USER'S NOTES FOR EXPERIMENTS C-08 AND D-08 RATE PLOTS

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Space Radiation Laboratory
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EXPERIMENT

Instrumentation and Measurement

The low-energy proton and alpha particle experiment on the OGO-II and OGO-IV satellites (experiments C-08 and D-08) consisted of two charged particle telescopes. One, referred to as the vertical telescope, was aligned so that its axis of symmetry was parallel to the -Z spacecraft body axis, with the opening pointing toward the zenith whenever the spin axis was properly aligned (Figure 1). Since OGO-II tumbled, the user of any of this data should consult the Caltech Space Radiation Lab Internal Report #9 for help in obtaining the correct attitude of the instrument. This internal report is also being submitted to the National Data Center. The second charged particle telescope, referred to as the horizontal telescope, was oriented so that its axis of symmetry was nearly parallel to the -Y spacecraft body axis (Figure 2). Each telescope was sensitive to electrons, protons, and helium nuclei. Identification of these particles was possible only in the vertical telescope. Measurements consisted of counting rates, energy loss, and range of incident particles.

The horizontal telescope consisted of a single gold-silicon surface barrier detector (H1) mounted in a magnesium collimator (see Figure 2). Since the Au-Si detector was sensitive to light, the collimator opening was covered by a 0.00035" aluminized mylar window. This window and the electronic threshold set an incident energy threshold of 0.72 MeV for protons (see Table I). The characteristics of this detector are given in Table II. The experiment gave an indication of the total number of counts (i.e. particles leaving more energy than the electronically established threshold in the detector) registered by the detector. The energy dependent geometrical factors have been calculated for the horizontal telescope of each satellite, and are presented in Figures 3 and 4.

The vertical telescope consisted of two gold-silicon surface barrier detectors (V1 and V2) mounted with absorbers in a plastic scintillator cup, which served as a third detector (V3). (See Figure 1). Again, since the Au-Si detectors were sensitive to light, the aperture to the telescope was covered by a 0.00075" aluminized mylar window. The window and the electronic threshold set incident energy thresholds for incident radiation as indicated in Table I. The characteristics of the detectors in this telescope are given in Table II.

The plastic scintillator was used as an anticoincidence detector. A photomultiplier tube, viewing the scintillator through a light-scattering chamber at the bottom of the telescope, recorded any charged particle which passed through the scintillator. Incident energy thresholds for various types of radiation are given in Table I. Any charged particle entering the telescope along any path other than through the aperture or escaping the telescope out the sides or bottom was rejected.

The experiment gave an indication of the total number of counts registered by the detectors in the vertical telescope for the following electronic configurations: V3, $V1\overline{V3}$, $V2\overline{V3}$, and $V1V2\overline{V3}$. The energy dependent geometrical factors have been calculated for the last three configurations and are given in Figure 5.

A 256-channel pulse height analyzer connected to the output from V1 recorded the amount of energy deposited by a particle in V1. Since the results of only one pulse height analysis can be stored on the spacecraft, only the last analysis to occur before a commutator readout was transmitted. The pulse height analysis thus gave a sampling of the charge, mass and energy of the incident charged particle flux.

Four principal factors limited the resolution of the pulse height analysis of the output from V1: (1) the non-uniformity of the depletion depth over the sensitive area of the detector; (2) statistical fluctuations associated with the Landau effect; (3) noise from the charge sensitive amplifier, and (4) variations in incident angle at which detected radiation strkies the telescope The noise from the charge sensitive amplifier was measured prior to launch. The second and fourth factors can be treated analytically, and calibrations on a tandem van de Graff accelerator provided the means of estimating the overall resolution.

DATA

Included in every readout of the instrument were: 1) pulse height analysis (256 channels) of detector V1; 2) a flag to indicate whether this represented a new event since the last readout (only the last analyzed event since the previous readout is transmitted); 3) a flag to indicate if the threshold of detector V2 was exceeded in the event analyzed; 4) the state of the 2^0, 2^4, 2^9 bits in each of five recycling scalars, one scalar responding respectively to each of the previously mentioned logical configurations: $V1\overline{V3}$, $V2\overline{V3}$, $V1V2\overline{V3}$, H1, V3; and, 5) a digitization of an analog rate meter connected to the output of the V3 discriminator. At a satellite data rate of 4 kilobits/sec there were 3.47 readouts/sec; whereas 55.6 readouts/sec were available for a 64 kilobit rate.

Format

The data submitted to the National Data Center on 35 mm microfilm is in the form of plots of the following versus Universal time:

A. Experiment data (logarithmic scale)

1) V3 rate (from analog rate meter)

2) H1 rate

3) $V1\overline{V3}$ rate (V1, not V3)

4) $V2\overline{V3}$ rate

5) $V1V2\overline{V3}$ rate

B. Satellite orbital data (obtained from OGO orbital tapes)

6) Invariant latitude (degrees)

7) Height above spheroid (km)

8) Magnetic field (gauss)

9) McIlwain "L" parameter (earth radii, logarithmic scale)

10) Either dipole local time, or magnetic local time (hours)

Dipole local time (DLT) is

$$DLT = UT + (289.8/15) + \Psi_0/15$$

where UT = universal time in hours

Ψ_0 = longitude of spacecraft relative to meridian passing through dipole and rotation axis, measured about dipole axis, i.e. the dipole longitude of the spacecraft.

and 289.8 is the geographic longitude of north magnetic pole

$$MLT = (\Psi_0 - \Psi_s)/15 + 12$$

where Ψ_0 = dipole longitude of spacecraft (degrees)

Ψ_s = dipole longitude of sun (degrees)

(where, again, the longitudes are relative to meridian passing through dipole and rotation axis, measured about dipole axis)

Throughout the microfilm, the relevant scales are included approximately every one hundred frames.

The V3 rate plotted is an average rate obtained over 5 readouts, whereas the other four rates, as calculated for these plots, have a nominal accumulation time of 15 sec. Although 15 sec represents a traversal of 1° of latitude for a polar orbiting satellite, this accumulation time is found to be a good compromise between fine time resolution and statistical fluctuations in the plotted rates.

While such a display does not provide all of the data available to the experimenter, it represents a comprehensible, compact form of of the data. If more detailed data, such as pulse height information, are desired, they exist on magnetic tape. For OGO IV, orbital data have been merged into experiment data on these tapes. Arrangements to obtain copies of any of these tapes, descriptions of the data format on them, and copies of programs used in analysis may be made with Dr. E. C. Stone. Data processing at Caltech has been done with either an IBM 7094, or an IBM-360/75.

Figures 6 and 7 are typical of the format in which data are submitted. For OGO-IV, orbital and experiment data were combined in one plot, whereas for OGO-II these data were plotted separately. Furthermore, for OGO-II orbital and experimental data have not been processed for each orbit in which data are available.

Problems in Data

As presented, there are certain problems and errors in the data of which one must be aware. Some of these are in the raw data, such as bit drop out, fill, and wrong orbit numbers. Other problems are due to bugs in computer programs or hardware used to plot the data. When computer problems caused only obvious errors which could be eliminated with little inconvenience by any user of the plot, no attempt was made to go back and replot the data. Typical of these latter problems are examples 1 and 2 of figure 6. Example 1, a spike in only one of the rates, seems to arise as a result of the plotting program electing to change from using either the 2^0, 2^4, or 2^9 bit for a rate, to using one of the others. Usually, this change takes place correctly, but occasionally either a spike or a retrace (example #1 of figure 7) occurs. When such a spike manifests itself in more than 1 rate, or appears many times in a short time interval, it is normally a result of errors in the raw data (example 2, of figure 6).

Data gaps appear in several ways. The first is fill data. In OGO-IV this is denoted by a horizontal line near the abscissa indicating the fill time (example 3 of figure 6). In OGO-II no notification of the presence of fill is given. Another type of gap occurs when only V3 data are present. Since the V3 rate meter was an analog word, it was sometimes available even though the digital rates were not, as illustrated by example 2 of figure 7. Similar in appearance is the data gap which seems to exist at the beginning of a data stream. This arises from the requirement by the rate program of 2 bit flips before reporting a rate, which for low event rates gives the effect of missing data.

The user should be cognizant of the fact that sometimes the plots are slightly offset with respect to the grid lines of the paper. When MLT is plotted outside the interval [0,24] the correct value can be obtained by adding or subtracting 24 as appropriate.

Rely on the date, day number, and times on the plot. We know of no case in which they are incorrect. Orbit numbers on the plot are, however, occasionally wrong, resulting from incorrect values on the original attitude/orbit tape.

Conclusion

We have tried to provide sufficient instruction to allow the use of the OGO-II and IV, experiments C-08 and D-08, data which resides in the National Data Center. However, in the actual use of this data questions may well arise which are not covered here. These should be referred to:

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TABLE I

	OGO II		OGO IV	
Depletion Depths (microns)				
V1 (measured)	240		240	
V2 (estimated)	240		240	
H1 (nominal)	25		25	
Sensitive Areas (cm^2)				
V1	2.4		2.4	
V2	3.5		3.5	
H1	0.079		0.079	
Thresholds (kev) (Temperature coefficient in kev/^oC is given in parenthesis)				
V1	397	(0.1)	424	(0.0)
V2	260	(0.2)	253	(0.3)
H1	366	(0.6)	377	(0.6)
V3 Threshold (mv) (Temperature coefficient in mv/^oC is given in parenthesis)	70	(-0.2)	53	(-0.1)
Sea level muon energy-loss peak perpendicular to sides of V3 (mv)				
(Through 2 thicknesses)	287		325	
Sea level muon energy-loss though bottom of V3 (mv)				
(Through 1 thickness)	290		290	

TABLE II

INCIDENT ENERGY THRESHOLDS (MEV)

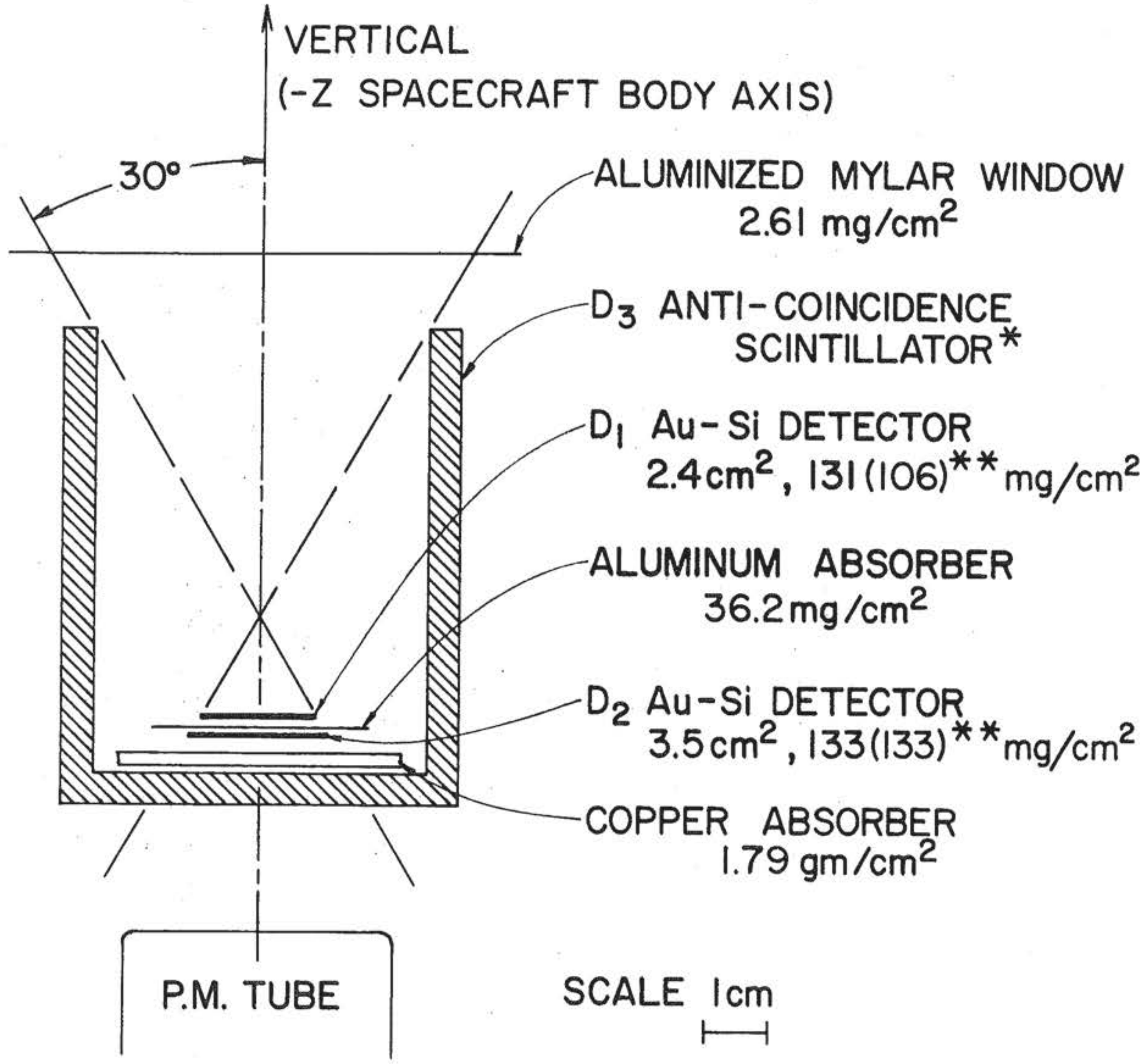
	Electrons	Protons	Alpha Particles	Muons	Electromagnetic Radiation
OGO-II					
$V1\overline{V3}$	>0.4	1.22	4.88		
$V2\overline{V3}$	>0.7	9.32	37.3		
V3 (normally incident at the top of telescope)	0.62	9.4	37.0	3.6	>0.39
V3 (normally incident on bottom of telescope after penetrating V1 and V2)		39.2	156.8		>0.19
H1	---	0.72	2.88		
OGO-IV					
$V1\overline{V3}$	>0.4	1.22	4.88		
$V2\overline{V3}$	>0.7	9.32	37.3		
V3 (normally incident on top of telescope)	0.53	9.3	37.0	3.6	>0.26
V3 (normally incident on bottom of telescope after penetrating V1 and V2)		39.2	156.8		>0.15
H1	---	0.72	2.88		

TABLE III

Factor by which plotted OGO-IV V3 rate must be multiplied to obtain actual rate into analog ratemeter. (The ratemeter was sensitive to the V3 discriminator, which had a maximum repetition rate of approximately 1.25×10^5 sec^{-1}. No correction has been made for discriminator dead time.

Plotted Rate (sec^{-1})	Factor by which to Multiply Plotted Rate to Give Actual Rate of V3 Discriminator Output
100	.85
200	1.25
400	1.45
1000	1.40
2000	1.35
4000	1.35
10000	1.20
20000	1.05
40000	1.12
100000	.95

OGO-II, IV VERTICAL PARTICLE TELESCOPE



* SCINTILLATOR IS SURROUNDED BY 138 mg/cm^2 OF MAGNESIUM.

** VALUES FOR OGO-IV ARE IN PARENTHESES.

D_1 AND D_2 BOTH HAVE DEPLETION DEPTHS OF 56 mg/cm^2.

Fig. 1

OGO - II, IV HORIZONTAL PARTICLE TELESCOPE

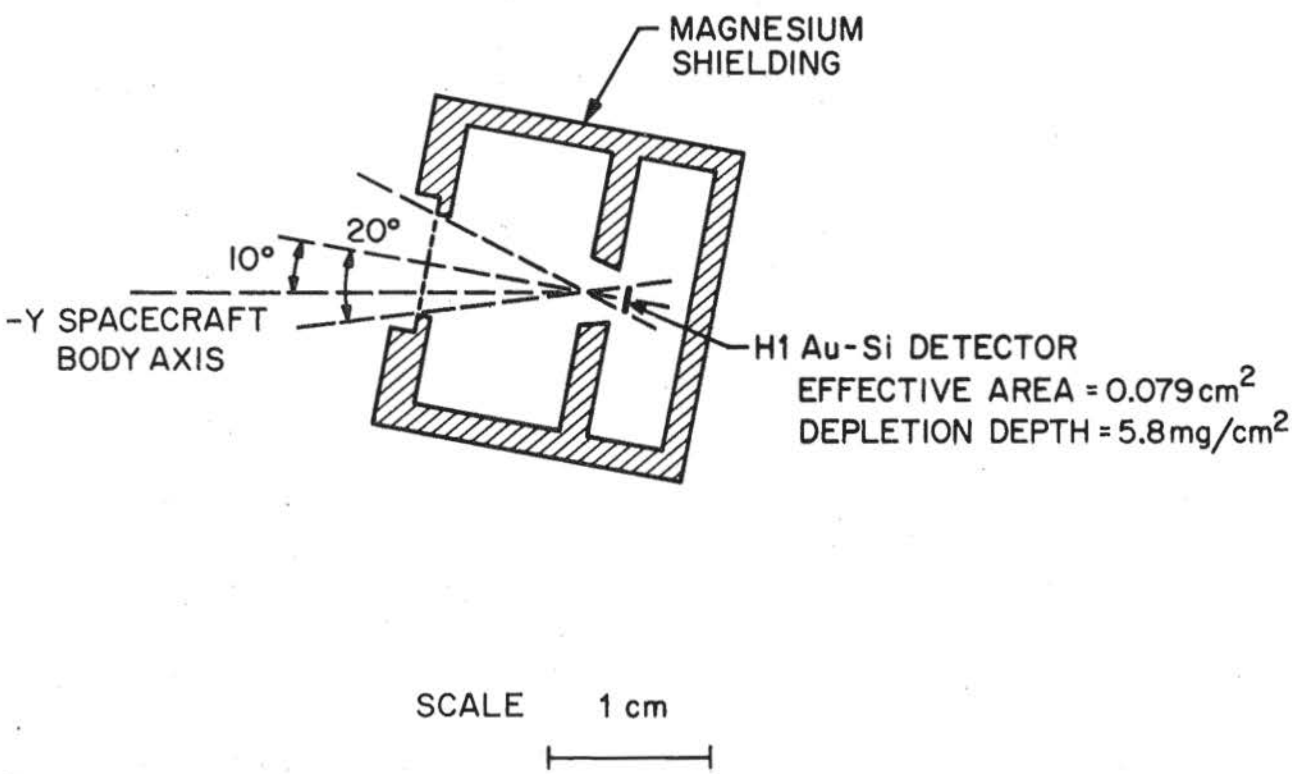


Fig. 2

OGO-II HORIZONTAL TELESCOPE
GEOMETRICAL FACTOR

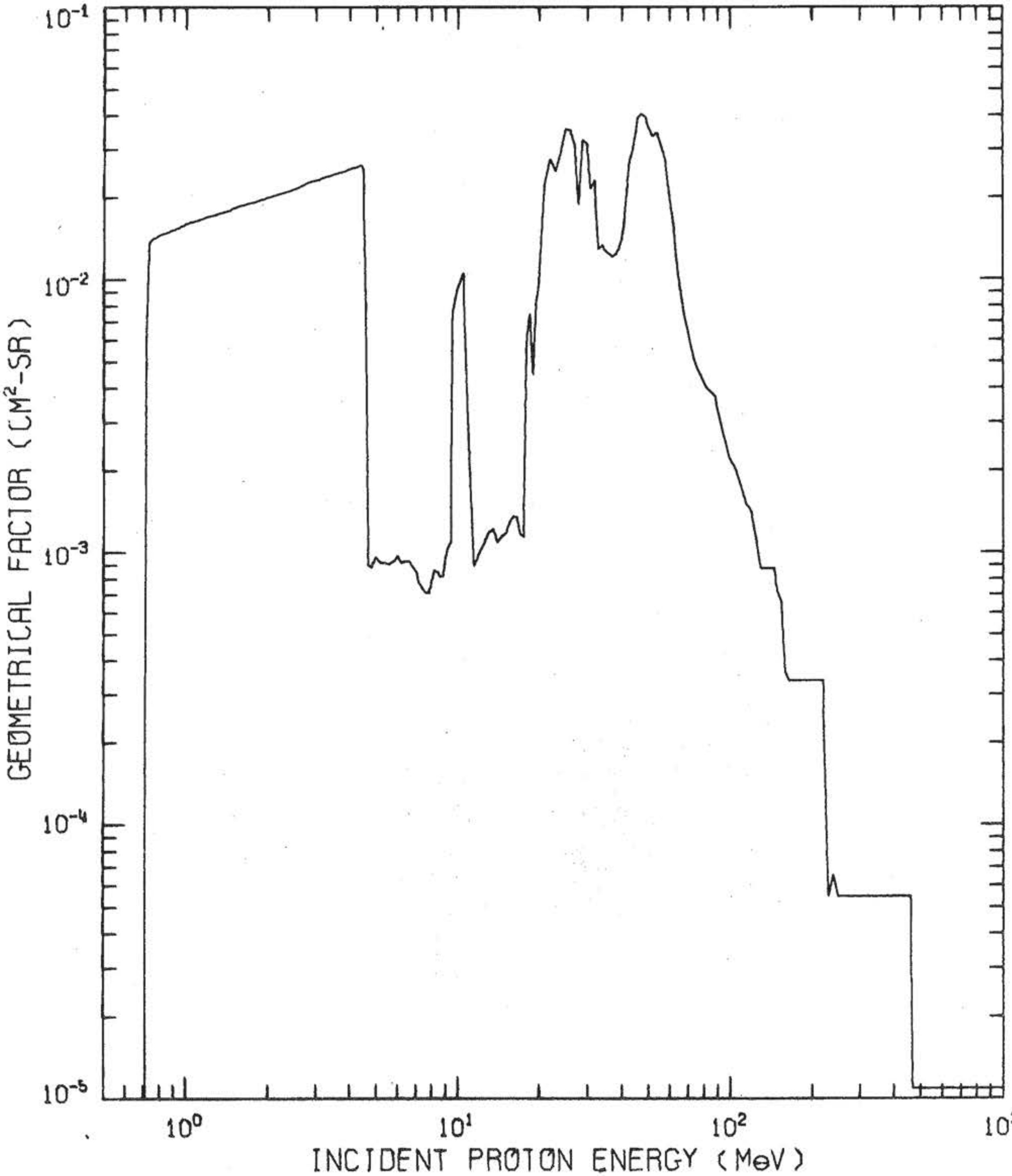


Fig. 3

OGO-IV HORIZONTAL TELESCOPE
GEOMETRICAL FACTOR

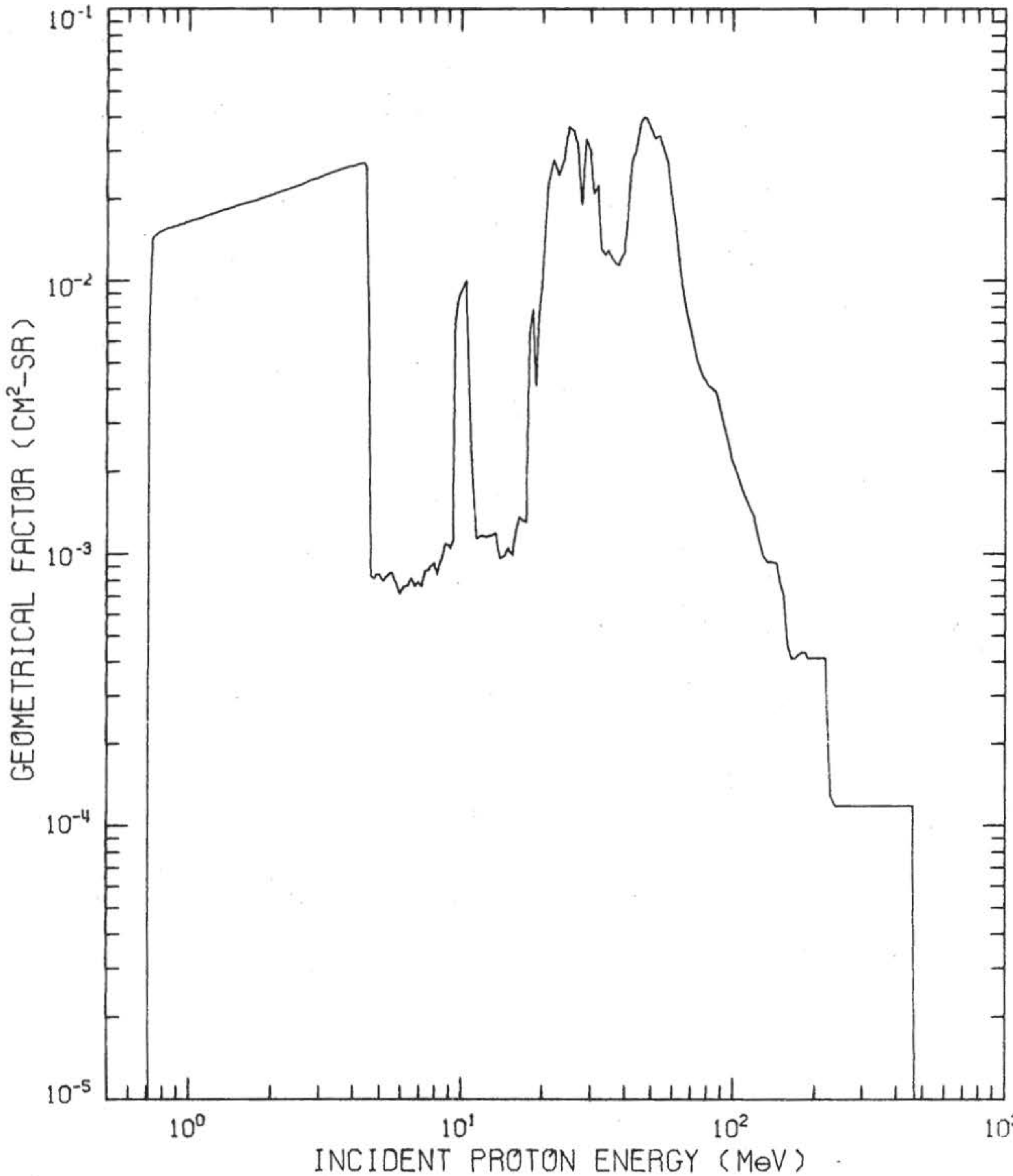
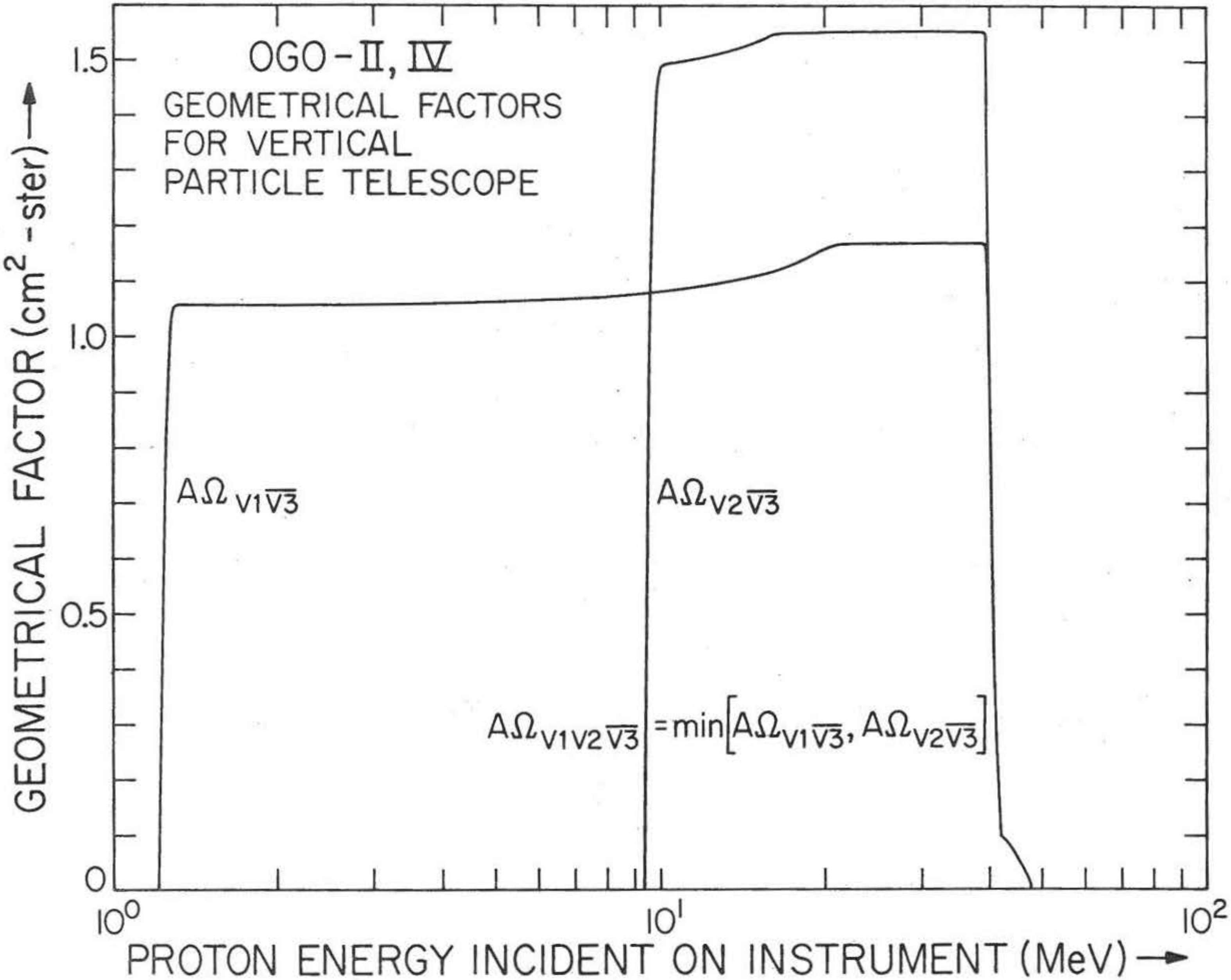


Fig. 4



OGO-II, IV
GEOMETRICAL FACTORS
FOR VERTICAL
PARTICLE TELESCOPE
GEOMETRICAL FACTOR (cm^2 -ster)
1.5
1.0
0.5
0
$A\Omega_{V1\overline{V3}}$
$A\Omega_{V2\overline{V3}}$
$A\Omega_{V1V2\overline{V3}} = \min[A\Omega_{V1\overline{V3}}, A\Omega_{V2\overline{V3}}]$
10^0
10^1
10^2
PROTON ENERGY INCIDENT ON INSTRUMENT (MeV)

Fig. 5

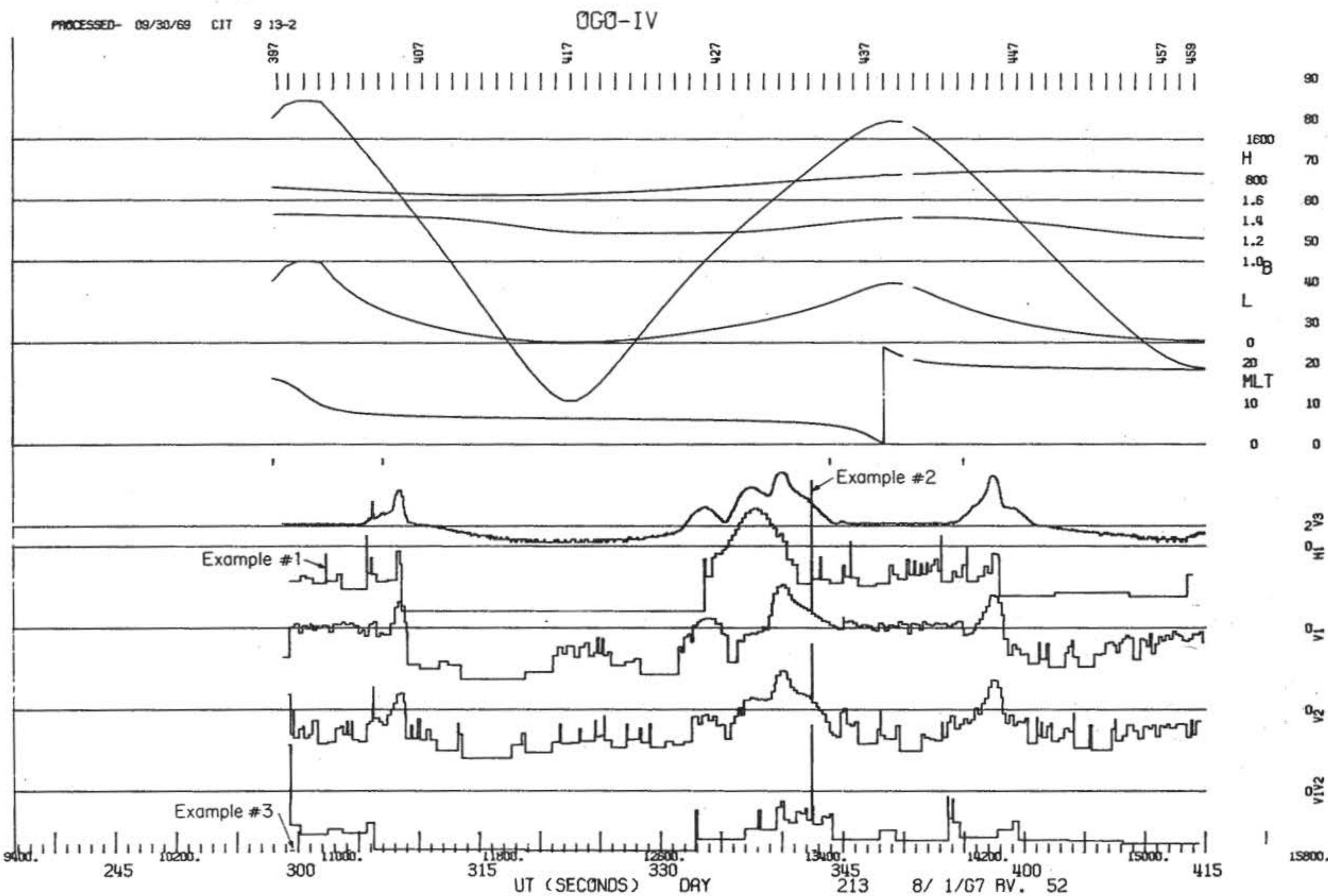

PROCESSED- 09/30/69 CIT 9 13-2
OGO-IV
Example #1
Example #2
Example #3
H
B
L
MLT
UT (SECONDS) DAY 213 8/ 1/67 RV. 52

Fig. 6

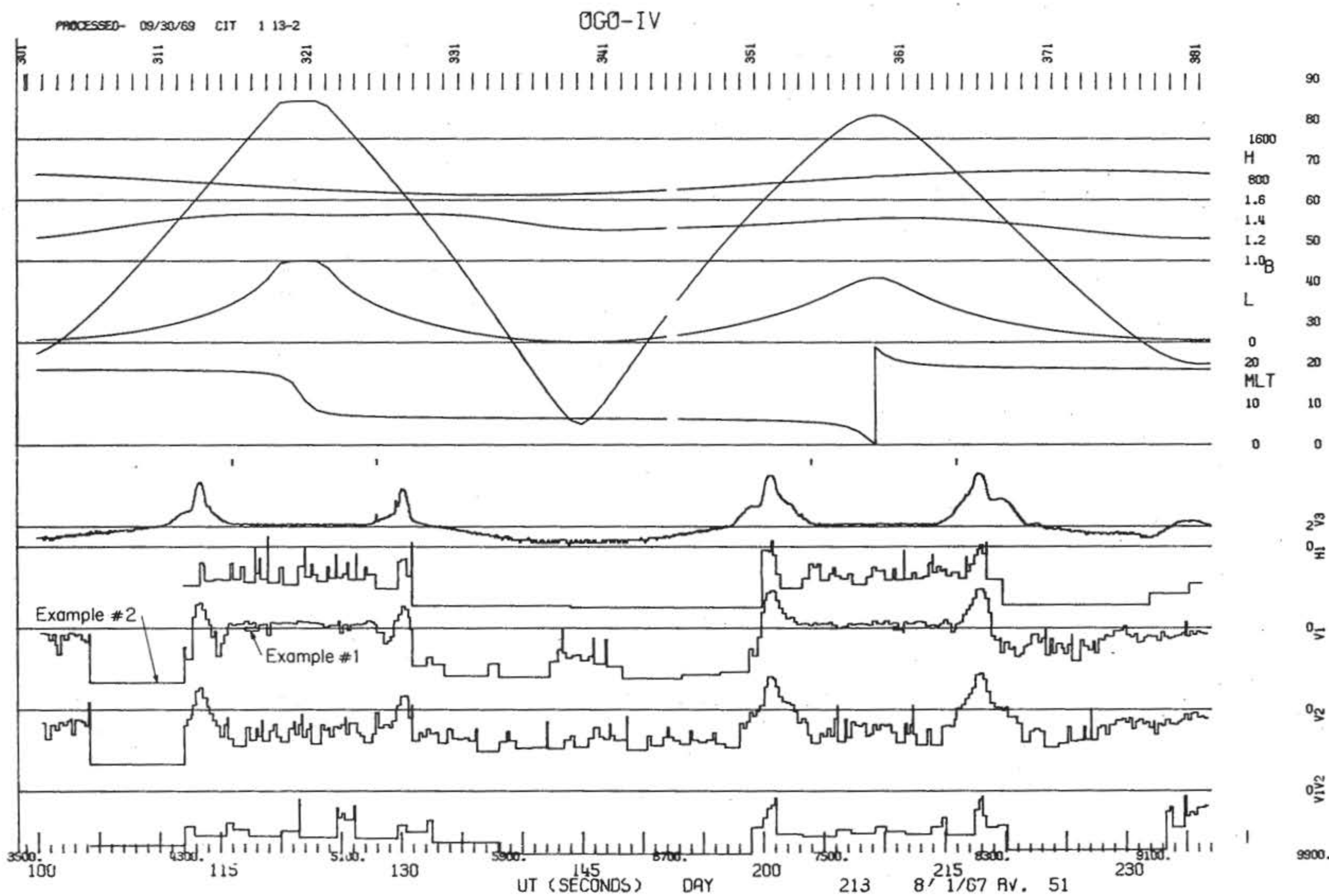

PROCESSED- 09/30/69 CIT 1 13-2
OGO-IV
301
311
321
331
341
351
361
371
381
1600
H
800
1.6
1.4
1.2
1.0
B
L
0
20
MLT
10
0
90
80
70
60
50
40
30
20
10
0
Example #2
Example #1
V3
H1
V1
V2
V1V2
3500.
4300.
5100.
5900.
6700.
7500.
8300.
9100.
9900.
100
115
130
145
200
215
230
UT (SECONDS)
DAY
213
8/ 1/67 RV. 51

Fig.7