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Search for Large-Scale Anisotropy with HiRes Data

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Abstract: The AGASA collaboration has presented results that indicate the presence of large-scale anisotropy in the arrival direction of ultra-high-energy cosmic rays. While this data has been interpreted as an enhancement from the Galactic Center and the Cygnus region and a deficit from the Galactic anti-center their map indicates a possibly much larger affect. Independent of the AGASA data, the search for anisotropy in the cosmic-ray arrival directions is inherently interesting as it may provide clues to the origins of these particles. In our presentation, we will describe a technique suitable for searching for large-scale anisotropy in the HiRes data. Results based on the HiRes II monocular data set, which was chosen because of its larger statistics, will be presented.

Introduction

The anisotropy of ultra-high energy cosmic rays may hold clues to their origin. The AGASA collaboration has reported an anisotropy associated with the Galaxy over a narrow energy band [1]. Selecting events with energies between 1 and 2 EeV, AGASA observed a 20% excess from a direction near the Galactic center and somewhat smaller enhancement from the Cygnus region (Galactic longitude 80 degrees). In the same data set they observed a 10% deficit from the Galactic anti-center. Their data show a strong dipole nature in equatorial coordinates, with right ascensions between 0 and 200 degrees showing large deficits relative to right ascensions between 200 and 360 degrees. These results have not yet been confirmed by an independent experiment. Several hypothesizes have been put forth to explain these results. One theory invokes the leaky box model of cosmic-ray propagation and requires the proton spectrum to steepen near 10^{18}eV. The other model assumes that the anisotropy is due to cosmic-ray neutrons. At 10^{18}eV neutrons have a decay length of about 10 kpc, however this would require a rather sharp cutoff in the neutron energy spectrum above $10^{18.5}$eV to account for the lack of anisotropy at higher energies.

The HiRes Experiment

The High Resolution Fly's Eye (HiRes) experiment consisted of two air fluorescence detectors (HiRes-I and HiRes-II) located on Dugway Proving Ground, Utah. HiRes-I incorporated 19 mirrors in a single ring covering 3° to 18° in elevation. HiRes-II had 2 rings with 42 mirrors giving a 3° to 32° view in elevation. The two detector stations were separated by 12.6 km. Each detector saw 360° in azimuthal and each mirror had an effective area of 3.92 m^2, which was viewed by a camera made of 256 photo multipliers. Each photo multiplier covered 1° of the sky. Detailed detector descriptions can be found in [2, 3]. The HiRes detector was sensitive to cosmic rays with energies above 2×10^{17}eV.

The work presented in the upcoming poster is based on data taken in the period from 2002 to 2006 by the HiRes-II in monocular mode and has passed standard event quality cuts (goodness of geometrical and profile fit, zenith angle less than 80 degrees, good weather days).

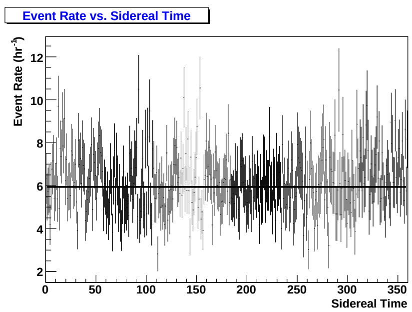

Figure 1: Event rate versus sidereal time

Analysis Method

To search for sources of ultra-high-energy cosmic rays it is necessary to compare the actual number of detected events in some region of the sky, with an estimate of the background in the same region of the sky. The estimate of the background is normally carried out under the assumption that the cosmic rays are isotropic. The problem then is reduced to determining the sensitivity of the detector to cosmic rays as a function of the local coordinates (zenith and azimuth) and the exposure of the detector to different regions of the celestial sky. Here we slightly modify the method developed in [4] (known as "direct integration") and the background estimate N_{bkg} for a given region of right ascension (ra) and declination (δ) is given by

$$N_{bkg}(ra, \delta) = R_{evts} \times T_i \times LSM^{norm}(ha, \delta), \tag{1}$$

where T_i is the detector on-time in sidereal time bin i and $LSM^{norm}(ha, \delta)$ is the nomalized sky map in local coordinates (ha, δ). The event rate R_{evts} in this background estimation method is assumed to be constant over sidereal time, which has been shown for the data used in our presentation and can be seen in Figure 1.

Presentation

Since it is crucial for the background estimation, possible seasonal effects on the event rate and on the local sky map have been studied and results will be presented in the upcoming poster. The background-corrected distribution of events on the sky in right ascension and declination will also be shown.

Acknowledgments

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