MULTI-COMPONENT OBSERVATIONS OF 10^{17} eV EAS WITH A HYBRID FLUORESCENCE AND SURFACE DETECTOR

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ABSTRACT

2486 quality HIRES-MIA coincident EAS around 10^{17} eV were recorded and analyzed, providing event direction, energy, and muon content The muon lateral distribution and the ration multiplicity as it function of energy are presented. Good agreement is found with Akeno.

Introduction

The HIRES prototype fluorescence air detector. located at Dugway, UT, was oriented to overlook the C ASA-MIA array (Sinclair, 1989) at a distance of 3.-1 kin. This provided an opportunity to observe coincident. EAS with an accurate determination of the muon content from the 2500 m2 MIA array and the superior energy reconstruction from the fluorescence technique. Trajectory reconstruction, which affects both energy and muon number reconstruction, was also improved. This allowed the effective aperture of MIA to be extended outside the 0.23 km2 CASA-MIA array. CASA data was not used in this study.

Coincident. data was collected from September 1993 through May 1996. Two basic cuts were imposed immediately: a 15 degree track length cut and a 40 or 80 raw muon cut. The higher muon cut was used when C ASA data was also present. This left 2486 events. Additional quality and antibias cuts reduced the analysis dataset to 552 events.

Results

The muon LDF was found by binning the normalized muon density in logarithmically equispaced annular bins centered on the shower core for the 552 showers. The muon density w determined by the number of counters hit. in each bin relative to the number which could have been hit after accounting for poisson statistics and expected background. The normalization was provided by $N_i \sim E^{0.80}$ where E is the HIRES determined energy and the intercept $^{105.91}$ at 10^{17} eV. Not all showers contribute to each annular bin.

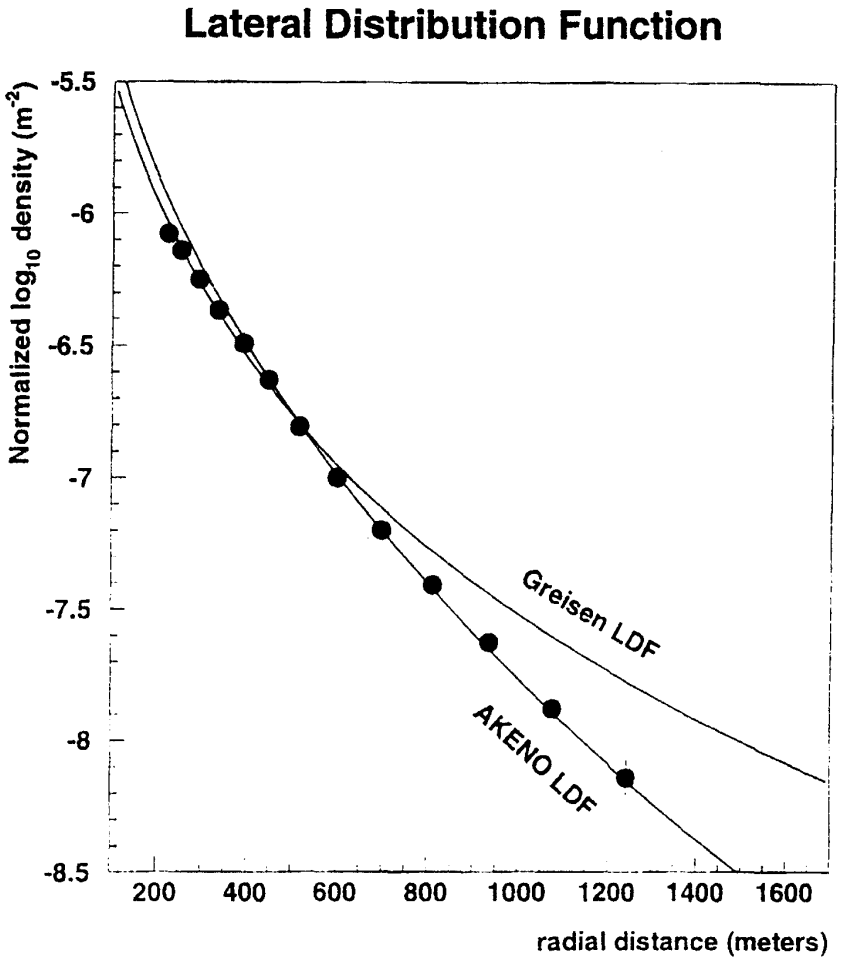

Figure 1: *Muon Lateral Distribution P unction derived from the normalized muon density. The Greisen and Akeno functions are shown for comparison.*

Figure 1 shows the resulting LDF. We are in good agreement with the modified Greisen form proposed by the Akeno group (Hayashida, 1995) based on their observations. The results are clearly inconsistent with the Greisen form at large distances. Although muon. hits occur beyond 1200 meters, the difficulty of discriminating between in time muons and accidentals becomes quite serious since the shower thickness grows at large distances from the core. Events more than 1000 meters from the center of MIA are rejected. The slight departure from the Akeno form at short distance is a known saturation effect, reproducible in monte carlo.

Figure 2 shows the N_i -E correlation. The total N_i determined by MIA relies on a maximum log likelihood fit to the Akeno muon LDF form. A strong correlation is present. even before the quality and antibias cuts. After these cuts, the best fitted line has a slope 0.80 ± 0.03 (stat) with a loglo intercept of 5.91 ± 0.05 (stat) ± 0.09 (sys) at 10^{17} eV. This compares with the Akeno result (Hayashida, 1995) over the range $10^{16.5}$-$10^{17.8}$ eV:

$$\text{Log}_{10}\, N_i = (0.84 \pm 0.02)\, \log_{10} \text{E} - (8.38 \pm 0.35) \quad (1)$$

The Akeno result is equivalent to a $\log_{10}$ intercept of 5.90 ± 0.35 at 1017 eV. We are solidly in agreement with their intercept and consistent with their slope.

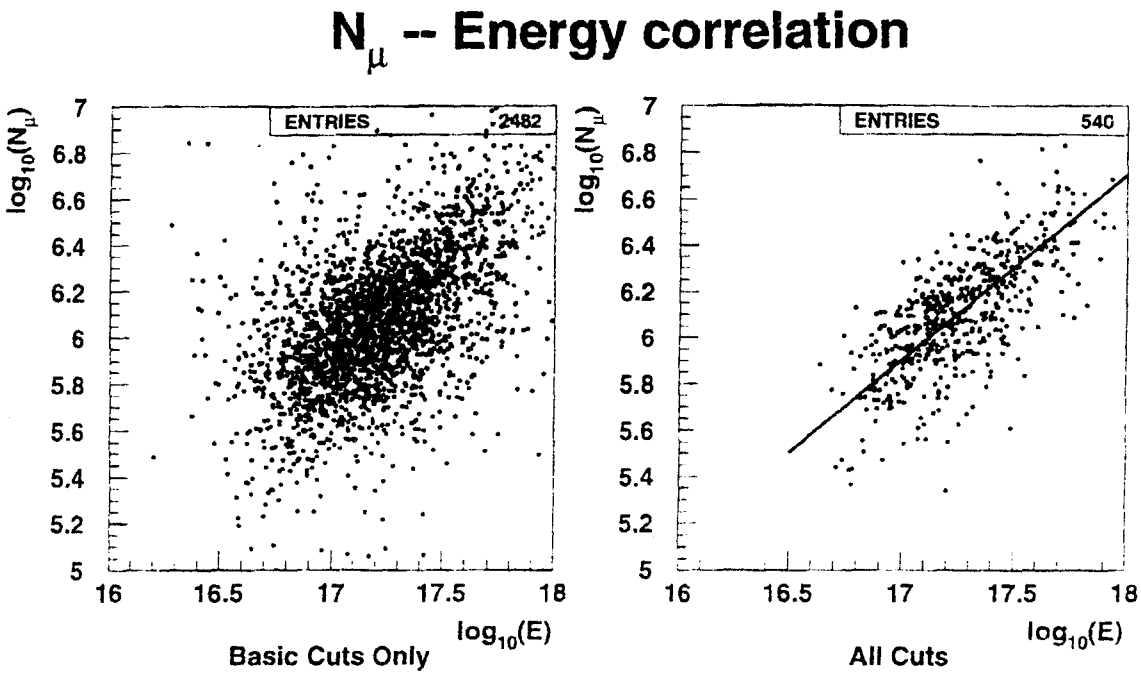

Figure 2: N vs. Energy correlation

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References

Hayashida, *et al*. Muons 1 GeV in large extensive air showers of energies between $10^{16.5}$ eV and $10^{19.5}$ e1% observed at Akeno, *J. Physics G*. **21**. pp 1101 1119, (1995).
Sinclair, D., *NIM*, **A278**, pg 583, (1989).