ENGINEERING RESEARCH INSTITUTE
UNIVERSITY OF MICHIGAN
ANN ARBOR

REPORT NO. 2

MEASUREMENT OF PENETRATING COSMIC RAY PARTICLES

BY

W. E. HAZEN
Associate Professor of Physics

NOAH SHERMAN
Research Assistant

University of Michigan
Ann Arbor, Michigan
September 30, 1951

Project M953

The research reported in this document has been made possible through support and sponsorship extended by the Geophysics Research Division, Air Force Cambridge Research Center under Contract AF19(122)-465. It is published for technical information only and does not represent recommendations or conclusions of the sponsoring agency.

CONTRACT AF19(122)-465

July 1, 1951 - September 30, 1951

REPORT NO. 2

MEASUREMENT OF PENETRATING COSMIC RAY PARTICLES

In the period covered by this report, the collection and analysis of experimental data were continued, and the temperature coefficient, derived from all data collected to date, was obtained. This temperature coefficient is a measure of the correlation between underground cosmic-ray intensity and temperatures in the stratosphere, as described in Report No. 1. The experimental values, for the temperature coefficient, are considerably smaller than the corresponding theoretical estimate (.4% deg^{-1}) based on a model for meson production, where it is assumed that μ-mesons are produced only by π-mesons. This hypothesis is in agreement with experimental observations involving mesons of <u>low</u> (~75 mev) and <u>moderate</u> (~150 mev) energies. Since the present investigation involves μ-mesons of higher average energy (~10^5 mev) and produces results which are not in clear agreement with the hypothesis requiring μ-mesons to originate in π-μ decay only, this suggests that the model may not be applicable, at least at high energies. Before examining this suggestion critically, it should be demonstrated that the experimental procedure is sound.

Although no discrepancy between theory and experiment was anticipated, precautions were taken, at the outset, to insure that variations in the behaviour of the apparatus would not produce effects which could be confused with variations is cosmic-ray intensity. (The apparatus is described in Report No. 1.) First, the plateau characteristics of the Geiger counters were considered. These were recorded for each counter, and subsequent checks found them unchanged or rendered completely useless; i.e., tests, conducted twice weekly, revealed either the original plateau or a counter whose plateau had vanished. On the infrequent occasions of such failure, the data accumulated in the immediately preceding period were discarded. Failures were immediately evident from changes in the counting rates of separate trays. Secondly, it was necessary to design the electronic circuits to be insensitive to the variations in pulse size which are characteristic of the counters. This was accomplished by amplifying the counter pulses to heights well above the threshold for triggering a pulse-generating circuit. The percentage of counter pulses which failed to trigger was checked twice weekly and found to remain below 0.01 per cent. The output pulses of the pulse generator were of uniform size, and were required to be approximately rectangular to minimize possible variations in the resolving time of the coincidence circuit. Monthly checks of the resolving time showed these variations to remain less than 2 per cent.

Finally, the nature of the recorded events must be considered in order to determine the reliability of cosmic-ray variations deduced therefrom. Among the coincidences recorded, there may be true coincidences from cosmic rays and from γ-rays (emitted from nearby radioactive contaminants) which produce Compton electrons in the walls of counters in both trays. The remaining coincidences are accidental and are due to incoherent particles passing through each tray during the resolving time of the coincidence circuit. A layer of lead, one inch thick, was placed between the two counter trays to eliminate the effects of true γ-ray coincidences. Less than 1 per cent of the γ-rays ($E \leq 2.5$ mev) can traverse this absorber, and those that do traverse it produce coincidences with an efficiency of only .007. Since 1/3 of the counts registered in a single tray are produced by γ-rays, even if all these represented quanta moving in the direction of the other tray, the maximum contribution to the coincidence rate would be less than .1 per cent. Variations in γ-ray background can be seen to have a negligible effect, since the single counting rates remain essentially constant; and even large γ-ray variations would produce errors of second order compared with the expected variations due to temperature. The accidental coincidences can be determined from the resolving time of the coincidence circuit and the single counting rates of the two counter trays. The accidental rate was found to be 1.3 per cent of the total coincidence rate, so that the 2 per cent variations in this quantity (as found from measured variations in resolving time and single counting rates) also have a negligible effect on derived cosmic-ray variations. The remaining events, which were recorded by the apparatus, were cosmic rays capable of penetrating one inch of lead. These were presumably μ-mesons and their energetic knock-on electrons. Variations in this component were taken to reflect the validity of the π-μ decay model, and these variations were found to be less strongly correlated, with stratospheric temperatures, than was indicated by the theoretical model.

The values of the temperature coefficient, α, as obtained from least square and linear regression methods, from the 100 mb, 150 mb, 200 mb, and 300 mb atmospheric pressure levels, are listed below.

	α (% deg^{-1})	Significance Level (%)
100 mb	$.079 \pm .058$	18
150 mb	$.100 \pm .047$	3
200 mb	$-(.129 \pm .079)$	11
300 mb	$.021 \pm .036$	56

These results are to be compared with the theoretical value, .4 per cent deg^{-1}. The significance level indicates the statistical probability of obtaining the given value of α, or greater, from completely uncorrelated pairs of data.

The collection of data continues. In the coming months, the collection of data is expected to by possible during periods when the temperature is at one of the extremes of its range of values. These data have greater weight in determining the temperature coefficient, than those collected in the summer months.