

An Underground Cosmic Ray Muon Telescope
for Observation of Cosmic Ray Anisotropy

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Abstract

A telescope housed in a tunnel laboratory has an overburden of 573 hg cm^{-2} and is located under the centre of a saddle-shaped landscape. It is composed of triple layers of proportional counters, each layer of area $\sim 4\text{m} \times 2\text{m}$ and their separation 0.5m . Events are selected by triple coincidence and software track identification. The telescope is in operation for over a year and the overall count rate is 1280 hr^{-1} . The structure and operation of the system is reported.

1. Introduction. Construction of a cosmic ray muon telescope in a road tunnel laboratory on Hong Kong Island was proposed in 1979¹ for the purpose of measuring high energy cosmic ray sidereal variations in the light of similar experiments at Poatina² and Utah³. The work was delayed due to the tunnel construction, but was finally in operation since August 1983.

The laboratory site is under a saddle-shaped landscape with a vertical rock overburden of 573 hg cm^{-2} (including the atmospheric depth). Two hill peaks of height $\sim 420\text{m}$ limits the East-West zenith view. The North-South profile of the 'saddle' is given in figure 1. With the detectors (proportional counters) placed along E-W direction, 23 directional bins are obtained in the N-S profile.

The experiment is expected to run continuously for three more years in order to obtain statistically significant data. A preliminary data analysis is given at this Conference (OG5.3-9). This paper only reports on the structure and operation of the system.

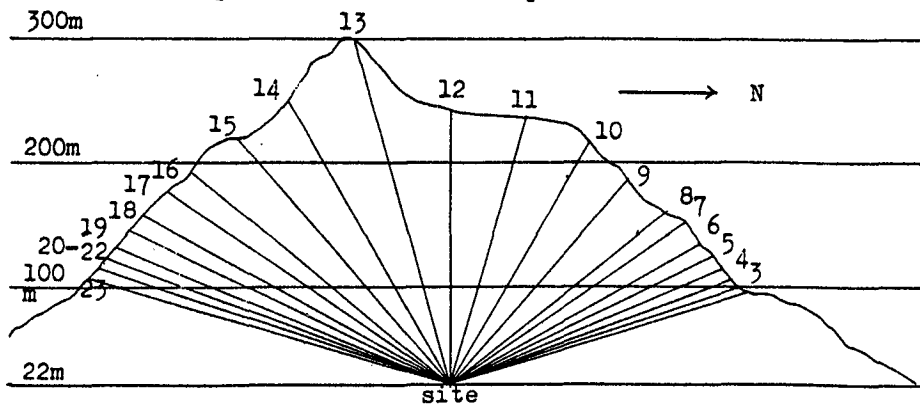


Fig. 1 The N-S profile of the landscape.

2. Detection system. Large area proportional counters (2m x 7.6cm dia.) are used. The counter body is made of 0.16cm thick stainless steel with 50 μ m stainless steel anode wire under 100g tension. The tube is filled with a standard P-10 gas at 1 atmospheric pressure. Figure 2 shows the arrangement of the counters with 48 tubes in one layer. The whole assembly is covered by lead sheets to minimize soft radiation from the tunnel rocks.

The counters are operated at the limited proportional region (EHT = +2600 V) and the single count rate is $\sim 80 \text{ s}^{-1}$. Operation of the counters is indicated hourly by a monitor spectrum described in later sections. Long term drift due to slow aging is found insignificant.

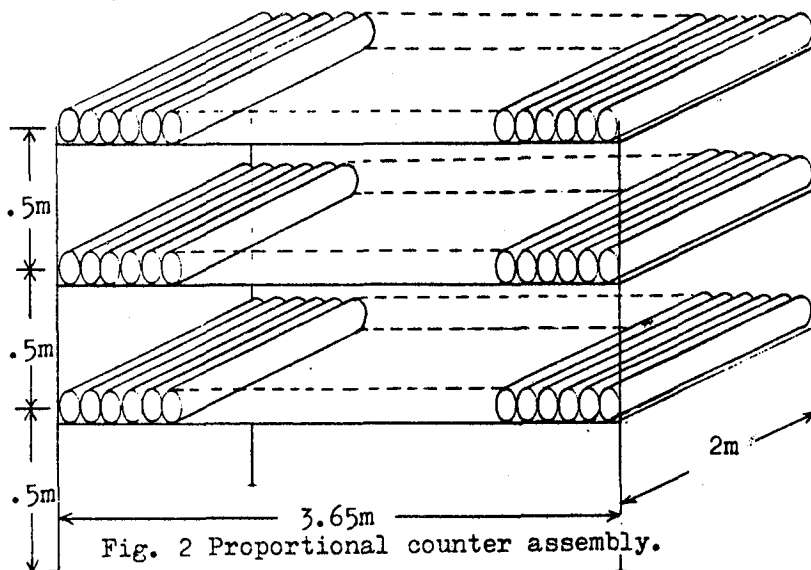


Fig. 2 Proportional counter assembly.

3. Electronics. Each proportional counter has its own pre-amplifier, and they are binned together with 4 counter in one bin shown in figure 3. For more precise track identification, counters in the middle layer are binned in two ways A and B as shown.

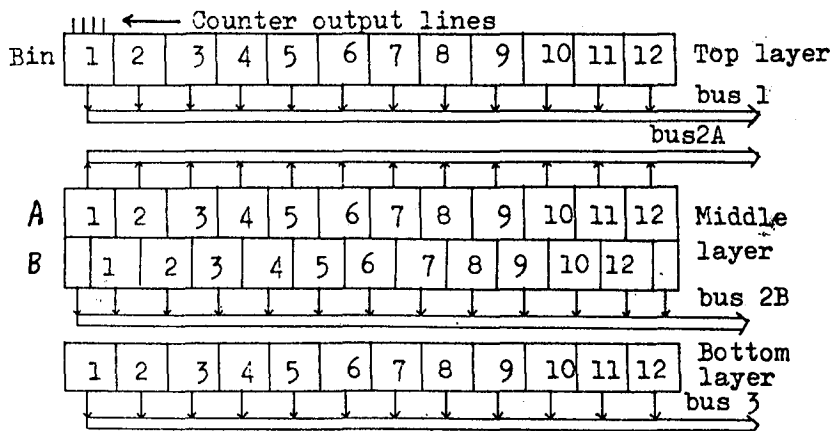


Fig. 3 Counter output bins.

The digital system mainly consists of counter latches, a triple coincidence system and three microprocessor systems MPS (Motorola 6800) as shown in figure 4.

The coincidence unit with window $1.14 \mu\text{s}$ provides the required master pulse which commands holding of the counter information in the latches and starts a series of operations in the three MPS systems. The wires in each input bus to the coincidence unit are ORed before entering the unit. MPS1 reads the latched counter information and sends the raw data to the remote system MPS2. If MPS2 is busy, the data is temporarily held in the MPS1 output buffer. MPS2 accumulates hourly a muon directional spectrum and a monitor spectrum of individual bin counts. It also keeps time and date; and for visual checking, it can provide an option of slow video display of particle tracks in a current event. The triple coincidence rate, the two spectra and the time and date are finally transferred to MPS3 which stores them hourly in floppy disks and hard prints.

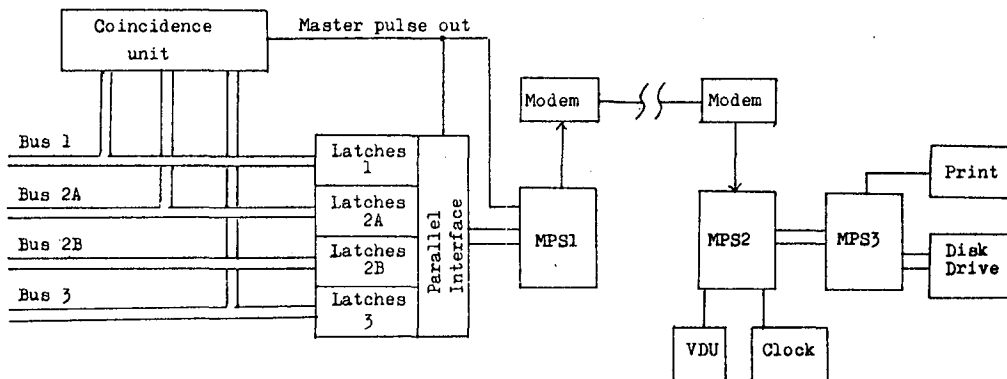


Fig. 4 The digital system.

4 Data collection. From the single count rate and the triple coincidence time window, the chance rate is about 800 hr^{-1} , which is very significant when compared with the corrected event rate of 1280 hr^{-1} . Hence software particle track identification is carried out in MPS2 as follows:

The counter bins in each layer are labelled from 1 to 12 (see figure 3). If a muon traverses Bin p on the top layer and Bin q on the bottom layer, the track direction is given by the number $N = (p-q)$. Thus the directional spectrum contains 23 bins ranging from $N = -11$ to $+11$. The track identification criteria are (i) the top layer or the bottom layer should not have more than two bins fired. (When a bin fires, its latch stores a '1', otherwise a '0'); and (ii) the track must pass through a fired bin on the middle layer, either among bins in A if the number N is even, or in B if N is odd).

The monitor spectrum contains the accumulated counts during triple coincidence from each counter bin. The count

rate in each bin therefore depends on the bin location. But the spectral shape should not vary if the counters are operating normally. This determines the data reliability.

5. Comparison and discussion. The table below compares the experimental system with those at Utah and Poatina.

	Hong Kong	Utah	Poatina
Site latitude	22.2° N	40.6° N	41.8° S
Effective depth/hg cm ⁻²	573	486	365
Vertical threshold muon energy/GeV	157	121	~80
Median regidity/GV	1915	1500	~1000
Effective area/m ²	7	37	4
Total counts	1.27.10 ⁷	1.52.10 ⁸	--

From the particle track identification criteria, it is obvious that showers and local bursts are excluded and so are the chance events. However, the second particle identification criterion was considered to be too restrictive which could exclude some genuine events due to deviation in the counter alignment. This criterion was then relaxed by including the neighbouring bins on the middle layer. This relaxation only results in a chance coincidence of 1.4 counts per hour. The merit of this system over a scintillator system is that all particle tracks are identified first before acceptance.

6. Acknowledgement. We are grateful to the Hong Kong Royal Observatory for the continuous supply of meteorological data, the Public Works Department and the Transport Department of Hong Kong for the construction and maintenance of the tunnel laboratory.

References.

1. Ng L K et al, Proc. 16th ICRC (Kyoto) 4 (1979) 232.
2. Fenton A G et al, Proc. 15th ICRC (Plovdiv) 11 (1977) 242.
3. Bergeson HE et al, Proc. 16th ICRC (Kyoto) 4 (1979) 188.