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

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The air shower array has been developed since it started operation in 1981. The array covering an area of 900 m^2 now incorporates 21 particle density sampling detectors around two muon magnetic spectrographs. The air showers are detected in the size range 10^4 to 10^6 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 0.8 to 1.7 for various shower sizes in the range 10^4 to 10^6 particles. In the present study the shower size 'N_e' and shower age 's' (average and local shower age) have been determined through standard χ^2 - method using NKG and various structure functions.

2. Methods In an array of 21 detectors covering an area of 900 m^2, 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 χ^2-minimisation method is shown in the figures for showers falling within zenith angle 0^o - 30^o. 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

$$S(r) = \frac{1}{2X+1}\left[(X+1)\frac{\partial \ln f}{\partial \ln X} + (2+\beta_0)X + 2\right]$$

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 $X = r/r_o$, r_o = Moliere radius.

The value of S(r) is numerically estimated in a small band of distance $[r_i, r_j]$

$$S_{ij} = \frac{\text{Ln}\left[F_{ij}\, X_{ij}^2\, Y_{ij}^{4.5}\right]}{\text{Ln}\left[X_{ij}\, Y_{ij}\right]}$$

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

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

and $S_{ij} \longrightarrow S(r)$ if $r_i \longrightarrow r_j$ 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 - 2×10^4 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 $4.0 < \log N_e < 4.6$, 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 Khristiansen et al[4], Asakimori et al[5], Abdullah et al[6] and Gerhardy et al[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 DAE Project at North Bengal University.

References

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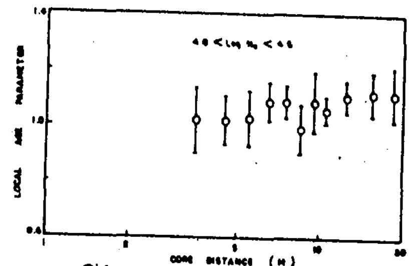

FIG. 2.1 LOCAL AGE DISTRIBUTION WITH CORE DISTANCE.

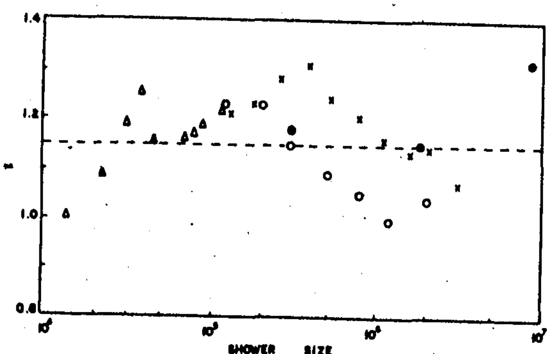

FIG. 4. VARIATION OF AVERAGE AGE PARAMETER WITH SHOWER SIZE. ---- KHRISTIANSEN et al (1981)[4], ● - ABDULLAH et al (1981)[6], O - ASAKIMORI et al (1981)[5], x - GERHARDY et al (1981)[7] AND Δ - PRESENT EXPERIMENT.

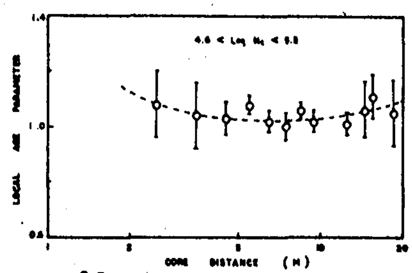

FIG. 2.2 LOCAL AGE DISTRIBUTION WITH CORE DISTANCE.

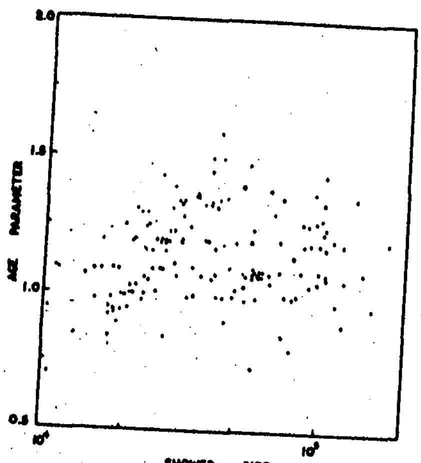

FIG. 1. AGE PARAMETER DISTRIBUTION WITH SHOWER SIZE OF SELECTED SHOWERS.

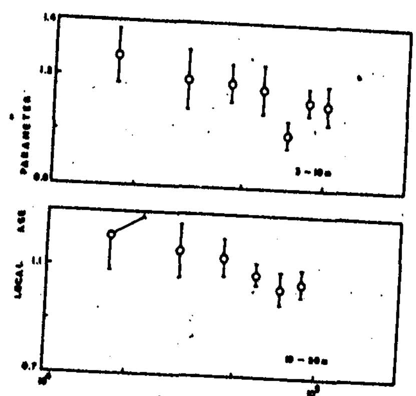

FIG. 3. LOCAL AGE DISTRIBUTION WITH SHOWER SIZE.