# THE STRUCTURE OF THE SHOWER DISK OBSERVED AT MT. NORIKURA

Sasaki,H.,Nishioka,A.,Ohmori,N.,Kusunose,M.
Kochi University, Kochi, Japan
Nakatsuka,T.
Konan University, Kobe , Japan
Horiki,T.
The Institute of Physical and Chemical Research, Wako, Japan
Hatano,Y.
Institute for Cosmic Ray Research, University of Tokyo, Tokyo, Japan

## §1 Introduction.

It is very important to find out parameters describing the air shower phenomena, so the fine measurement of the structure of the shower disk, that is, the arrival time distribution of the all charged particles (mainly electron component) near the core of the small or middle size EAS were planned at Mt.Norikura since 1982.(1)

Pulse wave-form measurement of the electron and muon component of the EAS had been made by several groups (e.g.(2)) and also with respect to delayed hadrons in the EAS. (e.g.(3)) Up to now, however, the structure of the shower disk does not studied precisely, especially at near the core of a small or middle size EAS.

At the previous conference, the preliminary study on the pulse wave-form was reported with some problems, such as the effect of the PT-pulse(4) , and the existence of the abnormal pulse wave-form. These observed data by the same apparatus as this work were affected the effect of the PT-pulse and not so good time response appeared in the value of the FWHM for a single muon. As mentioned in another paper at this conference (4), we made some improvements on the fast scintillation counter (FS) system (i.e. on the fast trigger scintillation counter (TFS) system) and on the system response of the FS.

## §2 Experimental.

Four fast scintillation counters whose area is $0.25 m^2$ and four TFS have been added to Mt.Norikura EAS array as shown in Fig. 1. The triggering requirement for this run was that four TFS counters show the pulse height greater than 4 particles/$0.25 m^2$ at the same time whose allowable time delay is 80nS for each TFS.

Approximately 6200 showers were caught for this work in last summer.

Digitized data by storage oscilloscope were transmitted to the personal computer through the GPIB bus and were recorded on the floppy disk. To measure the rise time of the pulse, some improvements were made. First, we change the design of the FS vessel to as shown in Fig. 2, because this change means the increase of

Fig. 1

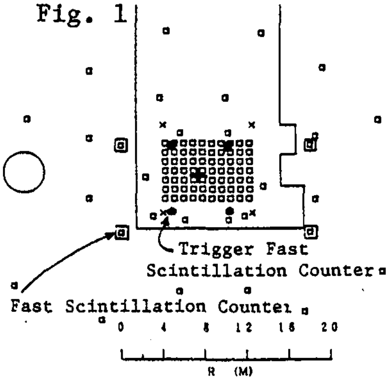
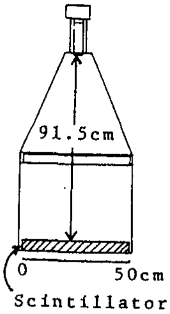


Fig. 2



time difference between the prompt PT-pulse and the main scintillation pulse. So we can easily eliminate such a pulse shape data that affected by the PT-pulse. Secondary, the dynode chain of the resistance (i.e. voltage distribution ratio) for the photo-tube was improved to that for the pulse linearity measurement, consequently, the effect of a saturation of pulse height was avoided. Finally, we changed a high voltage to feed the photo-tube up to about 1900 volts, from 1550 volts at the previous experiment, and if the time response characteristics has the same tendency as for the photo-tube 931A, circular cage type, the rise time of the photo-tube (R329-02) may be improved about 0.5nS (i.e. the rise time become 2.1nS).

The definition of the various parameters of the pulse wave-form are reported in another paper at this conference (4). About the definition of the FWHM, care must be taken, because only when the time of the 50% of the main peak pulse height is found at the trailing edge of the main peak, the FWHM is obtained.

## §3 Experimental Results.

### 3.1 Rise time, FWHM and FWTM

Fig. 3 (a),(b),(c) show the rise time, the FWHM and the FWTM distributions of the fast scintillation counter FS1 against the lateral distance from the shower axis to FS1, where size region is $10^6$ to $2*10^6$ ,age is greater than 0.2 and zenith angle is less than 30°, the core distance

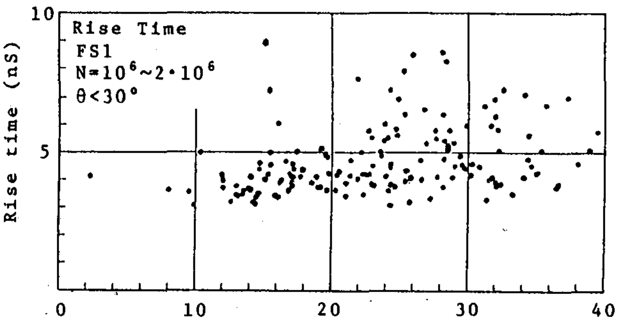


Fig. 3(a)

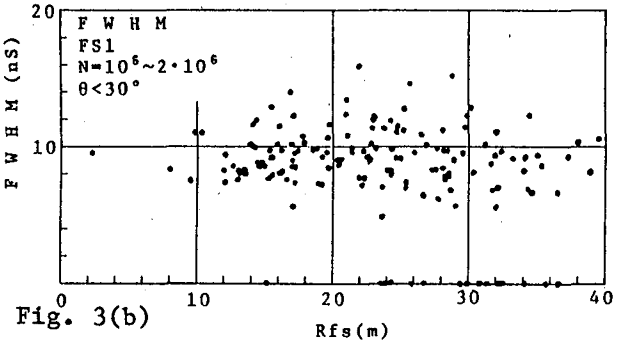


Fig. 3(b)

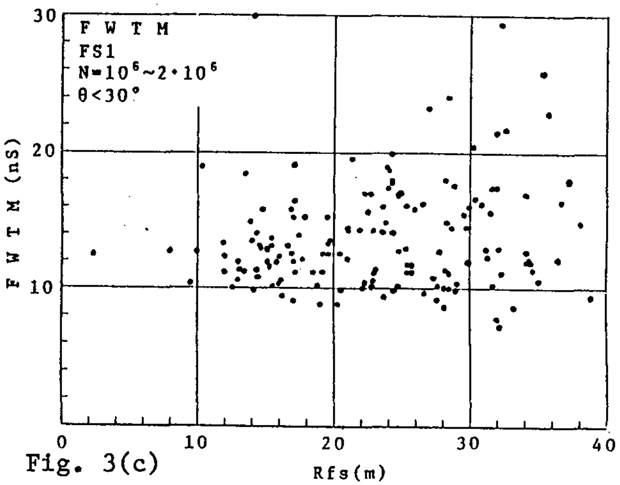


Fig. 3(c)

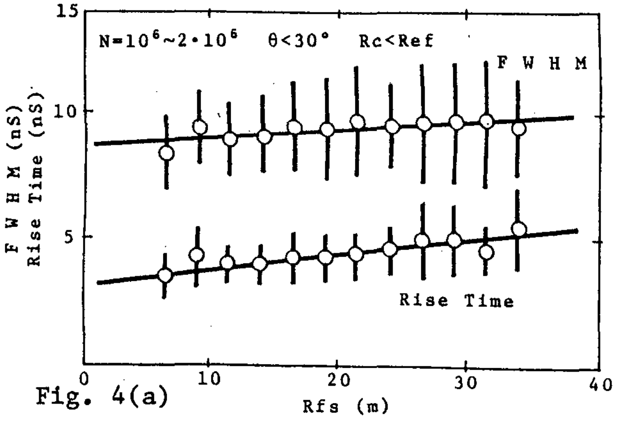


Fig. 4(a)

(between the axis and the trigger center) Rc is less than the effective distance Ref. At the selection of the pulse wave-form data, we considered how to eliminate the PT- pulse events as shown in Fig. 5 and the pulse wave-form data which have a ringing tail at the trailing edge of the main pulse. Considerable such events were omitted by the adoption of the condition with respect to the rise time, that is T-rise>=3.0nS.

What is evident from the figures is that the fluctuation of the rise time and the FWTM become large with the lateral distance but the distribution of the FWHM is not so broad.

3-2. Structure of the shower disk.

All the data of every FS were summarized and we obtained an average feature of shower disk as in Fig. 4 (a),(b),(c), where the error bar represents a standard deviation. From these figures the following become clear as an average structure of the EAS disk. (A) The rise time shows an increasing tendency with a lateral distance from 3.5nS to 5.4nS. (B) The FWTM, also shows the same tendency as that of the rise time and it changes from 25nS to 33nS. (C) The FWHM has slight dependence on the lateral distance. (D) All the parameters of the pulse wave-form show large fluctuations for each shower.

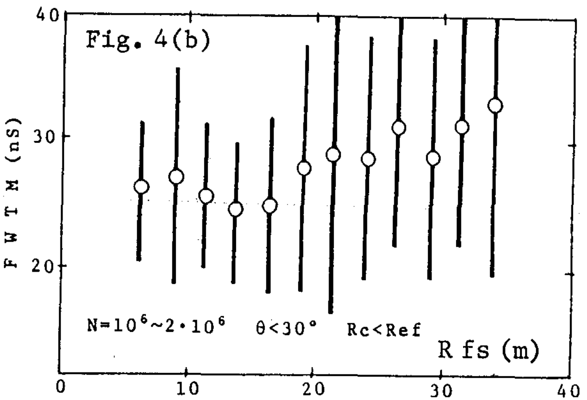


Fig. 4(b)

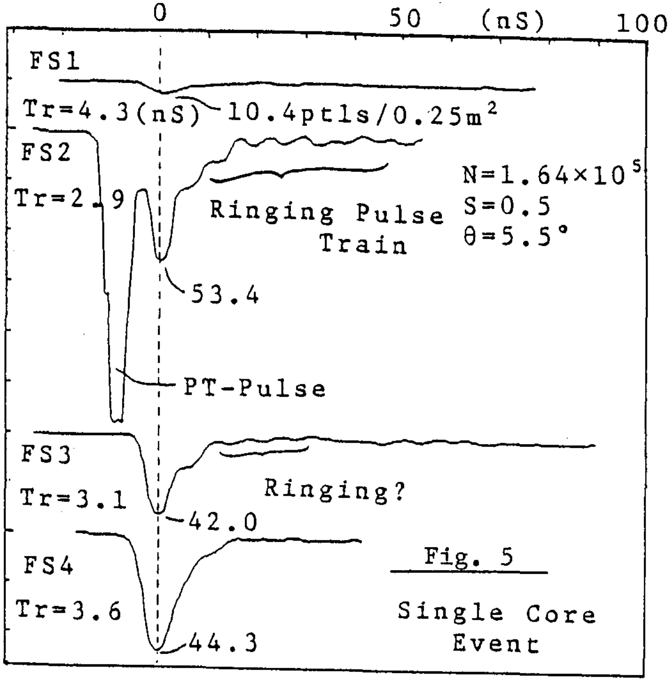


Fig. 5

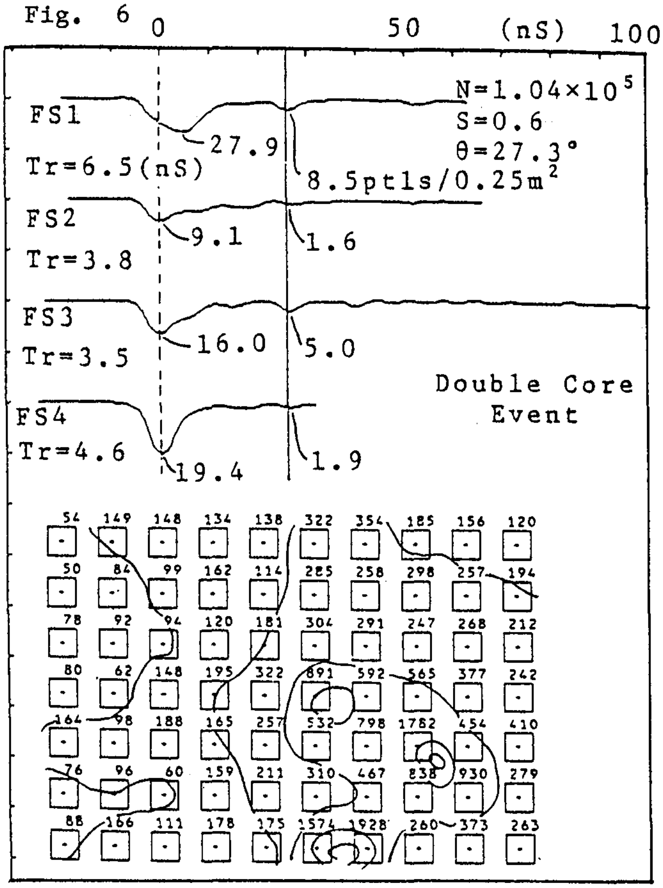
Single Core Event

Similarly, the average parameters for the EAS whose size region is $10^5$ to $2*10^5$ were obtained. Compared with above results, size dependence of these parameters may be described as follows. (A) The rise time of the size $10^6 \sim 2*10^6$ is less than that of $10^5 \sim 2*10^5$. (B) The FWHM of the size $10^6 \sim 2*10^6$ has greater value than that of $10^5$. (C) The variation of the FWTM with the distance from the axis for the size region 10 2*10 is larger than that for the size $10^6 \sim 2*10^6$.

3-3. Observed pulse wave-form and its core structure.

All pulse wave-form data obtained were printed again by a computer and we found various types of pulse profiles. The core maps of interesting events, also, were obtained and 40 showers whose core hit the central array were analysed up to now, together with the pulse data. Fig. 6 shows an example of the multi-core event that all of the pulse wave-form of this event have a subpeak at time=26.0nS∼27.4nS delayed from the main peak time. On the other hand, an example of the single core event is shown in Fig. 5. The pulse wave-form from the FS2 has a PT-pulse and also has a ringing pulse train. This event has not any coincident subpeak whose time allowance was 2.5nS around the time of the biggest subpeak.

Fig. 6



## §4 Conclusions.

(A) The average structure of the shower disk became clear and further analysis will be continued with respect to the size and age dependence of the pulse wave-form parameters.

(B) Considerable pulse wave-forms of the electron component observed have two decay constant and the simulated pulses reported in another paper (4) also have same tendency.

(C) Rough analysis on the correlation between the core and time structure, it seems that about 1/3 of the core event have 3 or 4 coincident subpeaks where the limit of the pulse height of subpeak is 1 particle. And the rate of a multi-cored shower was ∼60% out of them at the size $10^5$∼$10^6$. Simulation work and further technical development will be necessary, because small subpeak less than 10% of the pulse height may be under the influence of the ringing pulse appeared in the single particle pulse.

## References

(1) Sasaki,H. et al.: Proc. 18th Int. Cosmic Ray Conf., Bangalore 11(1983) 205
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(3) Mincer,A.I. et al.: Proc. 18th Int. Cosmic Ray Conf., Bangalore 11(1983) 264
(4) Sasaki,H. et al.: in this conference, HE 4.6-10