particles in the bottom scintillator. Because of high mean energy, the events near the meeting point correspond to the core of various sizes. The result shows that the character of the core of EAS fluctuate largely below certain size which can be estimated from corresponding density or absolute frequency. In the series of this experiment, the critical size was estimated as about 10^5. From the observed frequencies of air showers (T+AS and B+AS) at sea level and at mountain altitude, the absorption length of rate was 115 ± 10 g/cm^2, then, we can conclude that the change of character in the core of EAS is not due to the primaries but to the character of interaction in high energy region.

Fig. 6 shows new arrangement to study the core structure of small size EAS. We can observe simultaneously density and core position at the top, and energy flow carried by soft component and of N-component which interact in the water tank. In the initial stage of construction, the water was not wed and six energy flow detectors were used to measure the area of highest energy flow which correspond to core region, and this was estimated as about 0.5 m in diameter. Later the water tank was set up and we found that the events triggered by energy flow are not mainly due to nucleon component since the rate did not change much with and without water. We are now taking runs with various kind of triggering namely, by the density, energy flow and nucleon component. The observation is now going on and some preriminaly result from the energy flow and nucleon component triggering runs are given in the following table for nearly same time of operation (52 and 42 hours respectively). The energy flow triggering is very useful to detect cores of small size EAS, and we find frequently the existence of steep cores which are probably due to γ-rays of energy greater than 10^{12} ev, as can be seen in the table.

References

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INTERNATIONAL CONFERENCE ON COSMIC RAYS AND THE EARTH STORM Part III

III-4-26. Cloud Chamber Study of Extensive Air Showers near the Sea Level

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A multiplate cloud chamber was operated at Institute for Nuclear Study during the past one year and a half. The cloud chamber has the illuminated region of 120 cm width, 50 cm depth and 100 cm height at the centre, and contains 7 plates of 8 mm thickness of lead lined with 5 mm thickness of iron, and 8 plates of 18 mm thickness of lead lined with 5 mm thickness of iron.

§ 1. Lateral distribution and energy spectra of the high energy electronic components

Table I shows the values of the exponent n, when the energy spectra in various bands of distance from the axis are assumed to be represented by the power law of the form E^{-n}. Examples of the lateral distribution of the high energy electronic components are shown in Figs. 1, 2. The former is the lateral distribution of particles of more than 5 Bev, and the density of each point is normalized to EAS with total number of 10^5. The latter shows that of particles of more than 1.5 Bev. The triangles in the figure are the results obtained at Mt. Norikura, 2770 m elevation, and they coincide well with

Table I. Values of the exponent of energy spectrum.

Distance from the axis (m)		Energy (Bev) 1-3	3-10	10-30	30-100
<0.8	S	0.7±0.1	0.8±0.1	0.8±0.1	1.1±0.3
	M		0.8±0.3	0.6±0.4	0.8±0.5
1	S	1.2±0.2	1.2±0.2	1.3±0.4	
	M	0.6±0.1	1.1±0.2	1.1±0.3	
1.5-2	S	1.4±0.2	1.2±0.3	1.5±0.6	
	M	1.4±0.1	1.6±0.3	2.1±1.2	
	L		1.0±0.3	1.0±0.3	1.7±0.6
3-4	S	1.4±0.3	1.4±0.5	1.4±1.0	
	M	1.5±0.3	1.9±0.3	1.9±0.6	
	L	1.4±0.4	1.4±0.4	1.4±0.5	1.6±0.6
5-7	M	1.7±0.2	2.4±0.6		
	L	1.6±0.1	2.4±0.4		
8-10	M	1.9±0.3			
	L	1.5±0.2	2.2±1.0		
11-15	L	1.7±0.2	1.9±0.4		
16-30	L	2.4±0.4	2.4±1.0		

S: small size shower ($2\times10^4 \leq N \leq 6\times10^4$)
M: median size shower ($7\times10^4 \leq N \leq 4\times10^5$)
L: large size shower ($5\times10^5 \leq N \leq 6\times10^6$)

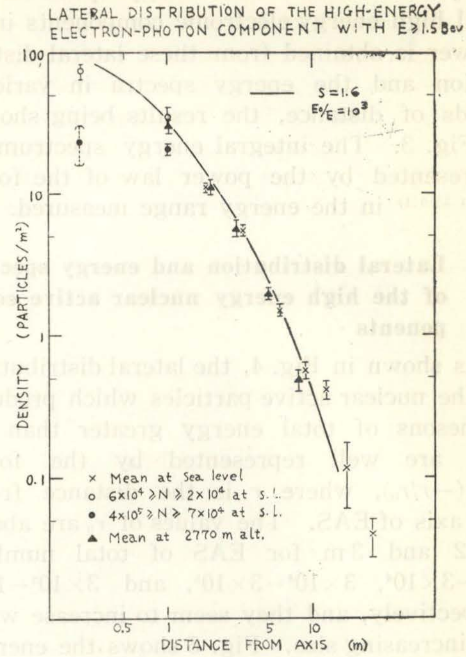

Fig. 2. Lateral distribution of the high-energy electron-photon component with E≥1.5 Bev.

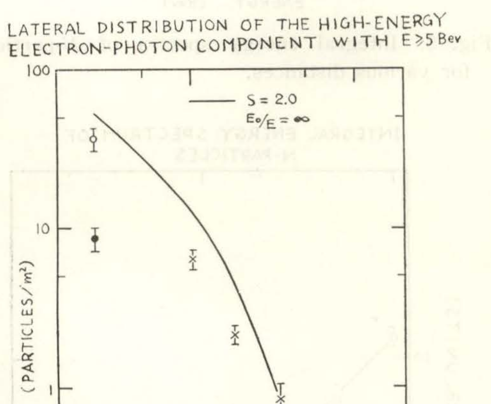

Fig. 1. Lateral distribution of the high-neergy electron-photon component with E≥5 Bev.

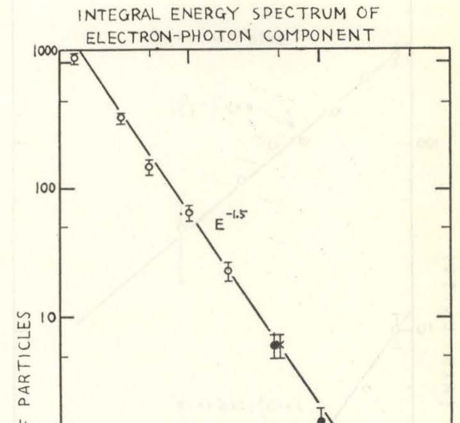

Fig. 3. Integral energy spectrum of eelctron-photon component.

the present ones. The energy spectrum of total high energy electronic components in a shower is obtained from these lateral distribution and the energy spectra in various bands of distance, the results being shown in Fig. 3. The integral energy spectrum is represented by the power law of the form $E^{-(1.5\pm0.1)}$ in the energy range measured.

§ 2. Lateral distribution and energy spectra of the high energy nuclear active components

As shown in Fig. 4, the lateral distribution of the nuclear active particles which produce π^0-mesons of total energy greater than 10 Bev are well represented by the form $\exp(-r/r_0)$, where r is the distance from the axis of EAS. The values of r_0 are about 1, 2 and 3 m for EAS of total number $10^4-3\times10^4$, $3\times10^4-3\times10^5$, and $3\times10^5-10^6$, respectively, and they seem to increase with the increasing size. Fig. 5 shows the energy spectra of the high energy nuclear active particles in the three bands of distance from the axis of EAS. Any remarkable difference of the form of spectra are not found between EAS of total number of 10^4-10^5 and those of 10^5-10^6. Assuming the power law of the form E^{-n} for the energy spectra, n is de-

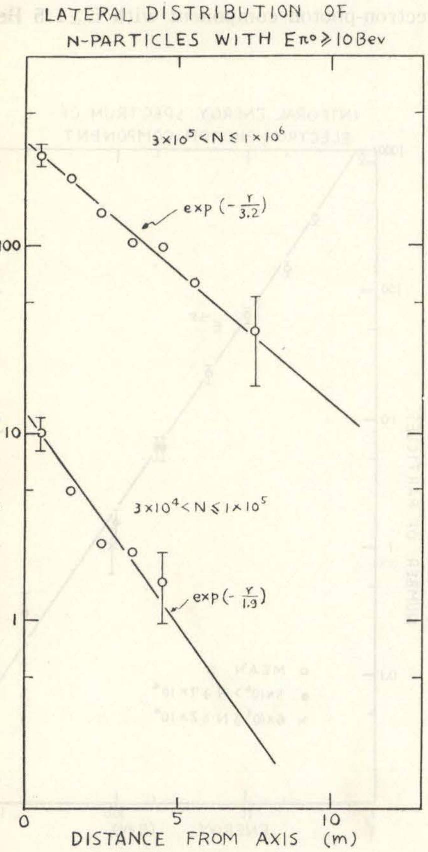

Fig. 4. Lateral distribution of N-particles with $E\pi^0 \geq 10$ Bev.

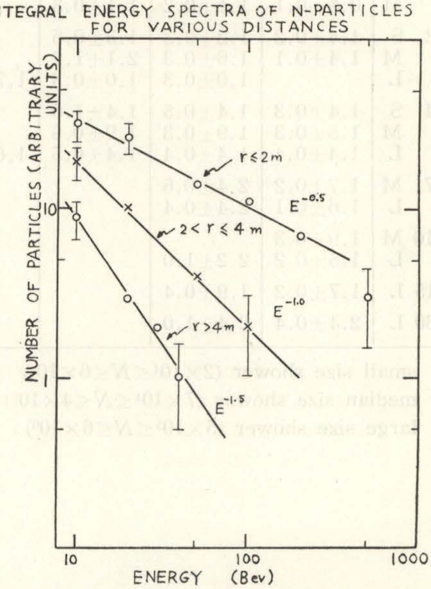

Fig. 5. Integral energy spectra of N-particles for various distances.

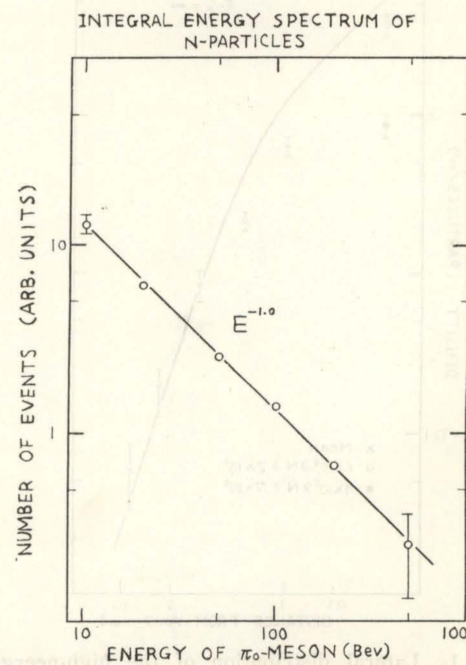

Fig. 6. Integral energy spectrum of N-particles.

pendent on the distance from the axis of EAS, as shown in Fig. 5, and its value changes from 0.5 to 1.5. Based on the lateral distribution and energy spectra in three bands of distance, the energy spectrum of total high energy nuclear active particles in a shower can be obtained, and the result is shown in Fig. 6. The spectrum obeys the power law of the form $E^{-(1.0\pm0.15)}$ in the energy between 10–500 Bev. Fig. 7 gives the relation between the total number of the high energy nuclear active particles and the size of EAS, and the relation is expressed by

$$N_N=(13\pm4)\times\left(\frac{N}{10^5}\right).$$

The charge to neutral ratio of such particles is measured to be 5:1, that is, about 70% of them seem to be π-mesons. An energy spectrum of the nuclear active components which produce π^0-mesons of total energy between 1 and 10 Bev is obtained in a similar way. The integral energy spectrum of them is found to be represented by $E^{-(0.4\pm0.15)}$ in the above mentioned energy range.

§ 3. Atmospheric cascade showers

Narrow bundles of electrons and photons with total energy exceeding 100 Bev are examined to check the π^0-meson production in § 2, taking into consideration that such bundles are produced in the atmosphere near the cloud chamber by γ-rays decaying from π^0-mesons.

The lateral distribution of them is neither expressed by the power law nor the exponential law. The bundles concentrate within about 1 m and 2 m from the axis for EAS of total number of 10^4–10^5, and 10^5–10^6, respectively. The region of the concentration increases slowly with the increasing shower size. The energy spectrum of them in a shower shows a power law of the form $E^{-(1.0\pm0.2)}$ in the energy range of 100–1000 Bev, as shown in Fig. 8, and there is no remark-

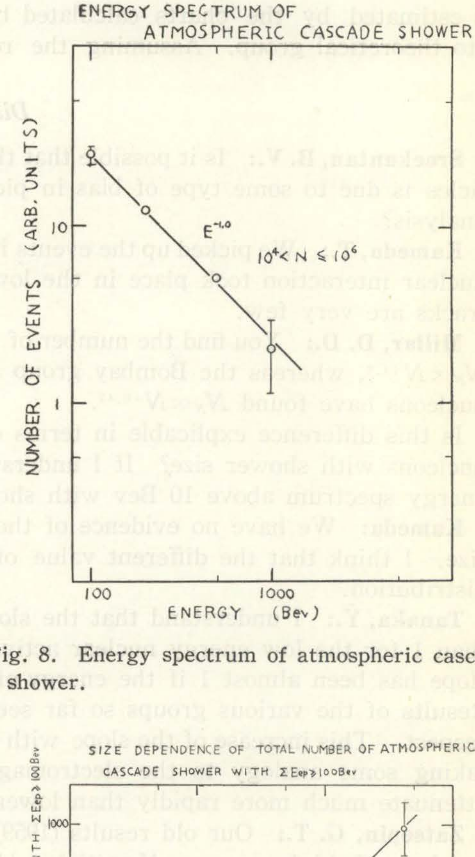

Fig. 8. Energy spectrum of atmospheric cascade shower.

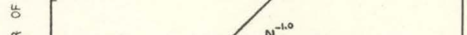

Fig. 7. Size dependence of total number of N-particles with $E\pi^0 \geq 10$ Bev.

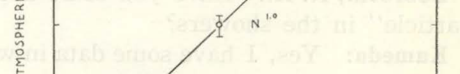

Fig. 9. Dependence of total number of atmospheric cascade shower with ΣEep$\geq$100 Bev.

able change of the exponent between EAS with total number of 10^4-10^5, and of 10^5-10^6. The dependence of the total number of such atmospheric cascade showers in an EAS on the size of EAS is given in Fig. 9, and their relation is expressed by

$$N_A=(2.5\pm 0.5)\times\left(\frac{N}{10^5}\right).$$

The height of production of such events is obtained by the assumption of $\pi^0-2\gamma$ decay in some favorable cases, and in other cases it is estimated by the charts calculated by Kyoto theoretical group. Assuming the results mentioned in § 2 and taking into account the production height of π^0-mesons, the total number and the energy spectrum of the atmospheric cascade showers can be found, though they are in some degree dependent on the model of meson production and the nuclear collision mean free path. The results obtained by assuming the usually accepted model and the mean free path confirm the above mentioned value of N_A and the energy spectrum of the atmospheric cascade showers, and this indicates the adequacy of the results in § 2.

Discussion

Sreekantan, B. V.: Is it possible that the charge to neutral ratio of nuclear active particles is due to some type of bias in picking up clear cloud chamber events for this analysis?

Kameda, T.: We picked up the events in which no bias enters, that is, events in which nuclear interaction took place in the lower part of the cloud chamber where other tracks are very few.

Millar, D. D.: You find the number of nucleons to be proportional to the shower size, $N_N\propto N^{+1.0}$, whereas the Bombay group and the Sydney group detecting lower energy nucleons have found $N_N\propto N^{+0.45}$.

Is this difference explicable in terms of a change in the energy spectrum of the nucleons with shower size? If I understood correctly you observed no change of the energy spectrum above 10 Bev with shower size?

Kameda: We have no evidence of the change of the energy spectrum with shower size. I think that the different value of exponent is due to the difference of lateral distribution.

Tanaka, Y.: I understand that the slope of the relation N_N-N_e has been always less than 1 for the low energy nuclear active particles of the order of 1 Gev, while that slope has been almost 1 if the energy of nuclear active particle is as high as 100 Gev. Results of the various groups so far seem to be in agreement with each other in this respect. This increase of the slope with increasing energy can be partly explained by taking some analogy to the electromagnetic cascade, where higher energy electrons attenuate much more rapidly than lower energy ones.

Zatsepin, G. T.: Our old results (1959) for showers $N=10^4\sim 3\ 10^5$ showed that the number of high energy N-particles ($E>10^{12}$ ev) increases with N_e very fast, *i.e.* $N_N(>10^{12}\text{ ev})\propto N_e^{1.3\pm 0.1}$. That is in good agreement with what Dr. Tanaka has told; the exponent rises with energy of nuclear active particles.

Dobrotin, N. A.: Have you some data about the existence of the so-called "leading particle" in the showers?

Kameda: Yes, I have some data in which a single unusually high energy N-particle or electronic component exists.