# STUDY OF THE TIME-DIFFERENTIATED PARTICLE FLUX DENSITY AT VARIOUS DISTANCES FROM EAS AXIS

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This work is devoted to studying the EAS time structure with the enlarged EAS array of the Moscow State University. The array was described earlier in /1,2/.

The time measurements are made using 22 scintillators which form 13 rectanges of 180x190 $m^2$ size covering the entire array area. The array was triggered by a signal of 4-fold coincidences of the pulses from the detectors forming each of the rectangles.

The data presented below were obtained during 2200 hours of the array operation in 1984.816 showers to which at least 14 of 22 scintillator detectors responded were selected among all the detected showers. The coordinates of the EAS axis in the observation plane and the EAS sizes were determined by the maximum likelihood method using a computer /1/ on the assumption that the electron LDF is of the NKG form. 492 showers in the interval of EAS size $Ne = 5x10^6 - 2x10^8$ ($\overline{Ne} = 1.7x10^7$) with zenith angles $\theta \leq 45°$ and axes within the array were analyzed.

The spatial orientation of the shower axis was determined using only the data of four scintillators included in the rectangle containing shower axis ( it is called central system). The shower axis angles $\theta, \varphi$ were found on the assymption of a plane shower front /2/. The front plane was drawn through the central system detector with the maximum detected density of the charged particle flux. The delays of the particle arrivals at the detectors $\tau$ were treated with respect to front plane. The r.m.s. error of the distribution of the delays with respect to the front plane in the central system is $\sigma$ = 8 ns for 492 showers as the whole, To have a sufficiently reliable determination of the shower front plane, we selected the events in which the maximum delays in the central system detectors did not exceed 10 ns. (The r.m.s. error of the distribution derived from the analysis of the showers with Ne $\geqslant 7.10^7$ proves to be $\sigma$ = 5 ns). At the above mentioned value of the maximum delay ( 10 ns), $\sigma$ of the distribution is 4 ns and the spreads of angles are $\Delta\theta \leqslant 1.6°$ and $\Delta\varphi \leqslant 5.6°$. This criterion was used to select 341 showers.

To obtain the distribution $f(\tau)$ of the delays in the times of particle arrival at the detector relative to the shower front we examined the showers with Ne=(0.5-2)x x$10^7$ and made allowance for the delays accompanied by the respences of not more than m=5 Geiger counters (the value m =5 corresponds in average to the passage of a single particle through a scintillator). Analysis of the dependence $f(\tau)$ on m shows that $f(\tau)$ does not depend on m for m $\leq$ 5 in the present statistics (see also /2/).

The distributions of the delays $f(\tau)$ for three intervals of distances $\Delta R_\perp$ from shower axis are given in Fig. 1. The negative delays in the distributions of the particle arrival times are contingent on the errors in determining the angles $\theta, \varphi$ and, probably, on the mesons moving ahead of EAS electrons at large Lorentz factors. The distributions exhibit durable falls which extend at the level of several events up to the delays of ~ 2 mcs (at $R_\perp$= 300-600 m ) and cannot be accounted for by random particles. The fraction of such events is ~ 3% of all events.

From the fig. 1 it is seen that when moving away from EAS axis the mean delay $\bar{\tau}$ and the r.m.s. error $\sigma$ increase while the relative shower disc depth $\sigma/\bar{\tau}$ does not vary within the errors. The value of $\bar{\tau}$ may be used to estimate the shower curvature radius. At the mean distances from the axis of 270 m, 350 m and 470 m, the curvature radii are obtained to be ( in km) $1.43 \pm 0.06$; $1.5 \pm 0.07$; $1.57 \pm 0.06$, respectively.

It is seen that there is a tendency for increasing of curvature radius with increasing the distance from shower axis. The values obtained are much below the curvature radii when many particles traverse a detector ( see below). The difference may be accounted for by the fact that the high values of the curvature radii observed at high densities are determined by the fastest particles produced high in the atmosphere which are probably muons /3/ or electrons from the photons converted near the array. In case of the passage of single particles through a detector the curvature radius characterizes the altitude where the major bulk of the particles are produced.

The dependence of the distribution $f(\tau)$ on the shower age S was studied for two intervals of distances from EAS axis. With this purpose, the examined showers were broken into two groups with $S < 1.45$ ($\bar{S} = 1.35$) and $S \geq 1.45$ ($\bar{S} = 1.55$). The values of $\bar{\tau}$, $\sigma$ and $\sigma/\bar{\tau}$ are presented in the Table. From the Table it follows that in each of the intervals of distances from EAS axis, as the shower age increases, the mean delay of particle arrivals $\bar{\tau}$ decreases slightly, while the values of $\sigma$ and $\sigma/\bar{\tau}$ are within the errors. The more statistics is required to obtain the final result on the dependence $f(\tau)$ on S.

15 showers with $N_e \geq 7 \times 10^7$ were selected for estima-

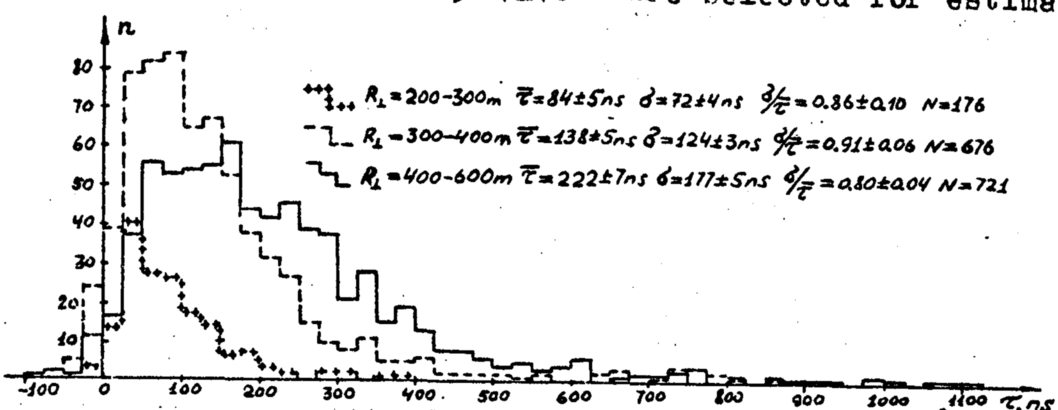


Fig. 1

| $S$ \ $R_\perp$, m | 300–400 | | | 400–600 | | |
|---|---|---|---|---|---|---|
| | $\bar{\tau}$, ns | $\sigma$, ns | $\sigma/\bar{\tau}$ | $\bar{\tau}$, ns | $\sigma$, ns | $\sigma/\bar{\tau}$ |
| $S \geq 1.45$ | 129±6 | 121±6 | 0.94±0.08 | 207±8 | 172±6 | 0.83±0.06 |
| $S < 1.45$ | 148±7 | 127±5 | 0.86±0.08 | 246±11 | 184±8 | 0.75±0.06 |

mating the shower front curvature. The curvature radius was calculated from the readings of individual detectors and was determined using the formula $R_c = R_\perp^2 - (C\tau)^2 \; /2C\tau$ (C is speed of light, $R_\perp$ is the detector-shower axis distance). One can obtain the distribution f(Re) for not so big $R_c$, this is a consequence of errors in $\tau$. Therefore, the values of $R_c > 10$ km (which corresponds to $\tau = 2\sigma$, $\sigma = 5$ ns) are excluded. Fig. 2 shows the resultant curvature radius distributions for three intervals of distances from shower axis. From the values presented it follows that the mean curvature radius of shower front does not vary within the errors at distances of 200-500 m from shower axis.

It should be noted that the distribution f($R_c$)does not arise because of different $R_c$ for different EAS. The distribution exists also in individual showers. This result means that there are big fluctuations in different altitude contribution to the flux of shower-front particles at a given distance from the axis.

References

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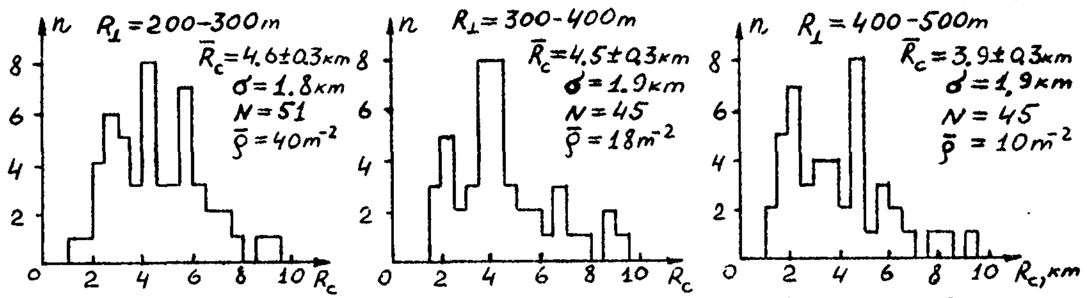


Fig. 2.