Internal Report #21
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User's Guide to OGO-VI Rate Plots

by

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EXPERIMENT

Instrumentation and Measurement

The cosmic ray experiment on OGO-VI (experiment F-20) consists of 3 charged particle telescopes. Each telescope is oriented so that it points away from the surface of the earth (-Z direction in spacecraft coordinates). These telescopes (Range, Čerenkov, Flare) monitor cosmic ray charged particles in various energy and flux intervals. The Range telescope allows differential flux measurements to be obtained for protons and helium nuclei with energy from ~1 MeV/nucleon to ~300 MeV/nucleon and integral flux determinations for higher energies. With the proper ground commands, this telescope can also monitor electrons with energies from 250 keV to 2 MeV. The Čerenkov telescope is capable of differential flux measurements for charge particles up to Z = 8 in the energy range from ~450 MeV/nucleon to ~1 GeV/nucleon. Integral fluxes are obtained for energies greater than 1 GeV/nucleon. Both of these telescopes are designed to be operative when the incident flux is less than 10^5 particles/m^2 sec. The Flare telescope is sensitive to protons and helium nuclei in the energy range 17 MeV/nucleon to ~100 MeV/nucleon. Because it has a very small geometrical factor compared with the other telescopes, this telescope is operable for incident fluxes up to 10^{10} particles/m^2 sec. The experiment has been described by Althouse et al. (B1) at the

IEEE Nuclear Science Symposium. The brief description which follows is therefore not intended to be complete.

The Range telescope (figure B-1) consists of seven totally depleted gold-silicon surface barrier detectors (D1-D7) mounted in a stack with five absorbers (A2-A6) sandwiched between the detectors. Surrounding the stack is a plastic scintillator cup which is viewed by a photomultiplier tube (D8). A 0.00075 inch aluminized mylar window which serves as a light shield covers the top of the scintillator. Table B-I lists the relevant characteristics of the detectors and associated electronics. The window coupled with the discriminator threshold of D1 sets the low energy threshold of the Range telescope at 1.17 MeV for protons. The discriminator thresholds for D2-D7 are set so that at least 99% of all minimum ionizing protons will trigger the circuit. D4-D7 have an additional discriminator which provides crude energy loss determinations in these detectors. The energy loss in D1-D3 is determined more accurately with the aid of three 256 channel pulse height analyzers. For low energy particles which do not reach D4 the energy losses in D1-D3 are recorded. For higher energy particles the energy losses in D2 and D3 are recorded along with information indicating the range of the particle.

The Čerenkov telescope consists of two totally depleted gold-silicon surface barrier detectors (D1', D2') mounted in

Figure B-1

Cross-sectional view of the Range telescope.

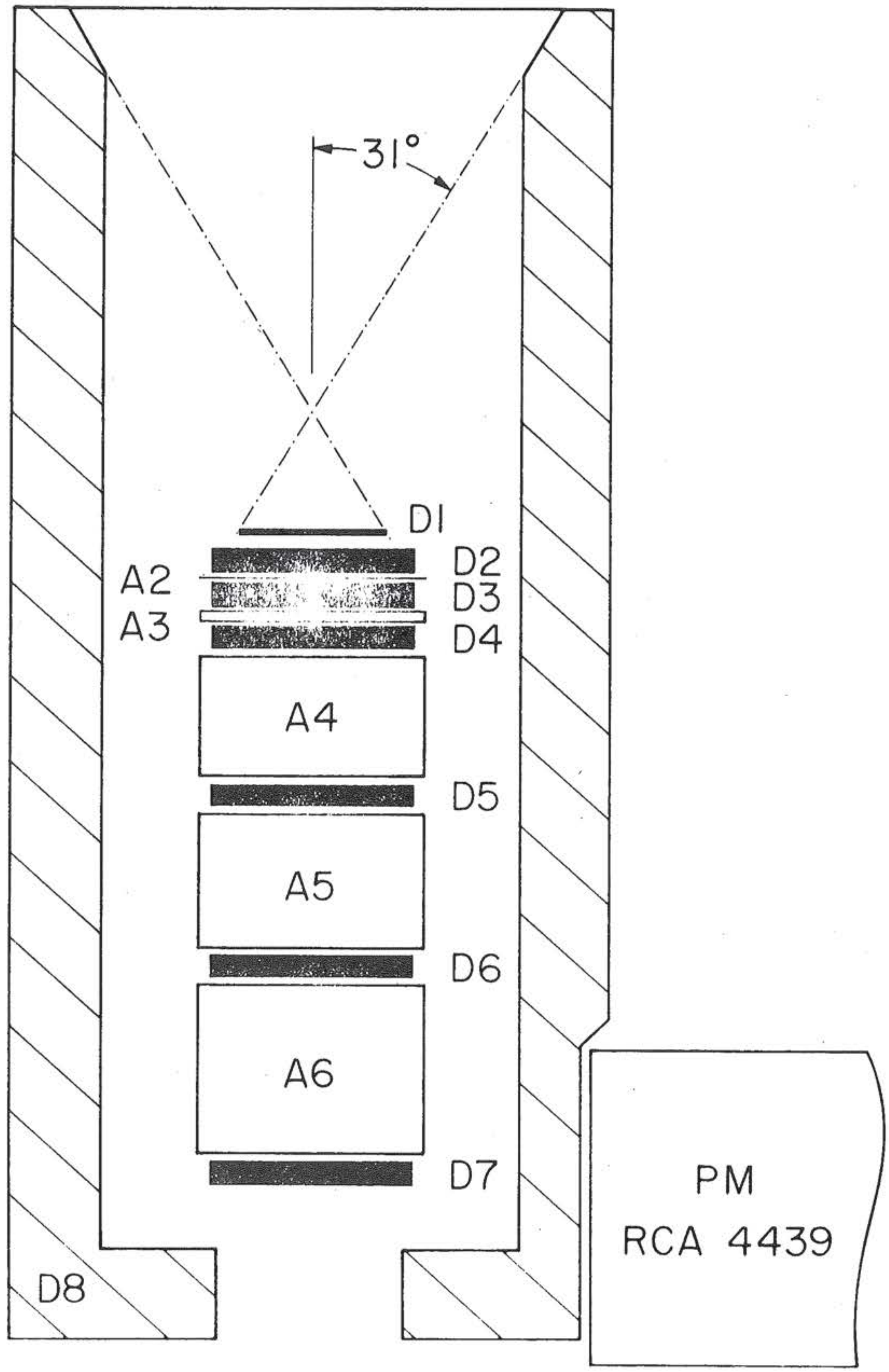

31°
D1
D2
A2
D3
A3
D4
A4
D5
A5
D6
A6
D7
D8
PM
RCA 4439

TABLE B-I

RANGE TELESCOPE DETECTORS

Detector	Thickness (mg/cm²)	Area (cm²)	Discriminator Thresholds Low (keV)	High keV)
D1	22.1±3%	2.01±6%	398±8	
D2	233	3.80	147±4	
D3	227	4.08	153±3	
D4	227	3.87	149±4	563±14
D5	236	4.01	142±4	559±14
D6	227	4.08	141±4	700±15
D7	236	4.08	148±4	841±19

RANGE TELESCOPE ABSORBERS

Absorber	Thickness (gm/cm²)	
A2	0.205±1%	(Aluminum)
A3	2.94	(Mallory 2000 Tungsten Alloy)
A4	27.57	(Mallory 2000 Tungsten Alloy)
A5	30.98	(Mallory 2000 Tungsten Alloy)
A6	38.73	(Mallory 2000 Tungsten Alloy)
Window	0.00232±1%	(Mylar)

RANGE TELESCOPE ANTICOINCIDENCE

PM Tube	Scintillator	Threshold Energy Protons	Electrons	Gamma Rays	μ-Mesons
RCA 4438	NE 102 0.375" thick	8.9 MeV	0.62 MeV	0.42 MeV	3.5 MeV

an aluminum can which is on top of a 1 cm thick quartz window of a photomultiplier tube (D3'). This stack is surrounded by a plastic scintillator viewed by another photomultiplier tube. The top of this telescope is also covered by a .00075 inch aluminized mylar window. Figure B-2 shows a cross-sectional view of the Čerenkov telescope and table B-II lists the relevant characteristics of the detectors and associated electronics.

The Flare telescope consists of two totally depleted gold-silicon surface barrier detectors (D5', D6') and one absorber between them (equivalent to A2 in the Range telescope). These are mounted in a gold plated copper collimator which will stop protons up to ~100 MeV. An aluminum foil window simulates the window and detector D1 of the Range telescope so that the responses of D5' and D6' are essentially the same as those of D2 and D3 in the Range telescope. Figure B-3 shows a cross-sectional view of the Flare telescope, and table B-III lists the relevant characteristics of the detectors and associated electronics.

DATA

The experiment data are read by the spacecraft telemetry system and transmitted to the various ground stations. Each readout consists of data associated with the most recent event detected. An event is defined by a specific combination of logic signals from the telescopes. Table B-IV contains the

Figure B-2

Cross-sectional view of the Čerenkov telescope.

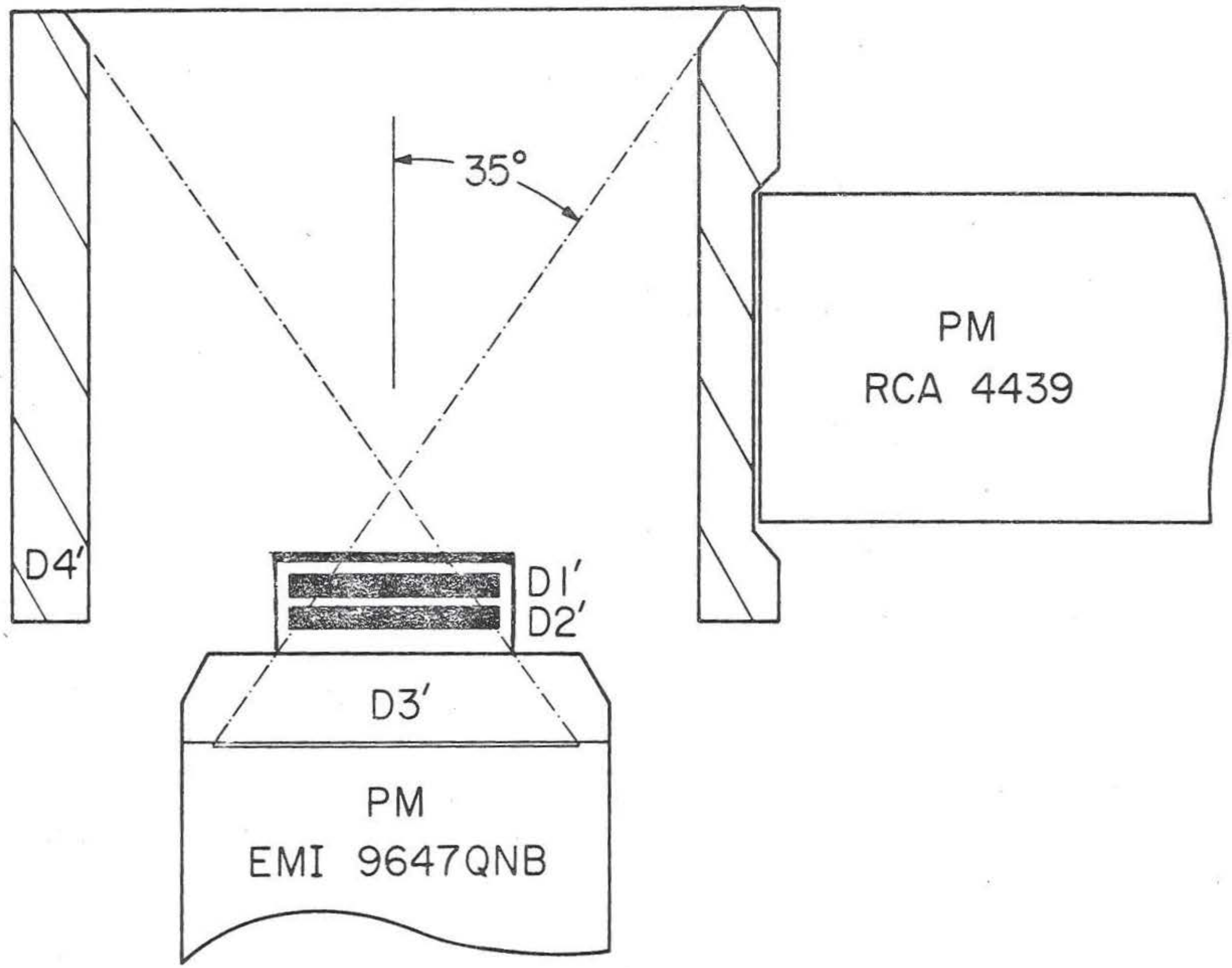

35°
PM
RCA 4439
D4′
D1′
D2′
D3′
PM
EMI 9647QNB

TABLE B-II

ČERENKOV TELESCOPE DETECTORS

Detector	Thickness (mg/cm^2	Area (cm^2)	Discriminator Threshold (keV)
D1'	254±3%	4.30±6%	169±4
D2'	245±3%	4.30±6%	155±3
D3'*	1 cm quartz	~20	$(2.01\pm.03) \times 10^{-1}$

*D3' is the quartz Čerenkov radiator. Discriminator and amplifier saturation are given in units of the Čerenkov peak for a charge Z = 1 particle with velocity β = 1.

ČERENKOV TELESCOPE ANTICOINCIDENCE

PM Tube	Scintillator	Threshold Energy			
		Protons	Electrons	Gamma Rays	μ-Mesons
RCA 4438	NE 102 0.25"thick	10.2 MeV	0.70 MeV	0.42 MeV	4.0 MeV

Figure B-3

Cross-sectional view of the Flare telescope.

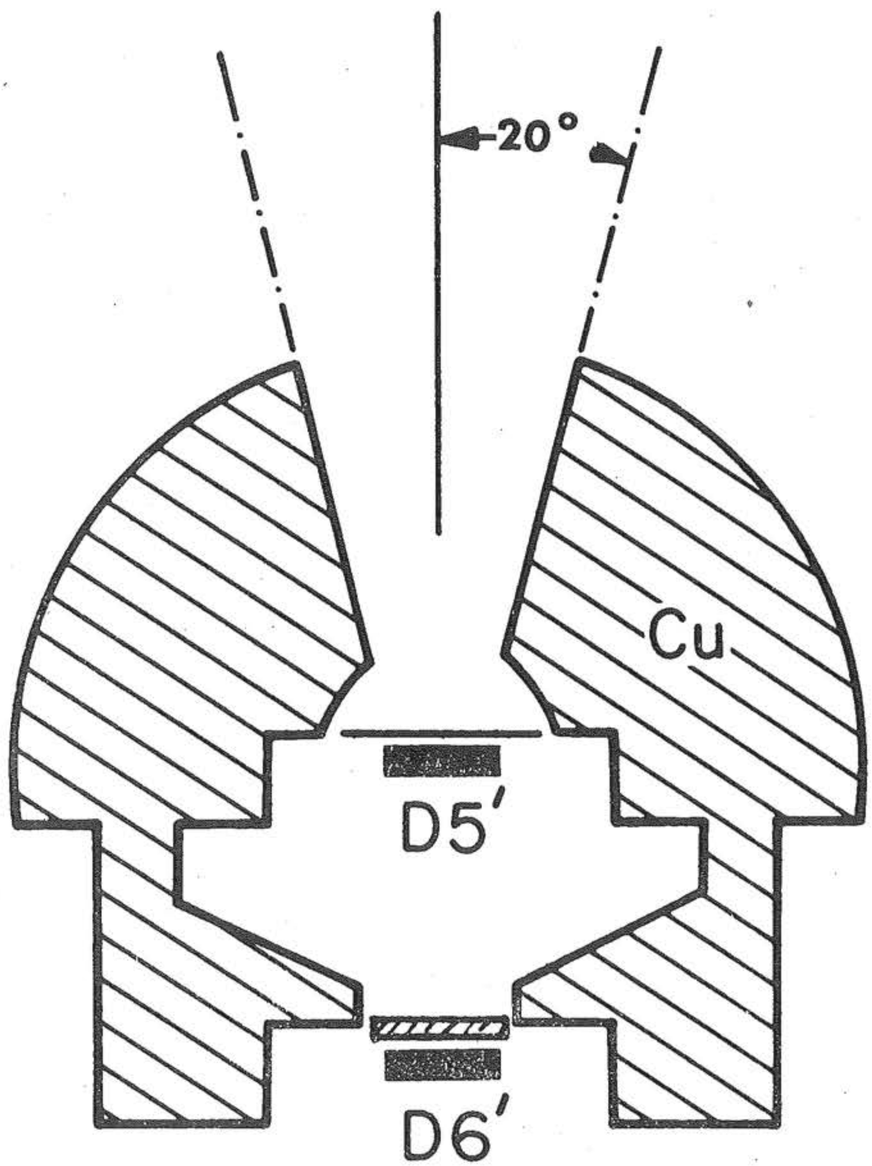

20°
Cu
D5'
D6'

TABLE B-III

FLARE TELESCOPE DETECTORS AND ABSORBERS

Detector	Thickness (mg/cm^2)	Area (cm^2)	Discriminator Threshold (KeV)
D5'	245±3%	0.224±6%	408±5
D6'	233	0.203	370±5

WINDOW	29.5 (Aluminum)
ABSORBER	194 (Aluminum)

TABLE B-IV

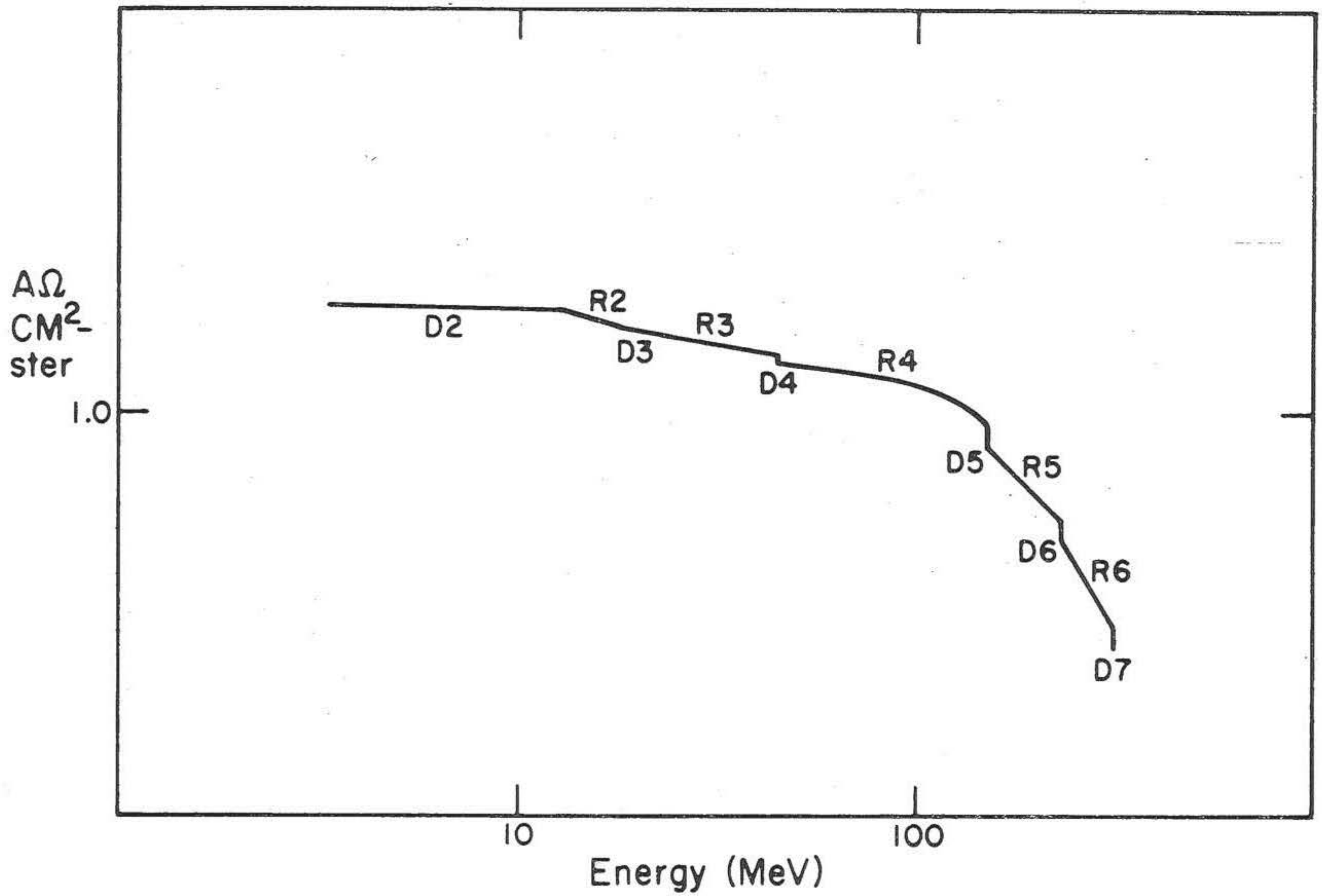
EVENT ENERGY THRESHOLDS

Event	Threshold Energy (Protons MeV)	Geometrical Factor (cm^2-sterad)
$D1\overline{D8}$	1.17±3%	1.14±6%
$D1D2\overline{D8}$	3.31	1.14
$D2D3\overline{D8}$	17.9	1.62
$D2D3R4\overline{D8}$	45.2	1.38
$D2D3R5\overline{D8}$	152	0.824
$D2D3R6\overline{D8}$	230	0.480
$D2D3R7\overline{D8}$	309	0.259
$D1'D2'D3'\overline{D4'}$	350	2.58
D5'D6'	17.9	0.0231

Note: Geometrical factors for the Range telescope events are energy dependent. The values listed are for the threshold energies. Figure B-4 is a plot of the geometrical factor as a function of energy.

Figure B-4

Geometrical factor for the Range telescope vs. incident particle kinetic energy.


AΩ
CM²-ster
1.0
D2
R2
D3
R3
D4
R4
D5
R5
D6
R6
D7
10
100
Energy (MeV)

definitions of events and the threshold energies at which they occur. For each event, appropriate energy loss and range data are recorded as well as the various coincidence and singles rates monitored by the experiment.

The user is referred to SRL Internal Report No. 19 (B2) for details concerning the data from this experiment. Summarized briefly, the data in any readout of the instrument consist of the following:

1) Event type indicators
2) New event flag
3) Pulse height information appropriate to the event
4) Range data when applicable
5) Commutated rate data
6) Temperature/Command mode data

From the above data various plots vs. universal time are made and recorded on 35 mm microfilm. Examples are shown in figures B-5, -6 and -7. This film is submitted to the National Data Center. The plots contain the following data:

1) Rates (plotted logarithmically vs. UT)
   (See table B-V.)
2) Representative pulse height data vs. UT
   (Scatter plots) (See table B-VI.)
3) Orbital data vs. UT
   (See table V-II.)

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Figure B-5

Typical Rate Plot page 1.

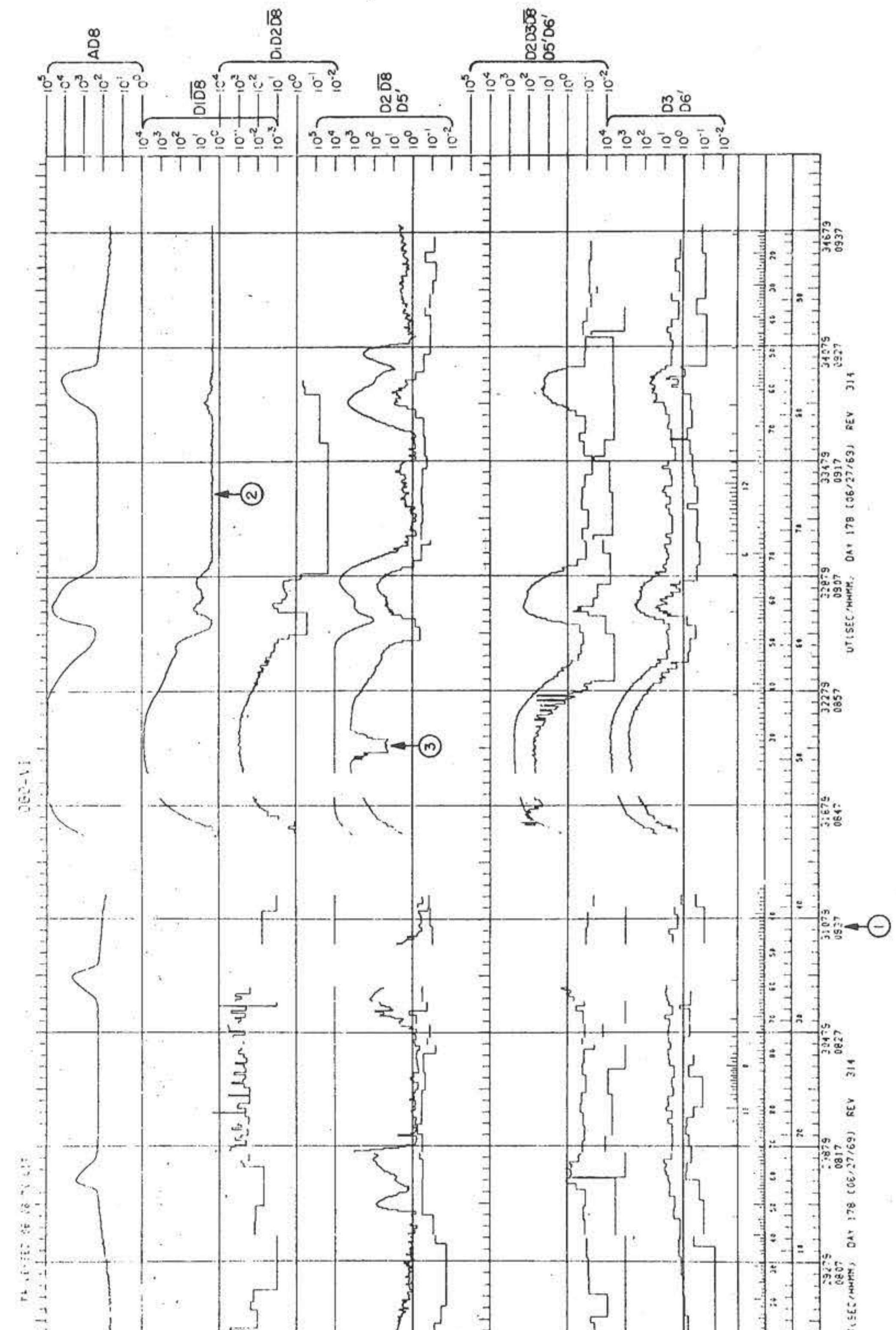
AD8
D3
D6'
UT(SEC/HHMM) DAY 178 (06/27/69) REV 314

Figure B-6

Typical Rate Plot page 2.

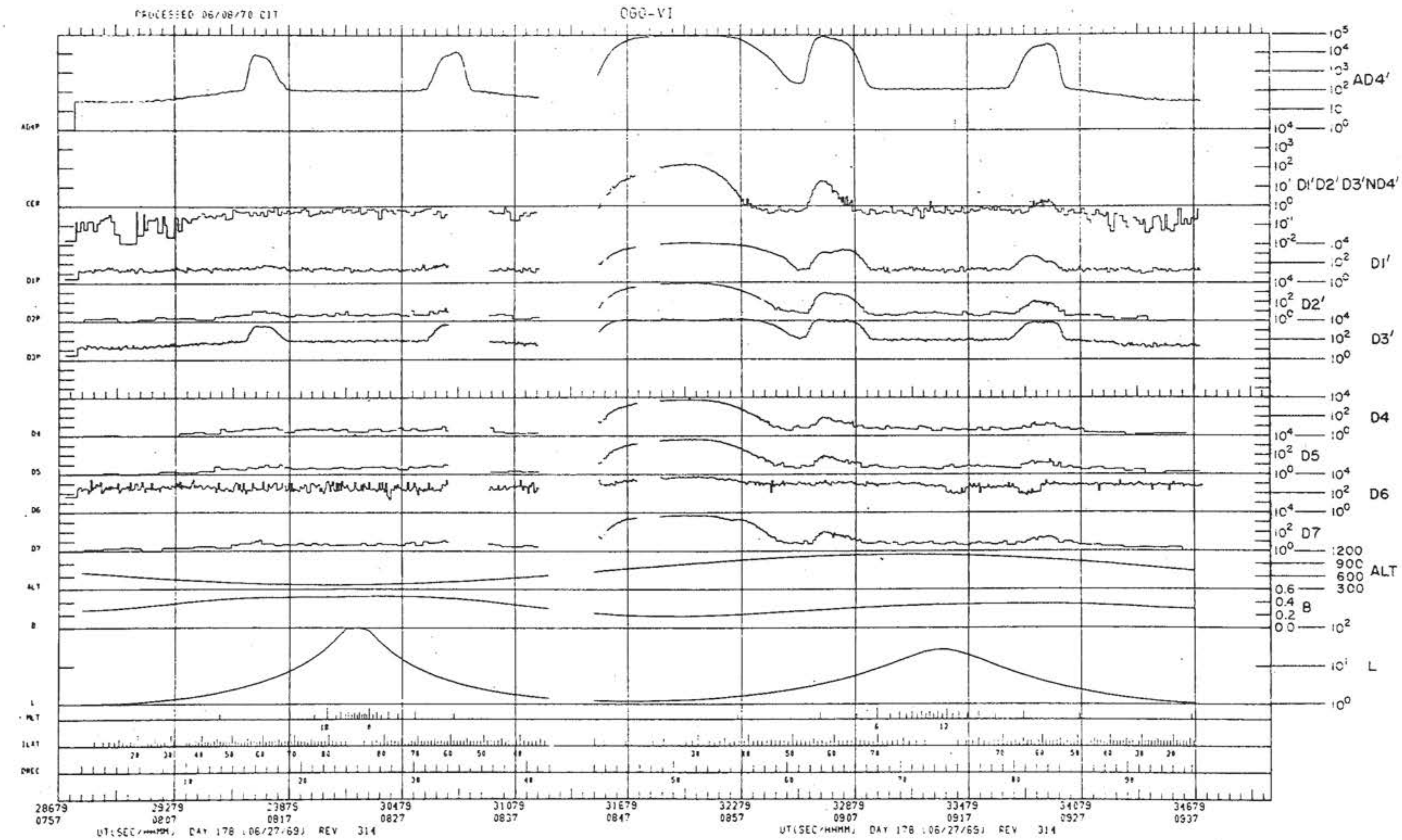
PROCESSED 06/08/70 CIT
OGO-VI
AD4'
D1'D2'D3'ND4'
D1'
D2'
D3'
D4
D5
D6
D7
ALT
B
L
28679 0757
29279 0807
29879 0817
30479 0827
31079 0837
31679 0847
32279 0857
32879 0907
33479 0917
34079 0927
34679 0937
UT(SEC/HHMM) DAY 178 (06/27/69) REV 314
UT(SEC/HHMM) DAY 178 (06/27/69) REV 314

Figure B-7

Typical Rate Plot page 3.

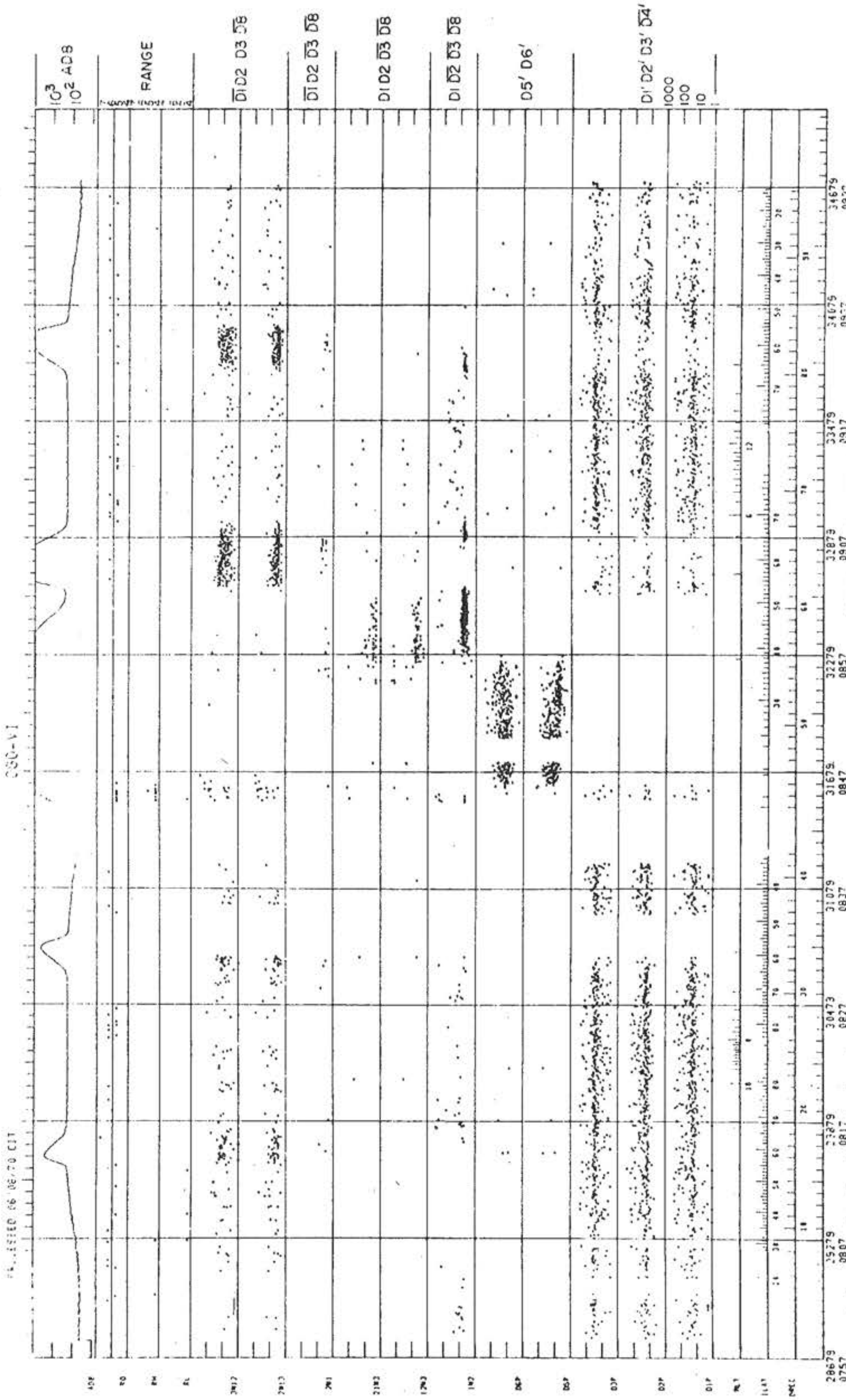
OGO-VI
RANGE
D5' D6'
1000
100
10
DAY 178 (06/27/69) REV 314

TABLE B-V

RATES*

Rate	Plot Label	Scale†	Min Max (sec^{-1})
D8	AD8	1	$10^0 - 10^5$
D1$\overline{D8}$	D18	1	$10^{-3}-10^4$
D1D2$\overline{D8}$	D128	1	$10^{-2}-10^4$
D2$\overline{D8}$	D28	1	$10^{-3}-10^4$
D5'	D5P	1	$10^{-3}-10^5$
D2D3$\overline{D8}$	D238	1	$10^{-3}-10^4$
D5'D6'	FLR	1	$10^{-3}-10^5$
D3	D3	1	$10^{-2}-10^4$
D6'	D6	1	$10^{-2}-10^4$
D4'	Ad4P	1	10^0-10^5
D1'D2'D3'$\overline{D4'}$	CER	1	$10^{-2}-10^4$
D1'	DIP	1/2	10^0-10^4
D2'	D2P	1/2	10^0-10^4
D3'	D3P	1/2	10^0-10^4
D4	D4	1/2	10^0-10^4
D5	D5	1/2	10^0-10^4
D6	D6	1/2	10^0-10^4
D7	D7	1/2	10^0-10^4

*Rates are plotted as $\log_{10}$ (rate) vs. time; tick marks drawn for each decade and labeled in the accompanying figures B-5, -6 and -7.

†Scale is relative scale; if plot is enlarged so that full scale in the vertical direction is 10 inches scale of 1 => 1/4"/decade.

TABLE B-VI

PULSE HEIGHT DATA

I) RANGE EVENTS WITH RANGE INDICATORS

A range event with range indicators means a $D2D3\overline{D8}$ coincidence with at least one of D4-D7 also in coincidence. These events are broken down into 3 categories for plotting.

RL) Only the low level range discriminators have been triggered (RL). The final range value (4, 5, 6 or 7) is plotted if all the preceding ranges have also fired.

RH) The high and low level discriminators have been triggered for each range indicator (RH). The final range value is plotted if all the preceding ranges have also fired.

RO) Combinations of high and low discriminators have been triggered (RO). The final range value is plotted if all the preceding ranges have also fired.

All other range events are not plotted.

II) OTHER EVENTS†

Event	Label	Pulse Height Plotted
$\overline{D1}D2D3\overline{D8}$	3N12	D3
$\overline{D1}D2D3\overline{D8}$	2N13	D2
$\overline{D1}D2\overline{D3}\overline{D8}$	2N1	D2
$D1D2\overline{D3}\overline{D8}$	21N3	D2
$D1D2\overline{D3}\overline{D8}$	12N3	D1
$D1\overline{D2}\overline{D3}\overline{D8}$	1N2	D1
D5'D6'	D6P	D6'
D5'D6'	D5P	D5'
$D1'D2'D3'\overline{D4'}$	D3P	D3'
$D1'D2'D3'\overline{D4'}$	D2P	D2'
$D1'D2'D3'\overline{D4'}$	D1P	D1'

†All pulse heights are plotted as $\log_{10}$ (pulse height) vs. time. A maximum of 1 event/sec is plotted.

TABLE B-VII

ORBITAL DATA

Datum	Plot Label	Comments	Units
Magnetic Local Time (B3)	MLT	$MLT = (\Phi_0 - \Phi_s)/15+12$ where Φ_s = dipole longitude of sun (degrees) Φ_0 = dipole longitude of spacecraft (degrees)	Hours
Invariant Latitude	ILAT	$ILAT = \cos^{-1}(1/\sqrt{L})$ where L = McIlwain parameter (earth Radii)	Degrees
Orbital Record Number	DREC	Orbital data record number on CIT abstract tape	
Altitude	ALT	Altitude of spacecraft (from GSFC orbit tape)	Km
Magnetic Field	B	Magnetic field strength (from GSFC orbit tape)	Gauss
McIlwain Parameter	L	Magnetic shell parameter (from GSFC orbit tape)	Earth Radii

For each orbit of the satellite three pages of plots are produced. In addition to the information mentioned above, each plotted page contains a time line on which the satellite position in invariant latitude and magnetic local time is given. These plots are also labeled with the data date, day number, revolution number and date of processing.

Problems in Data

As presented, there are several annoying but relatively minor errors on the rate plots. Some of these are due to problems in the raw data; others are due to program bugs. Since these are minor problems, the data which were already plotted have not been replotted.

1) The most significant error deals with labels on the time axis. The time axis has one minute tick marks with a label every 10 minutes. An error in round off results in times (in seconds) that end in a "9" instead of a "0". Such times are 1 second too small, thus a time of xxx49 seconds should be read as xxx50 seconds. Whenever the printed time in seconds ends with a "9", the time in hours and minutes which is listed below will be 1 minute too small. Figure B-5(1) illustrates this.
2) Due to a problem with the raw data, a rate (usually D1$\overline{D8}$ or D5') will appear to be constant

for a long time (>10 minutes) at a value greater than 1 count/second. This can be recognized fairly easily since the normal statistical fluctuations in the rate are not present. Figure B-5(2) illustrates this problem.

3) Finally the D5' rate will occasionally appear to change drastically from a high rate to a lower rate. This is due to a program bug and is again easily spotted. Figure B-5(3) illustrates this problem.

Conclusions

We have tried to provide sufficient instruction to allow the use of the OGO-VI rate plots which are available in the National Data Center. However, in the actual use of these data questions may well arise which are not covered here. These should be referred to:

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220 Downs Laboratory
California Institute of Technology
1201 E. California Boulevard
Pasadena, California 91109

REFERENCES

B1. W. E. Althouse _et al_., "A Solar and Galactic Cosmic Ray Satellite Experiment," IEEE Transactions on Nuclear Science, _15_, pp 229-237 (1968).

B2. S. S. Murray, "OGO-F-20 Data Format," California Institute of Technology, Space Radiation Laboratory Internal Report No. 19 (1970).

B3. T. A. Fritz and D. A. Gurnett, "Diurnal and Latitudinal Effects Observed for 10 KeV Electrons at Low Satellite Altitudes," J. Geophys. Res. _70_, 2485 (1965)