# DESCRIPTION AND STATUS OF THE HIGH RESOLUTION (HIRES) FLY'S EYE EXPERIMENT.

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ABSTRACT The High Resolution (HiRes) Fly's Eye Experiment is designed to provide several orders of magnitude increase in EHE cosmic ray aperture over the present Fly's Eye experiment. This paper describes the HiRes Eye apparatus. This paper also describes the present operation of two prototype HiRes detectors.

INTRODUCTION The extremely low primary cosmic ray flux in the EHE energy range ( $E > 10^{18}$ eV ) has made characterization of these particles difficult. Present measurements of the primary energy spectrum and anisotropy above $10^{19}$ eV suffer from a lack of resolution as well as a lack of statistics. This lack of information has thwarted theoretical efforts to conclusively determine the acceleration mechanisms for these particles. A new detector, the HiRes Fly's Eye, will provide improved energy, directional and shower development resolution, combined with the event statistics necessary to remedy this situation[1,2].

THE HIGH RESOLUTION (HIRES) FLY'S EYE The goal of the Hires experiment is to measure over 200 events per year above $10^{19}$ eV with 20% energy resolution[2]. The detector should be capable of measuring shower direction with 0.6° accuracy to allow searches for point sources of cosmic radiation. The detector should also have sufficient resolution of longitudinal track development to allow determination of the primary composition. We have chosen to base the HiRes Eye design upon the proven nitrogen fluorescence track measurement technique employed with the present Fly's Eye experiment[3]. This technique provides a full profile of the extensive air shower development, and measures the total primary energy of the shower directly from the energy deposition curve. This provides a more robust measurement of the primary energy as ground based electron arrays must relate ground shower size to the primary energy using model dependent Monte Carlo simulations.

The successful Monte Carlo simulations of the present experiment have been employed to determine the most cost efficient method for producing a detector with these capabilities. To achieve these goals, the emulations have shown that the HiRes Eye requires:

• Stereo (mufti-station) viewing of all tracks.

• Large (15 km.) separation between each station.

• 1° photomultiplier tube (PMT) aperture.

• Zenith coverage from 3°- 57° above the horizon.

• Mirror diameter of 2.0 m.

The optimized HiRes Eye design consists of 3 identical installations with a 15 km separation between each installation. Stereo event reconstruction between adjacent installations is employed to eliminate reconstruction biases. Each installation consists of 54 detection units; each detection unit consists of a 2.0 m. Mirror which reflects the nitrogen fluorescence track onto a PMT cluster ( Figure 1 ). The detection units are housed in inexpensive prefabricated steel buildings, with two detectors ft . per house. A large forward door on the building opens up to provide unobscured access to the night sky for both detectors.

An individual detection system a mirror, PMT cluster, and data recording electronics. The mirror is composed of four separate mirror segments which are mounted and aligned onto a rigid mirror frame. Each mirror segment mount has two independent axis controls to allow easy alignment of the four segments with a laser calibration system. This laser system is also used to align the PMT cluster with respect to the mirror.

Each PMT cluster contains 256 phototubes arranged in a 16 x 16 hexagonal matrix. PMT apertures are reduced from the present 5° down to 1° in the HiRes Eye in order to gain sufficient track length for measuring the most distant events. The smaller tube apertures and larger mirror diameter also results in a substantial improvement in the ratio of signal to sky-noise over the present Fly's Eye experiment. The PMT cathodes are mounted behind a UV pass filter. Each tube has a high voltage bleeder chain, amplifier, and cable driver located inside an aluminum mounting tube. The mounting tube fits into a mechanical frame with a circuit board back plane which is used to distribute power and PMT signals.

Two data recording electronics designs are currently under consideration. The first design is a two channel sample-and-hold system which experience of the present Fly's Eye with the modular design of a fully Ethernet-based data acquisition network. In this system, each mirror can trigger and record information independent of the adjacent mirrors. This modular design allows operation of each detection unit as soon it is completed. Additional units are simply tied into the single Ethernet line when they are brought into operation. Additional triggering capabilities have been added to detection units sharing adjacent sky patches to allow inter-detector triggering, thus increasing the probability of triggering on short tracks which traverse detector boundaries. When a cosmic ray track traverses the fiducial volume of the installation, individual detection units generate trigger signals. This trigger initiates the PMT pulse height and time readout for the detector. Each unit places its pulse height and timing data into an individual Ethernet packet which is sent to the central computer which records this data. Timing between detection units is recorded via the central electronics system. This system records the trigger time of each individual mirror with 50 ns resolution, provides a UTC time stamp, and also sends an Ethernet packet with this information back to the central computer. The central computer sorts the arriving packets into events according to timing and staler information. This design has been shown by Monte Carlo simulation to provide the necessary capabilities for reaching the experimental goals. The prototype sample-and hold system has already been field tested with excellent results[4].

A more ambitious design incorporates a Flash ADC (FADC) system to continuously monitor each photomultiplier tube signal. This system may be able to measure low pulse height PMT signals at the beginning and end of the fluorescence track. These signals would be too small to trigger the sample-and-hold electronics, This system also has the advantage that one can look at low-level PMT signals well away from the track which could provide information about the night sky background. This system is still in the design stage.

The entire HiRes Eye consists of three such installations; each installation is ideally located at the vertex of a 15 km. side equilateral triangle. The preferred location of the detector is at the Dugway Proving Grounds in Dugway, Utah U.S.A. ( 40° N, 122° W, depth 870 g $cm^{-2}$ ). This site is also the location of the present Fly's Eye detectors ( I and II ), the Chicago Air Shower Array ( CASA ), and the Michigan extensive muon array ( MIA ).

HIRES FLY'S EYE PROTOTYPE The modular Ethernet-based data acquisition system allows data acquisition to begin with only a few detection elements. In order to take advantage of this capability, two prototype detectors of the High Resolution Fly's Eye experiment have been constructed. These detectors are located on top of Little Granite Mountain at the Dugway Proving Grounds, at the site of the present Fly's Eye 1 detector. The detectors are oriented to measure extensive air shower -tracks that strike the region surrounding the present Fly's Eye 2 / CASA / MIA area, : R, 3.4 km to the northeast. The detectors began operation on January 20, 1991, and the first cosmic ray track ( > 15 PMT triggers in a row with good timing, Figure 2 ) was observed within 10 minutes of the startup. Since that time we have logged over 40 hours of prototype operation with near-perfect weather. The raw trigger rate of each detection unit is approximately 0.25 Hz per detector unit, with most of this rate due to Cerenkov light triggers from low energy ( $10^{13}$ - $10^{14}$ eV ) cosmic rays. The detector unit track rate ( > 12 PMT hits with good timing ) is approximately 0.75 $min^{-1}$.

Several test procedures have been used to examine the performance of these

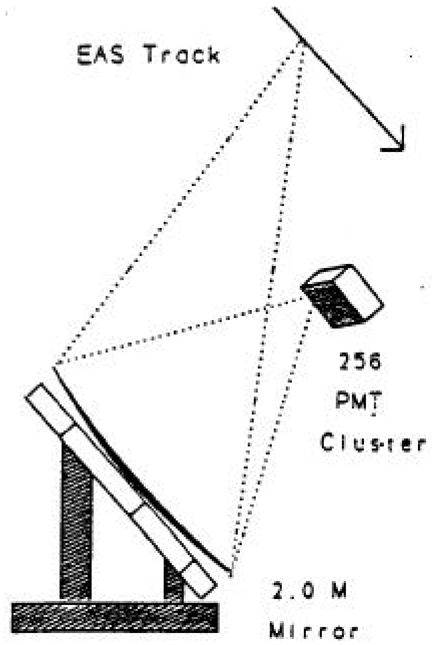


Figure 1: Single HiRes detection unit. The 2.0 m. mirror focuses nitrogen fluorescence from the EAS track onto the PMT cluster.

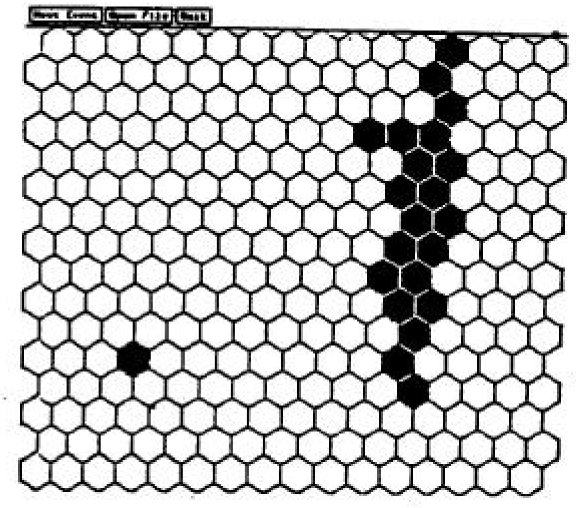

Figure 2: The first cosmic ray track observed by the prototype HiRes de- detector (January 20, 1991).

including the recording of high-energy nitrogen laser shots at distances of up to 12 km away, and collimated Xenon pencil-beam flashers located 2-3 km distant from the prototypes. The results of these tests are described in detail elsewhere in these proceedings[4].

We are currently expanding the prototype HiRes detector to 14 detection units. These units will cover the entire volume above the CASA / MIA arrays, allowing measurement of coincident events between the three detectors. The coincident events provide the measurements necessary to evaluate the performance of the HiRes device. Monte Carlo calculations indicate several hundred coincident events per year will be measured. A total of five detection units will be operational by the end of 1991, with the remaining units to be deployed by Summer 1992. In addition, several prototype units will be equipped with both the sample-and-hold and the FADC data acquisition systems. The comparison between the two systems will allow us to fully evaluate both data acquisition systems.

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