View metadata, citation and similar papers at core.ac.uk
brought to you by CORE
provided by NASA Technical Reports Server

A CRITICAL ANALYSIS OF AIR SHOWER STRUCTURE FUNCTIONS AND SIZE SPECTRUM MEASUREMENTS WITH THE NBU AIR SHOWER ARRAY

N.Chaudhuri and D.K.Basak
Department of Physics
North Bengal University
Darjeeling-734430,India

A total of 11,000 showers in the size range 10^4 to 10^6 particles so far detected by the NBU air shower array has been analysed using five different structure functions. A comparison of structure functions in terms (i) of shower size (ii) electron density at various core distances has been discussed to indicate the present status of structure functions in air shower analysis.

1.Introduction   A small air shower array of 21 detectors has been set up at North Bengal University to cover shower size measurement in the range 10^4 to 10^6 particles. The shower sizes determined by taking any one of the different structure functions[1-5] for each set of observed showers show dispersion of individual shower sizes. It has been found that the lateral density distribution of electrons cannot be represented by a standard NKG function at all core distances with the single age parameter.

2.Methods   The air shower array at NBU comprising 21 scintillation counters covers an area of 900 m^2. The detectors are of two different sizes. One is of 25cm x 50cm and the other is 50cm x 50cm. The layout of the array (Basak et al[6]) is based on the arrangement of detectors in a square symmetry. Each scintillator is of 5cm thickness mounted firmly on the box made of aluminium sheet. The small area detectors are placed near the centre of the array.

The analog pulses from all the 21 detectors are amplified first by preamplifiers each of gain ≈ 30 and are then sent to the main laboratory where they are again amplified by main amplifiers of appropriate gain. These pulses are then digitised with the help of analog-to-digital converter and the observed density information are printed on a paper tape.

3.Results

3.1.The structure functions in terms of shower size

The observed density is corrected by considering the effect of transition in the scintillator material and aluminium box using the formula of Asakimori et al[7] as given below

$$\Delta_c = \Delta_o/(1.192 - 0.136 \log r)$$

where Δ_c is the corrected density and Δ_o is the observed density and r is the core distance in metre.

The structure functions in terms of shower sizes computed by taking NKG function and any one of the other structure functions for each observed shower are shown in Figs. 1 to 4. It is found that Fig. 1 shows the dispersion of individual shower sizes about the expected undeviated shower size line. However Fig.4 shows a significant deviation between the expected and deviated line fitting the dispersion of the computed shower sizes using NKG and Hillas function. The important characteristics of air showers is the size spectrum which has been determined from the density distribution. The differential size spectrum can be represented by a power-law of the type

$$F(N_e) = (0.42 \pm 0.02) \times 10^{-8}(N_e/10^4)^{-2.51 \pm 0.01}$$
$$m^{-2}sec^{-1}sr^{-1}particle^{-1}.$$

It is important in the sense that if the size-primary energy relation is known, then the primary particle energy spectrum can be derived from the size spectrum.

3.2.The structure functions in terms of electron density distribution

The structure functions in terms of published electron density distribution functions[1-5] have been compared with the observed density distribution for different shower size and age values as shown in Figs. 5 and 6. We find that the observed electron density distribution follows the Hillas distribution more accurately than other density distribution functions.

4.Discussion The structure functions in terms of size indicate that the change of shower age from 1.2 to 1.1 (Figs. 1 to 4) causes a shift of core coordinates and a consequent decrease of shower size from Hillas function by about 35%. The use of distribution function by Lagutin et al[4] yields shower sizes somewhat smaller than those computed by NKG function, whereas in the electron density distribution, the Hillas function gives better distribution with observed density distribution. The differential size spectrum determined using the Hillas function gives an exponent of 2.51 for showers of size range 10^4 to 10^6 electrons.

5. Conclusions It can be concluded that the data on electron lateral distribution are in agreement with Hillas distribution function and the size spectrum obtained from Hillas function with average age of 1.2 compares well with the spectrum by KGF group[8] as

$$F(N_e) = (1.37 \pm 0.07) \times 10^{-8}(N_e/10^4)^{-2.42 \pm 0.02} m^{-2} sec^{-1} sr^{-1} particle^{-1}$$

6. Acknowledgements The authors are grateful to the Department of Atomic Energy, Govt. of India for the financial assistance for carrying out research work at North Bengal University.

References

1. Greisen, K., (1960), Ann.Rev.Nucl.Sci., 10, 63. Nishimura, J. & Kamata, K., (1950), (1951), (1952), Prog.Theor.Phys. 5, 899, 6, 628, 7, 185.
2. Hillas, A.M. and Lapikens, J., (1977), Proc. 15th ICRC, Plovdiv, 8, 460.
3. Dedenko, L.G. et al, (1975), Proc. 14th ICRC, Munich 8, 2731.
4. Lagutin, A.A. et al, (1979), Proc. 16th ICRC, Kyoto, 7, 18.
5. Capdevielle, J.N. et al, (1983), Proc. 18th ICRC, Bangalore, 11, 307.
6. Basak, D.K. et al, (1984), Nucl.Intr.Meths., 227, 167.
7. Asakimori, K. et al, (1981), Proc. 17th ICRC, Paris, 11, 301.
8. Rao, S. (1981), Ph.D. thesis, TIFR, University of Bombay, India.

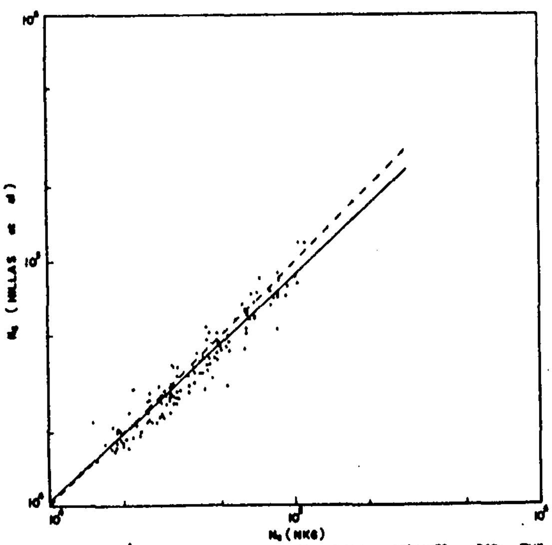

FIG. 1. THE DISPERSION OF SIZES OBTAINED FOR THE SAME SET OF SHOWERS USING THE FUNCTIONS OF HILLAS et al[2] AND NKG FOR s = 1.3.

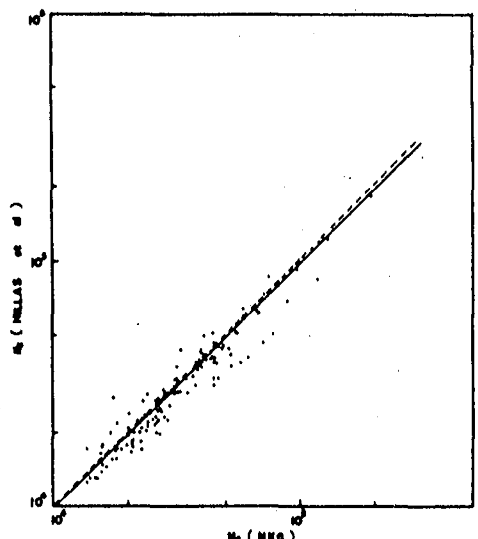

FIG. 2 THE DISPERSION OF SIZES OBTAINED FOR THE SAME SET OF SHOWERS USING THE FUNCTIONS OF HILLAS et al[2] AND NKG FOR s = 1.2.

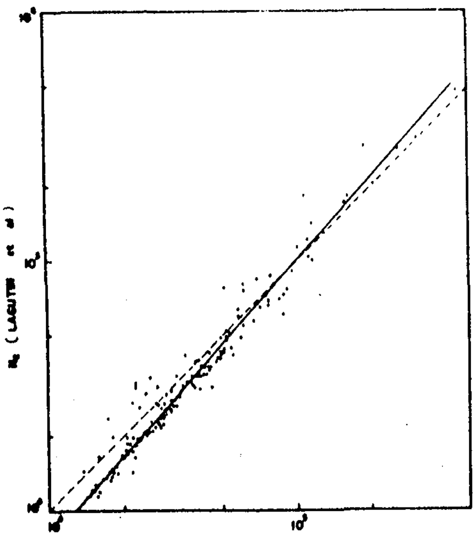

FIG. 3 . THE DISPERSION OF SIZES OBTAINED FOR THE SAME SET OF SHOWERS USING THE FUNCTIONS OF LAGUTIN et al[4] AND NKG FOR $s = 1.2$.

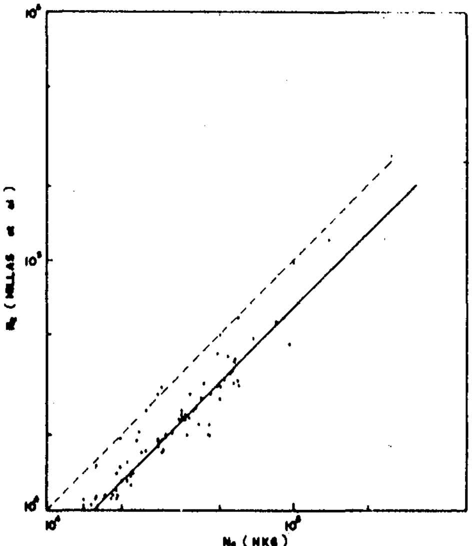

FIG. 4 . THE DISPERSION OF SIZES OBTAINED FOR THE SAME SET OF SHOWERS USING THE FUNCTIONS OF HILLAS et al[2] AND NKG FOR $s = 1.1$.

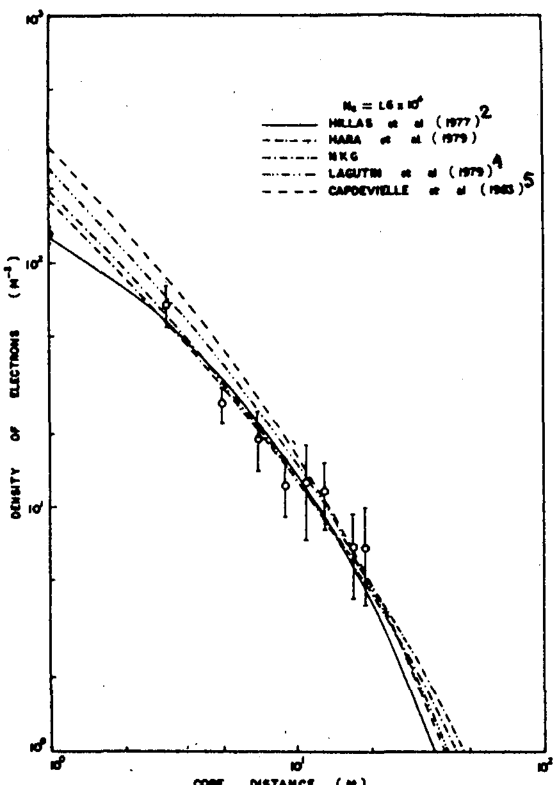

FIG. 5. COMPARISON OF OBSERVED LATERAL DISTRIBUTION OF ELECTRONS WITH THE THEORETICAL DISTRIBUTIONS ACCORDING TO VARIOUS STRUCTURE FUNCTIONS FOR $N_e = 1.6 \times 10^4$ & $s = 1.0$.

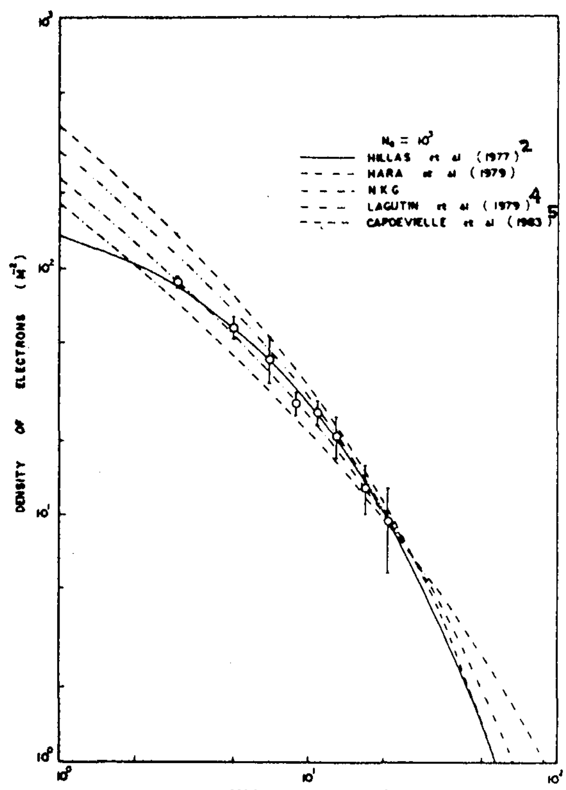

FIG. 6. COMPARISON OF OBSERVED LATERAL DISTRIBUTION OF ELECTRONS WITH THE THEORETICAL DISTRIBUTIONS ACCORDING TO VARIOUS STRUCTURE FUNCTIONS FOR $N_e = 10^5$ AND $s = 1.2$