STUDY OF THE SHOWER MAXIMUM DEPTH BY THE METHOD OF DETECTION OF THE EAS CERENKOV LIGHT PULSE SHAPE

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ABSTRACT

The report presents the results of processing the data on the shape of the EAS Cerenkov light pulses recorded by the EAS array of the Samarkand University in 1983. The pulse FWHM is used to find the mean depth of EAS maximum.

In 1983 the Samarkand EAS array consisted of 13 integral detectors of Cerenkov radiation arranged as was described in /1/ and 18 scintillators arraged symmetrically around the array center, with 6 instruments located on each of the circles of 15, 30, and 60-m radii. The detector of Cerenkov pulse shape was installed at 250 m from the array center and included 13 photomultiplier tubes of the XP-2041 type. The detector is described in more detail in /2/.

The pulse shape was recorded with a 6LOR-04 oscillographic recorder, as described in /2/, and sometimes with the AFI-16 digital analyzer of pulse shape described in /3/. The digital analyzer recorded the instantaneous values of the pulse amplitude at 16 points with a 2-6 ns step which was selected automatically depending on the detected pulse duration. The digital analyzer threshold was above the oscillograph threshold.

The total resolution time of the recorders was estimated as the minimum duration at half-maximum of the Cerenkov light pulses whose amplitude is 2 times as high as the threshold amplitude.

Such duration proved to be 7.5 ns for the oscillograph and 6.5 ns for AFI-16.

The showers were selected using their Cerenkov light. Some 2500 showers accompanied by the oscillograph pulses and about 1500 showers accompanied by the digital analyzer pulses were detected.

For the purpose of processing we selected EAS with $\Theta < 30°$ and the photon flux densities in 6 detectors at the 60-m distance from the array center $q > 8$ photon/cm^2·eV, at the 120-m distance from the array center $q > 5$ photon/cm^{2}eV, in the pulse shape detector $q > 3$ photon/cm^{2}eV for the oscillographic recording and $q > 5.3$ photon/cm^2 eV for the digital recording.

The EAS arrival directions were inferred from the readings of the detectors at $r = 60$ m. The axis coordinates and the EAS size were determined from the readings of the scintillators. The energy was found from the Cerenkov light flux density at a 100-m distance from EAS axis. The processing procedure is described in detail in /4/.

The results were obtained using the showers whose axes fall inside the array ($r < 60$ m) at a > 200 m distance from the pulse shape detector. The selection probability calculated allowing for the fluctuations of the Cerenkov light LDF is >0.9. In such a way, we have selected 55 events recorded with the oscillograph and 28 events recorded with the digital analyzer. The FWHM of the pulses were measured for all the events. The depths of the individual shower maxima were inferred from the duration and the distance from EAS axis using the method described in /2/.

In terms of energy, all the events were broken into three groups. The mean depths of the maxima for the three groups are shown in Fig. 1 which also presents the results obtained earlier with the EAS arrays at Samarkand /2/, Yakutsk /5/, Tien-Shan /6/, in Japan (Akeno)/7/, and Australia (Adelaida) /8/.

A certain systematic shift of the dots obtained with the Samarkand EAS array may be explained by the transition from the density-based selection of showers ag 60 m from the array center /2/ to the density-based selection at r=120 m. Our calculations /11/ have shown that the latter selection is closer to the selection of showers with a fixed energy.

A good agreement is observed with the data obtained at Tien-Shan and in Japan. The data of /8/ may be significantly distorted by the shower selection effects, as was noted in the work /9/ carried out using the same EAS array.

Fig. 1 shows the results of calculating the depths of EAS maxima in terms of the supracritical pomeron model described in /10/ for primary protons and complex chemical composition (40% of p and 15% of nuclei with A= 4,15,31, and 56 each). A good agreement of the dots of this works and of the dots obtained in /6,7/ with the theoretical dependence for the complex chemical composition can be seen. The dots obtained with the Yakutsk EAS array at $E_o > 10^{17}$ eV do not contradict the dependence either. At lower energies the Yakutsk dots deviate from the dependence by 2 statistical errors. This is probably due to the poor allowance for the erros arising from the application of the photomultiplier tubes of a high time resolution (~ 2 3ns) for EAS with $E_o < 10^{17}$ eV.

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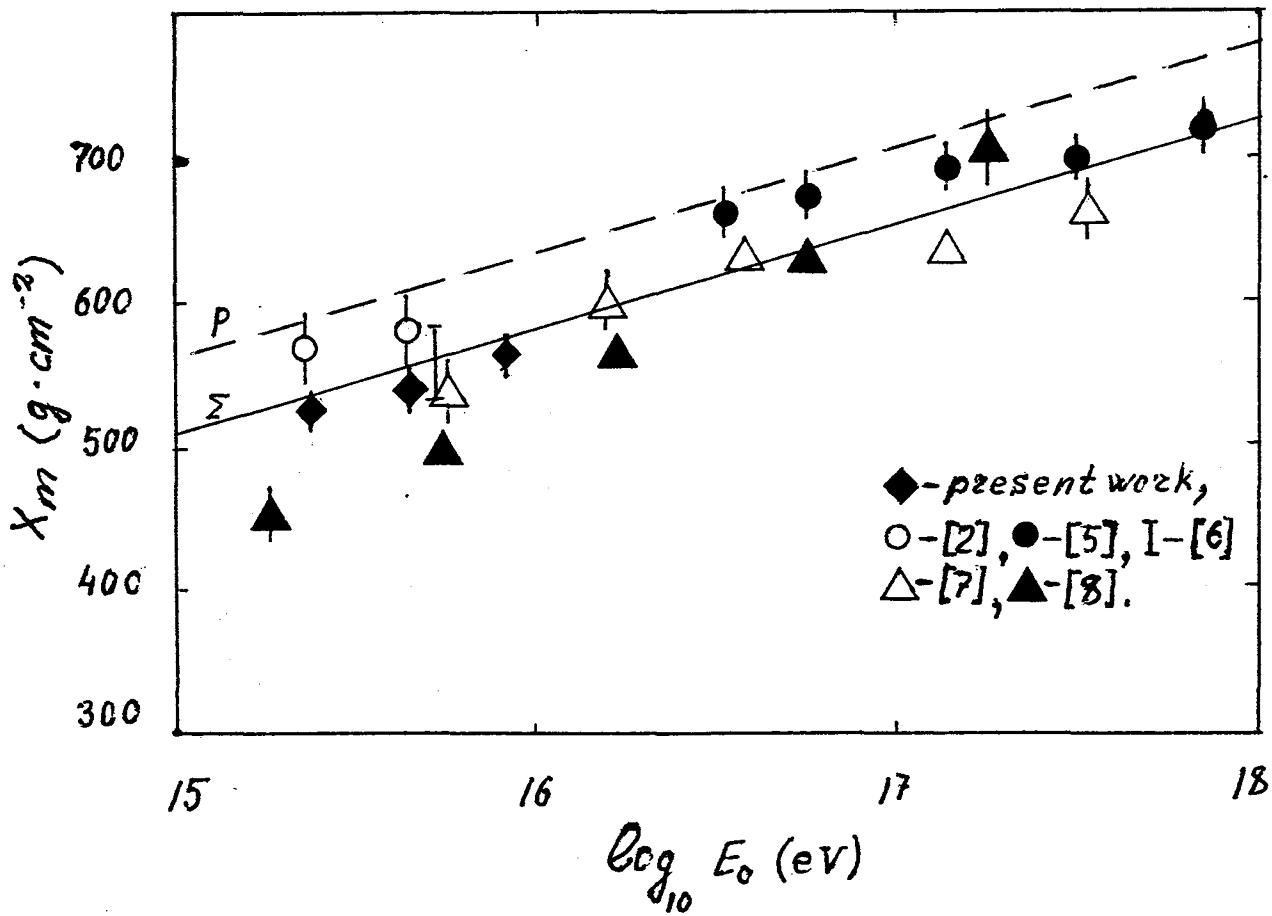

700
600
500
400
300
X_m (g·cm^{-2})
P
Σ
15
16
17
18
$\log_{10} E_0$ (eV)
◆- present work,
○-[2], ●-[5], I-[6]
△-[7], ▲-[8].