the measured number of events weighted as to include the angular response of the instrument, and an approximate upper limit to this flux of gamma rays from these directions. These upper limits are approximate to a 95% statistical confidence limit, and include as estimated 20% detection efficiency.

Acknowledgment

An experiment of this kind has of course relied upon the efforts and skills of many people. Particularly important have been the contributions of Dr. James Kupperian who coordinated the project and others of the Goddard Space Flight Center of NASA, personnel of the Marshall Space Flight Center who engineered and built much of the satellite, and G. Garmire and Charles Moore and W. B. Smith and E. Mangan of M.I.T.'s Laboratory of Nuclear Science in which the gamma ray detector was designed and built. A. Womack and A. Hershdorfer made essential contribution to the data analysis.

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Discussion

Kaplon, M.F.: What is the influence of the galactic halo? Wouldn't it effect your limits?

Kraushaar, W.L.: I believe that the gas density and probably the cosmic ray flux are comparatively small in the halo, but I agree that they should be taken into account. The purpose of the model assumed was simply to provide a basis for comparison with our experimental results, and should a contribution from the halo become evident experimentally, we would of course be very pleased.

Hayakawa, S.: Is the rate of albedo gamma rays that you have found consistent with previous measurements?

Kraushaar: Provisionally, yes. But we have more work to do on this point since previous measurement must be carefully interpretted.

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III-1-2. Some Properties of the Primary Cosmic Ray Electrons*

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The discovery of primary cosmic ray electrons in the vicinity of the earth (Meyer and Vogt, 1961; Earl, 1961) opens the question of the origin of these particles. There exist two obvious alternatives, namely (1) solar origin with subsequent storage in interplanetary space, and (2) galactic origin. In the second case the electrons would most likely be identical with the long postulated source of galactic radio noise. Their intensity and energy spectrum near the earth would be modified by the modulation mechanisms which are known to affect the flux of protons arriving from the galaxy. This modification would be strongest during periods close to

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the maximum of solar activity.

It is important to make a decision among the two alternatives of solar and galactic origin. Although there does not exist any experimental evidence as yet which leads to an unambiguous answer, we are able to report here on some results which bear on this question.

These results concern:

1) The production of electrons at the sun during the Sept. 3, 1960 solar flare which is known to have produced a large flux of high energy protons.

2) The short term intensity variation of the primary electron flux during a Forbush-type decrease.

The results are based on three measurements which were carried out at balloon altitudes over Ft. Churchill, Manitoba on Aug. 22, Sept. 8 and Sept. 15, 1960. The equipment consisted of a scintillation counter telescope, designed to measure the initial energy loss and the range in lead of low energy primary particles. A cross section of the detector is shown in Fig. 1. Full details of its properties have been published else-

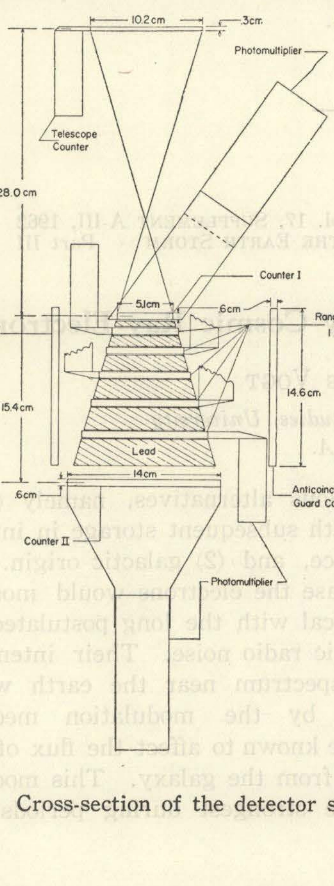

Fig. 1. Cross-section of the detector system.

where (Meyer and Vogt, 1961; Vogt, 1961).

In Fig. 2 the neutron monitor data of the Deep River station* are shown for the period in which the balloon measurements were made. On Sept. 3, a solar flare occurred which resulted in the emission of solar protons with energies up to several hundred Mev. These protons were studied through balloon and rocket measurements by Winckler *et al*, 1961 and Davis, *et al*, 1961. The energy spectrum of the stored flare particles has also been investigated without apparatus

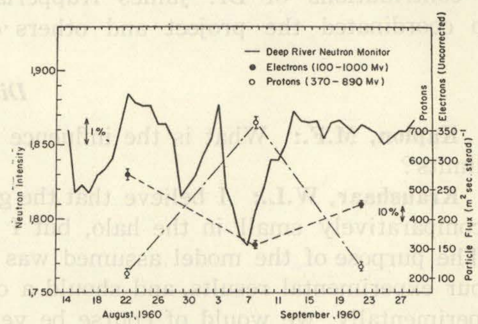

Fig. 2. Daily averages of Deep River neutron monitar data during period of balloon measurements. Also shown are the proton and uncorrected electron flux in similar rigidity intervals for the three days of measurement.

on Sept. 8, five days after their emission (Vogt, 1961), when the *total* cosmic ray intensity had undergone a Forbush decrease with an amplitude of about 4% at the high latitude neutron monitor ground stations. At that time the observed integral flux of primary protons with energies greater than 350 Mev was slightly increased above the values of Aug. 22 and Sept. 15. It could be shown that, after the subtraction of flare particles, the flux of *galactic* protons with $E>350$ Mev had decreased by at most 9%. This is consistent with the station data.

In order to investigate the behavior of the primary electrons during the Forbush decrease we give in Fig. 3 the altitude dependence of the electron events for the three balloon flights. The graph shows the flux of electrons with energies ranging from approximately 100 to 1000 Mev including the contribution of high energy protons or mesons which fake an "electron" event by making

* These neutron monitor data were kindly made available to us by Drs. H. Carmichael and T. Steljes.

a nuclear interaction in the lead absorber.

One finds that, under 3 to 5 g/cm² of air, where the contribution of secondary electrons becomes insignificant, the flux decreased by 43% between August 22 and September 8 and recovered to a level close to the August 22 value on September 15. Towards larger atmospheric depth the contribution of secondary electrons increases rapidly. Near and below the transition maximum, which is dominated by secondary electrons, no significant intensity changes can be observed.

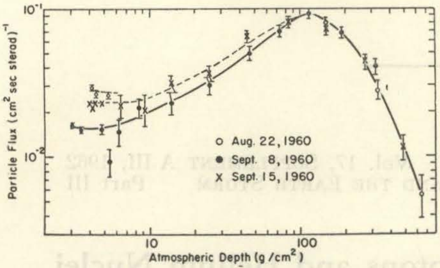

Fig. 3. Vertical flux versus atmospheric depth for minimum-ionizing particles with range between 10.5 and 122 g/cm² of lead (Error limits shown are standard deviations).

—·—·— Aug. 22, 1960
——— Sept. 8, 1960
– – – – Sept. 15, 1960

This is in agreement with the fact that the proton flux with energies above 350 Mev, which is the prime source of the secondary electrons, changed very little between the flights. It is, in addition, an independent proof that we are indeed observing primary electrons near the top of the atmosphepe.

Fig. 2 shows the flux of protons in the rigidity interval from 370 to 890 MV and of electrons (uncorrected) in the rigidity interval from about 100 to about 1000 MV. On Sept. 8 the proton flux in the above rigidity interval is greatly enhanced due to storage of the solar flare particles from Sept. 3. In a similar rigidity interval the electron flux is reduced as a consequence of the Forbush decrease. The uncorrected electron flux contains a background caused by interacting near relativistic protons. Since we know that the flux of these protons remained almost unchanged in the three measurements (Vogt, 1961) a subtraction of its contribution to the electron events would enhance the amplitude of the Forbush decrease observed in the electron component. Therefore, the 43% change of the electron flux is a lower limit.

We draw the following conclusions from these observations:

1) If, during the Sept. 3 flare, electrons were produced on the sun, they were not stored in interplanetary space like protons of similar rigidity. Since this does not appear plausible, the measurement indicates that the flare did not lead to an emission of electrons.

2) A Forbush decrease which began on Sept. 4, 1960, and amounted to about 4% at high latitude neutron monitor stations, and to about 9% for primary protons with $E>350$ Mev, affected the primay electron component and reduced the electron flux by more than 40% in the rigidity range from 100 to 1000 MV. This strongly suggests that the electrons observed at the earth have a history which is similar to the galactic protons. The evidence, therefore, points to a galactic origin of the primary electrons. However, it does not exclude the possibility of solar emission with subsequent, temporary storage in interplanetary space at other times.

We are deeply indebted to Mr. T. Burdick for his invaluable assistance throughout the experiment and to Mr. G. Lentz who carried out the computer analysis.

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Discussion

Menon, M.G.K.: Let me ask more detail of Forbush decrease?

Meyer, P.: The *F*-decrease started on Sept. 4 and reached a maximum amplitude of 4% at the Deep River Neutron monitor station. During our mesurement of Sept. 8 recovery had first begun. It was at that time that we measured the $\sim$40% decrease in electron flux.

Peters, B.: Can you give me absolute flux value corrected for the proton effect?

Meyer: I can not. We are going to calculate the proton contribution but I can not guess an answer yet. I have only a lower limit available.

Kraushaar, W.L.: Have you estimated the electron intensity you would expect from collisions of cosmic rays in the galactic gas?

Meyer: No, we have not. In order to do that, we would have to use the rather uncertain figures for the galactic magnetic fields. Also we are in no position to estimate the attenuation of the electron flux by solar modulation in the energy range that we observe.

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III-1-3. The Flux of Primary Protons and Helium Nuclei Near the Geomagnetic Equator

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Introduction:

Balloon flights have been made from Hyderabad (India)-geomagnetic latitude 9°N, longitude 78.5°E-to determine the flux of primary protons and helium nuclei at the top of the atmosphere, near the geomagnetic equator. Measurements were made using both Cerenkov-scintillation counter telescopes and nuclear research emulsions.

A. *Measurements with Cerenkov-scintillation counter telescopes*:

Three counter telescopes of identical geometry, using lucite Cerenkov counters and plastic scintillation counters in combination, were flown successfully from Hyderabad during February-March 1961, to level altitudes of $\sim$10 gm/cm² for several hours each time.

The geometry of the telescopes is shown in Fig. 1. The geometry is similar to that employed by McDonald[1] except for two specific points of difference: (a), in our case the Cerenkov radiator was blackened at the top and at the sides; this blackening resulted in very good directional discrimination-for example, the back to front ratio in detection efficiency was <1%; we thus eliminated upward moving "splash albedo"; also, the

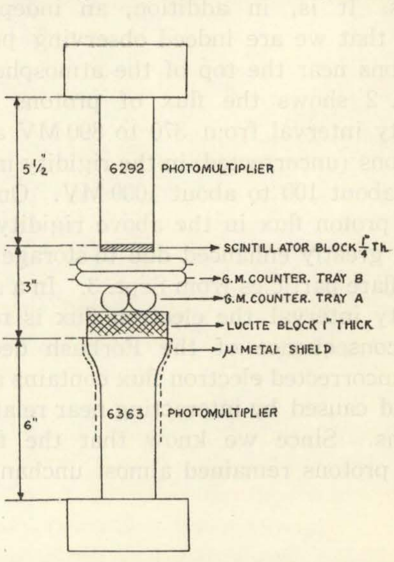

Fig. 1. Geometry of the cosmic-ray telescope