DATA SET CATALOG #21

Explorer 33 ION Chamber Geiger counter

66-058A-04A 7 tapes

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1. INTRODUCTION:

The documentation for this data set was originally on paper, kept in NSSDC's Data Set Catalogs (DSCs). The paper documentation in the Data Set Catalogs have been made into digital images, and then collected into a single PDF file for each Data Set Catalog. The inventory information in these DSCs is current as of July 1, 2004. This inventory information is now no longer maintained in the DSCs, but is now managed in the inventory part of the NSSDC information system. The information existing in the DSCs is now not needed for locating the data files, but we did not remove that inventory information.

The offline tape datasets have now been migrated from the original magnetic tape to Archival Information Packages (AIP's).

A prior restoration may have been done on data sets, if a requestor of this data set has questions; they should send an inquiry to the request office to see if additional information exists.

2. ERRATA/CHANGE LOG:

NOTE: Changes are made in a text box, and will show up that way when displayed on screen with a PDF reader.

When printing, special settings may be required to make the text box appear on the printed output.

Version	Date	Person	Page	Description of Change
01				
02				

3 LINKS TO RELEVANT INFORMATION IN THE ONLINE NSSDC INFORMATION SYSTEM:

http://nssdc.gsfc.nasa.gov/nmc/

[NOTE: This link will take you to the main page of the NSSDC Master Catalog. There you will be able to perform searches to find additional information]

4. CATALOG MATERIALS:

a. Associated Documents — To find associated documents you will need to know the document ID number and then click here. http://nssdcftp.gsfc.nasa.gov/miscellaneous/documents/

b. Core Catalog Materials

IMP-D

ORIGINAL GM & ION CHAMBER COUNTS, TAPE

66-058A-04A

THIS DATA SET HAS BEEN RESTORED. ORIGINALLY THERE WERE 7 7-TRACK, 800 BPI TAPES WRITTEN IN BCD. THERE ARE TWO RESTORED TAPES. THE DR TAPES ARE 3480 CARTRIDGES AND THE DS TAPES ARE 9-TRACK, 6250 BPI, WRITTEN IN EBCDIC. THE TAPES WERE CREATED ON A 7094 COMPUTER. THE DR AND DS NUMBERS ALONG THE CORRESPONDING D NUMBERS AND THE TIME SPANS ARE AS FOLLOWS:

DR#	DS#	D#	FILES	TIME SPAN
DR03455	DS03455	D02099	1	07/01/66 - 08/19/66
		D02100	2	08/20/66 - 10/07/66
		D02101	3	10/08/66 - 11/25/66
		D02102	4	11/26/66 - 01/13/67
DR03456	DS03456	D02103	1	01/14/67 - 03/03/67
		D02104	2	03/04/67 - 04/21/67
		D02105	3	04/22/67 - 06/09/67

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EXPLORER 33 ION CHAMBER - - GEIGER COUNTER
(66-058A-01A)

After unsuccessfully attempting to copy this data set using the NSSDC Dupe and Compare utility program (NA988), it was determined that there are data files written past the physical end-of-tape mark (reflective spot) on the tapes received from Berkeley. Since the 7094 will read data past the end-of-tape mark but will not write data pas the end-of-tape mark an alternate method of copying this data set was neccessary. The process decided upon involved the use of "Mulcpy" (A5.01.002). This program copies 'N' number of files from 'K' number of tapes onto one tape according to the data setup card. The program used for this data set has been modified to delete all end-of-file marks but the last one. Each original tape contains several hundred files so by deleting these end-of-file marks much less tape was required on each output reel. All of the tapes were successfully copied by this program and placed in the Data Repository. The original has a double end-of-file after the last data file. Every record on the C-tape (copy) can easily be indentified with a data file on the D-tape (original) be the 12-character indentification prefix. (Page 19 Explorer 33 documentation.)

Space Sciences Laboratory
University of California
Berkeley, California 94720

I. Technical Description of the University of California Explorer-[illegible] Energetic Particle Experiment

II. Description of the Data Format on Magnetic Tapes Supplied to the NASA Space Science Data Center

K.A. Anderson, Principal Investigator
R. P. Lin, Research Physicist
G.H. Pitt, Chief Programmer

Technical Report on NAS 5-9077
Series 10, Issue 8

March 20,, 1969

I. TECHNICAL DESCRIPTION OF EXPERIMENT

The University of California experiment aboard Explorer-33 consists of two Geiger-Mueller tubes, one of which looks out directly at particle fluxes while the other is in a configuration where it sees the particle flux backscattered off an 8 mil gold foil. Protons lose energy in the gold foil without backscattering while electrons backscatter with high efficiency and little energy loss. With this arrangement, proton and electron fluxes can be separated.

The open counter, GM2, and the scatter detector, GM1, are both pointing at 90° to the spin axis. GM1 is a Lionel 205 HT Geiger-Mueller tube with a standard window while GM2 is a thin-window version of the same tube with an energy threshold of about one-half as high as for GM1. Thus, for electrons it is possible to derive some energy spectrum information about the fluxes. A 4-inch ion chamber completes the detector complement which is shown in Figure 1. Table 1 summarizes the characteristics of the detectors.

Geiger-Mueller Detectors

The Lionel 205 HT tube has a cylindrical cathode of ¼" inside diameter, and it is sensitive to radiation over the entire ¼" diameter window. This tube has a 1.2-1.4 mg/cm^2 window, and a typical electron detection efficiency versus electron energy curve is shown in Figure 2. The threshold, arbitrarily defined as the 1/e efficiency point, is about 40 keV for these tubes. GM2 is a special thin-window (0.7 mg/cm^2 mica) modified Lionel 205 HT. The window diameter has been necked down to 0.17" in order to support the mica window against pressure. Its response to

Table 1. Explorer-35 Detector Characteristics

Designation	Type of Detector	Window mg/cm^2	Directional Sensitivity		Omnidirectional Sensitivity		Geometry Factor	
			Electrons	Protons	Electrons	Protons	Directional cm^2 - ster	Omnidirectional cm^2
GM1	Lionel 205 HT GM tube in scatter configuration	1.4 mica	>45 KeV	None	>2.5 MeV	35 MeV	2.4×10^{-2}	~0.75
GM2	Lionel 205 HT thin-window GM tube	0.7 mica	> 22 KeV	>0.3 MeV	> 2.5 MeV	35 MeV	0.29	~0.75
Ion Chamber	4" diameter spherical Neher-type integrating ion chamber	210 aluminum skin	--	--	> 0.7 MeV	12 MeV maximum sensitivity ~17 MeV	--	~80

electrons is also shown in Figure 2. As can be seen, its threshold is about 22 keV for electrons.

The proton response of these tubes is calculated from range energy curves given by Trower[1] after the tube window thicknesses are calibrated with an alpha-particle source.

The 8 mil gold scatter foil used in GM1 provides effective discrimination against protons. All particles seen by the counter must backscatter off the foil. Protons lose energy before they are scattered through large angles, as can be illustrated by calculating the rms scattering of a 10 MeV proton in a length equal to its range. From Fermi:[2]

$$\overline{\theta^2} \approx \frac{8\pi N D z^2 Z^2 e^4}{V^2 p^2} \ln \frac{a_o V p}{2 Z^{4/3} z\, e^2}$$

where N = number of atoms per cm^3, D = length of travel (placed equal to the range), z = charge of particle = 1 for proton, Z = charge of scatter = 79 for gold, e = electron charge, V = velocity of particle, p = momentum of particle, and a_o = Bohr radius. We obtain

$$\sqrt{\overline{\theta^2}} \approx 0.2 \text{ radians} \approx 10^o$$

Tests on the efficacy of the scatter foil were conducted using a cyclotron beam of 4 MeV protons.[3] An upper limit of 0.1% was obtained for the proton detection efficiency. Furthermore the observation of solar proton events has confirmed that the count rate of the scatter counter due to backscattered protons is negligible.

Electrons backscatter off the gold foil with high efficiency. A well referenced treatment of electron scattering is contained in Siegbahn,[4] and only the pertinent results will be mentioned here. The 8 mil gold foil is thick enough to insure saturation back-scattering of electrons of a few MeV or lower energies. Fifty per cent of a normally incident beam of electrons and 70% of a diffuse beam will be backscattered from the gold foil. The angular distribution of the backscattered electrons will be approximately $\cos^2\theta$ in angular dependence. Neither the backscatter efficiency nor the angular distribution of the backscattered electrons is dependent on the energy of the incident electron. However, energy loss occurs in the scattering foil. Measurements indicate that for a heavy element such as gold or lead the probable energy loss is about 5-10%, with about two-thirds of the particles losing less than 20% of their energy. The effect of this energy loss is two-fold:

1. the energy threshold of the scatter counters are about 5 keV higher than the bare GM tube, and
2. the counting efficiency versus electron energy curve is not quite as sharply falling.

Thus the scatter counter's (GM1) threshold is about 45 keV for electrons. From the above considerations the scattering efficiency would be expected to stay fairly constant over a wide range of electron energy above the threshold for the scatter counter. Figure 3 shows the measured efficiency versus energy for the IMP-3 scatter counter configuration.[5]

On Explorer-33, GM2 is pointed at right angles to the spin axis and the spin axis is pointed only 4° off the ecliptic plane.

The initial orientation of the spin axis just barely allows GM2 to see the sun; however, as the spin axis-sun angle changes due to the orbital motion of the earth, GM2 sees more and more of the sun. Because of its very thin window GM2 is quite sensitive to solar X-rays in the 1-14 Å region, and its background count rate is due primarily to such X-rays.

The X-ray response of these counters can be calculated if the composition of the mica window and the fill gas is known. If an X-ray beam of intensity $I_o(\lambda)$ is incident on a material of thickness, ℓ, then the intensity of the penetrating beam is .

$$I(\lambda) = I_o(\lambda) \exp [- \rho \ell \sigma (\lambda)]$$

where ρ = density of the material, and $\sigma(\lambda)$ = cross-section.

$$\sigma(\lambda) = \frac{1}{\rho} \sum_i \rho_i \sigma_i (\lambda)$$

where ρ_i = density of element i in the material and $\sigma_i(\lambda)$ = cross-section for element i.

For an X-ray to be counted by the Geiger-Mueller tube, it must penetrate the window and stop in the gas. Therefore, the counting efficiency is given by

$$\frac{I(\lambda)}{I_o(\lambda)} = \exp [- \rho \ell \sigma (\lambda)]_{mica} \{1 - \exp[- \rho \ell \sigma (\lambda)]_{gas}\}$$

Using the cross-sections kindly supplied by L. Acton (private communication), the calculation has been carried for GM2 of Explorer 33. The resulting efficiency curve is shown in Figure 4.

The GM tubes are shielded with 1.5 g/cm^2 of brass. This shielding is in addition to the spacecraft packaging and outer skin so that the total shielding is about 2.0 g/cm^2. Range-energy curves were used to determine the threshold energies for penetrating particles.[1]

The Geiger-Mueller tubes have dead times following a pulse. These dead times change at very high count rates since the voltage across the tube never recovers completely after a pulse before a new pulse starts. The variation of the count rate with flux is shown in Figure 5 for GM1 of the Explorer 33. The assumption of a constant dead time fits the curve well over most of the tube's useful range, and individually fitted dead times can be used to correct the count rates of the detectors. These are 1×10^{-4} seconds for both GM1 and GM2.

The accumulation and readout format of Explorer 33 is shown in Figure 6. Essentially the counts are accumulated over about 40 seconds, which is many spin periods. Thus, since the counters point 90° off the spin axis they will sweep out and average over a wide cone of angles.

On August 1, GM2 of Explorer 33 began to behave erratically. At this time it was counting a continuous 3000 counts per second from solar X-rays. By August 4, the count rate of GM2 had risen to 10,000 counts per second, which was higher than the saturation rate achieved in laboratory tests. On August 9, GM2 stopped counting and a few days later GM1 also stopped. Studies in the laboratory on similar tubes indicated that GM2 had apparently gone into a neon lamp type discharge, and drawn enough current to lower the power supply voltage below the starting potential of GM1. This malfunction may have been due to two causes:

1. loss of some gas from the counter, due to a pinhole leak in the very thin window of the counter, or a leak elsewhere in the counter walls; or
2. absorption of the quenching gas on the walls of the counter from the catalytic action of the large X-ray flux.

Eventually the current drawn by GM2 became sufficiently large to lower the supply voltage and stop GM1 also. The ion chamber continued to operate since its voltage threshold is 350V.

Ion Chamber

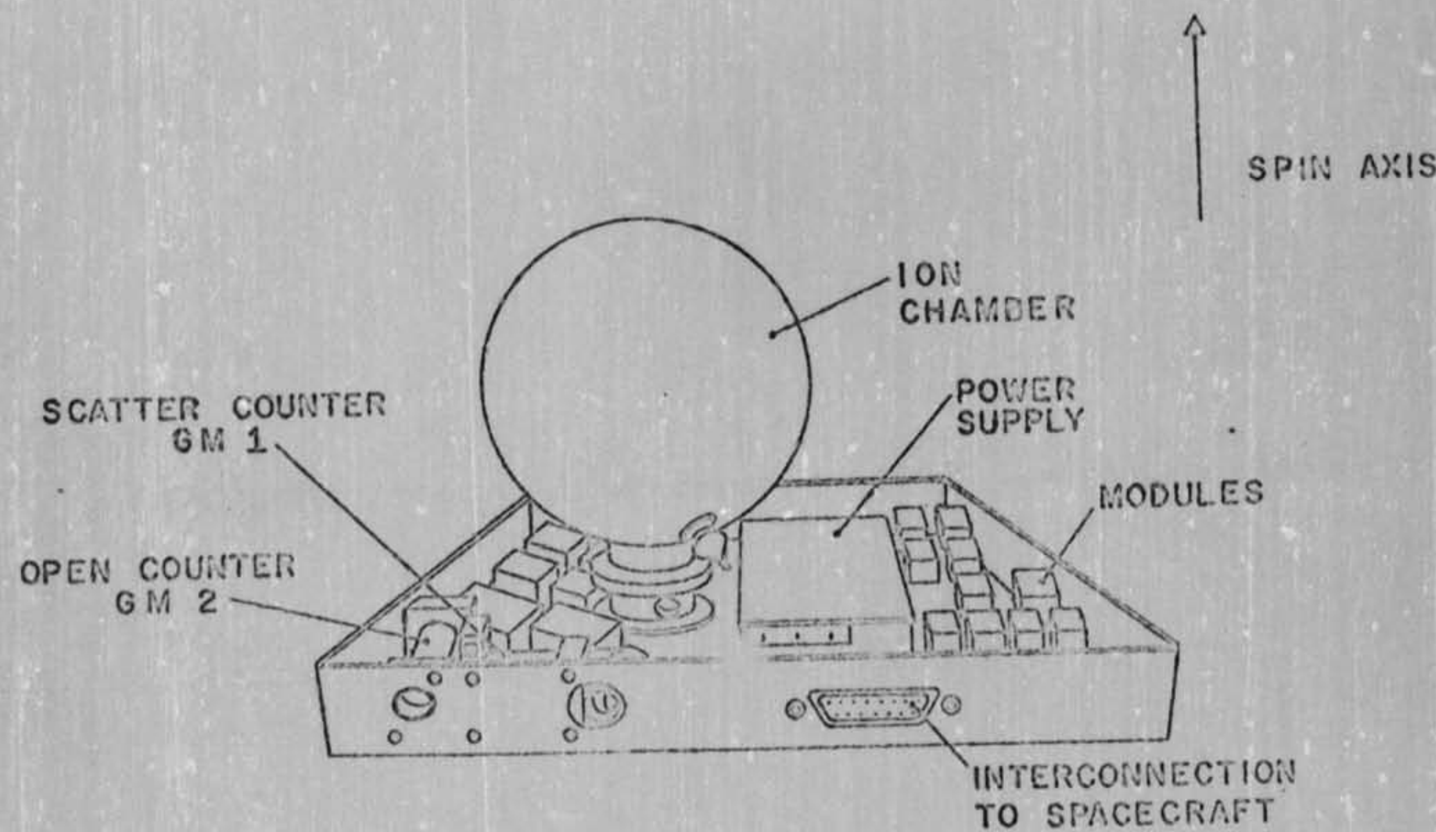
A schematic of the ion chamber carried aboard Explorer 33 is shown in Figure 7. This is an integrating Neher-type ionization chamber. The operation of the chamber is straightforward. The tungsten whisker flicks over and charges the anode to 700 volts. Then the anode collects electrons from ionization in the chamber, making the anode voltage drop. When the drop in anode voltage creates a powerful enough electrostatic force on the whisker, the whisker flicks over and recharges the anode. The pulse created by the recharging is recorded and represents a specific amount of ionization in the chamber. The calibration curve of the Explorer 33 chamber is shown in Figure 8.

The response of the chamber to protons and electrons of different energies can be calculated. For very high energy (minimum ionizing) particles which penetrate the spacecraft the calculation is fairly simple. However, for low energy particles both the thickness of material surrounding the chamber, and the varying ionization loss of the particle with energy must be taken into account. The amount of energy lost in the chamber can be calculated from range-energy curves, and the material to be traversed before entering the chamber may be estimated from considerations of the ion chamber location on the spacecraft. Figure 9 gives the results of such calculations.

For the Explorer-33 ion chamber the time span between pulses is measured to milliseconds and read out every 40 seconds. Thus the time resolution of the Explorer-33 ion chamber is a function of the radiation level. At galactic cosmic ray background levels the time resolution is about ten minutes.

REFERENCES

1. Trower, W.P., High Energy Particle Data, Volume II. Range-Energy and dE/dX Plots of Charged Particles in Matter, University of California, Lawrence Radiation Laboratory, Berkeley, Publication UCRL-2426, 1966
2. Fermi, E., Notes compiled by J. Orear, A.H. Rosenfeld, and R.A. Schluter, Nuclear Physics, University of Chicago Press, Chicago, Illinois, p. 36, 1950
3. Anderson, K.A., H.K. Harris and R.J. Paoli, J. Geophys. Res., 70, 1039, 1965
4. Siegbahn, K., Alpha-, Beta- and Gamma-Ray Spectroscopy, V1, N. Holland Publishing Co., Amsterdam, Netherlands, 1965



UNIVERSITY OF CALIFORNIA EXPERIMENT PACKAGE
FOR EXPLORER 33

FIGURE 1. The Explorer-33 package shown here is located on the top of the spacecraft. Both the open and scatter counters look out at 90° to the spin axis.

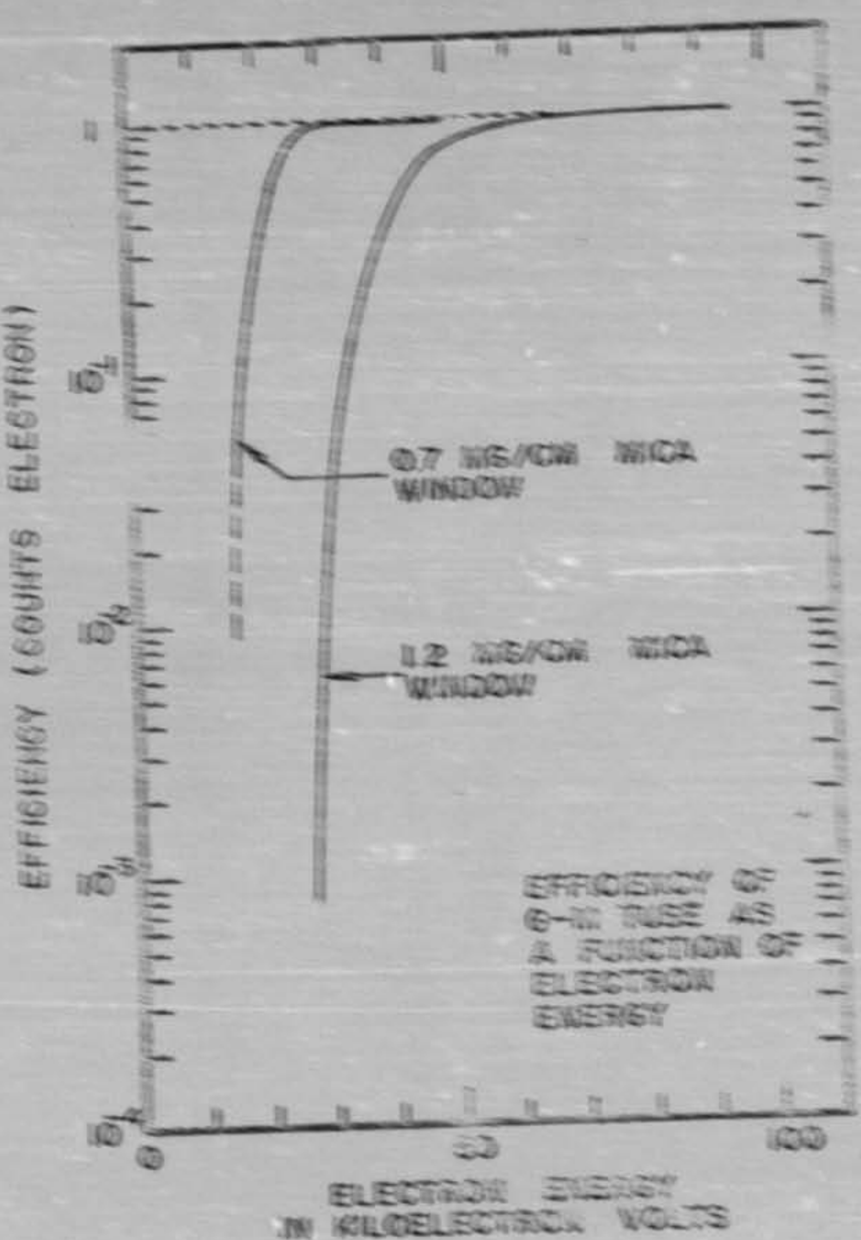


FIGURE 2. The measured efficiency of the Geiger-Mueller tubes with 1.2 mg/cm^2 and 0.7 mg/cm^2 mica windows is shown here as a function of energy.

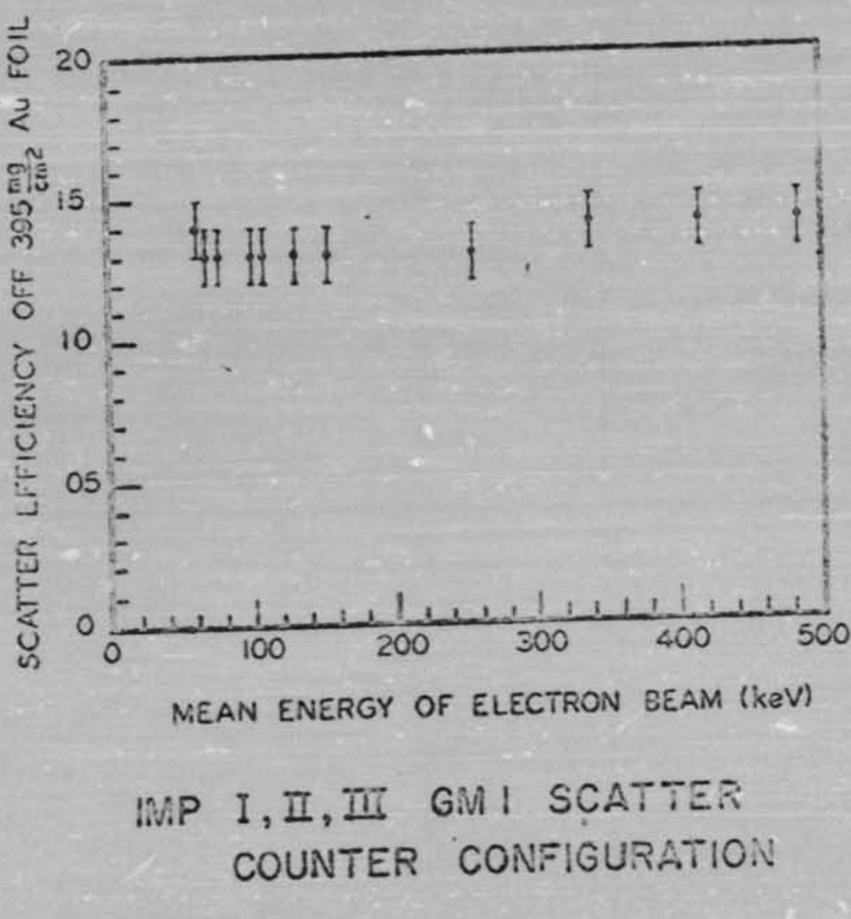


FIGURE 3. This figure illustrates the uniformity of the scattering efficiency of the gold foil over a wide range of electron energies.

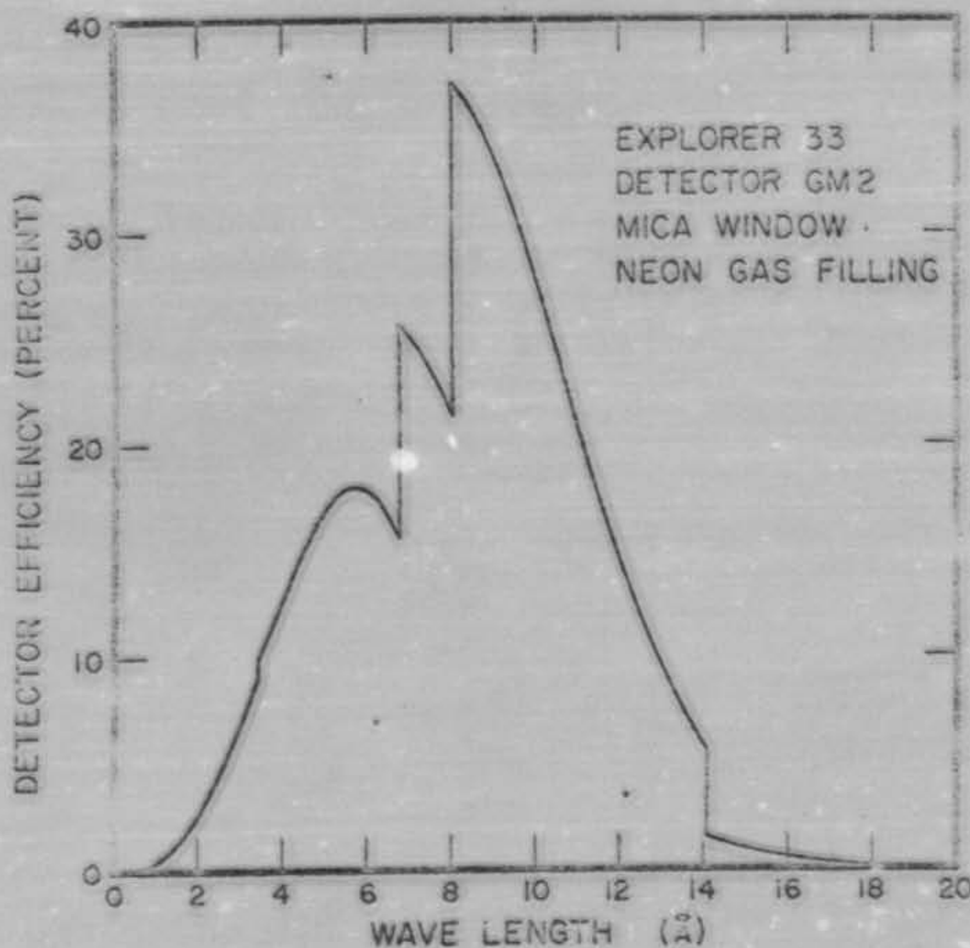


FIGURE 4. The efficiency of the 0.7 mg/cm² mica window open counter aboard Explorer-33 for counting X-rays has been calculated and is shown here as a function of X-ray wavelength.

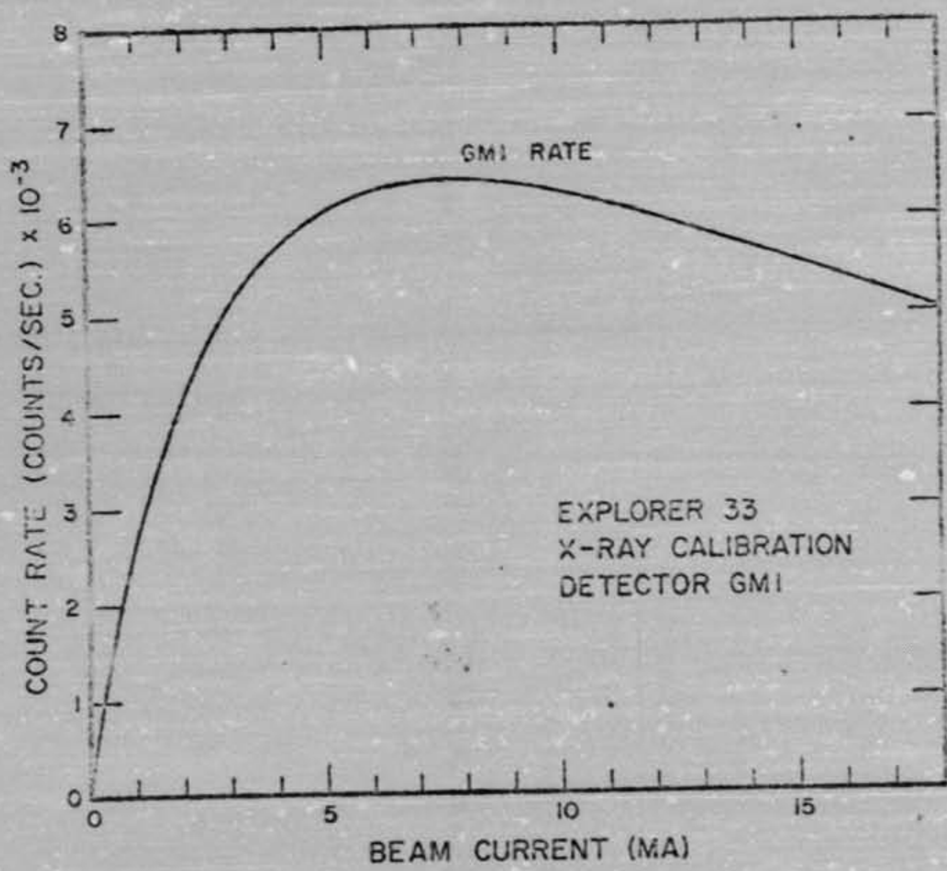


FIGURE 5. In this calibration of the Geiger-Mueller tube the incident flux of X-rays is proportional to the beam current. The count rate of the GM tube as a function of flux is well described up to ~5000 counts per second by a simple dead time correction.

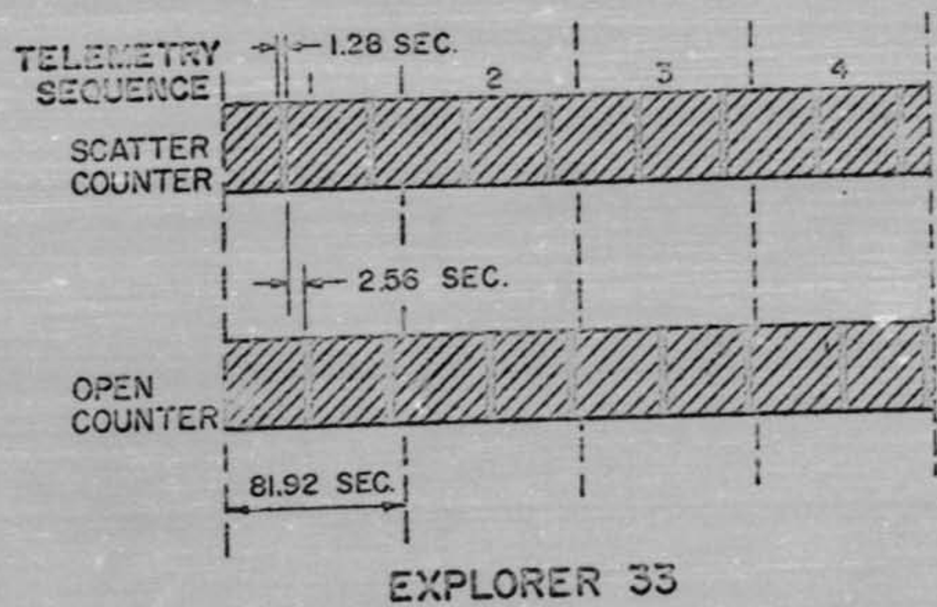
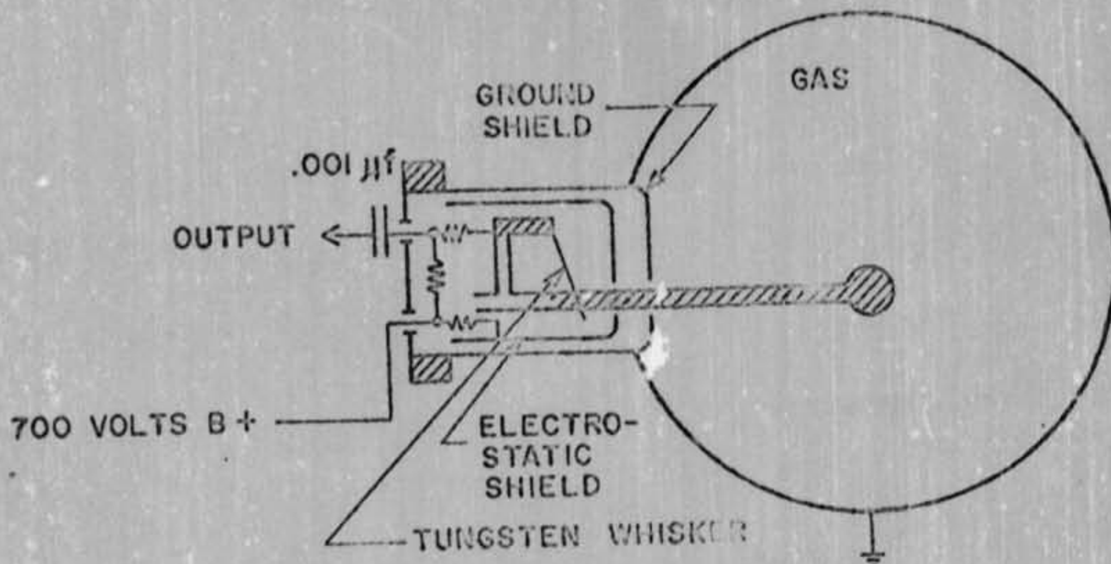


FIGURE 6. The Explorer-33 accumulation and telemetry sequence is shown here. The slanted line regions indicate when accumulation of counts is taking place. The solid bar indicates time of readout. The scatter counter readout is 2.56 seconds before the open counter.



EXPLORER 33

SCHEMATIC, 4" ION CHAMBER

FIGURE 7. This is a schematic of the Neher-type integrating ion chamber carried aboard Explorer-33.

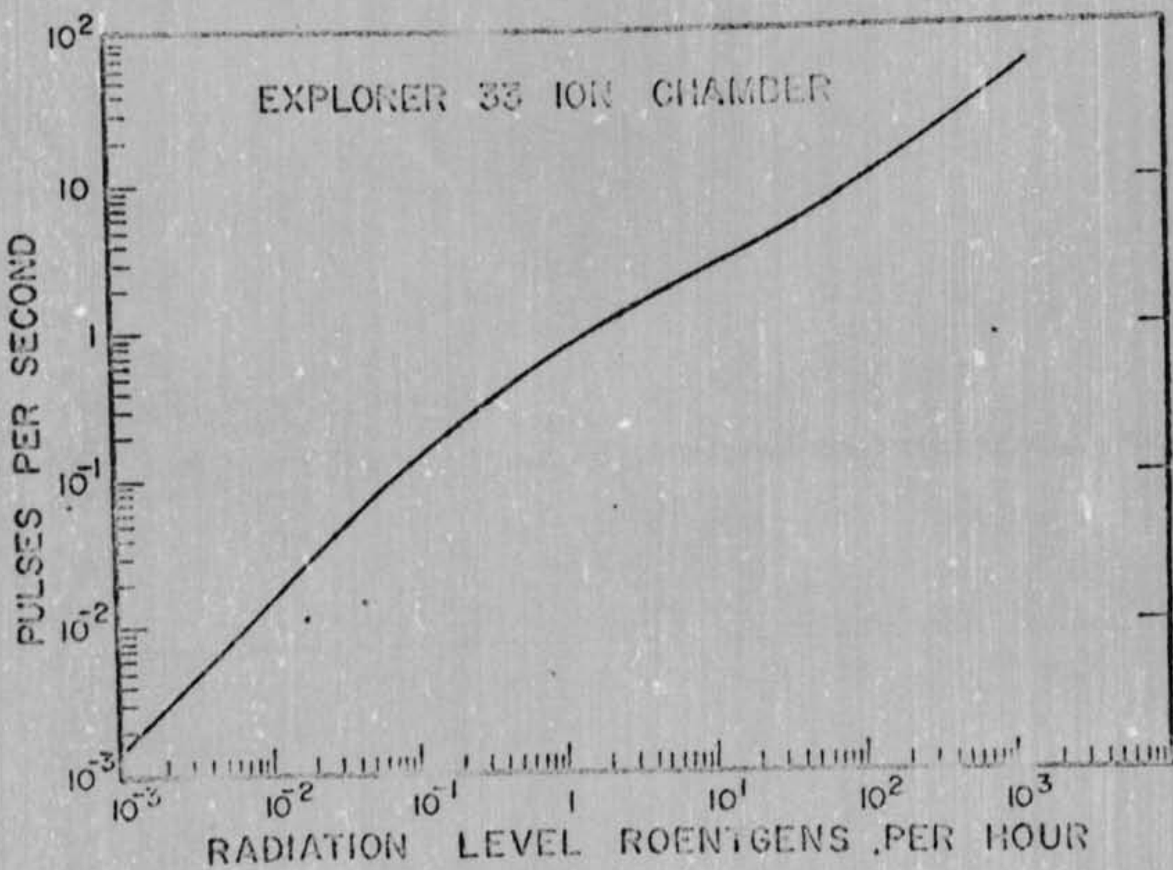


FIGURE 8. This shows the calibration of the Explorer-33 ion chamber for radiation dosage.

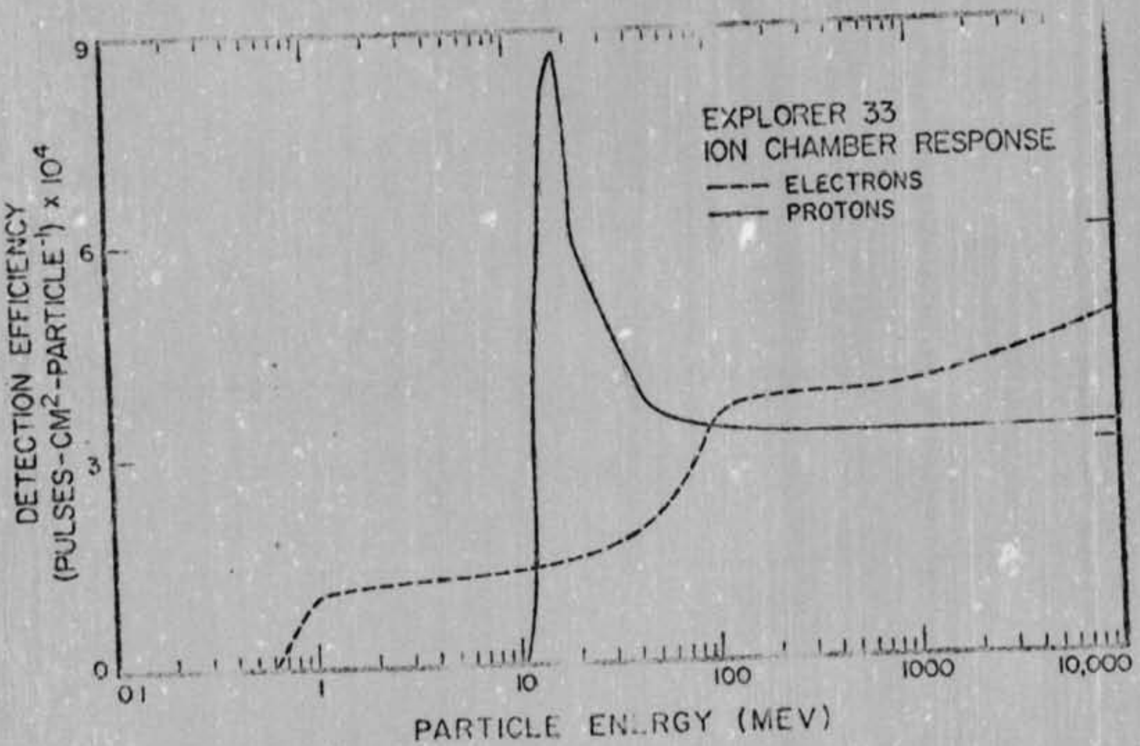


FIGURE 9. The ion chamber efficiency for electrons and protons as a function of energy was calculated from range-energy curves and shown here.

II. EXPLORER-33 UNIVERSITY OF CALIFORNIA EXPERIMENT DATA TAPES

All the useful data from the Explorer-33 University of California experiment is contained on seven 2400 foot magnetic tape reels. The data covers the period from day 181, 1966 to day 160, 1967. These tapes were generated by merging 49 reels received from Goddard Space Flight Center (GSFC) onto the seven longer reels in chronological order. Each long tape contains data from seven shorter reels. The tapes were generated on an IBM 360/40 system and contain BCD characters on a 7-track tape in even parity at 800 characters/inch density.

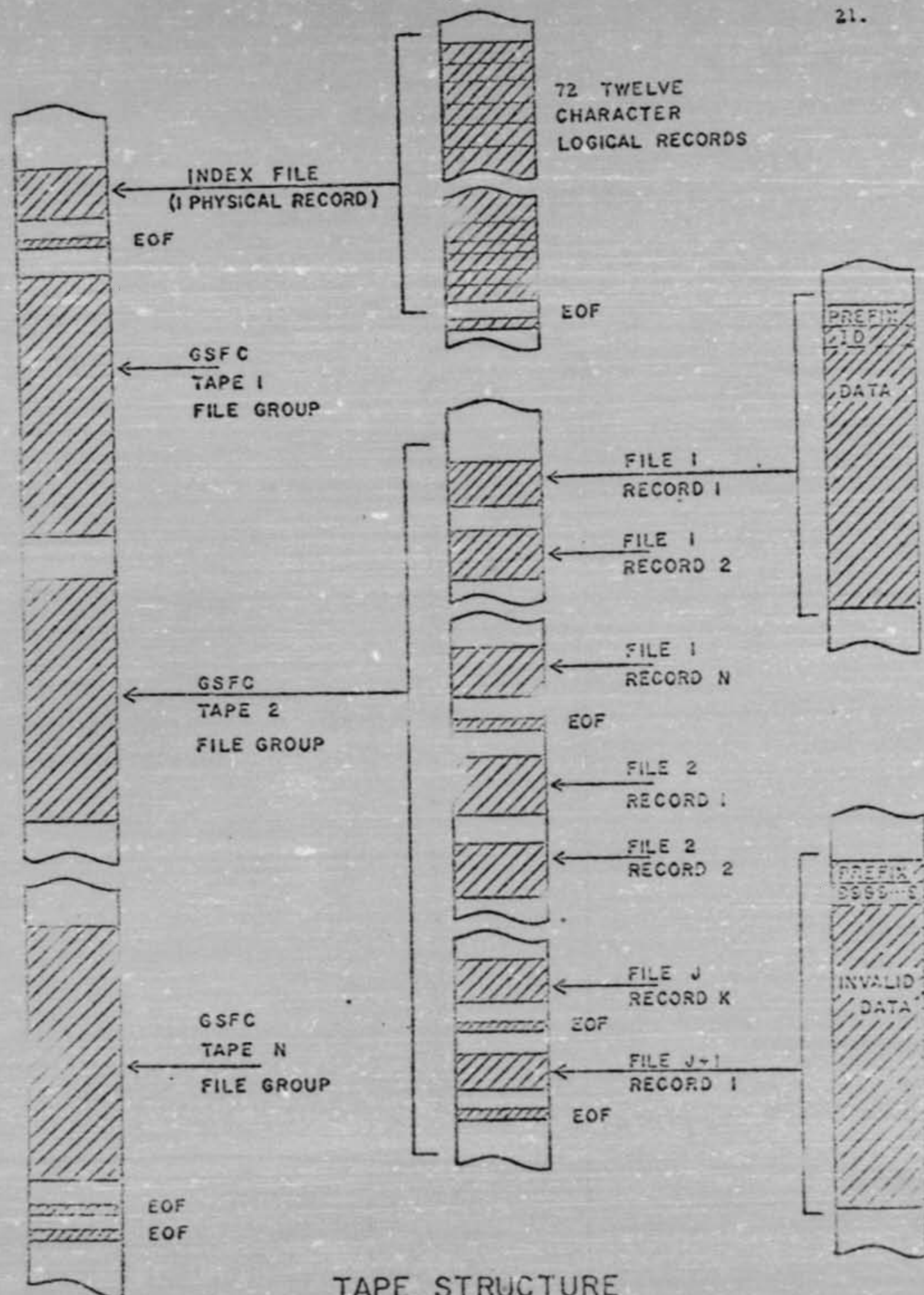
The first file of each stacked tape is a one record file which serves as an index to that tape. The physical record is 865 characters in length and consists of 72 twelve-character index entries. There is one index entry for each of the GSFC short reels stacked onto the larger tape. The entries are in the following format:

Characters	
1-6	GSFC reel number
7-9	Total number of files on the GSFC reel
10-12	blank

Each stacked tape contains seven entries. The remaining entries are blank. Following the index file is the stacked experiment data copied from the GSFC reels. The data is in the same file by file format as it appeared on the original tapes except that a 12-character field has been prefixed to each record to identify it to University of California programs using these tapes. The individual records are 865 characters (including prefix field) and are formatted as follows:

Characters	
1-6	The GSFC reel number on which this record originally appeared.
7-9	The file number within that GSFC reel.
10-12	The record number within the above file.
13-865	The experimental data in its original format (see tape format sheet).

The last file on each of the GSFC tapes is a one record file with the twelve character identification field (i.e., Satellite No., Julian Day, Year) set to nines. This field has also been copied onto the stacked tape. Thus the first record of the following file on the stacked tape will have a different GSFC reel number and a file number of 1 in the prefix field. Two end of file marks will follow the last data file on the stacked tape.



TAPE STRUCTURE

UCAL FINAL EXPLORER-33 EXPERIMENTER TAPE FORMAT

Item	Function	Number of BCD Characters
0	Prefix	12
1	Identification (ID)	
	(a) Satellite	2
	(b) Julian Day of Year	3
	(c) Year	2
	(d) Data Acquisition Station	2
	(e) Analog Tape Number	3
2	A/D Line Indicator	1
3	Time for the Middle of Channel Ø, Frame Ø	
	(a) Day ~~Count~~ of Year ~~(Jan 1 = 0)~~	3
	(b) Fractional Day of Year (millisecond precision)	8
	(c) Blank	1
4	Time Flag	2
5	Sequence Counter ("Satellite Clock") (1 Decimal Number)	6
6	Frame Rate	4
7	Sequence Identification	
	Items 8 through 23 repeated two (2) times per sequence, i.e., for frames 5 and 13.	
8	Frame Number	2
9	Pre Data Flag	1
10	Raw Data (4 Comb Filter Numbers)	12
11	Guardband Flag	1
12	Converted Data GM1(1 Decimal Number of max 65,535)	5
13	Raw Data (4 Comb Filter Numbers)	12
14	Guardband Flag	1
15	Converted Data IC Clock (1 Decimal No. of max 65,535)	5
16	Raw Data (4 Comb Filter Numbers)	12
17	Guardband Flag	1
18	Converted Data GM2(1 Decimal No. of max. 65,535)	5
19	Raw Data (1 Comb Filter Number)	3
20	Raw Data (3 Comb Filter Numbers)	9
21	Guardband Flag	1
22	Converted Data IC Count(1 Decimal No. of max. 4095)	4
23	Post Data Flag	1
24	Data Quality Flag	1
25	Performance Parameter (1 Decimal No. of max. 255)	3
26	Performance Parameter (1 Decimal No. of max. 255)	3
27	Performance Parameter (1 Decimal No. of max. 255)*	3
28	Optical Aspect	
	(a) Pseudo Sun Pulse Flag	2
	(b) Sun Angle (1 Octal No. of max. 777)	3
	(c) Spin Period (1 Decimal No. of max. 4095)	4
	(d) Sun Time (1 Decimal No. of max. 4095)	4
	(e) Moon Time 1 (1 Decimal No. of max. 4095)	4
	(f) Moon Time 2 (1 Decimal No. of max. 4095)	4
	(g) Moon Time 3 (1 Decimal No. of max. 4095)	4

TOTAL NUMBER OF CHARACTERS PER SEQUENCE 223

Four of the above described sequences will be blocked together with the exception that the last three sequences of the block will <u>not</u> contain the Identification (Item #1) or A/D Line Indicator (Item #2).

---

*In a sequence 1 Item #25, will be PP1, Item #26 will be PP2, Item #27 will be PP7.

In a sequence 2 Item #25 will be PP14, Item #26 will be PP15, Item #27 will be PP16.

In a sequence 3 Item #25 will be PP17, Item #26 will be PP18, Item #27 will be PP19.

In a sequence 4 Item #25 will be PP20, Item #26 will be PP22, Item #27 will be PP24.

EXPLORER 33 ION CHAMBER - - GEIGER COUNTER

INTERIM DATA SET CATALOG (66-058A-04A)

ORIGINAL TAPE NO.	NO. OF FILES	OUTPUT TAPE NO.
D-02099 (Master 1)	445	C-01907
D-02100 (Master 2)	429	C-01908
D-02101 (Master 3)	435	C-01909
D-02102 (Master 4)	384	C-01910
D-02103 (Master 5)	422	C-01911
D-02104 (Master 6)	427	C-01912
D-02105 (Master 7)	429	C-01913

Number of data files on original is one less than the total number of files. Output tape has one file only.

BB625707C AA1655050G BB520507A BB838905I B39981106E 339982051 AA

00000

REC 1. LENGTH 870

39982051 AA1731051

00000

BB6257006400151132555300111841168477948 020437325918103403404305007201375304004
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