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# CRRES TIME HISTORY DATA BASE DEVELOPMENT FOR THE HIGH ENERGY ELECTRON FLUXMETER, MEDIUM ENERGY ELECTRON SPECTROMETER, ELECTRON AND PROTON ANGLE SPECTROMETER, AND PROTON TELESCOPE

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The Combined Release and Radiation Effects Satellite (CRRES) payload included a number of instruments designed to provide data on particles, fields, and waves.

The Time History Data Base (THDB) for the CRRES mission provides the data source for short time duration event studies as well as long term efforts involving statistical analyses and modelling efforts. Prime uses of the THDB include the development of the static radiation belt model and cosmic ray model.

This document defines the analysis procedures and the instrument THDB file formats for each experiment.

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## 1.0 INTRODUCTION

The Combined Release and Radiation Effects Satellite (CRRES) payload included a number of instruments designed to provide data on particles, fields, and waves.

The Time History Data Base (THDB) for the CRRES mission provides the data source for short time duration event studies as well as long term efforts involving statistical analyses and modelling efforts. Prime uses of the THDB include the development of the static radiation belt model and cosmic ray model.

The purpose of this document is to define the analysis procedures and instrument THDB file formats for the GL701-4 High Energy Electrom Fluxmeter (HEEF), GL701-5A Medium Energy Electron Spectrometer (MEES), GL701-5B Electron and Proton Angle Spectrometer (EPAS) and the GL701-8/9 Proton Telescope (PROTEL).,

Chapter 1 contains an overview of the overall effort, the data flow, and the generic THDB structure.

Each succeeding chapter is devoted to one instrument (or element) for which the data is to be stored in the THDB. Each of these chapters contains a brief description of the instrument, the analysis used in the generation of the THDB generation, the parameter list, and the THDB file structure. The brief instrument description in each of these chapters was extracted from the "CRRES/SPACERAD Experiment Descriptions" document edited by M.S. Gussenhoven, E.G. Mullen, and R.C. Sagalyn. This document, dated 24 January 1985, is an AFGL Technical Report (AFGL-TR-85-0017, ADA160504). The analysis procedures and techniques resulted from discussions with a number of Principal Investigators and their analysts.

### 1.1 CRRES DATA FLOW

The down-linked telemetry data was recorded on instrumentation tape. The Phillips Laboratory/GPD (PL/GPD) decommutation center input the data from the instrumentation tapes and produced master-frame formatted files of the full telemetry stream. These files were placed on the PL mass storage device. The Agency Tape software accessed the master frame formatted files to produce the header files, magnetic field files, ephemeris files, attitude determination coefficient files, and the agency dependent telemetry file structures. These files were generated on an orbit by orbit basis. An orbit was defined as a spacecraft revolution about the earth starting at perigee and ending at the following perigee. The telemetry files received by each individual agency contain only the telemetry parameters required by that agency. Periodically, the agency files resident on mass storage were copied to digital tape for dissemination to the appropriate agencies. These digital tapes are referred to as Agency Tapes.

The THDB software uses individual agency files as input. Once generated, the THDB are placed on the mass storage device for easy access by folllow-on analysis routines.

File naming conventions were developed so that files for experiments and orbit numbers could be uniquely identified by taking a directory of the mass storage device.

## 1.2 THDB STRUCTURE

Since the CRRES spacecraft has a number of sensors in its payload with a 24 hour duty cycle, the philosophy adopted allowed for THDB creations in such a way that post-launch modifications to information such as calibration data bore no impact on THDB creation procedures. Further, some instruments required periods of on-orbit data to determine instrument background levels and calibration parameters. Since some of this information was not available for a period of time, the generation of the THDB in calibrated form would have been held up, or, in some cases, require regeneration as new or updated information was received.

Thus, the THDB was generated in integer form and consists of time tagged structured files in telemetry counts form for each of the various instruments.

By maintaining a separation between the telemetry data and the calibration data, once a THDB file for a particular instrument and orbit has been generated, it never needs to be re-generated.

Through the use of integer storage for the telemetry data portions of the THDB, flexibility is provided which allows individual Phillips Laboratory (PL) users to have data access from various computers (e.g. CYBER/NOSVE, VAX, or PC). All parameters are stored in INT*4, INT*2, or INT*1 form. This provides additional data compaction.

In general, the telemetry information is stored at the full data rate. Frame structures consist of a UT time tag and data groupings into logical structures (e.g. for particle sensors, the logical grouping consist of the data for a full spectra arranged from lowest to highest energy).

The THDB files are generated on an orbit by orbit and instrument by instrument basis.

## 2.0 AFGL-701-4 HIGH ENERGY ELECTRON FLUXMETER (HEEF)

### 2.1 INSTRUMENT DESCRIPTION

The High Energy Electron Fluxmeter (HEEF) is a solid state spectrometer telescope designed to measure the differential energy spectrum of electrons in the energy range from 1 to 10 MeV. Electrons in this energy range are the source of a significant portion of the total radiation dose received by microelectronic components in space systems operating in the Earth's radiation belts. As such, a determination of the average value and dynamic behavior of these electrons is critical to the mission of the Combined Release/Radiation Effects Satellite.

The High Energy Electron Fluxmeter is a telescope-type instrument in which a single BGO scintillating crystal is used to detect and measure the electrons with energies between 1 and 10 MeV. In order to overcome the background problems encountered in the past by similar instruments, an electron, to be counted, must produce a triple coincidence of pulses, one in the BGO crystal and one in each of two solid state detectors; additionally, it must have a single anticoincidence with a plastic scintillator surrounding the BGO crystal.

The BGO pulses are analyzed into ten energy bins.

### 2.2 ANALYSIS PROCEDURES

The prime data from the HEEF is carried on telemetry designation S30 which appears 9 times per minor frame. In GTO and CSM telemetry modes, the minor frame word locations are 20, 52, 84, 116, 148, 180, 212, 244, and 246; in LASSII mode the locations are 35, 38, 99, 102, 163, 166, 227, 230, and 233. For each of these minor frame words, the bit order is reversed from the normal convention (e.g. if the readout is 11 bits, reverse the order of the 11 bits; if the readout is 8 bits, reverse the order of the 8 bits); the MSB represents the least significant data bit and the LSB represents the most significant data bit. As the initial step in the processing, the bit order will be reversed to produce data in the normal convention. A full set of instrument readouts occurs every four minor frames and thus consists of 288 bits. Readouts from the 10 differential flux channels, the eleven singles channels, the integral flux channel, the 3 discretes and the HV monitor are strung together in the sequence of bits. Not all readouts are represented by the same number of bits, e.g. the 6 high energy differential flux channels are 10 bit readouts while the 4 low energy channels are 12 bit readouts.

The word order, data length, and exponent/mantissa information is as follows:

| Channel | Bits | Exp bits | Mantissa bits |
|---|---|---|---|
| SF2 | 11 | 3 | 8 |
| S1F | 11 | 3 | 8 |
| W1F | 12 | 4 | 8 |
| W2F | 12 | 4 | 8 |
| S2B | 11 | 3 | 8 |
| S1B | 11 | 3 | 8 |
| W1B | 13 | 3 | 10 |
| W2B | 13 | 3 | 10 |
| L10S | 13 | 3 | 10 |
| L10C | 13 | 3 | 10 |
| L9 | 10 | 0 | 10 |
| L8 | 10 | 0 | 10 |
| L7 | 10 | 0 | 10 |
| L6 | 10 | 0 | 10 |
| L5 | 10 | 0 | 10 |
| L4 | 10 | 0 | 10 |
| L3 | 12 | 0 | 12 |
| L2 | 12 | 0 | 12 |
| L1 | 12 | 0 | 12 |
| LL | 12 | 0 | 12 |
| BGO | 13 | 3 | 10 |
| LS | 12 | 4 | 8 |
| MB1 | 1 | 0 | 1 |
| MB2 | 1 | 0 | 1 |
| MB3 | 1 | 0 | 1 |
| HVM | 8 | 0 | 8 |

The 288 bit readout is sequentially stripped of the appropriate number of bits to extract the individual words. The THDB has the compressed counts from the 12 integral flux channels, the 10 differential flux channels and a packed word consisting of three discretes and the PCM counts for the HV monitor. The differential and integral flux data as well as the singles channels will be stored in 16 bit words to allow for data compression. One THDB record is generated for every 4 minor telemetry frames.

The decompression algorithm to be used for the integral flux and singles channels is as follows:

$$\text{TRUE COUNTS} = M * 2^{E}$$

where M is the mantissa and F is the exponent.

Conversion of decompressed counts to both integral flux and differential flux will be accomplished by means of one constant per channel. The calibration file will contain these constants along with the energy values associated with each of the differential flux channels.

### 2.3 PARAMETER LIST

Differential flux for 10 electron channels (1-10MeV), integral flux, and the dat for 11 singles channels are available at 0.512 second intervals.

### 2.4 THDB DATA RECORD STRUCTURE

The THDB file will consist of a 16 word (32 bit words) header record followed by a series of data records.

There is one data record per 0.512 secs (4 TLM frames). The compressed counts for the differential and integral channels as well as the singles channels are stored in 16 bit words.

HEADER RECORD (All words 32 bit integers)

| Word Number | Description |
|---|---|
| 1 | Experiment ID (value is 7014) |
| 2 | Year |
| 3 | Day of Year |
| 4 | Orbit Number |
| 5 | Start Time of orbit (UT in milliseconds) |
| 6 | End Time of orbit (UT in milliseconds) |
| 7-16 | Vacant (Zero fill) |

DATA RECORDS:

| Word No. | Description |
|---|---|
| 1 | UT (milliseconds) |
| 2-6 | Compressed counts for the 10 pt differential electron spectrum. The word order is L9, L8,...,L1, LL. |
| 7-12 | Compressed counts for the singles channels and the integral channel. The word order is S2F, S1F, W1F, W2F, S2B, S1B, W1B, W2B, L10S, L10C, BGO, and LS. |
| 13 | Bilevels MB1, MB2, MB3 and 8 bit HVM counts stored in the 11 LSBS of this word. |
| 14 | Dropout flag. |
| 15-16 | Vacant |

Note:

1. Dummy fill (1's fill) will be used for dropout within a spectra.

2. The dropout flag will have the value '1' if dropout occurred anywhere within the .512 second period.

## 3.0 AFGL 701-5A MEDIUM ENERGY ELECTRON SPECTROMETER (MEES)

### 3.1 INSTRUMENT DESCRIPTION

The Medium Energy Electron Spectrometer measures electrons with energies of order of magnitude 100 - 1000 keV. This sensor uses a uniform magnetic field of 850 gauss to momentum analyze electrons incident through an aperture. The electrons experience a V cross B force which constrains them to circular, or helical, paths within the instrument. An array of lithium-drifted silicon detectors at the 180 degree primary focus is used to detect them. The 180 degree focusing principle, which relies on the fact that chords subtending angles near 180 degrees do not differ much in length from a diameter of a circle, does not affect the motion parallel to the magnetic field and hence the focusing is effective in only one plane. Momentum analysis is achieved by virtue of the fact that the radius of the circle is proportional to the momentum of the charged particle. Electrons with similar momenta, or energies, which enter the aperture at various angles are focused into a vertical bar with the approximate width of the entrance aperture. At this focal plane, there are 18 detectors, one of which is covered and is used to measure penetrating particles such as cosmic rays. The other 17 detectors are used to separate the energy range of the instrument into 17 differential energy channels.

Data for this sensor is acquired only when the spacecraft is operating in GTO telemetry mode.

### 3.2 ANALYSIS PROCEDURES

The telemetry data for the 701-5A instrument is readout on the Aerospace data processing unit designated DPU57. The full DPU57 is readout on telemetry designation S33. The 12 bit compressed counts readouts corresponding to the 17 differential electron flux channels and the background value are readout every 0.512 seconds. Nine of the eighteen values are readout on every other minor frame. A nine bit sync word located in minor frame word 5 and the most significant bit of minor frame word 8 is to be used in determining the initial frame from which to extract data. This sync word appears in the same word location once every 8 minor frames. If the value of the sync word in the telemetry does not match the anticipated structure, the data will be suspect at best and a flag will be set in the data base to indicate that a non matching sync pattern was found. In addition, should data dropout occur anywhere within a spectra, the missing points will be 1's filled and a telemetry dropout flag set to 1 to indicate that telemetry dropout occurred within the frame. The first 9 values (MEA0-MEA8) occur on the same minor frame as the sync word; the remaining spectra points (MEA9-MEA17) are two minor frames later. Minor frame words 69, 72, 73, 100, 101, 104, 133, 136, 137, 164, 165, 168, 197, and 200 contain the compressed counts values for each pair of minor frames containing the full spectra. For the spectra data, each 12 bit compressed counts value will be placed in a 16 bit word and stored in the THDB.

The data format for DPU57 along with the word designations follows. This DPU contains the data for the AFGL 701-5A, AFGL701-5B, AFGL 701-7A, and AFGL 701-7B sensors.

DPU57 is readout on telemetry designation S33 which is located on 18 minor frame words. The minor frame word numbers are: 69, 72, 73, 100, 101, 104, 133, 136, 137, 164, 165, 168, 197, 200, 201, 228, 229, and 232. Blocks of DPU57 data are readout over 8 minor frames.

| NAME | BITS | TYPE DESCRIPTION |
|---|---|---|
| C | 1 | S MEB Sensor calibrate status. 0:off, 1:on. |
| CA0-CA3 | 8 | R Alcohol radiator Cerenkov rate scalers (RP). 1 second integration time. |
| COMMAND VERIFICATION | 16 | S Echo of 16-bit serial digital command received by DPU. |
| CS0-CS3 | 8 | R Fused silica radiator Cerenkov rate scalers (RP). 1 second integration time. |
| DSE | 4 | S MEB electron detector selected for PHA (1-10). |
| DSP | 2 | S MEB proton detector selected for PHA(1-4). |
| DPU HSK | 8 | A Analog data subcom from the DPU. |
| E0-E13 | 8 | R MEB electron detector PHA RAM scalar counting rates. |
| FORMAT/2 | 7 | S Defines position in a masterframe. (0-126 in steps of 2). |
| IDE0-IDE9 | 8 | R MEB integral counting rates for 10 electron det. |
| IDP0-IDP3 | 8 | R MEB integral counting rates for 4 proton det. |
| K | 1 | S RAM check status flag; 0: RAM ck passed,1:ckfailed |
| M | 1 | Photometer mode indicator (1=photometer) |
| MEA0-MEA17 | 12 | R MEA rate scalars. 0.5 second integration time. |
| MEB-PROG | 5 | S MEB detector selection pattern program. |
| N | 1 | S Format mode; 0:Normal, 1:Special release mode |
| P0-P11 | 8 | R MEB proton detector PHA RAM rate scalar counting rates. |
| PBKGND | 8 | R MEB proton detector background counting rate. |
| PCOINC | 8 | R MEB proton detector coincidence counting rate. |
| PS U,L (0,1) | 8 | R Upper and lower Proton Switch rate scalars. 2 thresholds, 4 second integration time. |

| | | |
|---|---|---|
| RE0-RE3 | 8 | R Electron scatter detector rate scalars (RP). 2 second integration time. |
| RM0-RM3 | 8 | R M-detector rate scalars (RP). 2 sec int. time. |
| S | 1 | S Sun pulse bit; 0:No sun pulse, 1:Sun pulse recd. |
| SYNC WORD | 9 | S FORMAT/2 sync word. Value=110001010. |
| T | 1 | S Defines TM contents; 0:sensor data;1:Dum p/fixed. |
| W | 1 | S W=1 means RAM reloaded from ROM due to detected fault. |

Data Types:
R: 8 or 12 bit compressed counting rates, 4 bit exponent.
S: Status bits, bytes, words.
A: Analog bytes convertible to engineering units.

The pattern below continues for every 1.024 seconds. DPU57 also has a Photometer mode, Memory Dump Mode, and Fixed Telemetry Mode. Data from the Memory Dump and Fixed Telemetry modes will

CRRES TELEMETRY FORMAT -DPU57

NORMAL MODE - 01OCT86 (REV E)

| FMT | FRM | WORD 5<br>69,133,197 | WORD8<br>72,136,200 | WORD9<br>73,137,201 | WORD36<br>100,164,228 | WORD37<br>101,165,229 | WORD40<br>104,168,232 |
|---|---|---|---|---|---|---|---|
| 0 | 0 | SYNC=110001010 | FORMAT/2 CTR | DPU-HSK | CA 0 | CS 0 | RE(0,2) |
| | 1 | MEA 0 | MEA 1 | | MEA 2 | | MEA 3 |
| | 2 | MEA 4 | MEA 5 | | MEA 6 | | MEA 7 |
| | 3 | MEA 8 | DSE | IDE 0 | IDE 6 | E 0 | E 1 |
| | 4 | E 2 | E 3 | E 4 | E 5 | E 6 | E 7 |
| | 5 | E 8 | E 9 | E 10 | E 11 | E 12 | E 13 |
| | 6 | IDE 1 | IDE 2 | IDE 3 | IDE 4 | IDE 5 | IDE 7 |
| | 7 | IDE 8 | IDE 9 | IDP 0 | IDP 1 | IDP 2 | IDP 3 |
| 1 | 0 | PCOINC | PBKGD | K\|W\|T\|-\|C\|S\|DSP | CA 1 | CS 1 | RM(0,2) |
| | 1 | MEA 9 | MEA 10 | | MEA 11 | | MEA 12 |
| | 2 | MEA 13 | MEA 14 | | MEA 15 | | MEA 16 |
| | 3 | MEA 17 | DSE | IDE 0 | IDE 6 | E 0 | E 1 |
| | 4 | E 2 | E 3 | E 4 | E 5 | E 6 | E 7 |
| | 5 | E 8 | E 9 | E 10 | E 11 | E 12 | E 13 |
| | 6 | P 0 | P 1 | P 2 | P 3 | P 4 | P 5 |
| | 7 | P 6 | P 7 | P 8 | P 9 | P 10 | P 11 |
| 2 | 0 | COMMAND VERIFY | | PS U,L(1,2) | CA 2 | CS 2 | RE(1,3) |
| | 1 | MEA 0 | MEA 1 | | MEA 2 | | MEA 3 |
| | 2 | MEA 4 | MEA 5 | | MEA 6 | | MEA 7 |
| | 3 | MEA 8 | DSE | IDE 0 | IDE 6 | E 0 | E 1 |
| | 4 | E 2 | E 3 | E 4 | E 5 | E 6 | E 7 |
| | 5 | E 8 | E 9 | E 10 | E 11 | E 12 | E 13 |
| | 6 | IDE 1 | IDE 2 | IDE 3 | IDE 4 | IDE 5 | IDE 7 |
| | 7 | IDE 8 | IDE 9 | IDP 0 | IDP 1 | IDP 2 | IDE 3 |
| 3 | 0 | PCOINC | PBKGD | M\|MEbPROG\|S\|DSP | CA 3 | CS 3 | RM(1,3) |
| | 1 | MEA 9 | MEA 10 | | MEA 11 | | MEA 12 |
| | 2 | MEA 13 | MEA 14 | | MEA 15 | | MEA 16 |
| | 3 | MEA 17 | DSE | IDE 0 | IDE 6 | E 0 | E 1 |
| | 4 | E 2 | E 3 | E 4 | E 5 | E 6 | E 7 |
| | 5 | E 8 | E 9 | E 10 | E 11 | E 12 | E 13 |
| | 6 | P 0 | P 1 | P 2 | P 3 | P 3 | P 5 |
| | 7 | P 6 | P 7 | P 8 | P 9 | P 10 | P 11 |

not be included in the THDB.

The data is 'sample and hold' with a .512 second time difference between the time of data sampling and the time that the first of the points is readout to telemetry. All spectra points are sampled over the same time period.

The decompression algorithm to convert to true counts requires the extraction of the 3 MSBs and the 9 LSBs of the 12 bit word. The 3 MSBs represent the exponent (e) and the 9 LSBs represent the mantissa (m). The formula to convert the compressed counts to true counts is as follows:

$$\text{COUNTS} = m \quad \text{if} \quad e = 0,$$

and

$$\text{COUNTS} = [2 ** (e-1)] * [512 + m] \quad \text{if } 0 < e < 8.$$

Conversion of the decompressed counts into differential flux will be accomplished by an equation of the form:

Diff. Flux(i) = [Counts(i) - Counts(16) x K(i)] / GF(i) / .512

where i = 0, 17,
Counts(16) represents background counts,
Counts(i) represents the counts for channel (i),
K(i) are channel dependent constants,
and GF(i) are the geometric factors used to convert to flux.

The 701-5A calibration file will contain records identifying the values of the channel energies, the channel dependent constants, and the geometric factors. Pre-launch values of K and GF will initially be placed in the calibration file. Fine tuning of these calibration values with early on-orbit data is anticipated. The file will be updated with the revised calibrations as soon as they become available.

Data flags contained in the DPU57 unit will be included in the THDB for possible use in data interpretation. These include the Ram Check Status (K), Format Mode (N), Sun Pulse Bit (S), Contents of TM (T), and Ram reload (R).

### 3.3 PARAMETER LIST

Differential flux for 17 electron channels (40keV-2.2MeV) is available every 0.512 s.

### 3.4 THDB DATA RECORD STRUCTURE

The THDB files for this sensor will consist of a header record (in 32 bit integer form) followed by a series of data records.

THDB Data Records - Medium Energy Electrons data for 17 differential electron energy channels plus one background channel will be stored in 16 bit words (two 16 bit words per 32 bit word). The vacant/flag word at the end of each record will have the value 0 (for normal operations) or 1 (to indicate that a data gap will follow due to the spacecraft telemetry mode being changed to CSM or LAS mode).

Each record will have data accumulated over 4 telemetry frames (0.512 secs). Dropout words within a spectra will be noted by 1's fill. If dropout occurs over a full spectra, there will be no fill. The data will simply be missing.

HEADER RECORD (All words 32 bit integers)

| Word Number | Description |
|---|---|
| 1 | Experiment ID (value is 70151) |
| 2 | Year |
| 3 | Day of Year |
| 4 | Orbit Number |
| 5 | Start Time of orbit (UT in milliseconds) |
| 6 | End Time of orbit (UT in milliseconds) |
| 7-12 | Vacant (Zero fill) |

DATA RECORDS (32 bit words):

| Word No. | Description |
|---|---|
| 1 | UT (milliseconds) |
| 2 | Compressed counts for E0 and E1 |
| 3 | " " " E2 and E3 |
| 4 | " " " E4 and E5 |
| 5 | " " " E6 and E7 |
| 6 | " " " E8 and E9 |
| 7 | " " " E10 and E11 |
| 8 | " " " E12 and E13 |
| 9 | " " " E14 and E15 |
| 10 | " " " E16 (background) and E17 |
| 11 | Byte 3: vacant<br>Byte 2:<br>Telemetry Dropout flag (Value = 1 if dropout in this frame, normal value is 0)<br>Byte 1:<br>Bit 7 = Sync indicator; 0=sync ok, 1=sync mismatch<br>Bit 6 = C (Calibration flag)<br>Bit 5 = K (Ram check status)<br>Bit 4 = N (Format mode)<br>Bit 3 = S (Sun Pulse bit)<br>Bit 2 = T (Contents of TM)<br>Bit 1 = W (Ram Reload) |

Bit 0 = Telemetry flag. Normally 0; will be set to 1 if a data gap follows due to a switch to CSM or LASSII telemetry mode.

12 Vacant

## 4.0 AFGL 701-5B ELECTRON-PROTON ANGLE SPECTROMETER (EPAS)

### 4.1 INSTRUMENT DESCRIPTION

The Electron-Proton-Angle Spectrometer (EPAS), or sensor 701-5B, measures protons and electrons with emphasis on wide pitch angle coverage with good pitch angle resolution. The viewing angles and apertures of the instrument are such that electron pitch angle coverage is achieved between 0 and 120 degrees with respect to the spacecraft axis. Protons are measured in four directions. The combination of a special magnetic deflection system and a solid- state particle detection technique makes it possible to obtain simultaneous measurements for different pitch angles.

Protons are measured in the energy range 20 keV - 2 MeV, and electrons in the range 20 - 300 keV.

All particle detectors (ions: P 0 to P 3; electrons E 0 to E 9) are followed by charge sensitive preamplifiers, pulse amplifiers, pulse formers, and discriminators.

The proton telescopes produce three different sets of data: the count rates of the front detectors (P 0 to P 3), the count rates of the back detectors (U 0 to U 3), and coincidence counts of the front and back detectors. The count rates of the front detectors go to a "Proton Selector" unit which selects one of the four for energy analysis in the proton pulse height analyzer (PHA). This analysis is only carried out if a coincidence between front and back detectors has not occurred. These data are called differential count rates.

Simultaneously the count rates of the four front detectors are routed via discriminators to the data processing unit (DPU); these are called integral count rates.

The data lines from the ten electron detectors (E 0 to E 9) pass the "Electron Selector" which determines on which of the ten channel energy analysis is carried out in the "Electron PHA". The ten data lines are also routed via discriminators as integral count rates directly to the DPU.

The proton and electron PHA sort the count rates from one selected proton and electron detector into 12 and 15 different energy intervals, respectively.

Data for this sensor is acquired only when the spacecraft is operating in GTO telemetry mode.

### 4.2 ANALYSIS PROCEDURES

The prime telemetry data for this instrument is also readout by Aerospace DPU57. The time cycle duration for this DPU is 16 major frames (65.536 seconds). As noted in the 701-5A description, a 9 bit sync word is readout once every 8 minor frames. This sync word will be used in locating the minor frames from which to extract the counts corresponding to the 14 point electron differential flux spectra; the 12 point proton differential flux spectra; the integral flux values from the 10 electron sensors and 4 proton sensors; and the proton coincidence and background counting rates.

The 8 bit compressed counting rate data for the 14 point electron flux spectra (E0-E13) follows a pattern of 2 words on the minor frame containing the sync word, followed by 12 words on the next minor frame. Thus, once sync is found, the alternating frame pattern is fixed. In addition, a four bit readout (DSE) identifies the detector from which the spectra was acquired. This 4 bit readout appears on alternating minor frames beginning with the frame containing the sync word. The 12 point proton spectra data (P0-P11) is readout on every fourth telemetry frame. These 8 bit readouts are located on the third minor frame following the sync word. A two bit readout (DSP) identifying the detector from which the spectra was acquired appears six minor frames preceding the spectra (i.e. it lags by one spectra).

The 8 bit compressed counts readouts corresponding to integral flux from the 10 electron sensors (data values IDE0-IDE9) and 4 proton sensors (IDP0-IDP3) are located on the minor frame containing the sync word and the succeeding minor frame. The two minor frames which then follow contain no integral flux data. The pattern then repeats on a 4 minor frame cycle.

The 8 bit coincidence (PCOINC) and background count rates (PBKGD) for protons appear on the second frames following a sync word frame and every fourth frame thereafter.

The THDB will have one record per four minor frames and contain the compressed counts (in byte form) from the two electron spectra and the associated detector numbers; the proton spectra and associated detector number; the 10 electron and 4 proton integral flux values; the proton coincidence and background counting rates; and selected discretes which may be useful in data interpretation. The bytes containing the compressed counts values will be stored in 32 bit integers.

The instrument has a calibrate mode which is executable by uplink command. The duration of the calibration mode is for integral multiples of 16 major frames beginning on the frame for which the FORMAT/2 counter value is zero. This counter is a 7 bit readout located in word 8 of a minor frame containing the 9 bit sync word. A single flag bit will be used to determine areas where the instrument is in calibrate mode.

For the 701-5B 8 bit compressed counts values, the 4 MSBs of the word represent the exponent (e) and the 4 LSBs represent the mantissa (m). The decompression algorithm is as follows:

$$COUNTS = m \text{ if } e = 0,$$

and

$$COUNTS = [\ 2 ** (e-1)] * [16 + m\ ] \quad \text{if } 0 < e < 16.$$

The 701-5B integral flux counts are converted to integral flux by means of a multiplication constant for each sensor.

The true counting rates for the spectra data are converted to differential flux by means of an equation of the form:

$$DIFF\ FLUX(I,J) = CTS(I,J) * G(I,J)$$

where I represents a channel number and J represents a detector number, CTS(I,J) represents true counts for channel I of the Jth detector, and G(I,J) are the multiplicative geometric factors. The spectra data points are simultaneously sampled. The time at which the sampling occurs is .256 seconds prior to readout.

The 701-5B calibration file will contain records identifying energies associated with each of the channels for differential flux spectra; multiplicative geometric factors necessary to convert spectra values to differential flux; and multiplicative factors necessary for the computation of integral flux.

## 4.3 PARAMETER LIST

Integral flux from 10 electron sensors is available every 0.512 seconds.

Integral flux from 4 proton sensors is available every 0.512 seconds.

From the 10 electron sensors, one sensor is selected and a 14 point differential flux spectra (20keV-250keV) is produced every 0.256 seconds.

From the 4 proton sensors, one sensor is selected and a 12 point differential flux spectra (30keV-20MeV) is produced every 0.512 seconds.

## 4.4 THDB DATA RECORD STRUCTURE

The THDB files for the AFGL 701-5B will consist of a header record followed by a series of data records.

There will be one data record per 0.512 seconds.

HEADER RECORD (All words 32 bit integers)

| Word Number | Description |
|---|---|
| 1 | Experiment ID (70152) |
| 2 | Year |
| 3 | Day of Year |
| 4 | Orbit Number |
| 5 | Start Time of orbit (UT in milliseconds) |
| 6 | End Time of orbit (UT in milliseconds) |
| 7-18 | Vacant (Zero fill) |

DATA RECORDS:

| Word No. | |
|---|---|
| 1 | UT (milliseconds) |
| 2 | Compressed counts:<br>Byte 1:Electron integral flux IDE0<br>Byte 2:Electron integral flux IDE1<br>Byte 3:Electron integral flux IDE2<br>Byte 4:Electron integral flux IDE3 |
| 3 | Byte 1:Electron integral flux IDE4<br>Byte 2:Electron integral flux IDE5<br>Byte 3:Electron integral flux IDE6<br>Byte 4:Electron integral flux IDE7 |
| 4 | Byte 1:Electron integral flux IDE8<br>Byte 2:Electron integral flux IDE9<br>Bytes 3-4:Vacant |
| 5 | Byte 1:Proton integral flux IDP0<br>Byte 2:Proton integral flux IDP1<br>Byte 3:Proton integral flux IDP2<br>Byte 4:Proton integral flux IDP3 |
| 6 | Byte 1:Sensor number for first electron spectrum<br>Byte 2:Sensor number for second electron spectrum<br>Byte 3:Sensor number for proton spectrum<br>Byte 4:Vacant |
| 7-13 | Compressed counts (in byte form) for the first 14 point electron spectrum followed by compressed counts (in byte form) for the second 14 point electron spectrum |
| 14-16 | Compressed counts (in byte form) for the 12 point proton spectrum |
| 17 | Byte 1:Compressed counts for proton coincidence counting rate;<br>Byte 2:Compressed counts for proton background counting rate;<br>Byte 3:Discrete information as follows:<br>Bit 7 = Telemetry dropout flag (=1 if dropout occurred in the .512 second interval)<br>Bit 6 = C (Calibration mode flag)<br>Bit 5 = K<br>Bit 4 = N<br>Bit 3 = S<br>Bit 2 = T<br>Bit 1 = W |

Bit 0 = Telemetry flag. Normally = 0; will be set to 1 if a data gap follows due to a switch to CSM or LASSII telemetry mode.

Byte 4: Vacant

18 Vacant

Notes:

1. Dummy fill (1 fill) will be used for dropout within a spectra.
2. If dropout occurs for a full .512 seconds resulting in loss of both electron spectra and the proton spectrum, no fill will take place.
3. If dropout occurs such that the sensor number from which a spectra is taken is lost, the sensor number will be 1's filled.

## 5.0 AFGL 701-8,-9 PROTON TELESCOPE (PROTEL)

### 5.1 INSTRUMENT DESCRIPTION

The objective of the Proton Telescope (PROTEL) is to make well-calibrated, high resolution measurements of 1- 100 MeV protons. PROTEL consists of two sensor head assemblies and a data processing unit (DPU). The low energy sensor head measures 1-9 MeV protons in 8 contiguous energy channels. The high energy sensor head measures 6-100 MeV protons in 16 contiguous energy channels. The entire 24 point spectrum is returned once per second. PROTEL will monitor the major energy contributors to the radiation belts for use in both static and dynamic radiation belt models.

Operation of this instrument is controlled by an experiment command system. A sixteen bit command word supplied by the spacecraft is decoded into a four by eight matrix of static on-off command elements, with each commandable function controlled by one or more command elements. The more critical functions utilize several redundant elements.

### 5.2 ANALYSIS PROCEDURES

The PROTEL telemetry consists of a 24 point proton differential flux spectra, 10 heavy ion dose measurements, 12 singles readouts from the high energy sensor head, and 9 singles readouts from the low energy sensor head, command state bits, and instrument housekeeping analogs. The prime science data from this instrument is readout 10 times per minor frame on designation S35 which is located on minor frame words 23, 27, 55, 59, 87, 119, 151, 183, 215, and 247 in GTO and CSM telemetry formats. In LASSII telemetry format, the word locations change to minor frame words 57, 59, 121, 123, 169, 185, 187, 201, 249, and 251. A full set of detector (S35) readouts is obtained every 8 minor frames beginning on sub-frames 0, 8, 16, and 24. All minor frame words are eleven bits comprised of a 4 bit exponent followed by a 7 bit mantissa. Minor frames 0 through 6 (mod 8) have seven science words (11 bits) followed by three spare bits; minor frame 7 (mod 8) has six science words followed by 14 spare bits. The sequence of words within the 8 minor frames is as follows:

| SUBFRAME | DATA |
|---|---|
| 0 | High energy channels 1 through 7 |
| 1 | High energy channels 8 through 14 |
| 2 | High energy channels 15 and 16 followed by high energy singles channels D1A, D12A, D123A, D134A and D145A |
| 3 | High energy singles channels D6, Dr, D1, D2, D3, D4, D5 |
| 4 | Low energy channels 1 through 7 |
| 5 | Low Energy channel 8 followed by low energy singles channels D1A, D12A, D123A, D134A, D5, D1 |

6 Low energy singles channels D2, D3, D4 followed by four ion dose channels.
7 6 ion dose channels

The data from the S35 science words will be extracted from the bit stream, decompressed into true counts, and stored in the THDB in 32 bit words. Thus one THDB data record will represent 4.096 seconds. The THDB will also include the 8 command state bits and bilevels, designations B29 and B30 (SC-14, SF19 and SF20); and the 17 instrument analogs (designations A221-A237 located on SC11 / SF15-31. The command state bits will be used to determine periods when the instrument is in calibration mode. Analog A236 identifies the command state row. The remaining analog words are for instrument housekeeping data. The analogs and bilevels will be stored in the THDB in their telemetry form (8 bit bytes).

The decompression algorithm to convert the 11 bit data (4 exponent bits, 7 mantissa bits) to true counts is as follows:

$$\text{TRUE COUNTS} = M * 2^E,$$

where M represents the mantissa and E represents the exponent.

For the 24 proton channels, the conversion from true counts to differential flux is by means of a multiplicative constant (geometric factor) for each channel. Thus,

$$\text{DIFF FLUX}(i) = \text{TCOUNTS}(i) * \text{GF}(i),$$

where TCOUNTS(i) is the true counts for proton channel(i), and GF(i) is the associated geometric factor.

The calibration procedure for the dose data is also by means of one multiplicative factor per channel. Thus,

$$\text{DOSE}(i) = \text{DCOUNTS}(i) * F(i),$$

where DCOUNTS(i) represents the decompressed counts for dose channel(i), and F(i) is the associated multiplicative factor.

The calibration file associated with this instrument will contain records identifying the energy values associated with the differential proton channels; the multiplicative geometric factors; the threshold energies for each of the ion dose channels; and the multiplicative factors necessary to obtain dose measurements.

### 5.3 PARAMETER LIST

The PROTEL parameter list consists of:

1. Differential flux for a 24 point proton spectra (1-100MeV) is available at 1.024 seconds .

2. Heavy ion dose in 10 channels (1.4-100MeV) is available at 1.024 seconds.

3. Twelve singles readouts from the high energy sensor head every 1.024 seconds.

4. Nine singles readouts from the low energy sensor head every 1.024 seconds.

5. Instrument bilevel and analog data every 4.096 seconds.

### 5.4 THDB DATA RECORD STRUCTURE

The AFGL 701-8,-9 THDB files will consist of a header record followed by a series of data records. Each data record will be made up of data accumulated over a master frame (4.096 seconds).

HEADER RECORD (All words 32 bit integers)

| Word Number | Description |
|---|---|
| 1 | Experiment ID (value is 70189) |
| 2 | Year |
| 3 | Day of Year |
| 4 | Orbit Number |
| 5 | Start Time of orbit (UT in milliseconds) |
| 6 | End Time of orbit (UT in milliseconds) |
| 7-230 | Vacant (Zero fill) |

DATA RECORDS:

| Word No. | Description |
|---|---|
| 1 | UT (Milliseconds) |
| 2-9 | Decompressed counts for the 8 LE differential proton spectra |
| 10-25 | Decompressed counts for the 16 HE differential proton spectra |
| 26-35 | Decompressed counts for the 10 heavy ion dose measurements |
| 36-56 | Decompressed counts for LE singles channels (D1A, D12A, D123A, D134A, D5, D1, D2, D3, D4) followed HE singles channels D1A, D12A, D123A, D134A, D145A, D6, Dr, D1, D2, D3, D4, D5. |
| 57-111 | Repeat the order of words 2-56 for the next 1.024s. |
| 112-166 | " " |
| 167-221 | " " |
| 222-226 | Bilevels, analogs, and dropout flag in byte form and in the order B29, B30, A221-A237, dropout flag. |
| 227-230 | Vacant |

Notes:

1 The dropout flag will be set to 1 if there is dropout anywhere within the master frame.

2. Dropout within a spectra will be 1 filled.