CSC/TM-81/6183

DATA PROCESSING SYSTEM GUIDE FOR THE VOYAGER-1 AND -2, AND THE ISEE-3 COSMIC RAY EXPERIMENTS

Prepared For
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
Goddard Space Flight Center
Greenbelt, Maryland

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ABSTRACT

This document provides an overview of the data processing system for the cosmic ray experiments on board Voyager-1 and -2 and ISEE-3. Procedures are described for time-series analysis, energy spectral analysis, and anisotropy studies. Geometrical factors, discriminator values, pointing vectors, and possible PHA modes are tabulated. Programs used to generate and access the data bases, and to display and plot the data are described. References are made to separate documentation for specific programs.

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Section 1

INTRODUCTION TO THE VOYAGER-1 AND -2, AND THE ISEE-3 COSMIC RAY EXPERIMENTS

The cosmic ray experiments on board the third International Sun-Earth Explorer (ISEE-3) spacecraft and the Voyager-1 and Voyager-2 spacecraft are used to study the composition and energy spectra of solar and galactic cosmic rays in the interplanetary region from about one Astronomical Unit (AU) to the outer solar system. The ability of the detectors to accurately measure the charge composition over a range in energy from 1 to 500 MeV per nucleon and for nuclear charge from 1 to 28 enables a comprehensive analysis of the properties of solar and galactic nucleosynthesis and cosmic ray acceleration mechanisms. The ISEE-3 spacecraft was launched into its orbit near one AU in August of 1978, and the Voyager-1 and Voyager-2 interplanetary craft were launched in September and August of 1977, respectively. They have all provided data on a continuing basis since launch.

The ISEE-3 spacecraft spin axis is normal to the ecliptic plane and has a spin rate of about 20 revolutions per minute (rpm). Thus, the spacecraft provides a near-Earth base for making cosmic ray measurements which can be compared with contemporary measurements from deep space probes. For more details on the scientific objective of the cosmic ray experiments on ISEE-3, see References 1 and 2. In contrast to the ISEE missions, the Voyager-1 and -2 missions allow scientists to conduct exploratory investigations of the cosmic rays out to Saturn. Included in these investigations are the behavior of cosmic rays in the interplanetary medium and studies of the trapped planetary energetic particle environment. The trajectories of the two Voyagers have been described in References 3 and 4. The launch of Voyager-1 was on September 5, 1977, 16 days after the launch of Voyager-2 which is on a lower-velocity, later arriving Jupiter trajectory. For more details on the scientific objectives of the cosmic ray experiments on Voyager-1 and 2, see Reference 5. For information concerning initial Voyager cosmic ray results, see References 4 and 12.

The data processing and analysis system developed at GSFC provides automated data reduction and archival, as well as some automated data analysis for these experiments. The system was developed using IBM assembly language and FORTRAN, and resides primarily in the Science and Applications Computer Center (SACC) IBM S/360 systems at GSFC.

This document provides an overview for programmers of the analysis and reduction methods, and of the computer software constituting this data processing system. In addition, it provides details of system level information such as experiment state definitions, external data bases, and primary system data bases. Section 2 discusses the methods of data analysis used to interpret the data; and Section 3 contains the system description. The appendices contain detailed information about the various data bases (Appendices A, B, D and E), about the experiment event logic and data structures (Appendix C), and about the special data resulting from Voyager planetary encounters (Appendix F). Programmers' Guides to specific programs are not included here, but are to be separate documents.

Section 2

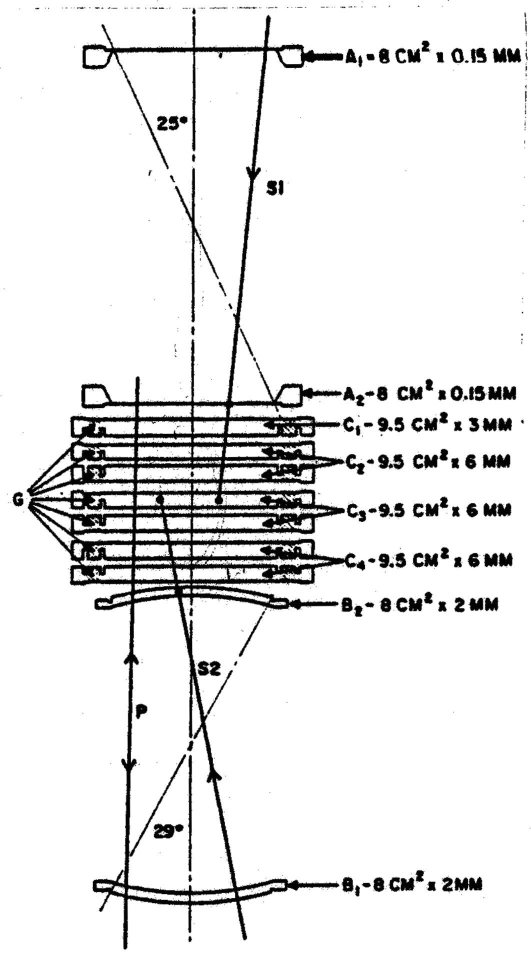
EXPERIMENTAL INSTRUMENTATION AND DATA ANALYSIS

2.1 INSTRUMENTATION

In order to obtain the objectives of the Voyager and ISEE missions, a number of detectors had to be mounted on the spacecraft with various viewing angles. The ISEE-3 cosmic ray detector systems are: the High Energy Telescopes (HETs) and the Very Low Energy Telescopes (VLETs). Each of the two HET telescopes (see Figure 1) is double ended with large acceptance angles at each end. The viewing directions of the two telescopes are nearly orthogonal. The HET system is designed to measure the energy spectra of electrons and all elements from hydrogen to iron over a broad range of energies. Individual isotopes can be resolved up through nitrogen, and individual charges are resolvable up through Z=26. An extensive description of the HETs is given in References 1, 5, and 6.

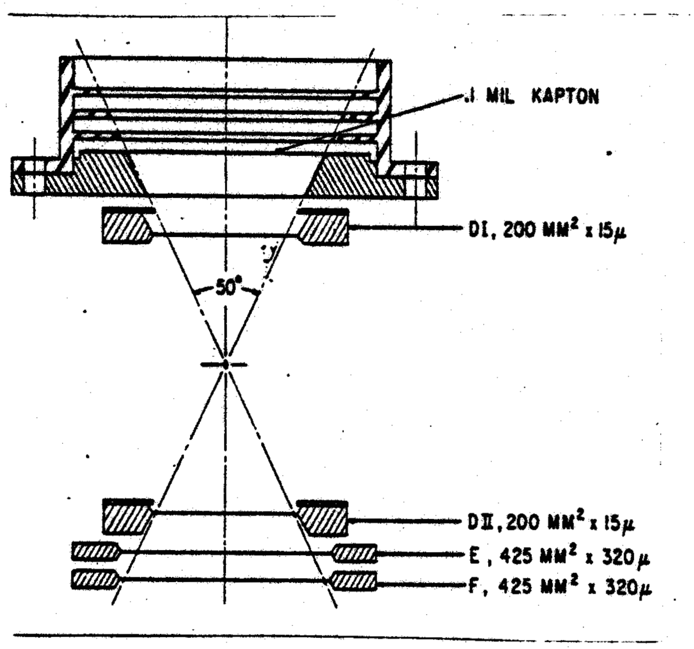
The ISEE-3 VLET system consists of two telescopes (see Figure 2) which have their symmetry axis lying in the spacecraft spin plane (nominally within ±1 degree of the ecliptic plane). They view the sun once every 3 seconds. The VLET system is designed to measure low energy nuclei from hydrogen to iron. The energy range extends from approximately 2 MeV/nucleon to energies greater than 5 MeV/nucleon. Helium-3 is resolvable from Helium-4 in the energy range from 1.3 to 7.9 MeV/ nucleon. As with the HET system, an extensive description of the VLET system is given in Reference 1.

Voyagers-1 and-2 contain HETs similar to those which are flown on ISEE-3. References 5 and 6 describe the Voyager HETs and how they are mounted on the spacecraft. In addition to the HETs, the Voyager carried two cosmic ray detector systems called the Low Energy Telescope (LET) System and the Electron Telescope (TET) (see Figure 3), which were not flown on ISEE-3. The LET consists of four telescopes which are designed and positioned to monitor three-dimensional flow patterns of interstellar and interplanetary cosmic ray fluxes. The LETs extend the high resolution elemental measurement ($1 \leq Z \leq 30$) which can be measured by the HETs down to energies as low as 1 MeV/nucleon. The addition of the single TET instrument of the Voyagers allow the monitoring of electron intensities in the energy range of approximately 5 to 110 MeV. Again, a more extensive description of the Voyager instruments is given in References 5 and 6.



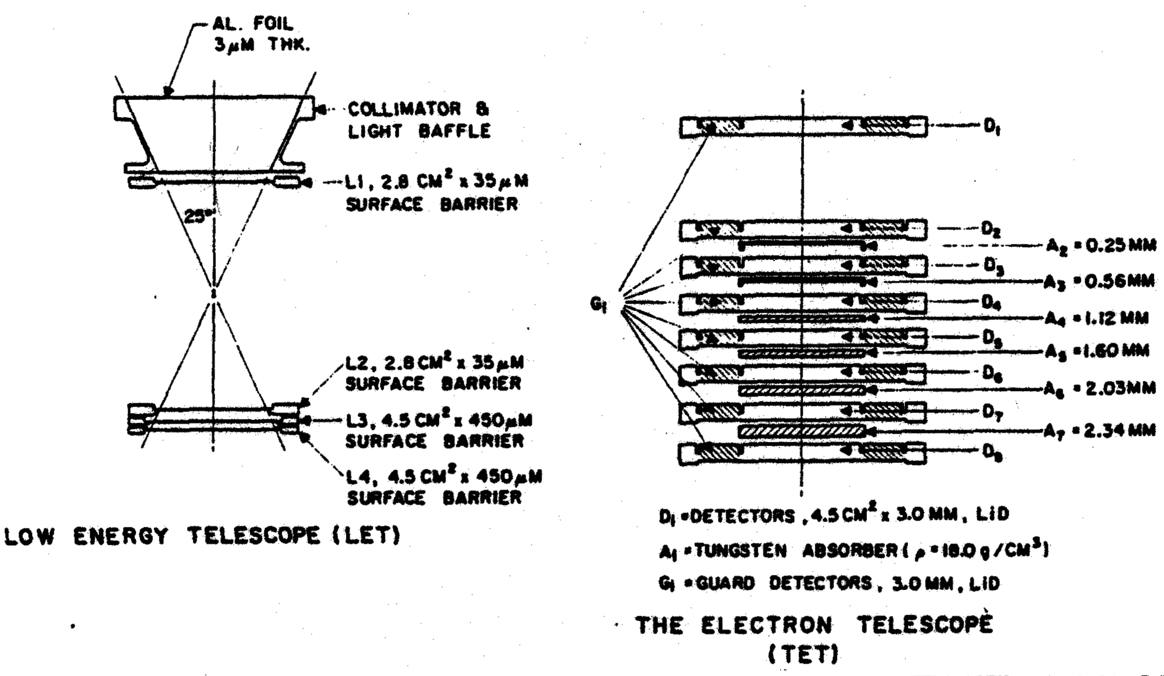
A schematic cross-sectional view of a HET telescope on ISEE-3 and Voyagers 1 and 2. Trajectories 1, 2, and 3 correspond to three different event types identified by the coincidental/anticoincidental logic.

Figure 1: High Energy Telescope (HET)



A schematic cross-sectional view of a VLET telescope on ISEE-3.

Figure 2: Very Low Energy Telescope (VLET)



Schematic Diagram of the Low Energy Telescope (LET) and The Electron Telescope (TET) systems on Voyager-1 and -2.

Figure 3: Low Energy Telescope (LET) and The Electron Telescope (TET)

2.2 EXPERIMENTAL DATA MEASUREMENTS

The data which is sent back by the Voyager-1 and -2, and the ISEE-3 cosmic ray telescopes consists of the following four generic types:

- Rates data
- Pulse Height Analysis (PHA) data
- Internal Calibration
- Engineering and Housekeeping Data

Rate data represents the total number of times per accumulation interval that coincident signals exceeding specified amplitudes from one or more detectors in each telescope occurred. These rate events are counted (accumulated) for a period of time dependent on bit rate and the mode of spacecraft operation, and are multiplexed into telemetry words using the telemetry formats described in Appendix A, B, and C. To conserve telemetry space, count in each of the 24-bit counters on the Voyager spacecraft is quasi-logarithmically compressed to a 12-bit pattern. After receipt of data on the ground, the original count is constructed from the 12-bit compressed value. The process of compression and decompression results in errors which are, in general, much smaller than the estimated statistical error. For details of the algorithm used to construct counts from the compressed value, refer to Reference 14.

Pulse Height Analyzer (PHA) data represents the digitized amplitude of each of three specified detector signals appearing in coincidence. The PHA resolves the amplitude of each pulse into one part in 1024 (10 bits). Each amplitude is transmitted in binary form as a 12-bit word. Each PHA readout is a selected coincidence event during the accumulation interval and the data represents the amplitudes of each of the three detector signals rather than the number of events per unit time. Appendices A and C describe the method used for selecting which PHA event is to be sent along with other details on how the PHA system works.

The internal calibration data, as well as the engineering and housekeeping data, are used by the spacecraft engineers for checking the operation of their instrument. This information is not used directly for the routine processing of data. Reference 11 indicates which engineering and housekeeping data are sent.

Section 3
ANALYSIS

3.1 INTRODUCTION

The previous section described from an analytical point of view the data which are input to the ISEE-3 and Voyager data processing systems. This section will describe the output from the Voyager and ISEE data processing systems which are used for analysis, and will list the crucial information which is needed to derive the appropriate output. Routine analysis of the output from the cosmic ray data processing systems will consist of either time history analysis or energy spectra analysis. Time history analysis examines the measured differential or integral intensities of different particle species over time. This analysis will often indicate time periods when the scientific data is particularly interesting and may also show evidence that the instrument is malfunctioning. Energy spectra analysis, on the other hand, is used routinely to assure proper operations of the instrument, and, on a more sporadic basis, to study data of particular interest. Examples of each type of analysis are given in the following subsections.

3.2 TIME HISTORY ANALYSIS

Often an analytical effort will begin by examining the flux of different particle species as a function of time. Here, flux is defined as number of particles/unit time/unit energy interval/detector area/solid angle. For example, Figure 4 shows proton flux data over 6-hour intervals measured by the HET and LET detectors. Normally, the data are derived from comprehensive pulse height information about individual events. However, when high particle fluxes are encountered, counting rates in various detectors and various coincidence rates are used. The data shown in Figure 4 contains proton fluxes obtained from the HET as well as a single LET detector.

To obtain the value of the flux at a particular time interval from rate data, the following information is used. The number of particles per unit time is measured by the rate counters. The unit energy intervals, which can be measured by the HET, LET, and TET detectors, are given by the threshold, channel width, and full scale readings for each detector as defined in Tables 1, 2, 3, and 4. The product of the detector area and solid angle measured by the detector is called the "geometry factor". The HET, LET, and TET geometry factors are given in Tables 5, 6, and 7. The averaging interval and the width of the energy bins are selected based on the phenomena being studied.

The experiments have been designed to provide enough rate equations so that meaningful information in most energy ranges of interest can be obtained. The ISEE-3 sectored rate data will also provide additional information on cosmic ray anisotropies. Some information about Voyager anisotropies can be obtained using the telescope pointing vectors (given in Table 8) and the attitude and orbit of the spacecraft, although this information is not as precise as the ISEE-3 sectored rate data.

As mentioned earlier, PHA data are often used for time histories except when particle fluxes are so high as to cause significant dead time corrections, anticoincidences or accidental coincidences.[1] To calculate particle fluxes from PHA data, the following equation is used:

$$\text{flux} = \frac{n * R}{T * GF * E * N}$$

n = number of events measured by the Pulse Height Analyzer in the energy range of interest

T = time elapsed

GF = Geometry Factor

E = Energy interval

R = number of events measured by the rate counters

N = Total number of events which were analyzed by the Pulse Height Analyzer

Methods for correcting for detector offsets and dead layers, as well as detector spacing and geometry factors, will be discussed in a separate document on Voyager calibration.

The example of cosmic ray data from Voyager-1 shown in Figure 4 was taken during a fairly quiet time of cosmic ray activity. Often, increased cosmic ray activity is of interest such as the Voyager data taken during September 1977 (see Figure 5) and the ISEE-3 data taken on September 24, 1978 (see Figure 6). These data could be more thoroughly analyzed by using the data products described in the following section.

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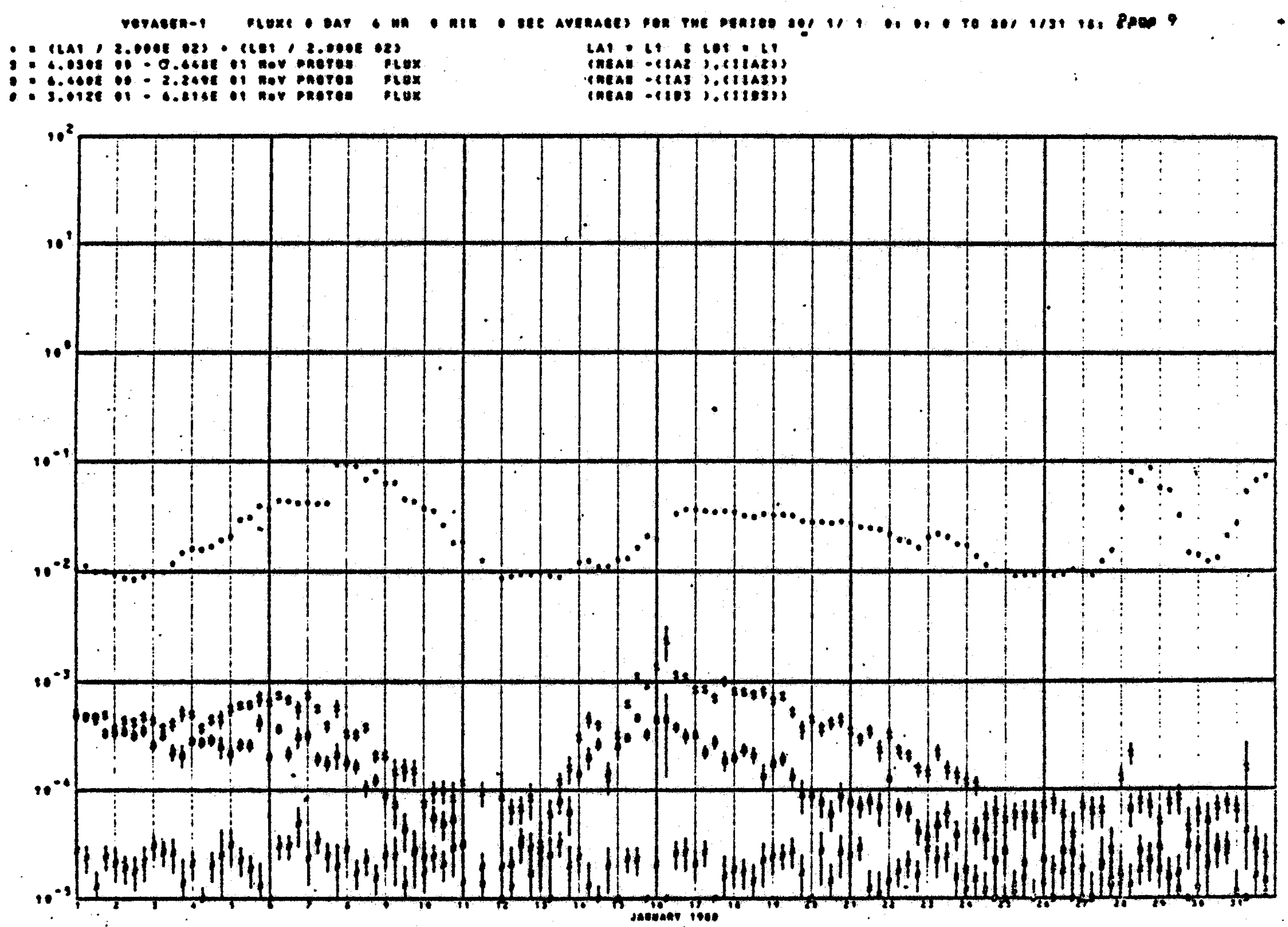
[1] An example of the use of these data for Jupiter flux measurements, which required extensive corrections for dead time, accidental coincidence, and anticoincidences, is given in appendix F.



Voyager proton flux data averaged over 6-hour intervals. The data were taken in January 1980.

Figure 4: Voyager Proton Flux Data

TABLE 1

HET PHA, Discriminator Values

design goals :

Detector	High Gain thresh (MeV)	full scale (MeV)	channel width (keV)	Low Gain thresh (MeV)	full scale (GeV)	channel width (MeV)	gain change factor
A1,A2	0.1	188	46	0.5	0.94	0.23	5.
B1	0.3	730	178	1.02	2.50	0.61	3.42
B2	0.3	730	178	2.04	5.00	1.22	6.84
C1	0.5	1024	250	2.5	5.12	1.25	5.
C2, C3, C4	0.92	XX	XX	4.6	XX	XX	5.
C1 + C2 + C3	XX	3523	860	XX	17.61	4.30	5.
C2 + C3 + C4	XX	3523	860	XX	:7.61	4.30	5.
G1	0.3	XX	XX	0.3	XX	XX	XX
G2	2.5	XX	XX	2.5	XX	XX	XX
G3	9.	XX	XX	9.	XX	XX	XX

Slants

SB : B1 + B2 + (2 + 3 + 4) = 60 (channels)
Low Gain B1 + 0.5B2 + 0.142(C2 + C3 + C4) = 36.6 (Mev)
High Gain B1 + B2 + 0.207(C2 + C3 + C4) = 10.7 (MeV)

SA : Low Gain only SA2 : A1 + 0.60A2 + 0.29(C1 + C2 + C3) = 24 (MeV)
SA1 : A1 + 0.60A2 + 0.02(C1 + C2 + C3) = 9 (MeV)
SA = SA1.SA2

Full Scale = 10V in preamp, 5v in ADC; coupling done with 2:1 transformer.
G1, G2, G3: 10V preamp output for 396 MeV, not gain switched.
C2, C3, C4: 10V preamp output for 1.86 GeV in high gain, 9.63 GeV in low gain.

TABLE 2

LET PHA, Discriminator Values

Detector	Threshold (MeV)	Full Scale (MeV)	Channel Width (keV)
L1, L2	0.2	307	75
L3	1.00	2048	500
L4	0.3	XX	XX

Slant
SL : L1 + 0.42L2 + 0.20L3 + 9.6 (MeV)

L4: 10V preamp output for 25 MeV.
2:1 transformer is on output of L4 preamp.

TABLE 3

TFT PHA, Discriminator Values

Detector	Threshold Lower (MeV)	Threshold Upper (MeV)	Full Scale (MeV)	Channel Width (keV)
D1, D2	0.5	2.5	2.5	19.4
D3 to D7	0.5	8.0	XX	XX
D8	0.2	XX	XX	XX
GA, GB	0.2	XX	XX	XX

Preamp full scale 10V = 24.70 MeV
2.47 MeV = channel 127 of ADC.

TABLE 4

CRS Detectors Used During Jupiter Encounter

Detector	Shielding	Energy Range+ (MeV)	Factor (cm^2ster)	Comments
PROTONS (LET):				
L1*	0.8 mg/cm^2 Al	0.42-12	4.5	Also, alphas above 0.32 MeV/n
L2*	8.1 mg/cm^2 Si	1.8 -13	0.43	Through L1
	>140 mg/cm^2 Al	>9	8.4	Protons through side. The intensity is comparable to those through front for E^{-2} spectrum
L1 L2 L4		1.8 - 8	0.43	ΔE - E analysis
ELECTRONS (HET):				
Range: 4-10 mm Si		2.6- 5.1	1.46	Coincidence rates with good background rejections, but accidental coincidence problems at high counting rates (for details, see Stone et al., 1977).
10-16 mm Si		5.8- 8	1.25	
16-22 mm Si		8 -12	0.96	
ELECTRONS (TET):				
D4 (3 mm Si)	~1.2 cm Si equivalent	>6	~14	Usable at higher flux than HET rates

*Single rates
+Small difference between similar detectors

TABLE 5

HET Geometry Factors

Event Type	Range	Geometry Factor (cm**2.sr)
AS	A2	1.235
AS	C3	0.851
BS	B2	1.691
BS	C2	0.960
PEN		1.650

TABLE 6

LET Geometry Factors

	L1 Active Area* (0.0037 cm)	L2 Active Area* (0.0037 cm)	L1-L2 Separation (0.005 cm)	A ** (0.0012 cm -sr)
FU-1				
LET A	2.8384	2.8259	4.076	0.4366
LET B	2.8228	2.8466	4.081	0.4364
LET C	2.8273	2.8222	4.079	0.4338
LET D	2.8112	2.8152	4.075	0.4312
FU-2				
LET A	2.8180	2.8299	4.075	0.4344
LET B	2.8064	2.8251	4.064	0.4341
LET C	2.8364	2.7900	4.084	0.4295
LET D	2.8344	2.8039	4.061	0.4357

* Area relative to the optical area of 15-158C (2.82939 cm); fourth place accuracy is only relative.

** L1xL2 required; fourth place accuracy is only relative.

TABLE 7

TET Geometry Factors

Nominal geometry factors for the various ranges are given by the formula:

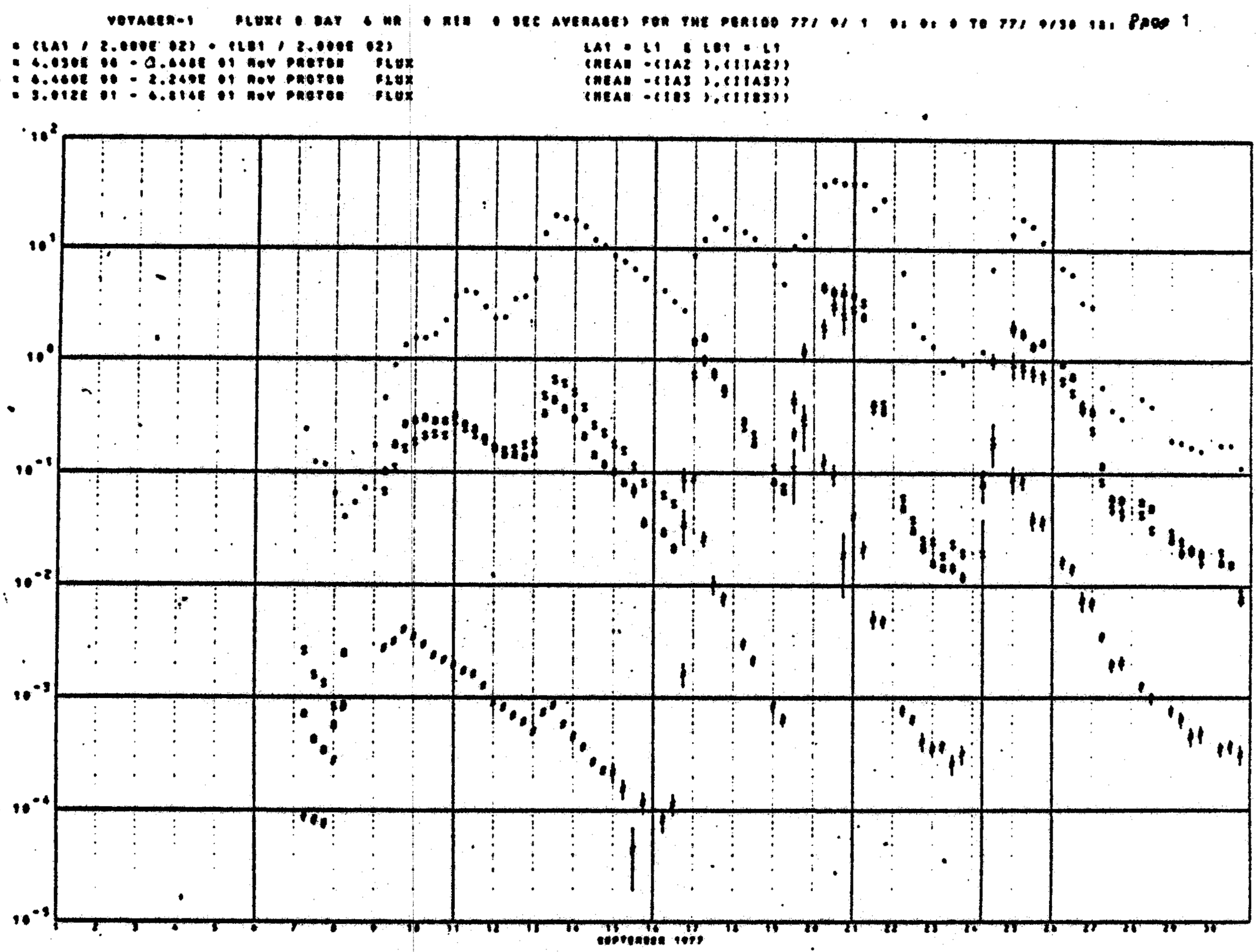
Geometry Factor = 0.5*PI**2[L**2 + 2*r**2 - L*SQRT(L**2 + 4*r**2)]
where r = 1.20 cm.

Range	L (cm)	Geometry Factor (cm**2-sr)
D12	2.00	3.12
D13	2.63	2.14
D14	3.26	1.53
D15	3.90	1.14
D16	4.58	0.86
D17	5.30	0.66

TABLE 8

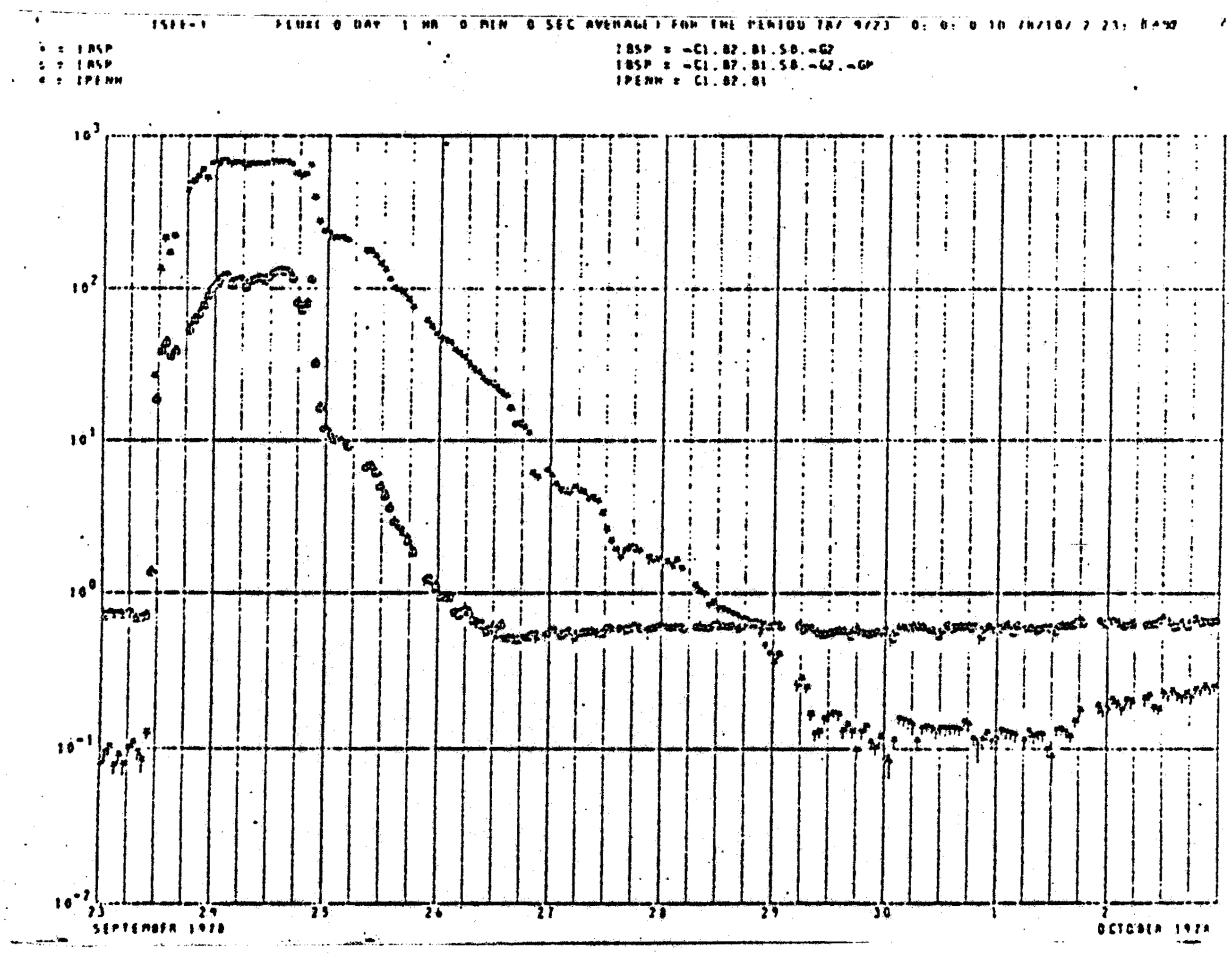
Telescope Pointing Vectors

	Cone (deg)	Clock (deg)
LETA & TET	115	305
LETC	65	125
LETB	53	236
LETD	47.49	9.69
HET1 A-end FU1&2	120	158
HET2 A-end FU1	104	78
HET2 A-end FU2	104	140



Voyager proton flux data averaged over 6-hour intervals. The data were taken in September 1977.

Figure 5: Voyager Proton Flux Data (Sept. 1977)



ISEE-3 proton flux data taken during the week of September 24, 1977.

Figure 6: ISEE-3 Proton Flux Data

3.3 ENERGY SPECTRA ANALYSIS

It is often necessary to examine the detailed energy spectra (i.e., double (or triple) dE/dx plots) for particular charged particles. The major objectives for examining these plots are to:

- Assure proper operation of the instrument
- Identify gross changes in instrument response
- Study the energy spectra of various isotopes and particles
- Identify short term variations by comparing energy spectra taken at different times
- Identify radial gradients in the cosmic ray flux by comparing ISEE-3 and Voyager spectra

To assure proper operation of the instrument, the following procedures can be used:

- Compare the actual measurements with preflight data taken at a high energy accelerator.
- Compare the actual data with a computer model of the instrument which was made using preflight data of the detector response, spacing, and curvatures; dead layer corrections; amplifier gains and thresholds, telescope geometry, etc. Sample theoretical double (or triple) dE/dx matrix plots for the Voyager, HET, LET, and TET are shown in Figures 7, 8, and 9 (Note the log scale).
- Check that the measurements made with different gain settings or with different instruments are self consistent. It is possible to obtain proton and other particle spectra in the same energy range by changing the gains of the various instruments. The resulting measurements should be self-consistent.

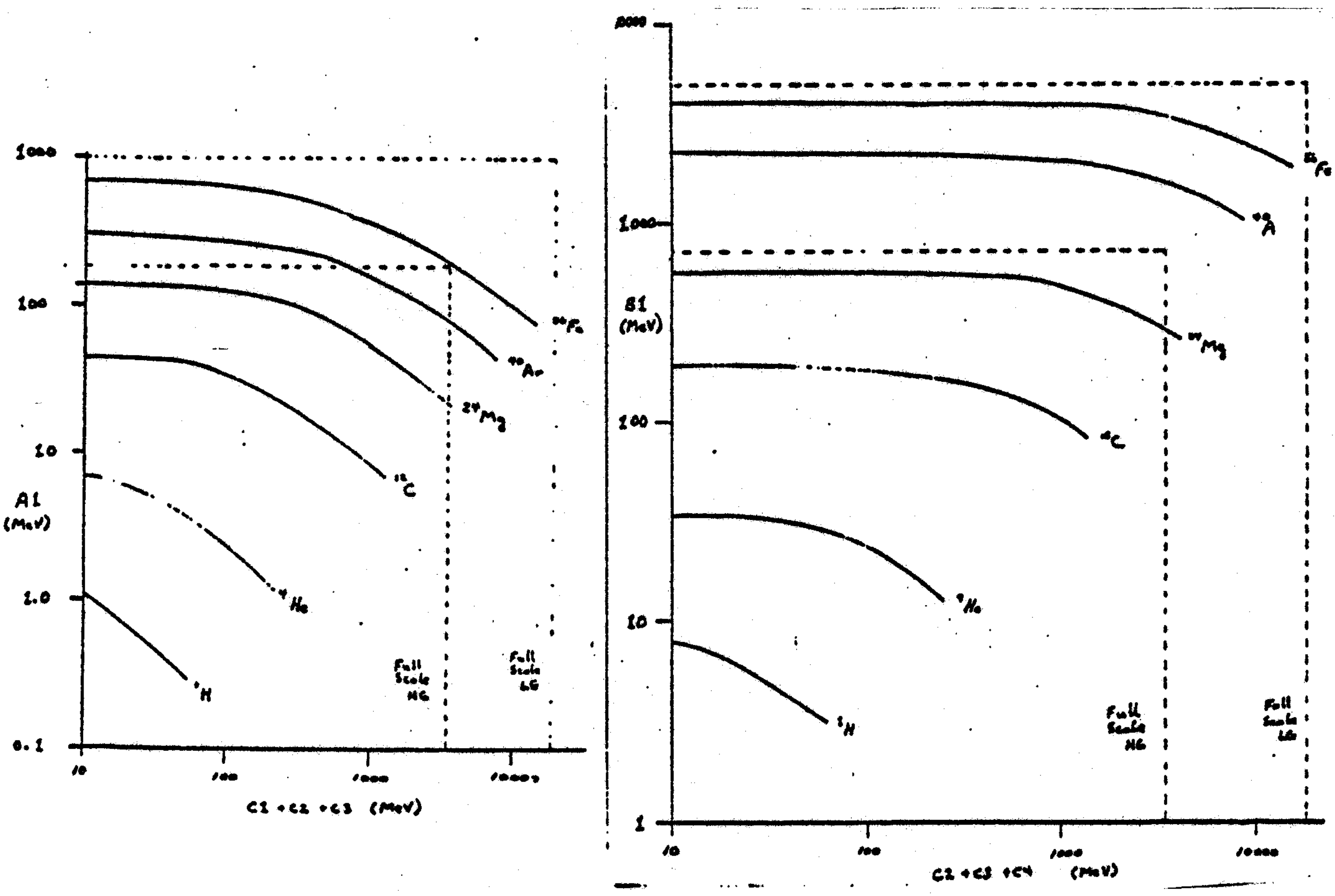


Figure 7: HET Delta E vs E' Plots

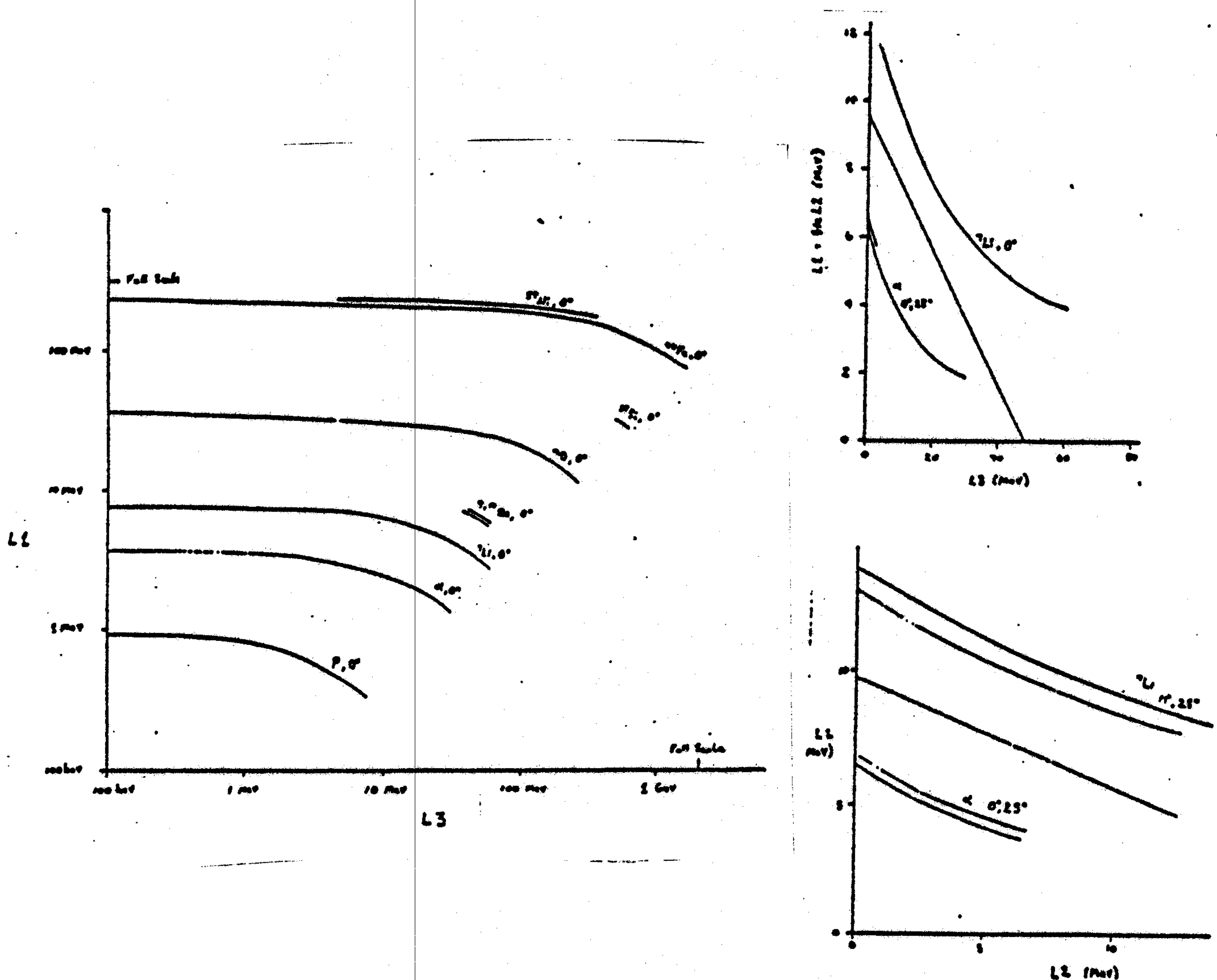


Figure 8: LET Delta E vs E' Plots

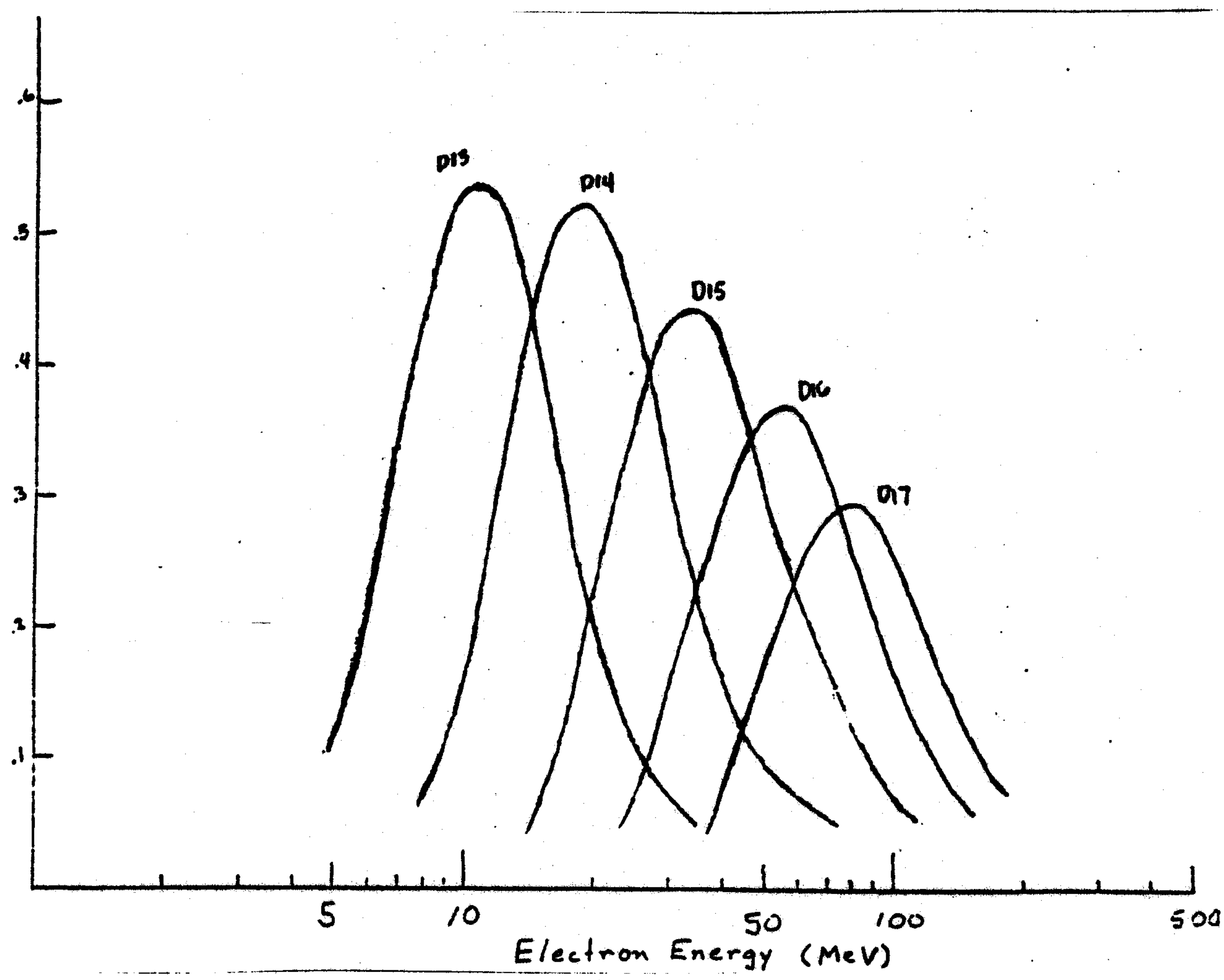
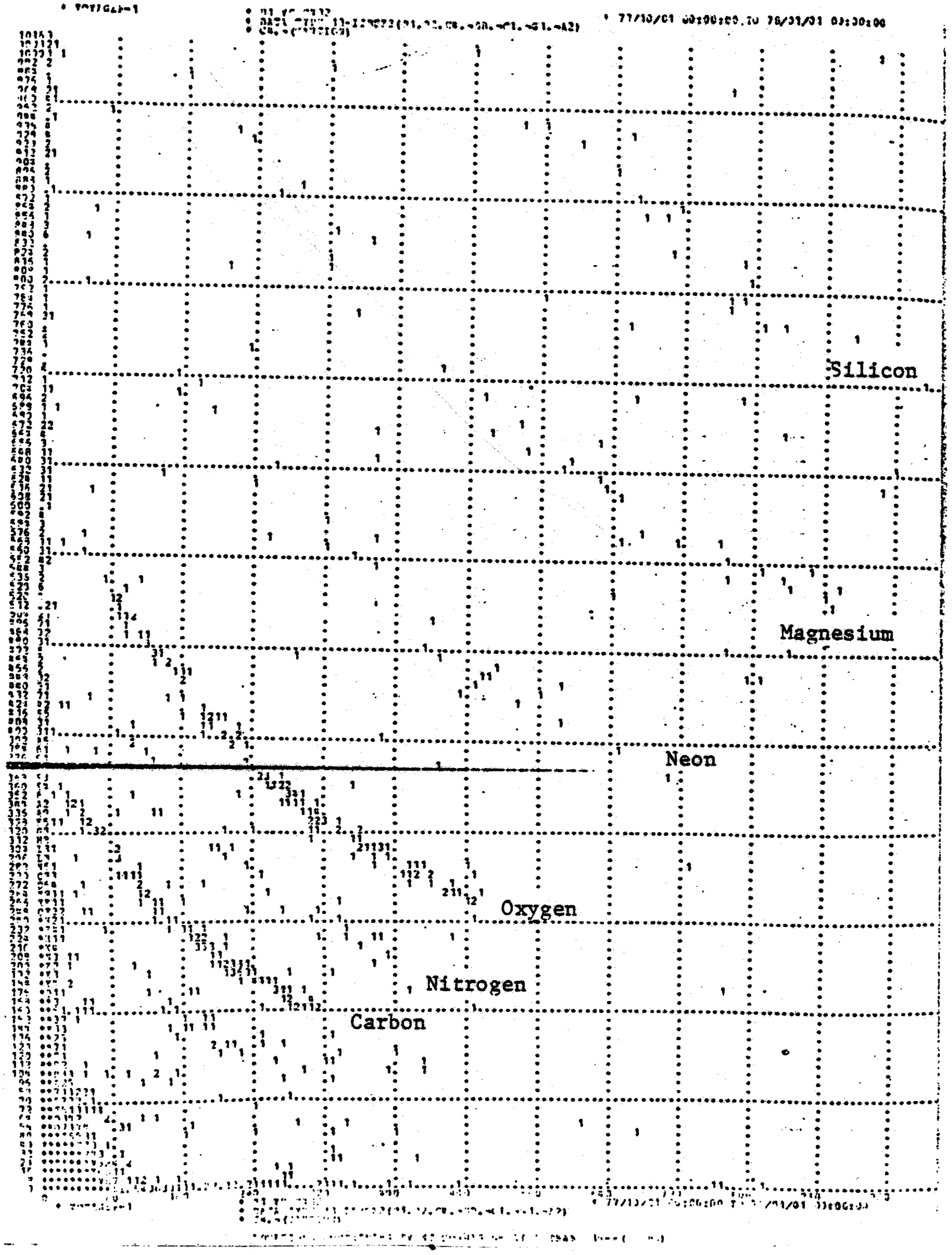


Figure 9: TET Nominal Electron Response

An example of the actual data taken by Voyager-1 is shown in Figure 10 (note the linear scale). This data can be compared with the theoretical energy matrix shown in Figure 7. (Note the log scale). Both figures show plots of the energy measured by the B1 versus C432 (i.e., C4 + C3 + C2) channels. The scale used in the horizontal and vertical axis of Figure 10 is "channel number" because the PHA electronics determines the amount of energy deposited in each layer of the detector in internal units of channel numbers. Moreover, the data was compressed 8 to 1, i.e., each row and each column represents the total events in eight consecutive PHA addresses. To convert to energy units, the data given in Tables 2, 3, and 4 should be used.

Figure 10 is used for identifying various elements and isotopes. The mass lines corresponding to carbon, nitrogen, and oxygen can be easily identified for the case shown. Mass lines for neon, magnesium, and silicon are also shown. Nevertheless, Figure 10 depicts only the bottom 1/4 of the B1 vs. C432 pulse height analyzer dynamic range. The mass lines of heavier particles are seen by using a larger compression factor while a smaller compression factor is used for lighter particles. Normally, the programs will be set to display output with a wide variety of compression factors so that all types of particles can be identified.



Energy matrix derived from Voyager B1 and C432 data.

Figure 10: Energy Matrix

Plots of energy spectra can be used for diagnosing problems with the instrument by comparing the calculated fluxes for a particular particle when the instrument is operating in different modes. For many particles and energy distributions, there are at least two instrument modes which can be used to measure the flux. The flux calculated from one mode should agree with that calculated by another one. In general, the mnemonic used to name a particular detector data taking mode will also give some information about what energy range can be measured in that mode. An example of a mnemonic for naming a particular mode is IA2, which is the HET-I, A stopping, 2-dimensional high gain matrix. A list of the possible PHA modes which can be used for measuring protons, electrons, and helium, along with other information, is given in Tables 9, 10, and 11. Basically, there are two types of modes: penetrating and stopping. They are defined as follows:

Penetrating Modes: The particle that penetrates through the C stack is called a Penetrating particle; it is called A PEN if it comes from the A end, and B PEN if it comes from the B end.

Stopping Modes: The particle as it penetrates through the detector stack may eventually stop in some layer. If the particle stops in the second layer such as A2 after penetrating through A1 then that is called a 2-dimensional mode. If it penetrates into the C stack after penetrating through A1 and A2 then it is called a 3-dimensional mode. The mnemonic IA2 would be the HET-I, A stopping (came from the A direction), 2-dimensional mode. The IA3 would be the 3-dimensional mode.

TABLE 9

ISEE PHA Modes

PROTON HAS 8 MODES
IA2 IA3 IB2 IIA2 IIA3 IIB2 IIB3

DEUTRON HAS 8 MODES
IA2 IA3 IB2 IIA2 IIA3 IIB2 IIB3

HE3 HAS 14 MODES
ID2 ID3 IID2 IID3 IA2 IA3 IB2 IB3 IIA2 IIA3 IIB2 IIB3 IL3 IIL3

HE4 HAS 16 MODES
ID2 ID3 IID2 IID3 IA2 IA3 IL2 IB2 IL3 IB3 IIA2 IIA3 IIL2 IIB2 IIL3 IIB3

LI6 HAS 3 MODES
IA2 IA3 IB3

LI7 HAS 3 MODES
IIA2 IIA3 IIB3

BE9 HAS 6 MODES
IA2 IIA2 IA3 IB3 IIA3 IIB3

B11 HAS 10 MODES
IA2 IIA2 ID2 ID3 IID2 IID3 IA3 IB3 IIA3 IIB3

C12 HAS 12 MODES
ID2 ID3 IID2 IID3 IA2 IA3 IB2 IB3 IIA2 IIA3 IIB2 IIB3

O16 HAS 12 MODES
ID2 ID3 IID2 IID3 IA2 IA3 IB2 IB3 IIA2 IIA3 IIB2 IIB3

F19 HAS 10 MODES
IA2 IIA2 ID2 ID3 IID2 IID3 IA3 IB3 IIA3 IIB3

NE20 HAS 12 MODES
ID2 ID3 IID2 IID3 IA2 IA3 IB2 IB3 IIA2 IIA3 IIB2 IIB3

NA23 HAS 10 MODES
IA2 IIA2 ID2 IID3 IID2 IID3 IA3 IB3 IIA3 IIB3

MG24 HAS 12 MODES
ID2 ID3 IID2 IID3 IA2 IA3 IB2 IB3 IIA2 IIA3 IIB2 IIB3

AL27 HAS 10 MODES
IA2 IIA2 ID2 ID3 IID2 IID3 IA3 IB3 IIA3 IIB3

SI28 HAS 12 MODES
ID2 ID3 IID2 IID3 IA2 IA3 IB2 IB3 IIA2 IIA3 IIB2 IIB3

S32 HAS 12 MODES
ID2 IA2 IA3 IB2 IB3 IIA2 IIA3 IIB2 IIB3 ID3 IID2 IID3

AR36 HAS 10 MODES
IA2 IIA2 ID2 ID3 IID2 IID3 IA3 IB3 IIA3 IIB3

TI48 HAS 10 MODES
IA2 IIA2 ID2 ID3 IID2 IID3 IA3 IB3 IIA3 IIB3

CR52 HAS 10 MODES
IA2 IIA2 ID2 ID3 IID2 IID3 IA3 IB3 IIA3 IIB3

FE56 HAS 12 MODES
ID2 ID3 IID2 IID3 IA2 IA3 IB2 IB3 IIA2 IIA3 IIB2 IIB3

NI58 HAS 10 MODES
IA2 IIA2 ID2 ID3 IID2 IID3 IA3 IB3 IIA3 IIB3

ZN64 HAS 10 MODES
IA2 IIA2 ID2 ID3 IID2 IID3 IA3 IB3 IIA3 IIB3

TABLE 10

Voyager PHA Modes

Voyager-1

PROTON HAS 19 MODES
IA2 IA3 IIA2 IIA3 IB2 IB3 IIB2 LA2 LA3 LB2 LB3 LC3 LD2 LD3 IIB3 IPZ
IPY IPH IIPH

ALPHA HAS 22 MODES
IA2 IA3 IIA2 IIA3 IB2 IB3 IIB2 IIB3 IL2 IL3 IIL2 IIL3 LA2 LA3 LB2 LB3
LC3 LD2 LD3 IPA IPB IP

ELECTRON HAS 2 MODES
IB3 IIB3

HE3 HAS 12 MODES
IA2 IA3 IB2 IB3 IL2 IL3 IIA2 IIA3 IIB2 IIB3 IIL2 IIL3

HE4 HAS 9 MODES
IIPA IIPB IIP IPZ IPY IPH IIPZ IIPY IIPH

Voyager-2

PROTON HAS 16 MODES
IA2 IA3 IIA2 IIA3 IB2 IB3 IIB2 IIB3 LA2 LA3 LB2 LB3 LC2 LC3 LD2 LD3

ALPHA HAS 20 MODES
IA2 IA3 IIA2 IIA3 IB2 IB3 IIB2 IIB3 IL2 IL3 IIL2 IIL3 LA2 LA3 LB2 LB3
LC2 LC3 LD2 LD3

ELECTRON HAS 2 MODES
IB3 IIB3

TABLE 11

Voyager-1 HET Stopping Modes for Protons and Alpha Particles

1. PROTON

	MODE	MNEMONIC	ENERGY RANGE
HET-I	2 parameter high gain AS	IA2	4.05 - 5.01
	3 parameter high gain AS	IA3	5.99 - 56.0
	2 parameter high gain BS	IB2	17.87- 26.72
	3 parameter high gain BS	IB3	26.72- 69.50
HET-II	2 parameter high gain AS	IIA2	4.05 - 6.24
	3 parameter high gain AS	IIA3	6.24 - 56.5
	2 parameter high gain BS	IIB2	17.88- 26.81
	3 parameter high gain BS	IIB3	26.81- 70.25

2. ALPHA

	MODE	MNEMONIC	ENERGY RANGE
HET-I	2 parameter high gain AS	IA2	4.01 - 5.89
	3 parameter high gain AS	IA3	6.00 - 56.8
	2 parameter high gain BS	IB2	17.88- 26.76
	3 parameter high gain BS	IB3	26.76- 69.55
	2 parameter low gain BS	IL2	17.78- 26.89
	3 parameter low gain BS	IL3	26.89- 70.00
HET-II	2 parameter high gain AS	IIA2	4.01 - 6.08
	3 parameter high gain AS	IIA3	6.08 - 56.72
	2 parameter high gain BS	IIB2	17.88- 26.78
	3 parameter high gain BS	IIB3	26.78- 69.64
	2 parameter low gain BS	IIL2	17.81- 26.87
	3 parameter LOW gain BS	IIL3	26.87- 69.86

Overlapping modes By energy region

1. Proton

4.05 - 6.01 Mev	IA2,IIA2
6.01 - 6.24 Mev	IIA2,IA3
6.24 - 17.87 Mev	IA3,IIA3
17.88- 26.72 Mev	IA3,IIA3,IB2,IIB2
26.81- 56.0 Mev	IA3,IIA3,IB3,IIB3
56.0 - 69.5 Mev	IB3,IIB3

2. Alpha

4.01 - 5.89 Mev	IA2,IIA2
6.08 - 17.81 Mev	IA3,IIA3
17.88- 26.76 Mev	IA3,IIA3,IB2,IIB2,IL2,IIL2
26.89- 56.72 Mev	IA3,IIA3,IB3,IIB3,IL3,IIL3
56.72- 69.55 Mev	IB3,IIB3,IL3,IIL3

C

Dead layer ranges

These ranges are regions of multi value and should not be split into parts when doing bin request for FLUXPLOT

Mode	Particle	Dead-Layer-Energies
IA3	PROTON	21-25 30-37 46-53
IA3	He4	21-26 31-57
IL3	He4	34-38 49-53 60-70
IB3	PROTON	34-38 48-54 60-71
IB3	He4	34-38 50-54 61-71

Voyager-2 HET Stopping Modes for Protons and Alpha Particles

1. PROTON

	MODE	MNEMONIC	ENERGY RANGE
HET-I	2 parameter high gain AS	IA2	4.05 - 6.00
	3 parameter high gain AS	IA3	6.00 - 56.5
	2 parameter high gain BS	IB2	17.86- 26.81
	3 parameter high gain BS	IB3	26.81- 70.20
HET-II	2 parameter high gain AS	IIA2	4.01 - 6.05
	3 parameter high gain AS	IIA3	6.05 - 56.0
	2 parameter high gain BS	IIB2	17.86- 26.75
	3 parameter high gain BS	IIB3	26.75- 69.57

2. ALPHA

	MODE	MNEMONIC	ENERGY RANGE
HET-I	2 parameter high gain AS	IA2	4.01 - 5.94
	3 parameter high gain AS	IA3	5.94 - 56.89
	2 parameter high gain BS	IB2	17.87- 26.78
	3 parameter high gain BS	IB3	26.78- 69.61
	2 parameter low gain BS	IL2	17.76- 26.88
	3 parameter low gain BS	IL3	26.89- 69.91
HET-II	2 parameter high gain AS	IIA2	3.98 - 6.02
	3 parameter high gain AS	IIA3	6.02 - 56.88
	2 parameter high gain BS	IIB2	17.87- 26.77
	3 parameter high gain BS	IIB3	26.77- 69.58
	2 parameter low gain BS	IIL2	17.73- 26.79
	3 parameter LOW gain BS	IIL3	26.79- 70.11

Overlapping modes By energy region

1. Proton

4.05 - 6.00 Mev	IA2,IIA2
6.05 - 17.86 Mev	IA3,IIA3
17.86- 26.75 Mev	IA3,IIA3,IB2,IIB2
26.81- 56.0 Mev	IA3,IIA3,IB3,IIB3
56.0 - 69.57 Mev	IB3,IIB3

2. Alpha

4.01 - 5.94 Mev	IA2,IIA2
6.02 - 17.73 Mev	IA3,IIA3
17.87- 26.77 Mev	IA3,IIA3,IB2,IIB2,IL2,IIL2
26.88- 56.88 Mev	IA3,IIA3,IB3,IIB3,IL3,IIL3
56.88- 69.58 Mev	IB3,IIB3,IL3,IIL3

C

Dead Layer Regions

Mode	Particle	Dead-Layer-Energies
IIA3	PROTON	20-25 30-37 46-52
IIA3	ALPHA	22-25 31-58
IIL3	ALPHA	34-39 49-54 61-70
IIB3	PROTON	34-39 48-54 60-70
IIB3	ALPHA	34-39 49-54 60-71

As an aid in analyzing the numerous data taking modes, response matrices have been generated which will determine the energy and identity of a particle whose passage through the telescope results in a measured pulse height. The expected response of each particle is generated using the preflight data on the thickness of the detector elements, telescope geometry, the threshold and gain of the amplifiers, and the range-energy relationships. These theoretical response matrices are overlayed on the actual flight data for comparison. The comparison is made from one end point of the mass line to the other end point. Here, one end point is defined by the threshold of the detector and the other end point is determined by the detector thickness and electronic conversion gain. Often, the electronics are set so that the second end point will be the particle energy needed to just penetrate two detectors without entering a third detector. See the Voyager calibration document for more information on mass line end points. To calibrate the response matrix, the amplifier gains and offsets are adjusted in a self-consistent manner until there is a good agreement between the predicted and observed tracks. Once agreement has been achieved, a box is placed over the appropriate mass line and the number of events inside that box are counted. The number of counts can be converted to flux using the formulas described above. Response matrices are necessary when a lot of data is being processed to obtain a time history of a particular particle. Response matrices are also useful in verifying that the response of the instrument has not changed over time. More information on the generation of response matrices and the calibration of the instrument will be provided in a separate document.

The analytical procedures described above have been primarily concerned with PHA data. Rate data modes also are used for analysis, especially when a large absolute cosmic ray flux is desired. (Note the rate counters have very small dead time corrections while the PHA counters can have substantial dead times). The rate mode IDs for ISEE and Voyager are given in Table 12.

TABLE 12

Rate Mode IDs

Rate Mode ID for ISEE

HET I:
IAS,IBSP,IBSE,IPENH,IPGH,IBS4P,IBS4E,IBS3P,IBS3E,IBS2P,IBS2E,
IASZ3,IBSZ2,IPENL,IPGL,IBS4Z2,IBS4,IBS3Z2,IBS3,IBS2Z2,IBS2
HET II:
IIAS, ETC.,,
HET I SECTORED HIGH GAIN:
IAS(1),IAS(2),IAS(3),IAS(4),IAS(5),IAS(6),IAS(7),IAS(8),IAS(9),IBSP(1),,
IBS4P(1),,IBSE(1),,
HET I SECTORED LOW GAIN:
IASZ3(1),,IBSZ2(1),,
HET II SECTORED:
IIAS(1),,ETC.,,
VLET I:
ILZ2,ILZ12,ILZ3,ILZ2E1,ILZ2E2,IL
VLET II:
IILZ2,,ETC.,,
VLET I SECTORED:
ILZ2(1),,ILZ2(9),,II(1),,
VLET II SECTORED:
IILZ2(1),,ETC.,
SINGLE RATES HET I HIGH GAIN:
IA1H,IA2H,IC1H,IC2H,IC3H,IC4H,IB2H,IB1H,ISA1H,ISA2H,ISBH,IG1H
SINGLE RATES HET I LOW GAIN:
IA1L,IA2L,,ETC.
SINGLE HET II RATES:
IIA1H,IIA2H,,ETC.,
SINGLE VLET RATES:
ILDI,ILDII,ILE,ILP,IILDI,IILDII,IILI,IILP

Rate Mode ID for Voyager

HET I
IAS,IASZ3,IBSE,IBSP,IBSZ2,IPENH,IPENL,IPGH,IPGL,IBS4E,IBS4P,IBS4,
IBS4Z2,IBS2E,IBS2P,IBS2,IBS2Z2
HET II
IIAS,,ETC.
LET
LA,LAZ3,LB,LBZ3,LC,LCZ3,LD,LDZ3
MISC
TAN,TLO,THI,IG1
HET I SINGLES HIGH GAIN
IA1H,IA2H,IC1H,IC2H,IB1H,ISBH,IC3H,IC4H,IB2H
HET 1 SINGLES LOW GAIN
IA1L,ETC
HET 2 SINGLES HIGH AND LOW GAIN
IIA1H,ETC.
LET SINGLES AND MISC
LA1,LA2,LA3,LA4,SL,SLB,LATRP,LBTRP,LB1,LB2,LB3,LB4,LC1,LC2,LC3,LC4,
SLC,SLD,LCTRP,LDTRP,LD1,LD2,LD3,LD4,L6L,GA+GB,D5H,D7L,D5L,D8L,D1H,
D4H,D2L,D3L,D1L,D3H,D2H,D4L

3.4 ANISOTROPY ANALYSIS

The HET and VLET particle detectors on ISEE-3 rotate perpendicularly to the spacecraft spin axis. This allows the incoming particle rate data to be divided into eight sectors. The individual sector count rates can be collectively fit to a curve which will determine the amplitude and phase of any cosmic ray anisotropy. The analytical expressions used for the geometric corrections and error analysis of the cosmic ray data are given in Reference 7. These formulas also take into account the finite detector geometries, the variable interplanetary magnetic field and the background count rate of the particle detectors. A description of the programs which make these geometric corrections is given in Reference 8. Unlike ISEE-3, the Voyager spacecraft does not spin. The various telescopes are oriented in such a manner that a meaningful measurement of cosmic ray anisotropies can be made.

Section 4

THE SOFTWARE SYSTEM

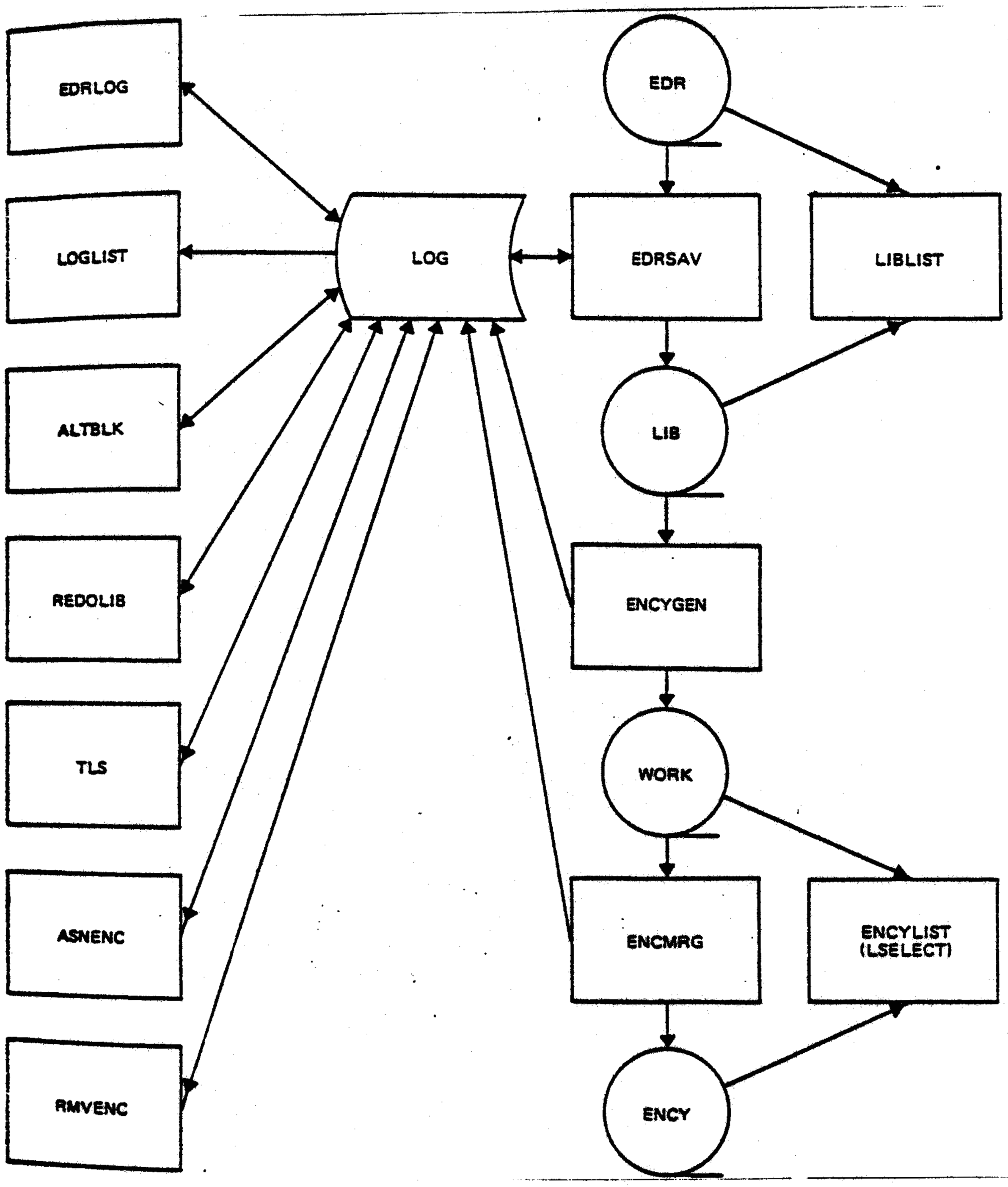
4.1 SOFTWARE SYSTEM OVERVIEW

The Voyager and ISEE multi-program data processing systems consist of modules to establish data bases for more convenient and efficient access as well as for data analysis. The systems are designed to be off-line "Production" data analysis systems capable of processing large quantities of data. However, the systems will provide "quicklook" data listings when fast processing of the data is needed. The general data processing flow through the Voyager and ISEE data reduction systems is similar in many respects, because of the similarity of the various cosmic ray detectors and spacecraft data collection systems. The individual programs are different, however, to account for the peculiarities of the individual cosmic ray detectors, data collection systems, telemetry formats, and spacecraft orbits.

The data reduction for ISEE and Voyager is accomplished in two stages. First, an "encyclopedia data base" is created containing the data used by the various cosmic ray scientific investigators. The programs used for generating these data bases are described in Subsection 3.2. Next, a series of data analysis programs are run which access the encyclopedia data base and generate plots as well as computer listings which are necessary for analyzing the data. These data analysis programs are described in Section 3.3. All the programs which are described are run on the IBM S/360-75 and S/360-91 computers at NASA/GSFC.

4.2 ENCYCLOPEDIA GENERATION

The data from each of the ISEE-3 detectors is collected on data tapes called Experimental Data Records (EDRs). Each EDR contains 1 week of data. To facilitate the data processing, the information on the EDR is compressed onto a file of a LIB tape using the program EDRSAV. A LIB tape has one file for each EDR and may contain up to seven files. The telemetry information contained on the ISEE-3 LIB and EDR tapes is given in Reference 9. In order to further facilitate the retrieval of data for the experimenters, the data from the LIB tapes is saved on a history data base called the encyclopedia. The Encyclopedia contains volumes of data in 15-minute time intervals in time sequential order. Volume 1 starts on January 1, 1977, and each succeeding volume starts an integral 15-minute boundary (i.e., 15 minutes after the hour, 30 minutes after the hour, 45 minutes after the hour, and on the next hour). An intermediate tape called the WORK tape must be created before the final encyclopedia is created. Figure 11 shows the data flow from the EDR until the final encyclopedia (ENCY) tape is created. The functions of the programs listed in Figure 11 are given in Table 13 along with the location of the computer source programmer user's guide and method of execution. Most user's guides are found in SEICC.USERGIDE.TEXT. Most CLISTs are found in SEICC.LIB.CLIST while most of the Job Control Language (JCL) is found in SEICC.LIB.CNTL. The computer sources generally contain both a prologue and a look-at-me data set to identify the purpose of each routine. References 9 and 10 contain more information on the data processing steps and utility programs that are needed to create the final encyclopedia tape data product.



The EDR, LIB, WORK, and ENCY tape formats, the LOG sequential data set, and the programs EDRLOG, LOGLIST, ALTBLK, REDOLIB, TLS, ASCNENC, RMVENC, EDRSAV, ENCYGEN, ENCMRG, LIBLIST, and ENCYLIST are described in References 6 and 7.

Figure 11: Data Flow for ISEE-3 Encyclopedia Generation

TABLE 13

ISEE-3 Encyclopedia Generation Programs

EDRLOG

- Purpose: enter EDR name into log:
- Documentation: usergide,prologues,lookatme:
- Source: SEICC.EDRLOG.SOURCE:
- Execution: SEICC.LIB.CLIST(EDRLOG):

LOGLIST

- Purpose: Generate formatted listing of ISEE log:
- Documentation: prologues,usergide,lookatme:
- Source: SEICC.LOGLIST.SOURCE:
- Execution: SEICC.LIB.CLIST(LOGLIST): Background execution from SEICC.LIB.CNTL(LISTALL)

ALTBLK

- Purpose: ALTBLK is used to alter a byte within the ISEE log.
- Documentation: The source has prologues within it and the CLIST quizzes the user as it runs.
- Source: SEICC.ALTBIK.SOURCE:
- Execution: The routine is normally run in foreground from SEICC.LIB.CLIST(ALTBLK)

REDOLIB

- Purpose: reset log to process a library tape through ENCYGEN:
- Documentation: userqide,prologue,lookatme:
- Source: 'SEICC.REDCLIB.SOURCE':
- Execution: SEICC.LIB.CIIST(REDOLIB):

TLS

- Purpose: Remove and add EDR and WORK tapes:
- Documentation: userqide,prologues,lookatme:
- Source: SEICC.TLS.SOURCE:
- Execution: SEICC.LIB.CIIST(TLS):

ASNENC

- Purpose: Assign new encyclopedia tapes to the log
- Documentation: The user quide is in the source and in SEICC.USERGIDE.TEXT. Each routine has prologues and there is a lookatme in the source to describe each routine. In addition, the routines ask the user questions as they run.
- Source: SEICC.ASNENC.SOURCE:
- Execution: Normally from foreground using SEICC.LIB.CLIST(ASNENC)

RMVENC

- Purpose: remove an encyclopedia tape from the log:
- Documentation: prologues,usergide,lookatme:
- Source: SEICC.RMVENC.SOURCE:
- Execution: SEICC.LIB.CLIST(RMVENC):

EDRSAVE

- Purpose: copy EDR onto library tape:
- Documentation: usergide,prologues,lookatme:
- Source: SEICC.EDRSAVE.SOURCE:
- Execution: SEICC.LIB.CNTL(EDRSAVE):

LIBLIST

- Purpose: Generate formatted listing of the library tapes:
- Documentation: usergide,lookatme,prologues:
- Source: SEICC.LIBLIST.SOURCE:
- Execution: SEICC.LIB.CNTL(LIBLST):

ENCGEN

- Purpose: process library onto fluxplot summary tape:
- Documentation: usergide,prologues,lookatme: CSC/TM-80/6208 "ISEE-3 Data Reduction Programmer's Guide"
- Source: SEICC.ENCGEN.ASM and SEICC.ENCGEN2.ASM:
- Execution: SEICC.LIB.CNTL(RUNENCY):

ENCMRG

- Purpose: Combine summary tapes onto time-ordered tape:
- Documentation: usergide,prologues,lookatme:
- Source: SEICC.ENCMRG.SOURCE:
- Execution: SEICC.LIB.CNTL(QENCMRG):

ENCYLIST

- Purpose: formatted listing of summary (encyclopedia) tapes:
- Documentation: prologues,usergide,lookatme:
- Source: SEICC.ENCYLIST.SOURCE:
- Execution: SEICC.LIB.CNTL(LSELECT):

The encyclopedia generation programs for ISEE-3, briefly described above and in more detail in References 9 and 10, have extracted the ISEE-3 cosmic ray raw experimental data, packed it, monitored its quality, summarized[2] it and put it in a format which is easily accessible by analysis programs. Similar programs were written at an earlier time for Voyagers 1 and 2. A brief description of the subroutines used to create the Voyager-1 and -2 encyclopedias can be found in Reference 9 along with a description of the differences between the ISEE and Voyager encyclopedia generation routines. The data flow for the Voyager encyclopedia generation is given in Figure 12. By comparing Figures 4 and 5, it can be seen that Voyager and ISEE use the following programs with the same name and purpose:

- EDRLOG
- LOGLIST
- ALTBLK
- REDOLIB
- ASNENC
- RMVENC
- EDRSAV
- ENCYGEN
- ENCMRG
- SELECTE (a modification of LSELECT to supply information to California Institute of Technology)

The location of the source and method of execution for the Voyager version of these programs is given in Table 14 (Note a reference to the USERGIDE refers to the SELCC.USERGIDE.TEXT data set.)

---

[2] Summarizing the data means in this case eliminating the binary zeros in the telemetry stream which are imbedded where there is no data taken during an instrument measurement period. One could recreate an EDR tape from an ENCY tape by including these binary zeros.

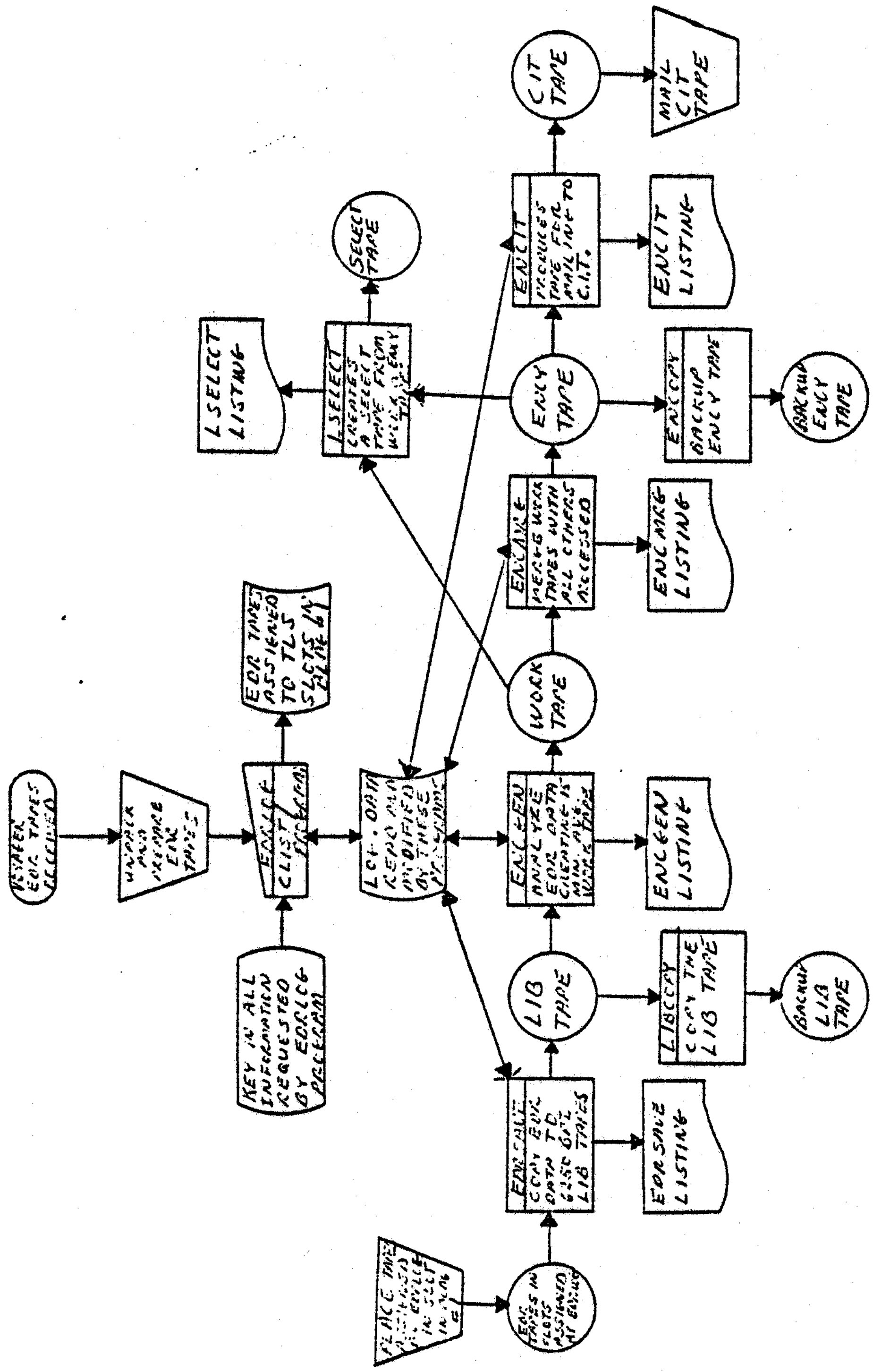


Figure 12: Data Flow for Voyager Encyclopedia Generation

TABLE 14

Voyager Encyclopedia Generation Programs with the Same Name as ISEE-3 Encyclopedia Programs

EDRLOG

- Purpose: enter EDR name into log:
- Documentation: Reference 14 and the ISEE usergide,prologues, lookatme:
- Source: SBMJS.EDRLOG.SOURCE:
- Execution: SBMJS.LIB.CLIST(EDRLOG):

LOGLIST

- Purpose: Generate formatted listing of Voyager log:
- Documentation: Reference 14 and the ISEE prologues,usergide, lookatme:
- Source: SBMJS.LOGLIST.SOURCE:
- Execution: SBMJS.LIB.CLIST.(LOGLIST): Background execution from SBMJS.LIB.CNTL(LOG)

ALTBLK

- Purpose: ALTBLK is used to alter a byte within the Voyager log.
- Documentation: See Reference 14. The source has prologues within it and the CLIST quizzes the user as it runs.
- Source: SBMJS.ALTBLK.SOURCE:
- Execution: The routine is normally run in foreground from SBMJS.LIB.CLIST(ALTBLK)

REDOLIB

- Purpose: reset log to process a library tape through encygen:
- Documentation: Reference 14 and the ISEE usergide, prologue, lookatme:
- Source: SEMJS.REDOIIB.SOURCE:
- Execution: SBMJS.LIB.CLIST(REDOLIB):

ASNENC

- Purpose: Assign new encyclopedia tapes to the log
- Documentation: See Reference 14. The user guide is in the source and in SEICC.USERGIDE.TEXT. Each routine has prologues and there is a lookatme in the source to describe each routine. In addition the routines ask the user questions as they run.
- Source: SEMJS.ASNENC.SOURCE:
- Execution: Normally from foreground using SBMJS.LIB.CLIST(ASNENC)

RMVENC

- Purpose: remove an encyclopedia tape from the log:
- Documentation: See Reference 14 and the ISEE prologues, usergide, lookatme:
- Source: SBMJS.RMVENC.SOURCE:
- Execution: SBMJS.LIB.CLIST(RMVENC):

EDRSAV

* Purpose: copy edr onto library tapes:
* Documentation: See Reference 14 and the ISEE userqide,prologues, lookatme:
* Source: SBMJS.EDRSAVE.SOURCE:
* Execution: SBMJS.LIB.CNTL(EDRSAVE):

ENCGEN

* Purpose: Process library onto fluxplot summary tape:
* Documentation: Reference 14 and the ISEE userqide,proloques, lookatme: See Reference 9
* Source: SBMJS.ENCGEN.SOURCE:
* Execution: SBMJS.LIB.CNTL(ENCGEN):

ENCMRG

* Purpose: Combine summary tapes onto time-ordered tape:
* Documentation: Reference 14 and the ISEE userqide,proloques, lookatme:
* Source: SBMJS.ENCMRG.SOURCE:
* Execution: SBMJS.LIB.CNTL(ENCMRG):

SELECTE

- Purpose: Tapes for California Institute of Technology (CIT):
- Documentation: Reference 14 and the ISEE prologues,userqide, lockatme:
- Source: SBMJS.LSELECT.SOURCE:
- Execution: SBMJS.LIB.CNTL(SELECTE):

An examination of Figures 11 and 12 will also show that the following programs are unique to Voyager encyclopedia generation.

- RMVEDR
- RMVWRK
- ASSIGN
- RMVCIT
- ENCOPY
- TOEBCD
- ENCWLT
- ENCIT
- EDRLIST

The location of the source, purpose, location of documentation, and method of execution for these programs are given in Table 15.

A description of the Voyager spacecraft telemetry format and EDR which are input to the encyclopedia generation programs can be found in Appendix B and C, and in Reference 11. The format of the output of the encyclopedia generation routines, i.e., the Voyager encyclopedia tape, is given in Appendix D of this document. Volume 1 of the Voyager-1 encyclopedia tape begins on January 1, 1977, as does Volume 1 of the Voyager-2 tapes. During encounters, an EDR tape will contain 12 hours of data; on the other hand, during the cruise portion of the mission, a Voyager encyclopedia tape will contain 1 to 5 days of data.

TABLE 15

Encyclopedia Generation Programs which are unique to Voyager

RMVEDR

- Purpose: Removes EDR tapes marked for removal one at a time from the Voyager log and Tape Library System
- Documentation: See Reference 14
- Source: SBMJS.RMVEDR.SOURCE
- Execution: SBMJS.LIB.CLIST(RMVEDR)

RMVWRK

- Purpose: Removes work tapes from tape library system
- Documentation: See Reference 14
- Source: SBMJS.RMVWRK.SOURCE
- Execution: SBMJS.LIB.CLIST(RMVWRK)

ASSIGN

- Purpose: Assigns a tape library slot to a volume of data in the encyclopedia
- Documentation: See Reference 14
- Source: SBMJS.ASSIGN.SOURCE
- Execution: SBMJS.LIB.CLIST(ASSIGN)

RMVCIT

- Purpose: Removes CII tapes within a user given range from the log and tape library system
- Documentation: See Reference 14
- Source: SBMJS.RMVCIT.SOURCE
- Execution: SBMJS.LIB.CLIST(RMCVIT)

ENCOPY

- Purpose: Executes the S/360-91 PATRICK routine for copying tapes
- Documentation: See SACC User Guide, PATRICK program
- Source: Available from SACC Program Assistance Center
- Execution: SBMJS.LIB.CNTL(ENCOPY)

TOEBCD

- Purpose: Converts a JPL light time correction tape from 1108 FIELD data format to EBCDIC format
- Documentation: Comments in Source
- Source: SBMJS.LIB.CNTL(TOEBCD)
- Execution: SBMJS.LIB.CNTL(OWLT2) or SBMJS.LIB.CNTL(CWLT)

ENOWLT

* Purpose: Creates a light time correction file for use by the encyclopedia generator program using the output from the TOEBCD program
* Documentation: Comments in Source
* Source: SBMJS.LIB.CNLT(ENOWLT)
* Execution: SBMJS.LIB.CNTL(CWLT2) or SBMJS.LIB.CNTL(OWLT)

ENCIT

* Purpose: Copies next 1000 volumes of data from the Encyclopedia to a CIT tape. The program recognizes what the last volume read had been by a word in the CIT control block
* Documentation: This is a modified version of the LSELECT program
* Source: SBMJS.ENCIT.SOURCE
* Execution: SBMJS.LIB.CLIST(ENCIT)

EDRLIST

* Purpose: Lists raw data from EDR tapes or library tapes
* Documentation: See Comments in JCL
* Source: SBMJS.EDRLIST.SOURCE
* Execution: SBMJS.LIB.CNTL(EDRLST)

4.3 DATA ANALYSIS PROGRAMS

The two major programs which are used for the analysis of Voyager and ISEE-3 data are called MATRIX and FLUXPLOT. The MATRIX program provides two-dimensional dE/dx displays showing the frequency of occurrence of cosmic ray events which have been measured by the pulse height analyzer. Section 2 discusses the use of these plots and presents sample output. Card input to the MATRIX program consists of a satellite descriptor card, followed by at least one plot-period group card and at least one plot-descriptor card. These cards must be carefully prepared because of the wide variety of output which can be generated by the program. Specifications for these input cards along with sample input are given in the data set SEICC.USERGIDE.TEXT. The data for the MATRIX program is stored on the encyclopedia data base described in Section 3.2.

The second major program used for analysis of Voyager and ISEE-3 data is FLUXPLOT. This program generates time-history plots of cosmic ray intensities according to user specified ordinate and abscissa scaling. The data can be displayed in any of the following six ways:

i) rate (counts per second) associated with a counter, either in its nominal coincidence condition state, or a specified coincidence condition state.

ii) rate, as defined above, divided by a specified number

iii) sum of two entities of type (i), or of type (ii), or a sum of an entity of type (i) and one of type (ii)

iv) difference between two entities of type (i), or of type (ii), or a difference between an entity of type (i) and one of type (ii).

v) ratio between two entities of type (i).

vi) intensity of particles of a certain species in a given energy range. The intensity may have been derived from a specified MODE, or from a subset of all modes applicable to the particle species in the specified energy range.

Card input to the program consists of a satellite descriptor card followed by at least one plot-period group card, at least one particle identifier card, at least one particle mode identifier card, and at least one particle bin (either flux or rate) card. Specifications for these cards along with sample input are given in the data set SEICC.USERGIDE.TEXT. Data for the FLUXPLOT program is stored on the encyclopedia data base described in subsection 3.2.

Other routines which are needed for the analysis of Voyager and ISEE-3 data are listed below.

- RESPONSE
- Accelerator routines
- Data pool routines

The purpose of these routines, location of the source, location of the documentation, and method of execution, are presented in Table 16.

TABLE 16

Analysis Programs

MATRIX

- Purpose: formatted plot of encyclopedia tapes:
- Documentation: userqide:
- Source: SBMJS.MATRIX.SOURCE
- Execution: SEICC.LIB.CNTL(MATRIX) or SBMJS.LIB.CNTL(MATRIX)

FLUXPLOT

- Purpose: analyze summary tapes and create plots:
- Documentation: userqide:
- Execution: SBMJS.LIB.CNTL(FLUXPLOT) or SEICC.LIB.CNTL(FLUXPLOT)
- Source: SBMJS.NEWFLUX.ASM: and ZB2NL.VOYSEE.FLUX.SOURCE

RESPONSE

- Purpose: This data set contains routines to list the lookup tables in the fluxplot catalogs and to install new tables or modify old tables.
- Source: SEICC.LISTES2.SOURCE:
- Documentation: userqide,prologues,lookatme:
- Execution: There are several execution routines for each function. The catalog listing is in foreground in SEICC.LIB.CLIST(RESPONSE) and in background as SEICC.LISTHS2.SOURCE(RUNID2). The install and overlay routines are documented in SEICC.USERGIDE.TEXT(RESPONSE)

ACCELERATOR ROUTINES (ISEE-3 ONLY)

- Source: SEICC.ACCEL.SOURCE:
- Additional Source: SEICC.ACLOGBCK.DATA,SEICC.ACSPNIST.FORT,SEICC.ACEDRLST.LOAD, SEICC.ACINTLOG.LOAD,SEICC.ACRUTGEF.SUMY,SEICC.ACCEL.VLET, SEICC.ACCEL.CNTL,SEICC.ACENCGEN.LOAD,SEICC.ACINTLOG.SOURCE, SEICC.ACLOG.DATA,SEICC.ACENCGEN.ASM,SEICC.ACENCGEN.ASM2,
- Documentation: SEICC.ACCEL.OVERVIEW: Additional documentation in SEICC.USERGIDE.TEXT(ACCEL)
- Purpose: This source handles the accelerator data in an identical manner to normal ISEE data. Flux tapes are created and logged.

DATA POOL (ISEE-3 ONLY)

- Source: There is a corresponding source for each data pool as for a normal ISEE run up to the creation of a library tape. Each source has its own usergide and lookatme to describe the routines. There is a copy of DPTSUM and DPTLIST usergides in SEICC.USERGIDE.TEXT also. The source is in SEICC.DPTLST.SOURCE,SEICC.DPTSUM.SOURCE, and SEICC.SETATT.SOURCE
- Purpose: The data pool routines copy the data pool EDR to a library tape. They also list the tapes and create summary tapes for mailing or for use on the PDP 11/70
- Documentation: CSC/TM-80/6087 "User's Guide for PDP-11/70 Data Pool General Plot Package". Each source has usergides and prologues and SEICC.USERGIDE.TEXT has the usergides for DPTLIST and DPTSUM which are most commonly used and which refer to other sources and usergides.
- Execution: SEICC.IIE.CLIST has foreground CLISTS and JCL is in SEICC.LIB.CNTL.

4.4 ENCOUNTER DATA PROGRAMS

The Voyager data processing system was run on the IBM 3032 computers at CIT during the Saturn Encounters. In order to successfully run the system, changes had to be made to the JCL, the encyclopedia generation programs, and the LCGLIST program. In particular, the GSFC input/output routines DREAD and DWRITE were replaced by LREAD and LWRITE in many programs. Also, the data collection interval in the master control block was made to be 96 seconds rather than 15 minutes. The source for building the encounter programs is stored on tapes EKE01 and EKE02. They contained the following data sets:

EKE01 Data Sets

KE.EDRSAVE.SOURCE
EEKE.EDRSAVE.LOAD
EKE.RESETW.SOURCE
ZEEKE.RESETW.LOAD
EKE.RESETC.SOURCE
ZEEKE.RESETC.LOAD
EKE.ENCGEN.SOURCE
EKE.INTLST.SOURCE
ZEEKE.INTLST.LOAD
EKE.INTLOG.SOURCE
ZEEKE.INTLOG.LOAD
ZEEKE.LOG.DATA
ZEEKE.VIUWLT.DATA
EKE.ENCENC.SOURCE
ZEEKE.ENCGEN.LOAD

EKE02 Data Sets

EKE.ENCENC.SOURCE
ZEEKE.ENCENC.LOAD
EKE.ENCGEN.SOURCE
ZEEKE.ENCGEN.LOAD
ZEEKE.CWLT.DATA
ZEEKE.SC.CNTL
ZEEKE.SELECTE.ASM
SYS2.MACLIB
EEKE.EDFSAVE.DATA
ZEEKE.SEMJS.CNTL
EEKE.LCGLIST.LOAD
E.SACCMODS.SOURCE
KE.EDRSAVE.SOURCE
EEKE.EDFSAVE.LOAD
KE.CWRKCIT.SOURCE
EEKE.CWRKCIT.LOAD
ZEEKE.SEMJS.CNTL
ZEEKE.LOG.DATA

KE.EDFSAVE.SOURCE
EEKE.EDFSAVE.LOAD
KE.LCGLIST.SOURCE
KE.LSELECT.SOURCE
EEKE.LSELECT.LOAD
EKE.ALTELK.SOURCE
ZEEKE.ALTELK.LOAD
KE.FEDCLIE.SOURCE
EEKE.FEDCLIE.LOAD
KE.EDFLIST.SOURCE
EEKE.EDFLIST.LOAD
EEKE.ENCIT.SOURCE
ZEEKE.ENCIT.LOAD
EKE.EDFLOG.SOURCE
ZEEKE.EDFLOG.LOAD
EKE.ENCMRG.SOURCE
ZEEKE.ENCMRG.LOAD
KE.GENERAL.SOURCE
EEKE.GENERAL.LOAD

The procedure for testing these programs is given in SBMJS.CMPENC.SOURCE.

For the Jupiter encounters, the data tapes were sent from JPL to GSFC via NASCOM telephone lines. The operational procedure for sending this information is described in Reference 13.

4.5 SPECIAL PURPOSE PROGRAMS

Table 17 lists programs that are run on special occasions to perform the functions listed in the table.

TABLE 17

Special Purpose Programs

STATLIST and LISTSTAT

- Purpose: List changes in ISEE status words:
- Documentation: prologues,lookatme,usergide:
- Source: SEICC.STATLIST.SOURCE,SEICC.LISTSTAT.SOURCE:
- Execution: SEICC.STATLIST.SOURCE(RUNN): see also SEICC.LISTSTAT.SOURCE(RUN)

INTLOG (ISEE)

- Purpose: Initializes ISEE log:
- Documentation: prologues,lookatme,usergide in source
- Source: SEICC.INTLOG.SOURCE
- Execution: SEICC.INTLOG.SOURCE(CLIST)

INTLOG (Voyager)

- Purpose: Initializes log
- Documentation: prologues,lookatme,usergide
- Source: SBMJS.INTLOG.SOURCE
- Execution: SBMJS.INTLOG.SOURCE(CLIST)

VOYCAL77

- Purpose: Enters Voyager calibration data taken in 1977 into the encyclopedia
- Documentation: SBMJS.VOYCAL77.SOURCE($NOTES$)
- Source: SBMJS.VOYCAL77.SOURCE
- Execution: See documentation

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(11) D.J. Street, "Voyager Experimental Data Record Format Specification - Revision D", Jet Propulsion Laboratory Internal Memorandum 618-306, December 9, 1977.

(12) R.E. Vogt, D.L. Chenette, A.C. Cummings, T.L. Garrard, E.C. Stone, A.W. Schardt, J.H. Trainor, N. Lal, F.B. McDonald, "Energetic Charged Particles in Saturn's Magnetosphere: Voyager-1 Results", Science, vol. 212, April 10, 1981, pp. 231-234.

(13) J.E. Zipse, "Voyager Jupiter Encounter Cosmic Ray System Tape Transmission Final Report", Computer Sciences Corporation Technical Memorandum, CSC/TM-79/6197, August 1979.

(14) J. Broomhall, N. Lal, and P. Rigterink, "Data Processing and Programmer's Guide for the Helios-1 and -2 Cosmic Ray Experiments", in preparation.

Appendix A

A DESCRIPTION OF THE ISEE-3 TELEMETRY FORMAT AND DATA COLLECTION SYSTEM

The ISEE-3 telemetry minor frame contains 128 8-bit words, counted 0 to 127. At 2048 bps, each frame takes 0.5 sec to transmit. The 256 minor frames constitute a major frame, counted 0-255. Within each frame, word 59 is reserved for digital housekeeping for the spacecraft, and words 58 and 122 are for analog housekeeping. These three words are commutated through 64 minor frames. They are referred to as the digital subcom (DSC) and the analog subcom 1 (ASC1) and 2 (ASC2). The group of 64 "subcom" frames are labelled 0-63. The engineering telemetry format will not be discussed here.

Appendix A, based on a document prepared by Tycho von Rosenvinge, October 1976, describes the cosmic ray telemetry from ISEE-3. The Experimental Data Record contains a selection of words from the telemetry. This document is useful for understanding all of the data reduction routines.

ISEE-C MEDIUM ENERGY
COSMIC RAY EXPERIMENT
TELEMETRY DESCRIPTION

Tycho von Rosenvinge

October 1, 1976

(REVISED JUNE 15, 1978)

ISEE-C TYH FORMAT

					VLET			HET							
					PHA		RATES	RATES	PHA						
0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47
48	49	50	51	52	53	54	55	56	57	ANA S/C 1 58	DIG S/C 59	60	61	62	63
64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79
80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95
96	97	98	99	100	101	102	103	104	105	106	107	108	109	110	111
112	113	114	115	116	117	118	119	120	121	ANA S/C 2 122	123	124	125	126	127

DMU Telemetry Format Convolutional Mode

1 MINOR FRAME

ISEE-C TYH DATA FORMAT

MINOR FRAME WORD	PARAMETER
5, 6	VLET PHA DATA
7	VLET RATES, FLAGS & PHA STATUS BITS
8	HET RATES
9, 10, 11	HET PHA DATA
58	ANALOG SUBCOM #1
59	DIGITAL SUBCOM
122	ANALOG SUBCOM #2

<u>ANALOG SUBCOM 1 (BY POSITIONS, = STEPS)</u>

STEP #	
51	VLETS ANALOG HOUSEKEEPING
52	HETS POWER MONITOR
53	VLETS POWER MONITOR

<u>ANALOG SUBCOM 2</u>

STEP #	
17	HETS THERMISTOR
19	VLETS THERMISTOR

<u>DIGITAL SUBCOM (BY POSITIONS, = STEPS)</u>

STEP #	
43, 44, 45, 46	HET SUBCOM BITS AND COMMAND STATUS AS FOLLOWS:

STEP #/Bit	7	6	5	4	3	2	1	0	
43	S5	S4	S3	S2	S1≡0	HG1	HG2	CAL	
44	CD8	CD7	CD6	-	-	-	-	CD1	S1≡0
45	CD16	CD15	-	-	-	-	-	CD9	
46	CD24	CD23	-	-	-	-	-	CD17	
43	S5	S4	S3	S2	S1≡1	HG1	HG2	CAL	
44	CD32	CD31	-	-	-	-	-	CD25	S1≡1
45	CD40	CD39	-	-	-	-	-	CD33	
46	CD48	CD47	-	-	-	-	-	CD41	

(By convention, Bit 7 is read out first in time and Bit 0 last)

HET SUBCOM POSITION = (S4)(S3)(S2)(S1)

COMMAND BIT ASSIGNMENT FOLLOWS:

CD1 - Dummy Bit (Always 0 in Readout).
CD2 - Suppress A_2 Term (HET-I).
CD3 - " B_2 " " .
CD4 - " $\overline{G}_1$ " " , B Stopping Only.
CD5 - " C_1 " " .
CD6 - " C_4 " " .
CD7 - " $\overline{G}_1$ " " , Other Than B Stopping.
CD8 - Delete AS Analysis (HET-I).
CD9 - " BSE " " .
CD10 - " BSp " " .
CD11 - " PEN " " .
CD12 - Suppress A_2 Term (HET-II).
CD13 - " B_2 " " .
CD14 - " $\overline{G}_1$ " " , B Stopping Only.
CD15 - " C_1 " " .
CD16 - " C_4 " " .
CD17 - " $\overline{G}$ " " , Other Than B Stopping.
CD18 - Delete AS Analysis " .
CD19 - " BSe " " .
CD20 - " BSp " " .

(CONTINUED)

COMMAND BIT ASSIGNMENT (CONT'D):

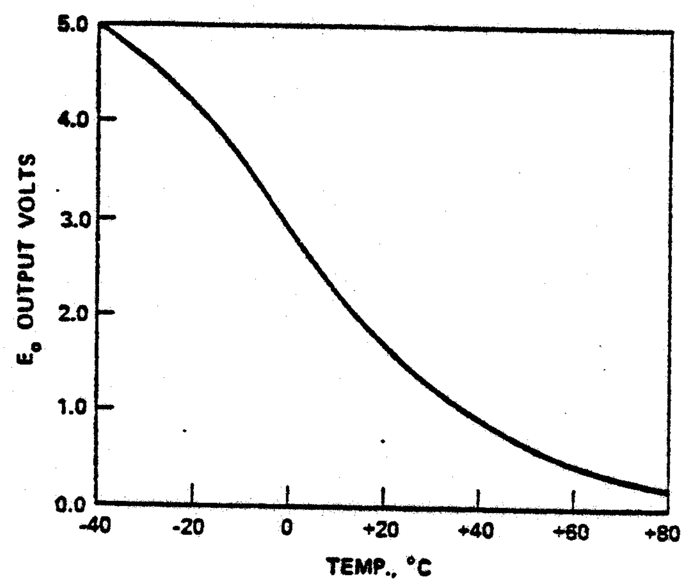
CD21 - Delete PEN Analysis (HET-II).
CD22 - Power Off G_4 (HET-I).
CD23 - " " G_3 " .
CD24 - " " G_2 " .
CD25 - " " G_1 " .
CD26 - " " B_2 " .
CD27 - " " B_1 " .
CD28 - " " A_2 " .
CD29 - " " A_1 " .
CD30 - " " C_4 " .
CD31 - " " C_3 " .
CD32 - " " C_2 " .
CD33 - " " C_1 " .
CD34 - " " G_4 (HET-II).
CD35 - " " G_3 " .
CD36 - " " G_2 " .
CD37 - " " G_1 " .
CD38 - " " B_2 " .
CD39 - " " B_1 " .
CD40 - " " A_2 " .
CD41 - " " A_1 " .
CD42 - " " C_4 " .
CD43 - " " C_3 " .
CD44 - " " C_2 " .
CD45 - " " C_1 " .
CD46 - CAL ENABLE (1 → CAL ENABLED).
CD47 - $HG_1 = S_5 \cdot CD47 + CD49 \cdot \overline{CD47}$
CD48 - $HG_2 = S_5 \cdot CD48 + CD50 \cdot \overline{CD48}$

(CD47, CD48:) HG = 1 → HIGH GAIN

The HETS and VLETS power monitors nominally sit at +4.0 volts when the experiment is ON and at ground when the experiment is OFF. For definition purposes, any value > 2.5 volts = ON; ≤ 2.5 volts = OFF. The analog subcom 8-bit readout value must be multiplied by .02 volts to obtain the voltage level at the input to the analog subcom converter. Hence 5.10 volts is the converter full scale.

The thermistor conversion table for all thermistors is as follows:

DIGITAL READOUT	TEMPERATURE °C
17	+70
20	+65
24	+60
28	+55
33	+50
39	+45
46	+40
53	+35
62	+30
72	+25
84	+20
97	+15
111	+10
126	+ 5
142	0
158	- 5
174	-10
190	-15
200	-20
230	-30
249	-40
255	-50



VLET DATA

Data for the VLET system includes:

1. Pulse height analysis data (PHA data)
2. Rates data
3. Analog housekeeping
4. Power monitor and temperature data

The positions in a minor frame where these are read out have been indicated on the preceeding pages. We will now discuss each in turn in more detail.

The pattern of PHA and rates data readouts is indicated on the next page. A single PHA event corresponds to a single particle entering one of the two VLET telescopes. The data for a single PHA event consists of a DI pulse-height (11 bits), a DII pulse-height (11 bits), an E pulse-height (10 bits) and event tag bits Po and P1. The three pulse-heights for a single event can be read out in 2 minor frames (words 5 and 6) as shown on the next page. However the Po and P1 tags are read out for two events at a time in word 7, frames 3, 7, 11, . . . as indicated. Thus the pulse height data and tag data for two PHA events is read out in four minor frames. The null event (no particle detected) is characterized by DI=DII=E=0. P1 tells whether the event was detected in Telescope 1 or in telescope 2; the state of the Po bit classifies the event as one of two different event types. Po and P1 indicate the set of storage registers from which readout occurs and need not be zero for null-events.

The VLET system contains 8 non-sectored rate counters and 8 sectored rate counters.

At the end of each block of 64 minor frames (minor frames 0-63) the contents of all 16 of these rate registers are transferred for read-out during the next block of 64 minor frames. The registers are then immediately cleared and any subcommutators are advanced in position. Non-sectored rate counters then immediately resume counting until the end of the new block of 64 minor frames. Each sectored rate counter counts a particular event rate only when the corresponding telescope is looking in a particular direction, i.e. the spin plane is divided into 8 different azimuthal sectors and to each sector corresponds one of the eight sector rate counters. After the end of one block of 64 minor frames, counting into the sector rate registers doesn't resume until the sun spike occurs. Events are then counted successively into the 8 different sector rate counters for 8, 16 or 32 complete spins depending upon whether the spacecraft bit-rate is 2048 IBPS, 1024 IBPS or 512 IBPS respectively. The nominal spin period is 3 seconds. Complete accumulation will therefore be finished by the end of the 64 minor frame block.

Each VLET rate register read-out (sectored and non-sectored) consists of 24 bits read out in word 7. Every fourth readout of word 7 contains tag/status information, however, so the contents of one rate register is read out every four minor frames and all 16 rate registers are read out in

64 minor frames (see Page C-11). Register R1 is read out first, R2 next and so on through R8, then sector rate register SR1 is read out followed by SR2, . . . SR8.

The rate counter subcommutation and rate coincidence conditions are indicated in the table on Page C-12. For 8-level subcommutation, the subcommutator position ≡ [(S2)(S1)(S0)] octal. The S2, S1 and S0 bits are obtained from word 7, frames 3, 7 and 11 (modulo 16) respectively as shown on Page C-12.

NOTE: ALL RATES REGISTERS (HET & VLET) ACCUMULATE DATA FOR 64 MINOR FRAMES AND READ OUT THE RESULTS DURING THE NEXT 64 MINOR FRAMES; THUS RATE READOUTS IN ONE 64 MINOR FRAME BLOCK SHOULD BE ASSOCIATED WITH THE SUBCOM POSITIONS READ OUT IN THE PRECEDING 64 MINOR FRAME BLOCK. THE HET AND VLET SUBCOMS ARE INDEPENDENT OF EACH OTHER.

The VLET analog housekeeping (step 51 on the spacecraft analog subcom #1) is further subcommed by 8 inside the experiment using the same subcommutator clock (S2)S1)(S0) as used for the VLET rate registers:

	PARAMETER	(S2)	(S1)	(S0)	ANALOG SUBCOM READOUT DESIGNATION
V_0 =	+12 V	0	0	0	X_0
V_1 =	+6 V	0	0	1	X_1
V_2 =	Thermistor 3	0	1	0	X_2
V_3 =	Thermistor 4	0	1	1	X_3
V_4 =	Spare	1	0	0	X_4
V_5 =	Spare	1	0	1	X_5
V_6 =	-6 V	1	1	0	X_6
V_7 =	-12 V	1	1	1	X_7

The VLETS Power Monitor (analog subcom #1, step 53) nominally sits at 4.0 volts when the experiment is ON and at ground when the experiment is OFF.

The spacecraft analog subcom has a linear range from 0 to 5.10 V. Hence, the following conversions are necessary to relate the subcom readout X's with the appropriate voltage:

$V_o = 0.06 \times X_o$ volts.

$V_1 = 0.04 \times X_1$ volts.

$V_6 = 0.4 \times X_6 - 0.44 \times X_1$ volts.

$V_7 = 0.0444 \times X_7 - 0.0733 \times X_o$ volts.

The thermistor temperature conversions are the same as given on Page C-7. X_o is read in the same 64 minor frame block as the one in which S_2, S_1 and S_o are zero, etc. (i.e., this is unlike the rates).

The VLETS Power Monitor (Analog Subcom #1, Step 53) nominally sits at 4.0 volts when the experiment is ON and at ground when the experiment is OFF. See Page C-7 for further details.

VLET status readout is as indicated on Page C-11. Systems 1 and 2 are both enabled when their status bits are zero. The PHA enable/disable commands are executed when they are received. The internal stimulus is not turned on, however, until the beginning of the first 64 minor frame block after the command is received. It remains on for 8x64 minor frame blocks and then automatically shuts itself off. It may also be commanded off. The internal stimulus system is ON during the 8x64 minor frame blocks which have the CAL ON bit set to 1. PHA events from the internal stimulus may continue to be read out for as many as eight pulse-height events after the system shuts off. The 64 minor frame block following the turn-off of the internal stimulus will contain rates accumulated when it was on, even though the CAL ON bit is reset to zero.

The VLET PHA counters are quite different from those for the HET. The counters for DI and DII start counting from zero and have no overflow protection. The E counter starts counting from zero and freezes at all ones if overflow is detected. (The HET PHA counters start counting from 1 and freeze at zero if overflow is detected.)

BIT STRUCTURE, VLET PHA/RATE READOUTS

WORD 5								WORD 6								WORD 7								
← PHA DATA															→	← RATE/TAGS							→	
Z 11	Z 10	Z 9	Z 8	Z 7	Z 6	Z 5	Z 4	Z 3	Z 2	Z 1	Y 11	Y 10	Y 9	Y 8	Y 7	B 24	B 23	B 22	B 21	B 20	B 19	B 18	B 17	FRAMES 0, 4, 8,...
MSB ← DI										→	← DII				→	MSB								
Y 6	Y 5	Y 4	Y 3	Y 2	Y 1	X 10	X 9	X 8	X 7	X 6	X 5	X 4	X 3	X 2	X 1	B 16	B 15	B 14	B 13	B 12	B 11	B 10	B 9	FRAMES 1, 5, 9,...
← DII					→	← E									→ LSB									
Z 11	Z 10	Z 9	Z 8	Z 7	Z 6	Z 5	Z 4	Z 3	Z 2	Z 1	Y 11	Y 10	Y 9	Y 8	Y 7	B 8	B 7	B 6	B 5	B 4	B 3	B 2	B 1	FRAMES 2, 6, 10,...
MSB ← DI										→	← DII				→								LSB	
Y 6	Y 5	Y 4	Y 3	Y 2	Y 1	X 10	X 9	X 8	X 7	X 6	X 5	X 4	X 3	X 2	X 1	A 8	A 7	A 6	A 5	A 4	A 3	A 2	A 1	FRAMES 3, 7, 11,...
← DII					→	← E									→ LSB									

BIT CONTENTS

X = E PHA
Y = DII PHA
Z = DI PHA
B = RATE
A_i = TAGS AND STATUS

P_1 0 = TELESCOPE 1
1 = TELESCOPE 2

P_o 0 = EVENT TYPE 0
1 = EVENT TYPE 1

Frame #
Modulo 16

A_1 = { 3 S2 (VLET); 7 S1 (VLET); 11 S0 (VLET); 15 CAL ALLOW }

A_2 = CAL ON

A_3 = P_1 }
A_4 = P_o } TAGS FOR PHA EVENT IN FRAMES (2,3), (6,7), . . .

A_5 = TELESCOPE 2 PHA ENABLE

A_6 = TELESCOPE 1 PHA ENABLE

A_7 = P_1 }
A_8 = P_o } TAGS FOR PHA EVENT IN FRAMES (0,1), (4,5), . . .

VLET ANALOG SUBCOM POSITION = (S2)(S1)(S0)

VLET RATE FORMAT (REVISED 9/2/76)

S2 = 8x64W7		0	0	0	0	1	1	1	1
S1 = 4x64W7		0	0	1	1	0	0	1	1
S0 = 2x64W7		0	1	0	1	0	1	0	1
T1	R1	DΣ1	DΣ1	DΣ1	DΣ1	DΣ1	DΣ1	DΣ1	DΣ1
	R2	DΣ2	DΣ2	DΣ2	DΣ2	DΣ2	DΣ2	DΣ2	DΣ2
	R3	DΣ1E1	DΣ1E2	DΣ1E1	DΣ1E2	DΣ1E1	DΣ1E2	DΣ1E1	DΣ1E2
T2	R4	DΣ1	DΣ1	DΣ1	DΣL	DΣ1	DΣ1	DΣ1	DΣ1
	R5	DΣ2	DΣ2	DΣ2	DΣ2	DΣ2	DΣ2	DΣ2	DΣ2
	R6	DΣ1E1	DΣ1E2	DΣ1E1	DΣ1E2	DΣ1E1	DΣ1E2	DΣ1E1	DΣ1E2
	R7	DT2	DT1 *	DT2	DT1	DT2	DT1	DT2	DT1
	R8	DIT1	DIIT1	ET1	FT1	DIT2	DIIT2	ET2	FT2
	RSE	DΣ1T1	DT1	DΣ1T2	DT2	DΣ1T1	DT1	DΣ1T2	DT2

D = $DIDII\overline{F}$ T1 = TELESCOPE 1, T2 = TELESCOPE 2

USE SUBCOM POSITION SAMPLE FROM PRECEDING 64 MINOR FRAME DATA BLOCK

[box] = length of subcom cycle

* NOTE 2,1 ORDER!

HET DATA

The TYH High-Energy Telescope (HET) produces three types of digital data (rate data, PHA data and command status data), and 3 analog parameters. One complete data cycle requires 16 blocks of 64 minor frames, or 1024 minor frames. A single 64 minor frame block format is shown in Figure 1.* Word 8 contains all the HET rate data, consisting of 16 consecutive 22-bit rate counter readouts, followed by 8 additional 20-bit sectored rate counter readouts, for a total of 512 bits in the 64 8-bit words. The first bit in the sequence (i.e., the first bit readout in time) appears in minor frame #0 and is the MSB (2^{21}) of rate counter #1; this is designated $R1_{22}$. The succeeding bits ($R1_{21}$, $R1_{20}$, $R1_{19}$ . . . R_1) complete the readout of R1, followed by R2 ($R2_{22}$, $R2_{21}$ . . . $R2_1$) and so on until all 16 rate counters and the 8 sectored rate counters (SR1 through SR8) have been readout. This represents 1/16 of a complete rate data cycle and corresponds to a single position of the rate counter commutator. The commutator position is read out as the S4, S3, S2 and S1 bits in the digital subcom (S4 is MSB) of the preceding 64 minor frame block. The logical rates, i.e., the required coincidence anticoincidence conditions among various elements of each telescope, are shown in Fig. 2.+ Some rates are not commutated at all (R3, R4, R11 and R12, for example), and represent the same coincidence condition regardless of the state of the S1-S4 bits and the HG_i bits (high gain/low gain) for each telescope. Other rates may be commutated between two quantities using only the S1 bit (e.g., R5) or only the HG_i bit (R1). R2 and R10, however, are commutated using both HG_i and the S1, S2 bits as well. The singles rates from each telescope element are commutated modulo 16 in R8 and R16 using all the bits S1, S2, S3, S4.

PHA (pulse-height analysis) data for selected events appears as a 48-bit sequence starting in the MSB of Word 9 of even-numbered frames and ending with the LSB of Word 11 of odd-numbered frames. The first 12 bits read out (T12-T1 in Fig. 1) are tag bits which identify the event type (A STopping, B STopping, or PENetrating), the telescope, the sector orientation of the spacecraft at the time of the particle detection, the penetration range of the particle through the C stack, and other house-keeping parameters of that event. The remaining 36 bits contain three 12-bit numbers representing the amplitude of three selected detector signals. Fig. 1 illustrates the various PHA addresses and identifies which detector quantity is represented for each of the PHA event types.

Command status data is read out in the digital subcom. Eight sub-com words, i.e., 128 minor frames, are required for a complete readout of all 48 status bits. Each block of 64 minor frames, however, contains one readout of the rate commutation position and the two gain bits, one for each telescope. See page C-5. Command status changes whenever a command is received; i.e., it is not aligned with 128 minor frame boundaries.

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* Drawing labelled TYH High Energy Telescope, ISEE-C Telemetry Format, p. C-14
\+ Drawing labelled ISEE HET Rate Table, p. C-15.

MINOR FRAME NO.	WORD 8: 7	6	5	4	3	2	1	0
0	$R1_{22}$	$R1_{21}$	$R1_{20}$	$R1_{19}$	$R1_{18}$	$R1_{17}$	$R1_{16}$	$R1_{15}$
1	$R1_{14}$	$R1_{13}$	$R1_{12}$	$R1_{11}$	$R1_{10}$	$R1_{9}$	$R1_{8}$	$R1_{7}$
2	$R1_{6}$	$R1_{5}$	$R1_{4}$	$R1_{3}$	$R1_{2}$	$R1_{1}$	$R2_{22}$	$R2_{21}$
3	$R2_{20}$	$R2_{19}$	$R2_{18}$	$R2_{17}$	$R2_{16}$	$R2_{15}$	$R2_{14}$	$R2_{13}$
4	$R2_{12}$	$R2_{11}$	$R2_{10}$	$R2_{9}$	$R2_{8}$	$R2_{7}$	$R2_{6}$	$R2_{5}$
5	$R2_{4}$	$R2_{3}$	$R2_{2}$	$R2_{1}$	$R3_{22}$	$R3_{21}$	$R3_{20}$	$R3_{19}$
6	$R3_{18}$	$R3_{17}$	$R3_{16}$	$R3_{15}$	$R3_{14}$	$R3_{13}$	$R3_{12}$	$R3_{11}$
7	$R3_{10}$	$R3_{9}$	$R3_{8}$	$R3_{7}$	$R3_{6}$	$R3_{5}$	$R3_{4}$	$R3_{3}$
8	$R3_{2}$	$R3_{1}$	$R4_{22}$	$R4_{21}$	$R4_{20}$	$R4_{19}$	$R4_{18}$	$R4_{17}$
9	$R4_{16}$	$R4_{15}$	$R4_{14}$	$R4_{13}$	$R4_{12}$	$R4_{11}$	$R4_{10}$	$R4_{9}$
10	$R4_{8}$	$R4_{7}$	$R4_{6}$	$R4_{5}$	$R4_{4}$	$R4_{3}$	$R4_{2}$	$R4_{1}$
11	$R5_{22}$	$R5_{21}$	$R5_{20}$	$R5_{19}$	-	-	-	-
-								
-								
21	-	-	-	-	$R8_{4}$	$R8_{3}$	$R8_{2}$	$R8_{1}$
22	$R9_{22}$	$R9_{21}$	$R9_{20}$	$R9_{19}$	-	-	-	-
-								
-								
32	-	-	-	-	$R12_{4}$	$R12_{3}$	$R12_{2}$	$R12_{1}$
33	$R13_{22}$	$R13_{21}$	$R13_{20}$	$R13_{19}$	-	-	-	-
-								
-								
43	-	-	-	-	$R16_{4}$	$R16_{3}$	$R16_{2}$	$R16_{1}$
44	$SR(1)_{20}$	$SR(1)_{19}$	$SR(1)_{18}$	$SR(1)_{17}$	$SR(1)_{16}$	$SR(1)_{15}$	$SR(1)_{14}$	$SR(1)_{13}$
45	$SR(1)_{12}$	$SR(1)_{11}$	$SR(1)_{10}$	$SR(1)_{9}$	$SR(1)_{8}$	$SR(1)_{7}$	$SR(1)_{6}$	$SR(1)_{5}$
46	$SR(1)_{4}$	$SR(1)_{3}$	$SR(1)_{2}$	$SR(1)_{1}$	$SR(2)_{20}$	$SR(2)_{19}$	$SR(2)_{18}$	$SR(2)_{17}$
47	$SR(2)_{16}$	$SR(2)_{15}$	$SR(2)_{14}$	$SR(2)_{13}$	$SR(2)_{12}$	$SR(2)_{11}$	$SR(2)_{10}$	$SR(2)_{9}$
48	$SR(2)_{8}$	$SR(2)_{7}$	$SR(2)_{6}$	$SR(2)_{5}$	$SR(2)_{4}$	$SR(2)_{3}$	$SR(2)_{2}$	$SR(2)_{1}$
49	$SR(3)_{20}$	$SR(3)_{19}$	$SR(3)_{18}$	-	-	-	-	-
50	-	-	-	-	-	-	-	-
51	$SR(3)_{4}$	$SR(3)_{3}$	$SR(3)_{2}$	$SR(3)_{1}$	$SR(4)_{20}$	$SR(4)_{19}$	$SR(4)_{18}$	$SR(4)_{17}$
52	-	-	-	-	-	-	-	-
53	-	-	-	-	$SR(4)_{4}$	$SR(4)_{3}$	$SR(4)_{2}$	$SR(4)_{1}$
54	$SR(5)_{20}$	$SR(5)_{19}$	$SR(5)_{18}$	-	-	-	-	-
55	-	-	-	-	-	-	-	-
56	$SR(5)_{4}$	$SR(5)_{3}$	$SR(5)_{2}$	$SR(5)_{1}$	$SR(6)_{20}$	$SR(6)_{19}$	$SR(6)_{18}$	-
57	-	-	-	-	-	-	-	-
58	-	-	-	-	$SR(6)_{4}$	$SR(6)_{3}$	$SR(6)_{2}$	$SR(6)_{1}$
59	$SR(7)_{20}$	$SR(7)_{19}$	$SR(7)_{18}$	$SR(7)_{17}$	-	-	-	-
60	-	-	-	-	-	-	-	-
61	-	$SR(7)_{3}$	$SR(7)_{2}$	$SR(7)_{1}$	$SR(8)_{20}$	$SR(8)_{19}$	$SR(8)_{18}$	$SR(8)_{17}$
62	-	-	-	-	-	-	-	-
63	-	-	-	-	-	$SR(8)_{3}$	$SR(8)_{2}$	$SR(8)_{1}$

MINOR FRAME NO.	WORD 9: 7	6	5	4	3	2	1	0	WORD 10: 7	6	5	4	3	2	1	0	WORD 11: 7	6	5	4	3	2	1	0
0	T12	T11	T10	T9	T8	T7	T6	T5	T4	T3	T2	T1	(MSB) ←				PHA ADDRESS 1 → (LSB)							
1	(MSB) ← PHA ADDRESS 2								→ (LSB)				(MSB) ←				PHA ADDRESS 3 → (LSB)							
2–63									PHA DATA AS ABOVE REPEATED EVERY 2 FRAMES															

TAGS / PHA 1 / PHA 2 / PHA 3

													PHA 1	PHA 2	PHA 3
AST:	$C_2 \oplus C_4$	C_3	C_1	SA	G_2	$G_1 G_3$	TEL ID	HG	SCTR 3	SCTR 2	EVENT ID (0)	SCTR 1	A_1	A_2	$C_1+C_2+C_3$
BST:	$C_2 \oplus C_4$	C_3	C_1 (0)	SB	G_2	$G_1 G_3$	TEL ID	HG	SCTR 3	SCTR 2	EVENT ID (1)	SCTR 1	B_1	B_2	$C_2+C_3+C_4$
PEN:	$C_2 \oplus C_4$	C_3	C_1 (1)	SB	G_2	$G_1 G_3$	TEL ID	HG	SCTR 3	SCTR 2	EVENT ID (1)	SCTR 1	B_1	C_1	$C_2+C_3+C_4$

"G"	G_2	$G_1 \bar{G}_3$	
0	0	0	$\bar{G}_1 \bar{G}_2 \bar{G}_3$
1	0	1	$G_1 \bar{G}_2 \bar{G}_3$
2	1	1	$G_1 G_2 \bar{G}_3$
3	1	0	$G_1 G_2 G_3$

"C"	C_1	C_3	C_2+C_4	
0	0	0	0	$\bar{C}_1 \bar{C}_2 \bar{C}_3 \bar{C}_4$
1	1	0	0	$C_1 \bar{C}_2 \bar{C}_3 \bar{C}_4$
2	1	0	1	$C_1 C_2 \bar{C}_3 \bar{C}_4$
3	1	1	1	$C_1 C_2 C_3 \bar{C}_4$
-	1	1	0	$C_1 C_2 C_3 C_4$
4	0	0	1	$\bar{C}_1 \bar{C}_2 \bar{C}_3 C_4$
3	0	1	1	$\bar{C}_1 \bar{C}_2 C_3 C_4$
2	0	1	0	$\bar{C}_1 C_2 C_3 C_4$

TYH HIGH ENERGY TELESCOPE
ISEE-C TELEMETRY FORMAT

ISEE HET RATE TABLE

COUNTER	RATE	HG I	HG II	S1	S2	S3	S4	DET.
R1	$A_1(A_2)(\bar{C}_4)(\bar{G}_1)\ \bar{G}_2$		1					
	$A_1(A_2)SA(\bar{C}_4)\bar{G}_3$		0					
R2	$B_1\ (B_2)SB(\bar{C}_1)(\bar{G}_1)\ \bar{G}_2$		1	3/4 S*				
	$B_1\ (B_2)(C_4)\overline{SB}(\bar{C}_1)\bar{G}_1$		1	1/4 *				
	$B_1\ (B_2)SB(\bar{C}_1)\ \bar{G}_3$		0					
R3	$B_1\ (B_2)(C_1)$		–					
R4	$B_1\ (B_2)(C_1)\ \bar{G}_1$		–					
R5	$B_1\ (B_2)(C_4)\bar{C}_3 SB\ \bar{G}_1$		–	0				
	$B_1\ (B_2)(C_4)\bar{C}_3 \overline{SB}\ \bar{G}_1$		–	1				
R6	$B_1\ (B_2)(C_4)C_3\bar{C}_2 SB\ \bar{G}_1$		–	0				HET-II
	$B_1\ (B_2)(C_4)C_3\bar{C}_2 \overline{SB}\ \bar{G}_1$		–	1				
R7	$B_1\ (B_2)(C_4)C_3C_2(\bar{C}_1)SB\ \bar{G}_1$		–	0				
	$B_1\ (B_2)(C_4)C_3C_2(\bar{C}_1)\overline{SB}\ \bar{G}_1$		–	1				
R8	A_1		–	0	0	0	0	
	A_2		–	1	0	0	0	
	C_1		–	0	1	0	0	
	C_2		–	1	1	0	0	
	B_1		–	0	0	1	0	
	SA_1		–	1	0	1	0	
	SA_2		–	0	1	1	0	
	SB		–	1	1	1	0	
	C_3		–	0	0	0	1	
	C_4		–	1	0	0	1	
	B_2		–	0	1	0	1	
	G_1		–	1	1	0	1	
	B_1 } REPEAT BLOCK		–	0	0	1	1	
	SA_1 } REPEAT BLOCK		–	1	0	1	1	
	SA_2 } REPEAT BLOCK		–	0	1	1	1	
	SB } REPEAT BLOCK		–	1	1	1	1	
R9 - R16	IDENTICAL TO R1 - R8	–		–	–	–	–	HET-I
SR a	$A_1(A_2)(\bar{C}_4)(\bar{G}_1)\ \bar{G}_2$		1	0	0	0		HET-II
b	$B_1\ (B_2)\ SB(\bar{C}_1)(\bar{G}_1)\ \bar{G}_2$		1	0	1	0		
c	$B_1\ (B_2)(C_4)\ SB(\bar{C}_1)(\bar{G}_1)\bar{G}_2$		1	0	0	1		
d	$B_1\ (B_2)(C_4)(\bar{C}_1)\overline{SB}(\bar{G}_1)\ \bar{G}_2$		1	0	1	1		
	REPEAT a, b, c, d FOR HET-I	1		1	–	–		HET-I
e	$A_1(A_2)\ SA(\bar{C}_4)\ \bar{G}_3$		0	0	0	0		HET-II
e	$A_1(A_2)\ SA(\bar{C}_4)\ \bar{G}_3$	0		1	0	0		HET-I
f	$B_1\ (B_2)\ SB(\bar{C}_1)\ \bar{G}_2$		0	0	$\bar{0}\cdot\bar{0}$			HET-II
f	REPEAT f FOR HET-II	0		1	$\bar{0}\cdot\bar{0}$			HET-I

NOTES:

R1, R9 RATES CORRESPOND TO THE A-STOPPING EVENT TYPE FOR HETS I AND II.

* R2, R10 RATES CORRESPOND TO THE B-STOPPING EVENT TYPE FOR HETS I AND II (IN HIGH GAIN THE B-STOPPING EVENT TYPE DEFINITION IS TIME MULTIPLEXED FOR 3/4 AND 1/4 OF THE TIME BETWEEN TWO DEFINING CONDITIONS; $1/4 \equiv S_1 \cdot S_2 \cdot 1)$

R3, R11 = PEN

$SA = SA_1 \cdot SA_2$

( ) = DENOTES TERMS WHICH MAY BE DELETED FROM LOGICAL EXPRESSIONS BY COMMAND.

HG = 0 → LOW GAIN; HG I ⇒ HET I; HG II ⇒ HET II
HET I AND HET II GAINS ARE THE SAME WHEN IN AUTOMATIC GAIN CHANGING MODE BUT EACH MAY BE COMMANDED TO A FIXED GAIN INDEPENDENTLY.

NOTE REPEAT BLOCK FOR SINGLES RATES; E.G. IN ONE FULL SUBCOM CYCLE THE B1 SAMPLE TIME IS TWICE THAT FOR, SAY, B2.

NOTE: NO ( ) AROUND $\bar{G}_3$, UNLIKE MJS.

ALL RATE EQUATIONS CONTAIN A STROBE TERM TO ESTABLISH A COINCIDENCE APERTURE OF ~ 3 μ SEC. THE STROBE OCCURS 5.5 μ SEC AFTER THE FIRST OF THE FOLLOWING BECOMES TRUE: A_1, B_1, (B_2), (C_1), (C_4)

BIT STATES: BLANK ⇒ NOT RELEVANT
– ⇒ 0 OR 1

BITS HG I, HG II, S1, S2, S3, S4 ARE QUOTED HERE FOR ACCUMULATE TIME; RATES ARE ACCUMULATED DURING ONE 64 MINOR FRAME BLOCK AND READ OUT IN THE NEXT 64 MINOR FRAME BLOCK; THE STATES OF BITS HG I, HG II, S1, S2, S3, S4 READ OUT IN A 64 MINOR FRAME BLOCK CORRESPOND TO THE RATES IN THE FOLLOWING 64 MINOR FRAME BLOCK.

DELETION OF (C_1) IS CONTROLLED BY THE SAME COMMAND BIT AS FOR DELETION OF $(\bar{C}_1)$ AND SIMILARLY FOR (C_4) AND $(\bar{C}_4)$. A SINGLE COMMAND BIT CONTROLS DELETION OF $(\bar{G}_1)$ TERMS IN R1 AND HET-II SECTOR RATES; A SEPERATE COMMAND BIT CONTROLS DELETION OF $(\bar{G}_1)$ TERM IN R2; SIMILARLY FOR HET-I.

The HET internal stimulus, however, is turned on at the beginning of the first 64 minor frame block after the internal stimulus command (P88, provided CD46=CAL ENABLE bit = 1) is received. The internal stimulus system then stays on for 16x64 minor frames (1 complete sybcom cycle) and then automatically shuts itself off. The internal stimulus may be shut off earlier by resetting the CAL ENABLE bit (CD46) to zero. Note that the CAL bit in the HET status data is set during the 16x64 minor frame blocks during which the internal stimulus is ON. Corresponding rate data extends into the following 64 minor frame block. PHA data accumulated while the internal stimulus is on can extend as much as 3 event readouts after the time it is shut off (i.e., a CAL bit = 0 in a 64 minor frame block is not a guarantee that this block contains no data from the internal stimulus).

HET null PHA events consist of a string of 48 zeros. The lowest PHA channel value for a non-null HET event is 1; a pulse-height readout of zero for a non-null event implies overflow of the corresponding counter; i.e., top of range. The tag bit field could be tested alone as a test for null events since it should be all zeros only for null events.

ISEE-C Sector Rates (HET + VLET).

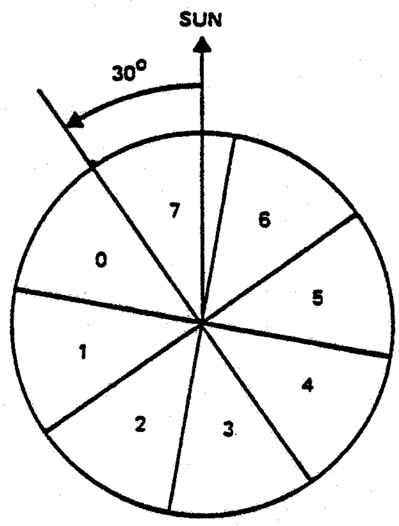
Nominal spin rate = 20 RPM → Spin Period T = 3 seconds. One complete readout of 8 sector rate counter contents takes 64 minor frames or 32 seconds at 2048 IBPS. At the end of a 64 minor frame block the contents of the 8 sector rate counters are transferred for readout during the next such block; the next rate to be sectored is selected by advancing the appropriate sub-com by one step and clearing the 8 counters. When the next sun-pulse is detected, rate accumulation begins in the first sector rate counter. One-eighth of a revolution later the rate pulses are switched from the first sector rate counter to the second for the next one-eighth of a spin and so on. At the end of one complete spin counting is resumed in counter one. The process stops after n complete spins, where n is bit-rate dependent:

IBPS	n
2048	8
1024	16
512	32

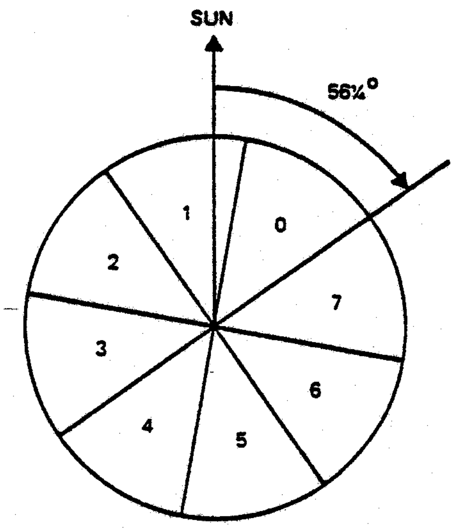
To obtain counts per second, divide the number of events counted by nxT/8 seconds.

The sun-pulse may be derived from either the Panoramic Attitude Sensor System (PAS) or from the Fine Sun Sensor System (FSS). The PAS and FSS systems are located in facets 6 and 14 respectively, 180° apart. However, each is canted by 22-1/2° and the sun-pulse from the FSS is delayed by 180° so that the sun-pulse is generated when sunlight is normally incident on facet 5 (actually the PAS pulse comes 0.35° later than this). The facets are numbered 1 to 16 according to a right-hand rule, the rotation of the spacecraft follows a right-hand rule and the spin axis will point to the North Ecliptic pole ±1°. The VLETS are located in facet 8 with their symmetry axes in the spin plane and rotated from a normal to facet 8 by 15° towards facet 7. The HETS are located such that their symmetry axes lie in the spin plane, the A-ends looking in a direction parallel to a vector from the center of the spacecraft to the junction of facets 2 and 3. This leads to the patterns on page C-18.

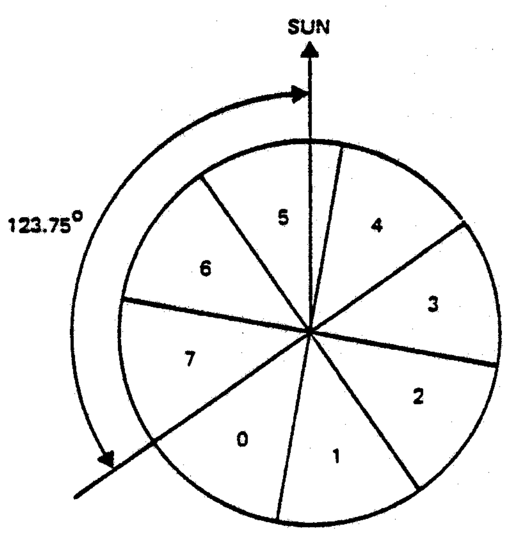
The VLET sector rates are accumulated in 24 bit counters; the HET sectored rates are accumulated in 20 bit counters.



VLET SECTORS



HET
A-STOPPING
SECTORS



HET
B-STOPPING
SECTORS

Appendix B

THE VOYAGER EXPERIMENTAL DATA RECORD TAPE FORMAT

There are seven possible formats for the Voyager CRS Experimental Data Records. Reference 11 gives a complete description of these formats. Format General Science-3 (GS-3), and the associated header information are duplicated on the following pages since it is used during encounters.

Section III

Experiment Data Record Descriptions

3.1 COSMIC RAY SCIENCE (CRS) EXPERIMENT

The CRS EDR science record is designed to a 48-second instrument measurement period. Any data not present during the instrument measurement will be filled with binary zeroes.

A logical record corresponds to an instrument measurement period and in this instance is also the science physical record structure. The formats which follow are applicable to the GS, OC, and IM (imbedded GS&E) data modes.

The science logical/physical record structure is diagrammed in Figure 3.1-1 and the physical magnetic tape lay-out is shown in Figure 3.1-2. The physical magnetic tape lay-out includes a change in decommutation maps during the time period covered by that EDR tape. Figure 3.1-3 and 3.1-4 and Table 3.1-1 define the structure and contents of the CRS science record subheader. Figure 3.1-5 defines the CRS data word. Figure 3.1-6, and Table 3.1.2 define the science record data block structure and contents.

Appendix A contains the Decommutation Map record format. Appendix B describes the Engineering Record format. Appendix C depicts the Record Header which will be Standard on all the physical records written to the CRS EDR tape.

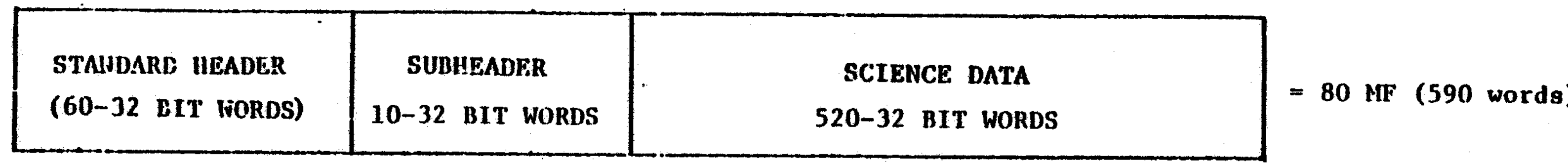
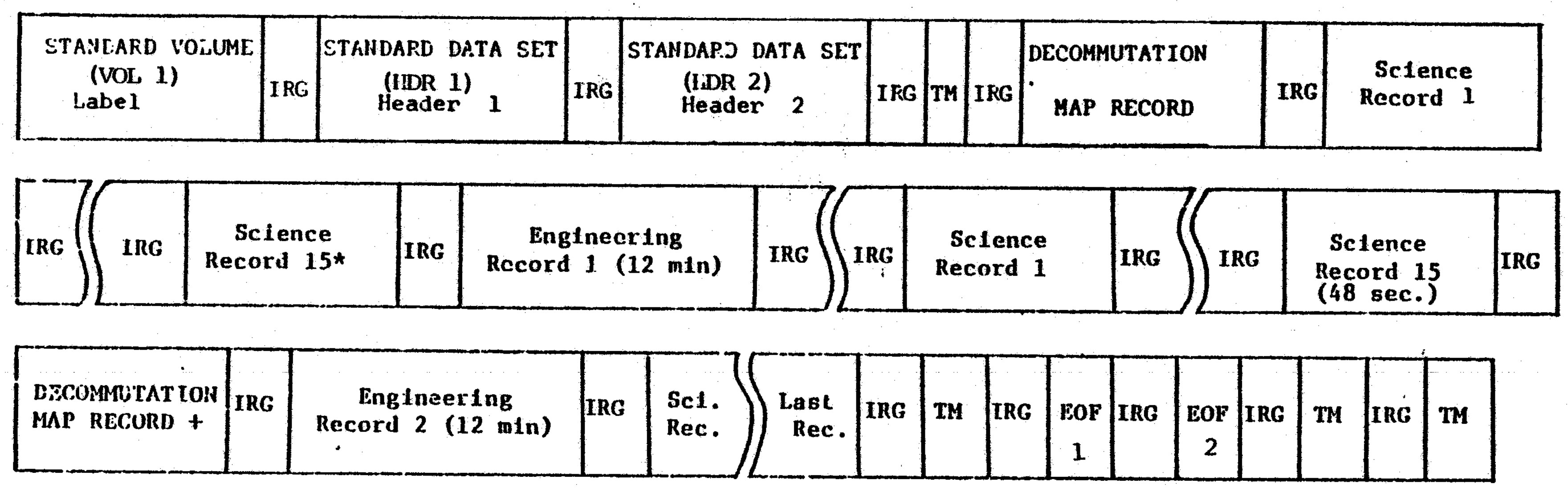


Figure 3.1-1 CRS EDR Tape Record (Science)



+ If Decom Map changed during processing interval for this EDR.

Figure 3.1-2 Physical Magnetic Tape Layout for CRS (GS,OC-1)

EDR DATA WORD	BITS 31–16	0 (BITS 15–0)	31–16	0 (15–0)
1	SPARE	INSTRUMENT COMMAND WORD	SPARE	
3	STATUS WORD 0	STATUS WORD 1	STATUS WORD 2	STATUS WORD 3
5	STATUS WORD 4	STATUS WORD 5	STATUS WORD 6	STATUS WORD 7
7	SPARE		SPARE	
9	SPARE		SPARE	

Figure 3.1-3 CRS Science Record Subheader Format (EVEN MOD 60)

EDR DATA WORD	BITS 31–16	0 (BITS 15–0)	31–16	0 (15–0)
1	SPARE	INSTRUMENT COMMAND WORD	SPARE	
3	STATUS WORD 8	STATUS WORD 9	STATUS WORD 10	STATUS WORD 11
5	STATUS WORD 12	STATUS WORD 13	STATUS WORD 14	STATUS WORD 15
7	SPARE		SPARE	
9	SPARE		SPARE	

Figure 3.1-4 CRS Science Record Subheader Format (ODD MOD 60) (GS,OC-1)

Table 3.1-1 CRS Science Record Subheader Block Table (GS,OC-1)

Item	Word	Bits	Description			
				EVEN	ODD	
1	1	31-16	Spare			
2	1	15-0	Instrument FDS command word			Subcom MF 61
3	2	31-0	Spare			
4	3	31-16	Instrument Status word	0	8	Subcom MF 62
5	3	15-0	Instrument Status word	1	9	Subcom MF 62
6	4	31-16	Instrument Status word	2	10	Subcom MF 62
7	4	15-0	Instrument Status word	3	11	Subcom MF 62
8	5	31-16	Instrument Status word	4	12	Subcom MF 71
9	5	15-0	Instrument Status word	5	13	Subcom MF 71
10	6	31-16	Instrument Status word	6	14	Subcom MF 71
11	6	15-0	Instrument Status word	7	15	Subcom MF 71
12	7	31-0	Spare			
13	8	31-0	Spare			
14	9	31-0	Spare			
15	10	31-0	Spare			

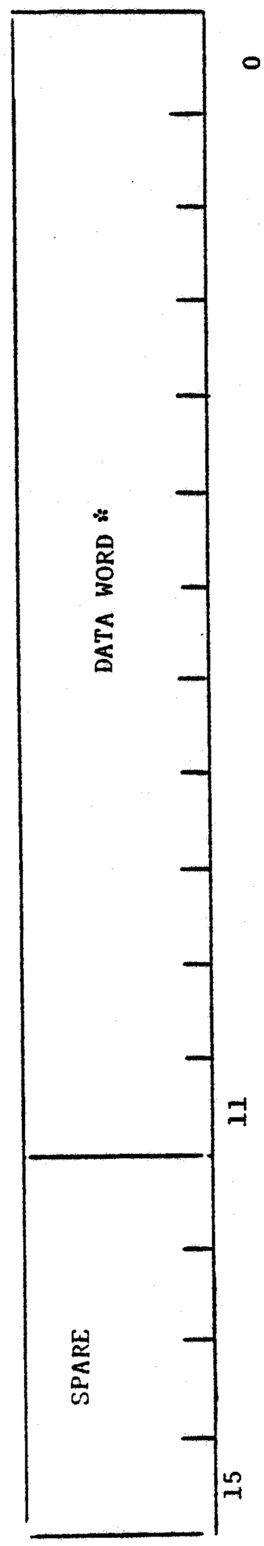


Figure 3.1-5 CRS Science Data Word (GS,OC-1)

* Zeros will be used as filler.

EDR DATA WORD	BITS 31–16	15–0	31–16	15–0
1 (4 MFs)	PHA_1 WORD MF 1	PHA_1 WORD MF 1	PHA_1 WORD MF 1	PHA_1 WORD MF 1
3	RATE WORD 1 MF 1	RATE WORD 2 MF 1	PHA_2 WORD MF 1	PHA_2 WORD MF 1
5	PHA_2 WORD MF 1	PHA_2 WORD MF 1	RATE WORD 3 MF 1	PHA_3 WORD MF 1
7	PHA_3 WORD MF 1	PHA_3 WORD MF 2	PHA_3 WORD MF 2	RATE WORD 4 MF 2
9	PHA_4 WORD MF 2	PHA_4 WORD MF 2	PHA_4 WORD MF 2	PHA_4 WORD MF 2
11	RATE WORD 5 MF 2	PHA_5 WORD MF 2	PHA_5 WORD MF 2	PHA_5 WORD MF 2
13	PHA_5 WORD MF 2	RATE WORD 6 MF 2	PHA_6 WORD MF 3	PHA_6 WORD MF 3
15	PHA_6 WORD MF 3	PHA_6 WORD MF 3	RATE WORD 7 MF 3	RATE WORD 8 MF 3
17	PHA_7 WORD MF 3	PHA_7 WORD MF 3	PHA_7 WORD MF 3	PHA_7 WORD MF 3
19	RATE WORD 9 MF 3	PHA_8 WORD MF 3	PHA_8 WORD MF 3	PHA_8 WORD MF 4
21	PHA_8 WORD MF 4	RATE WORD 10 MF 4	PHA_9 WORD MF 4	PHA_9 WORD MF 4
23	PHA_9 WORD MF 4	PHA_9 WORD MF 4	RATE WORD 11 MF 4	PHA_{10} WORD MF 4
25	PHA_{10} WORD MF 4	PHA_{10} WORD MF 4	PHA_{10} WORD MF 4	RATE WORD 12 MF 4
THE ABOVE STRUCTURE IS REPEATED 19 MORE TIMES TO COMPLETE THE RECORD OF 520 32-BIT WORDS				

Figure 3.1-6 CRS Science Data Block Format (GS,OC-1)

Table 3.1-2 CRS EDR Science Data Block Table (GS,OC-1)

Item	Word	Bits	Description	
1	1	31-16	PHA_1 word	MF 1
2	1	15-0	PHA_1 word	MF 1
3	2	31-16	PHA_1 word	MF 1
4	2	15-0	PHA_1 word	MF 1
5	3	31-16	RATE word 1	MF 1
6	3	15-0	RATE word 2	MF 1
7	4	31-16	PHA_2 word	MF 1
8	4	15-0	PHA_2 word	MF 1
9	5	31-16	PHA_2 word	MF 1
10	5	15-0	PHA_2 word	MF 1
11	6	31-16	RATE word 3	MF 1
12	6	15-0	PHA_3 word	MF 1
13	7	31-16	PHA_3 word	MF 1
14	7	15-0	PHA_3 word	MF 2
15	8	31-16	PHA_3 word	MF 2
16	8	15-0	RATE word 4	MF 2
17	9	31-16	PHA_4 word	MF 2
18	9	15-0	PHA_4 word	MF 2
19	10	31-16	PHA_4 word	MF 2
20	10	15-0	PHA_4 word	MF 2
21	11	31-16	RATE word 5	MF 2
22	11	15-0	PHA_5 word	MF 2
23	12	31-16	PHA_5 word	MF 2
24	12	15-0	PHA_5 word	MF 2
25	13	31-16	PHA_5 word	MF 2
26	13	15-0	RATE word 6	MF 2
27	14	31-16	PHA_6 word	MF 3
28	14	15-0	PHA_6 word	MF 3
29	15	31-16	PHA_6 word	MF 3
30	15	15-0	PHA_6 word	MF 3
31	16	31-16	RATE word 7	MF 3

Table 3.1-2 CRS EDR Science Date Block Table (contd)

Item	Word	Bits	Description
32	16	15-0	RATE word 8 MF 3
33	17	31-16	PHA_7 word MF 3
34	17	15-0	PHA_7 word MF 3
35	18	31-16	PHA_7 word MF 3
36	18	15-0	PHA_7 word MF 3
37	19	31-16	RATE word 9 MF 3
38	19	15-0	PHA_8 word MF 3
39	20	31-16	PHA_8 word MF 3
40	20	15-0	PHA_8 word MF 4
41	21	31-16	PHA_8 word MF 4
42	21	15-0	RATE word 10 MF 4
43	22	31-16	PHA_9 word MF 4
44	22	15-0	PHA_9 word MF 4
45	23	31-16	PHA_9 word MF 4
46	23	15-0	PHA_9 word MF 4
47	24	31-16	RATE word 11 MF 4
48	24	15-0	PHA_{10} word MF 4
49	25	31-16	PHA_{10} word MF 4
50	25	15-0	PHA_{10} word MF 4
51	26	31-16	PHA_{10} word MF 4
52	26	15-0	RATE word 12 MF 4
			(The structure shown above is repeated 19 more times to complete the block of 520 32-bit words.)

APPENDIX C

STANDARD EDR HEADER FORMAT

The Standard Record Header described in the following pages is designed to be utilized as the record header for all physical records written to and EDR tape.

Part A of this section describes the Standard Record Header to be written as part of every GS, OC, and IM derived science record. The contents and record structure are described in Figure C-1 and Table C-1.

Part B of this section describes the Standard Record Header to be written as part of every CR-6 derived science record. The contents and record structure are described in Figure C-2 and Table C-2.

Part C of this section describes the Standard Record Header to be written as part of every Engineering record. The contents and record structure are described in Figure C-3 and Table C-3.

Part D of this section describes the Standard Record to be written as part of every CR-2 derived science record. The contents and structure are described in Figure C-4 and Table C-4.

Part E of this section describes the Standard Record to be written as part of every Monitor record. The contents and structure are described in Figure C-5 and Table C-5.

Part F of this section describes the Standard Record to be written as part of every CR-1 derived science record. The contents and structure are described in Figure C-6 and Table C-6.

Part G of this section describes the Standard Record to be written as part of every CR-1 derived science record. The contents and structure are described in Figure C-7 and Table C-7.

For interpretation of day number and hour of day from hour of year, divide the number of hours by 24. The whole number is the day, the remainder is the hour of that day.

Examples:

36 Hours

```
   1
24/36 = Day 1, Hour 12 - Jan 1, 12 PM
   24
   12
```

3500 Hours

```
   145
24/3500 = Day 145, Hour 20 - May 25, 8 PM
   24
   110
    96
   140
   120
    20
```

PART A (GS, OC, IM)

Standard Record Header for extracted data from data modes GS-2, GS-3, GS-4, OC-1, IM-1 thru IM-12, PB-1, PB-2, and PB-3. If the source data for PB-4 and PB-5 was one of the above, then this record header will be used.

NOTE: Data Presence and Golay Correction Flags.

1) GS Type Records:
A pair of 8-bit words appear in the standard header for each minor frame (160 per 80 MF record). Ths first word is used to indicate data presence, the second indicates Golay correction. Only the 5 LSB bits are significant. Each of the 5 bits corresponds to one of the five 432-bit segments that constitute one GS type MF (extracted).

The bit assignments are:

BIT	BITS OF MF REPRESENTED
4	1 - 432
3	433 - 864
2	865 - 1296
1	1297 - 1728
0	1729 - 2160
5, 6, 7	Spares (=0)

The bit definitions are:

For data presence	1 = filler data
	0 = data present
For Golay Correction	1 = Golay corrected
	0 = Not Golay corrected

For non-segmented (non-extracted) GS type data, all the bits in the word are "ganged" together and set to one value (0 or 1).

2) Non-Golay Type Records:
Only data presence words are available and are defined as above for non-segmented GS type data. All bits are "ganged" and set to 0 or 1. The unused bits (Golay words in GS type records) are blocked as filler bits following the data presence words.

EDR DATA WORD	BIT 31–24	23–16	15–8	7–0	31–24	23–16	15–8	7–0
1	PROJECT IDENTIFICATION		REC. ID	S/C ID	PHYSICAL RECORD NUMBER		S/C DATA MODE	A, B, SPARE
3	STARTING ERT HOUR OF CURRENT YEAR		STARTING ERT SECOND OF CURRENT HR.		STARTING ERT MILLISECOND OF CURR SEC		YEAR	C, D, SEG. NO.
5	ENDING ERT HOUR OF CURRENT YEAR		ENDING ERT SECOND OF CURRENT HOUR		ENDING ERT MILLISECOND OF CURR SEC		YEAR	SOFTWARE VERSION
7	SCET HOUR OF CURRENT YEAR		SCET SECOND OF CURRENT HOUR		SCET MILLISECOND OF CURR SEC		YEAR	SCE FLAG, FDSC CORR FLAG
9	MOD 2^{16} COUNT		MOD 60 COUNT	LINE COUNT		DOWNLINK TLM RATE	EFFECTIVE EXPERIMENT BIT RATE	FID
11	BET	DSN CONFIG	GROUND RECEIVER AGC		DSN STATION	SPARE	PN EBEC	
13	SYMBOL SNR		DECODER SNR		PHYSICAL RECORD NO. OR UNUSED		DQSW *MF 17 - MF 24 MF 1 - MF 8	
15	DQSW *MF 25 - MF 32 MF 9 - MF 16		DQSW *MF 33 - MF 40 MF 17 - MF 24		DQSW *MF 41 - MF 48 MF 25 - MF 32		DQSW *MF 49 - MF 56 MF 33 - MF 40	
17	DQSW *MF 57 - MF 64 MF 41 - MF 48		DQSW *MF 64 - MF 72 MF 49 - MF 56		DQSW *MF 73 - MF 80 MF 57 - MF 64		DQSW *MF 1 - MF 8 MF 65 - MF 72	
19	DQSW *MF 9 - MF 16 MF 73 - MF 80		DPI *MF 17 MF 1	GCI *MF 17 MF 1	DPI *MF 18 MF 2	GCI *MF 18 MF 2	DPI *MF 19 MF 3	GCI *MF 19 MF 3
⋮	... ...							
59	DPI *MF 16 MF 80	GCI *MF 16 MF 80	IRIS DPI MF 17	IRIS GCI MF 17	DRS DATA TYPE	GOLAY CORRECTION BEC	GOLAY BIT ERROR SUMMATION	

A = Engineering Flag
B = S/C Playback Flag
C = Data Source
D = Golay Encoded Flag

* These fields require a special minor frame definition for IRIS and ENG EDRS

Figure C-1. Standard Experiment Data Record Header

Revision D

(GS, OC, IM)

Table C-1.

Standard

Experiment Data Record Header

Item	Word	Bits	Description
1	1	31-8	Project Identification - Identifies this tape as being written by the MJS77 project. The letters M, J, and S will be written in EBCDIC. HEX: D4, D1, E2
2	1	7-4	Record Identification - Identifies which experiment and data subgroup to which this record pertains. 0000 = Spare 0001 = CRS Science Record 0010 = IRIS (Unused in CR Modes) 0011 = LECP Science Record 0100 = MAG Science Record 0101 = PLS Science Record 0110 = PPS Science Record 0111 = PRA Science Record 1000 = PWS Science Record 1001 = UVS Science Record 1010 = RSS Science Record 1011 = Engineering Record (DQSW = ZEROs) 1100 = Unused 1101 = Imaging Status Record (DQSW = ZEROs) 1110 = Monitor Record (DQSW = ZEROs) 1111 = Decommutation Map Record (DQSW = ZEROs)
3	1	3-0	Spacecraft Identification - Identifies the spacecraft transmitting this data. 0000 = Flt 2 0001 = Flt 1 0010 = PTM 0011 = Unknown 0100 = SIM 1 (S/C 41) 0101 = SIM 2 (S/C 42) 0110 = } Unused 1111 = }

Table C-1
Standard
Experiment Data Record Header

Item	Word	Bits	Description
4	2	31-16	Physical Record Number - Sequential binary count of all physical records written on this EDR tape. The count is incremented by one after each successful write. This number is initially set to one (1).
5	2	15-8	Data Mode - Contains the telemetry format with respect to data content and data rate. 00_{16} = Engineering Zero - (See FID) 01_{16} = CR-2 02_{16} = CR-3 03_{16} = CR-4 04_{16} = CR-5 05_{16} = CR-6 06_{16} = Unused 07_{16} = CR-1 08_{16} = Unused 09_{16} = IM-7 $0A_{16}$ = GS-3 $0B_{16}$ = IM-9 $0C_{16}$ = PB-3 $0D_{16}$ = PB-2 $0E_{16}$ = PB-1 $0F_{16}$ = GS-4 10_{16} = Unused 11_{16} = GS-2 12_{16} = IM-14 13_{16} = Unused 14_{16} = IM-12 15_{16} = IM-11 16_{16} = IM-10 17_{16} = OC-1 18_{16} = IM-8

Table C-1

Standard (GS, OC, IM)

Experiment Data Record Header

Item	Word	Bits	Description
5	2	15-8	19_{16} = Unused $1A_{16}$ = IM-6 $1B_{16}$ = IM-5 $1C_{16}$ = IM-4 $1D_{16}$ = IM-3 $1E_{16}$ = IM-2 $1F_{16}$ = IM-13
6	2	7-6	Engineering Extraction Flag - Identifies whether the engineering data was extracted out of another data stream or was the primary data stream. 00 = stand-alone 11 = extracted
7	2	5	S/C Playback - Indicates that the data in this record is Spacecraft tape recorder playback data. 0 = no 1 = yes This flag is set only for data extracted from PB-1, PB-2, and PB-3 telemetry mode data.
8	2	4-0	Spare Starting Earth Received Time - Greenwich Mean Time (GMT) of the first PN bit of the first minor frame (MF) and contained in this record from which this record's prime data is extracted. Binary representation will be used.
9	3	31-16	Hour of Current Year - Binary hours since the beginning of the current year. See last paragraph Page C-2
10	3	15-0	Seconds of Current Hour - Binary seconds since the beginning of current hour.

Table C-1.
Standard
Experiment Data Record Header

Item	Word	Bits	Description
11	4	31-16	<u>Milliseconds of Current Second</u> - Binary milliseconds.
12	4	15-8	<u>Year</u> - Binary year (i.e., 77, 78).

Standard

Experiment Data Record Header

Item	Word	Bits	Description
13	4	7-6	Data Source - Contains information as to whether the data was derived from an IDR or Multiple Wide Band data (which indicates that the data was logged at the station and then transmitted to JPL from the log tapes). 00_2 = Unused 01_2 = Real-Time 10_2 = IDR 11_2 = Replay
14	4	5-4	Golay Encoded Flag - Indicates that the data in this record have been Golay coded for transmission to Earth and decoded upon Receipt at Earth, so any corrections will be flagged in the header of this record. 00_2 = Not Golay Decoded 01_2 = Golay Decoded 10_2 = Unused 11_2 = Unused
15	4	3-0	Segment Number - Other than those in the table below are zeros:

INSTRUMENT/ DATA MODE	SEG NO.	SEGS WITH MFs	MOD60 COUNT
PPS/OC-1	1	1-20	
	2	21-40	
	3	41-60	
	4	61-80	
PPS/CR-1,2&GS	1		0,5,10....55
	2	GS=1-80	1,6,11....56
	3	CR-1=1-80	2,7,12....57
	4	CR2=1-40	3,8,13....58
	5		4,9,14....59
PWS/CR-6	1	1-50	
	2	51-100	
	3	101-150	

Standard (GS, OC, IM)

Experiment Data Record Header

INSTRUMENT/ DATA MODE	SEG NO.	SEGS WITH MFs	MOD60 COUNT
LECP/CR-1, 2	1	CR-1=1-80	Even
	2	CR-2=1-40	Odd
LECP/CR-6	1	1-75	
	2	76-150	
MAG/CR-6	1	1-75	
	2	76-150	
CRS/CR-6	1	1-30	
	2	31-60	
	3	61-90	
	4	91-120	
	5	121-150	
UVS/GS	1	1-80	Even
	2	1-80	Odd
UVS/OC-1	1	1-8	
	2	9-16	
	3	17-24	
	4	25-32	
	5	33-40	
	6	41-48	
	7	49-56	
	8	57-64	
	9	65-72	
	10	73-80	
PLS/CR-6	1	1-75	
	2	76-150	
IRIS/GS	1	17-17	0,3,6....57
(if 144	2	17-17	1,4,7....58
Sec. Scan)	3	17-17	2,5,8....59

Item	Word	Bits	Description
			Ending Earth Received Time - GMT of the first bit of the last MF that is received and contained in this record from which this record's prime data is extracted.
16	5	31-16	Hour of Current Year - Binary hours since the beginning of the current year. See last par. page C-2.
17	5	15-0	Seconds of Current Hour - Binary seconds since the beginning of the current hour.
18	6	31-16	Millisecond of Current Second - Binary milliseconds.
19	6	15-8	Year - Binary year (i.e., 77, 78).

Item	Word	Bits	Description
20	6	7-0	Software Version - Contains identification (in binary) of the software system operating in the computer string which created the current record. Spacecraft Event Time - Greenwich Mean Time (GMT) that corresponds to the Spacecraft Time of the first MF from which this records prime data was extracted, in Binary representation. The format is as follows:
21	7	31-16	Hour of Current Year - Binary hours since the beginning of the current year. See Last paragraph Page C-2
22	7	15-0	Seconds of Current Hour - Binary number of seconds since the beginning of the current hour.
23	8	31-16	Milliseconds of Current Second - Binary milliseconds.
24	8	15-8	**Year** - Binary year (i.e., 77,78).
25	8	7-4	Spacecraft Event Time Flag -0=input by NORT file. 1=input by EDR PROC. Either all 0's or all 1's
26	8	3-0	FDSC Correction Flag - Indicates that FDSC has been corrected in some manner. (Binary) There is one bit for MOD 2, one for MOD 60 and one for line counts also. (1=corrected, 0=OK) 3=Spare. 2=MOD 2. 1=MOD 60. 0=L.C.
27	9	31-16	MJS MOD 2^{16} Count Word - Contains the 16-bit MM subcom time word for this record. Is incremented every 48-minutes.
28	9	15-8	MJS MOD 60 Count Word - Contains the module 60-spacecraft time as created within the FDS for the first minor frame received that is contained in this record. Increments every 48-seconds.
29	9	7-0	MJS Line Count Word - Contains the ISS line count which ranges between 1 and 800. Increments every 0.06 second.
30	10	31-24	
31	10	23-16	Downlink Telemetry Rate - Contains the rate at which the MJS spacecraft transmitted the telemetry data to earth. (i.e., 40 to 115,200 bits/second). (Binary Code) 00_{16} = Unused 01_{16} = 10 BPS 02_{16} = 20 BPS

Table C-1
Standard
Experiment Data Record Header

GS, OC, IM)

Item	Word	Bits	Description
32	10	23-16	03_{16} = 40 BPS; 04_{16} = 80 BPS; 05_{16} = 160 BPS; 06_{16} = 320 BPS; 07_{16} = 640 BPS; 08_{16} = 1200 BPS; 09_{16} = 1280 BPS; $0A_{16}$ = 2560 BPS; $0B_{16}$ = 7200 BPS; $0C_{16}$ = 19,200 BPS; $0D_{16}$ = 21,600 BPS; $0E_{16}$ = 29,866 2/3 BPS; $0F_{16}$ = 44,800 BPS; 10_{16} = 67,200 BPS; 11_{16} = 89,600 BPS; 12_{16} = 115,200 BPS; 13_{16} = 33,600 BPS; 14_{16} = 57,600 BPS
33	10	15-8	Effective Rate - Contains the effective bit rate of this data within the downlink telemetry rate. (Refer to downlink telemetry rate code)
34	10	7-0	FID-Format ID word used only for Engineering record (Extracted from telemetry data stream) Bits 7 & 6 Format Type 0 0 Engineering without AACS Memory Readout 0 1 Engineering with AACS Memory Readout 1 0 Imaging/Playback 1 1 GS & E Bits 5 & 4 Engineering Data Rate (bps) 0 0 10 0 1 40 1 0 1200 1 1 7200 (1200 recorded) Bits 3,2,1 Engineering Data Mode 0 0 0 Launch 0 0 1 Cruise 0 1 0 Encounter 0 1 1 TCM 1 0 0 Special 1 0 1 Science Maneuver 1 1 0 CCS Memory Readout 1 1 1 FDS Memory Readout Bit 0 Spacecraft ID 1 = FLT 1 0 = FLT 2

Table C-1

Standard (GS, OC, IM)

Expriment Data Record Header

Item	Word	Bit	Description
35	11	31-24	Bit Error Tolerance (BET) - Contains the PN bit error tolerance during frame synchronization. (Binary)
36	11	23-16	<u>DSN Equipment Configuration</u>- Contains the latest status of any change in station equipment configuration during the time corresponding to the first MF received in this record. BIT 23-21 = RECIVER (23=MSB) 001 = #1 010 = #2 011 = #3 100 = #4 BIT 20-18 = SUBCARRIER DEMODULATOR (SDA)(20=MSB) 001 = #1 010 = #2 011 = #3 100 = #4 BIT 17-16 = TELEMETRY PROCESSOR (TPA) (17=MSB) 00 = Telemetry Processor (TPA) #1, Symbol Synchronizer (SSA) #1 (TPA #3 at conjoint station) 01 = TPA #1 (or 3), SSA #2 10 = TPA #2, SSA #3 11 = TPA #2, SSA #4

Table C-1

Standard (GS, OC, IM)

Experiment Data Record Header

Item	Word	Bits	Description
37	11	15-0	Receiver Automatic Gain Control (AGC) - Contains the AGC extracted from the GCF block from which the first minor frame received was derived. (Binary)
38	12	31-24	DSN Station Number - Contains the identification number of the DSN station originating the data contained in the first minor frame received of this record. (Binary)
39	12	23-16	Spare
40	12	15-0	Estimated Bit Error Count(EBEC)-Count of the number of bits in error, looking at the first 64 bits of each prime MF over N number of frames. The count resets upon frame time domain or DSS change. Placed in header on LAD basis. Frame Time — Expected Frame Accumulated .06 Sec — 15625 .4,.6,1.2,2.4,4.8 — 1562 9.6,12.0,19.2 — 156
41	13	31-16	Symbol Signal-to-Noise Ratio (SNR) - Contains the symbol SNR extracted from the GCF block from which the first minor frame received was derived. (Binary)
42	13	15-0	Decoder SNR - Bit Error Rate out of the Data Decoder Assembly.
43	14	31-16	Physical Record Number A. For individual EDRs: Unused (set to zeros) B. For combined EDRs: Physical Record number in binary.
44	14	15-8	DQSW Data Quality Status Word for MF-1 through MF-8. For IRIS see page C-16 Station Lock Status Bit 15 = Unused Bit 14 = Unused Bit 13 = Unused Bit 12 = Receiver Bit 11 = SDA Bit 10 = SSA Bit 9 = MCD Bit 8 = TPA

Table C-1.
Standard
Experiment Data Record Header

Item	Word	Bits	Description
45	14	7-0	Data Quality Indicators Bit 7 = Unused Bit 6 = Unused Bit 5 = Unused Bit 4 = PN Error Outside BET (0=none, 1=bit errors exceed BET) Bit 3 = PN Error Within BET (0=none, 1=bit errors) Bit 2 = SPARE Bit 1 = Valid Data Flag (0=valid, 1=no data) Bit 0 = GCF Block Error (0=no, 1=yes)
46	15	31-16	DQSW for MF9-MF16
47	15	15-0	DQSW for MF17-MF24
49	16	31-16	DQSW for MF25-MF32
49	16	15-0	DQSW for MF33-MF40
50	17	31-16	DQSW for MF41-MF48
51	17	15-0	DQSW for MF49-MF56
52	18	31-16	DQSW for MF57-MF64
53	18	15-0	DQSW for MF65-MF72
54	19	31-16	DQSW for MF73-MF80
55-216	19-59	Descrip. follows	Data Presence and Golay Correction Indicators Two 8 bit fields to indicate Data Presence and Golay Correction are supplied for each of the 80* MF contained in this record. The low order 5 bits in an 8-bit field indicate[1] a) Data Presence (1=filler, 0=data) or b) Golay Correction (1=corrected, 0= not corrected) for 1 segment of the GS MF and are defined as: BIT POSITION (7-0, left to right) — BITS IN GS MF BEING FLAGGED 4 — 1-432 3 — 433-864 2 — 865=1296 1 — 1297-1728 0 — 1729-2160

* for IRIS see Page C-17

[1] For non-segmented data, the entire byte is set to one value.

Table C-1.

Standard (GS, OC, IM)

Experiment Data Record Header

Item	Word	Bits	Description
55	19	15-8	Data Presence Indicators for MF-1
56	19	7-0	Golay Correction Indicators for MF-1
⋮	⋮	⋮	⋮
213	59	31-24	Data Presence Indicators for MF-80 (for IRIS = MF-16)
214	59	23-16	Golay Correction Indicators for MF-80
215	59	15-8	Data Presence Indicators for IRIS = MF-17
216	59	7-0	Golay Correction Indicators for IRIS = MF-17
217	60	31-24	DRS Data Type - Numbers are in HEX IRIS = 20 ISR = 29 CRS = 21 DCOM = 2A LECP = 22 MONITOR = 2B MAG = 23 DCMS = 2C PLS = 24 ENGE = 2D PPS = 25 ENGS = 2E PRA = 26 PWS = 27 UVS = 28
218	60	23-16	Golay Correction Bit Error Count-Count of PN errors in a 48 sec. period (80 MF) which are in error. Maximum count displayed will be 255.
219	60	15-0	Golay Bit Error Summation - total number of bits modified by the Golay Correction algorithm during a major frame.

Appendix C

THE VOYAGER COSMIC RAY TELESCOPE DATA COLLECTION SYSTEM

There are 30 24-bit binary rate counters on the Voyager-1 and -2 spacecraft. Counters R1 to R8 are used to accumulate data from the first HET telescope, and counters R9 to R16 are used to accumulate data from the second HET. Table C1 indicates what rate information is accumulated by each of the counters for various telemetry subcom states. A definition of the various symbols used in Table C1 is given in Table C2. Also shown in Table C1 and C2 is the information accumulated by LET-A (see counters R17, R18, and R25), LET-B (see counters R19, R20, and R25), and the TET (see counters R28 to R30). Similar information for LET-C and LET-D is accumulated in counters R21 to R24 and R26. Note that counter R27 is used as a spare counter. From these tables, it can be seen that the system can detect 45 different coincidence/anticoincidence logic conditions corresponding to various particle types with separate energy windows and originating from various telescopes. Also, 56 different "singles" rates are sent which originate from only one detector.

The Voyagers also have eight 4096-channel pulse height analyzers (PHAs) for three parameter analysis of selected events. A group of three PHAs is referred to as a PHA block and is shared by the HET and two LETs. A second PHA block is shared by the other HET and the other two LETs. The final two PHAs are utilized by the TET. When data is to be sent to the ground, a polling system connected to each PHA block scans sequentially through eight event register positions (e.g., LET-SL* (also called LET-S1), LET-SL (also called LET-S2), TET, HET-AS (also called HET-S1), LET-SL*, LET-SL, HET-PS (also called HET-S2), and HET-PEN (also called HET-P), see next paragraph). When the polling system finds data, it holds that position until the data are read out and then advances to the next position. A block select system sends the information in the PHA data block if only one block has data, or it alternates between blocks if both have data. This polling system will more regularly record PHA events than the earlier Pioneer system which did not have a method for determining if a particular PHA register had data and, consequently, often sent zeros in the telemetry stream.

As mentioned earlier, various event register positions are recognized by the electronics including two stopping (AS and BS) and one penetrating (PEN). These events are described further in Tables C3 and C4. For the HET telescopes, event type AS (i.e., S1) represents particles which enter through detectors A1 and A2, but do not exit through the guards, G, or detector C4. BS (i.e., S2) events are stopping particles which enter the B side and PEN (i.e., P) type events penetrate detectors B1 and B2 and the complete C detector stack. Similar event register positions are used for pulse height analysis of the LET and TET systems. Each event type is stored in a 48-bit register dedicated to that event type. Each polling block has five registers. The TET system has one register that may be sampled by either polling block. Between readouts, the polling system scans the event registers in the sequence LETSL*, LETSL, HETAS, HETBS, LETSL*, LETSL, HETPEN, TET, stopping only at a full register. The block select system toggles alternately between blocks if both have data available or selects data from the appropriate block if only one has data. If both blocks are empty, 48 zeros are read out. The format of the 48-bit word used for PHA events is shown in Table C5. To understand this format, one needs to know the definition of the PHA tag word shown in Table C6, and the detector elements which are read out during a HETAS, HETBS, HETP, LET, or TET PHA event shown in Table C7. (Note: In Table C7 the symbol LA3 means detector LET-A, element L3 and the symbol LB3 means detector LET-B, element L3. Other symbols have been defined previously).

Rate table

SB	R1	R2	R3	R4	R5	R6	R7	R8	R17	R18	R19	R20	R25	R28	R29	R30
0	ASZ3	BSZ2	PEN	PG	BS4Z2	BS3Z2	BS2Z2	A1	LAZ3*	LAZ3	LBZ3*	LBZ3	LA1	TAN	TLO	D6L
1	ASZ3	BSZ2	PEN	PG	BS4Z2*	BS3Z2*	BS2Z2*	A2	LAZ3*	LAZ3	LBZ3*	LBZ3	LA2	TAN	THI	GA + GB
2	ASZ3	BSZ2	PEN	PG	BS4Z2	BS3Z2	BS2Z2	C1	LAZ3*	LAZ3	LBZ3*	LBZ3	LA3	TAN	TLO	D5H
3	ASZ3	BSZ2	PEN	PG	BS4Z2*	BS3Z2*	BS2Z2*	C2	LAZ3*	LAZ3	LBZ3*	LBZ3	LA4	TAN	THI	D7L
4	ASZ3	BSZ2	PEN	PG	BS4Z2	BS3Z2	BS2Z2	B1	LAZ3*	LAZ3	LBZ3*	LBZ3	LASL	TAN	TLO	D6H
5	ASZ3	BSZ2	PEN	PG	BS4Z2*	BS3Z2*	BS2Z2*	SA1	LAZ3*	LAZ3	LBZ3*	LBZ3	LBSL	TAN	THI	D7H
6	ASZ3	BSZ2	PEN	PG	BS4Z2	BS3Z2	BS2Z2	SA2	LAZ3*	LAZ3	LBZ3*	LBZ3	LATRP	TAN	TLO	D5L
7	ASZ3	BSZ2	PEN	PG	BS4Z2*	BS3Z2*	BS2Z2*	SB	LAZ3*	LAZ3	LBZ3*	LBZ3	LBTRP	TAN	THI	D8L
8	ASZ3	BSZ2	PEN	PG	BS4Z2	BS3Z2	BS2Z2	C3	LAZ3*	LAZ3	LBZ3*	LBZ3	LB1	TAN	TLO	D1H
9	ASZ3	BSZ2	PEN	PG	BS4Z2*	BS3Z2*	BS2Z2*	C4	LAZ3*	LAZ3	LBZ3*	LBZ3	LB2	TAN	THI	D4H
10	ASZ3	BSZ2	PEN	PG	BS4Z2	BS3Z2	BS2Z2	B2	LAZ3*	LAZ3	LBZ3*	LBZ3	LB3	TAN	TLO	D2L
11	ASZ3	BSZ2	PEN	PG	BS4Z2*	BS3Z2*	BS2Z2*	G1	LAZ3*	LAZ3	LBZ3*	LBZ3	LB4	TAN	THI	D3L
12	ASZ3	BSZ2	PEN	PG	BS4Z2	BS3Z2	BS2Z2	B1	LAZ3*	LAZ3	LBZ3*	LBZ3	LASL	TAN	TLO	D1L
13	ASZ3	BSZ2	PEN	PG	BS4Z2*	BS3Z2*	BS2Z2*	SA1	LAZ3*	LAZ3	LBZ3*	LBZ3	LBSL	TAN	THI	D3H
14	ASZ3	BSZ2	PEN	PG	BS4Z2	BS3Z2	BS2Z2	SA2	LAZ3*	LAZ3	LBZ3*	LBZ3	LATRP	TAN	TLO	D2H
15	ASZ3	BSZ2	PEN	PG	BS4Z2*	BS3Z2*	BS2Z2*	SB	LAZ3*	LAZ3	LBZ3*	LBZ3	LBTRP	TAN	THI	D4L
16	AS	BSp	PEN	PG	BS4p	BS3p	BS2p	A1	LAZ3*	LAZ3	LBZ3*	LBZ3	LA1	TAN	TLO	D6L
17	AS	BSp	PEN	PG	BS4e	BS3e	BS2e	A2	LAZ3*	LAZ3	LBZ3*	LBZ3	LA2	TAN	THI	GA + GB
18	AS	BSp	PEN	PG	BS4p	BS3p	BS2p	C1	LAZ3*	LAZ3	LBZ3*	LBZ3	LA3	TAN	TLO	D5H
19	AS	BSe	PEN	PG	BS4e	BS3e	BS2e	C2	LAZ3*	LAZ3	LBZ3*	LBZ3	LA4	TAN	THI	D7L
20	AS	BSp	PEN	PG	BS4p	BS3p	BS2p	B1	LAZ3*	LAZ3	LBZ3*	LBZ3	LASL	TAN	TLO	D6H
21	AS	BSp	PEN	PG	BS4e	BS3e	BS2e	SA1	LAZ3*	LAZ3	LBZ3*	LBZ3	LBSL	TAN	THI	D7H
22	AS	BSp	PEN	PG	BS4p	BS3p	BS2p	SA2	LAZ3*	LAZ3	LBZ3*	LBZ3	LATRP	TAN	TLO	D5L
23	AS	BSe	PEN	PG	BS4e	BS3e	BS2e	SB	LAZ3*	LAZ3	LBZ3*	LBZ3	LBTRP	TAN	THI	D8L
24	AS	BSp	PEN	PG	BS4p	BS3p	BS2p	C3	LAZ3*	LAZ3	LBZ3*	LBZ3	LB1	TAN	TLO	D1H
25	AS	BSp	PEN	PG	BS4e	BS3e	BS2e	C4	LAZ3*	LAZ3	LBZ3*	LBZ3	LB2	TAN	THI	D4H
26	AS	BSp	PEN	PG	BS4p	BS3p	BS2p	B2	LAZ3*	LAZ3	LBZ3*	LBZ3	LB3	TAN	TLO	D2L
27	AS	BSe	PEN	PG	BS4e	BS3e	BS2e	G1	LAZ3*	LAZ3	LBZ3*	LBZ3	LB4	TAN	THI	D3L
28	AS	BSp	PEN	PG	BS4p	BS3p	BS2p	B1	LAZ3*	LAZ3	LBZ3*	LBZ3	LASL	TAN	TLO	D1L
29	AS	BSp	PEN	PG	BS4e	BS3e	BS2e	SA1	LAZ3*	LAZ3	LBZ3*	LBZ3	LBSL	TAN	THI	D3H
30	AS	BSp	PEN	PG	BS4p	BS3p	BS2p	SA2	LAZ3*	LAZ3	LBZ3*	LBZ3	LATRP	TAN	TLO	D2H
31	AS	BSe	PEN	PG	BS4e	BS3e	BS2e	SB	LAZ3*	LAZ3	LBZ3*	LBZ3	LBTRP	TAN	THI	D4L

SB = Subcom state = S1 + 2.S2 + 4.S3 +8.S4 + 16.S5   S5 = HG
Rate table is for AUTO mode. When CRS is commanded to HG or HG* mode only the bottom or top half is read out.
Note that there are actually two high gain bits.

Table C1 - Voyager Rate Telemetry Information

HET 5) Rates and Analysis

HET 1 is described; HET 2 is similar.

Name	Accum Number	Gain (S5)	Subcom State (S1 - S4)	Simplified Logic Equation	Description
AS	R1	HG	all	A1.A2.C4*.G1*	All nuclei of appropriate range, 0.15 to 15.3 mm Si nominal. Electrons eliminated by thin A detectors.
ASZ3	R1	LG	all	A1.A2.SA.C4*.G3*	All nuclei of Z>=3 of appropriate range, 0.15 to 15.3 mm Si nomir Z<3 eliminated by slant, SA.
BSZ2	R2	LG	all	B1.B2.SB.C1*.G3*	All nuclei of Z>=2 of appropriate range, 2 to 22 mm Si nominal. Electrons, Z=1 eliminated by slant, SB.
BSp	R2	HG	S1=0 or S2=0 (3/4)	B1.B2.SB.C1*.G1*	All nuclei of appropriate range, 2 to 22 mm Si nominal.
BSe	R2	HG	S1=S2=1 (1/4)	B1.B2.C4.SB*.C1*.G1*	Electrons of appropriate range, 4 to 22 mm Si nominal. Nuclei eliminated by slants.
PEN	R3	both	all	B1.B2.C1	All particles of range greater than 22 mm Si nominal.
PG	R4	both	all	PEN.G1*	Same as PEN, but some heavies lost due to knock-ons and cross-ta in guards.
BS4Z2*	R5	LG	odd (S1=1)	B1.B2.C4.C3*.SB*.G1*	Protons of appropriate range, 4 to 10 mm. Z>=2 eliminated by sl Most electrons eliminated by high thresholds on B1 and B2.
BS4Z2	R5	LG	even (S1=0)	B1.B2.C4.C3*.SB.G1*	Z>=2 of appropriate range, 4 to 10 mm.
BS4e	R5	HG	odd	B1.B2.C4.C3*.SB*.G1*	Electrons of 4 to 10 mm. Nuclei eliminated by slant.
BS4p	R5	HG	even	B1.B2.C4.C3*.SB.G1*	Nuclei of 4 to 10 mm. Electrons eliminated by slant.
BS3Z2* BS3Z2 BS3e BS3p	R6	as above		- - C4.C3.C2* - -	As above, except nominal range of 10 to 16 mm Si.
BS2Z2* BS2Z2 BS2e BS2p	R7	as above		- - C4.C3.C2.C1* - -	As above, except nominal range of 16 to 22 mm Si.

Analysis is tied to rates R1, R2, and R3. Buffers are called HET AS, HET BS, and HET P.
Following table shows name of analysis requirement as function of gain, subcom state, and buffer.

Gain	Subcom State \ Buffer	HET AS	HET BS	HET P
LG	all	ASZ3	BSZ2	PEN
HG	S1=0 or S2=0	AS	BSp	PEN
HG	S1=S2=1	AS	BSe	PEN

LET 5) Rates and Analysis

LET A is described; LET's B, C, and D are similar.

Name	Accum Number	Subcom State (S1-S4)	Simplified Logic Equation	Description
LAZ3*	R17	all	L1.L2.L3.SL*.L4*	Z<3 of appropriate range, 70 to 520 microns Si nominal.
LAZ3	R18	all	L1.L2.L3.SL.L4*	Z>=3 of appropriate range, 70 to 520 microns Si nominal.
LATHP	R25	6 & 14	L1.L2.L3.L4*	Nuclei of appropriate range, 70 to 520 microns Si nominal.

LAZ3* causes analysis and events are stored in buffer LET SL*.
LAZ3 causes analysis and events are stored in buffer LET SL.

Note that R17 and R18 are subject to modification by the command system; R25 is not.

TET 5) Rates and Analysis

Name	Accum Number	Subcom State (S1-S4)	Simplified Logic Equation	Description
TAN	R28	all	W1.W2.D3.D8*.G*	Electrons of appropriate range. See nominal response curves.
TLO	R29	even (S1=0)	TAN.D5.D6*.UT*	Low energy electrons.
THI	R29	odd (S1=1)	TAN.D6.D7.UT*	High energy electrons.

TAN causes analysis. Events are stored in buffer called TET.

Table C2 - Definition of Symbols Used in Table C1

for HET, LET, and TET

HET TELESCOPE PARAMETERS

Event Type	Type of Analysis	Proton Energy Range (MeV)	Coincidence Condition	Detectors Analyzed	Geometry Factor (cm^2-ster)
S_1	dE/dx vs. E	4- 57	$A_1A_2\overline{C}_4\overline{G}$	$A_1, A_2, C_1+C_2+C_3$	1.0-1.7
S_2	dE/dx vs. E	18- 70	$B_1B_2\overline{C}_1\overline{G}$	$B_1, B_2, C_2+C_3+C_4$	0.9-1.7
P	Triple dE/dx	70-500	$B_1B_2C_1$	$B_1, C_1, C_2+C_3+C_4$	1.7

Table C3 - HET Telescope Parameters

LET TELESCOPE PARAMETERS
(SL = Slant Condition)

Type	Element	Energy Range (MeV/nuc)	Coincidence Condition	Detectors Analyzed	Geometry Factor (cm^2-sr)
S_1	$Z \leq 2$	H:3-8.4	$L1L2L3\overline{L4}$ $\overline{SL}$	L1,L2,L3	0.44
S_2	$Z \geq 3$	{ ^{16}O:5.3-17; ^{56}Fe:7.4-23 }	$L1L2L3\overline{L4}$ SL	L1,L2,L3	0.44

Table C4 - LET Telescope Parameters

Word format:

	1 — 12	13 — 24	25 — 36	37 — 48
HET/LET	TAG WORD	PHA3	PHA2	PHA1
TET	TAG WORD 1	TAG WORD 2	PHA2	PHA1

Table C5 - PHA Word Format

Tag Bits :	1	2	3	4	5	6	7	8	9	10	11	12
HET AS	C1	C2	C3	C4	slant	G2*	G1.G3*	HG	0	0	block	caution
HET BS,PEN	C1	C2	C3	C4	slant	G2*	G1.G3*	HG	0	1	block	caution
LET A/B	slant	L3	L2	LB1	DLA2	DLB3	DLB2	DLA3	1	0	block=0	caution
LET C/D	slant	L3	L2	LD1	DLC2	DLD3	DLD2	DLC3	1	0	block=1	caution
TET (1)	D1L	D1H	D2L	D2H	D3L	D3H	D4L	D4H	1	1	0	caution
TET (2)	GA	GB	SD7/8	AD4L	D5L	D5H	D6L	D6H	D7L	D7H	D8L	GA + GB

Block = 0 for block I, 1 for Block II.

Caution flag = overflow in PHA or high gain/low gain switching in progress.

Table C6 - PHA Tag Word Definition

PHA Readout :

LET and HET

Sum	AS	BS	P	LET
A1 + LA3 + LB3	PHA3			PHA3
C2 + C3 + C4		PHA3	PHA3	
A2 + B2	PHA2	PHA2		
C1 + LA2 + LB2			PHA2	PHA2
C1 + C2 + C3	PHA1			
B1 + LA1 + LB1		PHA1	PHA1	PHA1

TET

D1	PHA1
D2	PHA2

Gain switching in HET is done with S5 after each 480 rate readouts when in AUTO mode.
High gain for S5 = 1

Table C7

Detector Readout During HET-AS, HET-BS, HET-P, LET and TET PHA Events

Appendix D
THE VOYAGER ENCYCLOPEDIA TAPE FORMAT

Each Voyager library consists of encyclopedias. The Encyclopedia is organized into volumes. Each volume is defined by a 15-minute interval that starts at an integral 15-minute boundary, (i.e., on the hour, 15 minutes after the hour, 30 minutes after the hour, and 45 minutes after the hour). The clock used for the purpose of determining time is the Universal time at the spacecraft. Each volume is assigned a unique number which is the number of 15-minute intervals elapsed since the start of calendar year 1977. A volume comprises an integral number of instrument subcom sequences, and therefore may contain experimental data for a time interval which differs from the time interval of the volume by as much as one subcom sequence. A volume begins with an identifying introduction and provides information regarding its contents. Following the introduction, there may be one or more chapters.

A chapter contains data obtained under the same instrument conditions (status, analog), and begins with an introduction. The introduction identifies the chapter and provides a general description of its contents, and the conditions that may have led to its creation. A chapter is terminated when either a change in experiment status occurs, or there is a gap in the data. The chapter introduction identifies the actual start-time and end-time of data included in the chapter. A number of verses follow the chapter introduction.

A verse contains all data of a specified type that was acquired with the time span covered by the chapter. Each verse begins with a preface that identifies the verse as belonging to a particular chapter of a given volume and describes the type of data contained in the verse. The data follows the preface in an appropriate format.

The formats of a Voyager encyclopedia , volume introduction, chapter introduction, and verse follow. Additional information on these formats is given in Tables 1 through 6, which are taken from the informal document entitled Library Organization, circulated by CSC in December 1976. Similar information for ISEE-3 Encyclopedia tapes can be found in Reference 9.

0.0 VOLUME INTRODUCTION

Byte	Length	Name	Description
0	1	VOCHPN	Chapter number (≡0)
1	1	VOVERN	Verse number (≡0)
2	1	EPV	Encyclopedia Program Version
3	1	SCID	Satellite Identification
4	4	VOVOLN	Volume number
8	6	EPDT	Encyclopedia Program Date
8	2	EPYR	(Year - 1900)
10	2	EPMN	Month of year
12	2	EPDY	Day of month
14	6	VCDT	Volume Creation Date
14	2	VCYR	(Year - 1900)
16	2	VCMN	Month of year
18	2	VCDY	Day of month
20	10	VSTRT	Time of Volume (Start Time)
20	2	VSYR	(Year - 1900)
22	2	VSMN	Month of year
24	2	VSDY	Day of month
26	2	VSHR	Hour of day
28	2	VSMN	Minute of hour
30	2		Spare
→ 32	2	NMCHP	Number of chapters in the volume (may be zero)
→ 34	52	APRMV	Twenty-six 2-byte fields, one for each of the analog parameters, that define acceptable range of variation of the parameters. Byte 0 - minimum acceptable value; 1 - maximum acceptable value. For parameters for which a percentage change is acceptable, byte 0 is set =255, and byte 1 contains acceptable variation, in parts per 256.

Byte	Length	Name	Description
→ 86	8	CHSMC	Subject matter code for each of the chapters in the volume. One byte field identifies each of the chapters in the volume according to the following code: Bit 0 - 0-nominal conditions wrt status 1-other conditions wrt status 1 - 0-real data 1-calibration data 2 - 0-analog parameters within tolerance 1-unusual (perhaps unacceptable) values of analog parameters 3 - 0-no time gap 1-time gap in data 4 - 0-no change in mode 1-change in S/C data mode 5-7 Spare bits
→ 94	1	DQAON	Data quality acceptance ON mask
→ 95	1	DQAOF	Data quality acceptance OFF mask
→ 96-99	4		Spare

n.0 CHAPTER INTRODUCTION n≥1

Byte	Length	Name	Description
0	1	CHCHPN	Chapter Number (≥1)
1	1	CHVERN	Chapter Verse Number - 0
2	1		Spare
3	1	CCHSMC	Subject Matter Code
4	4	CHVOLN	Volume Number

Byte	Length	Name	Description
8	8	DTSTRT	Starting S/C time of data included
8	2	DTYR	Year - 1900
10	2	DTHR	Hour of year
12	2	DTSC	Second of hour
14	2	DTMSC	Millisecond of second
16	8	DTEND	Ending S/C time of data
16	2	ENDYR	Year - 1900
18	2	ENDHR	Hour of year
20	2	ENDSC	Second of hour
22	2	ENDMSC	Millisecond of second
24	8	FDSCTR	Start FDS Count
24	2		Spare
26	2	CTR16	2^{16} Counter
28	2	CTR60	Mod 60 Counter
30	2	CTRLIN	Line count
32	2	DMOD	Format code of data in this chapter
34	2	NMVER	Number of verses in this chapter
36	100	CHCN	Chapter Contents Table nth byte of this field points to the verse containing nth type of data
136	2	CMDF	0 - no command received 1 - command received
138	2	CMD	Command text
140	32	STAT	Status words 0-15 that define chapter contents. Low order 12 bits of each 16-bit word contain status word. The structure of high order 4 bits follows:

Byte	Length	Name	Description
			Bit 0 PN error outside BET 0 - none 1 - bit errors exceed BET
			Bit 1 Valid data flag 0 - valid 1 - no data
			Bit 2 GCF Block error 0 - no 1 - yes
			Bit 3 0 - status read out in this chapter 1 - status inferred
172	48	AMX	Analog parameters (MUX) low order byte - value high order byte 0 - value read out in this chapter 1 - value inferred 2 - value not available
220	2	TTMP	Telescope temperature (format as with AMX)
222	2	ETMP	Electronics temperature (format as with AMX)
224-227	4		Spare

n.m VERSE (n, m≥1)

Verse Preface (Length = 8 bytes)

Byte	Name	Description
0	VECHPN	Chapter number
1	VEVERN	Verse number
2		Spare

Byte	Name	Description
3	VESMC	Subject matter code - Data Type (See Table 1.)
4-7	VEVOLN	Volume number
8-11		Spare
12		Verse body - Data

PREVERSE = offset of data = 12

Data Type 0 - Raw Rates Data

	Name	Description	Length (bytes)
PREVERSE+0	CMPS	Commutator position for the first set of rate readouts	1
+1	CMPS	Commutator position for the first set of rate readouts	1
+2	GAIN1	HET1 gain mode for the first set of readouts (0=low gain; 1=high gain)	1
+3	GAIN2	HET2 gain mode	1
+4	AUTO1	HET1 automatic gain switching (0=yes; 1=no)	1
+5	AUTO2	HET2 automatic gain switching	1
+6	NSEQ	Number of rate sequences in the verse	2
+8	RATE	30*NSEQ rate words in the format in Table 3	

Data Type 1 - Coincidence Condition Map (Length = 112 bytes)

PREVERSE+0	CCM	One 16-bit word for each of the first 53 rates in Table. Each word indicates the presence of terms in coincidence condition applicable to the corresponding rate.

Data Type 1 (continued)

	Name	Description	Length (bytes)
PREVERSE+106		Spare	6

Data Type 2 - Rate Summary

PREVERSE+0	RSM	135 rate summary blocks (16 bytes each) corresponding to the rates in Table 5	135x16

Data Type 3 - PHA History

PREVERSE+0	NUMPHA	Number of PHA events in this chapter	4
+4		Spare	
+8	EVNTYP	One byte field for each of the 16 PHA events that preceded the first PHA event in this chapter. Each byte contains the data type of the corresponding event. In the event of data discontinuity between previous volume and the current volume, these fields are padded.	16
+24		One byte field for each event in this chapter. Byte contains data type of the event. (Padded=all bits on; Null event=all bits off) Record filled to double-word boundary.	

Data Types 4-26

PREVERSE+0	PHARAT	Rate summary block for the corresponding rate	16
+16	PHAEV	Number of events corresponding to data type	4
+20		Spare	4
+24	PHA	PHA events; 8-byte entry for each event in the format in Table 6	

TABLE 1. DATA TYPES

Code	Description
0	Raw rates
1	Coincidence condition map
2	Rate Summary
3	PHA History
4	HET-I AS
5	HET-I ASZ3
6	HET-I BSZ2
7	HET-I BSP
8	HET-I BSE
9	HET-I PENL
10	HET-I PENH
11-17	HET-II corresponding to 4-10
18	LET-A Z3*
19	LET-A Z3
20	LET-B Z3*
21	LET-B Z3
22	LET-C Z3*
23	LET-C Z3
24	LET-D Z3*
25	LET-D Z3
26	TET

TABLE 2. BIT ASSIGNMENTS FOR COINCIDENCE CONDITION MAP

Bit	HET	LET	TET
0	A_1	L_1	W_1
1	A_2	L_2	W_2
2	C_1	L_3	D_{3L}
3	C_2	L_4	D_4
4	C_3	SL	$D_5 \equiv 1$
5	C_4	0	$D_6 \equiv 1$
6	B_2	0	D_7
7	B_1	0	D_8
8	SA	0	GA
9	SB	0	GB
10	G_1	0	U_T
11	G_2	0	0
12	G_3	0	0
13	0	0	0
14	0	0	0
15	0	0	0

1 in a bit position implies that corresponding term is present. Whether coincidence/anti-coincidence is determined by the rate definitions.

Bit 15 is set if the data type is disabled.

TABLE 3. RATE WORD FORMAT

Byte	Bit	Description
0	0	Fill data flag (0=no fill; 1=fill)
	1	PN error outside BET (0=none; 1=bit errors exceed BET)
	2	Valid data flag (0=valid; 1=no data)
	3	GCF Block error (0=no; 1=yes)
	4	Trend-check indicator 0 = readout follows trend 1 = readout does not follow trend
	5-7	Spare
1-3		Decompressed Rate Counts

TABLE 4. RATE SUMMARY BLOCK FORMAT

Byte	Description
0–3	Accumulated counts for this rate, excluding readouts which (a) appeared in a minor frame for which bit errors exceeded tolerance, or (b) failed trend check.
4–7	Time in seconds over which the counts above were accumulated.
8–11	Accumulated counts for this rate, excluding readouts for which data quality was unacceptable or gain mode was unavailable.
12–15	Time in seconds over which the counts in the preceding word were accumulated.

TABLE 5. LOCATION OF RATE SUMMARY BLOCKS IN RATE SUMMARY TEXT

1	AS	51	TAN	101	SLB
2	ASZ3	52	TLO	102	LATRP LBTRP ($LA_1 LA_2 LA_3 \overline{LA_4}$
3	BSe	53	THI	103	$LB_1 LB_2 LB_3 \overline{LB_4}$
4	BSp	54	A1H	104	LB_1
5	BSZ2	55	A2H	105	LB_2
6	PENH	56	C1H	106	LB_3
7	PENL	57	C2H	107	LB_4
8	PGH	58	B1H	108-119	LETC, LETD(cor ponding to 96-1
9	PGL	59	SBH		
10	BS4e	60	C3H	120-135	TET singles
11	BS4p	61	C4H		
12	BS4$\overline{Z2}$	62	B2H		
13	BS4Z2	63	G1		
14	BS3e	64	A1L		
15	BS3p	65	A2L		
16	BS3$\overline{Z2}$	66	C1L		
17	BS3Z2	67	C2L		
18	BS2e	68	B1L		
19	BS2p	69	SA1		
20	BS2$\overline{Z2}$	70	SA2		
21	BS2Z2	71	SBL		
22-42	HET-II (corresponding to 1-21)	72	C3L		
43	LA$\overline{Z3}$	73	C4L		
44	LAZ3	74	B2L		
45	LB$\overline{Z3}$	75-95	HET-II (corresponding to 54-74)		
46	LBZ3	96	LA_1		
47	LC$\overline{Z3}$	97	LA_2		
48	LCZ3	98	LA_3		
49	LD$\overline{Z3}$	99	LA_4		
50	LDZ3	100	SLA		

TABLE 6. PHA EVENT FORMAT

Byte	Bit	Description
0-1	0	PN error outside BET 0 = none 1 = bit errors exceed PN
	1	Valid data flag 0 = valid 1 = no data
	2	GCF Block error 0 = no 1 = yes
	3	Spare
	4-15	TAG_1
2-3	0-3	0
	4-15	PHA_3 (For TET TAG_2)
4-5	0-3	0
	4-15	PHA_2
6-7	0-3	0
	4-15	PHA_1

Number: 4-7008-1

Date: ________

SOFTWARE INTERFACE SPECIFICATION

GENERATING PROGRAM: SEDRGEN

USER PROGRAM: Fixed Instrument PI SEDR Processors

COMPUTER SYSTEM: UNIVAC 1108

COMPUTER SYSTEM:

PURPOSE OF INTERFACE

To provide the fixed or direct sensing instrument Principal Investigators with the prevailing navigation and orientation conditions when their scientific data were obtained.

INTERFACE DEVICE

Magnetic tape of seven or nine tracks written at a tape density of 800 BPI using odd lateral parity. The tape will contain a single file termed "Fixed Instrument SEDR File".

DATA CODE

The Fixed Instrument SEDR will be composed of 32-bit words which contain character, integer and floating point quantities. All character data will be Left Justified Space Filled (LJSF) in the standard IBM 360 EBCDIC code. All integer quantities will be in the 2's complement form. The floating point words will be in the standard IBM 360 format which is given below. In general, the tape will appear as if it had been written on an IBM 360.

IBM 360 Floating Point Word Format

Bit	0	1 7	8 31
	SIGN	CHAR	FRACTION

Where,

SIGN indicates the sign of the quantity represented by the floating point word. If SIGN = 0, the quantity is positive. If SIGN = 1, the quantity is negative.

CHAR indicates the location of the hexidecimal point of the FRACTION portion of the word. This value is normalized to a hexidecimal value of 40 such that CHAR - 40 (hexidecimal arithmetic) locates the hexidecimal point to the right when positive and to the left when negative. The CHAR can also also be considered as a decimal scale factor which the FRACTION when evaluated as a decimal number must be multiplied by to properly evaluate the quantity. Under this scheme, the normalized value is 64 (decimal) and the scale factor is the (CHAR - 64)th power of 16.

FRACTION	contains the significant digits of the quantity with the hexidecimal point located to the left of bit 8.

The following algorithm could be used to evaluate floating point quantities from this format:

$$VALUE_{10} = (1 - 2 * SIGN_{10}) * (FRACTION_{10}) * 16_{10} ** (CHAR_{10} - 64_{10})$$

RECORDING METHOD

UNIVAC 1108 System Library Routine, IOW (binary read/write routine)

DETAILED INTERFACE DEFINITION/FORMAT

The SEDRGEN Program will write a nine (9) track magnetic tape for the CRS, PRA, PLS, MAG, LECP, RSS, IRIS, PPS and UVS PIs and a seven (7) track magnetic tape for the PWS PI. All words will be 32 bits in length and all physical records except for the header record will contain the same number of words for any single SEDR. The following attachments to this document describes the structure and content of the Fixed Instrument SEDR File.

Attachment A	Fixed Instrument SEDR File Layout
Attachment B	Fixed Instrument SEDR Header Record Format
Attachment C	Navigation Data Block Format for Cruise Periods
Attachment D	Navigation Data Block Format for Jupiter Encounter
Attachment E	Navigation Data Block Format for Saturn Encounter
Attachment F	Pointing Vector Data Block Format

DEFINITION OF TERMS

Cartesian State	Cartesian position and velocity components in the following order: X-position, Y-position, Z-position, X-velocity, Y-velocity and Z-velocity.
Celestial Clock and Cone Angles	Clock and cone angles centered at the S/C with respect to the Sun - S/C - Canopus (ABC) reference system.
Equinox	Refers to the vernal equinox, i.e., for the planets the vernal equinox is defined as the axis from the center of the planet to the ascending node of the planet's orbit through the planet's equatorial plane.
Jupiter System I Prime Meridian	This prime meridian system is identified with the rotation of the visible features in the Jovian equatorial zone. The exact definition of this system can be found in the Explanatory Supplement to The Astronomical Ephemeris and The American Ephemeris and Nautical Almanac (Explanatory Supplement to the Ephemeris). JPL Technical Report (TR) 32-1508, dated January 15, 1971 which can be made available upon request also contains the definition.

Jupiter System III Prime Meridian	This prime meridian system is identified with the rotation of radio emissions from Jupiter. This rotation probably corresponds to the rotation of the Jovian inner core which is associated with the planet's magnetic field. The present System III is formally known as "System III (1957.0)" which is precisely defined in the U.S. Naval Observatory Circular No. 137, dated March 14, 1972. However, the International Astronomical Union (IAU) is planning to adopt a new System III definition sometime during the summer of 1976. This prime meridian system will be denoted "System III (1965.0)". Note that the SEDR will contain the system which is currently sanctioned by the IAU which will most likely be the latter system. Reference to the former system is given only because the latter system has not been formally defined and to give interested reader some idea of the essence of this prime meridian system.
Saturn Prime Meridian	This system is a JPL defined system which assumes a constant rotational rate of the prime meridian and a zero hour angle of the equinox at the epoch of 1950, January 1.0. The exact definition of this system can be found in JPL Technical Report 32-1508, dated January 15, 1971 which is available upon request.
Longitudes	The longitude conventions will conform to the IAU standards which specify positive west longitudes for both Jupiter and Saturn.

GLOSSARY

BPI	Bits Per Inch
C	Character Quantity
CRS	Cosmic Ray Subsystem
deg	degrees
dim	dimensionless
DPTRAJ	Double Precision Trajectory Program
E	Floating Point Quantity
FDSC	Flight Data Subsystem Count
FIP	Fixed Instrument Pointing
GMT	Grenwich Mean Time
HET	High Energy Telescope
HHMMSS	Hours-Minutes-Seconds
HGA	High Gain Antenna
I	Integer Quantity
IAU	International Astronomical Union

IRG	Inter-Record Gap
IRIS	Infrared Interferometer Spectrometer and Radiometer Subsystem
JPL	Jet Propulsion Laboratory
km	kilometers
km/sec	kilometers per second
LECP	Low Energy Charged Particle Subsystem
LET	Low Energy Telescope
LJSF	Left Justified Space Filled
MAG	Magnetometer Subsystem
MMDDYY	Month-Day-Year
MOD	Modulo
msec	milliseconds
PI	Principle Investigator
PLS	Plasma Subsystem
PPS	Photopolarimeter Subsystem
PRA	Planetary Radio Astronomy Subsystem
PWS	Plasma Wave Subsystem
RSS	Radio Science Subsystem
SCE	Spacecraft Event Time
sec	seconds
SEDR	Supplementary Experiment Data Record
SEDRGEN	Supplementary Experiment Data Record Generation Program
S/C	Spacecraft
TET	The Electron Telescope
UVS	Ultraviolet Spectrometer Subsystem

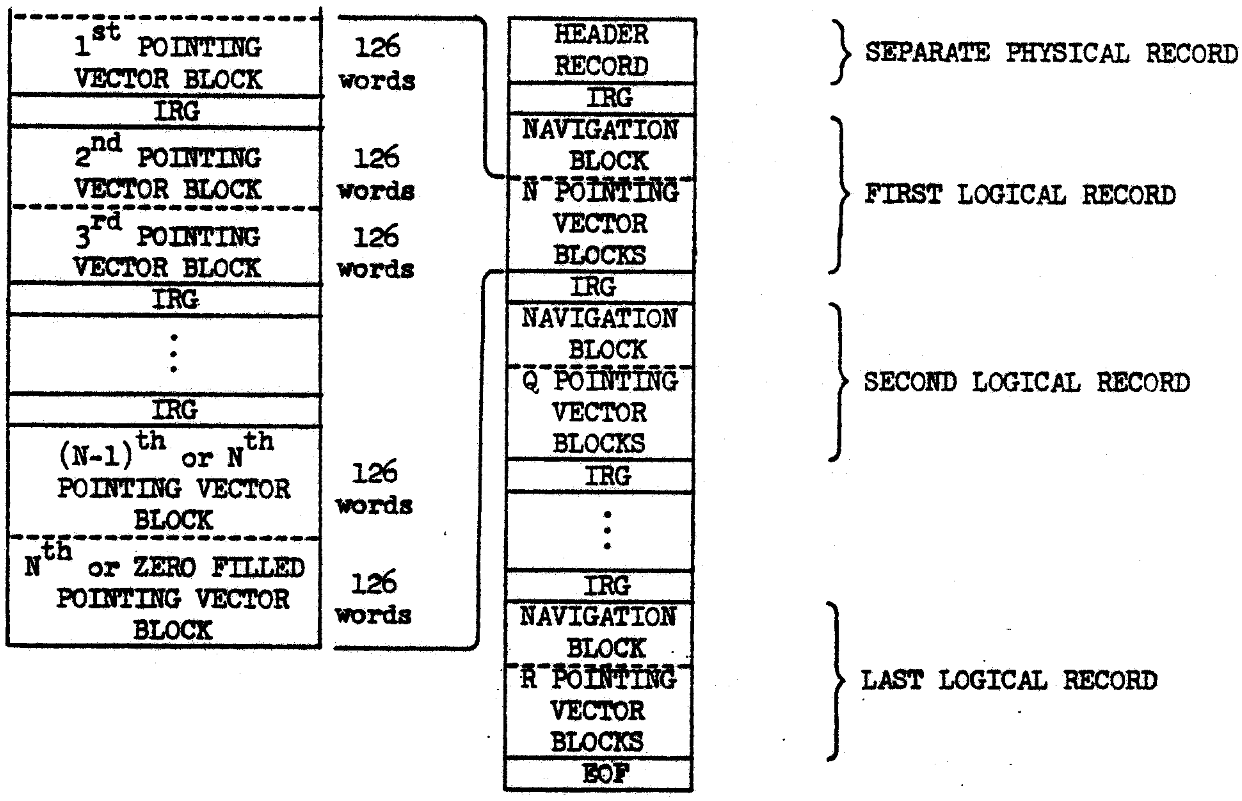
ATTACHMENT A

Fixed Instrument SEDR
File Layout

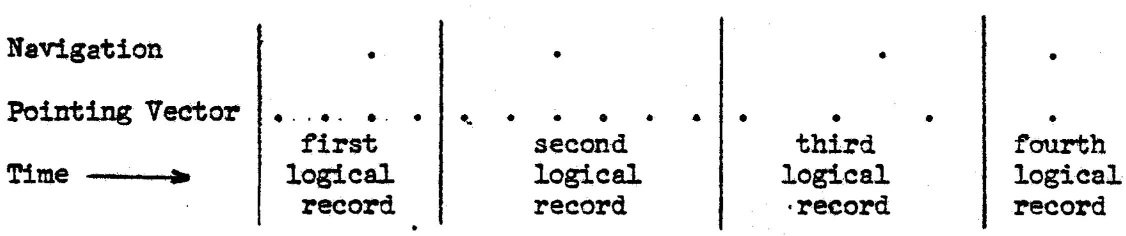
Attachment A

Fixed Instrument SEDR
File Layout

The following SEDR file (tape) layout represents the common file structure that will be supplied to fixed instrument Principle Investigators (PIs) of the MJS77 mission.



Each logical record will contain one navigation data block (one set of navigation data effective at a particular time) and all pointing vector data blocks associated with it. This association is determined by time such that the times of the pointing vector blocks in any logical record are closer to that logical record's navigation block time than any other navigation block time on the SEDR. The following figure illustrates how SEDR logical records would be formed given an arbitrary set of navigation and pointing vector times. Note that the navigation block is always the



first data in the logical record even though some of the pointing vector blocks may have earlier times. However, the navigation and pointing vector blocks taken as individual sets will always be in increasing time order.

Each logical record will be composed of an integral number of physical records. Also, each physical record will contain an integral number of 126 word logical blocks. The number of these blocks for each physical record will be determined from the size of the navigation data block and one pointing vector block. For cruise and Saturn encounter, the navigation data block occupies one logical block while the Jupiter encounter navigation block requires two logical blocks. The pointing vector block is mission phase independent and always occupies one logical block. Therefore, the physical record size for cruise and Saturn encounter is 2 logical blocks or 252 words while Jupiter encounter requires 3 logical blocks or 378 words. When multiple pointing vector blocks exist in a logical record, these data are filled into as many additional physical records as are required to contain the logical record. Each pointing vector block will contain a continuation bit which indicates if that pointing vector block is the last block in the logical record. If the last physical record is not evenly filled with pointing vector blocks, the remainder of the record will be zero filled. The lefthand portion of the file format presented at the start of this attachment illustrates the physical record - logical record structure/relationship for the cruise or Saturn encounter format. The Jupiter encounter format would be similar except that the physical records would contain three 126 word blocks instead of two.

ATTACHMENT B

Fixed Instrument SEDR
Header Record Format

Fixed Instrument SEDR Header Record Format

WORD	DESCRIPTION	UNITS	TYPE
1	Project Identification	'MJS '	C
2	File Identification	'SEDR'	C
3	S/C Identification 0 = Flt 2, 1 = Flt 1, 2 = PTM, 4 = Sim 1, 5 = Sim 2, Others = Unused	dim	I
4-5	SEDR Tape Identification	TBD	C
6	SEDR File Generation Date	MMDDYY	I
7	SEDR File Generation Time	HHMMSS	I
8-9	Pointing Vector (FIP) Tape Identification	TBD	C
10	FIP File Generation Data	MMDDYY	I
11	FIP File Generation Time	HHMMSS	I
12-13	Navigation (DPTRAJ Save Tape) Tape Identification	TBD	C
14-15	Navigation Data Block Identification, i.e., Cruise, Jupiter or Saturn	TBD	C
16-19	Same as 12-15 for Second DPTRAJ Save Tape		
20-23	Same as 12-15 for Third DPTRAJ Save Tape		
24-27	Same as 12-15 for Fourth DPTRAJ Save Tape		
28-45	Spares		

ATTACHMENT C

Navigation Data Block Format
for Cruise Periods

Attachment C

Navigation Data Block Format for Cruise Periods

WORD	DESCRIPTION	UNITS	TYPE
1	SCE GMT Year of Navigation Data Block	years, AD	I
2	SCE GMT Day of Navigation Data Block	day of year	I
3	SCE GMT Hour of Navigation Data Block	hour of day	I
4	SCE GMT Minute of Navigation Data Block	minute of hour	I
5	SCE GMT Second of Navigation Data Block	second of minute	I
6	SCE GMT Millisecond (msec) of Navigation Data Block	msec of second	I
7-12	Cartesian State of S/C, Earth Centered, Earth Mean Ecliptic and Equinox of 1950.0	km km/sec	E
13-18	Cartesian State of S/C, Sun Centered, Earth Mean Ecliptic and Equinox of 1950.0	km km/sec	E
19-24	Cartesian State of S/C, Jupiter Centered, Earth Mean Ecliptic and Equinox of 1950.0	km km/sec	E
25-30	Cartesian State of S/C, Saturn Centered, Earth Mean Ecliptic and Equinox of 1950.0	km km/sec	E
31-36	Cartesian State of Earth, Sun Centered, Earth Mean Ecliptic and Equinox of 1950.0	km km/sec	E
37-42	Cartesian State of Jupiter, Sun Centered, Earth Mean Ecliptic and Equinox of 1950.0	km km/sec	E
43-48	Cartesian State of Saturn, Sun Centered, Earth Mean Ecliptic and Equinox of 1950.0	km km/sec	E
49	Range Earth - S/C	km	E
50	Range Earth - Sun	km	E
51	Range Sun - S/C	km	E
52	Range Jupiter - S/C	km	E
53	Range Saturn - S/C	km	E

Attachment C

Navigation Data Block Format for Cruise Periods

WORD	DESCRIPTION	UNITS	TYPE
54	Range Sun - Jupiter	km	E
55	Range Sun - Saturn	km	E
56	Angle Earth - Sun - S/C	deg	E
57	Angle Sun - S/C - Earth (Celestial Cone Angle of Earth)	deg	E
58	Angle Sun - Earth - S/C	deg	E
59	Angle Jupiter - Sun - S/C	deg	E
60	Angle Sun - S/C - Jupiter (Celestial Cone Angle of Jupiter)	deg	E
61	Angle Sun - Jupiter - S/C	deg	E
62	Angle Saturn - Sun - S/C	deg	E
63	Angle Sun - S/C - Saturn (Celestial Cone Angle of Saturn)	deg	E
64	Angle Sun - Saturn - S/C	deg	E
65	Celestial Clock Angle of Earth	deg	E
66	Celestial Clock Angle of Jupiter	deg	E
67	Celestial Clock Angle of Saturn	deg	E
68-69	Right Ascension and Declination of S/C, Earth Centered, Earth Mean Equator and Equinox of 1950.0	deg	E
70-71	Right Ascension and Declination of Sun, Earth Centered, Earth Mean Equator and Equinox of 1950.0	deg	E
72-73	Right Ascension and Declination of Jupiter, Earth Centered, Earth Mean Equator and Equinox of 1950.0	deg	E
74-75	Right Ascension and Declination of Saturn, Earth Centered, Earth Mean Equator and Equinox of 1950.0	deg	E

Attachment C

Navigation Data Block Format for Cruise Periods

WORD	DESCRIPTION	UNITS	TYPE
76-77	Right Ascension and Declination of S/C, Jupiter Centered, Jupiter True Equinox and Equator of Date	deg	E
78-79	Right Ascension and Declination of Sun, Jupiter Centered, Jupiter True Equinox and Equator of Date	deg	E
80-81	Right Ascension and Declination of Earth, Jupiter Centered, Jupiter True Equinox and Equator of Date	deg	E
82-83	Right Ascension and Declination of Io, Jupiter Centered, Jupiter True Equinox and Equator of Date	deg	E
84-85	Right Ascension and Declination of S/C, Saturn Centered, Saturn True Equinox and Equator of Date	deg	E
86-87	Right Ascension and Declination of Sun, Saturn Centered, Saturn True Equinox and Equator of Date	deg	E
88-89	Right Ascension and Declination of Earth, Saturn Centered, Saturn True Equinox and Equator of Date	deg	E
90-91	Celestial Latitude and Longitude of S/C, Sun Centered, Earth True Equinox and Ecliptic of Date	deg	E
92-93	Celestial Latitude and Longitude of Earth, Sun Centered, Earth True Equinox and Ecliptic of Date	deg	E
94-95	Celestial Latitude and Longitude of Jupiter, Sun Centered, Earth True Equinox and Ecliptic of Date	deg	E
96-97	Celestial Latitude and Longitude of Saturn, Sun Centered, Earth True Equinox and Ecliptic of Date	deg	E
98-99	Right Ascension and Declination of S/C, Sun Centered, Sun True Equinox and Equator of Date	deg	E
100-101	Right Ascension and Declination of Earth, Sun Centered, Sun True Equinox and Equator of Date	deg	E
102-103	Right Ascension and Declination of Jupiter, Sun Centered, Sun True Equinox and Equator of Date	deg	E
104-105	Right Ascension and Declination of Saturn, Sun Centered, Sun True Equinox and Equator of Date	deg	E
106	Hour Angle of Jupiter System III Prime Meridian, Jupiter Centered, Jupiter True Equinox and Equator of Date	deg	E
-126	Spares		

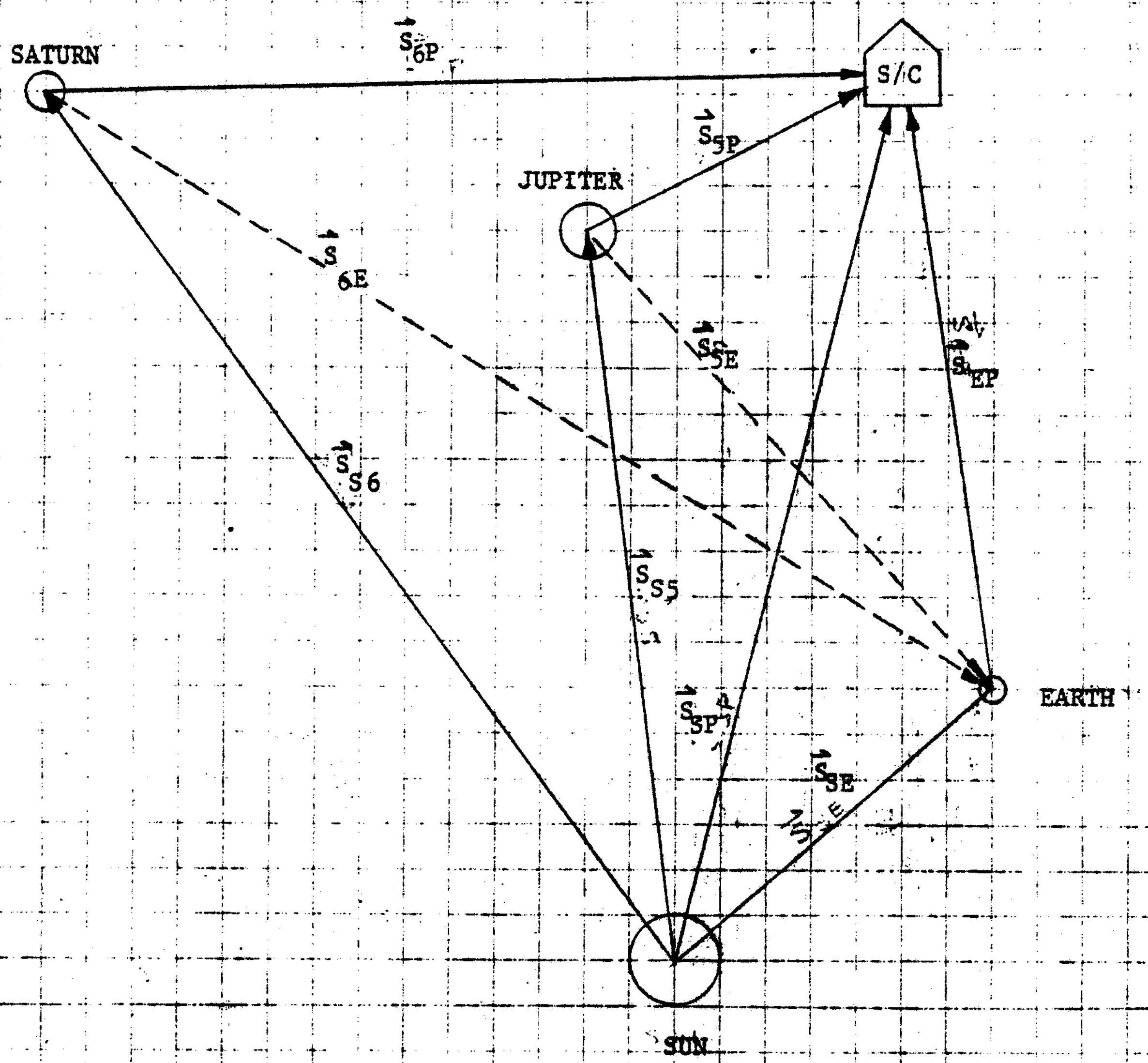


Figure C-1 Earth Mean Ecliptic and Equinox of 1950.0 (ECL50) Cruise SEDR State Vectors

Nomenclature ⟶ $\vec{S}$ refers to State Vector (Position and Velocity Components) with the subscripts AB, where, A is the reference or "From" body and B is the "To" body. The following body definitions are used: S-Sun, P-S/C or Probe, E-Earth, 5-Jupiter and 6-Saturn.

Note that the Earth State with respect to Jupiter and Saturn ($\vec{S}_{5E}$ and $\vec{S}_{6E}$ - dashed vectors in Figure) will not be provided. These states can be simply derived, if desired, by the PI by vector subtraction of the Sun to Earth State ($\vec{S}_{SE}$) and the Sun to Jupiter and the Sun to Saturn States ($\vec{S}_{S5}$ and $\vec{S}_{S6}$).

ATTACHMENT D

Navigation Data Block Format
for Jupiter Encounter

Navigation Data Block Format for Jupiter Encounter

WORD	DESCRIPTION	UNITS	TYPE
1	SCE GMT Year of Navigation Data Block	years, AD	I
2	SCE GMT Day of Navigation Data Block	day of year	I
3	SCE GMT Hour of Navigation Data Block	hour of day	I
4	SCE GMT Minute of Navigation Data Block	minute of hour	I
5	SCE GMT Second of Navigation Data Block	second of minute	I
6	SCE GMT Millisecond (msec) of Navigation Data Block	msec of second	I
7-12	Cartesian State of S/C, Earth Centered, Earth Mean Ecliptic and Equinox of 1950.0	km km/sec	E
13-18	Cartesian State of S/C, Sun Centered, Earth Mean Ecliptic and Equinox of 1950.0	km km/sec	E
19-24	Cartesian State of S/C, Jupiter Centered, Earth Mean Ecliptic and Equinox of 1950.0	km km/sec	E
25-30	Cartesian State of S/C, Io Centered, Earth Mean Ecliptic and Equinox of 1950.0	km km/sec	E
31-36	Cartesian State of S/C, Europa Centered, Earth Mean Ecliptic and Equinox of 1950.0	km km/sec	E
37-42	Cartesian State of S/C, Ganymede Centered, Earth Mean Ecliptic and Equinox of 1950.0	km km/sec	E
43-48	Cartesian State of S/C, Callisto Centered, Earth Mean Ecliptic and Equinox of 1950.0	km km/sec	E
49-54	Cartesian State of Earth, Sun Centered, Earth Mean Ecliptic and Equinox of 1950.0	km km/sec	E
55-60	Cartesian State of Jupiter, Sun Centered, Earth Mean Ecliptic and Equinox of 1950.0	km km/sec	E
61-66	Cartesian State of Earth, Jupiter Centered, Earth Mean Ecliptic and Equinox of 1950.0	km km/sec	E
67-72	Cartesian State of Io, Jupiter Centered, Earth Mean Ecliptic and Equinox of 1950.0	km km/sec	E
73-78	Cartesian State of Europa, Jupiter Centered, Earth Mean Ecliptic and Equinox of 1950.0	km km/sec	E

Navigation Data Block Format for Jupiter Encounter

WORD	DESCRIPTION	UNITS	TYPE
79-84	Cartesian State of Ganymede, Jupiter Centered, Earth Mean Ecliptic and Equinox of 1950.0	km km/sec	E
85-90	Cartesian State of Callisto, Jupiter Centered, Earth Mean Ecliptic and Equinox of 1950.0	km km/sec	E
91-96	Cartesian State of S/C, Jupiter Centered, Jupiter Mean Orbit and Prime Meridian in Sun Direction	km km/sec	E
97-102	Cartesian State of Io, Jupiter Centered, Jupiter Mean Orbit and Prime Meridian in Sun Direction	km km/sec	E
103-108	Cartesian State of Europa, Jupiter Centered, Jupiter Mean Orbit and Prime Meridian in Sun Direction	km km/sec	E
109-114	Cartesian State of Ganymede, Jupiter Centered, Jupiter Mean Orbit and Prime Meridian in Sun Direction	km km/sec	E
115-120	Cartesian State of Callisto, Jupiter Centered, Jupiter Mean Orbit and Prime Meridian in Sun Direction	km km/sec	E
121-126	Cartesian State of S/C, Jupiter Centered, Jupiter System I True Prime Meridian and Equator of Date	km km/sec	E
127-129	Cartesian Position of Io, Jupiter Centered, Jupiter System I True Prime Meridian and Equator of Date	km	E
130-132	Cartesian Position of Europa, Jupiter Centered, Jupiter System I True Prime Meridian and Equator of Date	km	E
133-135	Cartesian Position of Ganymede, Jupiter Centered, Jupiter System I True Prime Meridian and Equator of Date	km	E
136-138	Cartesian Position of Callisto, Jupiter Centered, Jupiter System I True Prime Meridian and Equator of Date	km	E
139-144	Cartesian State of S/C, Jupiter Centered, Jupiter System III True Prime Meridian and Equator of Date	km km/sec	E
145-147	Cartesian Position of Io, Jupiter Centered, Jupiter System III True Prime Meridian and Equator of Date	km	E
148-150	Cartesian Position of Europa, Jupiter Centered, Jupiter System III True Prime Meridian and Equator of Date	km	E
151-153	Cartesian Position of Ganymede, Jupiter Centered, Jupiter System III True Prime Meridian and Equator of Date	km	E
154-156	Cartesian Position of Callisto, Jupiter Centered, Jupiter System III True Prime Meridian and Equator of Date	km	E
157-159	Jupiter Latitude, System I Longitude and System III Longitude of S/C	deg	E

Attachment D

Navigation Data Block Format for Jupiter Encounter

WORD	DESCRIPTION	UNITS	TYPE
160-162	Jupiter Latitude, System I Longitude and System III Longitude of Io	deg	E
163-165	Jupiter Latitude, System I Longitude and System III Longitude of Europa	deg	E
166-168	Jupiter Latitude, System I Longitude and System III Longitude of Ganymede	deg	E
169-171	Jupiter Latitude, System I Longitude and System III Longitude of Callisto	deg	E
172	Range Earth - S/C	km	E
173	Range Sun - S/C	km	E
174	Range Sun - Earth	km	E
175	Range Sun - Jupiter	km	E
176	Range Jupiter - S/C	km	E
177	Range Jupiter - Io	km	E
178	Range Jupiter - Europa	km	E
179	Range Jupiter - Ganymede	km	E
180	Range Jupiter - Callisto	km	E
181	Angle Earth - Sun - S/C	deg	E
182	Angle Sun - S/C - Earth (Celestial Cone Angle of Earth)	deg	E
183	Angle Sun - Earth - S/C	deg	E
184	Angle Jupiter - Sun - S/C	deg	E
185	Angle Sun - S/C - Jupiter (Celestial Cone Angle of Jupiter)	deg	E

Attachment D

Navigation Data Block Format for Jupiter Encounter

WORD	DESCRIPTION	UNITS	TYPE
186	Angle Sun - Jupiter - S/C	deg	E
187	Celestial Clock Angle of Earth	deg	E
188	Celestial Clock Angle of Jupiter	deg	E
189-190	Celestial Clock and Cone Angles of Io	deg	E
191-192	Celestial Clock and Cone Angles of Europa	deg	E
193-194	Celestial Clock and Cone Angles of Ganymede	deg	E
195-196	Celestial Clock and Cone Angles of Callisto	deg	E
[illegible]-198	Right Ascension and Declination of S/C, Earth Centered, Earth Mean Equator and Equinox of 1950.0	deg	E
199-200	Right Ascension and Declination of Sun, Earth Centered, Earth Mean Equator and Equinox of 1950.0	deg	E
201-202	Right Ascension and Declination of Jupiter, Earth Centered, Earth Mean Equator and Equinox of 1950.0	deg	E
203-204	Right Ascension and Declination of S/C, Jupiter Centered, Jupiter True Equinox and Equator of Date	deg	E
205-206	Right Ascension and Declination of Sun, Jupiter Centered, Jupiter True Equinox and Equator of Date	deg	E
207-208	Right Ascension and Declination of Io, Jupiter Centered, Jupiter True Equinox and Equator of Date	deg	E
209-210	Right Ascension and Declination of Europa, Jupiter Centered, Jupiter True Equinox and Equator of Date	deg	E
211-212	Right Ascension and Declination of Ganymede, Jupiter Centered, Jupiter True Equinox and Equator of Date	deg	E
213-214	Right Ascension and Declination of Callisto, Jupiter Centered, Jupiter True Equinox and Equator of Date	deg	E
[illegible]5-216	Celestial Latitude and Longitude of S/C, Sun Centered, Earth True Equinox and Ecliptic of Date	deg	E
217-218	Celestial Latitude and Longitude of Earth, Sun Centered, Earth True Equinox and Ecliptic of Date	deg	E

Attachment D

Navigation Data Block Format for Jupiter Encounter

WORD	DESCRIPTION	UNITS	TYPE
219-220	Celestial Latitude and Longitude of Jupiter, Sun Centered, Earth True Equinox and Ecliptic of Date	deg	E
221-226	Cartesian State of S/C, Jupiter Magnetic Dipole Centered, Jupiter Magnetic Meridian and Equator of Date	km km/sec	E
227-232	Cartesian State of Io, Jupiter Magnetic Dipole Centered, Jupiter Magnetic Meridian and Equator of Date	km	E
233	Range Jupiter Magnetic Dipole - S/C	km	E
234	Range Jupiter Magnetic Dipole - Io	km	E
235-236	Latitude and Longitude of S/C, Jupiter Magnetic Dipole Centered, Jupiter Magnetic Meridian and Equator of Date	deg	E
237-238	Latitude and Longitude of Io, Jupiter Magnetic Dipole Centered, Jupiter Magnetic Meridian and Equator of Date	deg	E
239	Time To (-) / From (+) Jupiter Periapsis Passage	sec	E
240-252	Spares		

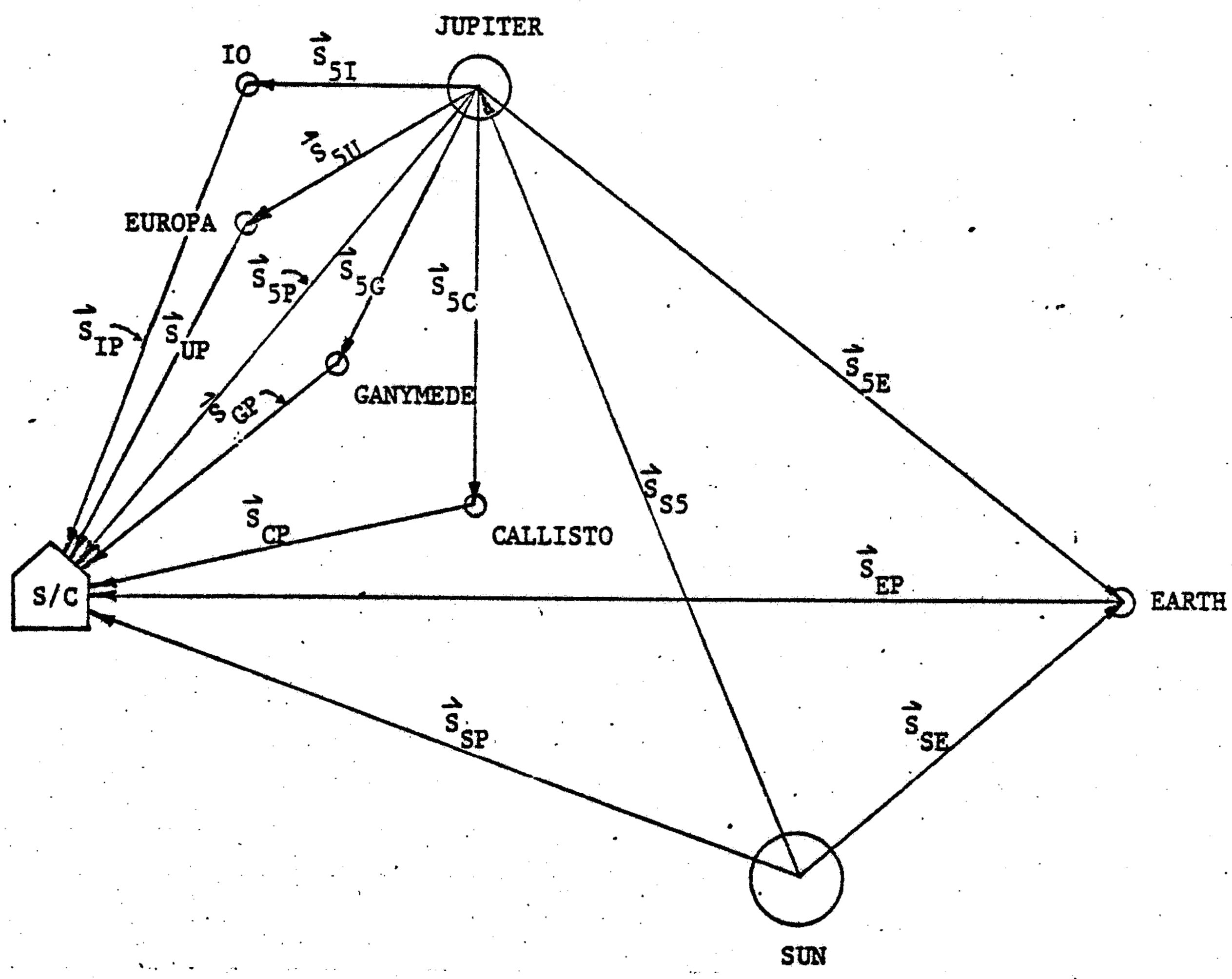


Figure D-1 Earth Mean Ecliptic and Equinox of 1950.0 (ECL50) Jupiter Encounter State Vectors

Nomenclature→ $\vec{S}$ refers to State Vector (Position and Velocity Components) with the subscripts AB, where A is the reference or "From" body and B is the "To" body. The following body definitions are used: S-Sun, P-S/C or Probe, E-Earth, 5-Jupiter, I-IO, U-Europa, G-Ganymede, C-Callisto.

ATTACHMENT E

Navigation Data Block Format
for Saturn Encounter

Navigation Data Block Format for Saturn Encounter

WORD	DESCRIPTION	UNITS	TYPE
1	SCE GMT Year of Navigation Data Block	years, AD	I
2	SCE GMT Day of Navigation Data Block	day of year	I
3	SCE GMT Hour of Navigation Data Block	hour of day	I
4	SCE GMT Minute of Navigation Data Block	minute of hour	I
5	SCE GMT Second of Navigation Data Block	second of minute	I
6	SCE GMT Millisecond (msec) of Navigation Data Block	msec of second	I
7-12	Cartesian State of S/C, Earth Centered, Earth Mean Ecliptic and Equinox of 1950.0	km km/sec	E
13-18	Cartesian State of S/C, Sun Centered, Earth Mean Ecliptic and Equinox of 1950.0	km km/sec	E
19-24	Cartesian State of S/C, Saturn Centered, Earth Mean Ecliptic and Equinox of 1950.0	km km/sec	E
25-30	Cartesian State of S/C, Titan Centered, Earth Mean Ecliptic and Equinox of 1950.0	km km/sec	E
31-36	Cartesian State of Earth, Sun Centered, Earth Mean Ecliptic and Equinox of 1950.0	km km/sec	E
37-42	Cartesian State of Saturn, Sun Centered, Earth Mean Ecliptic and Equinox of 1950.0	km km/sec	E
43-48	Cartesian State of Earth, Saturn Centered, Earth Mean Ecliptic and Equinox of 1950.0	km km/sec	E
49-54	Cartesian State of Titan, Saturn Centered, Earth Mean Ecliptic and Equinox of 1950.0	km km/sec	E
55-60	Cartesian State of S/C, Saturn Centered, Saturn Mean Orbit and Prime Meridian in Sun Direction	km km/sec	E
61-66	Cartesian State of Titan, Saturn Centered, Saturn Mean Orbit and Prime Meridian in Sun Direction	km km/sec	E
67-72	Cartesian State of S/C, Saturn Centered, Saturn True Prime Meridian and Equator of Date	km km/sec	E
73-75	Cartesian Position of Titan, Saturn Centered, Saturn True Prime Meridian and Equator of Date	km	E

Attachment E

Navigation Data Block Format for Saturn Encounter

WORD	DESCRIPTION	UNITS	TYPE
76-77	Saturn Latitude and Longitude of S/C	deg	E
78-79	Saturn Latitude and Longitude of Titan	deg	E
80	Range Earth - S/C	km	E
81	Range Earth - Sun	km	E
82	Range Sun - S/C	km	E
83	Range Saturn - S/C	km	E
84	Range Titan - S/C	km	E
85	Range Sun - Saturn	km	E
86	Range Saturn - Titan	km	E
87	Angle Earth - Sun - S/C	deg	E
88	Angle Sun - S/C - Earth (Celestial Cone Angle of Earth)	deg	E
89	Angle Sun - Earth - S/C	deg	E
90	Angle Saturn - Sun - S/C	deg	E
91	Angle Sun - S/C - Saturn (Celestial Cone Angle of Saturn)	deg	E
92	Angle Sun - Saturn - S/C	deg	E
93	Celestial Clock Angle of Earth	deg	E
94	Celestial Clock Angle of Saturn	deg	E
95-96	Celestial Clock and Cone Angles of Titan	deg	E

Attachment E

Navigation Data Block Format for Saturn Encounter

HD	DESCRIPTION	UNITS	TYPE
97-98	Right Ascension and Declination of S/C, Earth Centered, Earth Mean Equator and Equinox of 1950.0	deg	E
99-100	Right Ascension and Declination of Sun, Earth Centered, Earth Mean Equator and Equinox of 1950.0	deg	E
101-102	Right Ascension and Declination of Saturn, Earth Centered, Earth Mean Equator and Equinox of 1950.0	deg	E
103-104	Right Ascension and Declination of S/C, Saturn Centered, Saturn True Equinox and Equator of Date	deg	E
105-106	Right Ascension and Declination of Sun, Saturn Centered, Saturn True Equinox and Equator of Date	deg	E
107-108	Right Ascension and Declination of Titan, Saturn Centered, Saturn True Equinox and Equator of Date	deg	E
109-110	Celestial Latitude and Longitude of S/C, Sun Centered, Earth True Equinox and Ecliptic of Date	deg	E
111-112	Celestial Latitude and Longitude of Earth, Sun Centered, Earth True Equinox and Ecliptic of Date	deg	E
113-114	Celestial Latitude and Longitude of Saturn, Sun Centered, Earth True Equinox and Ecliptic of Date	deg	E
115	Time To (-) / From (+) Saturn Periapsis Passage	sec	E
116-126	Spares		

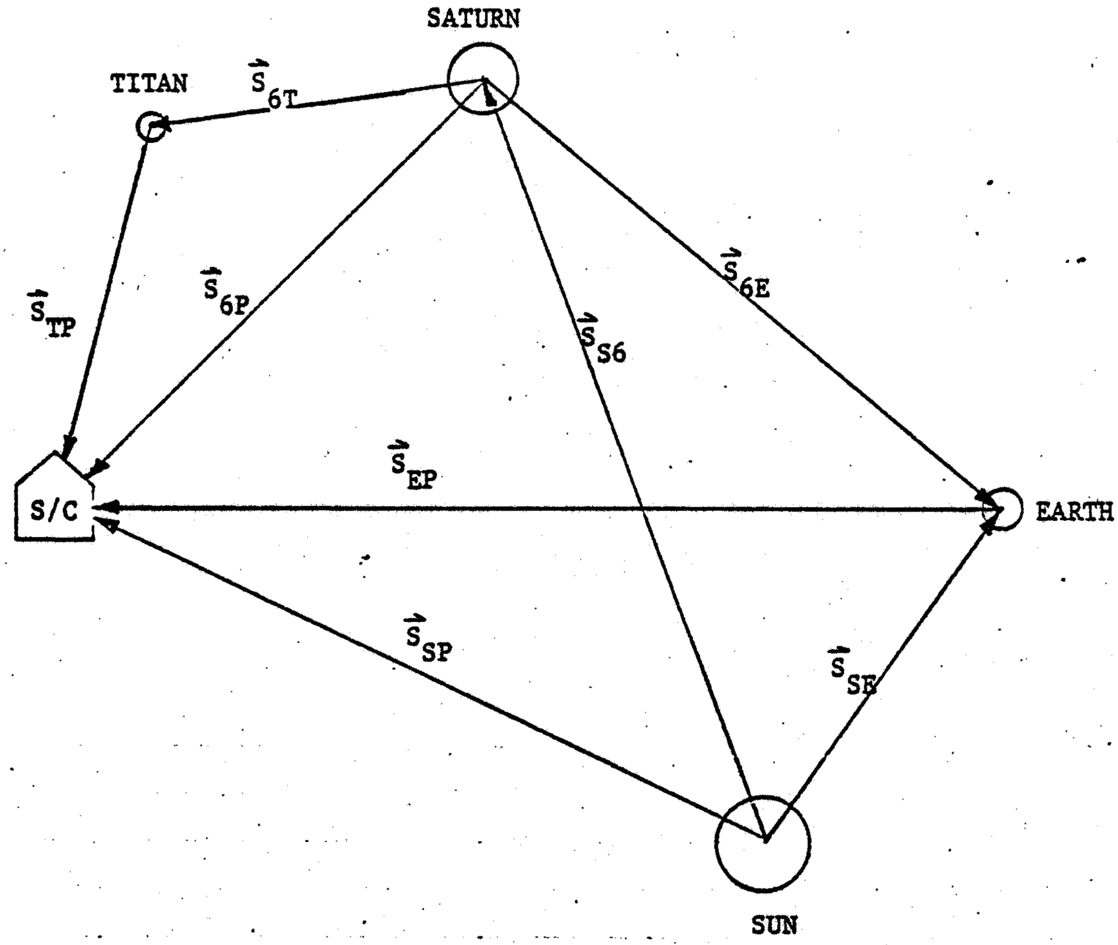


Figure E-1 Earth Mean Ecliptic and Equinox of 1950.0 (ECL50) Saturn Encounter State Vectors

Nomenclature⟶ $\vec{S}$ refers to State Vector (Position and Velocity Components) with the subscripts AB, where A is the reference or "From" body and B is the "To" body. The following body definitions are used: S-Sun, P-S/C or Probe, E-Earth, 6-Saturn, T-Titan.

ATTACHMENT F

Pointing Vector Data
Block Format

Pointing Vector Data Block Format

WORD	DESCRIPTION	UNITS	TYPE
1	SCE GMT Year of Pointing Vector Data Block	years, AD	I
2	SCE GMT Day of Pointing Vector Data Block	day of year	I
3	SCE GMT Hour of Pointing Vector Data Block	hour of day	I
4	SCE GMT Minute of Pointing Vector Data Block	minute of hour	I
5	SCE GMT Second of Pointing Vector Data Block	second of minute	I
6	SCE GMT Millisecond of Pointing Vector Data Block	msec of second	I
7	FDSC MOD16 Count Value of Pointing Vector Data Block	binary counts	I
8	FDSC MOD60 Count Value of Pointing Vector Data Block	binary counts	I
9	Pitch Limit Cycle Angle (Rotation about the S/C X-Axis with the positive direction determined by the right hand rule)	deg	E
10	Yaw Limit Cycle Angle (Rotation about the S/C Y-Axis with the Positive direction determined by the right hand rule)	deg	E
11	Roll Limit Cycle Angle (Rotation about the S/C Z-Axis with the positive direction determined by the right hand rule)	deg	E
12-14	Cartesian Unit Vector of the S/C X-Axis, S/C Centered, Earth Mean Ecliptic and Equinox of 1950.0	dim	E
15-17	Cartesian Unit Vector of the S/C Y-Axis, S/C Centered, Earth Mean Ecliptic and Equinox of 1950.0	dim	E
18-20	Cartesian Unit Vector of the S/C Z-Axis, S/C Centered, Earth Mean Ecliptic and Equinox of 1950.0	dim	E
21-22	Celestial Clock and Cone Angles of CRS LET A Boresight	deg	E
23-25	Cartesian Unit Vector of the CRS LET A Boresight, S/C Centered, Earth Mean Ecliptic and Equinox of 1950.0	dim	E
26-27	Celestial Clock and Cone Angles of the CRS LET B Boresight	deg	E
28-30	Cartesian Unit Vector of the CRS LET B Boresight, S/C Centered, Earth Mean Ecliptic and Equinox of 1950.0	dim	E

Pointing Vector Data Block Format

WORD	DESCRIPTION	UNITS	TYPE
31-32	Celestial Clock and Cone Angles of the CRS LET C Boresight	deg	E
33-35	Cartesian Unit Vector of the CRS LET C Boresight, S/C centered, Earth Mean Ecliptic and Equinox of 1950.0	dim	E
36-37	Celestial Clock and Cone Angles of the CRS LET D Boresight	deg	E
38-40	Cartesian Unit Vector of the CRS LET D Boresight, S/C Centered, Earth Mean Ecliptic and Equinox of 1950.0	dim	E
41-42	Celestial Clock and Cone Angles of the CRS TET Boresight	deg	E
43-45	Cartesian Unit Vector of the CRS TET Boresight, S/C Centered, Earth Mean Ecliptic and Equinox of 1950.0	dim	E
46-47	Celestial Clock and Cone Angles of the CRS HET 1 Boresight	deg	E
48-50	Cartesian Unit Vector of the CRS HET 1 Boresight, S/C Centered, Earth Mean Ecliptic and Equinox of 1950.0	dim	E
51-52	Celestial Clock and Cone Angles of the CRS HET 21* Boresight	deg	E
53-55	Cartesian Unit Vector of the CRS HET 21 Boresight, S/C Centered, Earth Mean Ecliptic and Equinox of 1950.0	dim	E
56-57	Celestial Clock and Cone Angles of the CRS HET 22* Boresight	deg	E
58-60	Cartesian Unit Vector of the CRS HET 22 Boresight, S/C Centered, Earth Mean Ecliptic and Equinox of 1950.0	dim	E
61-62	Celestial Clock and Cone Angles of the LECP Axis of Rotation	deg	E
63-65	Cartesian Unit Vector of the LECP Axis of Rotation, S/C Centered, Earth Mean Ecliptic and Equinox of 1950.0	dim	E
66-67	Celestial Clock and Cone Angles of the PLS Axis of Symmetry	deg	E
68-70	Cartesian Unit Vector of the PLS Axis of Symmetry, S/C Centered, Earth Mean Ecliptic and Equinox of 1950.0	dim	E
71-72	Celestial Clock and Cone of the PLS Lateral Detector Boresight	deg	E
73-75	Cartesian Unit Vector of the PLS Lateral Detector Boresight, S/C Centered, Earth Mean Ecliptic and Equinox of 1950.0	dim	E

*

Attachment F

Pointing Vector Data Block Format

WORD	DESCRIPTION	UNITS	TYPE
76-77	Celestial Clock and Cone Angles of the HGA Boresight	Deg	E
78-80	Cartesian Unit Vector of the HGA Boresight, S/C Centered, Earth Mean Ecliptic and Equinox of 1950.0	Dim	E
81-82	Celestial Clock and Cone Angles of the PPS Optic Axis	Deg	E
83-85	Cartesian Unit Vector of the PPS Optic Axis, S/C Centered, Earth Mean Ecliptic and Equinox of 1950.0	Dim	E
86-87	Celestial Clock and Cone Angles of the UVS Airglow Optic Axis	Deg	E
88-90	Cartesian Unit Vector of the UVS Airglow Optic Axis, S/C Centered, Earth Mean Ecliptic and Equinox of 1950.0	Dim	E
91-92	Celestial Clock and Cone Angles of the UVS Occultation Optic Axis	Deg	E
93-95	Cartesian Unit Vector of the UVS Occultation Optic Axis, S/C Centered, Earth Mean Ecliptic and Equinox of 1950.0	Dim	E
96-97	Celestial Clock and Cone Angles of the IRIS Optic Axis	Deg	E
98-100	Cartesian Unit Vector of the IRIS Optic Axis, S/C Centered, Earth Mean Ecliptic and Equinox of 1950.0	Dim	E
101	Continuation Bit: = 1, another pointing vector block follows; = 0, last pointing vector block in this logical record	Dim	E
102-126	Spares		

TABLE F-1

Nominal S/C Clock and Cone Angles
of the Fixed Instrument Boresights

BORESIGHT	S/C CLOCK AND CONE ANGLES*	
	CLOCK(deg)	CONE(deg)
CRS LET A	125	65
CRS LET B	305	115
CRS LET C	10	48
CRS LET D	236	53
CRS TET	305	115
CRS HET 1	338	60
CRS HET 21	104	78
CRS HET 22	104	140
LECP Axis of Rotation	200	90
PLS Axis of Symmetry	---	0
PLS Lateral Detector	262	90
HGA	---	0

*S/C clock and cone angles are not to be confused with celestial clock and cone angles. The S/C clock/cone system uses the HGA boresight and the Canopus Tracker optic axis as references while the celestial clock/cone system uses the Sun and Canopus.

Right Ascension and Declination Algorithm

The PI may wish to compute S/C centered right ascension and declination angles of his boresight or optic axis relative to the Earth Mean Equator and Equinox of 1950.0 (EME50). To obtain these angles the following two step algorithm is offered.

Step 1. Rotate ECL50 Unit Vector to EME50 Unit Vector

The instrument boresight or optic axis unit vector is available from the SEDR relative to the Earth Mean Ecliptic and Equinox of 1950.0 (ECL50). This unit vector must be rotated through the mean obliquity of the ecliptic (angle between the ecliptic and equatorial planes) at 1950.0 to obtain the EME50 unit vector. The following transformation matrix will accomplish the required rotation.

$$T_{\substack{ECL50\\ \downarrow \\ EME50}} = \begin{bmatrix} 1 & 0 & 0 \\ 0 & \cos \bar{\epsilon}_o & -\sin \bar{\epsilon}_o \\ 0 & \sin \bar{\epsilon}_o & \cos \bar{\epsilon}_o \end{bmatrix}$$

Where $\bar{\epsilon}_o$ is the mean obliquity of the ecliptic at 1950.0 and $\bar{\epsilon}_o = 23.445789^\circ$. The following example illustrates the proper use of this matrix.

$$\vec{U}_{EME50} = T_{\substack{ECL50\\ \downarrow \\ EME50}} * \vec{U}_{ECL50}$$

Where $\vec{U}_{EME50}$ and $\vec{U}_{ECL50}$ are the EME50 and ECL50 unit vectors, respectively, and $T_{\substack{ECL50\\ \downarrow \\ EME50}}$ is the transformation matrix.

Step 2. Compute the Right Ascension and Declination Angles

Once the unit vector has been transformed to EME50 coordinates, the right ascension and declination angles can be computed by using the following equations.

$$\alpha = \mathrm{Tan}^{-1} (y_{EME50} / x_{EME50})$$

$$\delta = \mathrm{Sin}^{-1} (z_{EME50})$$

Where α is the right ascension angle, δ is the declination angle and x_{EME50}, y_{EME50} and z_{EME50} are the x, y and z components of the EME50 unit vector.

Appendix E

THE ISEE-3 ORBIT AND VOYAGER TRAJECTORY INFORMATION

ISEE-3 was launched on August 12, 1978, into orbit about the inner Lagrangian point, L1, the point between the Earth and the Sun where their gravitational fields balance. This point is 1.5 x 10^6 km from Earth, or .01 AU from the Earth. The semi-major axis of the halo orbit is 6.7 x 10^5 km, in the ecliptic and normal to the Earth-Sun line, and the semi-minor axis is 1.2 x 10^5 km, normal to the ecliptic. ISEE-3 is therefore always more than 4 degrees from the Sun so that there is no interference with telemetry reception. The position of the ISEE-3 satellite in solar ecliptic inertial coordinates is given on the EDR tape.

The following information was supplied by the Jet Propulsion Laboratory and describes the format of the Voyager Trajectory tapes.

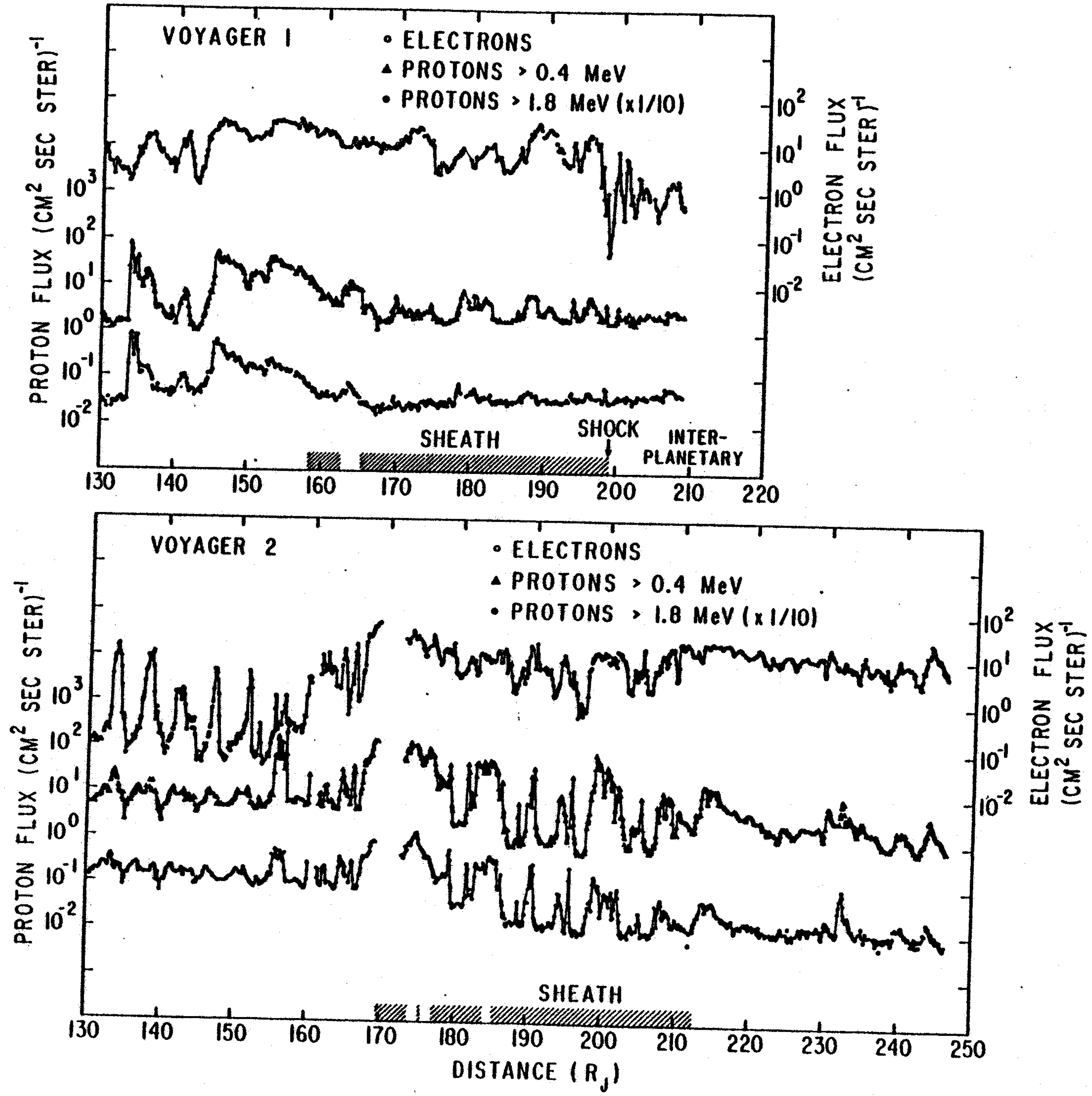


Fig. 7. The fluxes shown in Fig. 6 are extended from 130 to 250 Jovian radii. The shading near the distance scale indicates when the spacecraft were in the magnetotail.

Appendix F

VOYAGER-1 AND -2 JUPITER ENCOUNTER DATA

The following document describes the Cosmic Ray Subsystem data processing procedures and the characteristics of data taken during the Voyager-1 and -2 Jupiter encounters.

VOYAGER 1 AND 2

COSMIC RAY SUBSYSTEM

Description of Jupiter Encounter Data

Instrumentation

As its name implies, the Cosmic Ray Subsystem (CRS) was designed for cosmic ray studies (Stone et al., 1977). It consists of two High Energy Telescopes (HET), four Low Energy Telescopes (LET) and The Electron Telescope (TET). The detectors have large geometric factors (~ 0.48 to 8 cm^2 ster) and long electronic time constants (~ 24 μsec) for low power consumption and good stability. Normally, the data are primarily derived from comprehensive (ΔE_1, ΔE_2 and E) pulse-height information about individual events. Because of the high particle fluxes encountered at Jupiter and Saturn, greater reliance had to be placed on counting rates in single detectors and various coincidence rates. The detectors used for most of our work are listed in Table 1 and illustrated in Figure 1. In interplanetary space, guard counters are placed in anticoincidence with the primary detectors to reduce the background from high-energy particles penetrating through the sides of the telescopes. These guard counters were turned off in the Jovian magnetosphere when the accidental anticoincidence rate became high enough to block a substantial fraction of the desired counts. Fortunately, under these conditions the spectra were sufficiently soft that the background, due to penetrating particles, was small.

The data on proton and ion fluxes at Jupiter were obtained with the LET. The thicknesses of individual solid-state detectors in the LET and their trigger thresholds were chosen such that, even in the Jovian magnetosphere, electrons made, at most, a very minor contribution to the proton counting rates (Lupton and Stone, 1972). Dead time corrections and accidental coincidences were small (< 20%) throughout most of the magnetotail, but were substantial (> 50%) at flux maxima within 40 R_J of Jupiter. Data have been included in this package for those periods when the corrections are less than ~ 50% and can be corrected by the user with the dead time appropriate to the detector (2 to 25 μsec). The high counting rates, however, caused some baseline shift which may have raised proton thresholds significantly. In the inner magnetosphere, the L_2 counting rate was still useful because it never rolled over. This rate is due to 1.8- to 13-MeV protons penetrating L_1 (0.43 cm^2 ster) and > 9-MeV protons penetrating the shield (8.4 cm^2 ster). For an E^{-2} spectrum, the two groups would make comparable contributions; but in the magnetosphere, for the E^{-3} to E^{-4} spectrum above 2.5 MeV (McDonald et al., 1979), the contribution from protons penetrating the shield would be only 3 to 14%.

The LET $L_1L_2\overline{L_4}$ and $L_1L_2L_3$ coincidence-anticoincidence rates give the proton flux between 1.8 and 8 MeV and 3 to 8 MeV with a small alpha paticle contribution (~ 10^{-3}). Corrections are required for dead time losses in L_1, accidental L_1L_2 coincidences and anticoincidence losses from L_4. Data are given only for periods when these corrections are relatively small. In addition to the rates listed in the table, the energy lost in detectors L_1, L_2 and L_3 was measured for individual particles. For protons, this covered the energy range from 0.42 to 8.3 MeV. Protons can be identified positively by the ΔE vs. E technique, their spectra obtained and accidental coincidences greatly reduced. Because of telemetry limitations, however, only a small fraction of the events could be transmitted, and statistics become poor unless pulse-height data are averaged over a period of one hour.

HET and LET detectors share the same data lines and pulse-height analyzers; thus, the telescopes can interfere with one another during periods of high counting rates. To prevent such an interference and explore different coincidence conditions, the experiment was cycled through four operating modes, each 192 seconds long. Either the HETs or the LETs were turned on at a time. LET-D was cycled through L_1 only and L_1L_2 coincidence requirements. The TET was cycled through various coincidence conditions, including singles from the front detectors. At the expense of some time resolution, this procedure permitted us to obtain significant data in the outer magnetosphere and excellent data during the long passage through the magnetotail region.

Some of the published results from this experiment required extensive corrections for dead time, accidental coincidences and anticoincidences (Vogt et al., 1979a, 1979b; Schardt et al., 1981; Gehrels et al., 1981). These corrections can be aplied only on a case-by-case basis after a careful study of the environment and many self-consistency checks. They cannot be applied on a systematic basis and we have no computer programs to do so; therefore, data from such periods are not included in the Data Center submission. The scientists on the CRS team will, however, be glad to consider special requests if the desired information can be extracted from the data.

In order to acquaint the potential user of these data with the type of information that can be extracted from the CRS data, we are showing typical rates and fluxes in Figures 2 through 7.

Description of the Data

(1) LD1 RATE gives the nominal > 0.43-MeV proton flux $cm^{-2}s^{-1}sr^{-1}$. This rate includes all particles which pass through a 0.8 mg/cm^2 aluminum foil and deposits more than 220 keV in a 34.6 μ Si detector on Voyager 1 (209 keV, 33.9 μ on Voyager 2) Therefore, heavy ions, such as oxygen and sulfur are also detected; however, their contributin is believed to be relatiely

small. Only a small percentage of the pulses in this detector are larger than the maximum energy that can be deposited by a proton. Heavy ions would produce such large pulses, unless their energy spectra were much steeper than the proton spectrum. The true flux, F_t, can be calculated from the data:

$$F_t = \frac{F}{1 - 1.26\times10^{-4}F}$$

and corrections are small for $F < 1000\ cm^{-2}s^{-1}$.

(2) LD2 RATE is not suitable for an absolute flux determination and is given in counters per s. The detector responds to protons and ions that penetrate either (a) 0.8 mg/cm^2 Al plus 8.0 mg/cm^2 Si and lose at least 200 keV in a 35 µ Si detector (1.8 to 13 MeV) or (b) pass through > 140 mg/cm^2 Al. For an E^{-2} proton spectrum, the contributions from (a) and (b) would be about equal; however, the proton spectrum is substantially softer throughout most of the magnetosphere and the detector should respond primarily to (a). Dead time corrections are given by

$$R_t = \frac{R}{1 - 2.55\times10^{-5}R}$$

where R is the count rate in counts/s. Thus, correction to the supplied data are small for R < 4000 c/sec, but become so large in the middle magnetosphere that the magnitude of even relative intensity changes becomes uncertain.

(3) LD $L_1 \cdot L_2 \cdot L_4 \cdot$ SL COINCIDENCE RATE gives the total proton flux ($cm^{-2}s^{-1}sr^{-1}$) between ~ 1.8 and ~ 8.1 MeV with a small admixture of alpha particles. Accidental coincidences become substantial at higher rates and

the flux derived from pulse-height analysis should be used if accuracy is desired.

(4) LDTRP RATE gives proton flux ($cm^{-2}s^{-1}sr^{-1}$) between 3.0 and 8.0 MeV with a small alpha particle contribution ($L_1L_2L_3$ coincidences are required).

(5) IBS4E RATE gives the electron flux ($cm^{-2}s^{-1}sr^{-1}$) for electrons with a range between 4 and 10 mm in Si; this corresponds approximately to the energy range of 2.6-5.1 MeV. Accidental coincidence and dead time corrections are generally small in the magnetotail and have not been applied to these data. Because of differences between Voyager 1 and 2, we give the average rate for HET I and II for Voyager 1 and the HET I rate for Voyager 2.

(6) IBS3E RATE is the same as (5); but the electron range falls between 10 and 16 mm of Si, or approximately 5.1-8 MeV.

(7) IBS2E RATE is the same as (5); but the electron range falls etween 16 and 22 mm of Si, or approximately 8-12 MeV.

(8) D4L RATE is not suitable for an absolute electron flux determination. This counting rate includes all pulses from detector D_4 of TET (Fig. 1) which exceed 0.5 MeV. The shielding varies with direction of incidence but is at least 1.2 cm of Si. In the Jovian environment, the detector responds primarily to electrons with energies above ~ 6 MeV. The D_4L rate is useful primarily for determining relative changes in the high-energy electron flux. This rate has a high background from the RTG. Where needed, the dead time corrections should be applied as to the LD_2 rate ($\tau \sim 2.55\times10^{-5}$s).

(9) Pulse-height Analyzed Proton Flux (FPHA) is derived from a ΔE vs. E analysis of pulses from L_1, L_2 and L_3 of LET (Fig 1) and gives the

average proton flux ($cm^{-2}s^{-1}sr^{-1}MeV^{-1}$) in six energy channels. Where required, a correction should be applied for the dead time in LD1 as follows:

$$FPHA_t = \frac{FPHA}{1 - 1.26\times10^{-4}FLD1}$$

where FPHA is the listed flux of this rate (9) and FLD1 is the flux given in rate 1. FPHA gives the most accurate value of the proton flux available from this experiment; however, the counting statistics are poorer than for the other rates because of limited sampling. Fluxes derived from rate 3 (LD) which cover the same energy range as FPHA will be higher because of poorer definition of the energy threshold, accidental coincidences and a variable, but small, background contribution.

ENERGY CHANNELS (MEV) OF FPHA

(absolute accuracy ~ 10%)

	VOYAGER 1	VOYAGER 2
1	1.829 - 2.045	1.807 - 2.001
2	2.045 - 3.104	2.001 - 3.309
3	3.104 - 3.753	3.309 - 3.984
4	3.753 - 4.530	3.984 - 4.761
5	4.530 - 6.284	4.761 - 6.041
6	6.284 - 8.091	6.041 - 8.043

Data Format

Time-history of CRS data described above is being submitted on 9-track tapes recorded at 1600 BPI. Tape marked CRSJU1 contains Voyager 1 data and the one marked CRSJU2 contains Voyager 2 data.

Each tape contains nine files. Contents of CRSJU1 are described in Table 2, and those of CRSJU2 appear in Table 3. Each file consists of a number of Flux Time-History (FTH) records. An FTH record contains a count of the number of data items (NBIN) whose time-history is included in the record, a count of the number of averaging intervals (NINT) included in the record, definitions of data items included and time-history data. Table 4 defines the structure of an FTH record in detail. These tapes were generated on an IBM System 360 computer; thus, a word consists of 32 bits, half-word 1 is the high order 16-bit field of the word and half-word 2 the low order half (bits 16-31, with the left-most or MSB numbered 0). Characters are represented in 8-bit EBCDIC byte, real numbers are represented in the IBM single precision floating point format. Length (in words) of an FTH record is given by

$$200 + (3 + 2 * NBIN) * NINT \qquad NBIN \leq 5$$

$$233 + (3 + 2 * 6) * NINT \qquad NBIN = 6$$

For all files on CRSJU1 and CRSJU2, NINT $\leq$ 96. For file 9, NINT $\leq$ 24. Thus, maximum record length is 680 words (2720 bytes) for files 1-4 and 8, 872 words (3488 bytes) for files 5-7 and 593 words (2372 bytes) for file 9.

Table 1
CRS DETECTORS USED DURING JUPITER ENCOUNTER

Detector	Shielding	Energy Range+ (MeV)	Factor (cm^2ster)	Comments
PROTONS (LET):				
L1*	0.8 mg/cm^2 Aℓ	0.42-12	4.5	Also, alphas above 0.32 MeV/n
L2*	8.1 mg/cm^2 Si	1.8 -13	0.43	Through L1
	>140 mg/cm^2 Aℓ	>9	8.4	Protons through side. The intensity is comparable to those through front for E^{-2} spectrum
L1 L2 $\overline{L4}$		1.8 - 8	0.43	ΔE - E analysis
ELECTRONS (HET):				
Range: 4-10 mm Si		2.6- 5.1	1.46	Coincidence rates with good background rejections, but accidental coincidence problems at high counting rates (for details, see Stone et al., 1977).
10-16 mm Si		5.8- 8	1.25	
16-22 mm Si		8 -12	0.96	
ELECTRONS (TET):				
D4 (3 mm Si)	~1.2 cm Si equivalent	>6	~14	Usable at higher flux than HET rates

*Single rates
+Small difference between similar detectors

Table 2. CONTENTS OF CRSJU1

FILE #	DATA ITEM	AVERAGING INTERVAL	TIME PERIOD
1	LD1 RATE	15 min.	2/28/79, 00:00, to 3/04/79, 12:00 3/06/79, 06:45, to 3/17/79, 00:00
2	LD2 RATE	15 min.	2/28/79, 00:00, to 3/09/79, 12:00
3	LD RATE	15 min.	2/28/79, 00:00, to 3/03/79, 12:00 3/07/79, 08:00, to 3/17/79, 00:00
4	LDTRP RATE	15 min.	Same as for LD RATE
* 5	BS4E RATE	15 min.	2/28/79, 00:00, to 3/03/79, 00:00 3/07/79, 08:00, to 3/17/79, 00:00
* 6	BS3E RATE	15 min.	Same as for BS4E RATE
* 7	BS2E RATE	15 min.	Same as for BS4E RATE
8	D4L RATE	15 min.	2/28/79, 00:00, to 3/04/79, 20:00 3/06/79, 02:00, to 3/08/79, 00:00
9	FPHA	1 hour	2/28/79, 00:00, to 3/03/79, 12:00 3/07/79, 08:00, to 3/17/79, 00:00

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*These files nominally contain two quantities, the rate when guard anticoincidence is required and the rate when guard term is deleted from coincidence requirement. The experiment is in the latter state from ~ 01:15:00, March 2, 1979, to ~ 20:15:00, March 2, 1979. Note also that HET-I and HET-II data are averaged in these files.

Table 3. CONTENTS OF CRSJU2

	FILE #	DATA ITEM	AVERAGING INTERVAL	TIME PERIOD
	1	LD1 RATE	15 min.	7/03/79, 00:00, to 7/08/79, 12:00 7/11/79, 12:00, to 8/04/79, 00:00
	2	LD2 RATE	15 min.	7/03/79, 00:00, to 7/14/79, 00:00
	3	LD RATE	15 min.	7/03/79, 00:00, to 7/06/79, 00:00 7/11/79, 18:00, to 8/04/79, 00:00
	4	LDTRP RATE	15 min.	Same as LD RATE
*	5	BS4E RATE	15 min.	7/03/79, 00:00, to 7/06/79, 04:00 7/12/79, 12:00, to 8/04/79, 00:00
*	6	BS3E RATE	15 min.	Same as BS4E RATE
*	7	BS2E RATE	15 min.	Same as BS4E RATE
	8	D4L RATE	15 min.	7/03/79, 00:00, to 7/08/79, 12:00 7/11/79, 12:00, to 8/14/79, 00:00
	9	FPHA	1 hour	7/03/79, 00:00, to 7/06/79, 04:00 7/11/79, 18:00, to 8/04/79, 00:00

*These files nominally contain two quantities, the rate when guard anticoincidence is required and the rate when guard term is deleted from coincidence requirement. The experiment is in the latter state from ~ 12:15:00, July 12, 1979, to ~ 06:15:00, July 18, 1979.

Table 4. STRUCTURE OF FLUX TIME-HISTORY RECORD

WORD	HALFWORD	TYPE	DESCRIPTION
1	1	Integer	Number of data items contained in the record (NBIN).
	2	Integer	Number of averaging intervals (NINT) contained in the record.
3-35		character	132-character title identifies satellite and gives the start time of first averaging interval and last averaging interval in the record.
36-68		character	132-character description of first data item.
69-101		character	132-character description of second data item, if NBIN $\geq$ 2. Otherwise, not used.
102-134		character	132-character description of third data item, if NBIN $\geq$ 3. Otherwise, not used.
135-167		character	132-character description of fourth data item, if NBIN $\geq$ 4. Otherwise, not used.
168-200		character	132-character description of fifth data item, if NBIN $\geq$ 5. Otherwise, not used.
		NBIN $\leq$ 5	
201-			NINT Averaging Interval Entries (AIE). The structure of an AIE is shown in Table 5.
		NBIN = 6	
201-233		character	132-character description of sixth data item.
234-			NINT Averaging Interval Entries.

Table 5. STRUCTURE OF AVERAGING INTERVAL ENTRY

WORD	HALFWORD	TYPE	DESCRIPTION	
1	1	Integer	2-digit year	
	2	Integer	month of year	
2	1	Integer	day of month	Start time of averaging interval
	2	Integer	hour of day	
3	1	Integer	minute of hour	
	2	Integer	second of minute	
4-(3+2*NBIN)		Real	NBIN FLUX entries. Each FLUX entry is two words long. If the second word of the entry is -1.0, data for this item is not available; otherwise the first word is the value of flux and the second word contains the associated statistical error.	

REFERENCES

Gehrels, N., E.C. Stone and J.H. Trainor, "Energetic Oxygen and Sulful in the Jovian Magnetosphere," submitted to J. Geophys. Res., 1981.

Lupton, J.E., and E.C. Stone, "Measurement of Electron Detection Efficiencies in Solid-state Detectors," Nucl. Instr. and Meth. 98, 189, 1972.

McDonald, F.B., A.W. Schardt and J.H. Trainor, "Energetic Protons in the Jovian Magnetosphere," J. Geophys. Res. 84, 2579, 1979.

Schardt, A.W., F.B. McDonald and J.H. Trainor, "Energetic Particles in the Pre-dawn Magnetotail of Jupiter," J. Geophys. Res., special Voyager issue, 1981.

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Vogt, R.E., W.R. Cook, A.C. Cummings, T.L. Garrard, N. Gehrels, E.C. Stone, J.H. Trainor, A.W. Schardt, T. Conlon, N. Lal and F.B. McDonald, "Voyager 1: Energetic Ions and Electrons in the Jovian Manetosphere," Science 204, 1003, 1979a.

Vogt, R.E., A.C. Cummings, N. Gehrels, E.C. Stone, J.H. Trainor, A.W. Schardt, T.F. Conlon and F.B. McDonald, "Voyager 2: Energetic Ions and Electrons in the Jovian Magnetosphere," Science 206, 984, 1979b.

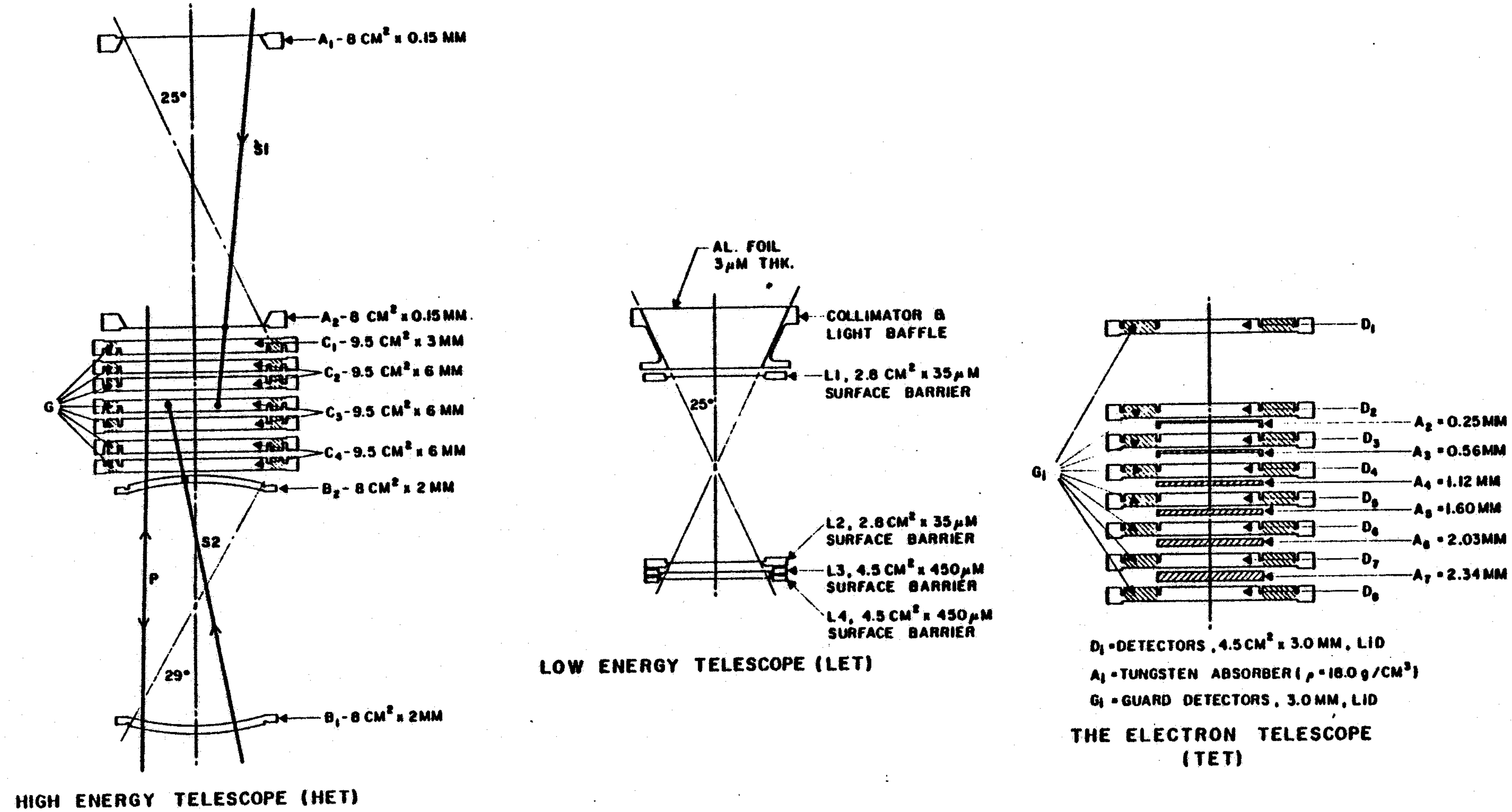

Fig. 1. Schematic diagram of the High Energy Telescope (HET), Low Energy Telescope (LET) and the Electron Telescope (TET) systems.

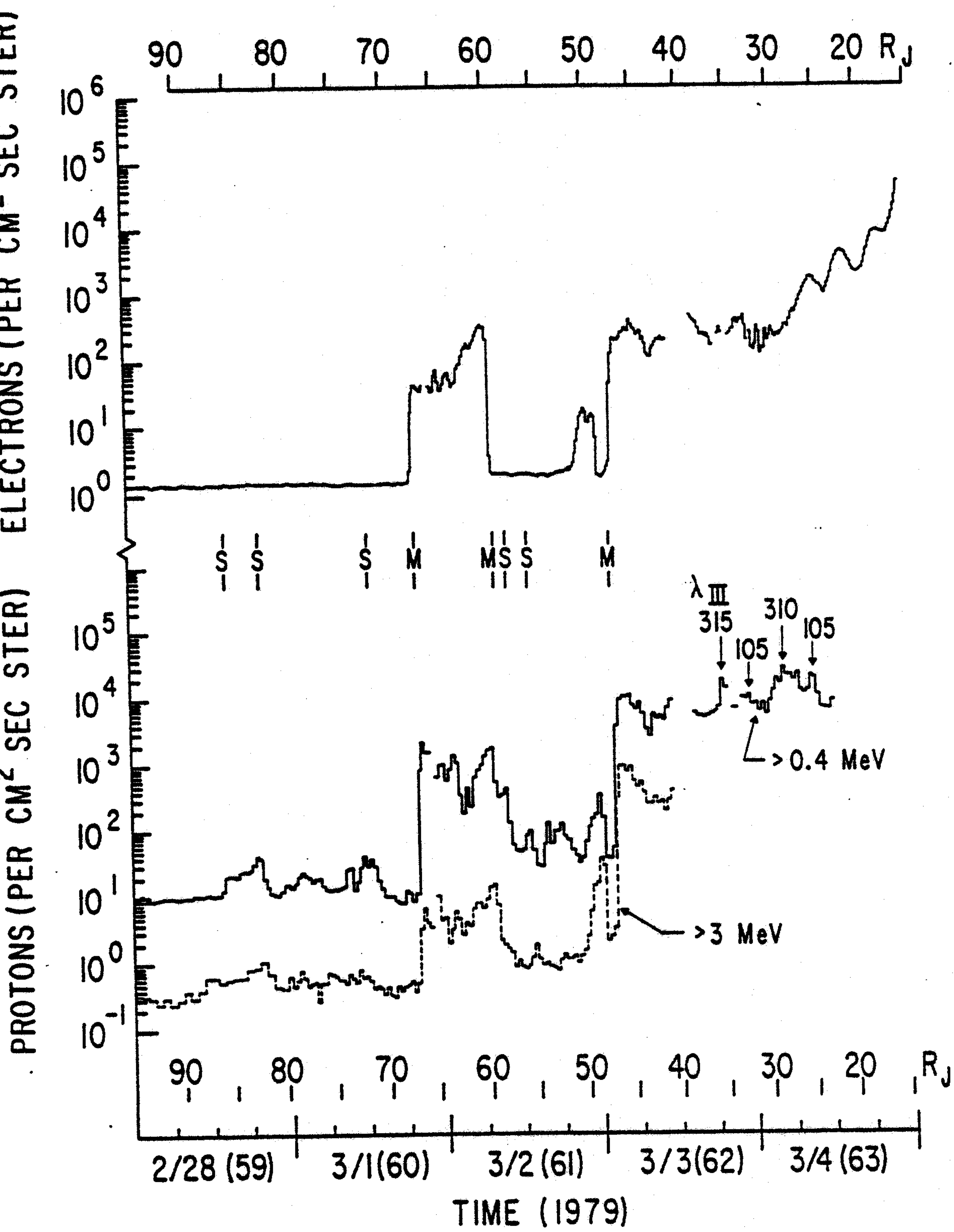

Fig. 2. Proton and > 5 MeV electron flux observed during the inbound pass of Voyager 1. Bow shock and magnetopause crossings are indicated by S and M, respectively. Jovicentric longitudes (λ_{III} 1965) of flux maxima near magnetic equatorial crossings are indicated.

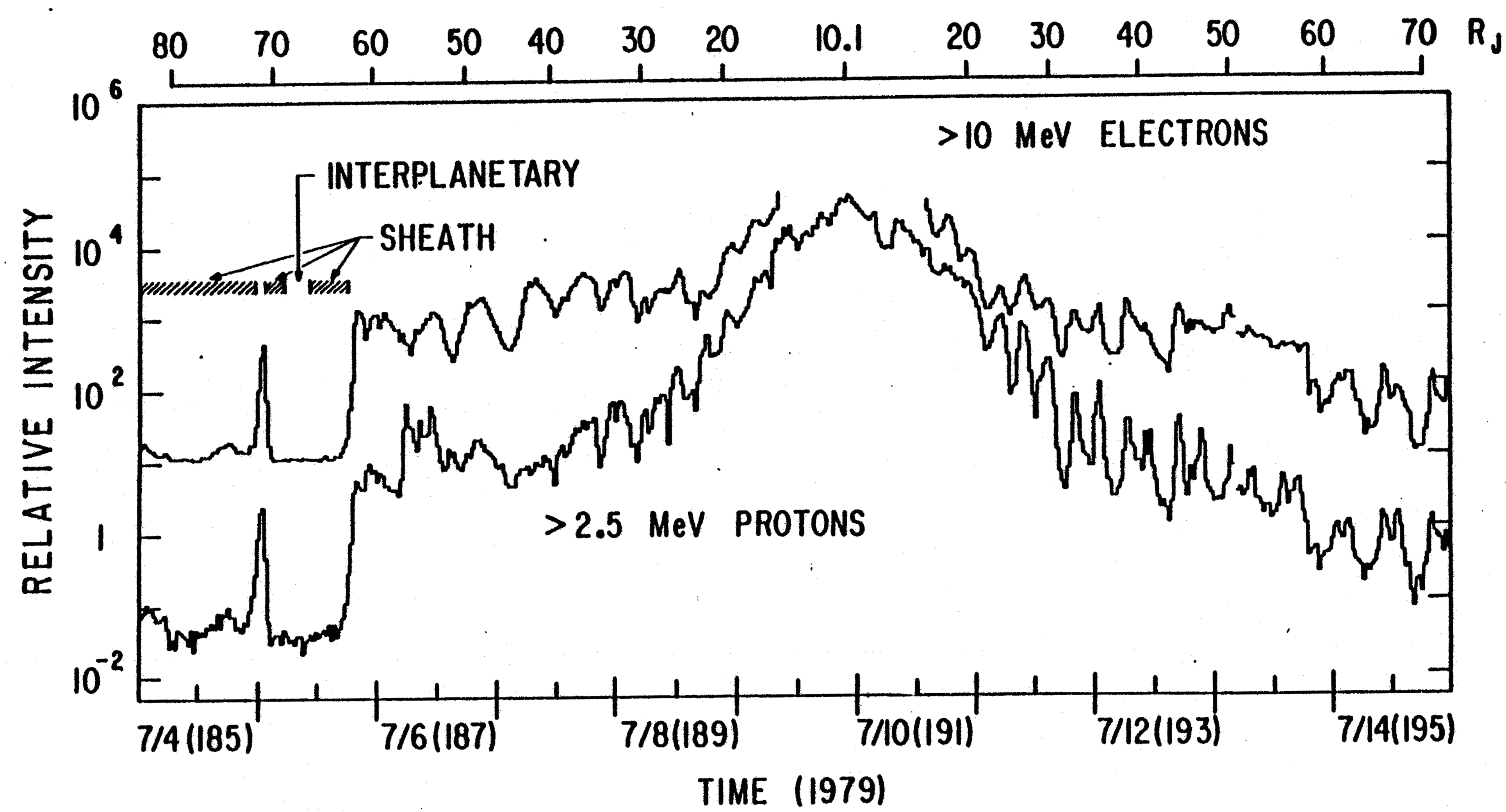

Fig. 3. Proton and electron intensities observed by Voyager 2

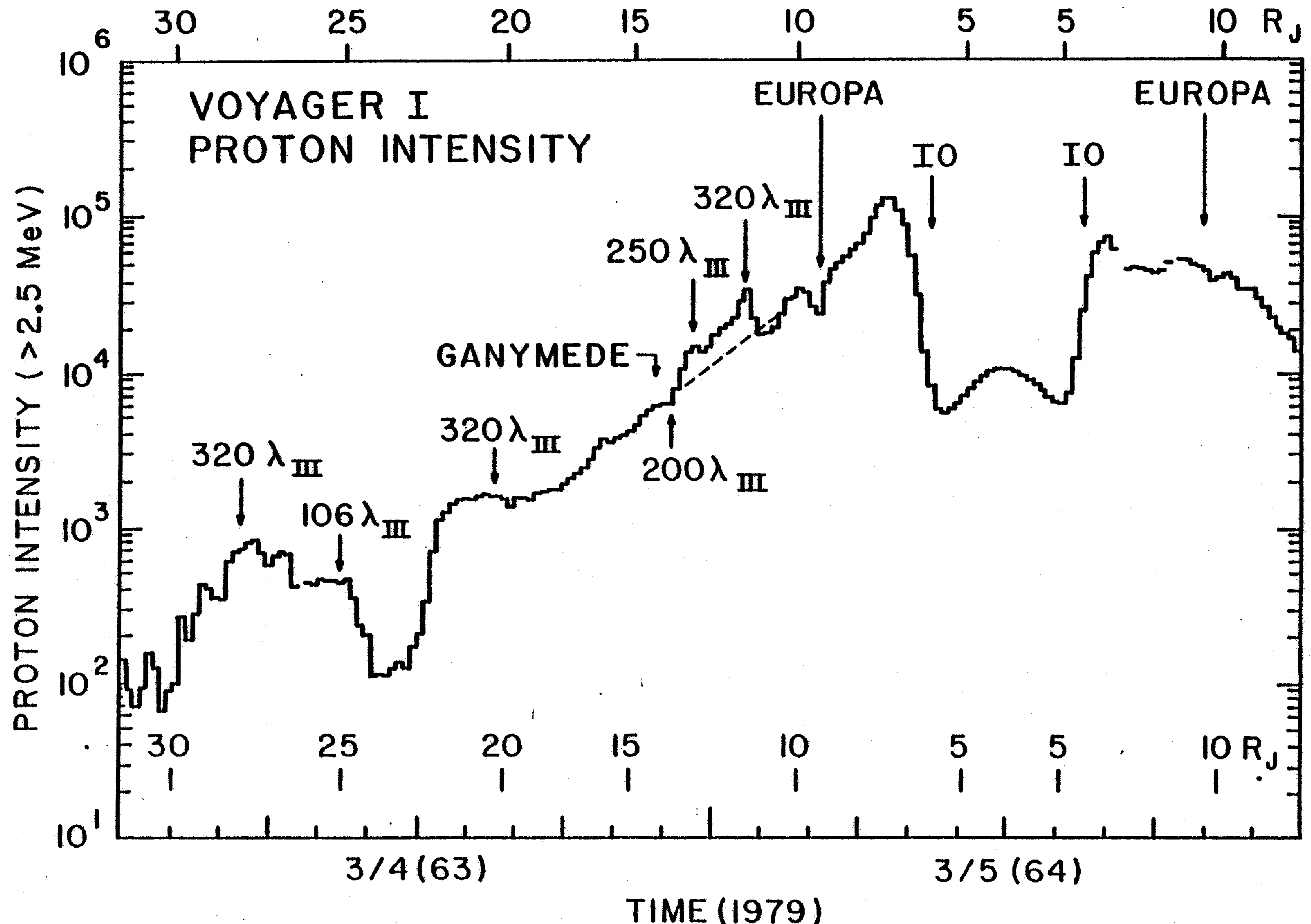

Fig. 4. Relative proton intensities in the middle magnetosphere observed with Voyager 1. Due to the extreme fluxes, the detector threshold shifted with counting rate.

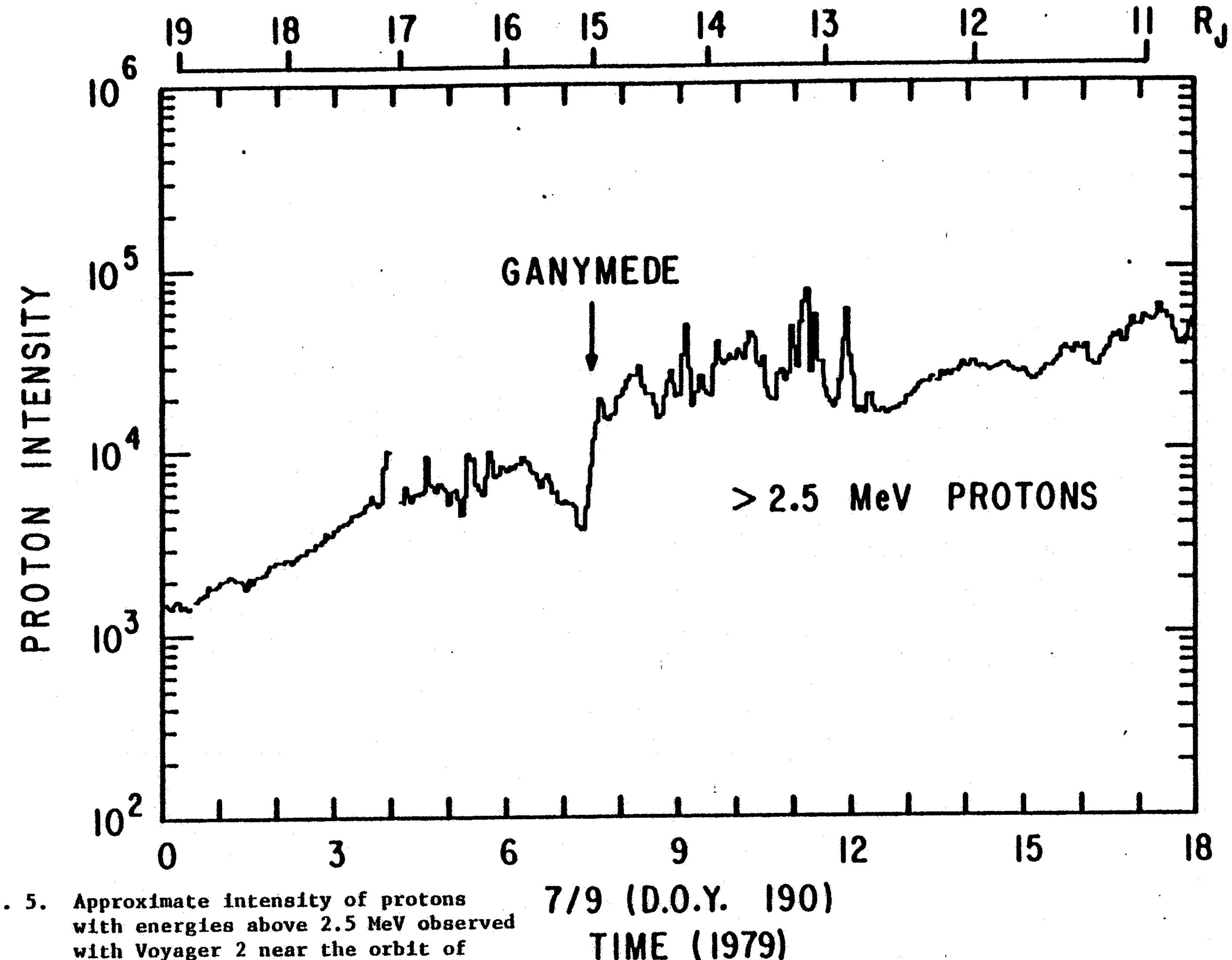

Fig. 5. Approximate intensity of protons with energies above 2.5 MeV observed with Voyager 2 near the orbit of Ganymede. Note the large intensity fluctuations which fall within ±4 hours of the closest approach to Ganymede.

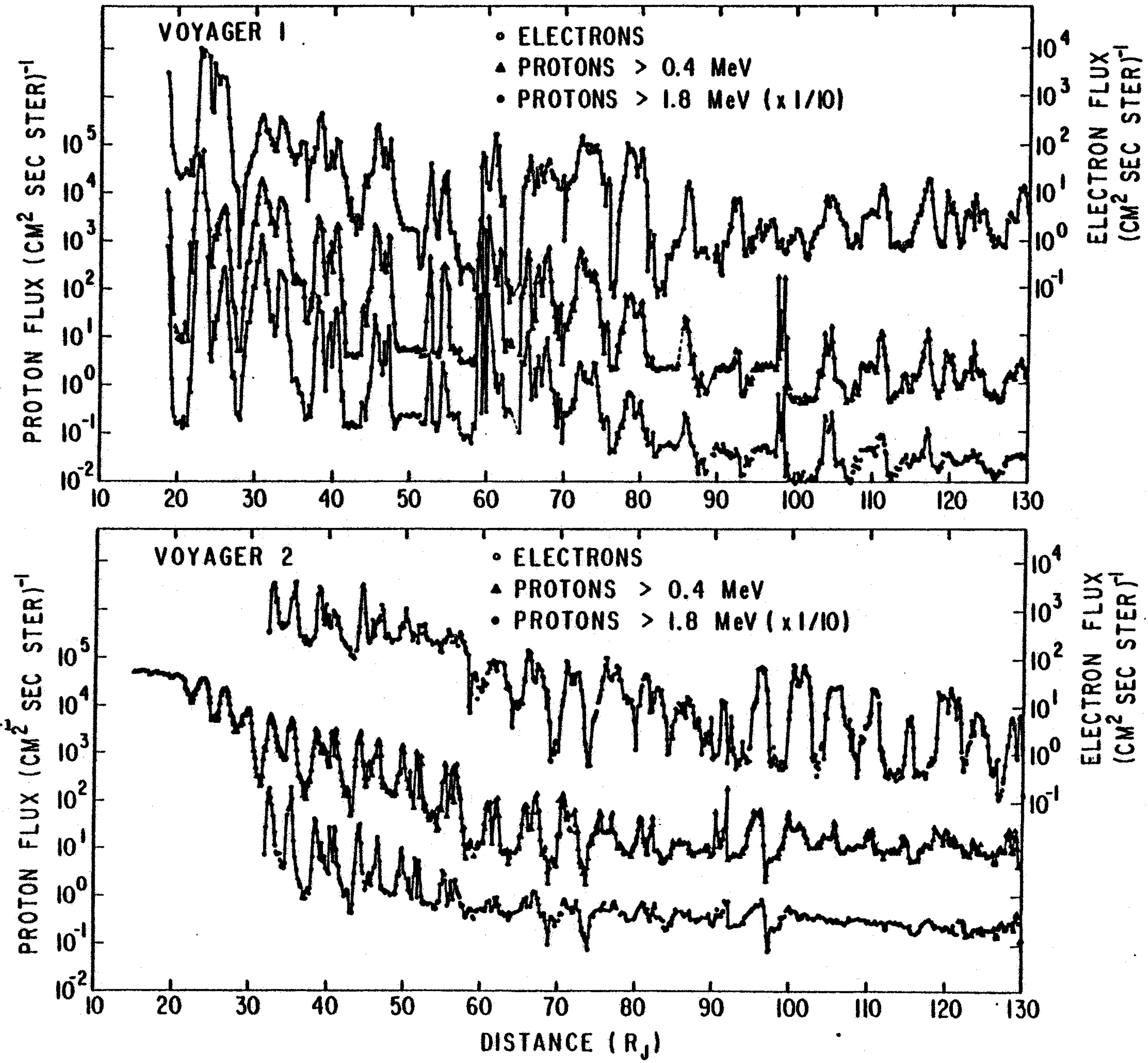

Fig. 6. Electron (2.6–5.1 MeV) and proton fluxes observed during the outbound passes of Voyagers 1 and 2. Electron and > 1.8 MeV proton fluxes above $10^3 cm^{-2} s^{-1} sr^{-1}$ are uncertain because of large corrections and show only relative trends.

```
**** TSO FOREGROUND HARDCOPY ****
DSNAME=XRPAS.LIB.CNTL                                    (ICMAT    )

//  EXEC  MATRIX,REG=500K,OUT=A                                             00000010
//MATRIX.FT50F001 DD DSN=XRPAS.BCKCAT.DATA,DISP=SHR                         00000020
//* CONSISTENCY CHECK USE OF MATRIX PROGRAM                                 00000030
//*  ON P CARD     COL 22 =  T                                              00000040
//*              COL 66-71 SPECIFIES 'TOLERANCE' TRY 1.5 OR LESS            00000050
//*              COL 72    CONTINUATION                                     00000060
//*   CONTINUATION CARD : COL 28-69, 6 FIELDS, 7 COLUMNS EACH :             00000070
//*          FIELD # 1   POWER GAMMA IN R=E**GAMMA   TRY   1.75             00000080
//*                # 2   = (B1 THICK + B2 THICK) / (B2 THICK)               00000090
//*                # 3   = (B1 THICK) / (B2 THICK)                          00000100
//*                # 4   B1 MEV/CH  (HIGH GAIN OR LOW GAIN)                 00000110
//*                # 5   B2 MEV/CH  (HIGH GAIN OR LOW GAIN)                 00000120
//*                # 6   SUMC MEV/CH  (HIGH GAIN OR LOW GAIN)               00000130
//*                                                                         00000140
//*   MUST BE A 3 PARAM STOPPING PLOT FOR USE OF THE CHECK                  00000150
//*                                                                         00000160
//*45678901234567890123456789012345678901234567890123456789012345678901200000170
//CARDS DD *,DCB=BLKSIZE=800                                                00000180
S ISEE-3                 999:00:00:00                                       00000190
SI        78/09/04 00:00:00 79/09/16  00:00:00                              00000200
SE        78/09/23 00:00:00 78/09/27  00:00:00                              00000210
SE        79/04/04 00:00:00 79/04/06  00:00:00                              00000220
SE        79/06/06 00:00:00 79/06/09  00:00:00                              00000230
P A1    A2              TFFFFFFFFFFFFF                01 00004095           00000231
P A1    A2              TFFFFFFFFFFFFF                04 00004095           00000232
P A1    A2              FFFFFFFTFFFFFF                01 00004095           00000233
P A1    A2              FFFFFFFTFFFFFF                04 00004095           00000234
P B1    B2              FFTFFFFFFFFFFF                01 00004095           00000235
P B1    B2              FFFFFFFFFTFFFF                01 00004095           00000236
P B1    B2              FFTFFFFFFFFFFF                04 00004095           00000237
P B1    B2              FFFFTFFFFFFFFF                01 00004095           00000238
P B1    B2              FFFFFFFFFTFFFF                04 00004095           00000239
P B1    B2              FFFFFFFFFFFTFF                01 00004095           00000240
P B1    C432          T FFTFFFFFFFFFFF                04 00004095 1.35     $00000241
                            1.75   1.992230.992230.1824 0.1843 0.8831        00000250
P B2    C432          T FFTFFFFFFFFFFF                04 00004095 1.35     $00000260
                            1.75   1.992230.992230.1824 0.1843 0.8831        00000270
P B1    C432          T FFFFTFFFFFFFFF                01 00004095 1.35     $00000280
                            1.75   1.992230.992230.6089 1.1987 4.2700        00000290
P B2    C432          T FFFFTFFFFFFFFF                01 00004095 1.35     $00000300
                            1.75   1.992230.992230.6089 1.1987 4.2700        00000310
P B1    C432          T FFFFFFFFFTFFFF                04 00004095 1.35     $00000320
                            1.75   1.992230.992230.1824 0.1843 0.8831        00000330
P B2    C432          T FFFFFFFFFTFFFF                04 00004095 1.35     $00000340
                            1.75   1.992230.992230.1824 0.1843 0.8831        00000350
P B1    C432          T FFFFFFFFFFFTFF                01 00004095 1.35     $00000360
                            1.75   1.992230.992230.6089 1.1987 4.2700        00000370
P B2    C432          T FFFFFFFFFFFTFF                01 00004095 1.35     $00000380
                            1.75   1.992230.992230.6089 1.1987 4.2700        00000390
P B1    C432          T FFTFFFFFFFFFFF                01 00004095 1.35     $00000400
                            1.75   1.992230.992230.1824 0.1843 0.8831        00000410
P B2    C432          T FFTFFFFFFFFFFF                01 00004095 1.35     $00000420
                            1.75   1.992230.992230.1824 0.1843 0.8831        00000430
```

Isee - Voyager versions