

## FINAL REPORT

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Cosmic Ray Telescope for OGO II and IV Spacecraft

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This document is the final report for Contract NAS 5-3096 which involved the construction and subsequent flight of a cosmic ray telescope aboard the OGO-II and IV Spacecraft. This instrument was a combination Cerenkov-scintillation counter telescope designed to measure the cosmic ray energy spectrum from 1-15 GV and charge composition from  $Z=1-8$ . OGO-II was launched in October 1965; however, attitude control problems caused a rapid loss of control gas, so that after ~2 weeks it was no longer possible to point the spacecraft. This mission was officially declared a failure. The cosmic ray instrument we constructed appeared to work well during this time period although only a limited amount of useful data was obtained because of the orientation problem.

OGO-IV was launched in July 1967, with a similar telescope aboard. It operated successfully for approximately one year. The details of the experiment, its operation and the results are given in the University of Minnesota Ph.D. thesis of Donald Sawyer (a copy of the abstract of this thesis is enclosed). Here we shall summarize the most important results obtained.

#### 1. Cut-off Rigidities in the Earth's Field

A considerable amount of data was obtained on the cut-off rigidities in the earth's field at much higher energies than previously measured. This data was obtained at quiet and flare times for both protons and helium nuclei. During solar

flare times the polar cap structure of the arriving particles was studied including dawn-dusk cut-offs and noon-midnight cut-offs. Basically it was observed that the quiet time cut-offs are lower than predicted from models of the earth's internal field. From the latitude dependence of this cut-off depression it was found that ring currents are probably the main cause of the cut-off depression.

## 2. Energy Spectra of Protons, Helium, and CNO Nuclei

Utilizing the latitude profiles constructed from many super-imposed passes of the spacecraft from N pole to S pole it has been possible to determine the differential spectra of protons, helium, and CNO nuclei between 1 and 15 GV by studying the differences in successive two dimensional matrices of events accumulated in narrow latitude (cut-off) intervals. Extensive analysis was necessary to separate the singly charged component into primary protons, and re-entrant and splash albedo. This study represented the first determination of the systematic spectra of several charge components using the earth's field as a magnetic spectrometer.

## 3. Charge Composition of Cosmic Ray Nuclei

From the previous studies (section 2) it was possible to determine the relative charge composition of cosmic ray nuclei from  $Z=1-8$  in the 1-15 GV range. This data suggested that

the rigidity spectra of He and CNO nuclei are substantially the same. There was evidence, however, that the spectrum of Li, Be, and B nuclei was steeper than that of either He or CNO. We regard this as the first evidence of this important point, a point since observed and interpreted by several experimental groups. The interpretation of this difference in the spectra of the secondary Li, Be, and B nuclei in terms of an energy dependent path length for cosmic ray nuclei in the galaxy has been one of the more significant developments of cosmic ray research in the past few years.

4. Studies of the Time Variations of the Primary Proton and Helium Nuclei Spectra

Studies of the effects of Solar Modulation were carried out by comparing the proton and helium nuclei spectra measured on OGO-II in 1965 with those determined on OGO-IV in 1967-1968. Data analysis funding limitations restricted the detail in which these time variations could be studied during the 1967-1968 period. Nevertheless, very useful data was obtained on the relative proton and helium nuclei modulation that provided some of the earliest evidence that the modulation of these two components was not strictly rigidity dependent and that energy loss effects were necessary for a complete explanation of this modulation.