Observation on Air Showers In the Size Regions 10^5 to 10^7 at Beijing

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Abstract

Huai Rou EAS array began to operate on March, 1988. Up to May, 1989, More than 30,000 events have been recorded. Total effective observation time is $1.3x10^7$ s. About 20,000 events can be used to analyze. In this paper, the preliminary results about the EAS frequency attenuation length for different size regions and integral size spectrum for different zenith angle regions are reported, the vertical integral size spectrum can he expressed as:

$$J(N) = (1.10 \pm 0.08) * 10^{-6} (N / 10^5)^{(-1.54 \pm 0.02)}.$$

The relative physics is also discussed.

1.Introduction

The characteristics of air showers in the size regions from 10^5 to 10^7 have been researched by several groups at sea level and mountain height. Still Some questions are in dispute. In these size regions, the shape of EAS size spectrum and changing tendency of frequency attenuation length involve important information on the primary spectrum of cosmic rays ,the mass compositions of primary particles and characteristics of nuclear interaction in ultra-high energy region. For getting consistent conclusion, more measurements are needed.

2.Experiment

The arrangement of this array and characteristics of detectors have been described in the paper (Y.H. Tan et al, HE 7.3-7). In the experiment, we choose two triggering conditions A anal B. The triggering criteria and triggering rate are shown in Table 1.

Table 1.

	triggering criteria	triggering rate	size range
A	#13 (Δ>5 ptls.) #1, #5, #21, #25. (all Δ > 0.5 plts.)	~ 5/hr.	> 1.58*10^5
B	#13 (Δ>1 plts.) #1, #5, #21, #25 (all Δ > 0.5 plts.)	~100/hr.	≤ 1.58*10^5

Note: # numbcr:dector

The effective acceptance area in which detecting showers efficiency is 100% is determined from $N\text{-}R^2$ distribution.

(N: events number in different ÄR^2 bins, R: distance from central detector #13), assuming that total number of event fall into the area is proportional to the area if the trigger is without bias.(S. Miyako, et a1,1979)
For individual EAS event, coordinates of core position, the total number of charged particles and age parameter are determined by fitting density data to NKG lateral distribution function with a variable age by a least square method. In our case, an average lateral distribution is well fitted to NKG function from core distance 2m to 80m (Y.H. Tan, et al HE 7.3-7). The 9 fast-timing data are fitted to a plane perpendicular to shower axis using a least square method to determine the arrival direction of EAS.

3. Results

(1)Size spectrum
The integral size spectrum for different zenith angle regions is given in fig. 1 From this figure, it is found that all of them can be well expressed as F (N) æ$N^{-ã}$ form with single slope, and size spectrum exponents increase with tile increasing of zenith angle. Table 2 gives the different size spectrum exponents in different zenith angle regions.

Table 2.

secθ	1.-1.05	1.05-1.1	1.1-1.15	1.15-1.2	1.2-1.3
γ	1.50±0.02	1.55±0.03	1.50±0.02	1.58±0.02	1.55±0.02
secθ	1.3-1.4	1.4-1.5			
γ	1.74±0.07	1.96±0.08			

Fig. 2 shown. the vertical integral size spectrum. It is expressed as follows:

$$J (N) = (1.10 \pm 0.08) * 10^{-6} (N / 10^5)^{(-1.54 \pm 0.02)} / m^2 \ sec \cdot ster.$$

between 10^5 and several times 10^7.
We use single power law to fit this spectrum, however, if we investigate this spectrum carefully, we can find we may use two spectrum exponents to fit this spectrum, but the difference of two exponents is small.
At sea level, the vertical integral flux for size above 10^6 is (3.3 ± 0.2)*10^{-8} / m^2sec. ster. This result is not contradictory with other results, as compared in Table 3.

Table 3

Groups	Moscow('73)	Durham('79)	Kobe('79)	our work('89)
Flux(N 10^6)	3.5*10^-8	3.5*10^-8	3.*10^-8	(3.3±0.2)*10^-8

(2) Frequency attenuation length of EAS
Using the expression I(θ) = I(0) cos^n(θ) to fit the measured zenith angle distribution of EAS, in different size bins, the values of n without angle correction are shown in Table. 4

Table 4.

Log size	5.-5.2	5.2-5.4	5.4-5.6	5.6-5.8	5.8-6.0
n	8.7±0.6	9.1±0.7	10.9±0.5	11.4±1.1	11.7±0.9
Log size	6.0-6.2	6.2-6.4	6.4-6.6	6.6-6.8	
n	10.7±0.4	11.2±0.6	11.3±0.5	10.4±0.5	

Fig. 3 is another expression of zenith angle distribution of EAS related to EAS longitude development in the atmosphere. From the slope of every line, we may calculate the frequency attenuation length in size bins. The values corrected by angle resolution of array are shown and compared with other results in Fig. 4. Bars only represent the fluctuation of statistic. As size N increases, Ë decreases when N below 10^6 and increases beyond 10^6. The tendency and absolute value are consistent with Durharm (F. Ashton et al, 1979) and Adelaide (Clay R.W. and Gerhardv.1981) groups data within measuring errors, a little lower than Akeno data(M. Nagano, et a1,1984).

4.Discussion

So far, size spectra have been obtained by various groups in the world, still some discrepancies exist among those results .Whether there is a 'knee' in the size spectra is an interesting question. From our result, we haven't found obvious so-called 'knee' sign.

With zenith angle increasing, the size spectra exponents increase, this phenomenon indicates that attenuation of EAS flux becomes serious with the increasing at atmospheric depths.

From the result of frequency attenuation length of EAS. it is found that the frequency attenuation length decreases from N 10^5 to 10^6. but beyond 10^6 ,it has a little rising. Owing to without 'knee' in size spectra, whether here has a hint on a Chang of COSMIC ray composition and/or interaction mechanism In relevant energy range, more data with large statistic and Monte Carlo simulation are needed.

5. Acknowledgements

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6.Reference:

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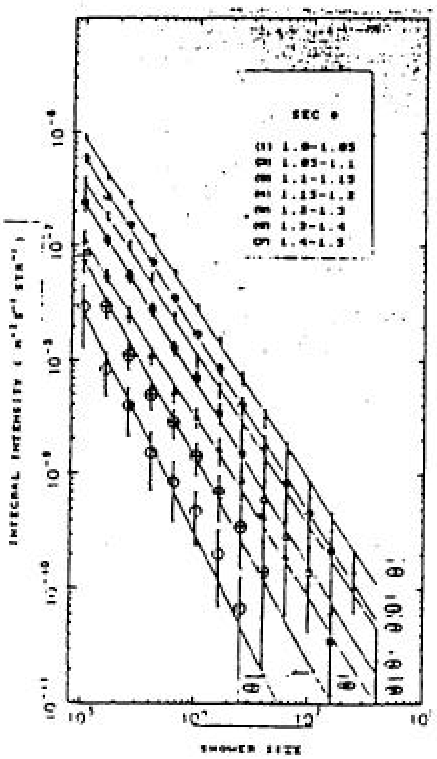

Fig. 1

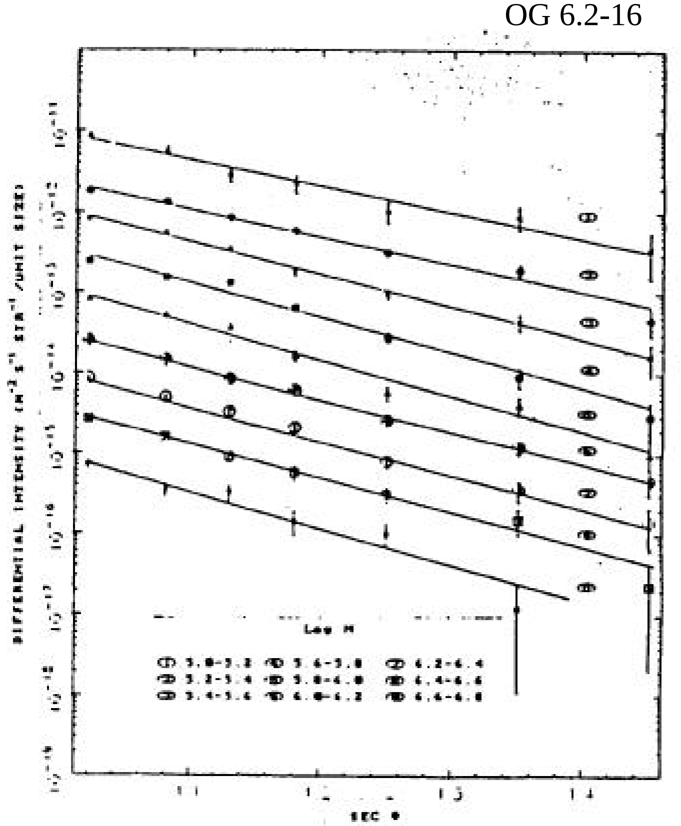

Fig. 3 EAS frequency vary with zenith Angles for different size regions

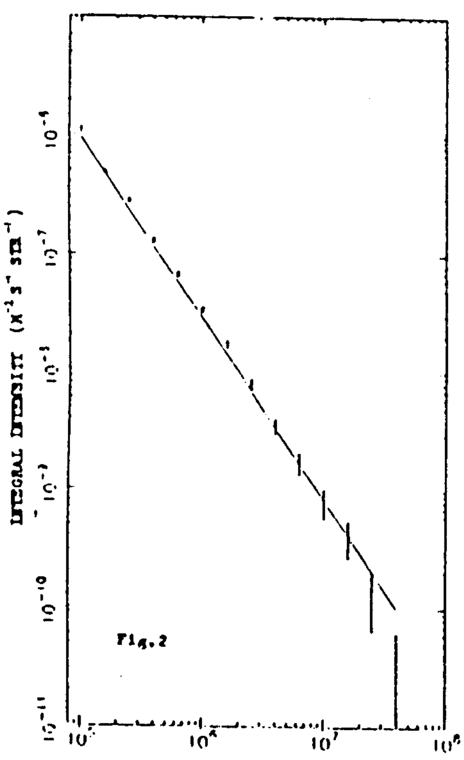

Fig. 1 Integral Size spectrum for different zenith angle regions

Fig. 2 Vertical integral wire Spectrum

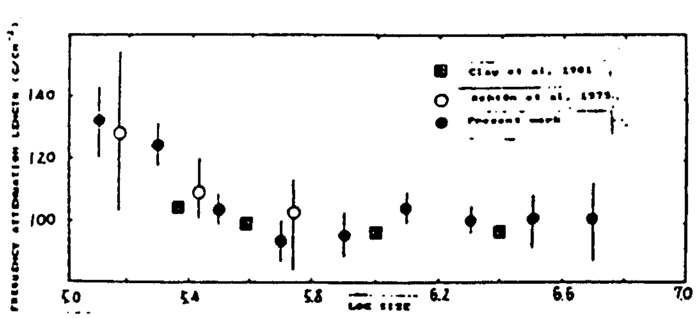

Fig.4 Size dependence of Frequency attenuation length