# Character of Energy Flow in Air Shower Core

K.Mizushima
Kobe Women's Junior College, Chuo-Ku,
Kobe 650, Japan
K.Asakimori and T.Maeda
Department of Physics, Kobe University
Nada-Ku Kobe 657, Japan
T.Kameda
Kobe Women's University, Suma-Ku, Kobe 654, Japan
Y.Misaki
Research Center for Nuclear Physics,
Osaka University, Ibaraki, Osaka 567, Japan

ABSTRACT

Energy per charged particle near the core of air showers was measured by 9 energy flow detectors,which were the combination of Cerenkov counters and scintillators. Energy per particle of each detector was normalized to energy at 2m from the core. We obtained the following results as to the energy flow ;

i) integral frequency distribution of mean energy per particle (averaged over 9 detectors) is composed of two groups separated distinctly,

ii) Showers contained in one group show an anisotropy of arrival direction.

1 Introduction As it is clear that energy flow is an importamt parameter of air showers, we have pursued it from various points of view. Some results were reported elsewhere (1) (2). One of the most interesting results was the possible existence of an anisotropy of arrival direction seen among the showers having large relative deviation. However, number of the showers selected was small in the previous report,and so there lies a fear that the anisotropy is a pretense due to small samples. Also the criterion of large relative deviation was not clear enough. To confirm these points the experiment has been carried out, and the data analized augmented in number by twice and a half time compared to ones reported previously.

2 Experiment and Results Arrangement of nine energy flow detectors in the air shower array of Kobe University and the characteristics of them were reported in (1) and (2).

The measurement was carried out during the period from October 1981 to November,1983. 2606 showers whose axes hit within 3m from the center of the assembly of energy flow detectors less than 30° of zenith angle, were selected. We denote the energy flow in i-th Cerenkov counter by Eobi, where i=1,2,------,9, and put Ei= Eobi/Ni, where Ni is the number of charged particle measured by the scintillator just above the Cerenkov counter. Next, to obtain mean energy per charged particle at 2m from the axis, Ei is normalized at 2m using the average lateral distribution of energy flow which is approximately independent on shower size and on age for showers of size range $10^5 \sim 10^6$. Because of strict condition of selection ( $\theta \leq 30°$, $r \leq 3$m) and characteristics of lateral distribution of Ei, errors induced in normalization are small. Each Ei normalized is ordered from maximum to minimum ,and is expressed by E2i (i=1,------9), where i=1 corresponds to maximum, and i=9 to minimum.

Using these E2i, we put $ME9=\sum^{9} E2i/9$ and $ME4=\sum^{9}_{6} E2i/4$.

Fig.1 shows the relation between ME9 and size of showers. Showers of large value of ME9 are found in region of smaller size ( $\leq 3 \times 10^5$ ). Fig.2 shows the integral spectra of ME9, corresponding to showers of different size region, $10^5 \leq N < 1.5 \times 10^5$, $1.5 \times 10^5 \leq N < 3 \times 10^5$, and $3 \times 10^5 \leq N$, and we denote these spectra as SP1,SP2,and SP3 respectly.

If we approximate these spectra by power function, SP1 and SP2 have at least two different powers, suggesting that showers in the small size region have at least two different kinds of shower groups. Considering the bending point in SP1 and SP2 as critical energy, we divide showers into two groups and denote showers above the critical energy as H-group. Straight line in Fig.1 is the boundary of two groups. In Fig.3 are plotted arrival directions of showers H-group. They seem to show an anisotropy in the region of galactic north pole. Fig.4 shows the integral spectrua in two regions of Right Ascension,12h $\sim$ 16h and the remainder. From these two spectra the anisotropy occurs at ME9 $\gtrsim$ 0.9 Gev and this value corresponds to the bending of SP1 and SP2 in Fig.2.

Fig.5 and Fig.6 show the relation between ME4 and size of showers and that between ME4 and age parameter. As ME4 is interpreted to be energy flow of background particles, it is supposed to reflect the longitudinal development of air showers. The figures prove such interpretation to be right.

Fig.7 shows the relation between ME4 and $E2_1$-ME4 (denote MAXE) in showers of different age regions. Detailed analysis of ME4 and MAXE is now being carried out.

3 Discussion The criterion imposed vaguely on the boundary of large relative deviation previously is now clarified, and the boundary indicates the crossing point of two different groups. And in the group above the boundary ( H-group) is seem an anisotropy to be exist. In spite of augmented data by factor 2.5, an anisotropy remaines still in the region near the galactic north pole.

If the anisotropy found here is confirmed by further accumulation of data, and if H-group has any difference of characteristics from the remainder, it is safely said that H-group reflects some composition of the primary cosmic rays. It seems to be also interesting to study the relevance of the anisotropy mentioned here to that found in $\mu$-rich showers and N-rich ones.

Considering these items, we intend to investigate the characteristics of indivisual shower in H-group in detail.

References

(1) Asakimori, K. et al.: 17th ICRC at Pris, 6(1981) 187.
(2) Asakimori, K. et al.: 18th ICRC at Bangalore, EA 1.1-27

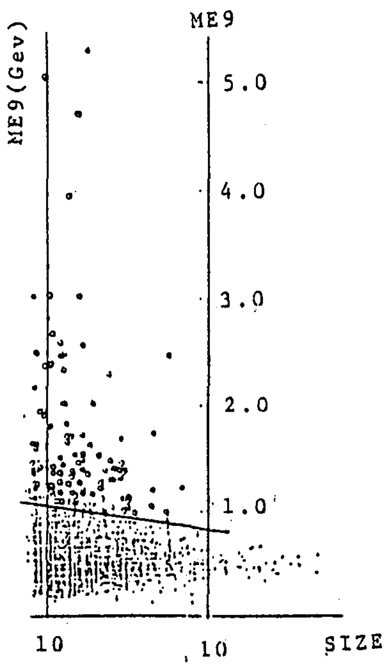


Fig. 1

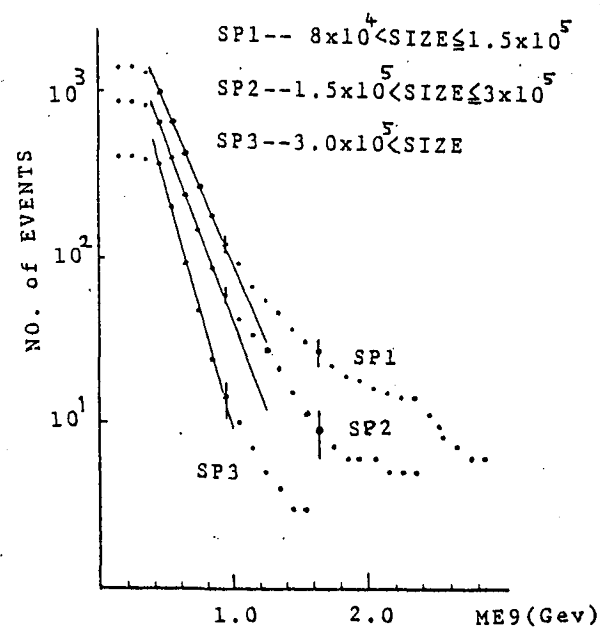


Fig. 2

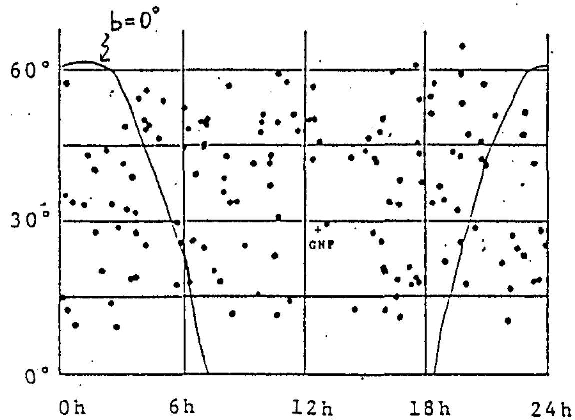


Fig.3

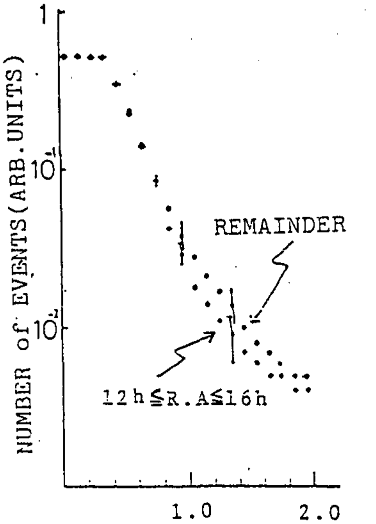


Fig.4

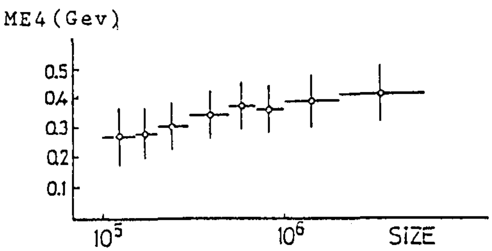


Fig.5

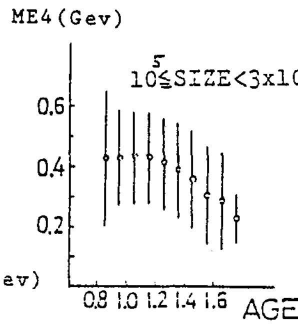


Fig.6

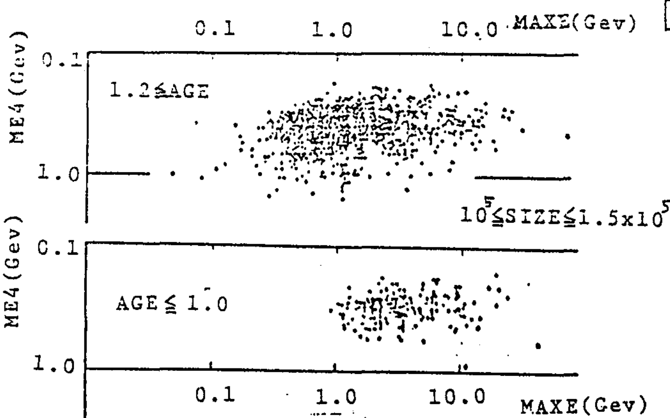


Fig.7