Energy Spectrum and Geomagnetic Cut-Off
of Primary Cosmic-Ray $\alpha$-Particles Near 41° N Mag (*)

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Summary. — The energy spectrum of the primary cosmic-ray $\alpha$-particles have been measured using nuclear photographic emulsions flown from Alamogordo, New Mexico, on 14th May 1962. An emulsion-orienting mechanism allowed estimates to be made of the average geomagnetic cut-off energies in the east and west directions up to 45° zenith angle. Around the zenith, the cut-off was found to be $(1.5 \pm 0.1)$ GeV/nucleon kinetic energy, with a total flux of $(80 \pm 7)$ particles/m² s sr. The slope of the integral energy spectrum was found to be $1.7 \pm 0.15$ in the kinetic energy range from 2.5 to 10 GeV/nucleon.

1. – Introduction.

A recent experiment by Guss (1,2) has demonstrated the feasibility of using multiple Coulomb scattering measurements, in nuclear photographic emulsions, to obtain information on the primary cosmic-ray energy spectrum up to kinetic energies of about 10 GeV/nucleon, for $\alpha$-particles. Glass-backed emulsions, after low-temperature isothermal processing, show very little, if any, of the semi-microscopic «spurious scattering» which often has limited the usefulness

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of scattering measurements to energies below about 3 GeV/nucleon. This experiment is the first of a series designed to measure directly geomagnetic cut-off energies in the relativistic region, as well as the slope of the primary \(\alpha\)-particle energy spectrum between about 2 and 10 GeV/nucleon. Here we describe the results of an experiment conducted near Alamogordo, New Mexico, in May 1962. Later papers will deal with the results of an experiment at Calvinia, South Africa, near the South Atlantic magnetic anomaly and will also discuss in more detail the geomagnetic effects. On all balloon flights, the emulsions were oriented with respect to the geomagnetic field and it has been possible to obtain estimates of the average cut-off energies in the east and west directions and to estimate the cut-off energy and spectrum slope values which are almost independent of one another, and quite independent of the measured particle flux.

With the availability of high-speed computers, it has become possible to derive cosmic-ray cut-off energies at geomagnetic latitudes less than about 55°, by the direct integration of particle trajectories in a multipole expansion simulation of the earth's magnetic field. Our experimental cut-off values are compared with the results of such computations for the flight location and also with the approximate cut-off calculations of Quenby and Wenk (3).

2. – Experimental details.

2.1. Exposure and Track Selection. – The stack consisted of 72 Ilford G-5 glass-backed emulsions each 16.5 cm square and \(\approx 600 \mu m\) thick; it was launched from Alamogordo, New Mexico, on the 14th May 1962 and reached a ceiling altitude of 125 000 feet. A mean residual atmospheric pressure of 4.3 gm/cm\(^2\) was maintained for 8 hours whilst the balloon drifted within a 20-mile radius of the launch site: 30° 15' N, 105° W (geographic). The plates were kept in a vertical plane after launch and were oriented to within 10° of the geomagnetic east-west plane at ceiling altitude.

Unfortunately, a first attempt to fly the stack on May 10th was unsuccessful. The balloon reached an altitude of only 75 000 feet (about 35 gm/cm\(^2\)) and descended immediately; however, calculation shows that although this short flight adds to the observed number of \(\alpha\)-particles, the shape of the energy spectrum is not changed significantly.

The emulsions were processed isothermally (4), and were scanned along a line, 2 cm from the top edge and extending to 1 cm from each side. Tracks were analysed in 22 emulsions subject to the selection criteria: projected zenith