A NEW STUDY OF SHOWER AGE DISTRIBUTION IN NEAR VERTICAL SHOWERS BY NBU AIR SHOWER ARRAY

N. Chaudhuri, D.K. Basak, G.C. Goswami and B. Ghosh
Department of Physics
North Bengal University
Darjeeling - 734430, India

The air shower array has been developed since it started operation in 1931. The array covering an area of 900 m² now incorporates 21 particle density sampling detectors around two muon magnetic spectrographs. The air showers are detected in the size range 10⁴ to 10⁶ particles. A total of 11000 showers has so far been detected. Average values of shower age have been obtained in various shower size ranges to study the dependence of shower age on shower size. The core distance dependence of shower age parameter has also been analysed for presentation in the conference.

1. Introduction

The age parameter which was calculated by fitting a particular shower with a given structure function is not constant over all core distances and shower sizes. Moreover the lateral distribution function does not fit well over all distances with the single age parameter. The age determination has been done using NKG as a reference function and also the forms of Hillas et al ¹, and Lagutin et al ². In all the cases of shower analysis it has been found that the age lies between 0.3 to 1.7 for various shower sizes in the range 10⁴ to 10⁶ particles. In the present study the shower size 'N_e' and shower age 's' (average and local shower age) have been determined through standard X² - method using NKG and various structure functions.

2. Methods

In an array of 21 detectors covering an area of 900 m², the density of the particles is estimated from the printed recording of the shower particles in each detector.

The shower age which is estimated by fitting the shower densities (r) with the help of the X²-minimisation method is shown in the figures for showers falling within zenith angle 0° - 30°. The fitting of NKG function for extensive air shower lateral electron distribution for a single age parameter gives some systematic errors. Hence the term 'local age parameter' (l.a.p.) S(r) is defined by Capdevielle et al ³ as

\[ S(r) = \frac{1}{2X+1} \left( X+1 \right) \frac{DLnX}{DLn(r)} + (2 + \beta_0) X + 2 \]
which gives the best fit in the neighbourhood of r for a given structure function f. Where $\beta_0 = 4.5$ if f is NKG function and $X = r/r_0$, $r_0 = $ Moliere radius.

The value of $S(r)$ is numerically estimated in a small band of distance $\left< r_i, r_j \right>$

$$S_{ij} = \frac{\ln \left< F_{ij} \right>}{\ln \left< X_{ij} \right> 4.5}$$

where $F_{ij} = f(r_i)/f(r_j)$,

$$X_{ij} = r_i/r_j \text{ and } Y_{ij} = (X_i + 1)/(X_j + 1)$$

and $S_{ij} \rightarrow S(r) \text{ if } r_i \rightarrow r_j$

with $r = (r_i + r_j)/2$.

3. Results

3.1. Age distribution  The age is calculated over a particular shower size range and a typical age 's' distribution is shown in Fig.1. We find that for showers falling within zenith angle 30° having sizes in the range $10^4$ - $2 \times 10^4$ particles the individual shower age lies between 0.3 and 1.25.

3.2. Variation of l.a.p. with core distance  The l.a.p. distribution is shown in Figs. 2.1 and 2.2 in the core distance range 1-20m. For showers in the size range $4.0 < \log N_e < 4.5$, the l.a.p. increases with the increase of core distance, whereas for showers in the size range $4.6 < \log N_e < 5.3$, the l.a.p. decreases very slowly from 2.5m to 10m and then increases from 10m to 20m.

3.3. Variation of l.a.p. with the shower size  The l.a.p. distribution is shown in Fig.3 for core distances in the range from 3-10m and from 10-20m. It has been found that the l.a.p. decreases as the shower size increases from $10^4$ to $10^5$ particles for both the distance ranges.

3.4. Variation of average age parameter distribution with shower size  The average age for a shower group was determined and plotted as a function of shower size as shown in Fig.4 along with the similar data of Kristiansen et al\textsuperscript{4}, Asakimori et al\textsuperscript{5}, Abdullah et al\textsuperscript{6} and Gerhardy et al\textsuperscript{7}. The average age is nearly constant over a shower size range $10^4$ - $10^6$ particles.
4. Discussion  Each shower was fitted to the Hillas function to obtain the core coordinates and shower age. The average age for a shower group is consistent with other experiments. The present data on the l.a.p. shown in Figs. 2.1 and 2.2 show the constancy of l.a.p. in the core distance range 2-20m. The dependence of l.a.p. on shower size in two core distance regions shown in Fig. 3 shows near constancy of l.a.p. in the size range $10^4 - 10^5$ particles.

5. Conclusions  It can be concluded from the plotted data that the determination of average age and l.a.p. from the present experiment is consistent with the measurements of other workers mentioned above.

6. Acknowledgements  The Department of Atomic Energy, Govt. of India is thanked for the financial assistance for the DAN Project at North Bengal University.

References
