Absolute Energy Scale of the HiRes Detector.

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Abstract

We describe the calibration of the HiRes detector[1,2] and the determination of its absolute energy scale. The gains of each channel of the two HiRes detector sites are set and equalized locally using stable calibrated light sources which are transported from telescope to telescope. The gains are monitored on a daily basis with YAG lasers, one per site, with light pulses distributed to the telescopes through optical fibers. Three steerable laser systems, located respectively at HiRes-1, HiRes-2, and in the field, fire shots which are observed by the detector from nearby to over 40 km away. On days with molecular atmosphere these allow us to verify the photometric scale of the detector.

1. Introduction

The energy scale of the UHECR flux measurement depends on several factors. The first is the relation between the energy of the primary and the production of light along the trajectory. The second is the transport of light through the atmosphere, and the third is the conversion of light incident on the detector to measured signals. Traditionally, the detector response is calibrated using local light sources, and the transmission of light through the atmosphere is modeled in a Monte Carlo simulation. We present a new stereo measurement of lasers fired into the atmosphere which we will use to set the absolute scale of light along the trajectory, simultaneously measuring the absolute scale of the detector response and continuously monitoring the atmospheric transmission.

2. Photometric Scale

The photometric scale of the detector depends on the transmission through the atmosphere of 300-400 nm wavelength light, on the collection efficiency of the telescopes, and on the electronic and photomultiplier gains. We ensure a uniform response of the detector to incident light using a stable light source which can be carried to each mirror. Detector stability over time is monitored by light from a central YAG laser [3]. The atmosphere is continuously monitored by reconstruction of steerable UV lasers [4].

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2.1. Uniformity of Electronic and Photomultiplier Gains

Site wide uniformity of photomultiplier response to uniform illumination is set using stable xenon flashers[5]. The sources are transported from telescope to telescope and positioned in the center of each of the light collecting mirrors, illuminating the photomultiplier cluster. A calibration run of at least 200 flashes at each mirror allows us to achieve a uniform calibration both within the mirror, and across all mirrors at both sites.

2.2. Stability Monitored by YAG Lasers

The stability of the photomultipliers gain is monitored on a daily basis using YAG laser light pulses distributed by fiber cables to each telescope mirror. We observe and correct for changes in detector response due to periodic recalibration, hardware changes, and possibly seasonal temperature effects. The corresponding corrections are applied in the reconstruction of lasers and UHECR events, and in the calculation of the detector aperture.

2.3. Monitoring of the Atmosphere

We continuously monitor the light transmission of the atmosphere by reconstructing laser shots. Steerable 355 nm wavelength lasers located at both sites fire a pattern of $\sim$ 2000 shots per hour along predefined directions, with various energies. We reconstruct the energies using the same procedures and programs as are used to reconstruct UHECR events. The scale is set by identifying days where there are virtually no aerosols in the atmosphere. Atmospheric parameters describing the aerosol content relative to the best days are determined hourly. These parameters are used to reconstruct each UHECR shower.

3. Stereo Reconstruction of Laser

A third laser is located 21.5 km from HiRes-1 and 34 km from HiRes-2. It is reconstructed in stereo using the calibration and atmospheric parameters described above. We observe agreement between the energy as independently measured at the two sites. By comparing to the energy measured by a radiometer probe, we confirm the absolute photometric scale.

4. Air Fluorescence

The relation between the primary particle energy and the number of photons generated along the shower depends on the development of the hadronic cascade, and on the ratio of flourescence light to deposited energy. Details of the hadronic cascade affect the observed profile, but not the total deposited energy.

The flourescence yield is a function of temperature, density, and composition of the atmosphere, and has been the subject of continuing studies[6,7,8].

5. Conclusions

Plots showing the atmospheric measurements and detector gain as a function of time, as well as plots of reconstructed laser energy compared to measurement by a radiometer probe will be presented at the conference.

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7. References

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