1. Observation Site

The multi-direction cosmic ray telescope is located inside the Upper Air Measuring Instruments Building of the Meteorological Research Institute, Tsukuba. This buiding has a flat-roof and is made with iron frames and 100 mm thick ALC (Autoclaved Light Weight Concrete, ~0.55 g/cm³). The building has an air conditioning system. Geographic and geomagnetic parameters of the observation site are given in Table 1.

Table 1 Location of Observation Site

Geographic	Latitude	36°03'N	Longitude	140°08'E
	Altitude	22 m above sea level		
Geomagnetic	Latitude	26.3°	Longitude	207.6°

2. Multi-Directional Cosmic ray Meson Telescope

The multi-directional cosmic ray telescope contains 32 detectors. Fig.1 shows arrangement of these detectors. There are 4 layers, each containing 8 detectors. The four layers are named A, B, C, and D from top to bottom. In each layer, 4 detectors are aligned in the geographic east-west direction and 2 detectors are aligned in the geographic north-south direction. The detectors in the southern row are named 1, 2, 3, and 4 from west to east, and those in the northern row are named 5, 6, 7, and 8 from west to east. The detectors are, therefore, named Al,...., Bl,...., Cl,...., and Dl,..... Lead (Pb) blocks (100 mm thickness) and 4.5 mm iron plates are set in the middle of the lower two layers C and D in order to absorb the soft component of cosmic rays. Each detector has 4 plastic scintillators (500 mm×500 mm×100 mm), making up a 1 m² effective area, set in the bottom of an iron plate box (1.2 mm thickness). These four plastic scintillators are viewed by a 5-inch photo-multiplier (HAMAMATSU R877).

3. Measuring System

A block diagram of the measuring system for the multi-directional cosmic ray telescope is presented in Fig.2. Signals from each photo-multiplier are amplified and are made into 0.5 microsecond rectangular pulses by a pulse shaper after passing through a discriminator. Seven components (vertical, 22°south, 22°north, 19°west, 19°east, 34°west, and 34°east) are constructed with signals from the 32 detectors. Twofold coincidence between the A layer and the B layer, i.e., T1 (A1, B1),....,T8 (A8, B8), and twofold

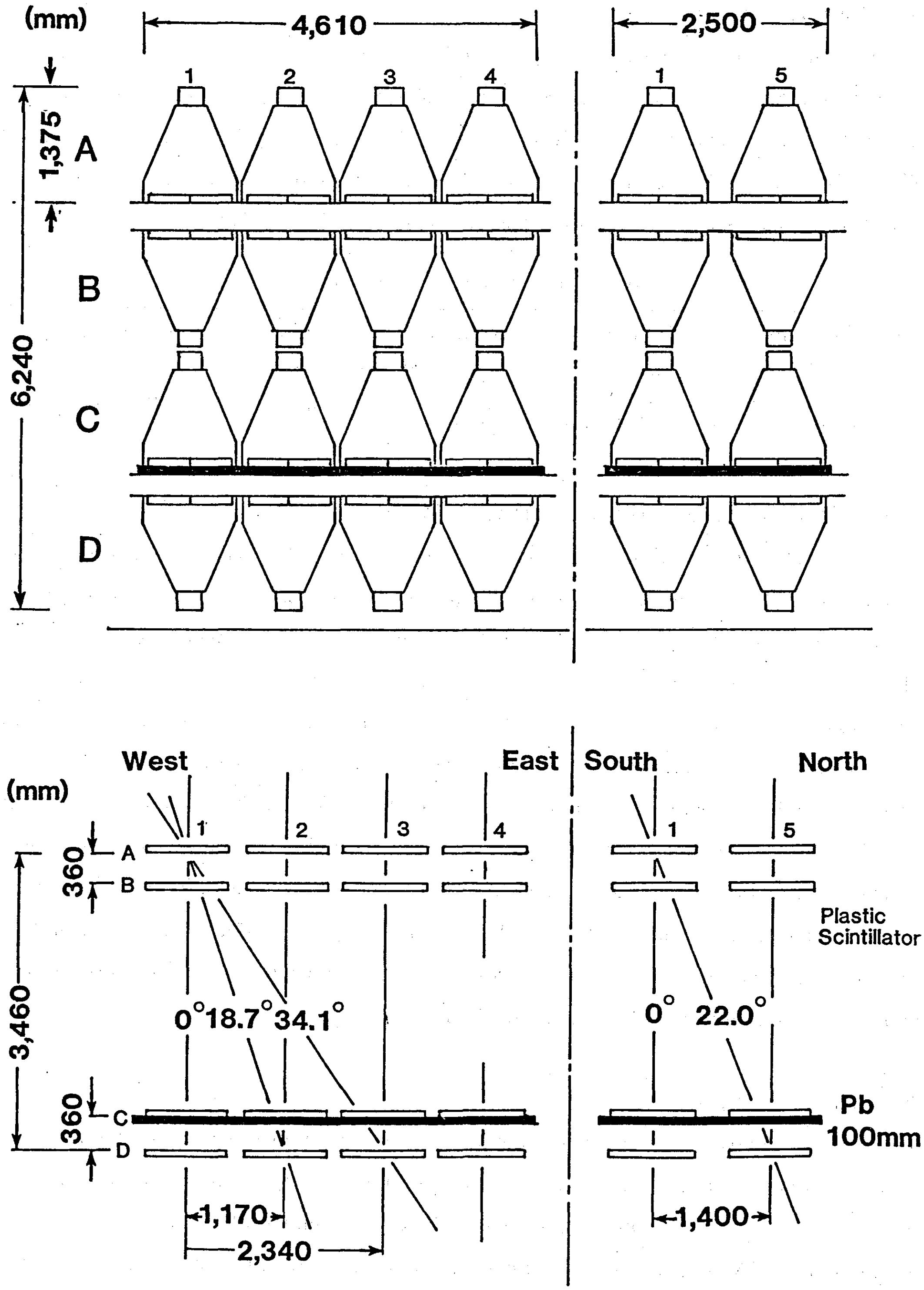

Fig. 1 Arrangement of detectors in the multi-directional cosmic ray meson telescope at Tsukuba. West-East view and South-Nouth view.

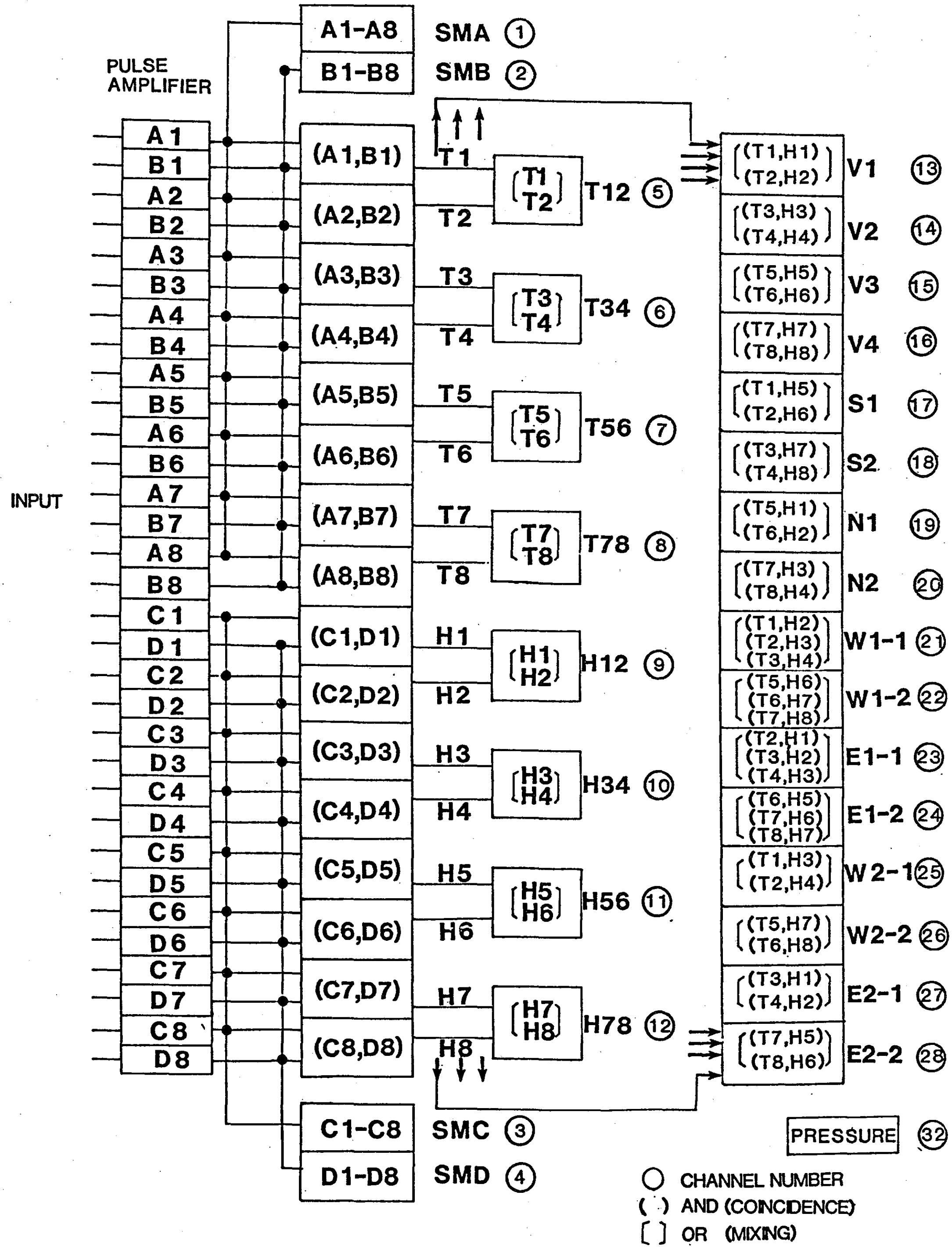

Fig. 2 Block diagram of the measuring system for the multi-directional cosmic ray meson telescope.

concidence between the C layer and the D layer, i.e., Hl (Cl, Dl),....,H8 (C8, D8), are made in the first stage. The total vertical component (soft component + hard component) has 4 channels T12, T34, T56, T78, made by mixing of T1,....,T8 and the hard vertical component has four channels H12, H34, H56, H78, made by mixing of H1,...,H8. The vertical component has 4 channels V1, V2, V3, V4, made by twofold coincidence between the upper 2 layers and the lower 2 layers. The other components have 2 channels for each. For example, 22° south component has 2 channels S1 and S2. S1 is made with twofold coincidence between T1 and H5 or twofold coincidence between T2 and H6 ((T1, H5) or (T2, H6)). The sum for each layer is made for monitoring the system and the outputs are called SMA, SMB, SMC, and SMD. The atmospheric pressure is measured by a barometer inside the building and the data are recorded in channel 32. The pressure data are occasionally checked by using the data from tha Aerological Observatory, separated by approximately 200 m. Scaling process is used in recording the data for convenience. Table 2 summarizes the channels for each component with scaling factor and cut-off rigidity. Cut-off rigidity for each component is calculated using the procedure by Shea et al. (1965). Asymptotic directions for 5 components are calculated using the procedure by Inoue et al. (1981), and the results are presented in Fig.3.

Table 2 Channels, Scaling Factor, Cut-Off Rigidity for Each Component

Channel					Component		Scaling Factor	Cut-off Rigidity GV
1 – 4	SMA	SMB	SMC	SMD			1000	
5 – 8	T12	T34	T56	T78	vertical (total)		100	11.33
9 – 12	H12	H34	H56	H78	vertical (hard)		100	11.33
13 – 16	V1	V2	V3	V4	vertical		100	11.33
17 – 18	S1	S2			south	22.0°	10	11.05
19 – 20	N1	N2			north	22.0°	10	11.20
21 – 22	W11	W12			west	18.7°	10	11.01
23 – 24	E11	E12			east	18.7°	10	14.09
25 – 26	W21	W22			west	34.1°	10	9.10
27 – 28	E21	E22			east	34.1°	10	16.77
32					atmospheric pressure			

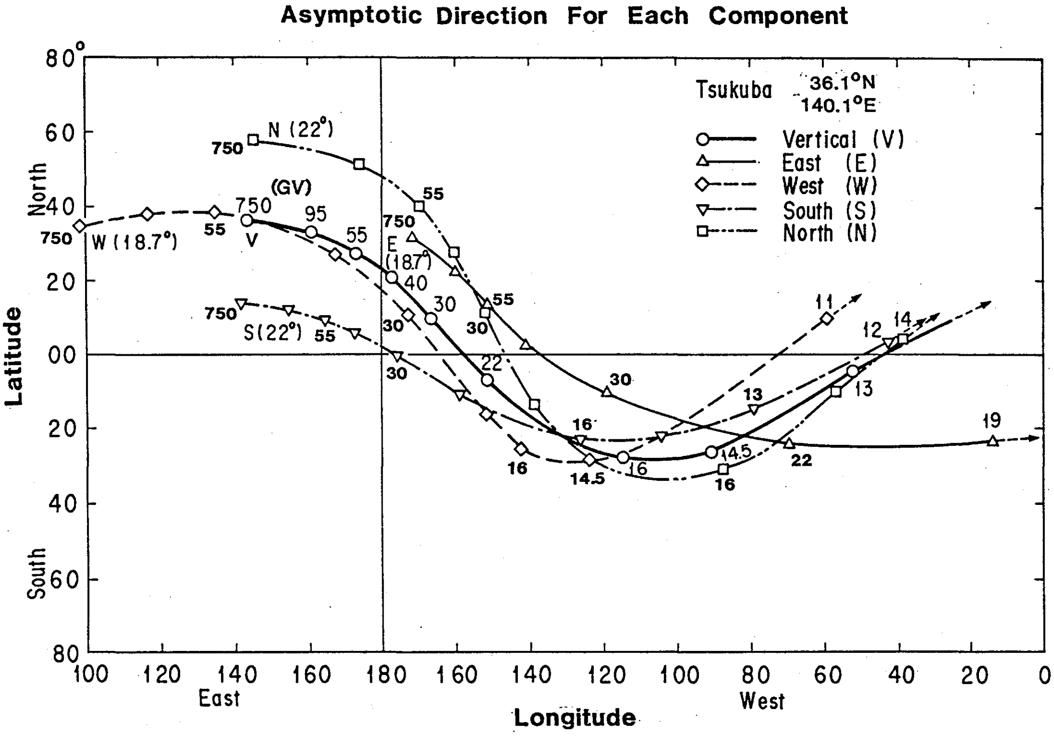

Fig. 3 Asymptotic direction traces for five direction components.
Rigidities are indicated by numbers.

4. Data

Hourly counting rates from each channel and hourly average pressure value are recorded. Pressure-corrected counting rates are obtained by the following:

$$C_p = C / \exp(\beta (P - P_B)) \qquad \beta < 0$$

C_p pressure-corrected counting rate

C raw counting rate

β pressure coefficient

P pressure

P_B basic pressure (1000 mb)

For simplicity, 1000 mb is adopted for P_B. Pressure coefficient are obtained from the data of 1984 and summarized in Table 3.

Table 3 Pressure Coefficients

vertical (all)	− 0.176 %/mb
vertical (hard)	− 0.150
vertical	− 0.154
22° south and north	− 0.157
19° west and east	− 0.157
34° west and east	− 0.162

The component data are represented using the natural logarithmic representation by Wada (1957) as follows.

$$C_F = 10^2 \times \mathrm{Ln}(C_p / C_o) + 15.00 \ \%$$

C_F relative intensity

C_p pressure-corrected counting rate

C_o base counting rate

The relative intensity is presented in percentages and 15.00 % is artificilly added to make all values positive. There were several troubles in the system and level changes caused by adjustment of the instruments in the observation period. Some channels are excluded to obtain the component data. Table 4 summarizes the channels used and Table 5 summarizes base counting rates.

Table 4 Cannels Used For Component

	vertical						south 22°		south 22°		east 19°		west 19°		east 34°		west 34°	
83 1 1																		
	T12	T34	H12	H34	V1	V2	S1	S2	N1	N2	E11	E12	W11	W12	E21	E22		W22
	T56	T78	H56	H78	V3	V4												
83 5 25																		
	T12	T34	H12			V2	S1	S2		N2	E11		W11		E21	E22	W21	W22
		T78	H56			V4												
83 12 31																		
	T12	T34	H12			V2	S1			N2	E11		W11		E21		W21	W22
		T78	H56			V4												
84 12 21																		
	T12	T34	H12			V2	S1			N2	E11		W11		E21		W21	W22
		T78				V4												
84 12 30																		
	T12	T34	H12	H34	V1	V2	S1			N2	E11		W11		E21		W21	W22
	T56	T78	H56		V3													
85 7 21																		
	T12	T34		H34		V2	S1				E11				E21			W22
	T56		H56		V3													
86 12 31																		
	T12	T34		H34		V2	S1				E11				E21			W22
	T56		H56		V3													
86 1 7																		
	T12	T34	H12	H34	V1	V2	S1	S2	N1	N2	E11	E12	W11	W12	E21	E22	W21	W22
	T56	T78	H56	H78	V3	V4												

Table 5 Base Count Rates

	vertical			south 22°	nouth 22°	east 19°	west 19°	east 34°	west 34°
1983 1 1	5335	4377	263	1454	1179	2758	2206	571	502
1983 5 25	5563	4848	311	1567	1556	2953	2853	587	525
1983 12 31	5678	4848	311	1567	1556	2953	2982	587	537
1984 10 21	5678	4719	311	1567	1556	2953	2875	587	537
1984 12 30	5683	4907	311	1644	1556	2904	2934	587	545
1985 7 21	5706	4995	314	1672	–	2942	–	598	527
1085 12 31	5844	4995	329	1703	–	2987	–	602	535
1086 1 7	5735	4824	329	1598	1556	2894	2856	591	562

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