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III-4-16. The Structure of Extensive Cosmic-Ray Air Showers Near the Shower Axis

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Cosmic ray air showers containing from 10^4 to 10^5 particles have been detected by an array of nineteen, closely-packed, circular scintillation counters situated under a light wooden roof at Leeds 100 m above sea level. The detectors used were flat discs of plastic scintillator (*Ne* 102), 12 inches diameter by 1/3 inch thick. Each scintillator disc was viewed by an E.M.I. type 9514*B* photomultiplier looking upwards through a central hole in the disc into a dome-shaped, whitened reflector. With this arrangement, the light produced by a single particle traversing the scintillator at minimum ionization released, on average, 11 photoelectrons from the cathode of the photomultiplier and this yielded a pulse 0.25 *V* high from the 12th dynode. The response of the counter was found to be uniform within 10% over 97% of its area. The sensitive area of each counter was 700 cm² and of the whole array, 1.3 m².

The electrical pulses from the photomultipliers were fed via cathode followers to delay lines and then lengthened sufficiently to be registered on nineteen voltmeters which could be photographed. When the selection system was satisfied, electronic gating circuits allowed the pulses through to the pulse-lengthening circuits and voltmeters, and the camera circuit was triggered. The information was fed into a Ferranti Pegasus computer which made corrections for any non-linearity of the electronic circuits and stored the corrected results, in the form of nineteen values for the particle densities in the counters, on magnetic tape.

The results were analysed in two different ways. In the first method, the structure function was assumed to be of the form $f(r) = Kr^{-n}$ and the position of the shower core and best value of n were found by comparing the densities observed, with those expected for different shower core positions and different values of n. About 400 different core positions on a pre-determined grid which extended to 4 m from the centre of the array were tried for values of n, 0.2, 0.3, ...1.1. The core positions and values of n yielding the best fit were selected for each event. The second method could only be used for 64 events in which the shower core fell on the array so that its position could be estimated from the counter records. In this case, the shower core position was assumed and a least squares fitting of the data to the structure function quoted above was performed in order to find the best value of n and the size of the shower.

During the course of the experiment, it became clear that the photomultipliers were saturating so that a non-linearity was occurring in the photomultiplier response. For the first method of analysis it has not been possible to make more than a rather crude allowance for this effect. It is quite clear however that the mean value of n increases with distance from the shower core; and we estimate that the mean value of n increases from 0.7 at 8 cm $<r<$ 100 cm to 1.0 at 100 cm $<r<$ 200 cm and 1.2 at 200 cm $<r<$ 300 cm. This is in agreement with the results of Kameda (1960) and Vernov (1960).

For showers whose axes crossed the array, a correction for the non-linearity of the photomultipliers has been applied and the most probable value of n has been found to be 0.75. The range of n extends from 0.4 to 1.8. It is probable that this observed variation of n from shower to shower is a real effect and not just the result of fluctuations in the detected particle densities.

An analysis of the particle densities for events where the mean counter response was a given value indicated that the distribution of counter responses was slightly broader than a Poisson distribution.

* This paper was not presented.

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III-4-17. A Study on EAS at Mt. Norikura

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Main results obtained at Mt. Norikura (2770 m a. s. l.) are as follows; (1) Fluctuation of the lateral density distribution function near the axis and distant range has been studied and their relation on the average was shown. (2) Absorption length of shower rates was about 100 g/cm^2 from 10^5 to 10^6 in size. The length changes from 125 to 94 g/cm^2 depending on the classification by lateral structure. Apparent attenuation length of shower size were 140, 170 and 200 g/cm^2 for 10^{-11}, 10^{-12} and 10^{-13} cm^{-2} sec^{-1} str^{-1} in frequency, respectively. (3) Lateral distribution of N-component of different energy range has been obtained in the form of $\exp(-r/r_0)$ where r_0 is 20 m, 7 m and 2 m for the energies 2×10^8 10^{10} and 10^{11} ev, respectively. Integral energy spectrum at various distances from the axis has also been observed. From these data, total integral energy spectrum was obtained as $E^{-1.3}$. (4) The relation of total number of N-particles to the size of the shower was $N_N \propto N_e^{0.6}$ independent of the energy of N-particles. (5) The change of character of core has been found by means of energy flow trigger system at the size of 10^5. (6) Density spectrum and its area effect have been observed. (7) Core structure has been discussed from the cloud chamber pictures.

The electron photon component and N-component of EAS were observed by the experimental arrangements as shown in Fig. 1 at Mt. Norikura (2770 m a.s.l.). The data about electron component were obtained by 16 plastic density detectors, and the data about the N-component were obtained by the multiplate cloud chamber and two standard neutron monitors.

Main results which have been obtained are as follows.

(1) The lateral density distribution of electrons shows large fluctuation, as reported already at Moscow Conference, for the region near axis. (0−20 m) In the distant range, the lateral density distribution fairly agrees with N.K. function with the age parameter one of 0.8, 1.0 or 1.2 for the size 10^5 -10^8 particles. In some cases (about 5% of the total) observed showers are especially young (0.4−0.6 in s) or do not fit to the function at the central region, namely, densities are almost flat up to several meters.

Exponent α of lateral distribution expressed by $r^{-\alpha}$ near axis does not correspond in each case to the age parameter s of N.K. function which is determined mainly using distant range, but average value of α in the same s group shows following relation; $s=2.3-\overline{\alpha}$, though the exponent, α, shows large fluctuation.

The lateral density distribution of central part does not show the true age of the shower but it shows activity of core in further de-