THE NAGOYA COSMIC-RAY MUON SPECTROMETER III

I PRELIMINARY OBSERVATIONS

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ABSTRACT

1.Introduction. There are some discrepancies among the data of absolute muon intensities at large zenith angles. Through the analysis of the data obtained in the previous measurement by Nagoya Cosmic Ray Spectrometer (II), we have found one of the sources of these discrepancies to be the ambiguity induced by the selection criteria with which "genuine" muons are distinguished from the backgrounds. To remove the ambiguity of this kind, it is necessary to know the amount of the backgrounds and their characteristics in detail.

At Paris conference, some features of the background events were reported from the observations by using this triggering system of Nagoya Cosmic Ray Spectrometer(III).

In this paper, the results of extended observations using track detector together with this system will be reported.

2.Experimental method. The trigger counter system consists of 1)outer trays(Sc1,Sc8 in Fig.1) placed at a distance of 5m from each other and 2)3 pairs of inner trays (Sc2,Sc5; Sc3,Sc6 and Sc4,Sc7 in Fig.1) placed on both sides of the magnet. The arrangement of them is shown Fig.1.

2 fold coincidence composed of outer trays determines the direction of incident particle with the time-of-flight method. At least one of the 3 pairs of inner trays has to be make a 2 fold coincidence.

If the delay time of T.O.F.method is set for 17nsec (corresponds to the distance 5m between outer trays), the events which satisfy conditions can be regarded as the horizontal muon passages.

The possible coincidences can be divided into 13 patterns of scintillator trays (No.1~No.13 in Fig.2). In addition to these, the sum of 12 patterns (No.2~No.13) is also given (No.14).

Counting rate of each pattern was measured at various delay times of

T.O.F. system and some examples of experimental results are shown in Fig. 3. It is shown that backgrounds can be considered the mixture of local shower (low density) and air shower (high density).

3. Analysis. On the basis of these experimental results, following estimations for counting rates of shower trigger events are given.

The frequency of showers that incident at zenith angle Z with density of particle between Δ and $(\Delta+d\Delta)$ in solid angle $d\Omega$, $f(Z,\Delta)d\Delta d\Omega$, will be approximated as follows,

$$f(Z,\Delta)d\Delta d\Omega = f_0 \cos^N Z(\Delta+\Delta_0)^{-\gamma} d\Delta d\Omega.$$

where $f_0 \cos^N Z$ and $(\Delta+\Delta_0)^{-\gamma}$ represent zenith angle distribution and density spectrum, respectively. If particle density is assumed to be uniform on a shower front, the coincidence rate can be expressed as a function of delay time, τ.

$$C(\tau)d\tau = 2f_0 \cdot 1/\tau m \cdot \{1-(\tau/\tau m)^2\}^{N/2} dt \int_0^{\pi/2} \cos^N \psi \cdot P \cdot d\psi d\Delta .$$

where P is a detection probability for each coincidence condition listed in Fig. 2. Using $C(\tau)$, practical counting rate of shower trigger events at each delay time can be expressed as follows,

$$F(\tau)d\tau = \frac{1}{\sqrt{2\pi}\sigma}\int_{-\infty}^{\infty} C(\tau')\, e^{-\frac{(\tau-\tau')^2}{2\sigma^2}}\, d\tau' .$$

where σ is the time resolution of detector including the fluctuation of shower front.

In above calculations, N, γ, Δ_0 and σ are included as parameters which describe the characteristics of shower. $F(\tau)$ is calculated for local shower ($F^L(\tau)$) and air shower ($F^A(\tau)$) respectively, and from these calculations counting rate $I^{cal}(\tau)$ which is comparable with experimental data can be expressed as follows,

$$I^{cal}(\tau) = \alpha_L \cdot F^L(\tau) + \alpha_A \cdot F^A(\tau)$$

where both of α_L and α_A are constants. From $I^{cal}(\tau)$ and experimental data $I^{exp}(\tau)$ around 0 nsec, chai-square value was calculated and 4 parameters for each of local shower and air shower were determined at chai- square minimum. α_L and α_A were also determined by the least square method between $I^{cal}(\tau)$ and $I^{exp}(\tau)$. The results are shown as follows.

	N	γ	$\Delta_0 (m^{-2})$	σ (ns)	f_0 ($h^{-1} \cdot sr^{-1} \cdot m^{-2}$)
local shower	2	4.5	0.07	6.5	1.88×10^3
air shower	7	3.0	5.0	6.5	3.84×10^5

4.Conclusions. It is found that one of the sources of the discrepancies among the data of absolute muon intensities is to be the ambiguity induced by the selection criteria.

Some features of the background events which are considered to be the mixture of the showers, air shower and local shower, with different density spectra and diffrent zenith angle dependence, are obtained.

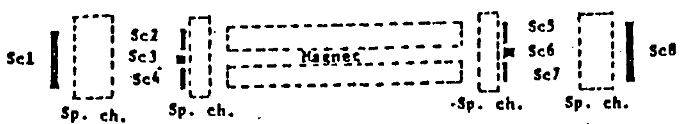

Fig.1, Arrangement of scintillator trays (top view)

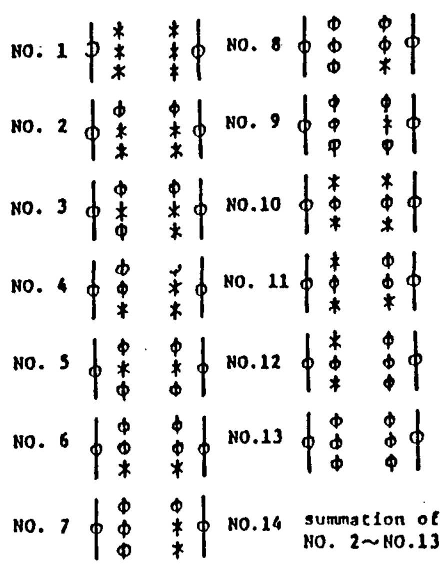

Fig.2,Patterns of coincidences

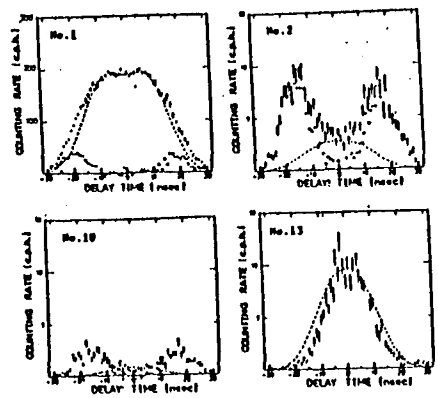

Fig.3, Counting rates of coincidences(examples)

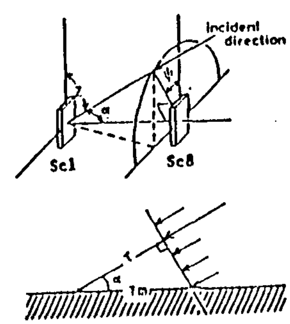

Fig.4