT " "
$WRITE SYS$OUTPUT "Caution:"
$IF(ND.LT.MXDAY) THEN WRITE SYS$OUTPUT -
  "First day precedes days already copied!"
$IF(ND.EQ.MXDAY) THEN WRITE SYS$OUTPUT -
  "This day has already been copied!"
$!IF(ND.EQ.MXDAY) THEN GOTO NEW_YEAR
$WRITE SYS$OUTPUT " "
$INQUIRE SURE "Are you sure there will be no duplication? [Y/N]"
$IF SURE THEN GOTO NO_OVERLAP1
$INQUIRE REDO "Want to correct dates? [Y/N]"
$IF REDO THEN GOTO NEW_YEAR
$GOTO REMOVE_TAPE
$OVERLAP2:
$WRITE SYS$OUTPUT " "
$WRITE SYS$OUTPUT "Caution:"
$IF(ND.GT.MNDAY) THEN WRITE SYS$OUTPUT -
  "Last day may be out of order!"
$IF(ND.EQ.MNDAY) THEN WRITE SYS$OUTPUT -
  "Last day has already been copied!"
$!IF(ND.EQ.MNDAY) THEN GOTO YEAR_STILL_OK
$WRITE SYS$OUTPUT " "
$INQUIRE SURE "Are you sure there will be no duplication? [Y/N]"
$IF SURE THEN GOTO NO_OVERLAP2
$INQUIRE REDO "Want to reenter both dates? [Y/N]"
$IF REDO THEN GOTO NEW_YEAR
$INQUIRE REDO "Want to reenter last day? [Y/N]"
$IF REDO THEN GOTO YEAR_STILL_OK
$REMOVE_TAPE:
$SET ON
$DISMOUNT 'DRIVE'
$DEALLOCATE 'DRIVE'
$!DELETE DRECTRY.TMP;*
$WRITE SYS$OUTPUT " "
$WRITE SYS$OUTPUT "EXIT"
$WRITE SYS$OUTPUT "That's the end of this run."
$WRITE SYS$OUTPUT -
  "Tape is dismounted and 'F$LOGICAL("TAPE")' is deallocated."
$EXIT

```

```

$!***** LOCKHEED PLASMA COMPOSITION EXPERIMENT ON ISEE-1 *****
$!          ***** DELETE_ISEEMS.COM *****
$!
$! Interactive command file for deleting ISEEMS archival files from disk
$! (can transfer the deleting to a batch job via REMOVE_ISEEMS_FILES.COM)
$!
$!          by O. W. Lennartsson
$!          Lockheed Martin Missiles & Space
$!          Advanced Technology Center
$!          Dept. H1-11, Bldg. 255
$!          3251 Hanover Street
$!          Palo Alto, CA 94304
$!
$! Telephone (650) 424-3259
$!
$! Developed under NASA Contract NAS5-33047 and NASA Grant NAGW-4496
$!
$! Operating system used: VAX/VMS version V5.5
$!
$! To execute this file, simply enter @DELETE_ISEEMS, if the file resides in the
$! same directory used for the data files, otherwise specify directory name in
$! the command: @directory_nameDELETE_ISEEMS (your default directory should be
$! the one used for data files).
$!*****
$WRITE SYS$OUTPUT " "
$DEFAULT_DIR = F$LOGICAL("SYS$DISK")+F$DIRECTORY()
$!
$!This directory may or may not be used for the command files.
$!If not, change next command line to appropriate directory:
$COMMAND_DIR = DEFAULT_DIR
$!
$WRITE SYS$OUTPUT "Your default directory is: ", 'DEFAULT_DIR'
$WRITE SYS$OUTPUT "Is this where the ISEEMS data files are?"
$WRITE SYS$OUTPUT "If not, Ctrl/Y and reset."
$WRITE SYS$OUTPUT " "
$WRITE SYS$OUTPUT "Files are deleted by date, starting with the ",-
"first day entered,"
$WRITE SYS$OUTPUT "and ending with the second day ",-
"-assuming one and the same year."
$WRITE SYS$OUTPUT " "
$WRITE SYS$OUTPUT "If files run into second year, ",-
"repeat this operation for that year's days."
$WRITE SYS$OUTPUT " "
$INQUIRE P2 "What YEAR? (two digits)"
$LENGTH_OF_YEAR:
$LP2=F$LENGTH(P2)
$IF(LP2.EQ.2) THEN GOTO CHECK_YEAR
$INQUIRE P2 "Enter two digits for the year: 77 through 82"
$GOTO LENGTH_OF_YEAR
$WRONG_YEAR:
$INQUIRE P2 "Enter either of 77, 78, 79, 80, 81, or 82"
$CHECK_YEAR:
$NY=F$INTEGER(F$EXTRACT(0,2,P2))
$IF(NY.LT.77.OR.NY.GT.82) THEN GOTO WRONG_YEAR
$YEAR_OK:
$WRITE SYS$OUTPUT " "
$INQUIRE P3 "First DAY? (one to three digits)"

```

```

$LP3=F$LENGTH(P3)
$IF(LP3.GT.3) THEN GOTO YEAR_OK
$IF(LP3.EQ.2) THEN P3:= "0''P3'"
$IF(LP3.EQ.1) THEN P3:= "00''P3'"
$ND=F$INTEGER(F$EXTRACT(0,3,P3))
$IF(NY.EQ.80) .AND. (ND.LT.1.OR.ND.GT.366) .OR. -
  (NY.NE.80) .AND. (ND.LT.1.OR.ND.GT.365) THEN GOTO YEAR_OK
$YDDD= F$EXTRACT(0,2,P2) + F$EXTRACT(0,3,P3)
$DIR/OUTPUT=DRECTRY.TMP 'DEFAULT_DIR'*'YDDD'.DAT
$IF $SEVERITY .EQ. 0 THEN GOTO NO_FILE
$DELETE DRECTRY.TMP;*
$ISTART=ND
$YEAR_STILL_OK:
$WRITE SYS$OUTPUT " "
$INQUIRE P3 "Second DAY? (last day of same year to be deleted)"
$LP3=F$LENGTH(P3)
$IF(LP3.GT.3) THEN GOTO YEAR_STILL_OK
$IF(LP3.EQ.2) THEN P3:= "0''P3'"
$IF(LP3.EQ.1) THEN P3:= "00''P3'"
$ND=F$INTEGER(F$EXTRACT(0,3,P3))
$IF(NY.EQ.80) .AND. (ND.LT.1.OR.ND.GT.366) .OR. -
  (NY.NE.80) .AND. (ND.LT.1.OR.ND.GT.365) THEN GOTO YEAR_STILL_OK
$YDDD= F$EXTRACT(0,2,P2) + F$EXTRACT(0,3,P3)
$DIR/OUTPUT=DRECTRY.TMP 'DEFAULT_DIR'*'YDDD'.DAT
$IF $SEVERITY .EQ. 0 THEN GOTO NO_FILE
$DELETE DRECTRY.TMP;*
$ISTOP=ND
$WRITE SYS$OUTPUT " "
$WRITE SYS$OUTPUT "If you are deleting a large number of files it may ",-
  "take a few minutes."
$WRITE SYS$OUTPUT "In the meantime this terminal will be tied up, ",-
  "unless you transfer this job"
$WRITE SYS$OUTPUT "to a batch queue."
$WRITE SYS$OUTPUT " "
$INQUIRE BAT "Would you rather delete in BATCH? [Y/N]"
$IF .NOT. BAT THEN GOTO NO_BAT
$INQUIRE BATQU "Enter name of batch queue"
$SUBMIT/QUEUE='BATQU'/LOG_FILE='DEFAULT_DIR'/NOPRINT-
  /PARAM=('DEFAULT_DIR','NY','ISTART','ISTOP) -
  'COMMAND_DIR'REMOVE_ISEEMS_FILES
$WRITE SYS$OUTPUT " "
$WRITE SYS$OUTPUT "This terminal is yours again"
$WRITE SYS$OUTPUT " "
$EXIT
$NO_BAT:
$WRITE SYS$OUTPUT " "
$WRITE SYS$OUTPUT "As you wish!"
$WRITE SYS$OUTPUT " "
$IDAY=ISTART
$DATA_DELETE:
$IF(IDAY.LE.9) THEN YDDD= F$STRING(NY) + "00" + F$STRING(IDAY)
$IF(IDAY.GT.9) .AND. (IDAY.LE.99) THEN -
  YDDD= F$STRING(NY) + "0" + F$STRING(IDAY)
$IF(IDAY.GT.99) THEN YDDD= F$STRING(NY) + F$STRING(IDAY)
$DELETE 'DEFAULT_DIR'*'YDDD'.DAT;*
$IDAY=IDAY+1
$IF(IDAY.GT.ISTOP) THEN GOTO FILES_LEFT

```

```
$GOTO DATA_DELETE
$FILES_LEFT:
$WRITE SYSS$OUTPUT " "
$WRITE SYSS$OUTPUT "Files left:"
$WRITE SYSS$OUTPUT " "
$DIR/SIZE=ALL/DATE/PROT ED*,EX*,MC*,MD*,MS*
$EXIT
$NO_FILE:
$WRITE SYSS$OUTPUT " "
$WRITE SYSS$OUTPUT "Files missing: No ED",'YYDDD','.DAT, etc."
$WRITE SYSS$OUTPUT "Check dates and reenter command."
$DELETE DRECTRY.TMP;*
$EXIT
```

```

$!***** LOCKHEED PLASMA COMPOSITION EXPERIMENT ON ISEE-1 *****
$!          ***** REMOVE_ISEEMS_FILES.COM *****
$!
$!      Batch command file for deleting ISEEMS archival files from disk
$!      (must be submitted from the interactive DELETE_ISEEMS.COM)
$!
$!          by O. W. Lennartsson
$!      Lockheed Martin Missiles & Space
$!      Advanced Technology Center
$!      Dept. H1-11, Bldg. 255
$!      3251 Hanover Street
$!      Palo Alto, CA 94304
$!
$! Telephone (650) 424-3259
$!
$! Developed under NASA Contract NAS5-33047 and NASA Grant NAGW-4496
$!
$! Operating system used: VAX/VMS version V5.5
$!*****
$DEFAULT_DIR=P1
$SET DEFAULT 'DEFAULT_DIR'
$NY=F$INTEGER(P2)
$ISTART=F$INTEGER(P3)
$ISTOP=F$INTEGER(P4)
$SET NOON
$SET NOVERIFY
$IDAY=ISTART
$DATA_DELETE:
$IF (IDAY.LE.9) THEN YYDDD= F$STRING(NY) + "00" + F$STRING(IDAY)
$IF (IDAY.GT.9) .AND. (IDAY.LE.99) THEN -
    YYDDD= F$STRING(NY) + "0" + F$STRING(IDAY)
$IF (IDAY.GT.99) THEN YYDDD= F$STRING(NY) + F$STRING(IDAY)
$DELETE **YYDDD'.DAT;*
$IDAY=IDAY+1
$IF (IDAY.LE.ISTOP) THEN GOTO DATA_DELETE
$SET VERIFY
$EXIT

```

Appendix 5

Sample Magnetic Tape Directory Listing
(1 page)

Listing of save set (s)

Save set: 80150.BCK
Written by: TIMLEE
UIC: [000120,000401]
Date: 27-AUG-1997 12:45:29.77
Command: BACKUP/LOG/LIST-TAPEDIR.LIS SCRATCH:[TEMPDISK.TIMLEE]*80150.DAT;1 TAPE:80150.BCK/LABEL=ISEEMS
Operating system: VAX/VMS version V5.5
BACKUP version: V5.5-2
CPU ID register: 13000202
Node name: _RDDVAX::
Written on: _\$4\$MUA9:
Block size: 8192
Group size: 10
Buffer count: 143

[TEMPDISK.TIMLEE]ED80150.DAT;1	173	19-JUN-1996	00:00
[TEMPDISK.TIMLEE]EX80150.DAT;1	7	19-JUN-1996	00:00
[TEMPDISK.TIMLEE]MC80150.DAT;1	700	19-JUN-1996	00:00
[TEMPDISK.TIMLEE]MD80150.DAT;1	106	19-JUN-1996	00:00
[TEMPDISK.TIMLEE]MS80150.DAT;1	495	19-JUN-1996	00:00

Total of 5 files, 1481 blocks
End of save set

Listing of save set (s)

Save set: 80151.BCK
Written by: TIMLEE
UIC: [000120,000401]
Date: 27-AUG-1997 12:45:35.10
Command: BACKUP/LOG/LIST-TAPEDIR.LIS SCRATCH:[TEMPDISK.TIMLEE]*80151.DAT;1 TAPE:80151.BCK/LABEL=ISEEMS
Operating system: VAX/VMS version V5.5
BACKUP version: V5.5-2
CPU ID register: 13000202
Node name: _RDDVAX::
Written on: _\$4\$MUA9:
Block size: 8192
Group size: 10
Buffer count: 143

[TEMPDISK.TIMLEE]ED80151.DAT;1	155	19-JUN-1996	00:00
[TEMPDISK.TIMLEE]EX80151.DAT;1	7	19-JUN-1996	00:00
[TEMPDISK.TIMLEE]MC80151.DAT;1	1081	19-JUN-1996	00:00
[TEMPDISK.TIMLEE]MD80151.DAT;1	164	19-JUN-1996	00:00
[TEMPDISK.TIMLEE]MS80151.DAT;1	436	19-JUN-1996	00:00

Total of 5 files, 1843 blocks
End of save set