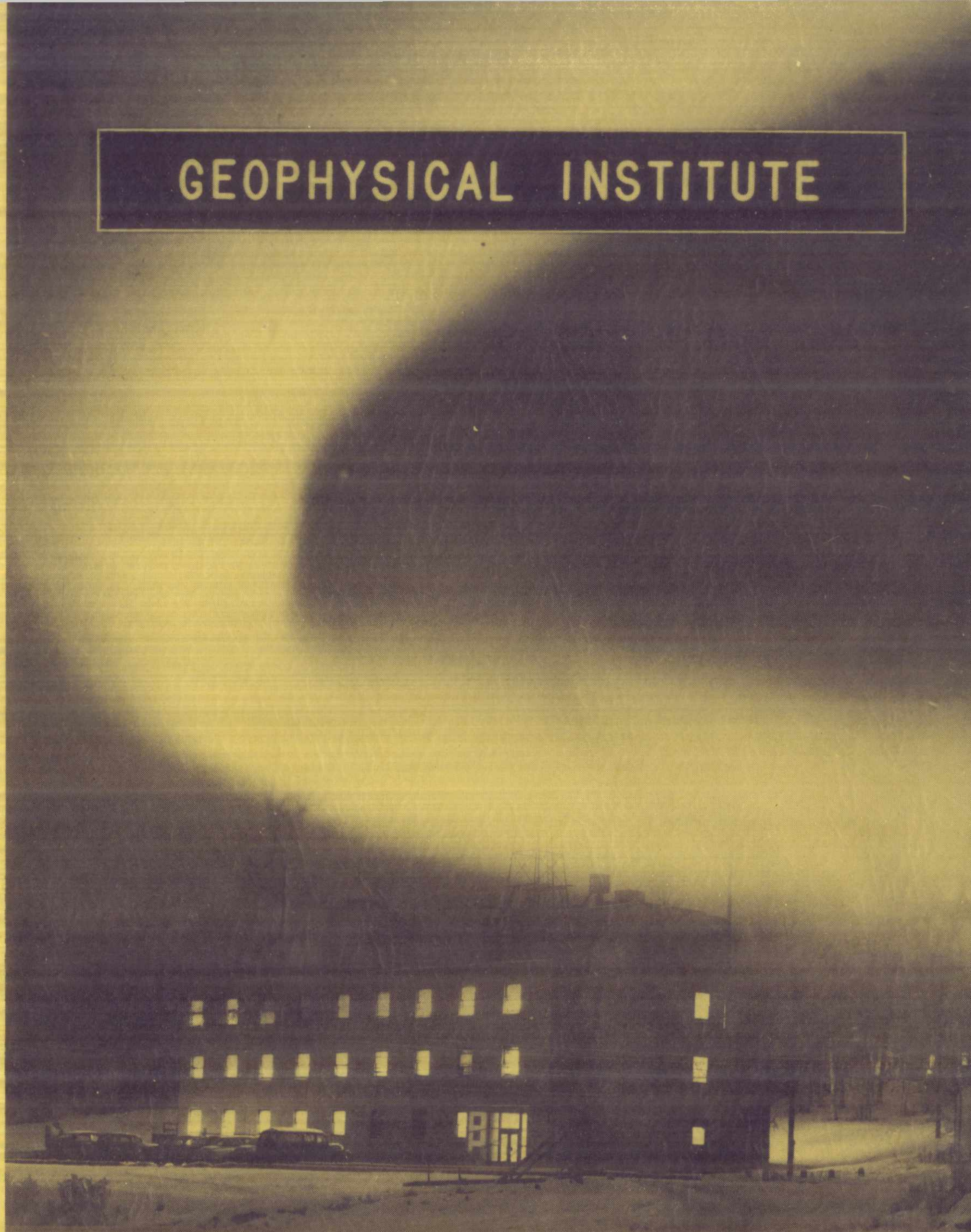


UNIVERSITY OF ALASKA

COLLEGE ALASKA



# RADIATION INFORMATION FROM 1958 $\delta$2

by

R. P. Basler, R. N. DeWitt, and G. C. Reid

Scientific Report No. 1

IGY Project No. 32.42
NSF Grant No. Y/32:42/268

Principal Investigator: C. T. Elvey

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GEOPHYSICAL INSTITUTE

of the

UNIVERSITY OF ALASKA

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## ABSTRACT

The telemetered radiation information from the satellite 1958 δ2 (Sputnik III) has been analyzed for sixty-two separate passes recorded in College, Alaska. The data indicate a dependence of radiation intensity on altitude in the range 250-500 km. Both the high and low energy components apparently contribute to the overall increase of intensity with altitude, but the presence of a continuous afterglow in the scintillating crystal prevented detailed interpretation of the results.

## INTRODUCTION

The Geophysical Institute at the University of Alaska has recorded the radio signal from the satellite 1958 δ2 (Sputnik III) since it was launched on May 15, 1958. The continuously telemetered radiation data from this satellite has been analyzed for sixty-two separate passes recorded in College, Alaska (64° 52'N, 147° 50'W) from May 18 until the partial failure of the telemetering system on June 17, 1958. This analysis was made on the basis of the information presented at the Rocket and Satellite Symposium during the Fifth Reunion of the Comitè Special de l' Annèe Geophysique Internationale held in Moscow, July 30-August 9, 1958. Much of the relevant material presented at this symposium has since been published elsewhere (Vernov *et al*. 1959).

DATA REDUCTION

The satellite's 20 Mc/s beacon radio transmission consists of a recurring series of 3 telemetry pulses and a marker pulse, repeating at intervals of 1.23 seconds. The durations of the 2nd and 3rd pulses give a measure of the radiation intensity incident on a sodium iodide crystal as recorded by a photomultiplier. The 2nd pulse changes length in response to the anode current of the photomultiplier and the 3rd pulse changes in response to the current at one of the dinodes. For high energy pulses the relation between these currents is non-linear, so that the difference between the radiation intensities recorded by the two channels at the same time should give a measure of the fraction of the radiation occurring in the form of high-energy pulses. For details of the telemetry system, the reader is referred to Vernov et al. (1959).

The radio signal strength was recorded on a Sanborn 150 recorder at a chart speed of 10 mm/sec. The individual pulses could readily be identified and their relative durations measured directly from the chart. These durations were tabulated for the entire readable portion of each record and reduced to values of radiation intensity using the published code. A typical graph of this information is shown in Figure 1.

The area under each curve represents the total energy released in the sodium iodide scintillating crystal during the recording. The true value of this energy is given by channel 3, the curve for channel 2 being somewhat lower due to the non-linearity in the later stages of the photomultiplier tube. The oscillations in the two curves are those referred to by Vernov et al. (1959) as due to the satellite's tumbling in the earth's magnetic field, thus affecting the sensitivity of the photomultiplier.

The average radiation intensity values for each of the sixty-two recordings are included in Table 1. These averages were taken from all the available data from any one recording without regard to which portions of the tumbling cycle were sampled, since it was sometimes difficult to determine the position of the crests and troughsof these cycles, especially in a short record. The error introduced by this averaging, however, can not exceed the tumbling modulation which is of the order of 10%.

It should be noted that the intensity values recorded are not the actual intensities, but are somewhat higher due to the perpetual afterglow in the scintillating crystal. Since this afterglow is largely due to the high intensity radiation encountered during the north-south crossings of the geomagnetic equator, it will have decayed to near its minimum value when the satellite passes over Alaska. The decay is never completed, partly because the crystal is constantly irradiated, but mostly because the time constant for the afterglow is comparable to the satellite's period; thus, the crystal is re-exposed to the high intensity radiation at the magnetic equator before it has had time to recover from its previous exposure. The intensities recorded on channel 3 can therefore be considered only as upper limits for the actual intensities.

## ALTITUDE DEPENDENCE

The satellite's position during each of the recordings was determined from the orbital information supplied by the Space Track Control Center at the L.G. Hanscom Field in Bedford, Massachusetts. As determined from this information, the height of the satellite at its point of closest approach to College is included in Table 1 for each pass. However, since the recordings were all made during the first weeks following the launching, before the orbit was well established, the heights given are probably not accurate to better than 20 kilometers. Unfortunately, no accurate ephemeris is available for the early months of 1958 $\delta 2$, so at present there is little hope of refining these estimates.

Figure 2 shows the average radiation intensity plotted against the closest approach altitude for each satellite passage. The possible height errors, together with the fact that the radiation intensity values have been rounded off to the nearest one-tenth BeV/sec, would be expected to produce some scatter in the points. However, the wide scatter, especially at higher altitudes, can not be explained on the basis of inaccurate data.

Figure 2 indicates that there is an increase of radiation with altitude, but no definite functional relationship is apparent. However, a straight line seems to be a good first approximation. There seems to be a tendency toward decreasing slope at higher altitudes, but this might be due to the reduced effect of the afterglow during these passes since they are further removed from the magnetic equator.

It is interesting to compare Figure 2 with the altitude-intensity curve published by Meredith, Gottlieb, and Van Allen (1955) for Rockoon flight number S.U.I. 20 on 30 August 1953. Both were at very nearly the same geomagnetic latitude, and although the Rockoon data are for a much lower altitude (up to about 100 km), both show a nearly linear increase of intensity with altitude.

## HIGH ENERGY INTENSITY

As described above, the telemetering system in 1958 δ2 was designed so that the combined information on channels 2 and 3 would serve to determine the portion of the total energy which is released in the scintillating crystal in the form of pulses whose individual amplitude is greater than 1-2 MeV. The description of this system by Vernov et al. (1959) is incomplete, but apparently it was intended that the intensity due to pulses greater than 1-2 MeV be given approximately by the difference in the intensities indicated on channel 2 and channel 3. However, the previously mentioned afterglow in the scintillating crystal prevented operation in this fashion by introducing a continuous component in the photomultiplier current which lowered the energy required for a pulse to exceed the linear response range of the anode current. This caused channel 2 to indicate a lower intensity than channel 3, thus indicating a spuriously high intensity of high energy radiation. The values of the high energy intensities as given by the difference between the channel 2 and channel 3 intensities are included in Table 1.

If the high-energy pulses are assumed to be entirely due to galactic cosmic rays, their intensity would be expected to be constant and independent of altitude in the range encountered during passages over Alaska. However, the recorded high energy intensity values range up to 40% of the total intensity, and seem to have an altitude dependence, as shown in Figure 3. The corresponding dependence of the low energy intensity on altitude is shown in Figure 4. It can be seen from this information that both the high and low energy components contribute to the previously noted general increase of intensity with altitude, although, as before, the wide scatter of the observed points makes the form of the increase uncertain. As in Figure 2, the tendency toward decreasing slope at higher altitudes in Figures 3 and 4 might be due to the reduced effect of the afterglow during these passes.

The values of intensity in Figures 3 and 4 and the channel 2 and high energy intensities in Table 1 are from all the recordings except those for which the total intensity exceeded the limit of the telemetering system; that is, the relay changing in response to the anode current switched more than once per cycle (1.23 sec.). A more detailed analysis in the manner of Herz et al. (1959), would probably yield this increased switching rate, but their technique does not seem warranted in our case since it would be necessary in only a few instances and would involve a much more elaborate scaling technique than we used. Also, due to the effect of the afterglow, the information on channel 2 is of questionable value, at least as an indicator of high energy intensity. At best, the difference between channels 2 and 3 can be regarded as the lower limit for the true intensity, the value from channel 3 already having been mentioned as the upper limit.

## DISCUSSION

Since the inclination of the satellite's orbit (65°) was very close to the latitude of College, Alaska, only a limited latitude range was sampled in all of our observations, so that no systematic intensity variation with latitude could be detected.

The intensities sampled ranged from 0.7 to 2.8 BeV/sec, much lower than the average intensity over the complete orbit, reported as 300 BeV/sec (Vernov et al. 1959), but comparable to what was recorded in the USSR. In all of our recordings the counting circuit was overloaded, indicating that the ionosphere over Alaska from 60 to 65 degrees latitude is also characterized by the permanent low energy (100 KeV) electron flux observed at similar geographic latitudes by Vernov et al. (1959).

Efforts were made to interpret the radiation observations in relation to ionospheric, magnetic, and solar activity, but there was no obvious correlation, and our data were too limited to warrant a statistical approach. However, it should be noted that this was a period of very little activity in any of these fields, and there were no major solar flares, magnetic storms, or radio wave absorption events. It should also be pointed out that the ionosphere over Alaska was constantly sunlit during the period of our recordings.

The general increase of intensity with altitude, represented in Figure 2, might be due to an increase in the number of geomagnetically trapped particles at greater heights. This increase would result from the reduced absorption in the less dense higher atmosphere and from an increased sampling of trapped particles, that is a sampling of particles with mirror heights up to and including the altitude of the satellite. The most that can be said about the scatter of points in Figure 2 is that there is an apparent time variation of intensity at any given altitude.

ACKNOWLEDGEMENTS

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Vernov, S. N., A. E. Chudakov, E. V. Gorchakov, J. L. Logachev, and P. V. Vakulov; "Study of the Cosmic-Ray Soft Component by the 3rd Soviet Earth Satellite," Planetary and Space Science Vol. 1, No. 2, p. 86 (1959).

TABLE 1.

| Date 1958 | Closest Approach UT | Average Radiation Intensity in BeV/sec Channel 3 | Average Radiation Intensity in BeV/sec Channel 2 | High Energy Intensity in BeV/sec | Altitude at Closest Approach in km |
|---|---|---|---|---|---|
| 18 May | 2325 | 1.3 | 1.1 | .2 | 300 |
| 19 May | 2223 | 1.1 | 0.9 | .2 | 277 |
| 20 May | 0010 | 1.3 | 1.1 | .2 | 338 |
| 20 May | 0158 | 1.7 | 1.5 | .2 | 380 |
| 20 May | 2310 | 1.1 | 0.9 | .2 | 285 |
| 23 May | 2142 | 0.9 | 0.7 | .2 | 263 |
| 23 May | 2330 | 1.3 | 1.1 | .2 | 300 |
| 24 May | 2225 | 1.2 | 1.0 | .2 | 300 |
| 25 May | 0015 | 1.4 | 1.2 | .2 | 344 |
| 25 May | 2123 | 1.1 | 0.9 | .2 | 275 |
| 25 May | 2311 | 1.4 | 1.1 | .3 | 350 |
| 26 May | 0059 | 2.0 | | | 366 |
| 26 May | 2206 | 1.1 | 0.8 | .3 | 300 |
| 26 May | 2354 | 1.4 | 1.1 | .3 | 339 |
| 27 May | 2101 | 1.0 | 0.8 | .2 | 271 |
| 27 May | 2248 | 1.3 | 1.1 | .2 | 300 |
| 28 May | 0036 | 1.6 | 1.3 | .3 | 339 |
| 28 May | 1955 | 0.8 | 0.6 | .2 | 258 |
| 28 May | 2143 | 1.2 | 1.0 | .2 | 300 |
| 28 May | 2331 | 1.4 | 1.1 | .3 | 341 |
| 29 May | 0119 | 2.2 | | | 412 |
| 29 May | 2038 | 1.0 | 0.7 | .3 | 284 |
| 29 May | 2226 | 1.2 | 1.1 | .1 | 324 |
| 30 May | 0013 | 1.8 | 1.6 | .2 | 375 |
| 2 June | 1950 | 1.0 | 0.8 | .2 | 290 |
| 2 June | 2135 | 1.3 | 0.9 | .4 | 327 |
| 2 June | 2323 | 1.6 | 1.2 | .4 | 390 |
| 3 June | 1841 | 0.9 | 0.7 | .2 | 270 |
| 3 June | 2030 | 1.3 | 0.9 | .4 | 310 |
| 3 June | 2218 | 1.5 | 1.0 | .5 | 354 |
| 4 June | 0006 | 2.2 | | | 406 |
| 4 June | 1735 | 0.7 | 0.5 | .2 | 273 |
| 4 June | 1922 | 1.1 | 0.8 | .3 | 326 |
| 4 June | 2110 | 1.3 | 1.1 | .2 | 471 |
| 4 June | 2259 | 2.0 | | | 530 |
| 5 June | 1814 | 1.0 | 0.7 | .3 | 299 |
| 5 June | 2002 | 1.4 | 1.0 | .4 | 349 |
| 5 June | 2151 | 1.6 | 1.2 | .4 | 430 |
| 6 June | 1858 | 1.2 | 0.8 | .4 | 332 |
| 6 June | 2046 | 1.6 | 1.1 | .5 | 395 |
| 6 June | 2234 | 2.8 | | | 470 |
| 7 June | 1940 | 1.4 | 0.9 | .5 | 352 |
| 7 June | 2125 | 1.6 | 1.2 | .4 | 432 |

TABLE 1. (cont'd)

| Date 1958 | Closest Approach UT | Average Radiation Intensity in BeV/sec Channel 3 | Channel 2 | High Energy Intensity in BeV/sec | Altitude at Closest Approach in km |
|---|---|---|---|---|---|
| 8 June | 1829 | 1.1 | 0.7 | .4 | 327 |
| 8 June | 2017 | 1.5 | 1.1 | .4 | 400 |
| 8 June | 2206 | 1.6 | 1.1 | .5 | 471 |
| 9 June | 1721 | 1.0 | 0.7 | .3 | 299 |
| 9 June | 1901 | 1.5 | 1.0 | .5 | 348 |
| 9 June | 2057 | 1.6 | 1.1 | .5 | 430 |
| 10 June | 1803 | 1.1 | 0.8 | .3 | 327 |
| 10 June | 2137 | 1.7 | 1.4 | .3 | 470 |
| 11 June | 1653 | 1.1 | 0.8 | .3 | 297 |
| 12 June | 1925 | 1.5 | 1.1 | .4 | 394 |
| 12 June | 2109 | 2.1 | | | 472 |
| 13 June | 1625 | 1.3 | 0.9 | .4 | 299 |
| 13 June | 1813 | 1.3 | 0.8 | .5 | 346 |
| 13 June | 2000 | 2.0 | | | 429 |
| 16 June | 1636 | 1.4 | 0.9 | .5 | 326 |
| 16 June | 2010 | 2.3 | | | 466 |
| 17 June | 1526 | 1.1 | 0.7 | .4 | 295 |
| 17 June | 1901 | 1.7 | 1.2 | .5 | 429 |
| 17 June | 2051 | 2.4 | | | 509 |

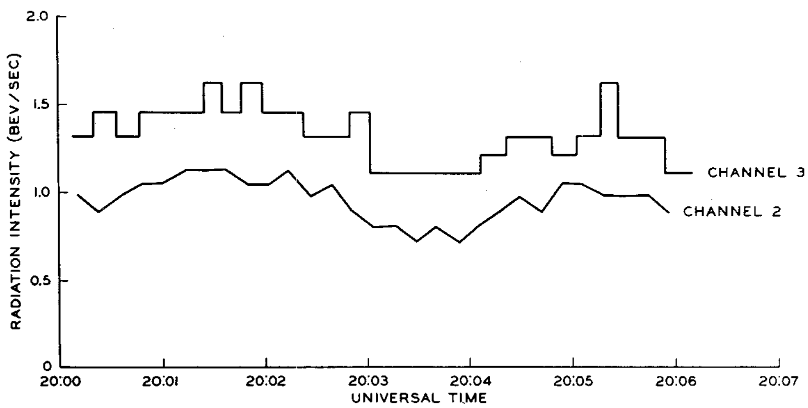


Fig. 1. Radiation intensity observed on channels 2 and 3 during a typical passage of 1958 δ 2 over College, Alaska on 5 June 1958. The points for channel 2 represent a 12.3 sec. (10 telemetering cycles) average of the telemetered intensities. Closest approach occurred at 20:03:09 Universal Time.

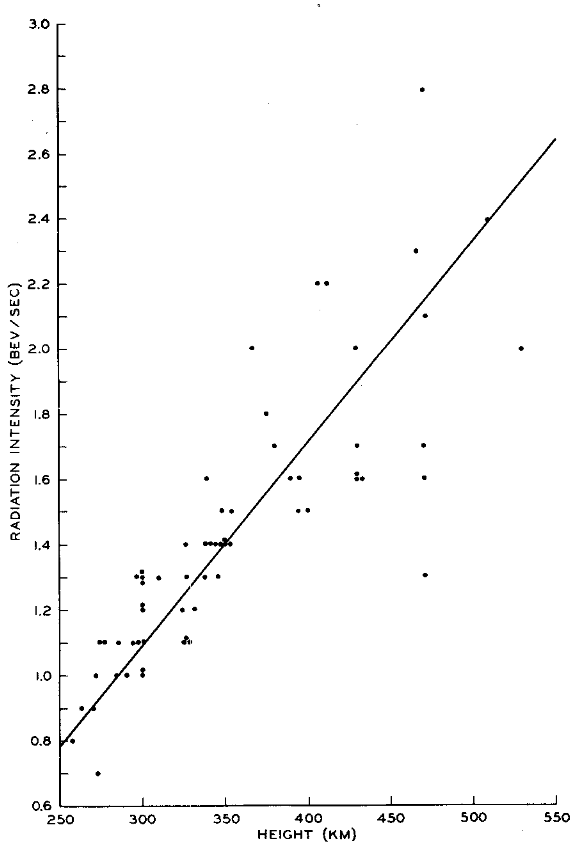


Fig. 2. Observed dependence of total radiation intensity on altitude. The straight line represents a least-squares fit to the data.

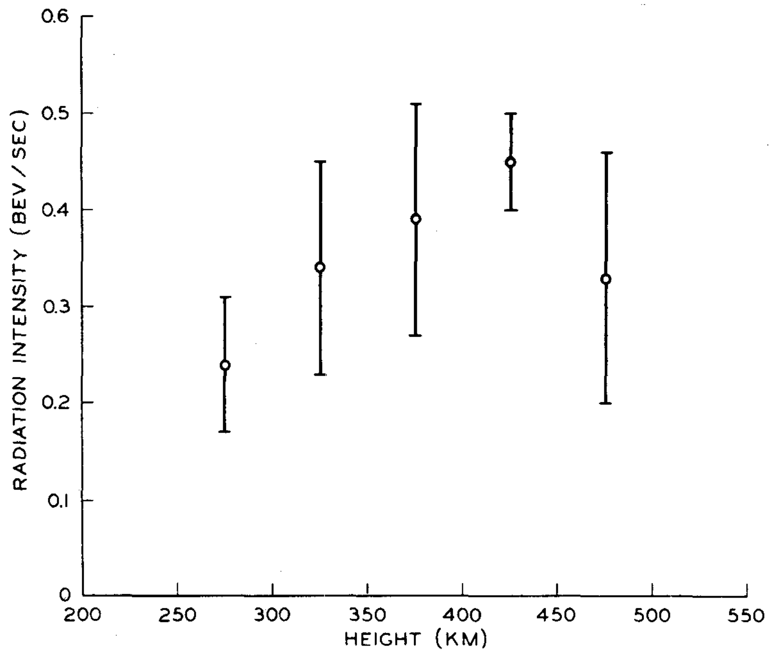


Fig. 3. Observed altitude dependence of the component of the total radiation intensity due to pulses larger than 1-2 MeV. Each point represents the weighted mean of all the observations within a 50 km height interval. The vertical bars represent the standard deviations.

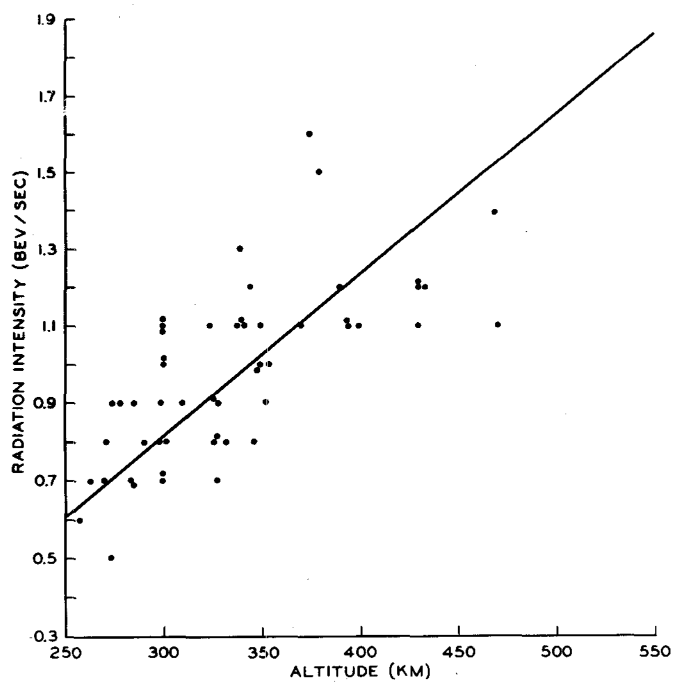


Fig. 4. Observed altitude dependence of the component of the total radiation intensity due to pulses smaller than 1-2 MeV. The straight line represents a least-squares fit to the data.