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HYBRID TLC-PAIR METER FOR THE SPHINX PROJECT

Tomonori Wada
Okayama University, Japan
Isao Yamamoto and Nobusuke Takahashi
Okayama University of Science, Okayama Japan
Akeo Misaki
Saitama University, Urawa Japan

1. Introduction. The chief aims in THE SPHINX PROJECT are research of super lepton physics and new detector experiments. At the second phase of THE SPHINX PROJECT, we designed a hybrid TLC-PAIR METER for measuring vertical muon spectrum in the muon energy range 10 – 100 TeV, searching high energy neutrino sources ($E\nu$ > * TeV), searching high energy muon sources ($E\mu$ > 1 TeV) and measuring muon group ($E\mu$ > 1 TeV).

The principle of "PAIR METER" has been already proposed[1,2,3]. In this TLC-PAIR METER, electromagnetic shower induced by cosmic ray muons are detected by using TL (Thermoluminescence) sheets with position counters.

2. Designe of TLC-PAIR METER One cell of TLC-PAIR METER is shown in Fig. 1 and one unit is composed of 14 cells. The full-scale is composed of 18 units which is shown in Fig. 2. The cell TLC-P.M. consists of a) trigger and time measurement counters (scintillation counter, 3 layers), b) XY-position counters (Proportional chamber, 9 layers) and TL calorimeters (TL-sheets + 14 cm irons, 40 layers). An old type PAIR METER consisted of PRC calorimeter (proportional counters + 14 cm irons, 32 layers)[4].

The following table is the comparison one between a TLC and a PRC for 40 layers-PAIR METER.

Items	Prototype P R C	Hybrid-type T L C
Detector Height (m)	9.6	6.5
Detectable Efficiency	1.0	2.2
Number of Position Counters	41	9
Budget for counters and electronics (PRC-Amp. ADC, Discri, CAMAC System)	140 k$	60 k$

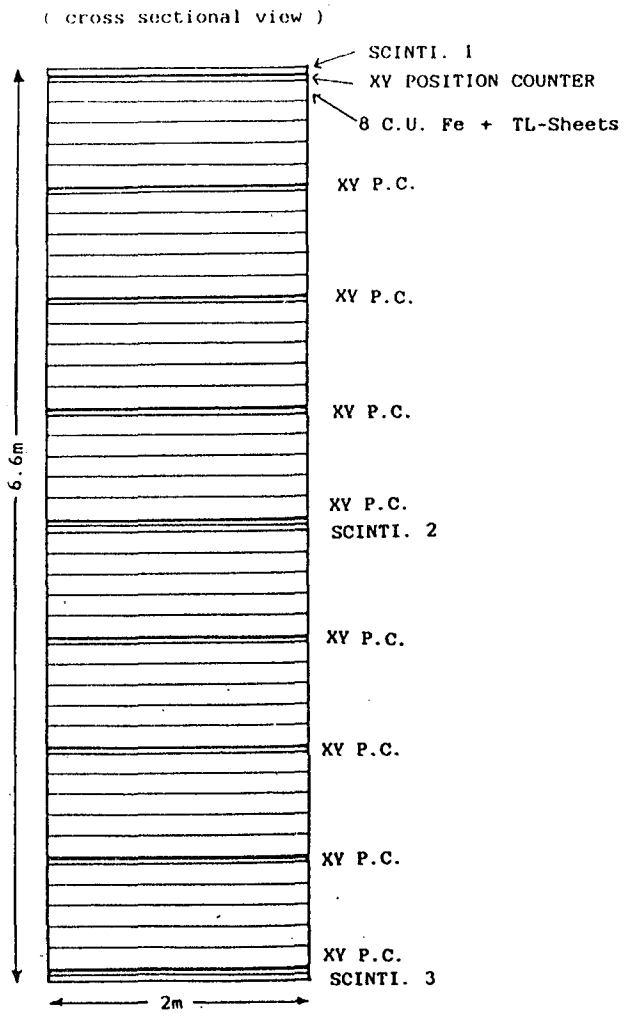

Fig. 1. One cell of TLC-PAIR METER. One cell size is 2 m x 2 m x 6.6 m. One unit of TLC-PAIR METER consists of 14 cells. TL-sheets which position counters indicate muon path are read out.

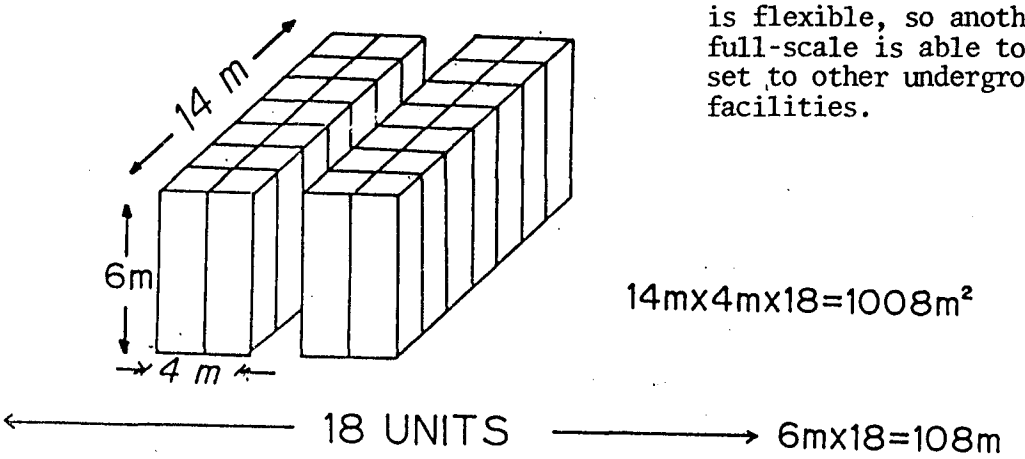

Fig. 2. The full-scale of TLC-PAIR METER. This scale is set to Gran Sasso Laboratory. A full-scale of TLC-PAIR METER is flexible, so another full-scale is able to be set to other underground facilities.

3. Simulations of TLC-PAIR METER For the PAIR METER, iron absorber is better than lead absorber and a thickness of one layer should have one nuclear mean free path, that is 14 cm; 8 C.U. The cell of PAIR METER shown in Fig. 1 has 40 layers, to attain little statistical fluctuation. Under these condition, various simulations have been performed. One of simulations is shown in Fig. 3. This figure shows that an incident muon energy ($E\mu$) relates to mean electron number ($\overline{Ne}$) of electromagnetic shower induced by a cosmic ray muon passing through 14 cm x 40 layers. By measuring $\overline{Ne}$ at PAIR METER, one can determine the $E\mu$ value with ± 30 %.

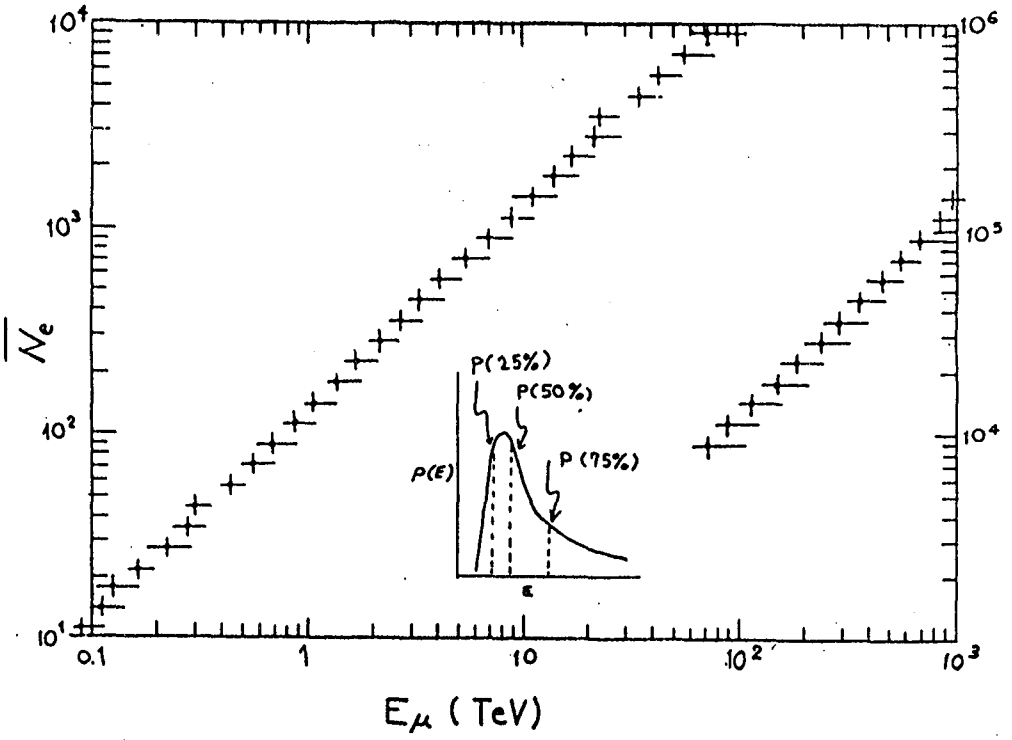

Fig. 3. Results of simulation to determine $E\mu$. In this case, vertical muon spectrum was used as $E\mu^{-2.7}$.

4. Detecting small shower In the 2nd phase of THE SPHINX PROJECT = a hybrid TLC-PAIR METER, the most important technique is to detect small electromagnetic showers induced by a high energy muon on a TL-sheet.

We tried to read out from a TL-sheet irradiated ^{90}Sr β-ray which is equivalent to electron number of 20 GeV shower and this sheet was already exposed by cosmic rays, background for one year at Mt.Norikura.

The " RAW DATA [f] " in Fig. 4 is a integrated frame picture. This irradiated sheet was read out by TL spatial distribution read out system[5]. The [f] corresponds to "Matrix" and each picture cell correspond to matrix

element. $[f_i]$ is an i-th frame picture, $\Sigma [f_i] = [f]$. $[S]$; S-matrix of standard Hadamard matrix, $[H]$.

$[S] \cdot [f_i] = [F_i]$; Hadamard transformed matrix,

$[F'_i]$: the treated matrix; when a matrix element has small value, that element reduces to zero.

$\Sigma [F'_i] = [F']$, $[S]^{-1} \cdot [F'] = [f']$

The matrix $[f']$ is a new frame picture applied Hadamard Transform Technique [HTT]. In Fig. 4, the frame picture $[f']$ after HTT is clearer than the $[f]$ for the shower position; the use of mutual-correlation at frame picture is effective to higher "Signal/Noise Ratio".

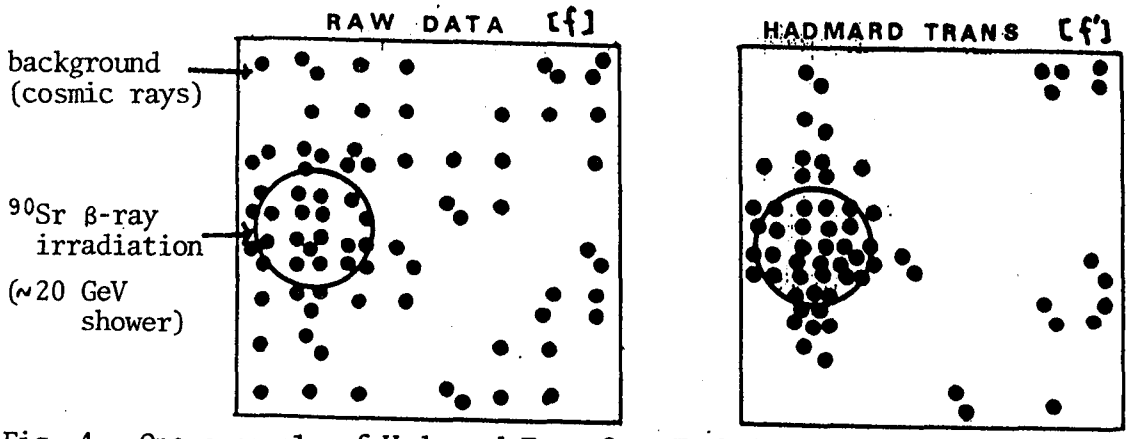

Fig. 4. One exsample of Hadamard Transform Technique.

5. Conclusions This TLC-PAIR METER proposal [Japan-Italy Colaboration] approved by the Gran Sasso International Committee. So, simulations are continued to attain more precise estimation-value and to select more suitable design. The HTT will be applied for frame pictures of real showers induced by muons.

References

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