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Performance of the Surface Scintillation Detector for The Telescope Array

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Systematic measurement on basic characteristics of surface detectors have been done in detail. These test are quite essential for reducing the systematic error in estimating the total number of charged particles in a giant air shower, so energy of primary cosmic rays. Some of those things, such as position sensitivity and temperature dependence of scintillation detector and surface sensitivity map of photo tubes were also measured. We found that all of these variation is within 10 to 15% and total performance of our scintillation systems are well inside our expectation.

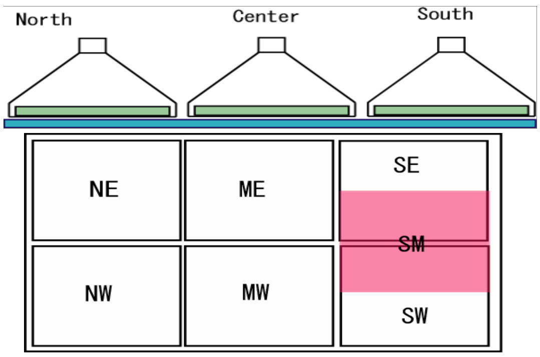
1. Introduction

The temperature at Utah's Delta county varies from around –10 degree to well over 35 degrees. Our measurement system should give reasonable response under this severe condition and stand for long time operation, say 10 years. In order to minimize the systematic error on energy estimation of primary ultra high energy cosmic rays the characteristics of surface scintillation detector have to be investigated thoroughly. Most of the case MC calculation should be adopted to deduce the energy of primary cosmic rays. There are several features that causes the error, for example, uniformity variation along with the surface of scintillator, since our SD has 3 m2 area. Temperature dependence of SD's out put signal is thought to be large enough to be corrected properly. Short time variation of these PMT's output can be monitored and corrected utilizing the monitored data such as pulse height distribution of

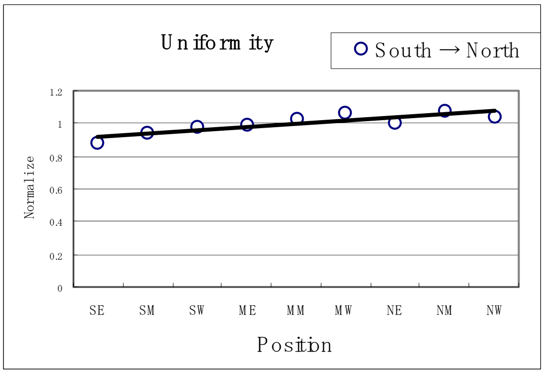
2. Measurements

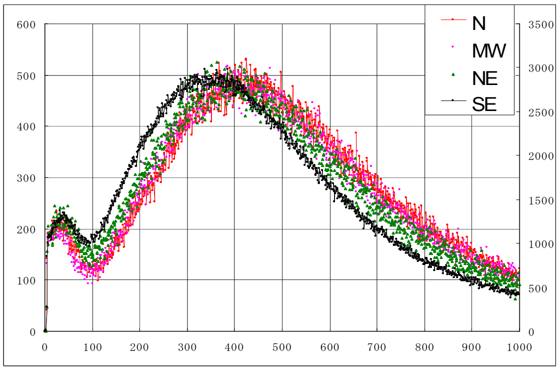
(i) Uniformity variation

Schematic block diagram for uniformity measurement over the surface of $1.5m^2$ is shown in fig.1.



Their results have been shown in fig.2 as relative efficiency. The raw data were also shown in fig3. As you can see in fig2., there might be systematic change in position sensitivity, around 7 to 8 % deviation from average. To confirm better uniformity, we are planning to measure their uniformity with much better

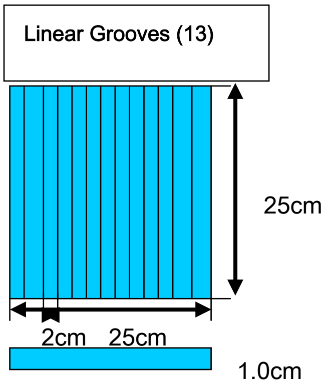


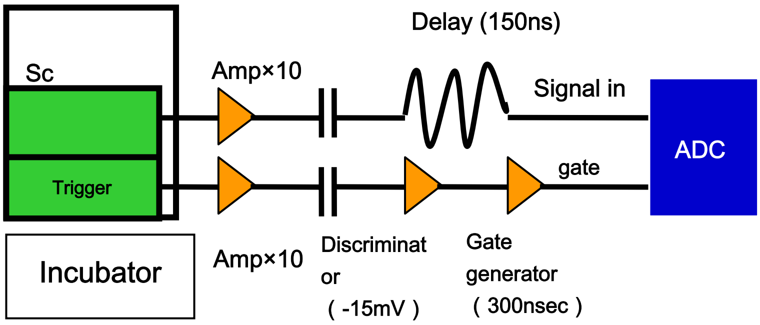


resolution.

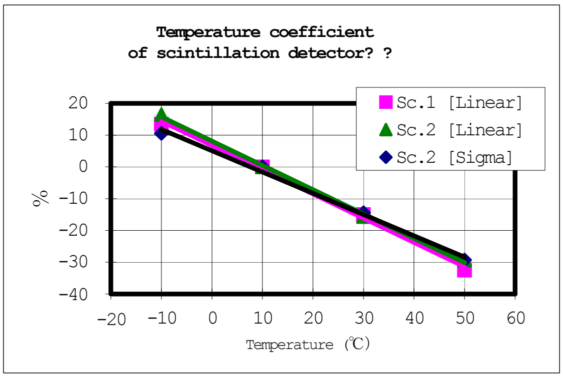
(ii) Temperature dependence

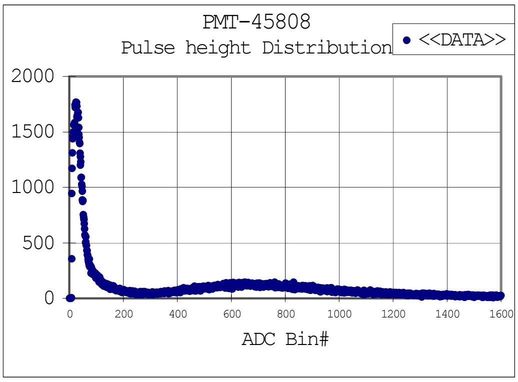
Fig.4 shows small testing detector for temperature dependence of scintillation detector very similar to the real one is to use as surface detector for Telescope Array

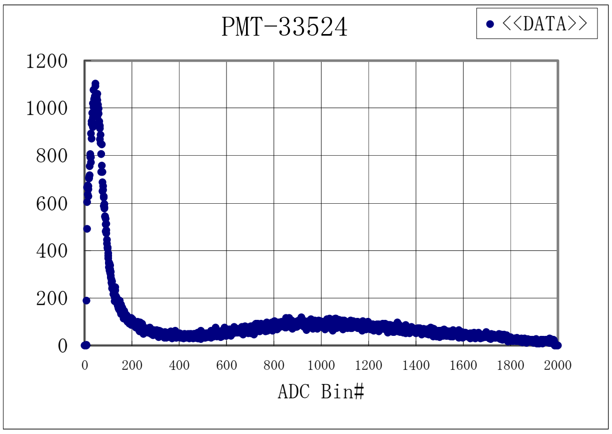




Project. Schematic diagram for the same is shown in Fig 5. The system consists of plastic scintillator, wave length shifting fibers, Photo multiplier and the socket with high voltage power supply. Its performance is shown in fig.6. We have completed 3 different arrangement in scintillator and shape of grooves. Practically there was no significant difference among these different type of test. As you can see in fig.6, temperature coefficient for whole detector system is 7 to 8 % /degree centigrade. It looks to be rather larger than expected





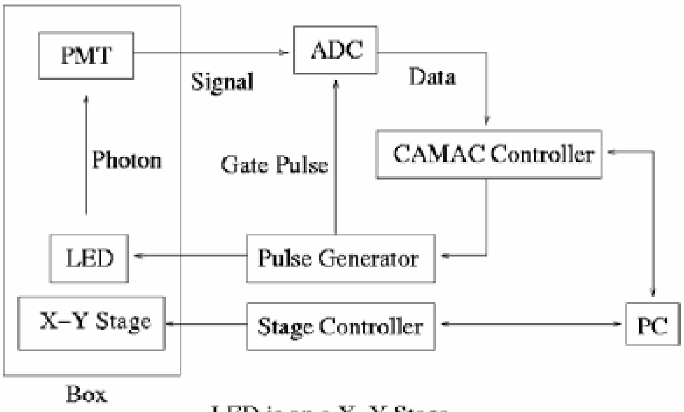


(iii) Overall performance of detector

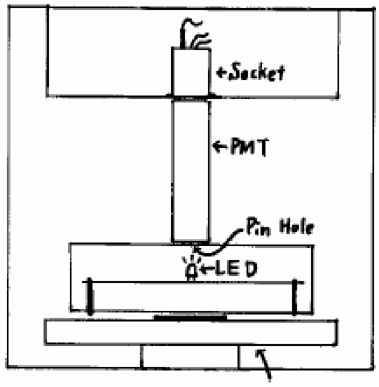
Typical output pulse height distribution of proto type ($1.5m^2$) scintillation detector for through going muons were shown in fig.7. Sharp peak is for single photo electron and broad peak is for through going muons. Since quantum efficiencies of present our PMT (1924SA) is about 25 %, it means that typically about 80 photons are collected along with wave length shifting fibers for through going muons.

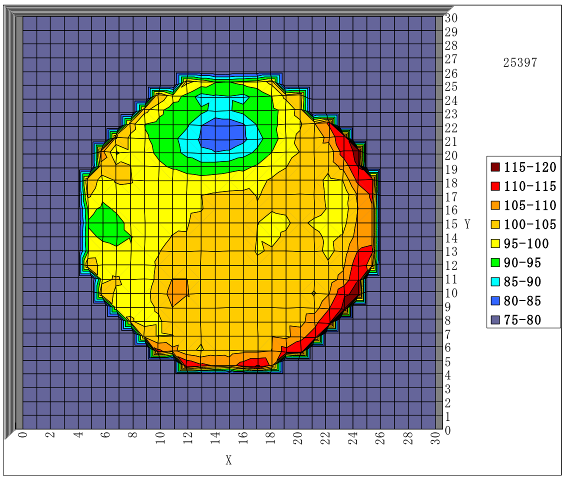
(iv) Position sensitivity of PMT

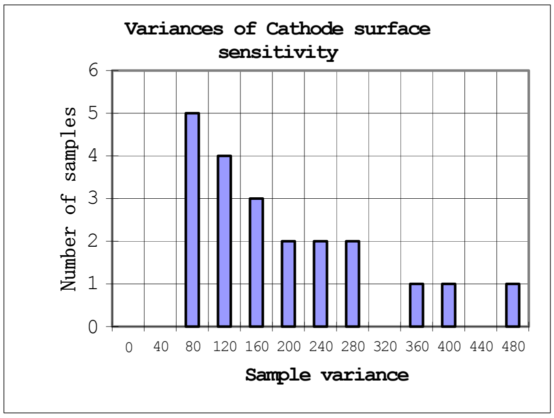
We measured the position sensitivity of Cathode surface of Photo Multiplier Tubes.The schematic view and its block diagram of measuring systems are shown in fig,8.See typical sensitivity distribution in fig.9. The histogram in fig.10 shows preliminary results about sample variance of Cathode surface sensitivity, only for 21 PMTs.



LED is on a X−Y Stage.







3.Summary

We have performed quite intensive investigation on detailed characteristics of proto type surfacr scintillation detector for Telescope Array Project. What we have got is quite useful for conducting detector simulations and without such information one cannot be confident with their results. Same time these results are quite satisfactory for conducting the Giant Air Shower observation on the whole. But we feel some of the characters and behaviors have to be checked up still.

4.Acknowledements

Authors are grateful to Prof. S.C.Tonwar and S.K.Gupta of Tata Institute of Fundamental Research for their support to design the proto type detector and useful comments and discussion on measurements.