

Description of the High Resolution Fly's Eye Detector

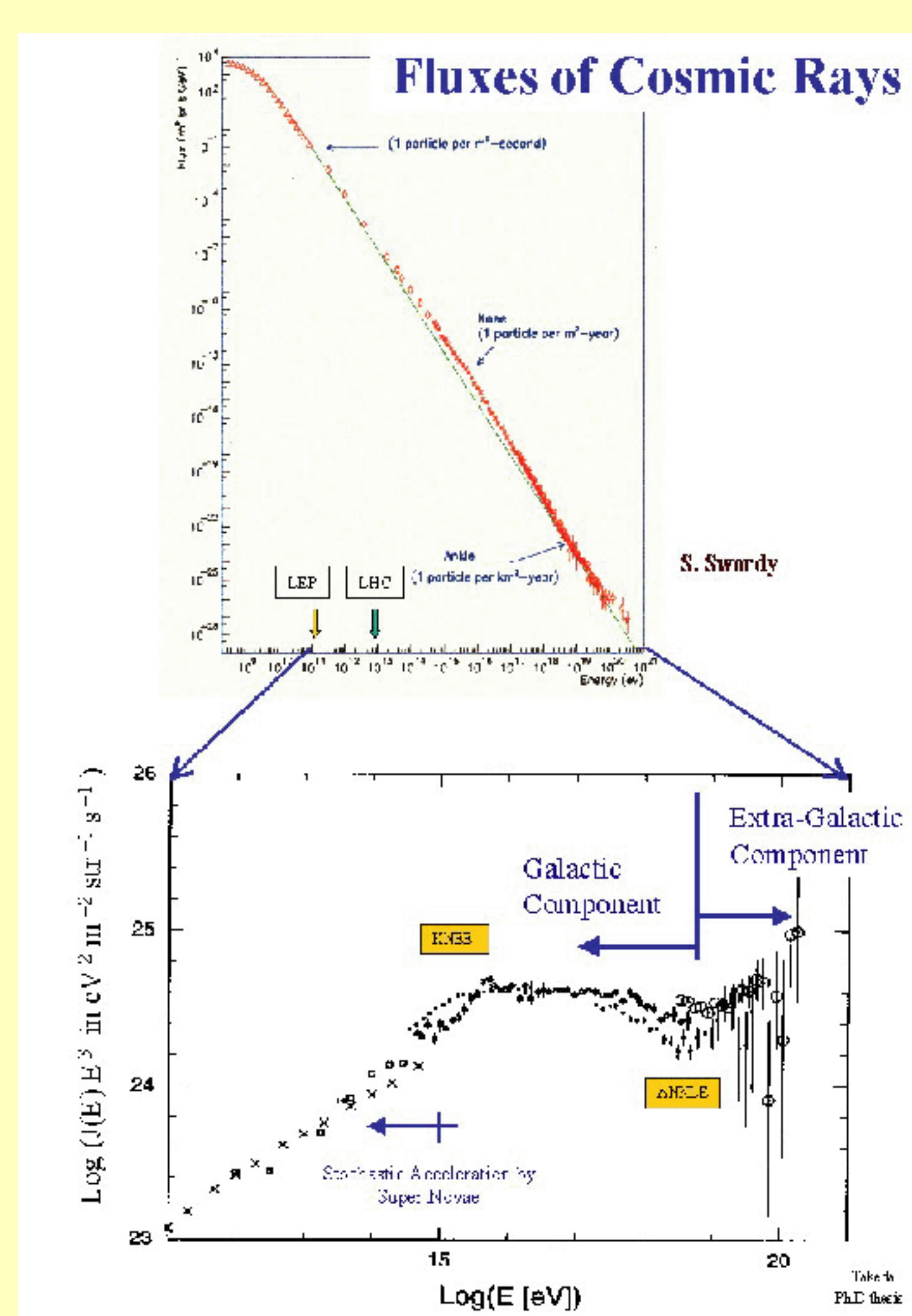
T. Abu-Zayyad¹, J. Albreton¹, G. Archbold¹, J. Balling¹, J. Bellido², K. Belov¹, J. Belz⁵, D. Bergman⁴, J. Boyer³, Z. Cao¹, R.W. Clay², M. Dalton¹, B.R. Dawson², A. Everett¹, J. Girard¹, R. Gray¹, W. Hanlon⁴, B.F. Jones¹, C.C.H. Jui¹, D. Kieda¹, K. Kim¹, B. Knapp³, W. Lee³, E.C. Loh¹, N. Manago⁷, E.J. Mannel⁹, K. Martens¹, G. Martin⁶, J.A.J. Matthews⁶, J.N. Matthews¹, A. McAllister¹, J. Meyer¹, S.A. Moore¹, A.N. Moosman¹, P. Morrison¹, J.R. Mumford¹, M. Munroe⁵, L.P. Perera⁴, K. Reil¹, R. Riehle¹, M. Roberts⁶, M. Sasaki⁷, M. Sasano⁷, M. Schindel⁵, S. Schnetzer⁴, M. Seman³, P. Shen¹, K.M. Simpson², J. Smith¹, J. Steck¹, P. Sokolsky¹, C. Song³, R.W. Springer¹, B.T. Stokes¹, M. Teshima⁷, S.B. Thomas¹, G.B. Thomson⁴, T.D. Vanderveen¹, S. Westerhoff³, L. Wiencke¹, A. Zech⁴, X. Zhang³

1. University of Utah Department of Physics and High Energy Astrophysics Institute, Salt Lake City, UT 84112, 2. University of Adelaide Department of Physics and Mathematical Physics, S.A. 5005 Australia, 3. Columbia University Department of Physics and Nevis Laboratories Irvington, NY 10533, 4. Rutgers University Department of Physics and Astronomy Piscataway, New Jersey 09885, 5. Montana State University Department of Physics Bozeman MT 59717, 6. University of New Mexico Department of Physics Albuquerque, New Mexico 87131, 7. University of Tokyo Institute for Cosmic Ray Research Kashiwa, Japan

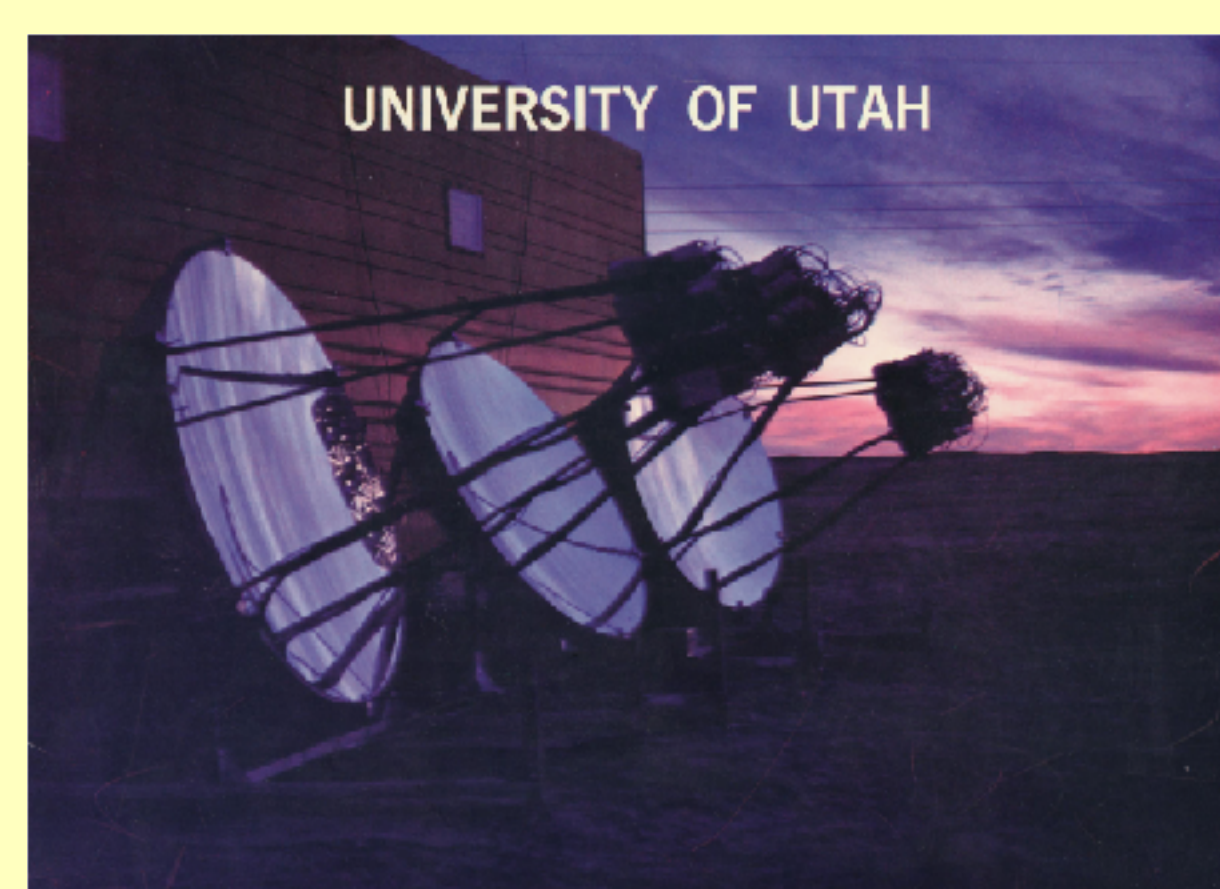
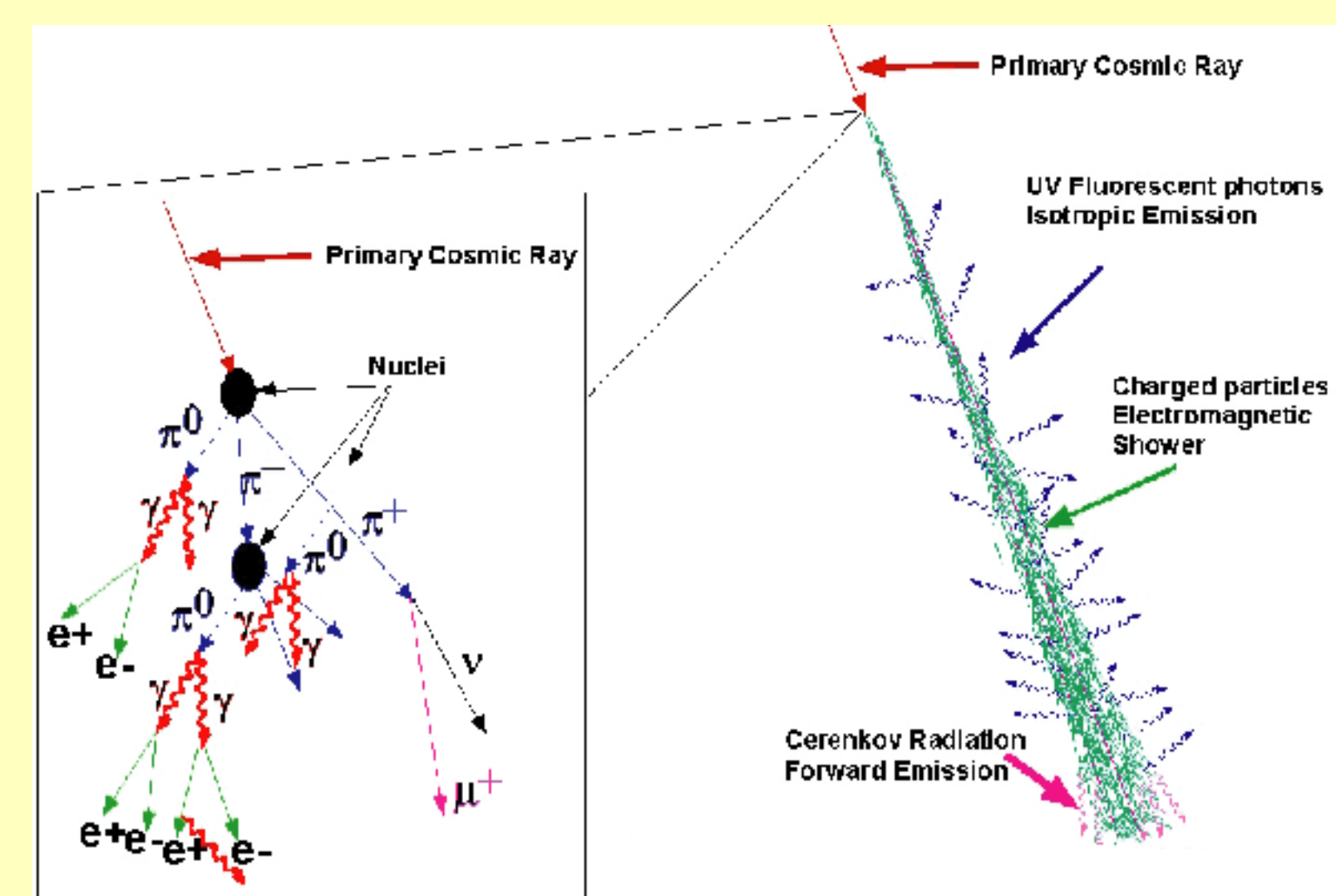
The High Resolution Fly's Eye seeks to measure the flux and composition of the highest energy cosmic rays. It also searches for anisotropy in arrival directions as well as exotic events such as neutrinos.

Technique and History

Above 10^{17} eV, the flux of cosmic ray particles is too low to measure directly. The traditional method to extend measurements into this region has been to observe Extensive Air Showers (EAS), produced by primary cosmic ray particles. The current HiRes experiment is designed to observe EAS at energies above 3×10^{18} eV.

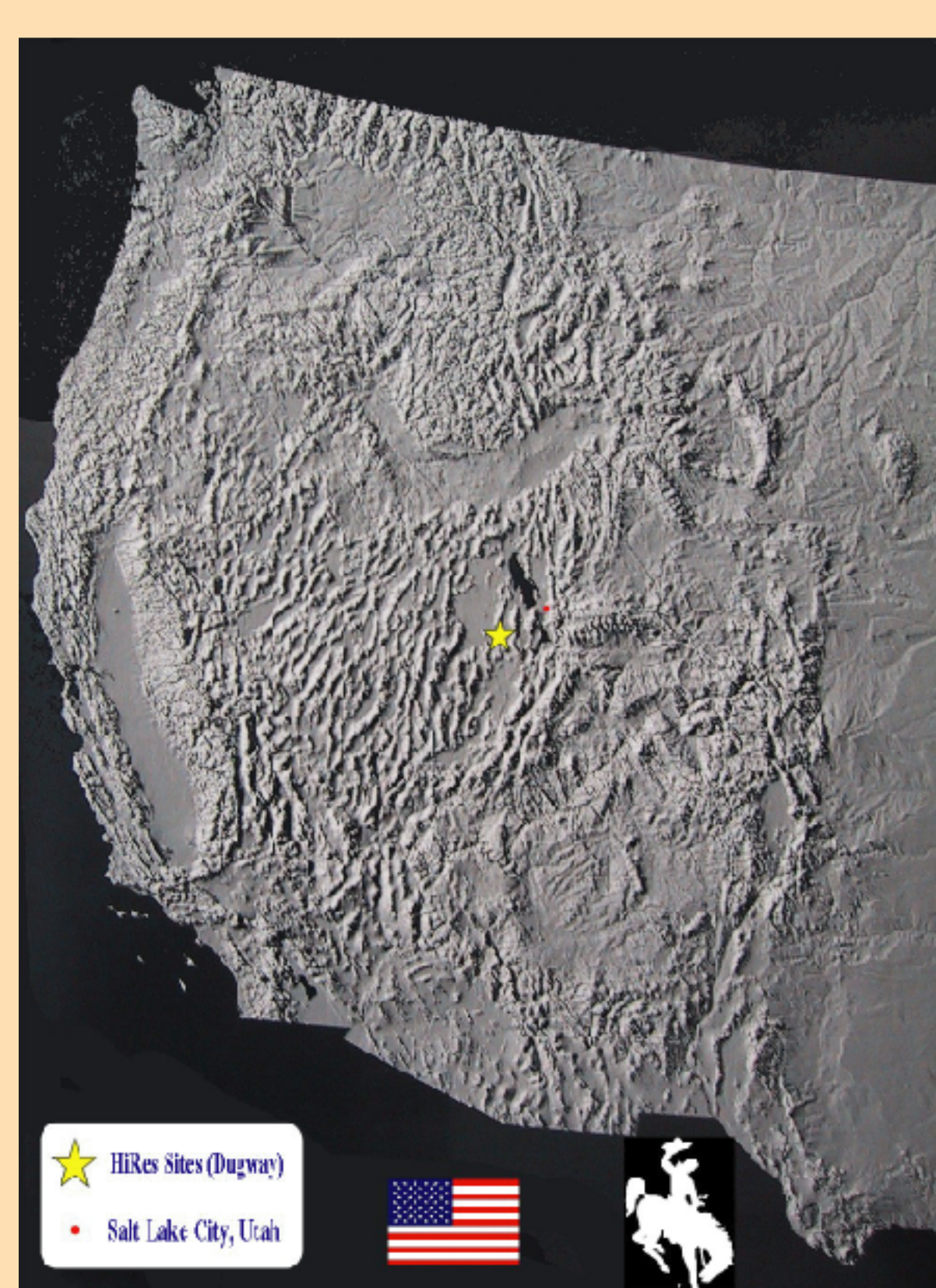


An EAS is a cascade of charged particles that develops over 10's of km. As it develops, the shower spreads eventually becoming a "pancake" a few hundred meters wide and a few meters thick which is moving nearly at the speed of light. As the EAS traverses the atmosphere, it excites air molecules which produce fluorescence light.

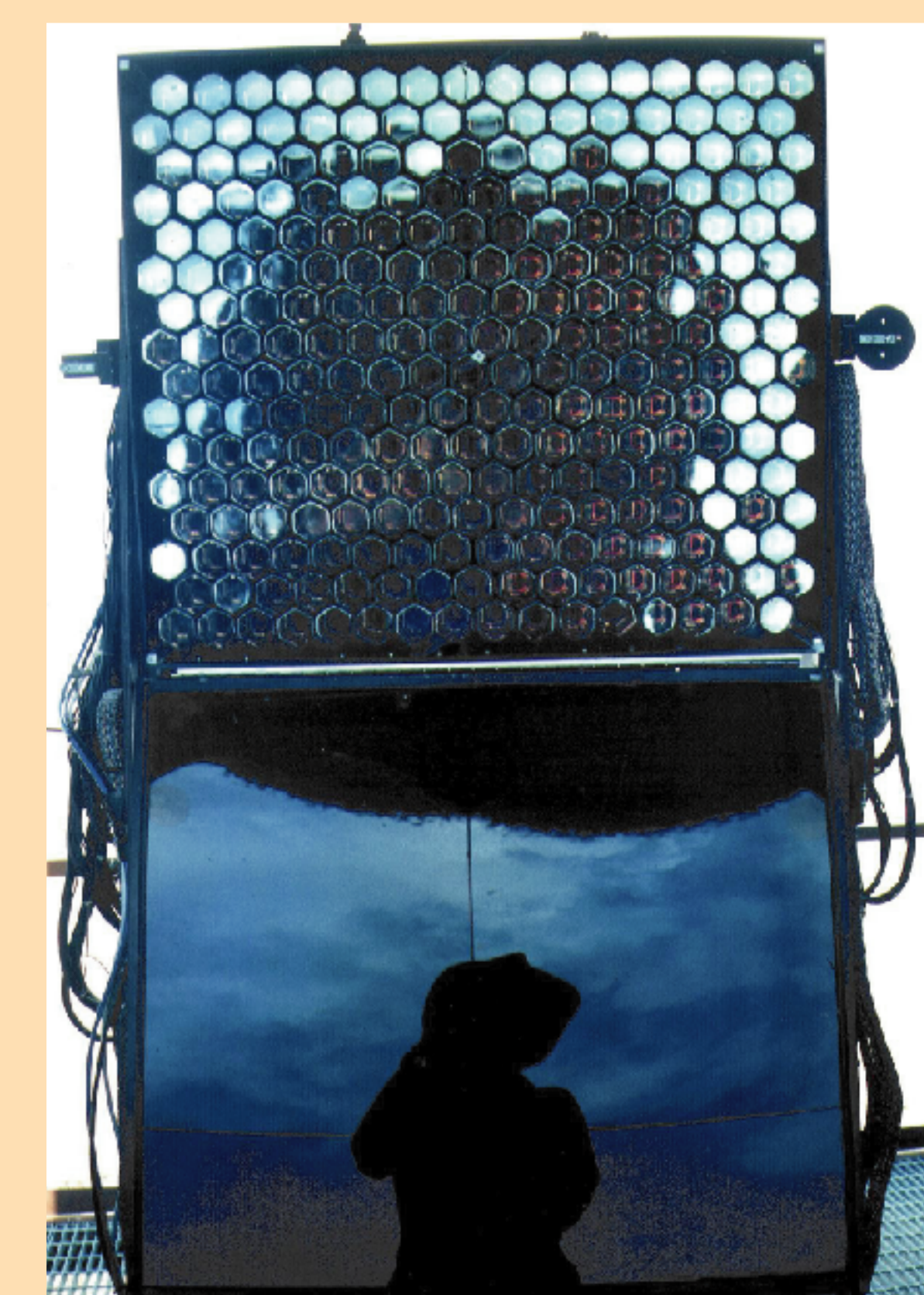
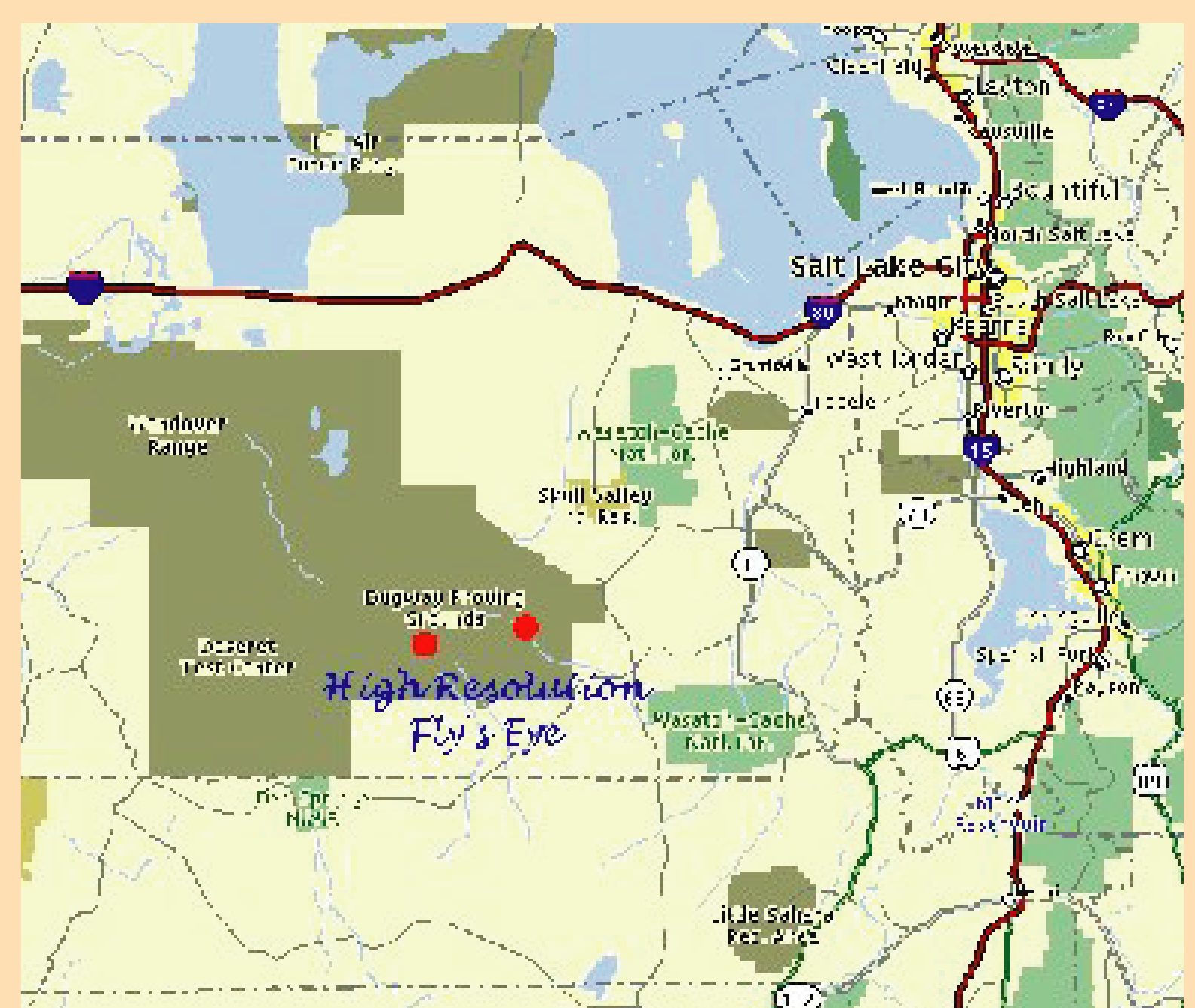


The first successful coincidence detection of an EAS via air fluorescence and a ground array was achieved in 1976 by a group at the University of Utah operating optical detectors in coincidence with the Volcano Ranch ground array. This group went on to complete the original Fly's Eye experiment, utilizing the air fluorescence technique, which collected data from 1981 through 1984.

The Detectors



The HiRes Observatories are located within the U.S. Army's Dugway Proving Ground, about two hours drive south-west of Salt Lake City, Utah. The experiment is comprised of two stations (HiRes-I and HiRes-II) separated by 12.6 km.



The detector elements are configured two to a building. Each detector element consists of a large spherical mirror, a 256 pixel (photomultiplier tubes) camera, and associated electronics. The spherical mirror has a radius of curvature of 474 cm and is composed of four segments arranged in a clover-like pattern. The on-axis effective area of the mirror is ~ 3.8 m². The spherical mirror collects fluorescence light from an EAS and focuses it onto the pixels of the camera.

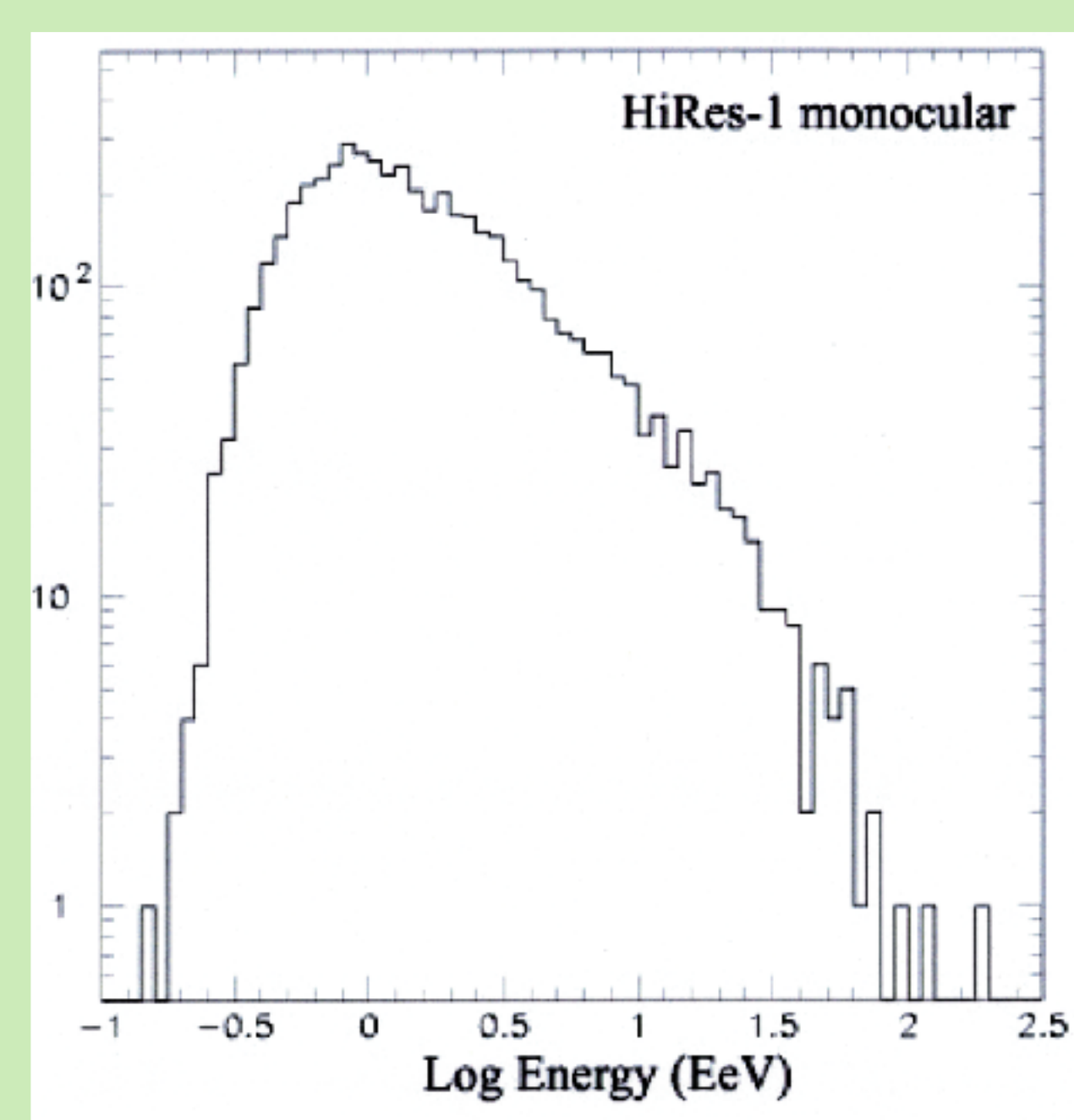
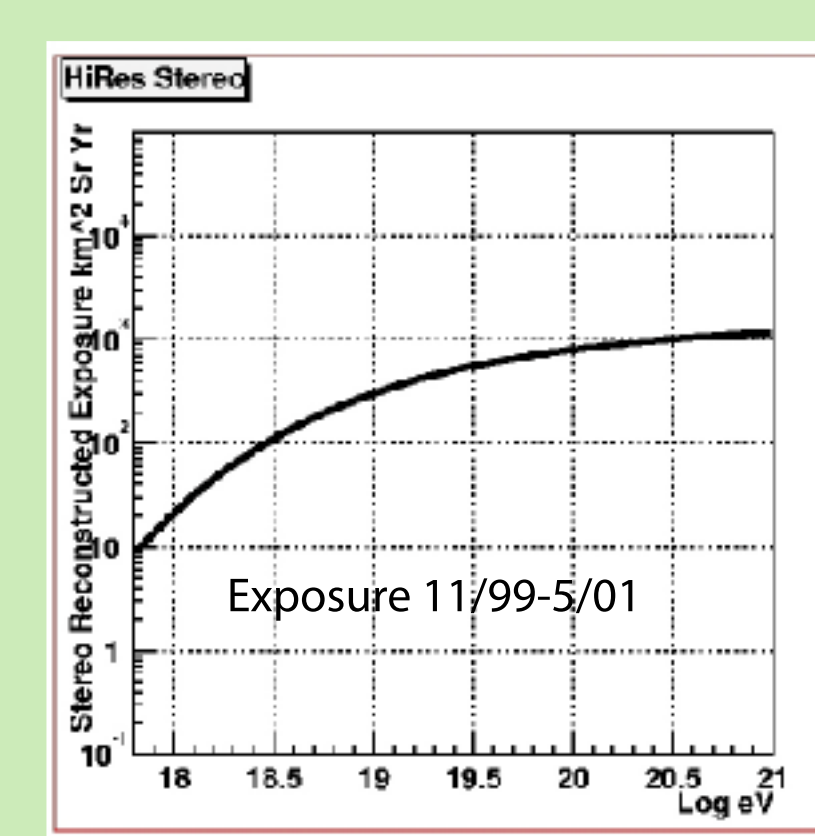
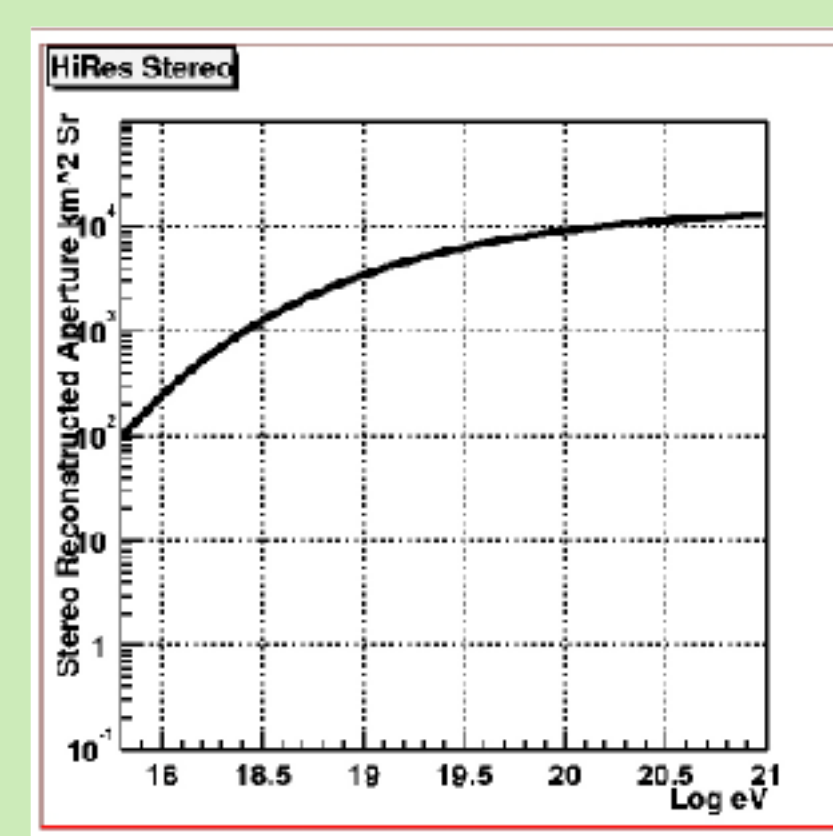
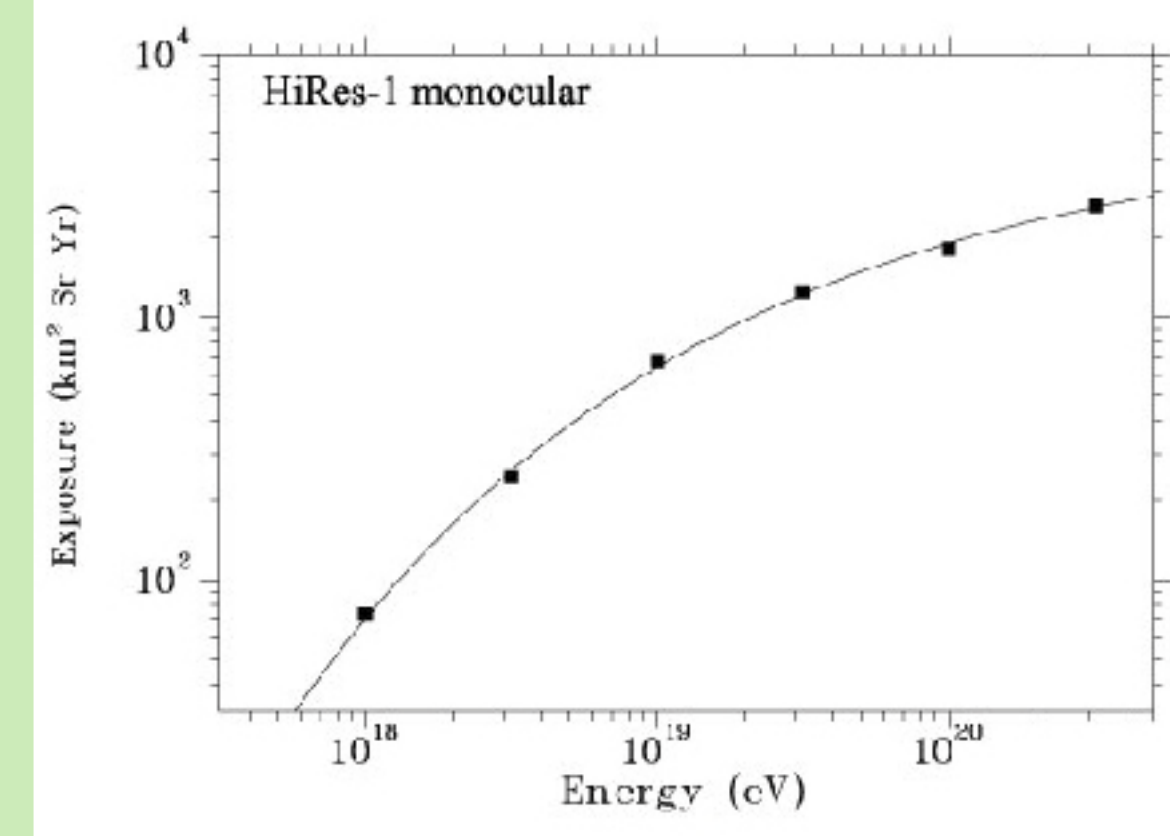
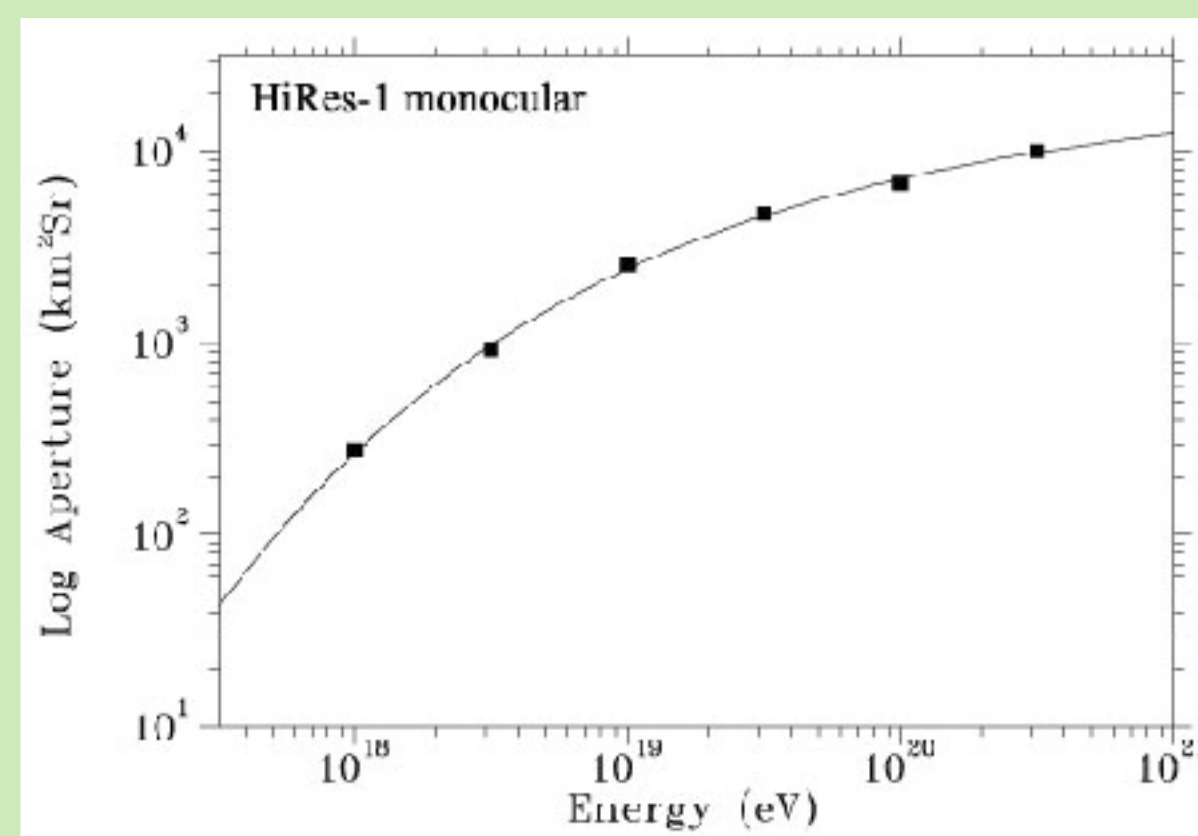
Operations

The first HiRes site, HiRes-I, began operations in June of 1997 and has accumulated about 2800 detector-hours of data with 2270 detector-hours being good weather data. The second HiRes site, HiRes-II began limited operations in August of 1999 and was in full operation by the end of that year. HiRes-II has accumulated about 1000 detector-hours of data. HiRes-I has observed 2880 events over 1 EeV and there are now over 1000 candidate events observed in stereo.

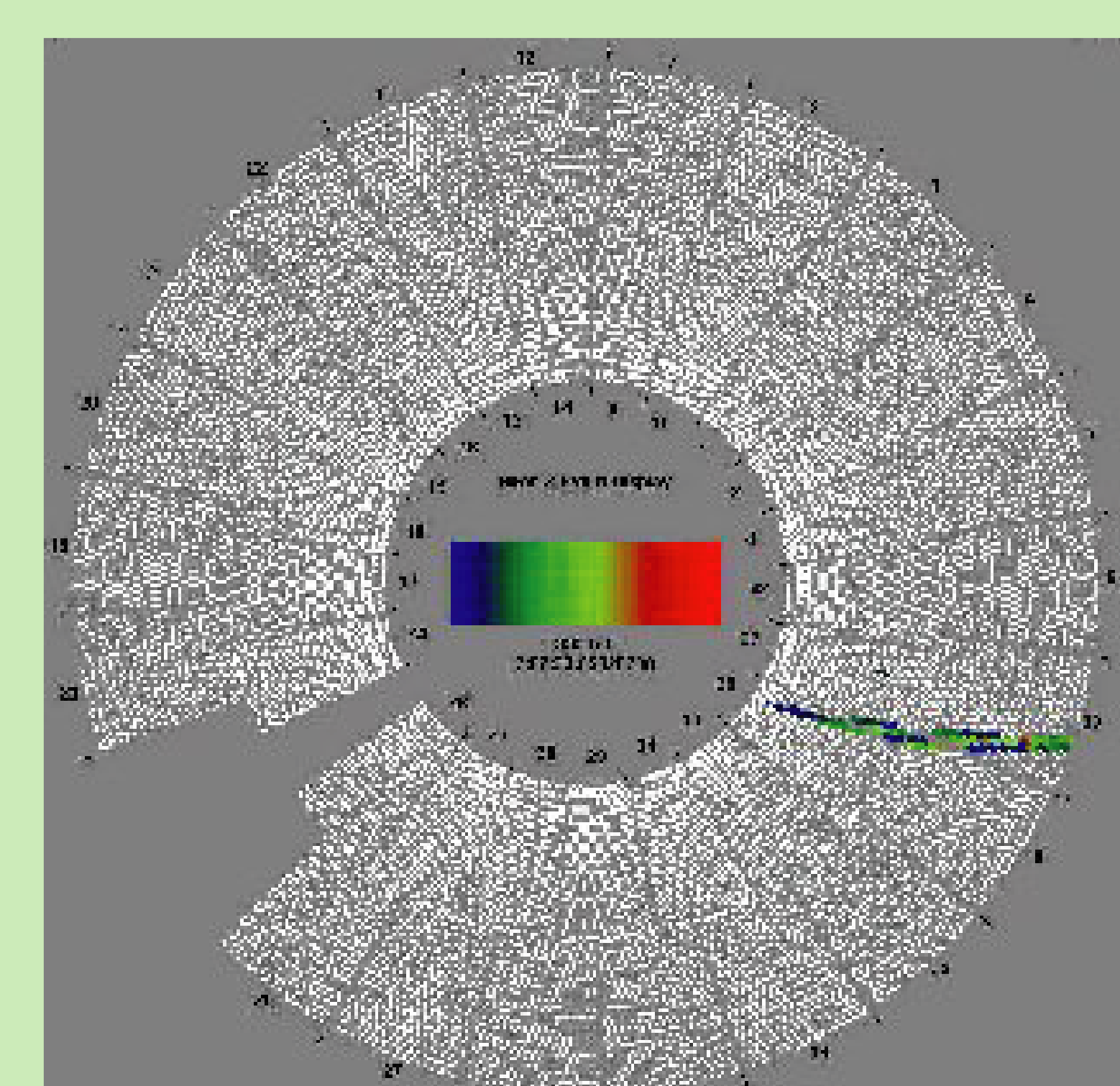
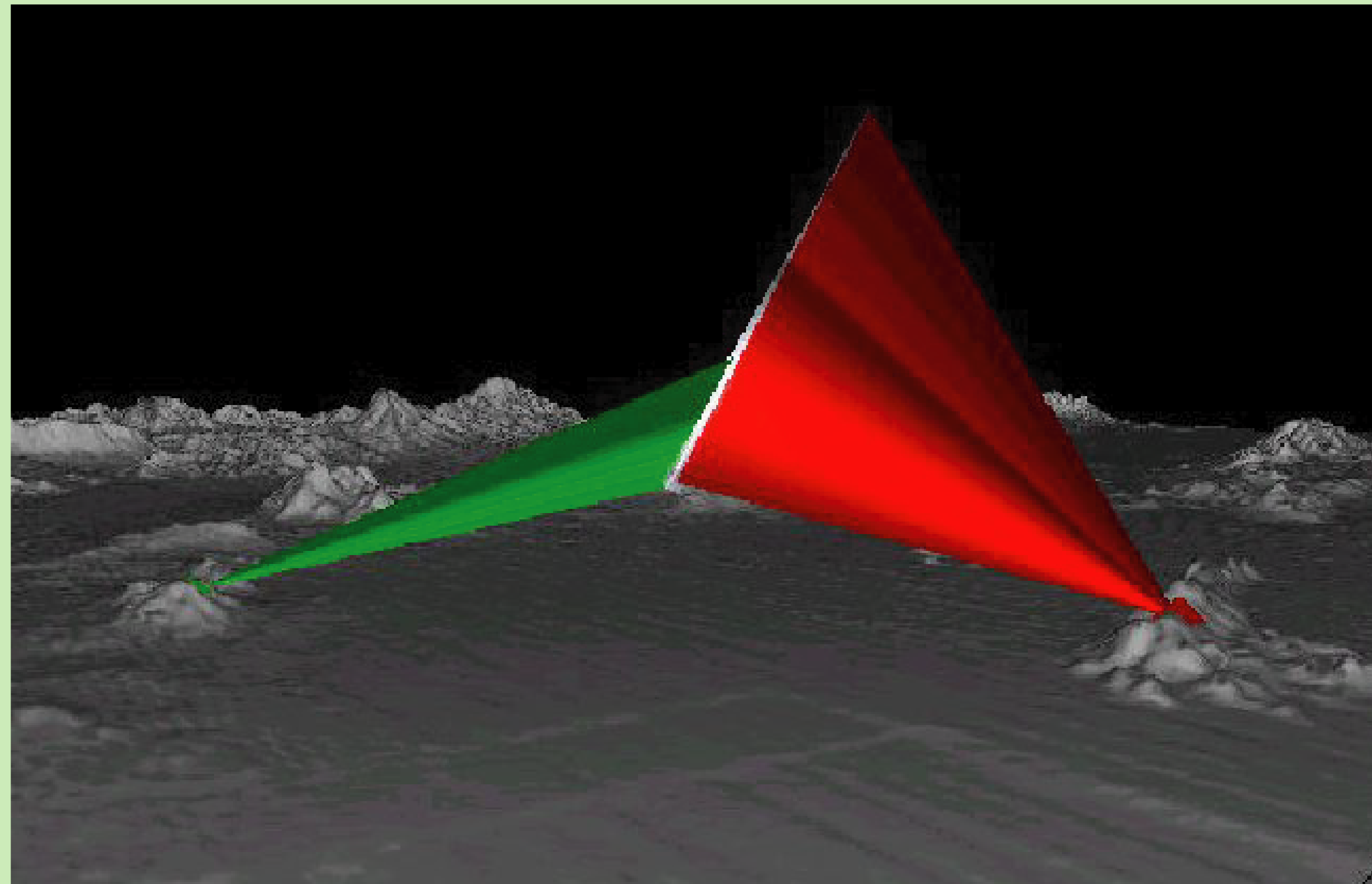
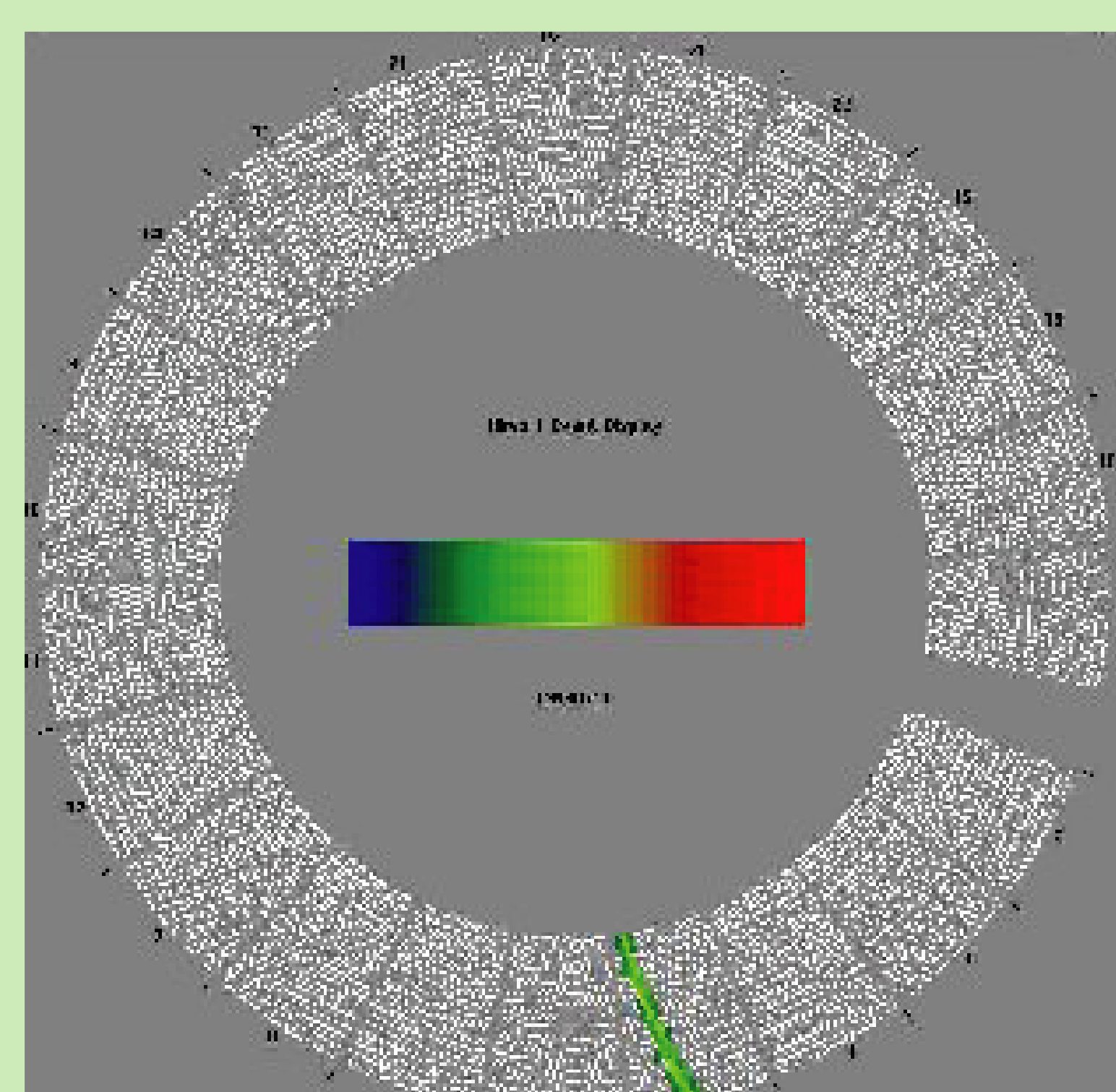
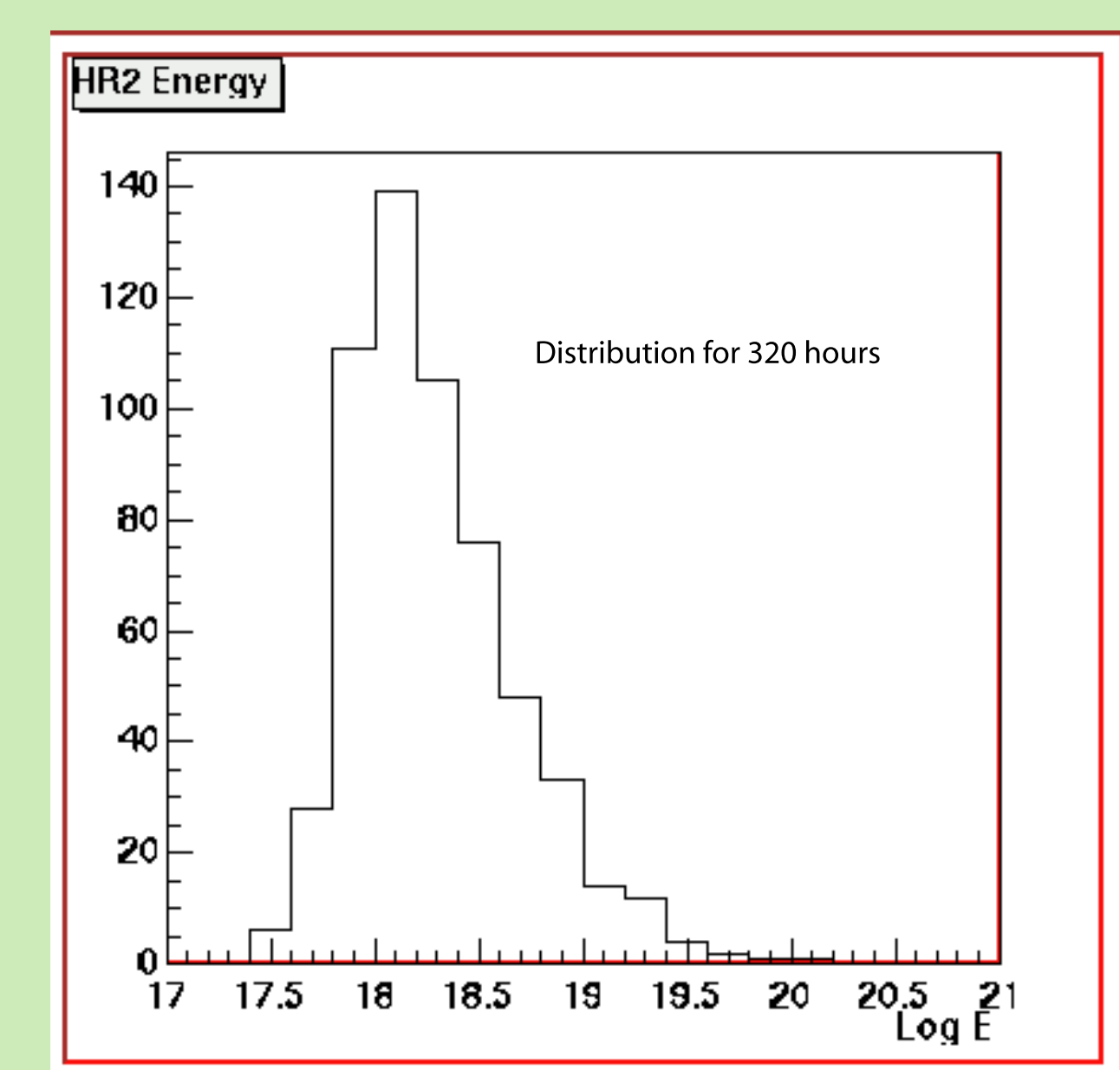
HiRes-I, located at Little Granite Mountain, consists of 22 detector elements and has almost full azimuthal coverage over a range of elevation angles from 3 to 17 degrees.



HiRes-II is located at Camel's Back Ridge. It is composed of 42 detectors providing nearly full azimuthal coverage for elevation angles between 3 and 31 degrees (Two Rings).



An EAS initiated by a cosmic ray forms a track across the pixels of the camera face. The width of the EAS is typically a few hundred meters and it's distance is typically 10-30 km or greater. Thus, the tracks appear basically line-like. The position of the detector and this line determine the shower-detector plane. Using timing information recorded at a single detector site, the full three dimensional EAS geometry can be reconstructed. However, the uncertainties can be large and difficult to determine. As shown, using simultaneous observations of the same EAS from two physically separated detectors (stereo observation), the geometry of the EAS can be determined precisely simply by calculating the intersection of the two shower detector planes. The addition of precise timing information from both sites further constrains the EAS reconstruction resulting in improved energy resolution, etc. Simultaneous observations of the EAS also provides model independent checks of the reconstructed EAS parameter resolutions.



Other HiRes Posters at ICRC 2001

- A Fiber-Optic Based Calibration System for the HiRes Experiment
- A Measurement of the Average Longitudinal Development Profile of Cosmic Ray Air Showers Between 10^{17} eV and 10^{18} eV
- Absolute GPS Time Event Generation and Capture for Remote
- Atmospheric Monitoring at HiRes Hardware System I
- Atmospheric Monitoring Hardware at HiRes
- Calibration and Stability of the High Resolution Fly's Eye Detector
- Measuring Air Shower Speeds With the HiRes Fluorescence Detectors
- Measurement of the Cosmic Ray Energy Spectrum from 10^{17} to $10^{18.3}$ eV Using a Hybrid Technique

Acknowledgements

This work is supported by US NSF grants PHY 9322298, PHY 9974537, PHY 9904048, PHY 0071069, DOE grant FG03-92ER40732, and the Australian Research Council. We gratefully acknowledge the contributions from the technical staffs of our home institutions. The cooperation of Colonel Fisher, US Army and Dugway Proving Ground staff is appreciated.

