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The arrival time distribution of EAS at Taro

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Abstract. The arrival time distribution of EAS has been observed since 1995 at Taro cosmic ray laboratory (200m above sea level). The EAS arrays consist of $1m^2$ and $0.25m^2$ scintillation detectors,$0.25m^2$ fast timing detectors and ultra fast Cherenkov detectors(UFC). 169 $0.25m^2$ scintillation detectors are arranged in a lattice configuration with a unit distance of 1.5m. UFC is placed at 20m from the center of lattice array. The arrival time distribution of electrons are simulated by both primary proton and iron nucleus, and is compared with experimental result.

1 Introduction

We have studied composition of primary cosmic ray particles above 10^{15}eV. Linsley (J.Linsley 1985) says that the early results of arrival time distribution of EAS particles near the EAS core have been confirmed using plastic scintillators (H.Sakuyama and N.Suzuki 1981, C. P. Woidneck et al. 1975). Recently we have observed arrival time distribution near the EAS core with acrylic plates (H.Sakuyama et al. 1997, H.Sakuyama et al. 1999).In order to examine the time structure of shower disk within several tens meter from the EAS core this time, UFC detectors installed in just under of the trigger detectors in November, 1999 were moved
from the center of the trigger detectors at the distance of about 20m (Fig. 1). It would be possible to examine curvature of the shower front, thickness of the shower disk and fluctuation in the arrival time from arrival time distribution of the particle in the EAS core vicinity by this fact.

As the parameter which shows the time structure, tr and FWHM have been used as a waveform parameter in the structure of the shower disk. In this conference, the following will be reported, average arrival time distribution near the EAS core (r=10m～35m) and at the zenith angle(sec θ <1.1).

2 Observation equipment

First trigger system is adopted from October 1999 to process the fast signal of UFC, as shown in Fig. 2. The observation system consists of 4 UFC detectors and 8 first timing detectors with angular resolution 1 degree. Scintillation detectors of 214 of $0.25m^2$ and $1m^2$ was placed at about $15400m^2$ in order to measure size and particle density distribution of EAS,

(Fig. 1). 169 detectors have been arranged in a lattice configuration (13 × 13) with 1.5m separation in order to observe particle number of the core vicinity of EAS. By arranging 4 for the position away from the center of array, the UFC detectors have been installed.

3 Analysis

It is as follows in observation period.

Observation period	
November third,1999	~May second, 2000.
Observation time	4368 hours.
Coincidence Events	46,380Events
Trigger Rate	13.27events/h

From these data, the analysis was carried out under the condition of the following.

1.The pulse height of the UFC detectors is more than 30mV (6 particles) and that the signal does not overflow it on the oscilloscope.

2.Tr makes over 1.4ns and FWHM over 2.2ns in order to remove the noise by the observation system.

3.Zenith angle $\sec\theta$ of EAS is made to be under 1.1.

4.The events of which core hit in the lattice array are analysed.

The shower front is assumed a plane, and the time to the fact of the pulse (or, particle) in which it reaches from the plane is arrival time.

4 Results and discussions

For the events which satisfied all conditions mentioned above, zenith angle, θ EAS size N_e, and distance r from the EAS core were made to be a parameter, and the curvature of the shower front was examined. It consisted as a result of dividing the relationship between arrival time and tr and FWHM for the distance from the EAS core separately as following.

1.The frequency distribution of EAS size N_e is shown (Fig. 3).

2.Relation between arrival time and r of every EAS size is shown (Fig. 4).

As a result compared with the empirical formula of Linsley in making arrival time to be a parameter in arrival time, the tendency which agreed with observed value and value of Linsley at r>10m was seen.

Both primary proton and iron nucleus were simulated (D.Heck. et al. 1998), and the arrival distributions of electrons were obtained and it seems to see a little difference for the result of observation, empirical formula of Linsley and simulation, and further accumulation of data is indispensable.

References

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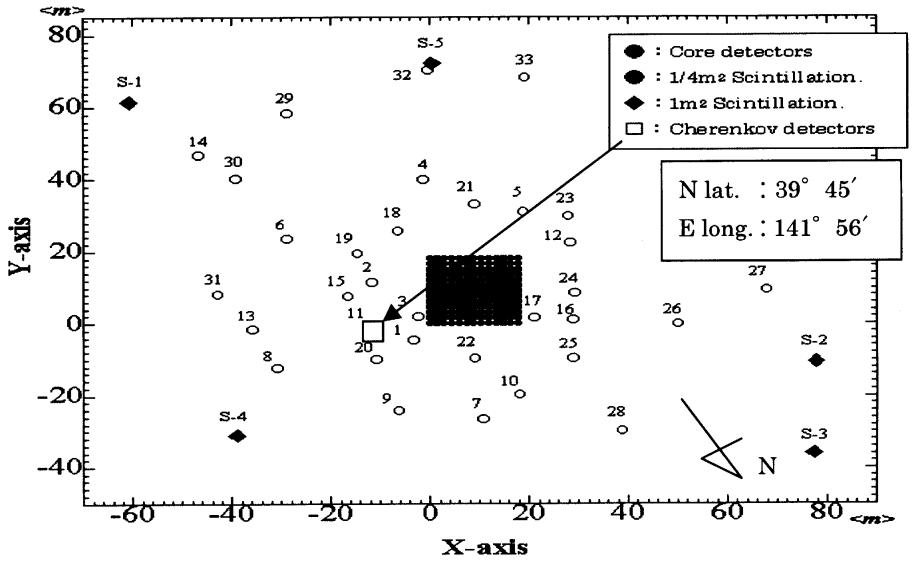

Fig. 1 Transfer position of the Cherenkov detector

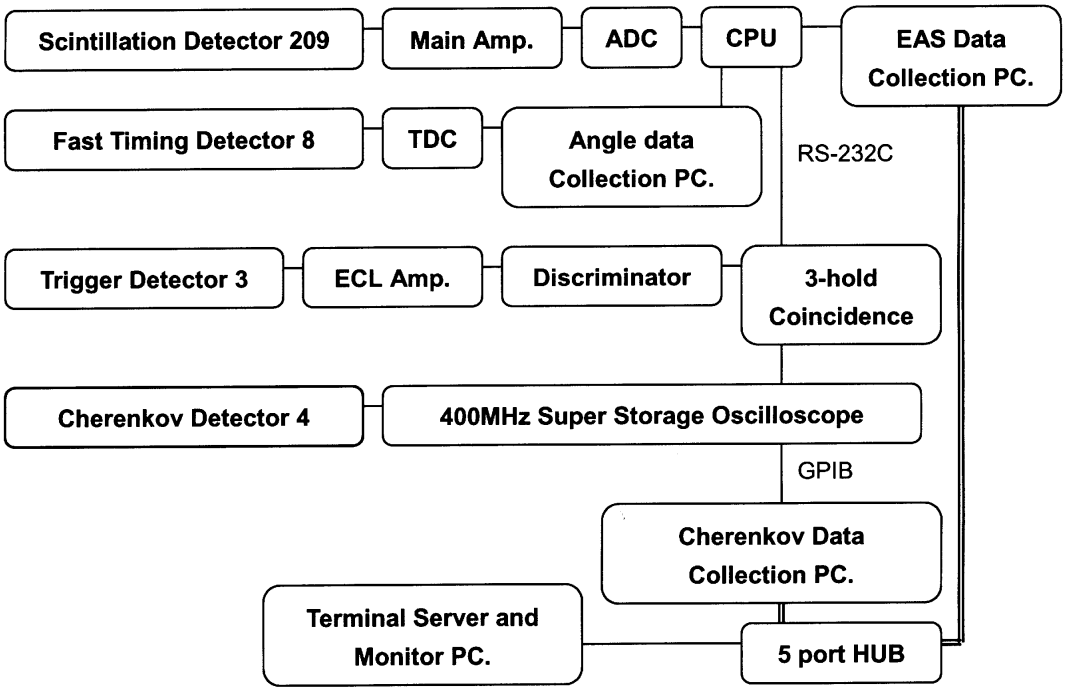

Fig. 2 Block diagram of first trigger system

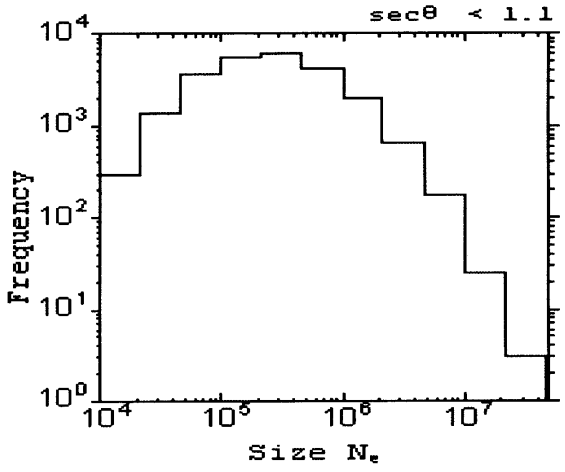

Fig. 3 The frequency distribution of EAS Size

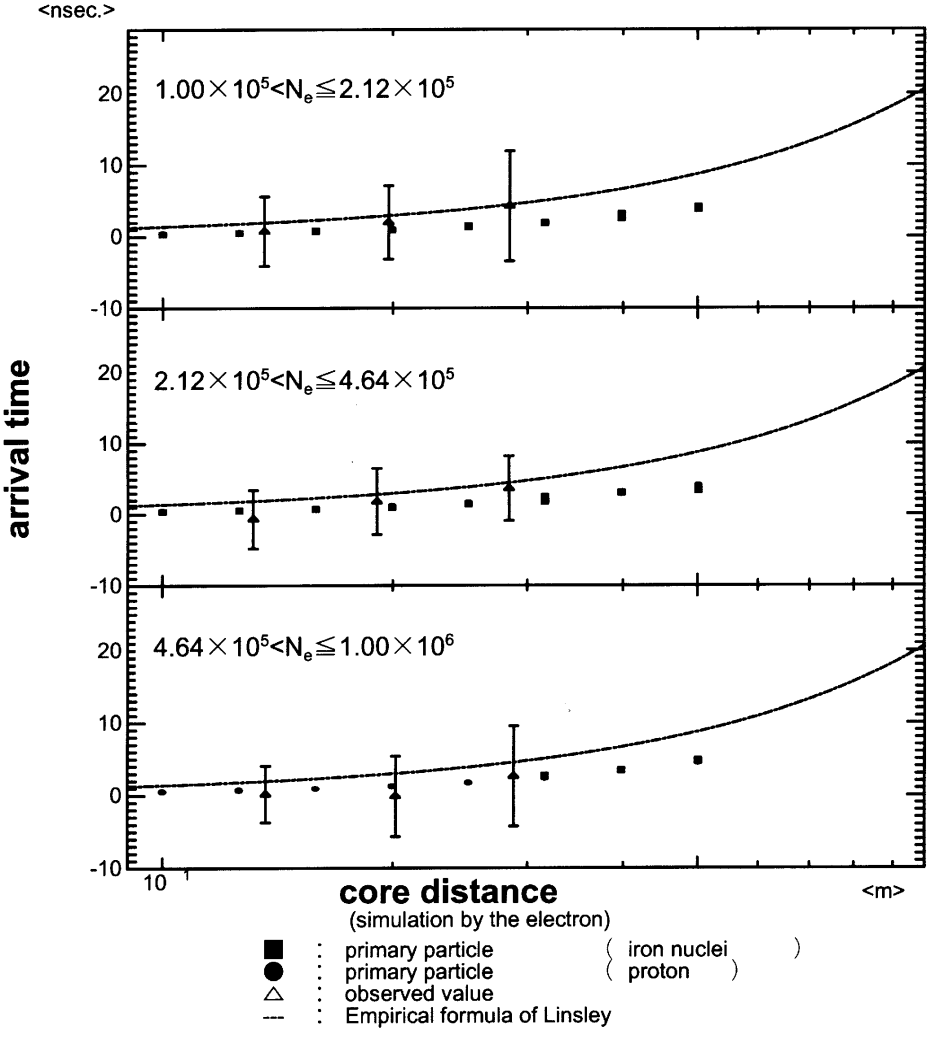

Fig.4 Relation between arrival time and core