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DELAYED PARTICLES IN EAS AT AKENO

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ABSTRACT

Using two 2.25 m^2 fast scintillation detectors, delayed particles in EAS have been observed at Akeno Observatory. These are set under 1 m concrete and 2.5 cm lead plates respectively. About 2500 EAS are analyzed. The lateral distribution of delayed particles for the EAS size $>10^7$ is flatter than that for $<10^7$. The lateral density of delayed particles is almost constant for the size range $2.2\times10^5 \sim 10^7$ and increases rapidly above 10^7.
These facts may suggest change of nuclear interaction at 10^7 and substantially the existence of heavy particles with long life.

Above 10^{15} eV delayed particles in EAS were observed near to the core, by using two 1 m^2 fast scintillation detectors telescoped.(1)(2)
These results are as follows.
Lateral distribution of delayed particles becomes flat for various EAS size ranges and lateral density for the size $<10^7$ is almost constant, while it increases rapidly $>10^7$.(3)
Relation between the frequency and the delay time for the EAS size $>10^5$ may be approximated by an exponential function. From these facts nuclear interaction for the EAS size 10^5 and 10^7 seems to change and two kinds of heavy particles with long life are claimed. The possibility of a massive particle has also been reported by measuring the arrival time distribution of electron.(4)

From the end of 1983, two 2.25 m^2 fast scintillation detectors are set at Akeno Observatory and in August, 1984 two more fast detectors(1 m^2, 2.25 m^2, respectively) are set. These are enclosed in a black housing and constructed Hamamatsu P.N. R-1250 fast photomultiplier; rise time and size of them are 3.4 ns(2000V) and 127 mm diameter. Output from them is connected with 100 MHz stragescope using a coaxial cable (11D-4AF). The recorder consists of 35 mm automatic camera. These are set under 1 m concrete and 2.5 cm lead respectively.

The experimental apparatus is shown in Fig. 1.

About 2500 EAS of the present experiment have been analyzed. The lateral distribution of delayed particles with a delay time larger than 20 ns and burst sizes more than 10 particles is shown for the EAS size range $10^5 \sim 2x10^8$, in Fig. 2. Relation between lateral density at some distance range (10-20 m) from the core axis and EAS size is shown in Fig. 3. Lateral density seems to be constant for the EAS size range $2.2x10^5 \sim 10^7$ and this is also seen in the other distance range from the core axis.

If the observed delayed particles are fluctuations of ordinary hadrons in EAS, their lateral density should increase with EAS size. Nevertheless it is almost constant for the EAS size range $2.2x10^5 \sim 10^7$ and increases rapidly above 10^7. From this, in $10^5 \sim 10^7$ and above 10^7 nuclear interaction seems to change and two kinds of heavy particles with long life seem to contribute for every new interaction.

An example is shown in Fig. 4 for which two detectors have two same delay signals in EAS with size 10^8 at a distance of 42 m from the core axis.

References

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(2) H. Sakuyama and K. Watanabe : Lett. Nuovo Cimento 36, 389 (1983)

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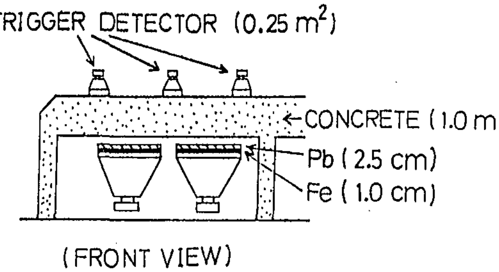
Fig. 1 Two 2.25 m^2 fast scintillation detectors



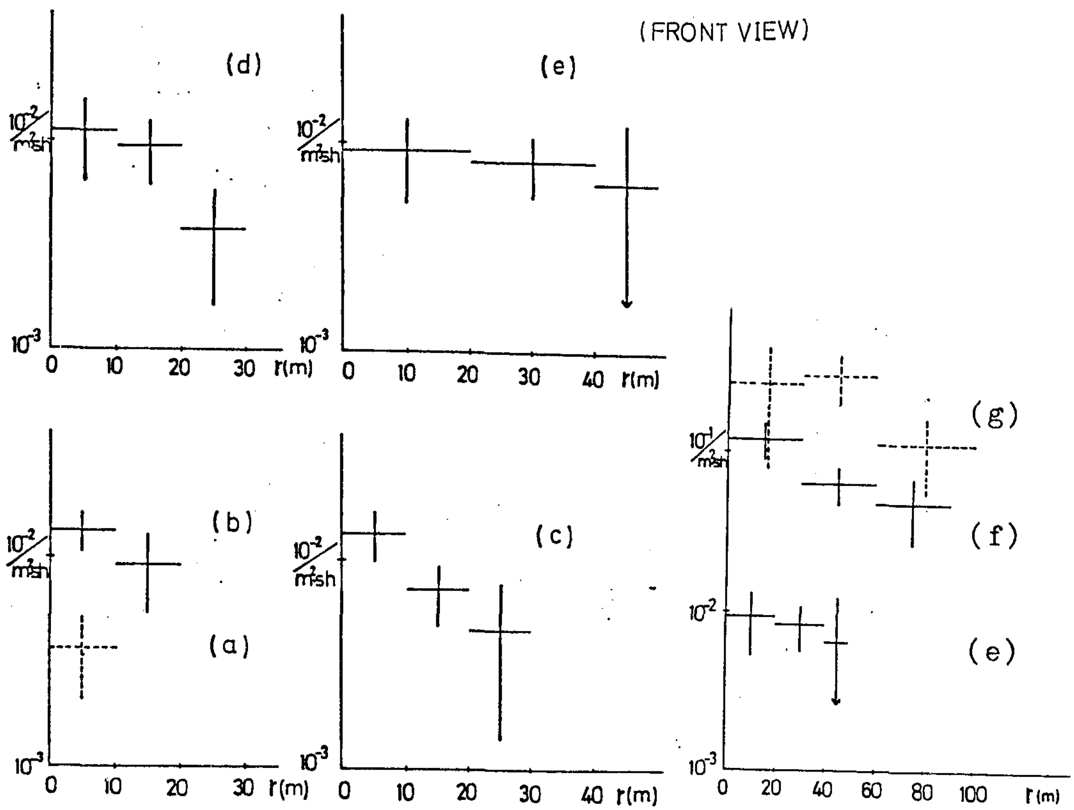


Fig. 2 Lateral distribution of delayed particles with a delay time larger than 20 ns and burst sizes more than 10 particles.

(a) $10^5 < Ne \leq 2.2x10^5$, (b) $2.2x10^5 < Ne \leq 4.8x10^5$,
(c) $4.8x10^5 < Ne \leq 10^6$, (d) $10^6 < Ne \leq 2.2x10^6$,
(e) $2.2x10^6 < Ne \leq 10^7$, (f) $10^7 < Ne \leq 4.8x10^7$,
(g) $4.8x10^7 < Ne \leq 2x10^8$

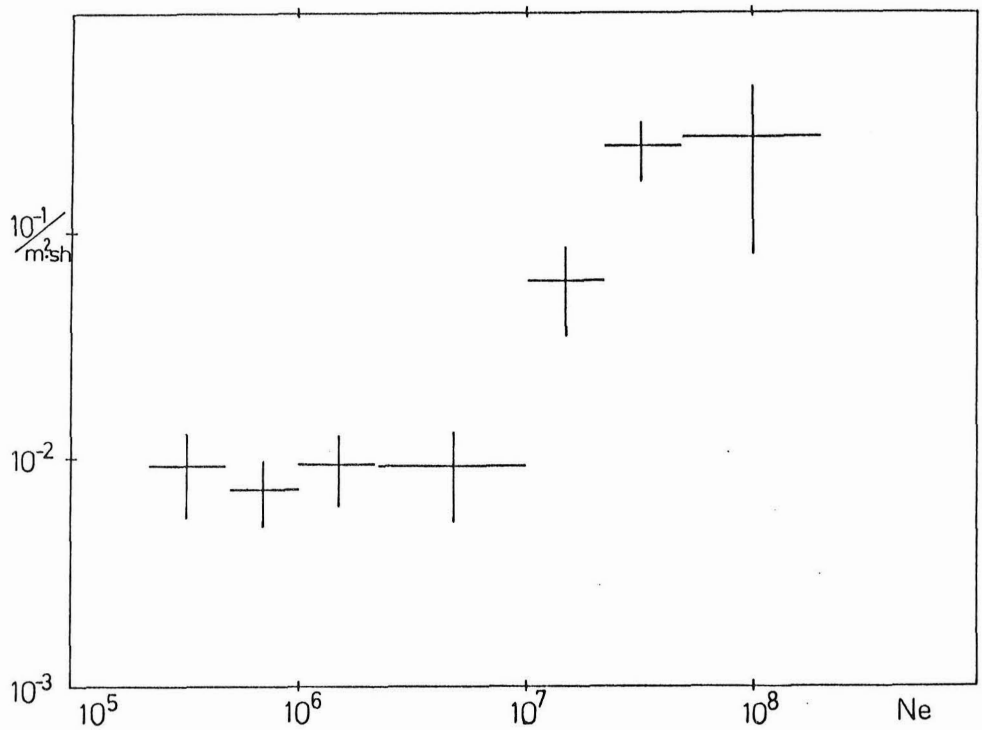


Fig. 3 Relation between EAS size and lateral density at 10-20 m from the core axis

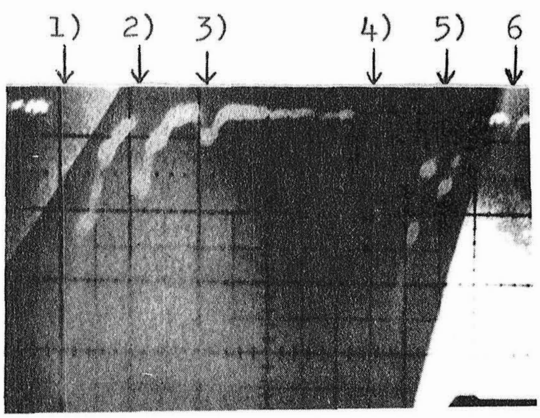


Fig. 4
An examle; two fast detectors have two same delay signals in EAS with size 10^8 at a distance of 42 m from the core axis.

1) No delay signal of fast detector.
2) Delayed signal with the time of 62 ns from signal 1) with the burst size of 43 particles. 3) Delayed signal with 107ns from 1) with 16 particles. 4) No delay signal of another fast detector. 5) Delayed signal with 62 ns from signal 4) with 12-16 particles. 6) Delayed signal with 109 ns from signal 4) with 4 particles.