

## FAST SCINTILLATION COUNTER SYSTEM AND PERFORMANCE

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## §1. Introduction.

At the investigation of the arrival time distribution, it is very important to measure the pulse wave-form precisely as much as possible and still the observation by fast pulse technique has attracted the attention of many researchers.(1),(2),(3),(4)

Experimental study of the fast scintillation counter(FS) system to observe a shower disk structure at Mt.Norikura are described in this paper, especially on the system performance and a pulse wave-form by a single charged particle. Some improvements were made on a few points. As reported at the previous conference, the photomultiplier tube pulse (PT-pulse, at Bangalore called a knot pulse) is appeared at the leading edge of the main pulse. To remove this PT-pulse from the main pulse, we changed the frame of the scintillator vessel (1) and have made the fast triggering system to decrease the dead time which came from the use of the function of the self triggering of the storage oscilloscope(OSC). To provide a new field on the multi-parameter study of the EAS, the system response of our FS system also improved as a results of many considerations.

## §2. Experimental.

For the fast triggering system, four  $0.25\text{m}^2$  trigger fast scintillation counters (TFS) were used for the air shower trigger and two  $0.0625\text{m}^2$  TFS used for the identification of a single particle at the present work, where the photomultiplier is the same one for the FS(R329-02,Hamamatsu). A block diagram of developed fast trigger system and the FS system is shown in Fig. 1. Four constant fraction timing discriminators (CFTD) were added last year, where its propagation delay is  $\sim 10\text{nS}$ , time walk is  $\sim 1.5\text{nS}$  and the out put pulse width was set to  $80\text{nS}$ , because of the usage for the EAS trigger.

Used plastic scintillators for the FS to measure pulse wave-forms, are the polymerization type ternry plastic scintillator plates( $50\times 50\times 5\text{cm}^3$ ) with the same lot(CI LTD). To avoid diffused reflection, the inside wall of the scintillator vessel is covered with a sheet of black paper except for the bottom. The signal outputs from the FS were connected to a storage oscilloscope(TS8123,IWATSU) with a  $15\text{m } 10\text{D}2\text{V}$  cable and a  $5\text{cm } 58\text{ U/G}$  cable and terminated to  $50\Omega$  by the terminator(BB50M1 frequency range is  $\text{DC}\sim 3\text{GHz}$ ) at the entrance of the storage main amplifier. Coincidence output signal triggers the storage OSC of the external trigger mode, first of all, and when the service request signal through GPIB control Bus is transmitted from the storage OSC to the personal computer, the computer begins to control the GPIB data Bus. It takes about 12 seconds per one record.

By the way, the definition of the pulse wave-form parameters, such as

a rise time, FWHM and FWTM, are illustrated in Fig. 2. As the FWTM represents a thickness of shower disk, we must pay attention to the definition.

### §3. Performance of the FS system.

As the measuring method of the time response of the system, we adopted the Cerenkov light signal observation from the acrylic acid resin plate ( $50 \times 50 \times 5 \text{ cm}^3$ ) with the same vessel and the photo-tube as for the FS scintillator. Fig.3(a) shows the arrangement of the Cerenkov detector. A single charged particle does not pass through the photo-tube, so the influence of the PT-pulse (e.g.  $\bar{C}$  light signal at the photocathode made by borsillicate glass with a concave surface, 1mm to 6.7mm thick) is avoidable. Most of the obtained pulse wave-form have a small ringing pulse train, gradually decreasing their amplitude, at the trailing edge of the main pulse which may be due to high frequency component contained in the main pulse. But the pulse height of the first ringing pulse is less than 10% of the main peak. The result of the time response is tabulated in Table 1.

### §4. Pulse wave-form of the FS by a single charged particle.

On the pulse wave-form measurement of the scintillation counter had been done mainly by the time spectrometer with a time to pulse height converter (TPHC) and the results show a smooth curve. (5) This pulse wave-form is an averaged one, so we must be handle with caution. On the other hand, the single particle response of the system must be known at the time when we discuss the arrival time distribution of the shower particles. Then, we observed the pulse wave-forms for single particles with the detector arrangement shown in Fig.3(b). TFS1, and TFS2 were installed as to avoid the PT-pulse occurrence.

The experimental results are shown in Fig.4. Various time response data in this work are listed in Table 1, where parenthesized values show

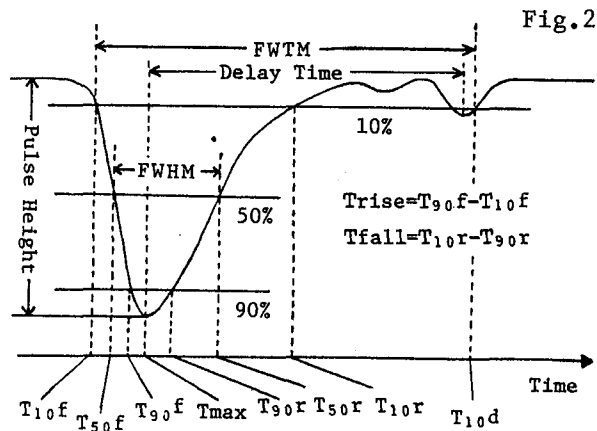
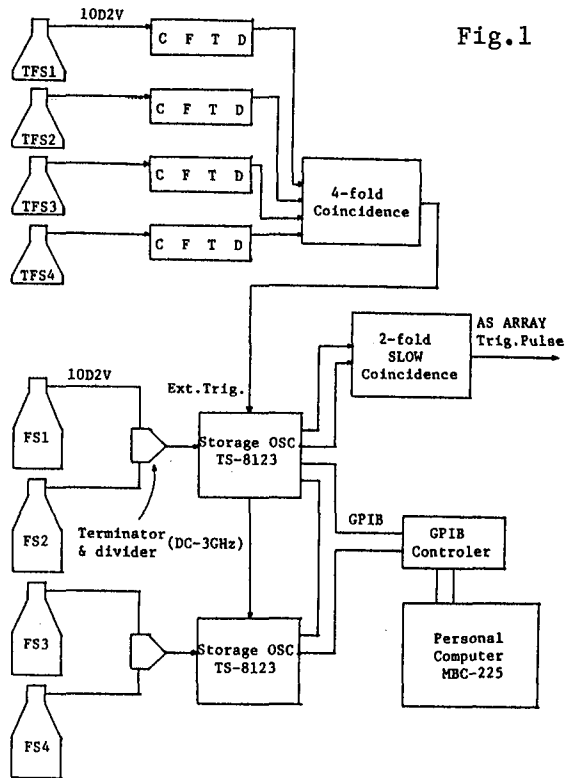


Fig.2

the standard deviation. Our data are quite sufficient one, because the maximum rise time of the storage OSC 3.5nS (Commercial data) is larger than our Cerenkov data.

Fig.3(a)

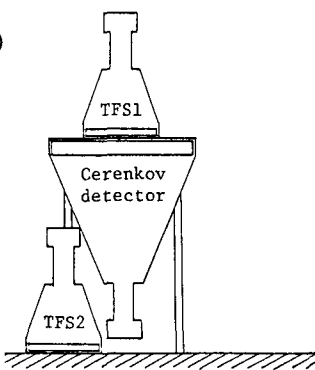


Fig.3(b)

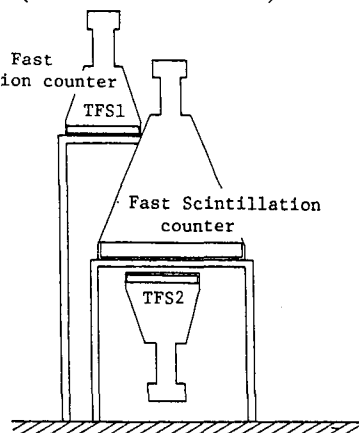
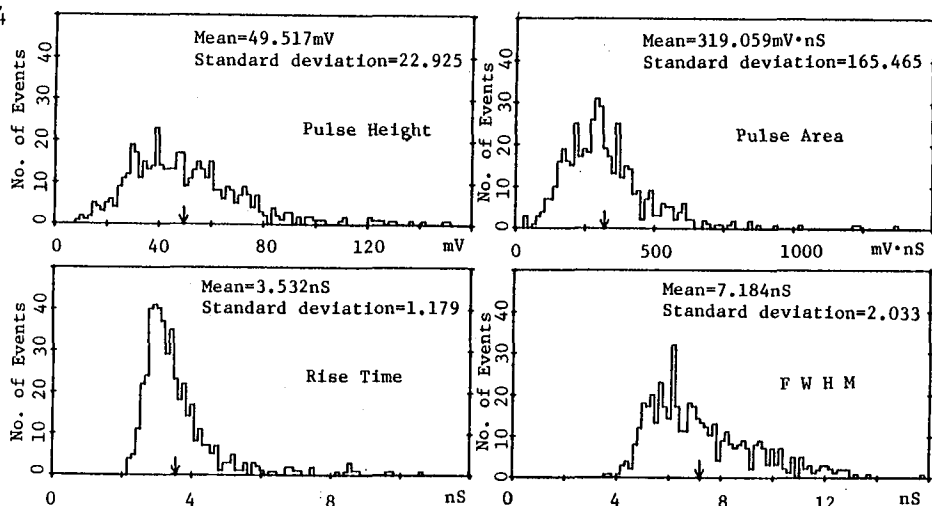


Table 1

Mode of Experiment	Rise Time (nS)	F W H M (nS)	Comment
Cerenkov Detector	2.68 ( $\pm 0.3$ )	4.31 ( $\pm 0.15$ )	present work
PT pulse	2.51 ( $\pm 0.2$ )	4.37 ( $\pm 0.2$ )	present work
Single particle	3.54 ( $\pm 1.18$ )	7.18 ( $\pm 2.03$ )	present work
Averaged Single particle	3.57	7.43	present work
PT pulse	2.5~3.5	5.2~5.5	Kobe Group Ref(2)
Single particle	4.3~4.5 (0.9~1.3)	8.6~8.8 (1.7~1.8)	Kobe Group Ref(2)

Fig.4

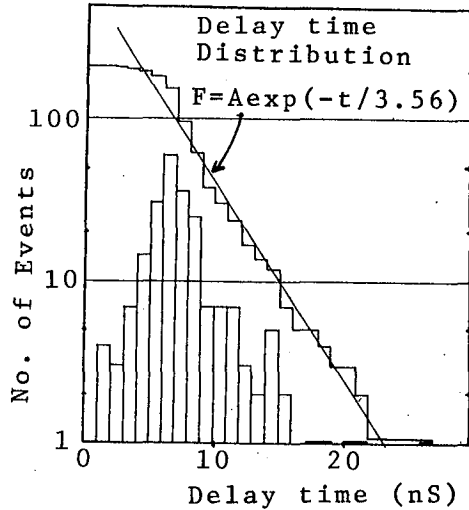


The fluctuation of the pulse wave-form from the plastic scintillator is larger than what we expected and this tendency is obvious at glance of individual pulse profile. The rate of subpeaks, at the condition that the peak height of a subpeak is greater than the 10% of the average peak height, is about 82%, and at the condition that larger than the 33% of the main the rate is about 48%. In the former case that is  $P.H.(subpeak) \geq 0.1 \times P.H.(mainpeak)$ , the rate is affected by the small ringing pulse. At the case  $P.H.(sub) \geq 0.33 \times P.H.(main)$ , the influence by the ringing pulse is small and the delay time distribution of subpeaks in this case is shown in Fig.5. This delay time distribution is expressed as

$$F = A \exp(-t/\tau_0) : \tau_0 = 3.56 \text{ nS}$$

the value  $\tau_0 = 3.56 \text{ nS}$  is quite reasonable as compared with the fall time measurement.(6)

Fig.5



### §5. Simulation of the pulse wave-form.

To give an effective and practical comment at the data analysis of the shower disk, we simulated pulse wave-forms at their density 10, 20 and 40 particles/ $0.25 \text{ m}^2$  using a sample arrival time distribution function :

$$f(t) = \frac{1}{\sqrt{2\pi}\sigma} \exp\left(-\frac{(t-m)^2}{2\sigma^2}\right)$$

, where  $\sigma = 0.5 \text{ nS}$  and  $m = 1.5 \text{ nS}$ , and observed pulse wave-form data for a single particle whose values of area are within 17% of that of the average area distribution. The number of simulated pulse wave-forms for density 10, 20 and 40 are 21, 23 and 16 events, respectively.

The average values of the obtained rise time, and the FWHM, are somewhat larger than those of the measured for a single particle. Analysis shows, also,

that the ratio of the sub peaks to total number of simulated events whose pulse height is larger than 1 particle, are 38%, 59% and 81%, respectively. Those high rate may come from the ringing pulses at the trailing edge of a single particle's pulse profile. While as an analysis of the subpeaks whose densities larger than 2 particles/ $0.25 \text{ m}^2$ , they are quite small and are 10%, 27% and 6% for each density.

### §6. Conclusions.

From the facts described above, we obtained satisfying results on the system performance and it becomes clear that the behavior of the pulse wave-form of the thick(5cm) plastic scintillator by a single charged particle.

On the other hand, with respect to the pulse wave-form simulation there are still many problem as a selection of the sample arrival time distribution function. And in future we must devise that how to decrease the effect of the PT pulse and the ringing pulses technically.

### References.

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