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III-2-4. Arrival Directions of the Multiple Penetrating Particles

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In our previous paper, we have observed below ground a group of penetrating particles in which four or more parallel particles pass through a cloud chamber simultaneously. How Multiple Penetrating Particles (MPP) correlated with Extensive Air Showers (EAS) was studied by the use of large cloud chambers, G-M counters and scintillation counters. It was concluded in another paper[1] that observing MPP corresponds to observing μ-meson component with the density of ≥ 7 /m^2 contained in EAS. Also, plotting the total number of μ-mesons of MPP events on the n_μ-N_e diagram, their points exist near the upper edge line shown by $n_\mu \propto N_e^{0.65}$. This situation suggests that some MPP events would be originated from any heavy primaries[2].

The present observations have been performed at Yaizu (35°N geog. lati.) from December 1959 to March 1961 and during the observing time of about 3000 hrs 51 events of MPP have been obtained. (This is the number of MPP obtained without any accident in the air shower detectors).

The arrival directions of EAS were supposed to be the same as those of MPP and the latters were obtained from the directions of MPP tracks obtained in the cloud chambers. Only 41 events were chosen from the condition that their points on the n_μ-N_e diagram should be situated near the edge line corresponding to their incident zenith angles (see Fig. 1). The directions of the chosen MPP events are shown on "celestial coordinate" in Fig. 2. The dotted line shows the vertical sky over Yaizu and the solid line the galactic equator (or galactic plane).

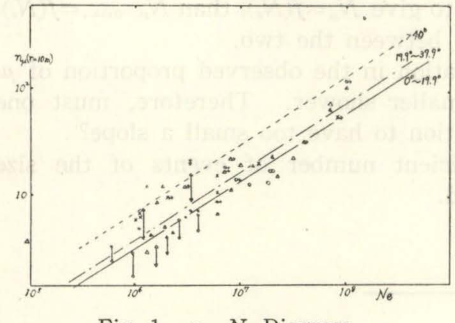

Fig. 1. n_μ-N_e Diagram.

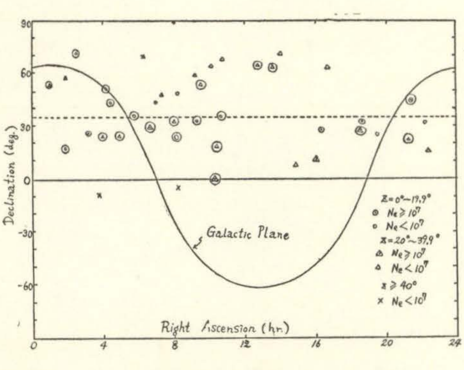

Fig. 2. Arrival Directions of MPP

There seem to be some concentrations of points on the morning side of sidereal time. Furthermore, we shall choose only MPP events of higher density of μ-meson component in EAS and also plot the arrival directions of the selected 21 events on the celestial coordinate. The selecting condition is that their points on the n_μ-N_e diagram should be over each upper edge line corresponding to their incident zenith angles (see points covered by open circle in Fig. 2). From the celestial map it is found that 16 out of 21 MPP arrived from the hemisphere of morning side. The situation seems to show more concentration of points on the morning side of sidereal time.

Such a tendency is in agreement with the arrival directions of μ-meson-riched-AS having around 10^7 of electronic component observed by Tokyo Air Shower Group[3]. If this tendency is taken for granted, the anisotropy would be attributed to the particles moving perpendicular to the Galactic arm as presented by Oda[4]. Fukui *et al.*[5] have shown that this situation would be interpreted with younger heavy primaries produced somewhere within the Galactic arm containing the sun because heavy particles could be accelerated still to such energy as 10^{17} eV at a source. MIT group[6], however, suggests that the arrival directions of EAS having very large electron component, say $\geq 10^9$, which are not selected as μ-meson-riched specially, would show the similar tendency as ours. If the arrival directions of EAS of size 10^9 would be the same as those of EAS of size 10^7, it may be concluded that their primaries should have the same order of their magnetic rigidities, in order to be explained with the idea proposed in ref. 5). In addition, it seems to us that the results obtained by Cornell group[7] suggest to be isotropy of arrival directions of EAS with around 10^8 of electron component.

It is the future subject to investigate whether anisotropy of arrival directions exists or not.

References

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2) Fukui, Hasegawa, Matano, Miura, Oda, Suga, Tanahashi and Tanaka: Suppl. Prog. Theor. Phys. No. 16 (1960) 1.
3) Hasegawa, Matano, Miura, Oda, Shibata, Tanahashi and Tanaka: III-2-3 of the present proceedings.
4) Oda: Private Communication.
5) Fukui, Hayakawa, Nishimura, Obayashi: III-3-5 of the present proceedings.
6) Linsley, Scarsi, and Rossi: III-2-5 of the present proceedings.
7) Delvaille, Kendziorski, and Greisen: III-2-1 of the present proceedings.

Discussion

Linsley, J.: What composition of the primaries was assumed?

Oda, M.: I assumed equal number of nuclei for p, He, M, and Fe group.

Suga, K.: How much is the proportion of the content of μ-mesons of gamma ray showers, compared with that of ordinary showers?

Oda: About 1/30.

Zatsepin, G. T.: Fluctuation comes not only from difference in the point of first collision, but also from secondary collisions, (their fluctuation of height-distribution and of elementary interactions). So it is better to give $\bar{N}_\mu = f(N_e)$, than $N_{\mu.\ \max.} = f(N_e)$.

Oda: Perhaps neither the average. Probably between the two.

Greisen: Is it not true that the pure fluctuation in the observed proportion of μ-mesons must be expected to be larger in the smaller shower. Therefore, must one not expect the upper edge of the n_μ-N_e distribution to have too small a slope?

Oda: Yes, that's right. Still, we have sufficient number of events of the size which is essentially free of the effect mentioned.