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A new fast timing scintillation detector

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To measure the pulse waveform of new FS detector, we had performed further improvements on the new FS system, especially around the photomultiplier tube (PMT) electronics and ultra fast timing plastic scintillator. The system response of the new FS detector improved over 60% from the conventional scintillation detector. Though the ultra fast Cherenkov(UFC) detector was very much excellent in the measurement in the rise time, it was unsuitable for the measurement of fall time and the FWHM. The resolution in the new FS detector became 2.64ns fall time and 2.61ns the FWHM..

1. Introduction

Arrival time distribution of near to the EAS core was observed at Taro (200m above sea level, 206.7 gcm^{-2}) since 1995 [1][2][3][4]. By using new FS detector, time structure of arrival time distribution is investigated in comparison with scintillation detector in more detail. The system response of this new FS detector is highly precise in comparison with the system response of scintillation detector. A new information of time structure of shower disk may be obtained by using this precise scale of new FS detector.

2. Results and Discussion

The EAS experiment has been carried out at Taro. 169 0.25m^2 scintillation detectors are core detectors of EAS and have been arranged in a lattice configuration (13×13) with a unit length of 1.5m, Figure1. The conventional EAS array of 20 0.25m^2 and 10 1m^2 detectors has also been arranged up to 120m from the center of the lattice array. In order to observe the arrival time distribution of EAS particles new FS detectors have been used. Up to September 2004 2 0.25 m^2 new FS detectors have been used and after that four new FS detectors is added. The system response of these detectors is shown in Table 1. Our new FS detectors are characteristic of fast photomultiplier tube (R2083, decay time=0.7ns), ultra fast timing plastic scintillator BC-420 (50×50×2cm,BICRON CO), thick coaxial cable (10DSFA) and 500MHz digital phosphor oscilloscope (TDS3054B).

The first improvement is related to the reduction of pulse train ringing. Actually when the PMT is illuminated by a large number of photons from the scintillator, the output pulse has a considerable amplitude of very high frequency components. So we devised an arrangement of voltage dividing resistances for the PMT. Moreover, we adjusted the voltage distribution ratio near the last dynode under so as to give a smaller change to improve the time response. The response of the PMT is expressed by the rise time(Tr) and a full width at half maximum(FWHM) of the PMT pulses which appear clearly when we cover the photo cathode with black paper. To show the result of improvement, we show the pulse waveforms of PMT pulse in Figure 2. The correlation of pulse height, fall time (Tf) and the FWHM was shown for the particle number in Figure 2. The EAS array was triggered by three fold coincidence at the central part of the lattice array. EAS whose cores were inside the central 13×13 scintillation detectors array were adopted for the analysis. In an operating time of 3360 hours, about 19500 showers have been recorded. The number in which the core of the air shower entered detector (13×13) is the 316 events. The analysis condition of the data analyzed 175 events that did not overflow the pulse height on the oscilloscope over 3 particles in the new FS detector.

The system response of these new FS detectors is shown in Table 1. When new FS pulse wave with more than 3 particles per one new FS detector was observed, shower event was adopted. Figure3 showed the response time between new FS detectors at Tr, FWHM and Tf. Figure4 shows the relationship between Ne and a FWHM, Ne and Tf. Table 2 shown the relationship between average response time (Tr,Tf,FWHM) and Ne.

3. Conclusions

The new FS detectors got the time response in 2.61ns FWHM using plastic scintillator. We have obtained value of Tr, Tf and FWHM more precisely. By optimizing tapered bleeder circuit, damping resistors and decoupling capacitors given to PMT, the time response of the pulse improved very much, and it became 0.86ns Tr, and 2.10ns Tf and 1.44ns FWHM each. In the future, the structure of the shower disk would be able to be analyzed more in detail from particle arrival time near the shower core.

References

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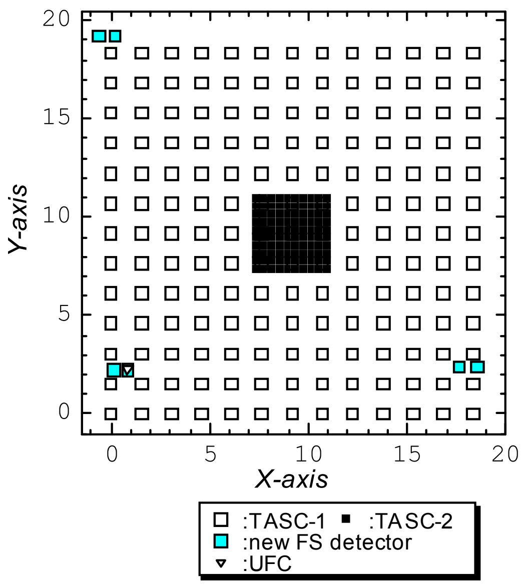

Figure 1. Arrangement of Core detector

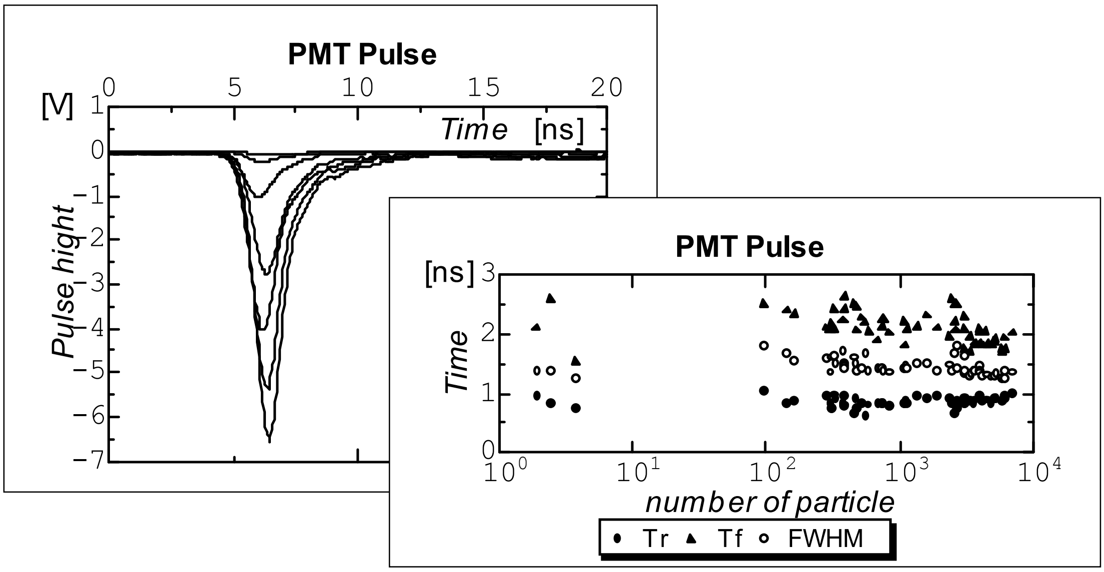

Figure 2. Waveform of PMT Pulse and response time for particle number

Table 1. System response of new FS detector

	PMT Pulse	Single Pulse
Tr(ns)	0.86	1.89
Tf(ns)	2.10	2.64
FWHM(ns)	1.44	2.61

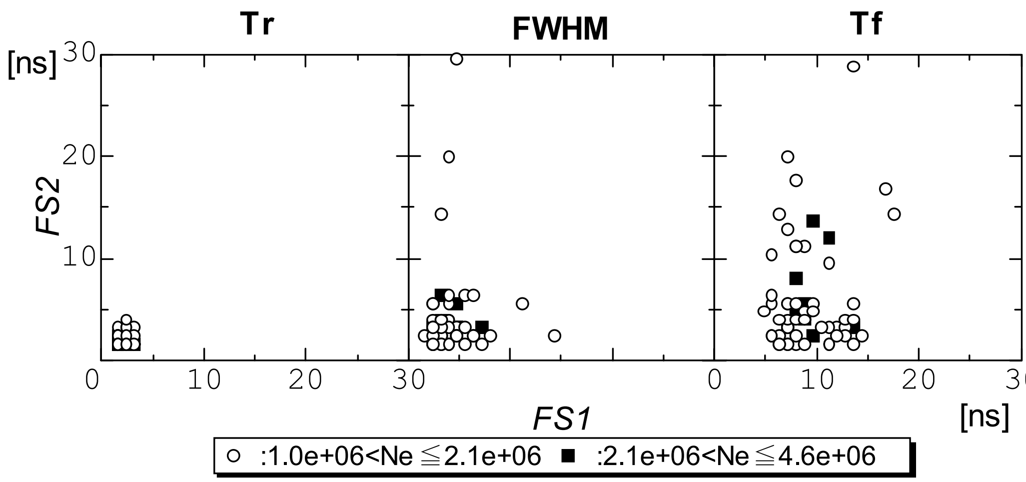

Figure 3. Response time between new FS detectors

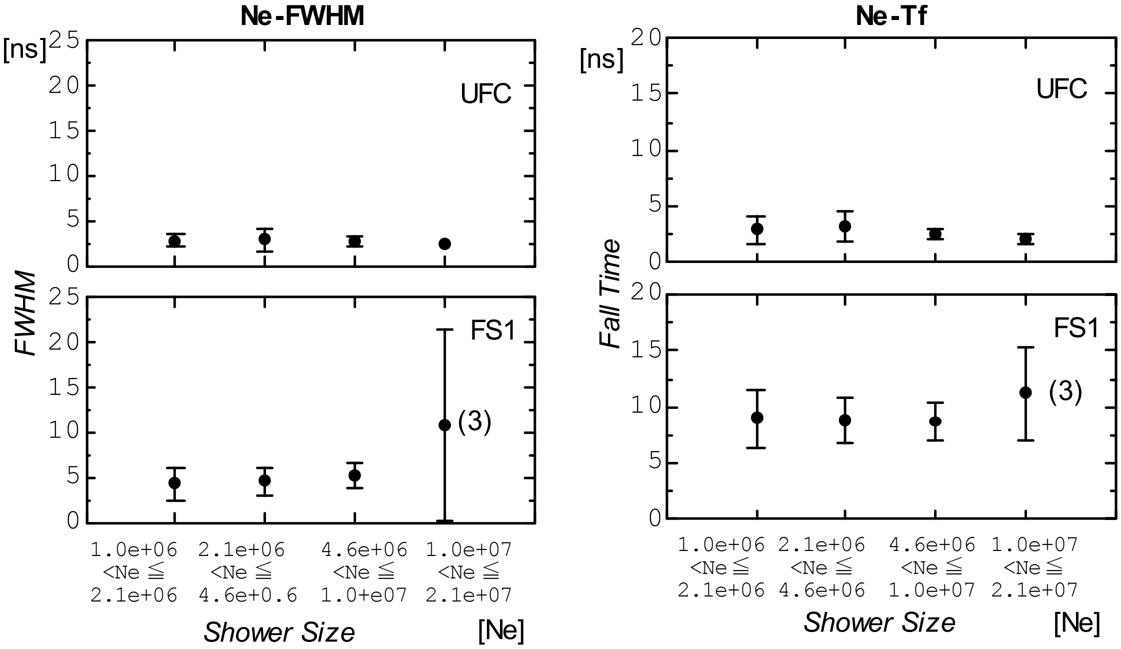

Figure 4. Relation between Ne-FWHM, Ne-Tf

Table 2. Relation between response time and Ne

	1.0e+06 < Ne ≦ 2.1e+0.6	2.1e+06 < Ne ≦ 4.6e+06	4.6e+06 < Ne ≦ 1.0e+07	1.0e+07 < Ne ≦ 2.1e+0.7
Tr(ns)	2.24	2.09	2.13	2.10
Tf(ns)	8.75	6.08	8.87	8.70
FWHM(ns)	4.30	4.52	4.64	5.23