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A SCIENCE CENTER FOR THE ADVANCED COMPOSITION EXPLORER

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ABSTRACT

The Advanced Composition Explorer (ACE) mission is supported by an ACE Science Center for the purposes of facilitating collaborative work. It is intended that coordinated use of a centralized science facility by the ACE team will ensure appropriate use of data formatting standards, thus easing access to the data; will improve communications within and to the ACE science working team; and will reduce redundant effort in data processing.

INTRODUCTION

The Advanced Composition Explorer, ACE, will perform comprehensive studies of the elemental, isotopic, and ionic charge-state composition of energetic nuclei in interplanetary space near the L1 point, ~0.01 astronomical units sunward of the earth, at energies ranging from <1 keV/nucleon (solar wind) to ~600 MeV/nucleon (cosmic radiation), including ions accelerated in the Sun, in interplanetary space, at the edges of the heliosphere, and beyond the heliosphere. Launch is planned for 21 August 1997. ACE includes six high-resolution spectrometers and three instruments for monitoring the heliospheric environment. Many of the instruments take advantage of the spacecraft's spin to scan for particle arrival direction distributions. A mission overview is given in a companion poster, (Garrard et al., '97); much longer papers on the mission and the Science Center will appear along with instrument papers and other related papers in a special issue of Space Science Reviews after launch.

DATA PROCESSING

After level zero processing, data are collected at the Science Center for a period ~one week, then undergo level one processing, in which the data are separated out by instrument and formatted (using the NCSA HDF standard) in a fashion which is both consistent with the other instruments and customized to meet the special requirements of that data set and team. The data are supplemented with ancillary data including position, attitude, and spin phase of the spacecraft; command history and comments; calibration of the spacecraft clock; and documentation of the data items. These level one data are archived at the ACE Science Center and transmitted to the National Space Science Data Center (the NSSDC) for "permanent" archiving.

The Science Center will also furnish a browse parameter file. Browse parameters are a subset of ACE measurements which serve the purpose of allowing the selection of time intervals of particular interest for more intensive study. These parameters are created with minimal computer processing and no iterative verification by scientists, so that they can be delivered to the public domain in a relatively short time (nominally less than ten days; if everything works well, in one or two days). The browse parameters are expected to be the most popular Science Center product for the larger community outside the instrument teams and early delivery is considered more important than full verification. Browse parameters are made available in three formats, HDF, CDF, and ASCII

Higher level processing, above level one and browse, will be the responsibility of the instrument teams. The ACE Science Center will attempt to facilitate these efforts, especially when high-level processing involves multiple instrument teams. After verification (~few months) these output data are copied to the ACE Science Center which will make them available to the other instrument teams, the space science community, and the NSSDC. As these data become available, dependence on the unverified browse parameter files should be lessened.

THE CONTENTS OF THE DATA

Here we present a uniform view of the "raw" instrument data so that they may be compared. This overview is primarily in terms of types of data and time resolution. The more physical aspects of the data such as charge or mass resolution, energy range, *etc.* are presented in the mission overview (Garrard et al., '97). See that paper also for decoding instrument acronyms. The magnetometer data are, of course, rather different from the data from the eight particle detecting instruments. Among the particle detectors there is a great deal of commonality in the raw data. The data are described as instances of the following data types.

Housekeeping and status data include the digitized readouts of analog parameters such as temperature, voltage, and current and the digital indicators of parameters such as command state, subsystem power on or off, *etc.* Since they describe the instrument or spacecraft rather than the physical phenomena measured by the instruments, they are generally of interest only to the instrument team.

Rates specify a count of the number of times a particular logical condition in the instrument electronics was satisfied during a particular time interval, usually the interval since that counter was last read out. The use of the word rates implies that the counter readout will eventually be normalized to the time interval. ACE rates can be subdivided into three major categories, singles, coincidence, and matrix rates, as detailed below. Some rates are sectored according to the phase of the spin of the spacecraft, *i.e.*, the pointing direction of the telescope.

Singles rates typically specify a count of particle detection events as seen in a single individual detector, as opposed to a rate of some logical coincidence of several detectors within a telescope or instrument. These rates are generally intended for monitoring the health of a detector and are frequently sub-commutated to avoid using too much telemetry. They do reflect the particle environment (when the detector is healthy) and are of some general interest.

Coincidence rates typically specify a count of particle detection events as identified by some combination of detectors and are less subject to background due to detector noise. They also generally respond to a much more well defined range of particle charges and energies. Matrix rates are counts of events identified by both a combination of detectors triggered and the signal sizes (the pulse heights) in those detectors. The use of pulse height information allows these rates to be even more specifically identified with particular particle charges and energies.

Pulse height events are telemetry items containing pulse height information describing one particular ion as observed in one or more detectors. All ACE instruments observe more ions than can be telemetered; thus there are priority systems to select the most interesting events for telemetry and it is necessary to use rate information to calculate dead time corrections to determine the flux of ions from the pulse height event data.

Other data include the MAG instrument's measurements of magnetic field and power spectra (Fourier transforms) of the magnetic field as a function of time.

Using this terminology, CRIS (SIS) has 64 (96) coincidence rates which are tied to the 64 (96) event priority buffers. The buffers are defined in terms of nuclear species or charge, range of penetration, timing hazard flag, and angle of incidence. There is no sectoring.

EPAM has sectoring information for all rates. Marix rates have eight sectors; coincidence rates may have either four or eight sectors. The coincidence rates include separate rates of ions and electrons from multiple telescopes at various energies. A very few of these rates mix both ions and electrons and require careful interpretation. The matrix rates select particular ions and energies.

SEPICA and SWICS rates include both coarse and fine mesh matrix rates. The coarse rates reflect the event priority system. The fine mesh matrix rates, as usual, furnish more detail about the ion species and energy. SWIMS telemeters only the coarse (basic) matrix rates.

SWEPAM has 16 ion rates and 7 electron rates which are singles rates. These rates are read out frequently as SWEPAM scans the voltage (which corresponds to particle energy per charge) and the azimuthal space (due to spacecraft spin). This parametric information is analyzed on the ground

Table 1: Table I: ACE Data Summary

	CRIS	EPAM	SEPICA	SIS	SWEPAM	SWICS	SWIMS	ULEIS	MAG
Matrix rates		$12s_8$				$27s_8$	$3s_8$	$64s_8$	
Coincidence rates	64	$23s_8 + 19s_4$	$6s_8$	96		2	1	$1s_8$	
Singles rates	64	$2s_4$	$3s_8 + 3$	117	23	4	6	$15s_8$	
Events	64	1	14	96	-	3	3	64	vector

The table entries for rates specify roughly the number of rates telemetered; for events, the number of kinds of events. The s_N after some rate numbers indicate that particular rate is sectored into N sectors. For example, $12s_8$ is a rate consisting of 12 individual items with 8 sectors each (a total of 96 numbers).

to yield a science result which looks like sectored matrix rates (and then analyzed further to yield a solar wind velocity *et cetera*). SWEPAM telemeters no events.

ULEIS has sectored matrix rates of ions of various species and energies. MAG has no rate equivalents. MAG measures the field six times a second; higher time resolution snapshots and Fourier transforms are measured on an irregular time basis ~once per minute.

In Table I we report numbers of rate readouts and numbers of types of events, for the various instruments.

The browse data are used to identify periods of particular interest, such as a solar energetic particle event, or a passage of an interplanetary shock. The data are not verified and their quality has been sacrificed in order to gain prompt delivery. They include count rates of ions at many different energies and electrons at a few energies. They also include solar wind speeds and temperatures and the magnetic field. Eventually they will be supplemented with event data from the particle detectors, but experience with the flight data is a pre-requisite for delivering useful products of that type.

The browse data will have time resolution ranging from 64 seconds (perhaps 16 for MAG) to one day or longer. The best time resolution is generally limited by data cycles in the instruments. SWICS, SWIMS, and SEPICA have a common 12-minute cycle, much SEPICA data is reported 12 times within that cycle, i.e., every 60 seconds. CRIS and SIS have separate 256-second cycles. EPAM and ULEIS have separate 128-second cycles. SWEPAM has a 64-second cycle and MAG data will be averaged in phase with the SWEPAM cycle. Except as noted above for SWICS *etc.* and MAG/SWEPAM none of these cycles are expected to have common time phase. These cycle/averaging times are repeated for convenience in Table II. All of the faster instruments will be averaged to the common 12-minute cycle of SWICS *etc.* as well as reported at their cycle speed. All instruments will also be averaged to one-hour and one-day cycles and these two cycles will be in time phase with UTC clock, *i.e.*, at integer hour and day values.

The ion counting rates in the browse data will include H, He, C, O, Ne-Ca, and iron-group counts. The pattern is shown in Table II. The instruments with C,O in the CNO column (SEPICA, SWICS SWIMS) report C and O separately instead of the CNO group. CRIS, SIS, and EPAM will report Ne-Ca + Fe group as a single rate. Only EPAM is sensitive to electrons and two rates will be furnished for browse. ULEIS will report a 3He rate and an O rate in addition to the rates listed in the table.

The use of data interchange standards is an important tool in making data freely available to the ACE team or to the space science community. Some standards are imposed by NASA regulations, in other cases a choice from a plethora of possible standards had to be made by the team. Different standards are optimal for different levels of processing of the data, but we have strived to compromise between using a minimal number of standards and supporting a heterogeneous community. The standard preferred by the ACE science team and most used for ACE data is HDF.

Of course, the World Wide Web is the tool of choice at this time for interfacing users to the data and the documentation. The Web site already exists and can be consulted for more details of this paper, including documentation of acronyms. At this time the url is

Table 2: Table II: Browse Time Resolution and Ion Rates

	time	H	He	CNO	Ne-Ca	Fe group
SEPICA	12 min	y	y	C,O	y	y
SWICS/SWIMS	12 min	y	y	C,O	TBD	TBD
CRIS/SIS	256 sec	y	y	y	+	+
EPAM	128 sec	y	y	y	+	+
ULEIS	128 sec	y	y	y	TBD	TBD
SWEPAM/MAG	64 sec					

A table entry of y (for yes) indicates that a rate of this ion at at least one energy will be reported in the browse data. The + sign indicates that Ne-Ca and Fe are reported as a single sum for this instrument. TBD indicates that details are yet To Be Determined.

http://www.srl.caltech.edu/ACE/ASC/ . The project home page is at http://www.gsfc.nasa.gov/ace/ace.html . Alternatively (since urls tend to have short lives), you can look for the ACE Science Center via the National Space Science Data Center or the Space Physics Data Facility. The Web site will provide documentation for the data, including calibrations, catalogs of the data files, and simple plots of browse pararmeters.

DISCUSSION

The ACE team has chosen to emphasize collaborative science and sharing of data within the team and with the larger space physics community. The browse data in particular are being made available very promptly, even at the risk of inadequate verification. Some evolution of browse parameter definitions/computation will almost certainly occur over the life of the mission as a result of user feedback and extended verification activities. In many cases, this evolution will be handled by adding new parameters; in some cases it may be necessary to identify some parameters as inadequately reflecting the desired physical phenomena and replace them with an improved version or retract them. The Science Center will make a practice of advising users to maintain close contact with instrument teams when analyzing ACE data, especially if attempting to do careful science based on browse parameters.

The Science Center has very actively coordinated with the Space Physics Data System organization and will continue to do so, either with SPDS or the potential Space Science Data System which might succeed it.

The ACE team, working through the ACE Science Center, are planning to investigate the composition of the interplanetary medium and all the various energetic particle populations penetrating the interplanetary medium in a coordinated and collaborative fashion. The team is making every effort to allow a larger community to participate in that collaboration. The tools used in that effort include data interchange standards, standard visualization tools, Web interfaces for data access, a variety of storage and/or communications media, and open channels of communication with scientists.

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REFERENCES

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