"Knee" of the Cosmic-Ray Latitude Curve*

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A PHENOMENON of considerable interest in the study of the distribution of cosmic-ray intensity over the earth has been the apparent absence of low-energy particles in the primary radiation. At sea level the "knee" is probably due to atmospheric absorption and has been placed at 40° to 45° geomagnetic north. At high altitudes a number of divergent results have been obtained by various observers.[1] We wish to point out that some of this seemingly contradictory evidence may be due to the fact that the data were taken at different times.

In Fig. 1 is given the ionization *vs* air mass overhead taken in the summer of 1954 near the north geomagnetic pole. The instrument reached an altitude of about 95 000 feet. The increased rate of ionization with decrease of pressure at the highest altitudes appeared on

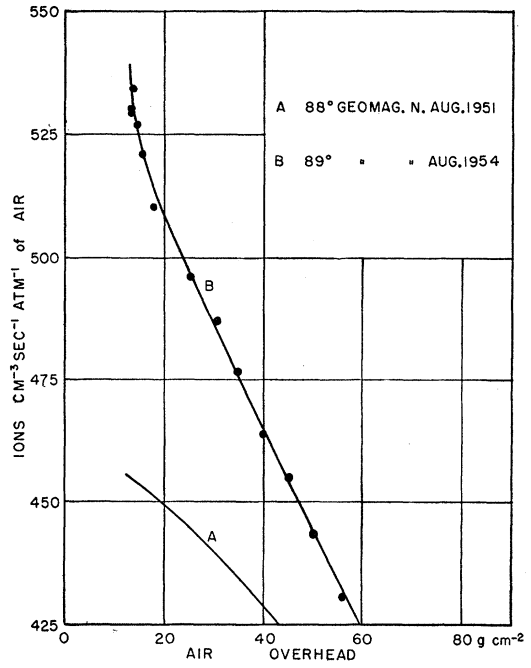

FIG. 1. On an expanded scale the ionization *vs* air mass overhead is shown for the two years, 1951 and 1954, near the geomagnetic pole. The increased slope in 1954 at the lowest pressures is evidence for low-energy particles (150 Mev if protons) present in 1954 that were absent in 1951.

all five flights that went to sufficient height. They were made from geomagnetic latitude 81°N to three degrees north of the geomagnetic pole and extended over the period July 28 to August 19, 1954.

In Fig. 2, the ionization *vs* geomagnetic latitude is given for the two years 1951[1] and 1954 at the atmospheric depths shown. It is evident that large changes in the radiation took place in the intervening three years at the northern latitudes at these high altitudes. While the change in 1951 from 58° to 68° was less than 1 percent at 20 g cm^{-2}, we found in 1954 a change of about

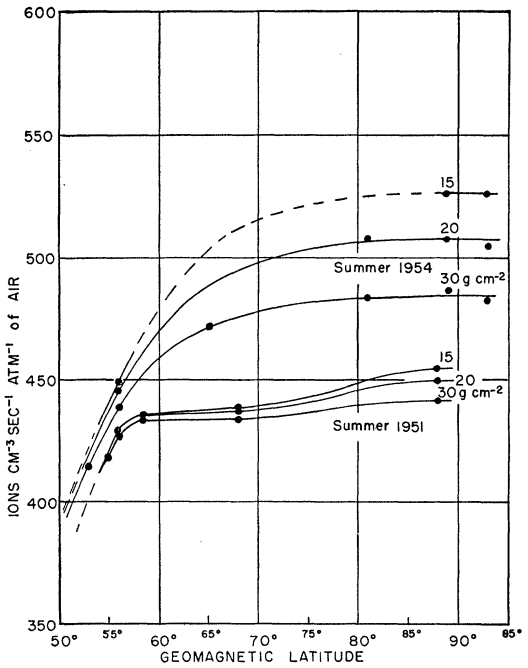

FIG. 2. The increase in ionization with increasing latitude in 1954 up to at least 68°N shows a lack of cutoff of primary particle down to at least 150 Mev, if protons.

6 percent at the same depth, covering the same range of latitude. This difference we interpret as being due to low-energy particles present in 1954 that were absent in 1951.

From geomagnetic theory, we find that 150-Mev protons can get in at the vertical at geomagnetic latitudes north of 65°. The evidence from Fig. 2 is that particles (if protons) were present in 1954 in the primary radiation down to 150 Mev. The increase in the ionization from 68° to 90° shown in the curves of Fig. 2, amounting to 12 ions cm^{-2} sec^{-1} atmos^{-1} of air at 20 g cm^{-2}, was the same in 1954 as in 1951. Since no new particles, admitted by the opening of the Stoermer cones, can reach our instrument north of 68°, we interpret this increase as due to the opening of the shadow cones[2] for both occasions.

From Fig. 1, the continued increase in the slope of the 1954 curve at 15 g cm^{-2} leads us also to believe that particles were present which had ranges equal to and less than this value.

These two pieces of evidence indicate that there was no cutoff of the primary particles down to at least 150

Mev (assuming protons) in the summer of 1954 at northern latitudes. In contrast, the apparent cutoff for protons in 1951 was estimated at 800 Mev.

The present experiments give added weight to the suggestion of Forbush[3] that there exists an inverse relationship between solar activity and cosmic-ray intensity. During the summer of 1954 the sun was at its lowest ebb in 22 years. The sun was permitting particles of low energy to arrive at the earth which at other times were excluded.

Further details will be published at a later date.

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[1] See *Progress in Cosmic Ray Physics*, edited by J. G. Wilson (North-Holland Publishing Company, Amsterdam, 1952), p. 323.

[2] Neher, Peterson, and Stern, Phys. Rev. **90**, 655 (1953).

[3] S. E. Forbush, J. Geophys. Research **59**, 525 (1954).