THE **UNIVERSITY OF UTAH EXTENSIVE AIR SHOWER ARRAY**

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Abstract

This paper describes the extensive air shower array that has recently been installed by the University of Utah at Dugway (860 gm cm^{-2}). The array consists of thirty three particle detectors each containing $1.5m^2$ of plastic scintillator, arranged in a series of circles centered on the Fly's Eye II air scintillation detector. The array encloses a total area of ~30,000 m^2 and is capable of detecting and analyzing extensive air showers with ground level sizes 7.10^{4} particles. The array is intended primarily to operate in conjunction with Fly's Eye II and a large (~1,000 m^2) underground muon _detector at the same site in searches for PeV gamma-ray sources.

1. Introduction. Recent reports of the observation of ultra high energy (10^{15}eV) gamma rays from several binary star systems within our own and nearby galaxies/1/ have renewed interest in the solution of the long-standing problems of the origin and acceleration of high energy cosmic rays. Unfortunately these observations are, of necessity, made via extensive air shower arrays and as such are hampered by the high background of hadron initiated air showers. Improved sensitivity to these and other sources can only be obtained by improving the angular resolution of air shower arrays and rejecting as many as possible of the hadron initiated (muon rich) showers which fall within the acceptance cone of an array. To this end, we have installed at Dugway, in collaboration with the University of Michigan, a surface array capable of determining shower arrival directions to an accuracy of ~1° and a large number (total area thus far ~$160m^2$) of underground muon detectors. A map of the surface array and the existing and proposed muon detectors appears in Fig. 1.

While the main goal of the experiment is the detection and study of PeV gamma-ray sources, the experiment will also provide information on the hadronic composition of primary cosmic rays at ~10^{14} - 10^{15} eV. An unbiased, accurate estimate of the primary energy of showers in this energy range can be obtained by combining data from the Fly's Eye-II operating in Cherenkov mode and the surface array. When combined with data from the muon array this data will allow a study of the total muon number and electron/moon ratio as a function of primary energy.

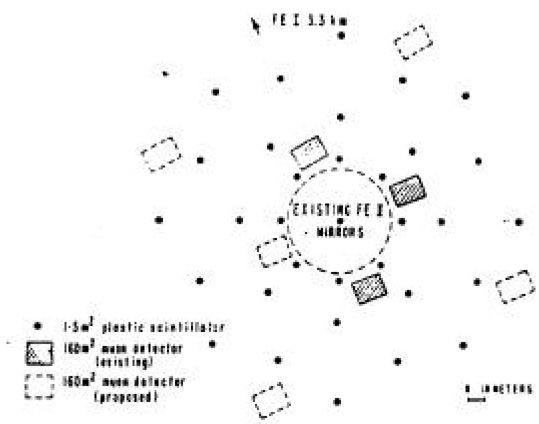

Figure 1.. Map,of the electron and moon arrays at Dugway, Utah

2. The Detector. A sketch of one of the thirty-three identical particle detectors used in the surface array is given in Figure 2. Each detector is composed of 4 pieces of plastic scintillator (Pilot F) each 1500 x 250 x 7mm in size (total scintillator area 1.5m2) housed in an insulated,

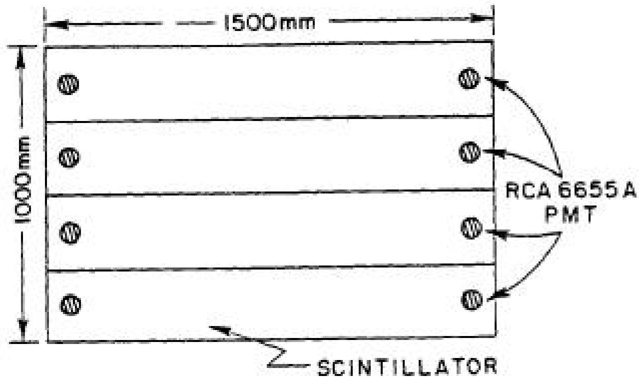

Figure 2. Sketch of detector construction, electron array,

weatherproof box 2400 x 1200 x 600mm. Each piece of scintillator is individually wrapped in aluminum foil and enclosed in a lightweight sheet aluminum shield, total thickness ~0.5mm. Two RCA type 6655A photomultipliers are coupled directly to the face of each scintillator 50mm from either end. The response of this confirguation to single muons passing through the scintillator at various distances from the end of the scintillator has been studied in detail. In particular the mean of the pulse-height spectrum obtained by summing the outputs of the two photomultipliers attached to the scintillator was found to vary by _ ± 10% over the length of the scintillator. Each photomultiplier is connected directly to the electronics room by a single length of wideband 75Ù CATV cable (Times Fiber Communications -T4412) which supplies high voltage to the photomultiplier base and returns the signal to the electronics room. Particle density estimates are obtained by linearly summing all eight photomultiplier outputs within a detector and the shower front arrival time estimated by the earliest firing mean-time of any pair of photomultipliers (on the same scintillator) within the detector.

3. The Electronics. The eight photomultiplier signals from each detector are processed by a single CAMAC-interfaceable module designed and constructed specifically for the experiment. A block diagram of the module appears in Figure 3. The module consists of two main sections; a summing integrator which integrates and sums the individual outputs of all 8 photomultipliers within the detector; and a mean-timer, which provides, to an accuracy of ~2ns, the arrival time of the earliest particles at the detector. The mean-timer consists of 4 identical mean-timers, one for each pair of photomultipliers on a scintillator, the outputs of which are OR-ed together to produce a 'start' pulse for the TDC system. The module is triggered any time a pair of photomultipliers (on the same scintillator) fire in coincidence at the one particle level. Each time this occurs the module first sets a CAMAC LAM; digitizes the output of the integrator; transmits a ‘start’ pulse to the TDC system; and stores a 4-bit ‘hit pattern’ to indicate which scintillators within the detector were

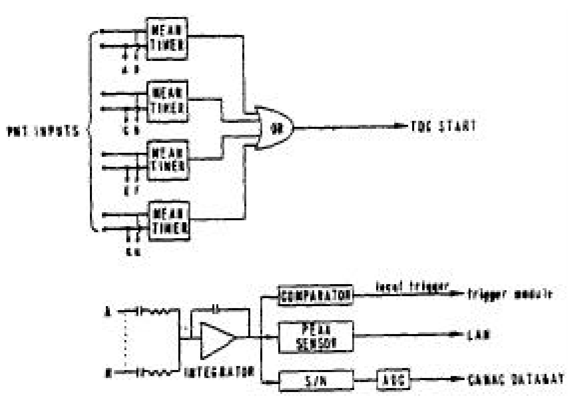

Figure 3. Black diagram of CAMAC module to process photomultiplier signals from electron. detector

struck. In addition, if the local particle density (integrator output) exceeds a preset value (such as 7 particles/square meter) an electron array trigger and a TDC `stop' condition are generated. If an array trigger does not develop, each `hit' nodule is reset upon completion of it's integrator digitization, approximately 25pa after it fired.

In response to CAMAC commands the photomultiplier outputs can be disconnected from their corresponding electronics and a sequence of pulses, of known amplitudes, can be sent to each electronics module to check its performance. The stability of each detector in the array is monitored by recording the singles rate for each tube in the detector and the coincidence rate for each pair of photomultipliers attached to the same scintillator. These rates are recorded by a separate system of 16-bit and 32-bit acalers; which are periodically read by a Micro-Vax II computer serving as control for the entire experiment.

The TDC `start' pulses from each of the CAMAC modules used to process the detector outputs are sent directly to a commercial TDC system (LeCroy 4298/4291B) operated in a common stop mode. This system digitizes, to 10-bit accuracy, the arrival time of the most recent start pulse from each detector, prior to the common stop being received. The TDC system also records the arrival of start pulses from any of the ~200 individual muon detectors presently in the muon array, which may have been fired by the same shower .

4. Array Performance. At the present time a loose triggering arrangement of any one detector at a 1evel of ~7 particles/square meter is envisaged for the electron array. The simulated efficiency of this triggering arrangement, as a function of shower size is given in Figure 4. Also shown is the expected _differential shower size spectrum. A more complete analysis of triggering schemes, including a study of the analyzability of showers detected under various triggering schemes is being undertaken and will be presented.

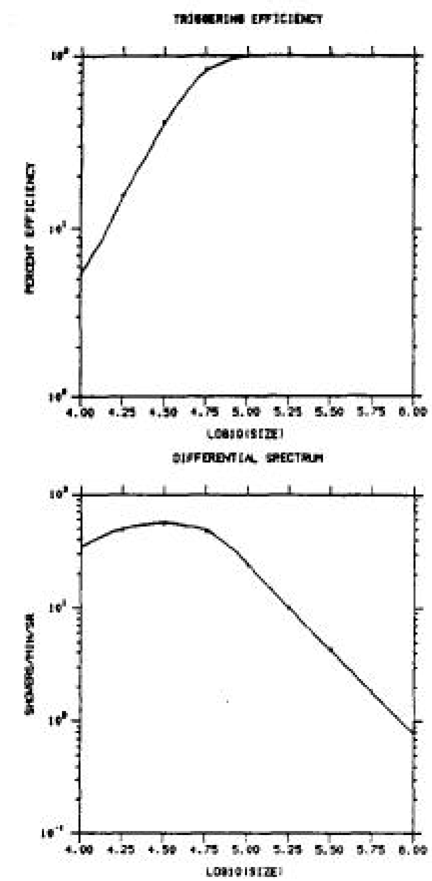

Figure 4. Monte-Carlo calculations of the expected performance of the electron array

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References

See Watson A.A. Proc.l9th International Cosmic Ray Conference LaJolla, 1985, 9. 111 for a review.

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