Planet. Space Sci. 1969, Vol. 17, pp. 255 to 260. Pergamon Press. Printed in Northern Ireland

A MEASUREMENT OF AURORAL ELECTRONS IN THE 1–10 MeV RANGE

J. N. VAN GILS, H. F. VAN BEEK, L. D. DE FEITER and R. V. HENDRICKX
Space Research Laboratory, University of Utrecht, The Netherlands

(*Received in final form* 3 *September* 1968)

Abstract—Particle fluxes have been measured by means of shielded Geiger–Müller telescopes mounted in a rocket, which was launched from ESRANGE(Kiruna) into a diffuse aurora. The analysis of the dependence of the counting rates on altitude indicates that a weak flux of energetic electrons, 1–10 MeV, has been detected.

1. INTRODUCTION AND INSTRUMENTATION

For launching in the ESRO program the Utrecht Space Research Laboratory has developed a simple particle detector, meant mainly for the measurement of proton fluxes during PCA events. This instrument has recently been flown during an aurora, on which occasion a rather weak, but energetic, electron flux has been measured.

The instrument consists of two Geiger–Müller telescopes. The geometrical configuration is shown in Fig. 1. Each of the telescopes consist essentially of two single counters, counter 1 and the central counter 2, followed by the counter cluster 3. The geometry is such, that a particle passing through the counters 1 and 2 must go through the cluster 3. By appropriate shielding, energy discrimination is attained.

The two telescopes are surrounded by a general shield *S*1 (0·6 mm *Al*) to protect them against saturation with low-energy particles. The cut-off energy of this shielding is 13 MeV for protons. Shields *S*2 and *S*3 consist of 2·8 mm *Al* (proton energy cut-off 28 MeV) and shield *S*4 is 4·5 mm Cu (60 MeV). By using an appropriate electronic circuit, three channels are defined with the following energy ranges for protons: 13–28 MeV, 28–60 MeV and above 60 MeV. The corresponding electron energies have not been indicated, because scattering of the electrons in the shielding material makes energy discrimination in this way completely unreliable.

2. LAUNCHING CHARACTERISTICS

The detector was launched on alert in an ESRO rocket from Kiruna, on the night of 4/5 February 1967 at 00·53 LT (4 February 23·53 UT). There was no PCA at the time of launching; the Riometer absorption of 1·8 dB was related to the diffuse aurora overhead and the magnetic storm in progress. The Sun had been quiet for 4 days preceding the magnetic storm. There had only been weak flares, importance 1 and subflares, on January 30 and 31; part of these flares were located in an active region at the extreme western limb.

Figure 2 gives the counting rates in the three channels as a function of the height. The decrease of intensity during the descending part of the rocket flight was somewhat steeper than the increase during the ascent; this was probably due to a tumbling of the rocket in the last part of its trajectory. The height dependence of the counting rates is given in Fig. 3.

3. INTERPRETATION

Although the detector was developed for measuring proton fluxes, it is sensitive to both protons and electrons. Whether one or the other type of particles has been detected can only be derived from the counting rate vs. altitude relation.

The strong increase of the counting rates between 60 and 120 km in the channels 28–60

MeV and above 60 MeV can be due to neither high-energy protons nor to low-energy protons coming from the sides. It was found impossible to deduce a reasonable spectrum for the incoming protons which explained the counting rate vs. altitude dependence for all three channels. The observed effect, on the other hand is typical for electrons.

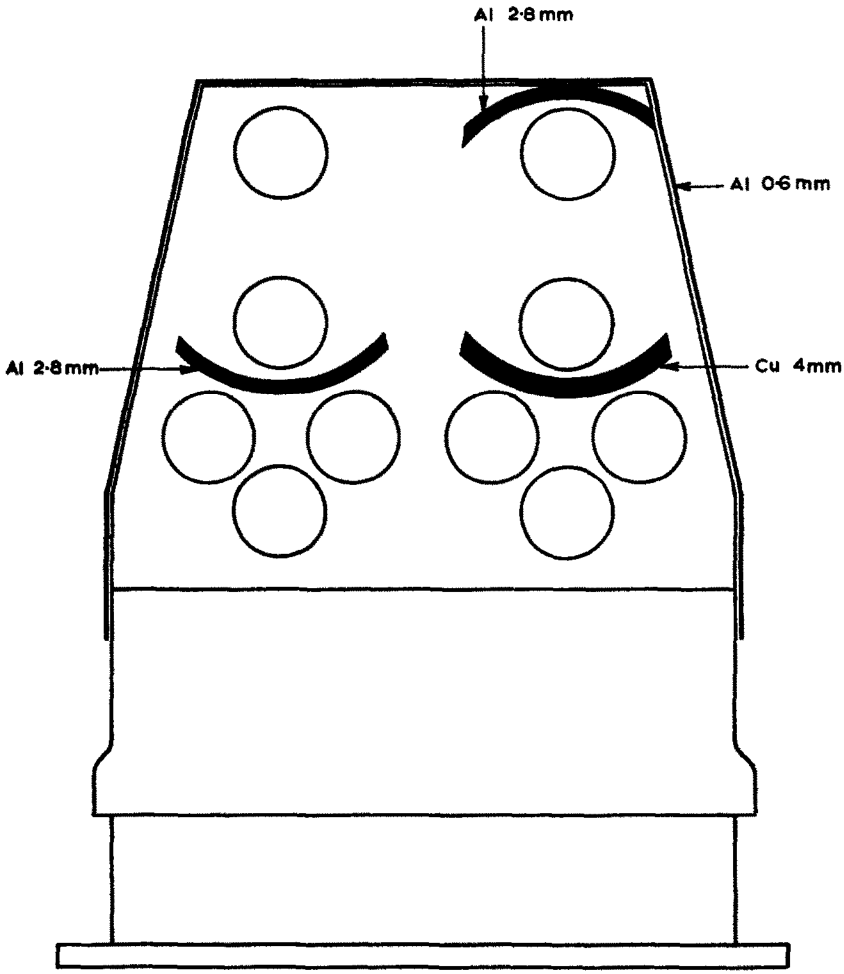

FIG. 1. SCHEMATIC DIAGRAM OF THE PARTICLE DETECTOR.

Let us assume then that the detector has been struck by a flux of energetic electrons. In that case the channels 28–60 MeV and above 60 MeV have counted only accidental coincidences, due to scattered electrons. For that reason the counting rates in the different channels cannot be used for spectrum analysis.

The counting rates observed in the first channel are corrected for accidental coincidences using a factor of 7 for the ratio of the geometric factors for these coincidences and the real ones. The resolving time of the electronics is 140 μsec. Furthermore we assume a nearly isotropic distribution of the electrons above the atmosphere. Because of the large field of view of the detector and the launching angle, particles coming from directions within a cone

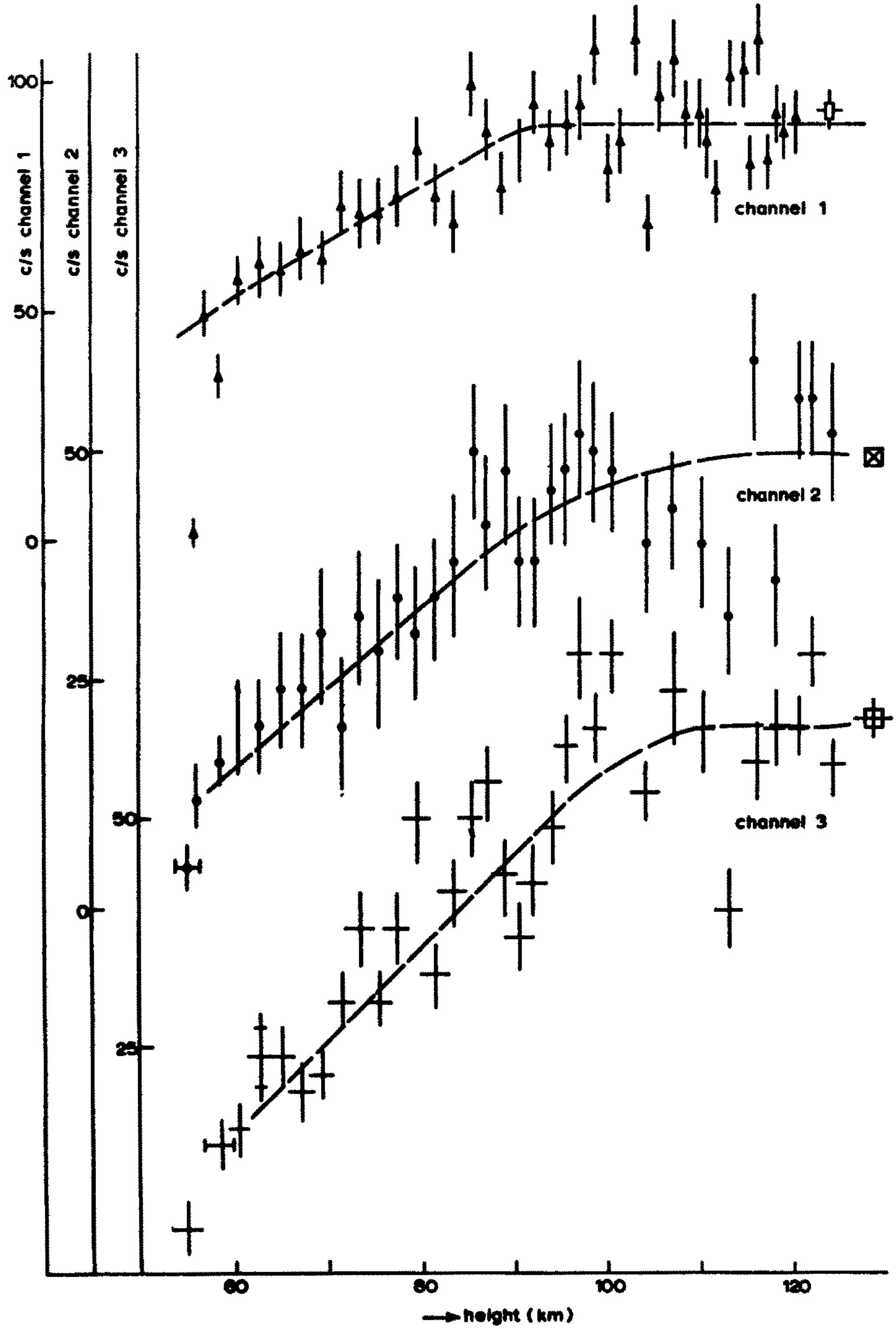

FIG. 2. COUNTING RATES IN THE THREE CHANNELS AS A FUNCTION OF HEIGHT.

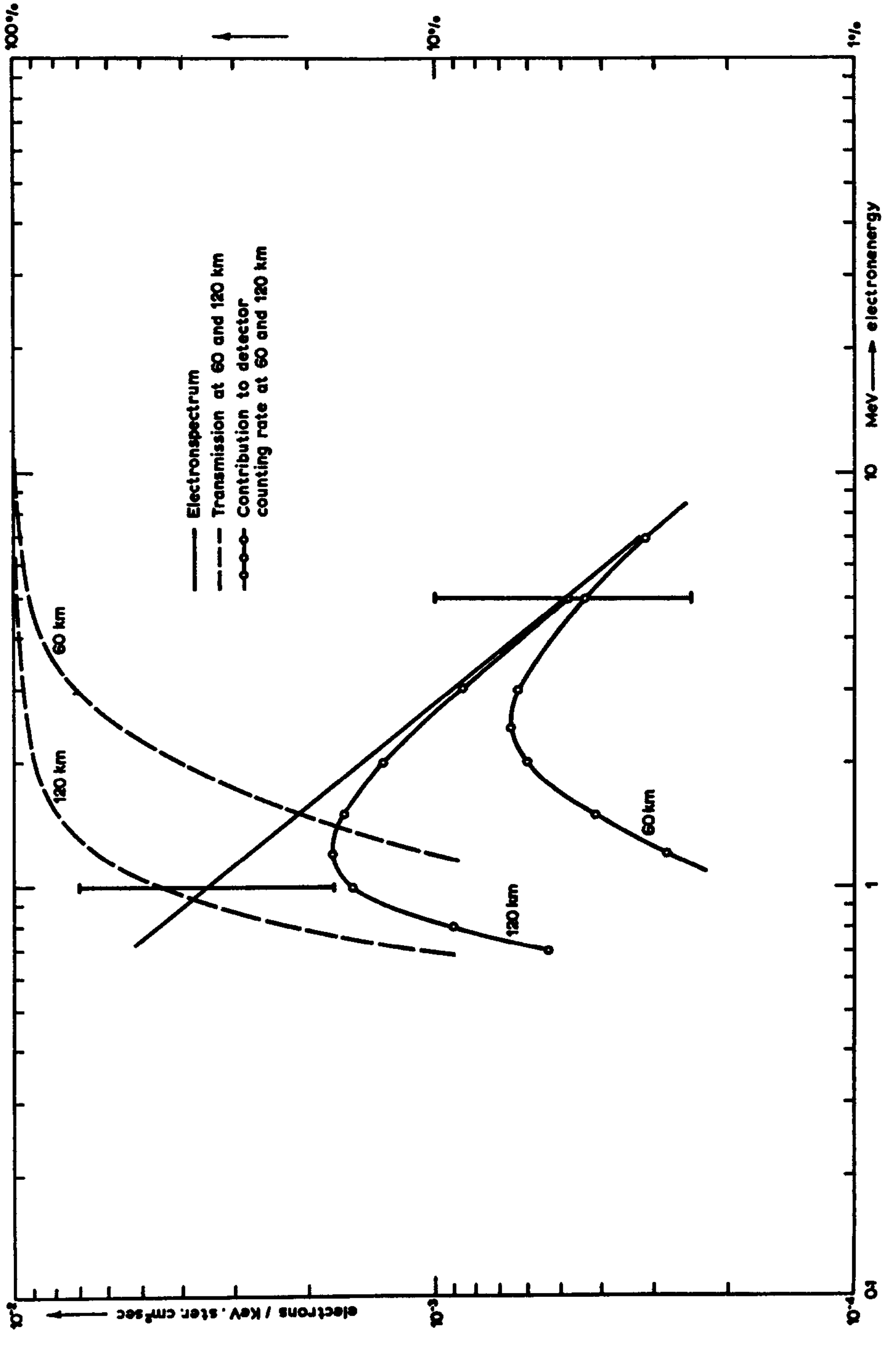

FIG. 3. CONTRIBUTIONS TO THE COUNTING RATES AT DIFFERENT ALTITUDES AS A FUNCTION OF ENERGY.

of about 55° around the direction to the Zenith can contribute to the counting rate. Instead of the real atmosphere depth h we used an average atmospheric depth H.

We found that $H = 1{\cdot}3h$ is a good enough approximation for our purpose. The transmission characteristics of the atmosphere-absorber combination has been assumed to

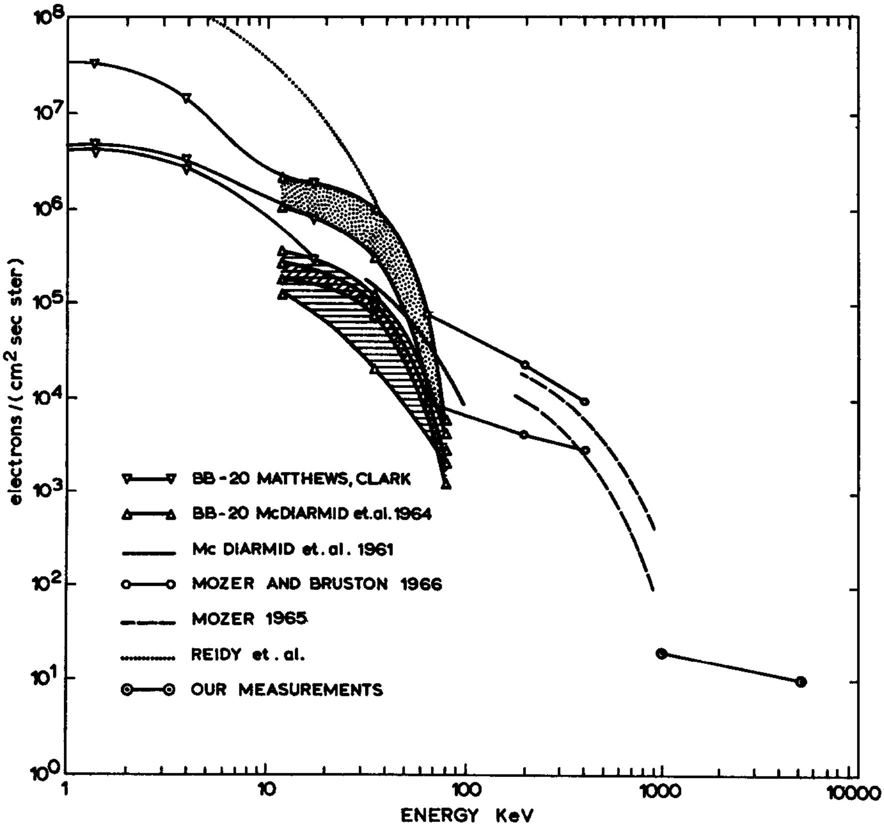

FIG. 4. COMPARISON OF THE OBSERVED ELECTRON SPECTRUM WITH A COMPILATION OF AURORAL ELECTRON SPECTRA AS GIVEN IN THE REVIEW PAPER BY PFISTER (1967).

be equal to the function given by Rester (1965). In Fig. 4 the overall transmission of the atmosphere plus absorber vs. energy is given for different altitudes.

Assuming a differential energy spectrum of the form:

$$n(E)\,\mathrm{d}E = AE^{b}\,\mathrm{d}E,$$

the counting rates at 60, 80 and 120 km are calculated for different values of the parameters A and b. The best fit to the observed counting rates was obtained for a primary spectrum

$$n(E)\,\mathrm{d}E = 3{\cdot}5\,.\,10^{-3}\,E^{-1{\cdot}2}\,\mathrm{d}E \text{ electrons/cm}^2 \text{ ster sec keV}$$

with E in MeV.

In Fig. 3 the contribution to the counting rate as a function of energy is given for the eventual spectrum. From this it can be seen that it is mainly electrons with energies between

1 and 10 MeV that have contributed to the observed counting rates; the high energy limit is set by the decreasing flux at high energies, whereas the low energy limit is due to atmospheric absorption.

The result is represented in Fig. 4 together with a compilation of recent measurements as given in the review paper by Pfister (1967). Our observations fit in fairly well, although Mozer's 1966 observations (Mozer and Bruston, 1966) indicate that under certain conditions higher fluxes could be expected.

4. CONCLUSIONS

From the above discussion we conclude that we have observed electrons in the energy range of 1–10 MeV during a weak, diffuse aurora. From this one observation it cannot be concluded that these electrons should be considered as real auroral particles or that the observed electrons form a more or less steady precipitation from the outer parts of the radiation belts as is suggested by Pfister to be the case for electrons above 100 keV. In order to draw more decisive conclusions, observations with more discriminative detectors should be made.

Acknowledgements—The authors greatly appreciate the stimulating discussions with Professor C. de Jager on the interpretation of the measurements reported in this paper.

REFERENCES

MOZER, F. S. and BRUSTON, P. (1966). *J. geophys. Res.* **71**, 4451.
PFISTER, W. (1967). *Space Sci. Rev.* **7**, 643.
RESTER, D. H. and DANCE, W. E. (1965). NASA-CR-759